PURPOSE

The City of Austin, d/b/a Austin Energy (AE) seeks proposals from firms qualified and experienced in the design, implementation and maintenance of Supervisory Control and Data Acquisition/Energy Management Systems (SCADA/EMS) and Advanced Distribution Management System—Supervisory Control and Data Acquisition (ADMS-SCADA) systems for the purpose of replacing the City’s current SCADA/EMS system. The Contractor will be required to provide all software, implementation and maintenance support services, with the option to deliver and support an ADMS-SCADA system as well.

BACKGROUND

The City of Austin, Texas, population 900,000, is the 11th largest city in the country. This vibrant and dynamic city tops numerous “Best” lists for business, entertainment, cost of living and quality of life. Austin was selected as the “Best City for the Next Decade” (Kiplinger), the “Top Creative Center” in the US (Entrepreneur.com), and is in the Top Seven List of Intelligent Communities for 2012 as ranked by the Intelligent Community Forum. Austin continues to lead the country with its vision of being the “Most Livable City in the Country”, emerging as a player on the international scene with such events as SXSW, Formula 1 and being home to companies such as Apple, Samsung, Dell, The Seton Healthcare Family and St. David's HealthCare systems. From the home of state government and the City of Texas, to the “Live Music Capital of the World” and its growth as a film center, Austin has gained worldwide attention as a hub for education, business, health, and sustainability. Since 1900, Austin's population has doubled every 20 years, with continued projected record-breaking growth into the next decade and beyond.

AUSTIN ENERGY

AE is the electric utility owned and operated by the City of Austin, Texas, engaged in the generation, distribution, and transmission of electricity to residential, commercial and industrial customers in Travis and Williamson County, Texas. The SCADA/EMS and ADMS-SCADA systems enable utilities to collect, store and analyze data from hundreds of thousands of data points in local or regional networks, perform network modeling, simulate power operation, pinpoint faults, preempt outages, and efficiently manage the transmission and distribution networks.

AE is currently operating on a discontinued software platform (ABB RANGER EMS), which ABB has replaced with a materially different version called Network Manager (NM).

The SCADA/EMS hardware and operating systems have been discontinued by HP and will go out of support at the end of 2020 putting Austin Energy at risk of North American Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP) violations and subject to substantial fines after that time.
**SCADA/EMS**

This system supervises, controls, optimizes and manages the AE transmission system. The EMS manages the operation of the bulk power grid. The SCADA system retrieves the real-time measurements and status conditions reflecting the topology of the power system for use by automatic generation control and advanced power network applications such as state estimation, operator power flow, and contingency analysis.

SCADA/EMS is considered a mission critical system since the potential consequences of losing visibility and control of bulk power grid operations are so severe. EMS systems are required to maintain the overall reliability and efficiency of the electric grid. The successful operation and reliance is further underscored by the requirements that are imposed by NERC on electric operating authorities.

**ADMS-SCADA**

This system brings together Distribution Management System (DMS), SCADA, Outage Management System (OMS) technologies, and advanced applications along with control room applications, into one secure platform with a single user interface. With this comprehensive mission critical solution, the electric utility can monitor, analyze and control the distribution network to improve the level and quality of service.

These systems are a vital part of modern power networks and enabling the development of smart grids which handle large quantities of meter data (and other monitored data points on the system) and renewable power sources all while maintaining grid stability in spite of these potentially disruptive sources of power and the two-way flow of power.
RFP Section 0500 Scope of Work and Technical Specifications
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>System Requirements and Architecture</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>Capacity and Performance</td>
<td>39</td>
</tr>
<tr>
<td>4</td>
<td>System Security</td>
<td>62</td>
</tr>
<tr>
<td>5</td>
<td>SCADA Functions</td>
<td>85</td>
</tr>
<tr>
<td>6</td>
<td>User Interface Requirements</td>
<td>136</td>
</tr>
<tr>
<td>7</td>
<td>Network Analysis</td>
<td>201</td>
</tr>
<tr>
<td>8</td>
<td>Operator Training Simulator</td>
<td>246</td>
</tr>
<tr>
<td>9</td>
<td>Model and Display Development</td>
<td>258</td>
</tr>
<tr>
<td>10</td>
<td>Information Storage and Retrieval (IS&amp;R)</td>
<td>281</td>
</tr>
<tr>
<td>11</td>
<td>System Software Requirements</td>
<td>298</td>
</tr>
<tr>
<td>12</td>
<td>Hardware Requirements</td>
<td>314</td>
</tr>
<tr>
<td>13</td>
<td>Documentation Requirements</td>
<td>331</td>
</tr>
<tr>
<td>14</td>
<td>Quality Assurance and System Testing</td>
<td>364</td>
</tr>
<tr>
<td>15</td>
<td>Project Implementation</td>
<td>387</td>
</tr>
<tr>
<td>16</td>
<td>Maintenance, Support, and Upgrade Program</td>
<td>412</td>
</tr>
<tr>
<td>17</td>
<td>Training and Knowledge Transfer</td>
<td>430</td>
</tr>
<tr>
<td>18</td>
<td>SCADA/EMS Project Milestone Payment Schedule</td>
<td>449</td>
</tr>
<tr>
<td>19</td>
<td>Advanced Distribution Management System (ADMS) - Option</td>
<td>459</td>
</tr>
</tbody>
</table>
1 INTRODUCTION

This document presents the Scope of Work and Technical Specifications for the purchase, implementation, and maintenance of a new SCADA/EMS for AE, hereinafter referred to as the Purchaser. This System will replace all existing SCADA/EMS hardware and software that was supplied by ABB in the existing system.

1.1 Existing SCADA/EMS and Power Network Applications Systems

The following sections provide a brief overview of the existing SCADA/EMS and Power Network Applications (PNA) systems. The specific requirements for the new SCADA/EMS are stated in the subsequent sections of the Scope of Work (SOW) and Technical Specifications.

1.1.1 Existing SCADA/Energy Management/PNA Systems

The existing SCADA/EMS consists of 2 (two) major components provided by ABB installed at the System Control Center (SCC) and Backup Control Center (BUCC):

1. The SCADA/EMS component SCADA, UI, Calculations package, and IS&R. This System receives and transmits data to other utilities, Purchaser systems, and ERCOT via ICCP.

2. The Power Network Applications (PNA) component that executes advanced power network applications including State Estimation, Contingency Analysis, and Power Flow as used for both real-time and study network analysis. An Operator Training Simulator is also included.

1.2 Overview of System Being Specified

In replacing the existing systems, the Purchaser is requiring a system that can perform all the functionality defined in these SOW Technical Specifications. The Purchaser also requires a new Operator Training Simulator (OTS), Quality Assurance System (QAS), and Development System (commissioned early in the project). The Production SCADA/EMS will be redundant at both sites. The QAS will be redundant at the Primary site but will not be included at the Backup site. The OTS and Early Development System will be staged only at the Primary site.

1.2.1 Architecture Overview

The new System’s architecture will be based on provision of SCADA/EMS functions at the Purchaser’s System Control Center (SCC) and Backup Control Center (BUCC).
1.2.2  Overview of Hardware Configuration

The new SCADA/EMS shall be built using an open design allowing the addition and integration of future hardware and/or software components. All critical functions of the SCADA/EMS shall be protected by appropriate cyber security measures and shall withstand the failure of any single hardware or software component for each control center.

The Production system will be comprised of a Virtual Cluster at the Primary site and a Virtual Cluster at the Backup site. Austin Energy intends to utilize Nutanix Hyper-Converged technology as the basis for the VM clusters. The QAS, OTS, and PDS will be contained within a second VM cluster at the Primary site.

The Contractor shall recommend equipment such as servers and workstations for the SCADA/EMS as specified in Section 12 Hardware Requirements, and elsewhere in the SOW Technical Specifications. Based on these Contractor recommendations, the Purchaser will procure the hardware directly.

1.2.3  Overview of Software Configuration

The software components of the SCADA/EMS shall include programs providing for data acquisition, data processing and alarm management, supervisory control, a modern graphical user interface, data modeling and engineering, display and report generation and maintenance, a CIM toolkit, backup and failover management, system and network management, and integration with other Employer OT/IT systems both now and in the future.

The Contractor shall provide the SCADA/EMS software to meet all functional requirements specified in the SOW Technical Specifications.

Vendor will support Austin Energy cyber-security products that are currently being used for NERC/CIP auditing purposes. At its discretion, Austin Energy may install additional cyber-security products on the systems prior to the beginning of acceptance testing.
1.3 Structure of the SOW Technical Specifications

The SOW Technical Specifications are organized as follows:

Section 1 – Introduction

Section 2 – System Requirements and Architecture

Section 3 – Capacity and Performance

Section 4 – System Security

Section 5 – SCADA Functions

Section 6 – User Interface Requirements

Section 7 – Network Analysis

Section 8 – Operator Training Simulator

Section 9 – Modeling and Display Development

Section 10 – Information Storage and Retrieval

Section 11 – System Software

Section 12 – System Hardware

Section 13 – Documentation

Section 14 – Quality Assurance and System Testing

Section 15 – Project Implementation

Section 16 – Maintenance Support

Section 17 – Training and Knowledge Transfer
2 System Requirements and Architecture.......................................................................................... 9
  2.1 SCADA/EMS Scope.................................................................................................................. 9
  2.2 Architectural Principles ......................................................................................................... 10
  2.3 SCADA/EMS System Configuration ..................................................................................... 12
    2.3.1 Definition of Users......................................................................................................... 13
    2.3.2 Production Environment ................................................................................................. 14
      2.3.2.1 Primary Control System (PCS)................................................................................ 14
      2.3.2.2 Backup Control System (BCS)................................................................................ 15
      2.3.2.3 Normal Mode of Operation.................................................................................... 16
    2.3.3 Support Environments .................................................................................................... 18
      2.3.3.1 Corporate and External User Environment.............................................................. 18
      2.3.3.2 Integration Capabilities............................................................................................ 18
      2.3.3.3 CIM Compliant Adapters....................................................................................... 19
      2.3.3.4 Model Management Environment .......................................................................... 20
      2.3.3.5 Quality Assurance System Environment (QAS)................................................... 20
      2.3.3.6 Early Delivery of the PDS Environment ................................................................. 21
      2.3.3.7 Early Delivery of the QAS Environment................................................................. 21
      2.3.3.8 Operator Training Simulator Environment .......................................................... 22
      2.3.3.9 Backup and Archiving Environment ..................................................................... 22
    2.3.4 Component Systems........................................................................................................... 23
      2.3.4.1 SCADA System......................................................................................................... 23
      2.3.4.2 EMS Application System.......................................................................................... 23
      2.3.4.3 User Interface Infrastructure.................................................................................... 23
      2.3.4.4 Data Acquisition System........................................................................................ 24
      2.3.4.5 ICCP Gateway ........................................................................................................ 25
2.3.4.6 Information Storage and Retrieval System ....................................................... 25
2.3.4.7 Remote Access System ..................................................................................... 25
2.3.4.8 System Management ......................................................................................... 26
2.3.5 Communication Facilities ..................................................................................... 27
  2.3.5.1 RTU Network .................................................................................................... 27
  2.3.5.2 Local and Wide Area Networks ........................................................................ 28
2.4 Redundant System Design Requirements ............................................................. 28
  2.4.1 Real Time Data Management .............................................................................. 28
  2.4.2 Redundancy Design Options ............................................................................. 30
  2.4.2.1 Dual-Redundant Design .................................................................................... 30
  2.4.2.2 Cluster Backup Design ..................................................................................... 30
  2.4.3 Backup of Data ..................................................................................................... 30
  2.4.4 Failover and Restarts ............................................................................................. 31
    2.4.4.1 Failover ............................................................................................................. 31
    2.4.4.2 System Restarts ................................................................................................. 32
    2.4.4.3 Manual Failover and Restart ............................................................................. 33
2.5 Critical and Non-Critical Functions ........................................................................ 33
  2.5.1 Critical Functions .................................................................................................. 33
  2.5.2 Non-Critical Functions .......................................................................................... 34
2.6 System Availability .................................................................................................... 34
  2.6.1 Calculation of Availability .................................................................................... 34
  2.6.2 Downtime Accumulation ....................................................................................... 35
  2.6.3 End of Downtime Accumulation ........................................................................... 35
2.7 Application Standards .............................................................................................. 36
2 SYSTEM REQUIREMENTS AND ARCHITECTURE

This section specifies overall requirements for the SCADA/EMS including architecture, expansion, security, and applicable design standards.

2.1 SCADA/EMS Scope

The new SCADA/EMS shall replace the Purchaser’s existing SCADA/EMS system.

Key components of the new System shall include:

1. A SCADA/EMS system
2. A Network Operational Model (NOM)
3. Advanced SCADA/EMS visualization tools that support on the fly modifications to the network connectivity and its visualization
4. Advanced SCADA/EMS situational awareness tools that work with the advanced visualization tools to enhance the Operator’s situational awareness of the power system
5. A set of Power Network Analysis tools based on the latest power flow techniques covering the Purchaser’s power system network
6. A Disaster Recovery capability that will incorporate multiple site operational capability
7. A Program Development System (PDS) Environment that allows support personnel to make changes to the database and displays as well as develop new applications. Two PDS Environments shall be provided: one located at the SCC and one at the BUCC.
8. A Quality Assurance System (QAS) Environment that allows changes to be fully tested prior to deployment to a Production Environment
9. An operational training environment in which the capability to accurately simulate the behavior of the electrical network and SCADA/EMS is provided
10. A corporate and external user support system that allows secure access to users for reporting and monitoring of the Purchaser’s power network data
11. An Information Storage and Retrieval (IS&R) system that includes a DBMS for storage of all historized information (e.g., status, analog, calculated, accumulator, application results, NERC reliability standards data, savecases, alarm and events and energy accounting data, etc.)
12. An interface to OSIsoft PI for archiving of real-time data and definition of PI tags (see Section 10.4.1 SCADA Historian Integration (AE Specific Requirement))

13. Interface to Primate server that drives video wall (see Section 11.3 Video Wall Display Workstation Software)

14. ICCP System for data exchanges

15. Interoperability Gateway for data exchange

16. Model Management system to build displays and different models (SCADA, Network applications, IS&R, OSIsoft PI, ICCP, etc.) in the SCADA/EMS. The data migration/conversion tools shall be available in the Model Management.

### 2.2 Architectural Principles

The configuration of the SCADA/EMS shall consist of a distributed computing environment with a highly secure architecture. The system architecture shall be open internally and externally to hardware or application software additions, whether supplied by the original system supplier or obtained from third party vendors, both for capacity expansion and for upgrading functionality, without affecting other SCADA/EMS components or its operation.

All internal communications among the SCADA/EMS processors and all external communications between the SCADA/EMS and other computer systems shall be based on widely accepted and published international or industry standards that are appropriate and relevant to the open systems concept. This applies to the operating system, Database Management System (DBMS), and display management system, as well as to Application Programming Interfaces (APIs) providing standardized interfacing between systems software and application software.

The following distributed and open-system design concepts shall apply:

1. The SCADA/EMS configuration shall be based on Open Systems Standards supporting a clear migration path toward an open architecture in which the software is totally transparent of the hardware, such that any hardware adhering to these standards can be replaced/upgraded with functionally similar hardware not necessarily manufactured by the original manufacturer.
2. The major environments of the System shall be distributed to different sets of redundant processing resources, such as SCADA processing resources, Application processing resources, Front-End processing resources, and User Interface processing resources. In this respect, the servers shall use a fault tolerant configuration to ensure that both control centers continue to operate under a single component failure condition. The operations UI should not be affected by it any system site switchover. The UI should be seamless when connecting to main site system or backup site system. Users and admin should be able to failover components and restart system from the UI. The UI should provide status on all major subsystem components for quick status alerts.

3. Hyper-converged infrastructure utilizing Nutanix Acropolis Hypervisor shall control all components including computation, storage, and virtualization resources.

4. Each processing resource unit shall be replaceable/upgradeable by simple change out without affecting the rest of the system and without requiring any software modification. Replacing/upgrading any processing resource shall be totally transparent to the functionality of other subsystems that reside on other processing units. Each disk drive subsystem shall be dedicated to a single processor.

5. The environment that acquires data from a field device associated with a SCADA point shall be responsible for obtaining, retaining, and forwarding the value. The value for a specific SCADA point may be available at more than one Data Acquisition environment depending on the actual physical communications to a given field device (for instance, an RTU may be dual ported and connected to two different sites) or the SCADA point may be available at one physical site but also needed at more than one site.

6. All processing units of the SCADA/EMS shall be interconnected using software defined networking based on Cisco Application Centric Infrastructure (ACI). The SDN network shall support exchange of data from the various system components to include: processing resources and servers, user consoles, communications processing resources, terminals, gateways, any stand-alone disks and removable media, etc. The system components may be dissimilar in architecture and/or operating systems.

7. For processing resources, the same revision of a widely accepted and latest version of the Windows or Linux operating system shall be used. For workstation processors, the latest version of Windows operating system shall be used. All software shall be written in standard
ANSI high-level languages. The SCADA/EMS shall be designed to provide the highest possible level of hardware and software independence using standard products, the use of standard toolkits, and through application modularity. All SCADA/EMS software shall be a mutually agreed upon version. All third-party software shall be compatible with the main SCADA/EMS software.

8. Expandability shall be provided using a hardware and software platform that allows for vertical growth, and a configuration that allows horizontal growth and distributed computer/server support.

9. Expansion of the system models (e.g., SCADA, power system models, etc.) in the SCADA/EMS shall be a simple and quick task. The expansion procedure shall be provided in a software maintenance manual.

### 2.3 SCADA/EMS System Configuration

The SCADA/EMS, also referred to in these specifications as the “System”, provides services using several environments:

1. Production Environment (PE)
2. Operator Training Simulator Environment (OTS)
3. Corporate and External User Environment (CEU)
4. Quality Assurance System Environment (QAS)
5. Program Development System Environment (PDS)
6. Backup and Archiving Environment (BAE)
7. Model Management Environment (MME)

Each of these environments consists of one or more systems, which may be replicated across several environments.

For the purposes of this specification the term RTU shall include the following SCADA devices:

1. RTUs located at substations, plants, and other facilities throughout the Purchaser’s power system.
2. Substation Automation Systems (SASs) using a gateway to convert IEC 61850 to DNP3

The major locations for the System are:
1. SCC (System Control Center), which as the Primary Control System (PCS) has the following facilities:
   1.1. 1 (one) Transmission Control Center (TCC1) room
   1.2. 1 (one) Engineering and OTS room
   1.3. A data center for housing Nutanix hyper-converged infrastructure (e.g. servers and communications equipment)
   1.4. Electrical room for housing Uninterruptible Power Supply (UPS) and batteries

2. BUCC (Back-Up Control Center) located at Decker Power Plant, which as the Backup Control System (BCS)/Disaster Recovery Site has the following facilities:
   2.1. 1 (one) Transmission Control Center (TCC2) room
   2.2. Electrical room for housing Uninterruptible Power Supply (UPS) and batteries

3. Backup Data Center housing Nutanix hyper-converged infrastructure (e.g. server and communications equipment).

The Contractor’s actual detailed configurations for each control center may be different as long as they meet all of the requirements of these specifications, including the functional, performance, security, and availability requirements, and are built on an open system architecture design that facilitates the maintenance, expansion, and upgrading of the System.

2.3.1 Definition of Users

Users are separated into 2 (two) categories: (a) System users and (b) non-System users, and the term “user” as used in these specifications may refer without qualification to both.

System users are personnel who have operational control of the System. This includes use of the system to monitor and control the power system. As here and elsewhere in these specifications, they are referred to as Operators and Administrators, where:

1. An Operator is a person responsible for monitoring and controlling the electrical network through the user interface provided by the System.
2. An Administrator is a person responsible for operations support and has access to certain System functions and data. This may include responsibility for continuing development and maintenance of the System functions, databases, displays, and reports.
Non-System users are personnel who have no control over operation of the System and only require access to information from the System (generally read only access). Typical non-System users are Power Network Planners, Business Managers, and general users within the corporation.

2.3.2 Production Environment

The Production Environment is the environment within which all power systems operations are run. This critical environment consists of the following systems:

1. Primary Control System
2. Backup Control System

2.3.2.1 PRIMARY CONTROL SYSTEM (PCS)

The PCS under normal conditions operates from the SCC Control Center. The PCS shall be a high-availability system characterized by high-speed data collection and presentation functions.

The PCS shall collect, process, and store real-time data from the following data sources:

1. Remote Terminal Units (RTUs) as defined in Section 2.3 SCADA/EMS System Configuration, including meters.
2. Computer systems connected to the control center WAN linking the System with neighboring utilities
3. Computer systems connected to the Purchaser’s Security Network.

The PCS includes a number of sub-systems. These are:

1. SCADA System
2. EMS Applications System
3. IS&R System
4. Data Acquisition System
5. ICCP Gateway
6. Operational User Interface Infrastructure
7. OSIsoft PI Data Historian
The database of the PCS shall be accessible by all sub-systems comprising the System. All data presented to the System users, used within the System, and transmitted to computer systems outside the System shall be derived from the database.

The capability to scan RTUs from both locations shall be provided (e.g., some RTUs scanned from the DAFE at the SOC and others from the ROC). The capability shall be provided on an individual FEP basis, channel basis, or individual RTU basis. Similar capability shall be provided for ICCP. That is, some ICCP links at the SCC shall be active while others at the BUCC shall be active and sending/receiving data.

The PCS shall include the capability to monitor the “health” of components at the BCS (e.g., the PCS shall check to make sure the clock at the BCS is connected and ready to take over in the case of a problem) and vice versa. The system shall generate an alarm if any of the components connected to the BCS are compromised.

The PCS shall meet the performance specifications described in Section 3 Capacity and Performance.

2.3.2.2 BACKUP CONTROL SYSTEM (BCS)

The BCS, located at the BUCC Control Center, shall perform the same PCS functions upon loss of the PCS (at component level such as DAFE, ICCP, etc.) or upon a commanded switchover to the backup control system. The functions and requirements of the PCS shall apply to the BCS, unless explicitly stated otherwise.

The database in the BCS shall be the backup database of the PCS database. The requirements for the backup database are defined in Section 2.3.3.9, Backup and Archiving Environment.

The System shall allow on-line assignment of any PCS functions to the BCS such as scanning of RTUs via the BCS Data Acquisition Front End (DAFE) equipment. The capability to scan RTUs

---

1 This specification uses the terms “database” and “databases” interchangeably. Unless specifically stated otherwise, either term refers to all information stored in the System relating to the power system and the System itself. This specifically includes information describing the power system, information describing the System, and execution parameters of System applications. This also specifically includes both “real-time” and “historical” information.
from both locations shall be provided (e.g., some RTUs scanned from the DAFE at the SCC and others from the BUCC). The capability shall be provided on an individual FEP basis, channel basis, or individual RTU basis. Similar capability shall be provided for ICCP. That is, some ICCP links at the SCC shall be active while others at the ROC shall be active and sending/receiving data.

The BCS shall satisfy the following requirements:

1. The BCS hardware and software shall be the same as the PCS
2. The BCS shall meet the performance specifications described in Section 3 Capacity and Performance.

2.3.2.3 NORMAL MODE OF OPERATION

The hardware and software comprising the PCS and BCS shall be identical so that the incremental maintenance costs for hardware, software, database, display and report updates, and training are minimized. Unless specifically stated otherwise, their functionality, performance, availability, and capacity shall be identical.

They shall be high-availability systems characterized by high-speed data collection, control, and presentation functions. They shall collect, process, and store real-time data from a number of data sources as described in Section 5.1 RTU Data Acquisition, and Section 5.5 Communications with Other Systems. Their data exchange functionality shall include the capability to send pre-defined data sets to systems that may or may not serve as EMS data sources. In particular, the SCADA/EMS shall exchange data with a number of external systems as described in Section 2.3.4.5, ICCP Gateway.

The PCS and BCS databases shall be accessible by all component systems of the SCADA/EMS. All data presented to the SCADA/EMS users, used within the SCADA/EMS, and transmitted to computer systems outside the SCADA/EMS shall be derived from these databases.

The conceptual architecture of the System is such that the SCADA/EMS during normal operating conditions (including communications) shall operate as a distributed network of processing resources with functions that provide real-time data sharing and resources supporting the users regardless of their location. In this context, the real-time data received by one control
center system may be made available to the other control center system that requires this data, and any user may access any computer resource provided the necessary communications and access rights are available to the user.

The SCADA/EMS shall have one active real-time processing resource designated as having the “Primary” role. The PCS should be the default primary system. The architecture, however, should be such that either system at the component level could be running in the role of Primary for extended periods. The SCADA/EMS shall also support an active-active configuration where the backup system at the component level is receiving all of the SCADA data and manual entries simultaneously with the primary system at the component level as well as having the applications running. The Purchaser shall have the flexibility to run a component (e.g., running PNA from the backup while AGC is running at the primary) and use the data from the primary.

Data Acquisition from field devices may occur concurrently at both SCADA/EMS sites to avoid the impact of common mode failures.

In the usual mode of operation, i.e., when the SCADA/EMS at both sites are capable of being the Primary system, the databases shall be kept fully synchronized in real time such that information at both control centers shall be the same to within the time specified in Section 3 Capacity and Performance. In this mode of operation, the users at the SOC and ROC shall be configured such that they manage the Purchaser’s power system network using the PCS.

The PCS and BCS shall act as a backup to each other. If one control center system should fail, the other will immediately be used to monitor and control the Purchaser’s power system network. The switchover to the BCS can be manually initiated as well as an automatic function of the System.

The BCS shall be capable of being used for extended periods if the PCS becomes non-operational. If the PCS is non-operational, the BCS shall be capable of undertaking data engineering functions using the resident PDS Environment.

The BCS shall also be used regularly as part of an overall capability check. During these regular capability checks, the PCS shall remain functional, in synchronism, and ready to resume the primary role in case the BCS were to fail.
2.3.3 **Support Environments**

The Support Environments are highly necessary for managing and maintaining the System and providing a secure mechanism for presenting information to the rest of the Purchaser’s business units.

2.3.3.1 **CORPORATE AND EXTERNAL USER ENVIRONMENT**

The function of the CEU Environment is to securely decouple the SCADA/EMS from the corporate network for enterprise integration and publishing historic and near-real time information for the use of approved corporate users.

The design of the CEU shall reflect the Cyber Security requirements in the Technical Specifications. The CEU Environment shall contain its own Authentication and Network Management system as part of a security defense in depth strategy.

Within the CEU the IS&R functions shall execute on a high-availability platform dedicated to serving non-system users. The IS&R platform shall be scalable to support other business applications in addition to those required of the System. The servicing of non-System users shall not compromise the security and performance of the other components of the System.

2.3.3.2 **INTEGRATION CAPABILITIES**

The SCADA/EMS shall be delivered in a form that, to the fullest extent possible, is system integration ready from the perspective of the Purchaser’s vision that its enterprise systems must be capable of supporting their interoperability both now and in the future. In this respect, information from one system’s applications and processes shall be capable of being exported and imported by another system, i.e., in those cases where it is required to support the other system’s applications and processes.

For even greater flexibility, however, the SCADA/EMS shall have the capability to support applicable industry standard based on IEC CIM to facilitate the Purchaser’s overall system integration needs.

Some of these interface standards are referenced elsewhere in the Technical Specifications.
2.3.3.3 **CIM COMPLIANT ADAPTERS**

To support future enterprise integration, the SCADA/EMS shall be capable of utilizing IEC 61968/61970 compliant adapters, i.e., CIM/XML using SOAP, JMS, REST, JSON, etc.

The implementation of these adapters, supporting CIM export/import capabilities, shall conform to all security requirements in these specifications. The Contractor’s adapters shall support the latest versions of the CIM Schema for CIM profiles such as those below in Exhibit 2-1. In this respect, the capability to export/import only incremental changes to a CIM/XML file is also required.

For the purposes of this section of the specification, CIM compliance means that the interface definitions comply with the CIM in terms of:

1. **Semantics** (i.e., meaning of data) – ability to map directly or using a simple translation, data elements of an interface data model to the respective attributes of the CIM.
2. **Syntax** (data type) – assumes semantic compliance between sender and receiver when both systems (sender and receiver) can process message structure (format)/payload derived from CIM.
3. **Relationship** (i.e., to other CIM components, to permit proper navigation within the model).

The Purchaser also requires documented open APIs that will support integrating Purchaser or third-party developed applications. The API and associated programming environment shall support XML based open interfaces such as SOAP, REST and Microsoft.NET architecture.

---

**Exhibit 2-1: CIM Profiles**

<table>
<thead>
<tr>
<th>IEC Standard</th>
<th>Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61970-452</td>
<td>Equipment (static transmission network model profiles). Identifies equipment, basic characteristics, and electrical connectivity of steady state network model. Also known as Common Power System Model (CPSM)</td>
</tr>
<tr>
<td>IEC 61970-453</td>
<td>Schematics layout profile - Describes how equipment objects are placed on schematic diagrams for display purposes</td>
</tr>
<tr>
<td>IEC 61970-456</td>
<td>Analog measurements, discrete measurements, state variable, and topology profiles comprising steady-state solution profile group</td>
</tr>
</tbody>
</table>
2.3.3.4 **MODEL MANAGEMENT ENVIRONMENT**

A Model Management Environment (MME) shall be provided for the management of the Network Operational Model (NOM), System Displays, DAFEs, and ICCP Gateways. The MME shall enable a single source of truth for model information such that updates shall be made once, in one place and in one place only, for use by all SCADA/EMS functions, modules, and applications. This shall include the definition of points for collection and storage in OSIsoft PI.

The MME shall provide an interactive graphical representation of the network to help visualize the connectivity of the power system.

2.3.3.5 **QUALITY ASSURANCE SYSTEM ENVIRONMENT (QAS)**

The QAS shall support the Purchaser’s testing of the System applications, databases, displays, and reports as well as Purchaser developed applications. To fulfill this purpose, it shall contain replica systems of the PCS/BCS with the addition of a modeling system (refer below to Section 2.3.3.4 Model Management Environment) to assist in the quality assurance of pending Production Environment data updates.

The QAS shall be capable of simultaneously acquiring real-time data directly from data sources (via the QAS data acquisition facilities) and from the PCS or the BCS. Control commands issued from the QAS shall be communicated to field devices only if those devices are directly and solely attached to the QAS, i.e., commands to devices communicating through the PCS or other System component systems shall be disabled, even though the QAS may be collecting data from the devices via the PCS or other System component system.

The QAS shall also be used to maintain the database, display, and application configuration and to develop and test new configurations without interfering with and degrading the operation of the System. A facility shall be provided to install a new configuration to any network node from a console connected to the QAS, and to affect the new configuration within the time specified in...
Section 3.3 Software Maintenance, without impairing data and operation integrity and without loss of data. The installation of a new configuration shall occur without operation interruption.

2.3.3.6 **EARLY DELIVERY OF THE PDS ENVIRONMENT**

As stated in Section 15.1.5, SCADA/EMS Quality Assurance System (QAS) and Program Development System (PDS) Environments, the Purchaser with the Contractor’s assistance will establish the PDS at the Purchaser’s sites at an early stage of the project to allow the Purchaser to perform or review database and display development or conversions from the existing SCADA/EMS.

The PDS shall be initially delivered with basic database and display generation capabilities and shall include the Contractor’s software and support tools sufficient to perform the database and display development or conversions from the existing SCADA/EMS. In addition, the PDS shall include the Contractor’s standard applications and base models. The MMS shall also be provided early as part of the early delivery PDS.

The PDS shall also be used early by the Contractor to test and debug RTU protocol and interface issues with new and existing RTUs by using the listening mode capability. It is further anticipated that the Contractor will use the PDS to pre-commission the ported database.

2.3.3.7 **EARLY DELIVERY OF THE QAS ENVIRONMENT**

The Purchaser with the Contractor’s assistance shall establish the QAS at the Purchaser’s site after completion of the early delivery PDS. The early delivery QAS shall include the Contractor’s standard software and with Purchaser’s converted databases and displays. In addition, the Contractor shall provide its standard test procedures and user guides. The Purchaser will use the early delivery QAS to familiarize itself with baseline functionality and use of the system. The QAS shall be incrementally enhanced throughout the project with the Contractor’s standard applications and data acquisition facilities to support verification of the data acquisition and processing functions of the System using actual data sources. The QAS shall be initially configured as a stand-alone system and shall retain its individual identity in the final System configuration, although it shall be networked with the System.
In its final configuration, the QAS will be used to aid in problem resolution and the development and testing of new applications. To support this functionality, a means shall be provided for the QAS to access or receive real-time data from RTUs and other sources of real-time and non-real-time data in the System. The access process shall be transparent to any function executing in the QAS using the data and shall not interfere with or degrade the operation of the System. It shall not be necessary to configure the source of the data to transmit to both the PCS and the QAS, such as by implementing a duplicate transmission of data over a data link. The data shall be retrieved from data sources by the PCS and sent on to the QAS by processes in the PCS. The Contractor shall update the QAS to ensure that it is in synchronism with the PCS as often as necessary to ensure that the requirements above are satisfied.

2.3.3.8 OPERATOR TRAINING SIMULATOR ENVIRONMENT

The OTS shall execute on hardware dedicated to that functionality. It shall provide the capability to train Operators by simulating both the power system and the System. Component sub-systems shall support the capability of the OTS to be initialized from System real-time snapshots as well as historical savecases. These and other functional requirements are further defined in Section 8, Operator Training Simulator. The OTS shall be delivered early in the project with the Contractor’s baseline software with the Purchaser’s converted network model installed.

2.3.3.9 BACKUP AND ARCHIVING ENVIRONMENT

Services to back up, archive, and restore all SCADA/EMS software, operating system image, displays, and data independently of its location shall be provided on the SCADA/EMS networks. The backup information shall include the SCADA/EMS.

Once initiated, the distributed backup and archiving services shall automatically back up all information needed to recover from failures or data corruption without manual intervention by users, except for replenishment of removable media.

Although the devices being backed up may be physically separate, the backup system shall be managed centrally.

While the backup is active, the System shall maintain the performance requirements as specified in Section 3 Capacity and Performance.
2.3.4 **Component Systems**

In the conceptual solution architecture of the Technical Specifications, there are numerous instances of systems being deployed in different environments. This section provides a brief account of these particular systems.

2.3.4.1 **SCADA SYSTEM**

The SCADA System shall be a high-availability system characterized by high-speed data collection and presentation functions. The SCADA System collects, processes, and stores real-time data collected via the Data Acquisition System and peripheral systems such as ICCP, weather, etc.

2.3.4.2 **EMS APPLICATION SYSTEM**

The EMS Application System (EAS) shall be a high-availability system characterized by high-speed applications execution and presentation functions. The EAS shall be responsible for the execution of the EMS applications. Applications data shall be available at the PCS and BCS depending on the Areas of Responsibility resulting from the login permissions granted to a user at a workstation.

As a minimum, separate processing resources shall be supplied for the EAS. The power network applications (e.g., SE, CA, etc.) portion of the EAS shall not share any processing resources with the SCADA system.

2.3.4.3 **USER INTERFACE INFRASTRUCTURE**

The Contractor shall recommend all user interface equipment to accommodate the locations, connections, and quantities as presented in these specifications.

The capability for any viewport at any console to be assigned (logically connected) to any SCADA/EMS component system since suitable communications paths exist between the console and the target system shall be provided. The design of the SCADA/EMS shall be flexible to allow the Purchaser to add, delete, or move control centers as determined by business needs.
Note that there will be some specific exceptions to this logical inter-connectivity to ensure security and reliability of the systems, e.g., the separation of the QAS from the Production Environment.

The arrangement of operating permissions and of alarm presentation and management capabilities must be flexible to support varying staff and location requirements associated with shift patterns, storm support, or emergency operations due to the loss of a control center.

Printers shall be considered shared devices. A user shall be able to direct any printed output to any accessible printer.

Non-System users shall have a Web browser user interface or an application that uses Open Systems interfaces to access the System. The service of non-System users shall not compromise the security and performance of the other component systems of the SCADA/EMS and as such should be addressed through a secure implementation in the CEU Environment.

### 2.3.4.4 DATA ACQUISITION SYSTEM

The Data Acquisition Front End (DAFE) equipment shall be responsible for communicating with the RTUs. They shall be redundant, high-availability equipment and shall meet the hardware and capacity requirements in Section 3 Capacity and Performance.

The capability to switch RTUs and communication channels back and forth between the DAFEs at the PCS and BCS on an individual RTU or communication channel basis as well as on an entire DAFE basis (i.e., move everything on DAFE 1 at the PCS to DAFE 1 at the BCS).

The Data Acquisition Front End equipment is part of the SCADA/EMS. The DAFE shall have the capability of being moved to locations physically separate from the PCS and BCS should it be required at some future time. Details of the initial and design capacity of the number of communication channels, and how many RTUs will need to communicate with, are given in Section 3 Capacity and Performance.

This specification assumes that a Data Acquisition Front End comprises Front End Processors (FEP) and communication couplers/switches.
If the PCS is evacuated without a manual switchover to the BCS being made, then the BCS shall be able to take control of the DAFE equipment. The DAFE equipment shall support this possibility and facilitate reconciliation to having only the PCS or BCS in operation.

2.3.4.5 **ICCP GATEWAY**

The ICCP Gateway is a communications system that will facilitate the processing of TASE.2 data with a nominated SCADA/EMS server. Additional information about the required functionality can be found in Section 5 SCADA Functions. The capacity and performance requirements for ICCP are defined in Section 3 Capacity and Performance.

As an option, the Contractor shall provide Secure ICCP.

2.3.4.6 **INFORMATION STORAGE AND RETRIEVAL SYSTEM**

The IS&R functions shall execute on a high-availability platform dedicated to that functionality and shall be implemented in the Production Environments and Corporate and External User Environment (CEU). The IS&R shall be scalable to support other business applications in addition to those required of the System. This includes the recording of time-stamped logs. These may include network notifications, security alerts, and other messages that are required for audit and troubleshooting purposes.

It shall service System users and a number of non-System users. The servicing of non-System users shall not compromise the security and performance of the other component systems of the System.

**Austin Energy Specific Requirements**

An Information Storage and Retrieval system shall be provided for capturing the OTS events during Operator Training sessions within the OTS environment.

2.3.4.7 **REMOTE ACCESS SYSTEM**

A Remote Access System is required to support the ongoing maintenance of the SCADA/EMS by the Contractor as part of the ongoing upkeep of the system. Hardware and software shall be supplied such that remote access can be made consistent with that described in Section 4.11.4,
Secure Maintenance Access. The system shall allow secure managed access to the Purchaser’s Environments via the Purchaser’s provided and administered VPN gateway.

Access to the SCADA/EMS shall be provided as described in Section 4.11.5, Security of Remote Access for Maintenance by Contractor.

2.3.4.8 SYSTEM MANAGEMENT

The SCADA/EMS shall include a centralized management function. Services shall be provided for the configuration, control, and monitoring of SCADA/EMS resources such as servers, processing resources, peripheral devices, network devices, applications, and database structures. Configuration management tools shall be accessible from any SCADA/EMS node and shall be capable of managing resources anywhere in the network, subject to security constraints. Management tools shall facilitate the orderly start-up, shutdown, and tuning of any SCADA/EMS resource without affecting the availability of other elements of the SCADA/EMS.

The SCADA/EMS management function shall include a graphics-based user interface. Preferably, it shall also include commercially available standards-based network management products supporting SNMPv3. All SCADA/EMS resources shall include SNMP agents for use by the SCADA/EMS management function.

The SCADA/EMS management function shall “discover” SCADA/EMS resources automatically and shall have the capability to automatically configure these resources. It shall also support SCADA/EMS performance monitoring capabilities.

The capability to add resources outside the SCADA/EMS to the SCADA/EMS management scheme shall be provided even though this may require modifications to the outside resources such as the addition of agents or other software plug-ins. Such modifications will be performed outside of this contract. Nevertheless, the Contractor’s documentation shall describe the SCADA/EMS management function’s capabilities and features as they apply to non-SCADA/EMS as well as SCADA/EMS resources.

The SCADA/EMS shall require manual acknowledgement or confirmation of the addition of network nodes to the SCADA/EMS networks to provide a secure network environment free of unauthorized computers, network monitors, and other potentially malicious network nodes.
All errors and other events detected by the SCADA/EMS management function shall be recorded and reported to the user. Fatal errors shall be reported as alarms. Where an error causes the SCADA/EMS management function to reconfigure the SCADA/EMS, such as shutting down a resource, this shall be reported as an alarm along with an error report.

2.3.5  Communication Facilities

The Contractor shall recommend hardware and software to connect with existing Purchaser’s communication facilities.

The Purchaser will provide high speed communication facilities using a software defined network to provide:

1. Communication between the Primary CC EMS and Backup CC EMS
2. Communication between the SCADA/EMS and other utilities’ and ISOs’ EMSs
3. Communication facilities for RTUs
4. Communication between the SCADA/EMS and Purchaser’s OT DMZ Network
5. Communication between the SCADA/EMS (OT Network) and Purchaser’s Corporate Network via OT DMZ and C DMZ networks

2.3.5.1  RTU NETWORK

The SCADA/EMS shall communicate with RTUs using the communication network provided by the Purchaser. This communications medium is used for RTUs that have TCP/IP communications.

RTUs shall be connected to the SCADA/EMS via DAFE equipment (Section 2.3.4.4, Data Acquisition System). The SCADA/EMS shall include a failover capability from one communications line to any other communications line, including failover from a communications line in one FEP to a communications line in another FEP. This capability shall support up to 2 (two) communications lines to an RTU for greater redundancy. Failover shall not require failover of any other sub-system. The communications lines from each RTU shall be connected to the same FEP or to different FEPs. The selection preference of these communications lines shall be configurable by the Administrator. Refer to Section 12.4 RTU Communications for RTU communication port requirements.
2.3.5.2 LOCAL AND WIDE AREA NETWORKS

The SCADA/EMS shall be located within “trusted” Control Secure Network (CSN). The Purchaser shall be responsible for designing and implementing the required networks to support the SCADA/EMS.

The Purchaser network, relevant for the SCADA/EMS upgrade project, is partitioned as follow:

1. OT zone (SCADA/EMS sanctum domain / SCADA/EMS LAN)
2. OT DMZ zone (internal CSN gateway / SCADA/EMS DMZ)
3. C DMZ zone (corporate internal DMZ / internal Corporate gateway)
4. Corporate zone (internal domains / intranet / IT domain)

2.4 Redundant System Design Requirements

A redundant configuration is required, in which no component failure can result in the loss of any critical function (as specified in Section 2.5, Critical and Non-Critical Functions) or degradation of performance below the required level.

2.4.1 Real Time Data Management

The DAFE that has the ability to acquire data from a field device associated with a SCADA point shall be responsible for obtaining, retaining, and forwarding the value. The value for a specific SCADA point may be available at more than one DAFE depending on the actual physical communications to a given field device (for instance an RTU may be dual ported).

A SCADA point definition within either the PCS or BCS may have a primary and a secondary DAFE associated with it. This definition may not be the same at each site.

Depending on the configuration, the PCS or BCS may require that the value associated with a SCADA point is made available for its purposes such as for applications, historical storage, or user interface presentation. The SCADA/EMS servers shall be responsible for managing the acquisition of the value from the relevant DAFE (Primary). The SCADA/EMS servers shall also consider where a point is available from an alternative (Secondary) DAFE and upon failure to acquire the value from a primary DAFE shall automatically seek to acquire the data from the
secondary source. The SCADA/EMS servers shall alternate between the two sources until successful acquisition.

In the case where the BCS takes over the responsibilities for power systems operations, it shall also take over the acquisition of data from the DAEs for all data points of the failed/switched site.

For the purposes of supervisory controls associated with a SCADA point, the capability for either the PCS or BCS to issue supervisory controls to points that belong to any DAFE depending on the configuration shall be provided. As acknowledgment via feedback, the system issuing the control shall receive the status change from the DAFE. In case of “no execution” (because for instance of interlocking conditions), the controlling system shall receive an error message indicating the failure of such request. This message shall alert the operator via the user interface. Supervisory controls shall also support scripts or automatic supervisory control sequences that may be created locally and that require the support of the supervisory control function.

At a particular time only one DAFE shall issue control commands to a data point.

Updating of manual inputs including limits and tagging entered by an operator shall be retained locally and replicated between sites.

Tagging shall also be able to be entered globally as required by the operator. Tags and manual entries associated with points shall be consistent as a matter of data integrity. The approach to manual input including tags handling and update shall be developed in conjunction with the Purchaser during the configuration workshops in the design phase. The approach shall consider the possibility that the PCS or BCS and its co-located DAFE may be isolated for periods of time due to failures within the Operational Communications Network. The recovery approach shall ensure data integrity is restored.

The final approach to Real-Time Data Management in the SCADA/EMS shall be developed in conjunction with the Purchaser during the design phase and shall be subject to the Purchaser’s approval.
2.4.2  **Redundancy Design Options**

The Contractor may choose either of two techniques, or a combination of the two, to design the system to continue to perform critical functions in the event of a failure of a unit of equipment: 1. dual redundant design using a pair of units, 1 (one) on-line and 1 (one) on standby, to perform critical functions; or 2. cluster backup design, using a cluster of units sharing the processing load. The final design will be subject to review and approval by the Purchaser.

2.4.2.1  **DUAL-REDUNDANT DESIGN**

A dual-redundant design requiring 2 (two) sets of equipment, on-line and standby, shall be provided for every category of equipment that performs or supports a critical function. The database of the stand-by unit shall be continuously updated with all data that is generated by the on-line unit (e.g., from user input or by calculation) to allow it to quickly assume the processing of the on-line unit upon failover.

2.4.2.2  **CLUSTER BACKUP DESIGN**

The SCADA/EMS may be designed so that each function is performed by a group or a cluster of processors, disks, etc. working together to perform certain functions with significant excess capacities; and such excess capacities would then be used in case of an equipment failure. With this approach, the SCADA/EMS shall continue to meet the specified performance in the event of the simultaneous failure of any 1 (one) unit of every functional cluster/group. For this alternative, all data inputs shall be received and processed by all components of the cluster. All data that is generated by a single unit shall be distributed to the other units within the time specified in Section 3.2.3 Execution Frequencies of SCADA/EMS Functions.

2.4.3  **Backup of Data**

At every processing resource, data that is stored in volatile memory (i.e., memory whose contents are lost when power is interrupted) shall also be stored on disk locally at that processing resource for use in warm restart. The entire contents of the real-time database at a processing resource shall be stored to disk at the frequency given in Section 3 Capacity and Performance.

If a processing resource has a backup unit (whether backed up by a standby unit or a cluster), the system shall ensure that the database at the backup unit(s) is maintained current and consistent.
with the database of the on-line unit. Data transferred to 1 (one) processing resource shall be
transferred simultaneously to the backup unit(s); data generated locally at 1 (one) processing
resource (e.g., as a calculation or user input) shall be transferred to the backup unit(s) within 1
(one) second of the generation of the data.

2.4.4 Failover and Restarts

2.4.4.1 FAILOVER

The failover software shall be responsible for detecting the failure of a processing resource or
associated disk, RAM, power supply, or other critical component, and for automatically initiating
an appropriate action to recover from the detected failure by switching to redundant equipment
or transferring processing responsibilities between the surviving processing resources. Failure
detection and recovery capabilities are required for all redundant devices. Failover software shall
also supervise the process of switching from the use of 1 (one) processor to the use of an
alternative on command by an authorized user. Failover logic shall reside in both the on-line and
backup processing resources, each monitoring the performance of the other and ready to take
appropriate action as necessary.

Events leading to a failover shall include:

1. Failure of an on-line processing resource or any of its critical components
2. Failure of the disk associated with an on-line processing resource
3. Power failure of the on-line equipment
4. Command of an authorized user. However, if a backup processing resource is unavailable,
   then the command shall be rejected, and the user shall have the option to request a hot restart.
5. Significant degradation of performance as defined by the Purchaser.

If the system is configured with on-line spare components, such as spare communications ports,
then upon the detection of the failure of one of these components the failover software shall
automatically substitute a spare component, or failing that, shall cause a failover to allow the full
backup subsystem to take over and continue system operations.

Failover of any system component shall cause a major alarm to be generated. The alarm shall
indicate the reason for the failover, the failed unit, and the unit which assumed responsibility.
Upon the failure of an off-line processing resource or one of its critical components, or upon the failure of the disk associated with the off-line processing resource, an alarm shall be generated, but no failover action shall be performed. If a processing resource which fails had exclusive possession of a system resource (such as access to a file or to a peripheral), then upon the failure of the processing resource, that resource shall be automatically re-assigned to the new on-line processing resource.

Failover shall not disrupt any on-going processes, such as calculations; they shall continue, using the backup database. Periodic calculations that were interrupted by failover shall automatically be completed or repeated. User data entries that were made earlier than the update time before failover shall not have to be re-entered by the Operator. No alarms shall be lost and Operator visibility of the power system shall not be lost. Reports that were in the process of printing when failover occurred shall not be lost, and shall be resumed where interrupted or restarted. Periodic calculations that were interrupted shall also be restarted with the re-initialized input values.

Failover shall not disrupt work at any console; the user’s sets of windows and displays shall not be affected. While a failover is in progress, users shall be notified to that effect through a message displayed on the consoles, and shall be prohibited from performing any action (such as supervisory control or data entry) which cannot be successfully completed under the circumstances.

2.4.4.2 SYSTEM RESTARTS

A mechanism for restarting a processing resource of the SCADA/EMS shall be provided. In this respect, 3 (three) restart modes are required as follows:

1. A hot restart in which the most recent version of the entire memory-resident database is used for continued operation.
2. A warm restart in which the database resident in volatile memory is restored from disk. A warm restart shall be automatically initiated after a power loss to the processing resource.
3. A cold restart is a complete re-initialization of the processing resource from the most recent available version of the database. A cold restart shall be initiated by an auto-recovery process or in response to a request issued from an authorized console.
4. Following failover or restart, no user log-in or manual intervention shall be required for the processing resource and the complete SCADA/EMS to recover its data, its functions, and the full unchanged set of displays on each monitor. No operator actions shall be required to recover the previous alarm status. All still existing but previously acknowledged alarms shall remain acknowledged.

5. Automatic restarts shall generate a major alarm.

2.4.4.3 MANUAL FAILOVER AND RESTART

The capability for an authorized user at a workstation to command equipment and system failover, or to restart an on-line or backup processing resource shall be provided. A manual restart shall be recorded as an event.

2.5 Critical and Non-Critical Functions

All SCADA/EMS functions shall be considered Critical unless explicitly shown as Non-Critical in Section 2.5.2 Non-Critical Functions, below. Critical functions shall explicitly include those listed in the following Section 2.5.1.

2.5.1 Critical Functions

Critical functions are defined as functions that shall not be lost as the result of any single failure. Component systems within the Production Environment will meet this requirement in addition to the requirements in Section 2.6 System Availability. Thus, functions running on critical component systems are also critical. Within this context, the following SCADA/EMS functions are explicitly defined as Critical:

1. Data acquisition and supervisory control via RTUs
2. Data exchange between the SCADA/EMS systems at the Primary and Backup control centers
3. Data exchange including ICCP with other utility EMSs
4. Processing of acquired data (including alarming, refreshing displays, updating the database, calculations, etc.)
5. All Network Analysis functions (Section 7, Network Analysis)
6. User interface functions
7. Historical data processing
8. System failover and system restart without loss of any data
9. Transmission and monitoring of exchange of heartbeat signal with the other SCADA/EMS
10. System configuration control
11. On-line diagnostics
12. Information Storage and Retrieval

2.5.2 Non-Critical Functions

The following major SCADA/EMS functions are defined as Non-Critical, in that automatic failover is not required to keep them available. It is acceptable to require manual switching or reassignment of processing resources to make them available for use.

1. Operator Training Simulator (OTS) functions
2. Access to on-line documentation (except for the Help function)
3. Database, display, and report generation and maintenance
4. Software development.
5. Model Management System

2.6 System Availability

The annual availability of each of the PCS and BCS systems shall be 99.99 (ninety-nine point ninety-nine) percent, i.e., downtime for each of the PCS and BCS systems shall not exceed 52 (fifty-two) minutes per year. After the completion of cutover, each system performing a critical function in the SCADA/EMS shall be subject to an Availability Test for a 1,000-hour period, during which the accumulated downtime shall not exceed 6 (six) minutes.

2.6.1 Calculation of Availability

Availability is defined as:

\[
\text{Availability} (\%) = \frac{\text{Total Operating Time} - \text{Cumulative Downtime}}{\text{Total Operating Time}} \times 100
\]

Cumulative downtime for the system shall be accrued in accordance with the following Section 2.6.2, Downtime Accumulation.
2.6.2 **Downtime Accumulation**

A System is considered down and downtime shall be recorded upon occurrence of any of the following circumstances:

1. One or more of the critical functions has become unusable at a SCADA/EMS. The assumption of the functions of a SCADA/EMS by the Backup SCADA/EMS shall not be considered as a lifting of downtime unless in active-active mode. “Unusable” shall be construed as either continuously inoperable or intermittently non-functional to a level that the Purchaser determines that it is necessary to take actions resulting in the loss of critical functions to perform corrective maintenance.

2. A critical function is interrupted by removal of System equipment for mandatory corrective maintenance.

3. More than one Operator workstation is down. A workstation shall be considered to be "down" if any critical function is not fully available at the workstations at a desk due to problems with software furnished by the Contractor or due to problems with hardware that was either supplied by the Contractor or was purchased by the Purchaser on the recommendation or approval of the Contractor.

Downtime directly attributable to failures of equipment for which the Contractor is not responsible will not be included in the computation of the SCADA/EMS downtime assigned to the Contractor. If the system is down because of failure of equipment or communications facilities provided by the Purchaser or a third party, the Availability Test shall be suspended until the problem is corrected, and neither downtime nor operating time shall be accrued.

2.6.3 **End of Downtime Accumulation**

System downtime accumulation shall be stopped upon occurrence of either of the following:

1. When all critical functions become usable and are restored to fully operational service

2. The Contractor and the Purchaser agree that the SCADA/EMS is usable to a level that it should be in service.

3. The Purchaser elects to restore the equipment to temporary or interim use on-line service during repair procedures, if repairs could otherwise have continued. In this case, the time that
the equipment is back in service and the time needed for repeated maintenance will be
accrued neither to down time nor to operating time.

2.7 Application Standards

Except where otherwise specified, the design, construction, and performance of all equipment
and software furnished by the Contractor shall conform, as applicable, to the latest versions of
the following standards (as a minimum):

1. International Electrotechnical Council (IEC) Standards
2. International Standards Organization (ISO) Standards
3. National Electrical Manufacturers Association (NEMA) Standards
4. American National Standards Institute, Inc. (ANSI) Standards
5. Electrical Industry Association (EIA) Standards
6. NERC Reliability Standards and CIP Standards
7. NIST Standards

In case of conflict between the requirements of any of these authorities, the conflict shall be
referred to the Purchaser for resolution.
3 Capacity and Performance ................................................................. 39

3.1 System Sizing Requirements ....................................................... 39

3.1.1 System to be Delivered ......................................................... 45

3.1.2 Expansion Requirements ...................................................... 45

3.1.2.1 Expansion Capabilities .................................................. 45

3.1.2.2 Software Licenses .......................................................... 46

3.1.3 Upgrading Capabilities ....................................................... 46

3.2 System Performance Requirements ........................................... 48

3.2.1 System Activity Level Definitions ........................................ 48

3.2.1.1 Base Conditions .......................................................... 48

3.2.1.2 Steady State ............................................................... 49

3.2.1.3 High Activity State ...................................................... 50

3.2.1.4 Overload State ............................................................ 50

3.2.2 Utilization Requirements ..................................................... 50

3.2.3 Execution Frequencies of SCADA/EMS Functions ............ 51

3.2.4 Application Functions Completion Time ........................... 53

3.2.5 Data Retrieval Access Time ................................................. 53

3.2.6 Display Call-up Response Time .......................................... 53

3.2.7 Display Update Time .......................................................... 54

3.2.8 Alarm and Event Response Time ......................................... 55

3.2.9 User Request Completion Time .......................................... 55

3.2.10 System Failsoft Capability ............................................... 57

3.2.11 System Failover, Restart, and Startup Times .................... 57

3.2.11.1 Failover and Restarts ................................................ 57

3.2.11.2 System Start-up Time ............................................... 57

Austin Energy SCADA Replacement 0500-Scope of Work
Proprietary © Austin Energy 2017 – All Rights Reserved
3.2.11.3 User Workstation Boot-up Time and Start-up Time

3.2.11.4 Start-up Time for Start-up of Backup Functions at Backup System

3.3 Software Maintenance
3 CAPACITY AND PERFORMANCE

The System shall be designed to meet the capacity and performance requirements defined in this section and as noted throughout these Technical Specifications. There shall be no restrictions on the vertical expansion (i.e., upgrade of processors or workstations, etc.) or horizontal expansion (that is, adding processors, workstations, peripherals, or connections to other LANs or WANs, etc.) of the proposed configuration. The capacity and performance of the SCADA/EMS as delivered shall take into account the need to support not only data exchange between the Primary and Backup control centers, but also with other systems.

3.1 System Sizing Requirements

Exhibit 3-1: Power System and Network Model Sizing (EMS/OTS)

<table>
<thead>
<tr>
<th>No</th>
<th>Component</th>
<th>Intended Go-live (2020) Size</th>
<th>Delivered Capacity (Allows for 25% growth)</th>
<th>OTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Physical Buses – Internal Model</td>
<td>250</td>
<td>312</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>2</td>
<td>Physical Buses – External Model</td>
<td>7,500</td>
<td>9,375</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>3</td>
<td>Transmission Lines – Internal Model</td>
<td>160</td>
<td>200</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>4</td>
<td>Transmission Line – External Model</td>
<td>5,500</td>
<td>6,875</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>5</td>
<td>HVDC Lines – Internal Model</td>
<td>0</td>
<td>0</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>6</td>
<td>HVDC Lines – External Model</td>
<td>4</td>
<td>5</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>7</td>
<td>Substations – Internal Model</td>
<td>90</td>
<td>112</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>8</td>
<td>Substations – External Model</td>
<td>5,000</td>
<td>6,250</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>9</td>
<td>Generators – Internal Model</td>
<td>22</td>
<td>27</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>10</td>
<td>Generators – External Model</td>
<td>750</td>
<td>937</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>11</td>
<td>External Companies</td>
<td>3</td>
<td>4</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>12</td>
<td>Switching Devices – Internal Model</td>
<td>2,000</td>
<td>2,500</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>No</td>
<td>Component</td>
<td>Intended Go-live (2020) Size</td>
<td>Delivered Capacity (Allows for 25% growth)</td>
<td>OTS</td>
</tr>
<tr>
<td>----</td>
<td>-----------------------------------------------</td>
<td>-----------------------------</td>
<td>---------------------------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>13</td>
<td>Switching Devices – External Model</td>
<td></td>
<td></td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>14</td>
<td>Fixed Tap Transformers – Internal Model</td>
<td>200</td>
<td>250</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>15</td>
<td>TCUL Transformers – Internal Model</td>
<td>11</td>
<td>14</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>16</td>
<td>Phase Shifting Transformers – Internal Model</td>
<td>0</td>
<td>0</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>17</td>
<td>Tie Lines</td>
<td>N/A</td>
<td>N/A</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>18</td>
<td>Control Areas</td>
<td>1</td>
<td>1</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>19</td>
<td>Plants</td>
<td>5</td>
<td>6</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>20</td>
<td>Capacitors and Reactors</td>
<td>20</td>
<td>25</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>21</td>
<td>Load Zones</td>
<td>1</td>
<td>1</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>22</td>
<td>Conforming Loads - Internal</td>
<td>100</td>
<td>150</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>23</td>
<td>Nonconforming Loads</td>
<td>1</td>
<td>1</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>24</td>
<td>Number of Islands</td>
<td>1</td>
<td>5</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>25</td>
<td>Branch Over-Current Relays</td>
<td>50</td>
<td>100</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>26</td>
<td>Under and Over-Frequency Relays</td>
<td>50</td>
<td>100</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>27</td>
<td>Under and Over Voltage Relays</td>
<td>50</td>
<td>100</td>
<td>Same as Network Model</td>
</tr>
<tr>
<td>28</td>
<td>Synch Check Relays</td>
<td>50</td>
<td>100</td>
<td>Same as Network Model</td>
</tr>
</tbody>
</table>
### Exhibit 3-2: RTU Sizing

<table>
<thead>
<tr>
<th>No</th>
<th>Protocol</th>
<th>Intended (Go-Live 2020) Number of RTUs</th>
<th>Delivered Capacity (Allows for 50% growth)</th>
<th>Number of Channels Primary CC</th>
<th>Number of Channels Backup CC</th>
<th>Data Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DNP3 Serial</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>DNP3 IP</td>
<td>400</td>
<td>600</td>
<td>400</td>
<td>400</td>
<td>19,200</td>
</tr>
</tbody>
</table>

### Exhibit 3-3: Telemetered and Calculated Points Sizing

<table>
<thead>
<tr>
<th>No</th>
<th>Data Type</th>
<th>Periodicity</th>
<th>Intended Number of Points (Go-live 2020)</th>
<th>Delivered Capacity (Allows for 25% growth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Telemetered - Analog</td>
<td>2 sec</td>
<td>17,500</td>
<td>22,000</td>
</tr>
<tr>
<td>2</td>
<td>Telemetered - Analog</td>
<td>4 sec</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Telemetered - Analog</td>
<td>10 sec</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Telemetered - Status</td>
<td>2 sec</td>
<td>25,000</td>
<td>32,000</td>
</tr>
<tr>
<td>5</td>
<td>Telemetered - Controls</td>
<td>2 sec</td>
<td>3,600</td>
<td>4,500</td>
</tr>
<tr>
<td>6</td>
<td>Telemetered - Accumulators</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Calculated Analogs</td>
<td>1,900</td>
<td>2,400</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Calculated Status</td>
<td>200</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Calculated Accumulators</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Exhibit 3-4: Data Exchange Sizing

<table>
<thead>
<tr>
<th>No</th>
<th>From</th>
<th>To</th>
<th>Protocol</th>
<th>Type</th>
<th>Periodicity</th>
<th>Intended Number (Go-Live 2020)</th>
<th>Delivered Capacity (Allows for 25% growth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AE EMS</td>
<td>ERCOT</td>
<td>TASE.2</td>
<td>Analog</td>
<td>10 sec</td>
<td>3,800</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>AE EMS</td>
<td>ERCOT</td>
<td>TASE.2</td>
<td>Status</td>
<td>10 sec</td>
<td>3,800</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ERCOT</td>
<td>AE EMS</td>
<td>TASE.2</td>
<td>Analog</td>
<td>10 sec</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ERCOT</td>
<td>AE EMS</td>
<td>TASE.2</td>
<td>Status</td>
<td>10 sec</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>ADMS</td>
<td>EMS</td>
<td>TASE.2</td>
<td>Analog</td>
<td>10 sec</td>
<td>9,000</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>ADMS</td>
<td>EMS</td>
<td>TASE.2</td>
<td>Status</td>
<td>10 sec</td>
<td>12,000</td>
<td></td>
</tr>
</tbody>
</table>
NOTES:

1. EMS to ERCOT EMS - is the number of Analogs/Status points going out of the AE EMS system to the ERCOT EMS via ICCP.
2. ERCOT EMS to EMS - is the number of Analog/Status points that are received from ERCOT for use by the State Estimator.
3. Option – AE is looking to expand its external network model and support it with bringing in a significant increase in ICCP data. As an option, the Contractor shall provide support of receiving up to 100,000 analog and 100,000 status points from ERCOT to support AE applications.

Exhibit 3-5 Non-telemetered SCADA Sizing

<table>
<thead>
<tr>
<th>No</th>
<th>Data Type</th>
<th>Periodicity</th>
<th>Intended Number of Points (Go-live 2020)</th>
<th>Delivered Capacity ( Allows for 25% growth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-telemetered - Analog</td>
<td></td>
<td>4000</td>
<td>5,000</td>
</tr>
<tr>
<td>2</td>
<td>Non-telemetered – Status</td>
<td></td>
<td>24,000</td>
<td>30,000</td>
</tr>
<tr>
<td>3</td>
<td>Non-telemetered - Accumulators</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>Redundant Data Processing - Analogs</td>
<td></td>
<td>100</td>
<td>125</td>
</tr>
<tr>
<td>5</td>
<td>Redundant Data Processing - Status</td>
<td></td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>6</td>
<td>Redundant Data Processing - Accumulators</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Exhibit 3-6 Information Storage and Retrieval Sizes

<table>
<thead>
<tr>
<th>No</th>
<th>Type</th>
<th>Periodicity</th>
<th>Quantity</th>
<th>Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Alarm and Events</td>
<td>Daily</td>
<td>100,000</td>
<td>Current year plus 3 years</td>
</tr>
<tr>
<td>2</td>
<td>SOE</td>
<td>On occurrence</td>
<td>50,000</td>
<td>Current year plus 4 years</td>
</tr>
<tr>
<td>3</td>
<td>Application Data</td>
<td>On occurrence</td>
<td>As required</td>
<td>1 year</td>
</tr>
<tr>
<td>4</td>
<td>SCADA Data</td>
<td>Upon change</td>
<td>All data in Exhibit 3-3, Exhibit 3-4, Exhibit 3-5</td>
<td>Current year plus 4 years</td>
</tr>
</tbody>
</table>
### Exhibit 3-7 Application Sizes

<table>
<thead>
<tr>
<th>No</th>
<th>Application</th>
<th>Quantity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Contingency Analysis</td>
<td>2,000</td>
<td>Multi-threaded contingency analysis</td>
</tr>
<tr>
<td></td>
<td>Number of Contingencies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>PNA Savecases</td>
<td>5040</td>
<td>In addition, a real-time SE savecase shall be made every 4 minutes. This shall not be a rolling buffer in that the savecases shall be stored to long term storage once the 5040 limit is reached.</td>
</tr>
<tr>
<td></td>
<td>SE cases</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>OTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. of scenarios</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Events per scenario</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PF periodicity</td>
<td>2 sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dynamic calculation periodicity</td>
<td>1 sec</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Savecases</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>User Interface</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. of alarms</td>
<td>100,000</td>
<td>Alarms buffer/file</td>
</tr>
<tr>
<td></td>
<td>No. of events</td>
<td>150,000</td>
<td>Event buffer/file</td>
</tr>
<tr>
<td></td>
<td>No. of SOE events</td>
<td>100,000</td>
<td>SOE buffer/file</td>
</tr>
<tr>
<td>5</td>
<td>Load Shedding</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. of Load Shed Blocks</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No. of feeders per block</td>
<td>Block 1 – 33 Feeders</td>
<td>Block 2 – 57 Feeders</td>
</tr>
</tbody>
</table>
Exhibit 3-8: User Interface Equipment Sizing

<table>
<thead>
<tr>
<th>No</th>
<th>Location</th>
<th>System</th>
<th>Type</th>
<th># of Workstations</th>
<th># of Monitors</th>
<th>Monitor Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SCC</td>
<td>Primary EMS</td>
<td>Operator</td>
<td>6</td>
<td>4 each</td>
<td>30”</td>
</tr>
<tr>
<td>2</td>
<td>SCC</td>
<td>Primary EMS</td>
<td>Engineering / Analyst</td>
<td>35</td>
<td>3 each</td>
<td>30”</td>
</tr>
<tr>
<td>3</td>
<td>SCC</td>
<td>Primary EMS</td>
<td>Control Room Manager</td>
<td>5</td>
<td>2 each</td>
<td>30”</td>
</tr>
<tr>
<td>4</td>
<td>SCC</td>
<td>Primary EMS</td>
<td>Video Wall</td>
<td>1</td>
<td>1</td>
<td>12,600 x 4,200 pixels</td>
</tr>
<tr>
<td>5</td>
<td>SCC</td>
<td>PDS</td>
<td>Developer</td>
<td>5</td>
<td>3 each</td>
<td>30”</td>
</tr>
<tr>
<td>6</td>
<td>SCC</td>
<td>OTS</td>
<td>Trainer</td>
<td>1</td>
<td>4</td>
<td>30”</td>
</tr>
<tr>
<td>7</td>
<td>SCC</td>
<td>OTS</td>
<td>Trainee</td>
<td>6</td>
<td>4 each</td>
<td>30”</td>
</tr>
<tr>
<td>8</td>
<td>SCC</td>
<td>QAS</td>
<td>Operator</td>
<td>6</td>
<td>4 each</td>
<td>30”</td>
</tr>
<tr>
<td>9</td>
<td>SCC</td>
<td>QAS</td>
<td>Engineering</td>
<td>35</td>
<td>3 each</td>
<td>30”</td>
</tr>
<tr>
<td>10</td>
<td>BCC</td>
<td>Primary EMS</td>
<td>Operator</td>
<td>6</td>
<td>4 each</td>
<td>30”</td>
</tr>
<tr>
<td>11</td>
<td>BCC</td>
<td>Primary EMS</td>
<td>Engineering / Analyst</td>
<td>4</td>
<td>3 each</td>
<td>30”</td>
</tr>
<tr>
<td>12</td>
<td>BCC</td>
<td>PDS</td>
<td>Developer</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>13</td>
<td>BCC</td>
<td>OTS (connects to OTS server at SCC)</td>
<td>Trainer</td>
<td>1</td>
<td>4</td>
<td>30”</td>
</tr>
<tr>
<td>14</td>
<td>BCC</td>
<td>OTS (connect to OTS server at SCC)</td>
<td>Trainee</td>
<td>6</td>
<td>4 each</td>
<td>30”</td>
</tr>
<tr>
<td>15</td>
<td>Portable Workstations</td>
<td>Support</td>
<td>25</td>
<td>1 each</td>
<td>30”</td>
<td></td>
</tr>
</tbody>
</table>

AE Special Requirements

AE will be procuring the workstations based on the Contractor’s requirements.

AE is interested in workstation consoles with touch screen capability.
### Exhibit 3-9: Miscellaneous Equipment Sizing

<table>
<thead>
<tr>
<th>No</th>
<th>Location</th>
<th>System</th>
<th>Type</th>
<th>Quantity</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primary Control Center</td>
<td>Primary EMS</td>
<td>Time and Frequency</td>
<td>2</td>
<td>1 is a primary device in production 1 is a spare device</td>
</tr>
<tr>
<td>2</td>
<td>Backup Control Center</td>
<td>Backup EMS</td>
<td>Time and Frequency</td>
<td>1</td>
<td>1 is a primary device</td>
</tr>
<tr>
<td>3</td>
<td>Primary Control Center</td>
<td>Printers</td>
<td>Printers</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Backup Control Center</td>
<td>Printers</td>
<td>Printers</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

### NOTES:

1. A Time and Frequency device shall be installed at the primary center with a spare and a Time and Frequency device is installed at the backup center. Each Time and Frequency device, w/exception of the spare, is connected to both servers noted above.

#### 3.1.1 System to be Delivered

Upon delivery, the SCADA/EMS hardware shall include all the equipment necessary to meet the requirements specified in Exhibits 3-1 through 3-9, and elsewhere in the Technical Specifications. However, the SCADA/EMS shall be delivered with all software and database dimensioned up to the Delivered Capacity sizes without a need for reconfiguration.

1. At least 25 (twenty-five) percent of the installed main memory shall be provided as spare memory in each major processing resource, such as those in the Production Environment, OTS Environment, and peripheral devices (where they exist).

2. At least 25 (twenty-five) percent of the processing capacity shall be unused and reserved for future use by the Purchaser on the disks included in or associated with each major processor.

#### 3.1.2 Expansion Requirements

##### 3.1.2.1 EXPANSION CAPABILITIES

In order to accommodate system expansion to, and possibly beyond, the Delivered Capacity size of the SCADA/EMS shall be designed to facilitate the addition of processors and memory, as well as disk units, as follows:
1. The installed memory for each server shall be expandable to at least twice the installed size within the delivered enclosures by the Purchaser using hand tools and without the need to remove lower capacity modules at the time of System acceptance.

2. The installed disk capacity shall be expandable to at least 5 (five) times the installed capacity within the delivered enclosures, by the Purchaser using hand tools at the time of System acceptance.

3. The Delivered Capacity should be configurable and parameterized.

With appropriate training by the Contractor, the Purchaser’s personnel shall be able to make all database and System changes related to the additional equipment, communication networks, and links to external systems solely with the support software supplied and without the assistance of the Contractor. Expansion shall be done via database generation from batch files, using procedures supplied with the installed System and without regeneration of the software system. No program (logic) change shall be necessary to implement such expansion. Apart from documentation and training requirements noted elsewhere in this specification, the Contractor shall provide all related documentation and training to allow this capability to be fulfilled.

The capability to meet the indicated expansion requirements with field addition of servers, workstations, memory, disks, peripherals, and necessary communication interface equipment shall be provided.

The Contractor shall demonstrate in acceptance tests that the SCADA/EMS can adequately meet the indicated hardware expansion requirements.

### 3.1.2.2 SOFTWARE LICENSES

Software licenses for Contractor’s software shall be irrevocable “enterprise-wide” licenses which shall apply also to all servers, workstations, and other equipment that the Purchaser may acquire (whether from the Contractor or from a third party) to expand or upgrade any parts of the SCADA/EMS up to and beyond the specified Delivered Capacity SCADA/EMS size.

### 3.1.3 Upgrading Capabilities

The SCADA/EMS shall be designed to facilitate expansion, if necessary, beyond the specified Delivered Capacity sizes and replacement of equipment with new equipment to improve system
performance and replace old equipment when it becomes difficult to maintain. Specifically, the system shall be designed to facilitate the implementation by the Purchaser of upgrades that are expected to be released by the Contractor and OEM suppliers in the future. Accordingly, the following capabilities are required for the SCADA/EMS:

1. Servers (dedicated or virtual) – A growth path shall be provided that allows upgrading of computational power and main memory by means of field expansion or change out of the servers. Such upgrades shall be possible by changing servers or adding servers while retaining software and hardware compatibility.

2. Computer Peripheral Equipment – All peripheral equipment shall be standard products with standard interfaces that can be replaced with more powerful or newer models without requiring additional hardware or software changes.

3. User Workstations – The design of the user workstations shall enable the Purchaser to take advantage of new and improved Contractor software versions and offerings as they become available. No modifications to standard hardware, the operating system, or any other third-party software if used, shall be required.

4. Local Area Network (LAN) – An internationally recognized standard LAN and associated protocol shall be used for the interconnection of processors, workstations, communications interfaces, and system support equipment. The LAN shall allow for several important growth features including incremental expansion and the ability to add servers, resource sharing, parallel operation of functions, and backup of functions.

5. Data Communications – All data networks and links shall conform to internationally recognized data communication standards, except where this contradicts explicit data exchange and interface requirements specified by the Purchaser. All communications shall be supported by the software protocol access interfaces in such a way that physical connections and details of the link procedures are transparent to the application programs.

6. Applications Software – In developing applications programs, the Purchaser shall be able to utilize all standard high-level languages (i.e., C++, C#) supported by the computer manufacturer. Interface libraries shall be provided to allow access to database elements, displays and real-time executive services.

7. Documentation – All documentation supplied shall be sufficiently detailed to allow the Purchaser to maintain the SCADA/EMS, and to design and integrate new applications and
capabilities into it without requiring additional design information. The use of proprietary designs for which design information will not be made available to the Purchaser is not permitted.

3.2 System Performance Requirements

The SCADA/EMS shall comply with the performance requirements given here and elsewhere in the Technical Specifications. To demonstrate this compliance, the loading on the processors, LANs, and communication interfaces shall be determined for the intended configuration of the SCADA/EMS utilizing simulation during Factory Acceptance Testing and Site Acceptance Testing.

3.2.1 System Activity Level Definitions

For the purpose of specifying the system performance under different system activity levels, the terms "Steady State", "High Activity State", and "Overload State" are defined below. These states shall be maintained, using simulation inputs, as needed, during acceptance testing to verify that the performance and utilization requirements are met. These conditions shall be maintained as long as necessary to complete the system response time and application run time tests. System utilization tests shall be performed under these conditions over 5 (five) minute periods that include the beginning of an hour, i.e., utilization tests shall be started shortly before the beginning of an hour.

3.2.1.1 BASE CONDITIONS

The following conditions shall apply to both the steady state and high activity state scenarios:

1. The SCADA/EMS is acquiring and processing for the Intended (up to the Delivered Capacity) number of status, analog, and accumulator data from the Intended (up to the Delivered Capacity) number of RTUs, from other utility EMSs and all the real-time data that may be received from other sources.

2. All calculated status and analog points are processed for the Intended number of points (up to the Delivered Capacity), whenever data for the RTDB is received from the RTUs and other sources, that is referenced above and elsewhere in the Technical Specifications.
3. The SCADA/EMS is executing all the critical functions listed in **Exhibit 3-10** Major Periodic Functions, at the specified periodicities, and completes the executions of all critical functions within the completion times specified in this document. A study mode Operator Power Flow and Contingency Analysis executions are initiated by 2 Operators or Engineers.

4. The SCADA/EMS is collecting, processing, and storing historical data and is archiving it on schedule.

5. The SCADA/EMS communicates and interacts with other utility EMS.

6. The Real-Time Sequence executes.

7. All hourly and other periodic processing of data and network analysis functions is performed on schedule.

8. A System Data Backup has been initiated.

9. The Intended number (up to the Delivered Capacity) of user workstations is logged on and their displays are updated at the required rates.

### 3.2.1.2 **STEADY STATE**

The Steady State Scenario shall consist of the Base Conditions and the following activities over a 60 (sixty) minute period:

1. All the user workstations are in the Operator or Supervisor mode. Each monitor on each workstation is showing at least 5 (five) windows; each window contains a display showing real-time data, including 1 (one) window that contains a substation one-line diagram of the Purchaser’s choice which belongs to a substation whose RTU is included in the FAT configuration; a different display shall be placed on each monitor. At the Operator and OTS workstations 1 (one) window is reserved on each monitor to call up other displays during performance testing.

2. A new one-line substation diagram of the Purchaser’s choice is called up every 60 (sixty) seconds at each Operator and OTS user workstation.

3. At least 1 (one) new status alarm and 3 (three) new analog alarms are processed every 1 (one) second. The alarms shall be uniformly distributed among different RTUs.

4. At least 50 (fifty) percent of all analog points being monitored change whenever they are scanned (every 2 seconds) sufficiently to require processing by the SCADA/EMS, including updating of their values in the RTDB.
5. At a 20 (twenty) minute interval, 1 (one) of the non-periodic applications specified in Section 7 Network Analysis is run twice at each of the Operator workstations at the same time. The Purchaser shall choose the application to be run.

3.2.1.3 HIGH ACTIVITY STATE

The High Activity State Scenario shall consist of the Base Conditions and the following activities over a 60 (sixty) minute period:

1. At least 500 new status alarms and 1000 new analog alarms are processed every 1 (one) second for a period of 5 (five) minutes. The alarms shall be distributed among different RTUs, i.e., 1 (one) such alarm per RTU.
2. At least 75 (seventy-five) percent of all analog points being monitored change sufficiently to require processing whenever they are reported (every 2 seconds).
3. A new one-line diagram display, a new alarm summary, and a new tabular display chosen by the Purchaser are called up every 15 (fifteen) seconds at each Operator and Supervisor workstation.
4. Users acknowledge all outstanding alarms as fast as possible.
5. At a 15 (fifteen) minute interval, 1 (one) of the non-periodic applications specified in Section 7 Network Analysis is run 3 (three) times at each of the Operator workstations at the same time. The Purchaser shall choose the application to be run.

3.2.1.4 OVERLOAD STATE

Whenever the activity levels exceed those defined for the High-Activity State, the SCADA/EMS is said to be in the Overload State; the definition of the Overload State does not set any limit on the level of activity that may be imposed on the system for Overload State testing. The Overload State is defined to ensure that the system will be able to cope with unexpectedly high stress conditions without losing data, without ceasing to perform critical functions, and with acceptable response times (as specified in Exhibit 3-12, Display Call-up Response Requirements).

3.2.2 Utilization Requirements

The test time shall be a minimum of 65 (sixty-five) minutes and shall be repeated to ensure that all “end-of” scenarios are tested. Over any 5 (five) minute period during which the
SCADA/EMS is in the Steady State, the utilization of the components of the SCADA/EMS shall meet the following criteria:

1. The total loading of each SCADA and applications processor shall not exceed 25 (twenty-five) percent.
2. The total loading of each SCADA user workstation shall not exceed 25 (twenty-five) percent.
3. Each disk associated with each SCADA and application processor shall not be busy with data transfers for more than 20 (twenty) percent of the time.
4. Each local area network shall not be busy with data transfers for more than 5 (five) percent of the time.

Over a 5 (five) minute period, during which the SCADA/EMS is in the High Activity State, the utilization of resources, measured during any 15 (fifteen) second window, shall meet the following criteria:

1. The total loading of each SCADA and applications processor shall not exceed 30 (thirty) percent.
2. The total loading of each SCADA user workstation shall not exceed 30 (thirty) percent.
3. Each disk associated with each SCADA and application processor shall not be busy with data transfers for more than 35 (thirty-five) percent of the time.
4. Each local area network shall not be busy with data transfers for more than 10 (ten) percent of the time.

The SCADA/EMS shall include hardware and software measuring tools to enable precise measurements of the utilization of all computing resources and relevant devices for verifying that these requirements are met.

3.2.3 Execution Frequencies of SCADA/EMS Functions

The execution conditions and frequencies specified below shall be maintained in the Steady State and the High Activity State:
### Exhibit 3-10: Execution Conditions or Frequencies for Major Periodic Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Condition or Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SCADA FUNCTIONS</strong></td>
<td></td>
</tr>
<tr>
<td>1. Processing of field data</td>
<td>As soon as the acquisition of data from an RTU is completed or real-time data is received from another source.</td>
</tr>
<tr>
<td>2. Alarm and Event Processing</td>
<td>With the processing of RTU data, other sources and upon internal events.</td>
</tr>
<tr>
<td>3. Processing of calculated Status and Analog Points</td>
<td>When processing of field data is completed and upon manual inputs that affect a value.</td>
</tr>
<tr>
<td>4. Processing of power system network topology</td>
<td>As soon as the processing of field data and processing of calculated status and analog points are updated.</td>
</tr>
<tr>
<td>5. Supervisory Control</td>
<td>Upon user request.</td>
</tr>
<tr>
<td>6. Transfer inputs/data to other members of a cluster of processors</td>
<td>Within 1 (one) second of the reception or generation of the inputs/data.</td>
</tr>
<tr>
<td>7. Real-Time database on the disks of online and backup SCADA/applications processors</td>
<td>At least once every 30 (thirty) seconds for scanned and other field data.</td>
</tr>
<tr>
<td>8. Display Update of all Monitors</td>
<td>As specified in Section 3.2.7 Display Update Time</td>
</tr>
<tr>
<td>9. Recalculation of calculated historical data</td>
<td>Upon any change that affects the values</td>
</tr>
<tr>
<td>10. Data Retrieval/Scanning</td>
<td>As specified in Section 5.1.2 Data Polling, Section 5.1.3 Report by Exception (RBE), Section 5.1.7 Uploading of Sequence of Events (SOE) Data and Section 5.5 Communications with Other Systems</td>
</tr>
<tr>
<td><strong>NETWORK ANALYSIS FUNCTIONS (EMS/OTS)</strong></td>
<td></td>
</tr>
<tr>
<td>1. Real-Time Sequence</td>
<td>Every 2 (two) minutes</td>
</tr>
<tr>
<td>2. Real-Time Model Update</td>
<td>Every 2 (two) minutes</td>
</tr>
<tr>
<td>3. Bus Load Forecast</td>
<td>Every 2 (two) minutes</td>
</tr>
<tr>
<td>4. State Estimator</td>
<td>Every 2 (two) minutes</td>
</tr>
<tr>
<td>5. Network Parameter Adaptation (NPA)</td>
<td>Every 2 (two) minutes</td>
</tr>
<tr>
<td>6. Security Analysis (SA)</td>
<td>Every 2 (two) minutes</td>
</tr>
<tr>
<td>7. Power Flow (PF)</td>
<td>Upon user initiation</td>
</tr>
</tbody>
</table>
3.2.4 Application Functions Completion Time

Exhibit 3-11: Application Functions Completion Time (EMS/OTS)

<table>
<thead>
<tr>
<th>Functions</th>
<th>Completion Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Real-Time Sequence</td>
<td>1 (one) minute</td>
</tr>
<tr>
<td>2. Real-Time Model Update</td>
<td>10 (ten) seconds</td>
</tr>
<tr>
<td>3. Bus Load Forecast</td>
<td>10 (ten) seconds</td>
</tr>
<tr>
<td>4. State Estimator</td>
<td>10 (ten) seconds</td>
</tr>
<tr>
<td>5. Network Parameter Adaptation (NPA)</td>
<td>10 (ten) seconds</td>
</tr>
<tr>
<td>6. Security Analysis (SA)</td>
<td>30 (thirty) seconds</td>
</tr>
<tr>
<td>7. Power Flow (PF)</td>
<td>10 (ten) seconds</td>
</tr>
</tbody>
</table>

3.2.5 Data Retrieval Access Time

Data requested from historical files shall be available to the requesting application or displayed to the requesting user within 4 (four) seconds, when:

1. No more than 3 (three) search keys are specified; or
2. The requested data spans a time range that does not exceed 12 (twelve) months.

3.2.6 Display Call-up Response Time

A user may call up a display in the active window of a monitor at every local or remote workstation by any of the methods specified in Exhibit 3-12, Display Call-Up Response Requirements. The display response time is defined as the elapsed time from the last step of a display request made by the user until the requested display is completely shown in the window on the monitor. Since identical display requests will produce different display response times depending on the availability of the system resources at the instant of the requests, the display response time requirements are defined in statistical terms for 95 (ninety-five) percent of the observations and 100 (one hundred) percent of the observations. The specified display response times shall also apply for paging forward/backward.

Display response times for all user workstations for the system operating in the Steady State, High Activity State, and Overload State, shall conform to the requirements shown in Exhibit 3-12, Display Call-up Response Requirements.
## Exhibit 3-12: Display Call-up Response Requirements

<table>
<thead>
<tr>
<th>Item</th>
<th>Not-to-Exceed Response Time for Steady State and High Activity State</th>
<th>Not-to-Exceed Response Time for Overload State</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>95% of the Time (Seconds)</td>
<td>100% of the Time (Seconds)</td>
</tr>
<tr>
<td>Displays without real-time data (Text, Directory, Message, etc.)</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>World Map Displays and Station One-Line Displays</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Summary Displays</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Queries-based Displays</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Trend Displays (for a display with at least 4 (four) curves showing historical trend data)</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Historical Data Displays</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>All Other Displays</td>
<td>1.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Web Browser Displays</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Reports</td>
<td>2.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

### 3.2.7 Display Update Time

The following not-to-exceed display update times apply to all user workstations as well as the Overview Display when the SCADA/EMS is in either the Steady State or High Activity State:

1. Status changes, new (updated) analog values, limit crossings of analog values, and annunciation of alarms by flashing (where applicable) shall appear in every window of every monitor on every workstation as well as the Overview Display where the point is shown within 1 (one) second of the time instant that the data with the corresponding new status or analog value is received by the SCADA/EMS.

2. The display of calculated real-time database points shall be updated within 1 (one) second from the instant that any telemetered value used in the calculation is received by the SCADA/EMS.

3. The display of points manually entered/updated at another user workstation, and of calculated points that are a function of the entered value shall be updated within 1 (one) second from the instant that the data was entered by the user.
System time shall be shown on every user workstation with a resolution of 1 (one) second, and shall be updated once per second. Under all circumstances, the same system time displayed at a workstation shall not deviate from the time displayed at another workstation or from the time provided by the time standard.

3.2.8 **Alarm and Event Response Time**

When the system is in the Steady State, an alarm or event shall be annunciated at the local and remote user workstations as well as the Overview Display by all associated visual indications and, if applicable, an audible signal, within 1 (one) second after the SCADA/EMS has completed the acquisition of the data that includes the alarmed point. Alarm and event annunciation shall occur within 2 (two) seconds when the system is in the High Activity State. If a Summary Display (Alarm Summary, A&E Summary, etc.) containing the point is already being shown on a monitor, then the corresponding entry on that display shall also be created or updated within the above-specified time periods.

Under no conditions, including Overload State, shall any alarm or event be lost.

3.2.9 **User Request Completion Time**

When the SCADA/EMS is in the Steady State or High Activity State, the system shall complete responses to user requests made from any user workstation within 1 (one) second after the request is made. These requirements shall apply to all the user requests including those in the following **Exhibit 3-13**.

**Exhibit 3-13: User Request Completion Time**

<table>
<thead>
<tr>
<th>User Request</th>
<th>System Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point selection on a monitor</td>
<td>Pop-up window appears.</td>
</tr>
<tr>
<td>Alarm acknowledgement</td>
<td>Acknowledged alarm stops flashing.</td>
</tr>
<tr>
<td>Data entry execution</td>
<td>Newly-entered data shown on monitor.</td>
</tr>
<tr>
<td>Control request</td>
<td>System confirms control action selected.</td>
</tr>
<tr>
<td>Control execute</td>
<td>Control sent to RTU.</td>
</tr>
<tr>
<td>Control point tagged</td>
<td>Tag is in effect and shown on monitor. The Tag Summary is updated.</td>
</tr>
<tr>
<td>Alarm inhibit</td>
<td>Alarm checking stopped, inhibit indication (I) shown on appropriate displays, Inhibit Summary is updated.</td>
</tr>
<tr>
<td>Silence audible alarm</td>
<td>Sound stops.</td>
</tr>
</tbody>
</table>
### User Request

<table>
<thead>
<tr>
<th>Scanned point deactivation/activation</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Response</td>
</tr>
<tr>
<td>Processing of the point is stopped or resumed, Deactivated Summary is updated.</td>
</tr>
</tbody>
</table>

When the SCADA/EMS is in the Overload State, the response to the user requests shall be completed within 3 (three) seconds.

Whenever completion of a user request is expected to require more than 1 (one) second, as when lengthy calculations or multiple accesses to historical data are required or when an application that requires extensive processing is initiated, the system shall, under all conditions, post an appropriate indication (e.g., an hour-glass symbol or an appropriate message) to the requesting workstation within 1 (one) second, 3 (three) seconds for the Overload State, and shall be ready to accept further inputs.

Virtually instant response, i.e., less than 0.25 seconds, is required under all conditions and at all user workstations for panning and zooming, and for window manipulations as follows in **Exhibit 3-14**.

### Exhibit 3-14: Display Manipulation

<table>
<thead>
<tr>
<th>User Action</th>
<th>System Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drag on border of a window</td>
<td>Change the window size or shape</td>
</tr>
<tr>
<td>Drag a window</td>
<td>Window follows the mouse movement</td>
</tr>
<tr>
<td>Scroll</td>
<td>Scrolling contents of window is completed</td>
</tr>
<tr>
<td>Minimize a window</td>
<td>Window disappears</td>
</tr>
<tr>
<td>Maximize/restore a window</td>
<td>Window assumes the requested size</td>
</tr>
<tr>
<td>Click a Help button</td>
<td>Help dialogue appears</td>
</tr>
<tr>
<td>Click a pushbutton</td>
<td>Dialog menu or other response is presented</td>
</tr>
</tbody>
</table>

When the user requests a hardcopy of a display or screen, the printing shall start within 3 (three) seconds of the placing of the request (except in the Overload State), unless the printer is already busy.
3.2.10  **System Failsoft Capability**

The SCADA/EMS shall be designed to ensure that all critical functions continue to be performed under all conditions, although their performance may be slower in the Overload State. Under no circumstances shall the system fail to process inputs obtained from an RTU, communication links, local inputs, and normal user interface processes. In the Overload State (when the changes in analog and status points exceed the level defined as High Activity State), the system shall enter a failsoft state wherein certain performance requirements, such as scan times, may be relaxed to make optimal use of the system’s resources. In the Overload State, the execution of the non-critical functions may be temporarily suspended. Any failsoft-mode performance degradation under activity levels defined herein as Steady State or High Activity State is not acceptable.

3.2.11  **System Failover, Restart, and Startup Times**

3.2.11.1  **FAILOVER AND RESTARTS**

The time until full functionality and performance are restored after failover or a restart (see Section 2.4.4 Failover and Restarts) shall not exceed the following:

**Exhibit 3-15: Failover and Restart/Start-Up Times**

<table>
<thead>
<tr>
<th>Description</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Failover Time, elapsed time for a complete failover, from the moment of</td>
<td>15 (fifteen) seconds</td>
</tr>
<tr>
<td>the failure or manual initiation of the failover</td>
<td></td>
</tr>
<tr>
<td>2. Time for a hot restart (see Section 2.4.4.2, System Restarts)</td>
<td>5 (five) seconds</td>
</tr>
<tr>
<td>3. Time for a warm restart (see Section 2.4.4.2, System Restarts)</td>
<td>30 (thirty) seconds</td>
</tr>
<tr>
<td>4. Time for a cold restart (see Section 2.4.4.2, System Restarts)</td>
<td>5 (five) minutes</td>
</tr>
</tbody>
</table>

3.2.11.2  **SYSTEM START-UP TIME**

After a power outage or total shutdown of the SCADA/EMS, the total elapsed time for a complete system start-up shall not exceed 2 (two) minutes, i.e., from the time that power is restored until the time that data processing is initialized, real-time data is available at all processors and workstations, and all critical functions are operational.
3.2.11.3 USER WORKSTATION BOOT-UP TIME AND START-UP TIME

The user workstation boot-up time is defined as the time from the moment when the workstation’s power is turned on, or when the workstation is rebooted, until the user is prompted to enter log-in identification. The boot-up time shall not exceed 1 (one) minute from the hypervisor startup.

The user workstation start-up time is defined as the time from the moment when the user completes the log-on procedure at a user workstation until the initial set of displays are generated on all monitors of the user workstation, the user workstation is receiving and processing input data, the displays are updated with real-time data, and the user workstation is ready to accept user input. The start-up time shall not exceed 30 (thirty) seconds.

3.2.11.4 START-UP TIME FOR START-UP OF BACKUP FUNCTIONS AT BACKUP SYSTEM

The Backup System Start-Up Time is defined as the time from the moment that a user commands the SCADA/EMS to assume responsibility for performing the functions of acting as a Backup System until the Backup System has completely initialized the database belonging to the RTUs in the region of the failed SCADA/EMS, and updated the corresponding displays. The Backup System Start-Up Time shall be less than 2 (two) minutes.

3.3 Software Maintenance

In case of a failure at the PCS or BCS, the time until full functionality and performance of database, display and application configuration in the PDS (see Section 2.3.3 Support Environments) are regenerated or built shall not exceed the time specified in Exhibit 3-16, Software Maintenance Activities.

The time until full functionality and performance are recovered and restored after any equipment failure (see Section 4.18, Recovery Plans for Critical Assets) shall not exceed the time specified in Exhibit 3-16, Software Maintenance Activities.

Exhibit 3-16: Software Maintenance Activities
<table>
<thead>
<tr>
<th>Action</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete database regeneration</td>
<td>1 (one) hour</td>
</tr>
<tr>
<td>Software build of all applications and databases</td>
<td>2 (two) hours</td>
</tr>
<tr>
<td>Software build of a single application and databases</td>
<td>30 (thirty) minutes</td>
</tr>
<tr>
<td>Installation of a single, new display including distribution to all</td>
<td>30 (thirty) seconds</td>
</tr>
<tr>
<td>workstations</td>
<td></td>
</tr>
<tr>
<td>Reinstallation of all displays</td>
<td>15 (fifteen) minutes</td>
</tr>
<tr>
<td>Perform an on-line update of a database parameter and propagation of</td>
<td>60 (sixty) seconds</td>
</tr>
<tr>
<td>the change to the source data</td>
<td></td>
</tr>
<tr>
<td>Bare metal restoration of a Critical System Function (i.e., IS&amp;R,</td>
<td>Complete and ready for</td>
</tr>
<tr>
<td>SCADA etc.) to an operational state</td>
<td>operation within 2 (two)</td>
</tr>
<tr>
<td></td>
<td>hours</td>
</tr>
</tbody>
</table>
## System Security

### 4.1 Security Architecture

- **Management of Electronic Security Perimeters**

### 4.2 Systems Security Management

### 4.3 BES Cyber Systems and Associated BES Cyber Assets

- **SCADA/EMS as BES Cyber System**

### 4.4 System Hardening

- **Removal of Unnecessary Services and Programs**
- **Changes to File System and Operating System Permission**

### 4.5 Free of “Electronic Self-Help” Enabled Software

### 4.6 Host Based Firewall Protection

### 4.7 Hardware Configuration Protection

### 4.8 Security Patch Management

### 4.9 Notification of Security Vulnerabilities in Contractor-Provided Software

### 4.10 Malicious Software Prevention

### 4.11 Account Management

- **Role-Based Access Control (RBAC)**
- **Disabling, Removing, or Modifying Well-Known or Guest Functional Accounts**
- **Session Management**
- **Secure Maintenance Access**
- **Security of Remote Access for Maintenance by Contractor**
- **User Account Password/Authentication Policy and Management**
- **Account Audit and Logging**
- **Single Sign On**
4.11.8.1  AE Specific Requirement ................................................................. 79
4.12  Web-Based Interfaces Toolbars.............................................................. 79
4.13  Security Status Monitoring ................................................................. 80
4.14  Centralized Logging System ............................................................... 81
4.15  Detection of Unauthorized Modifications to Software (Option) ............. 81
4.16  Authorization Process ....................................................................... 81
4.17  Security Updating and Expandability Requirements ....................... 81
4.18  Recovery Plans for BES Cyber Assets ............................................... 82
4 SYSTEM SECURITY

Due to the critical nature of the SCADA/EMS operations and its networking with other systems, cyber security is of major concern to the Purchaser. While recognizing that cyber security is a combination of user security procedures and system security technologies, the SCADA/EMS shall incorporate all necessary security system technologies to minimize the possibility of successful security compromises, and to provide mechanisms for identifying, mitigating, and recovering from successful security attacks. The Contractor shall also recommend user security procedures that will make the most effective use of the system security technologies.

Therefore, security as defined in this document for the project includes security for personnel, security procedures, cyber technologies, and physical security.

The Contractor shall implement the system security according to the Purchaser’s security policy. The Purchaser will provide its security policy during project implementation. The Purchaser will be doing deep packet inspection and the Contractor shall work with the Purchaser during project implementation to ensure the system works with this requirement.

The System shall be designed using a risk-based approach and applying the principle of defense in depth to provide a robust and resilient system. That is, multiple layers of security controls shall be placed throughout the system such that in the event a security control fails or, a vulnerability is exploited there is a secondary or redundant control that will prevent, delay, or mitigate the exploit, in addition to alerting the Purchaser such that mitigation steps can be taken. The SCADA/EMS software shall be audited and tested during the FAT prior to delivery and during SAT to ensure that the cyber security requirements are met.

The SCADA/EMS software, when delivered, shall have no special undocumented user sign-on procedure, such as might be used by the programming staff of the Contractor or the supplier of the operating system or third-party software while the software is being developed. No documented hard coded unchangeable password or entry method shall be allowed.

The major cyber security requirements that need to be addressed by Contractor in coordination with Purchaser are:

1. Resilience and security recommendation for disruptions -
2. Resilience and security recommendations against deliberate attacks, equipment failures, and natural disasters

3. Resilience and security recommendations covering power system equipment, control systems and infrastructure (e.g. electrical and communication networks) managing the grid

4. Recommendations for key security requirements such as
   4.1. Confidentiality
   4.2. Integrity
   4.3. Authentication
   4.4. Availability
   4.5. Accountability / Non-repudiation, as applicable

The Contractor shall address applicable Security Requirements, Threats and Attacks as illustrated in **Exhibit 4-1: Security Requirements, Threats and Possible Attacks**.
The Contractor, in coordination with Purchaser, shall provide security solutions leveraging standards such as:

1. NISTIR 7628 security guidelines making use of a “Logical Interface” diagram Exhibit 4-1 to associate the most appropriate security requirements with each of the interfaces between the logical systems (“NISTIR Actors”).
3. ISO/IEC 27019 – Information technology — Security techniques — Information security management guidelines based on ISO/IEC 27002 for process control systems specific to the energy industry
4. NERC CIP 2-11, 14 – Critical Infrastructure Protection
5. IEC 62351 series – Power systems management and associated information exchange – Data and communications security
6. NIST SP 800-53, NIST SP 800-82

### 4.1 Security Architecture

All systems and equipment shall be located within a security perimeter, as well as the equipment that defines the security perimeter shall be treated and configured as BES (Bulk Electric System) Cyber Systems and associated BES Cyber Assets consistent with NERC reliability standards.

The Contractor’s system shall work within the Purchaser’s security architecture. Each component of the system shall be in a separate microsegment with layers 3 through 7 security policies applied between microsegments.

The security architecture provides external users access to data without affecting the performance, reliability, or security of the SCADA/EMS or its component systems.

#### 4.1.1 Management of Electronic Security Perimeters

The Contractor shall identify and provide document and drawings depicting all interconnected SCADA/EMS components within the electronic security perimeters, all interface points within the electronic security perimeters
The Purchaser shall implement and document the organization processes and technical and procedural mechanisms for control of electronic access at all electronic access points to the electronic security perimeter(s). These processes and procedures shall address, but shall not be limited to the following requirements:

1. Contractor shall use an access control model that denies access by default, such that users and applications shall be required to have explicit access rights defined.

2. At all access points to the electronic security perimeter(s), the Purchaser shall enable only ports and services required for operations and for monitoring BES Cyber Assets within the Electronic Security Perimeter, and the Contractor shall document, individually or by specified grouping, the configuration of these ports and services. The Contractor shall provide a separate document for ports and services that details the source process, source ip, source port, destination ip, destination port, protocols required preferably in tabular format that is suitable for configuring firewall rules. Each rule shall have a unique identifier. The document shall be subject to Purchaser review and approval. The document shall be provided at least 2 months prior to the hardware arriving on-site at Purchaser’s site and provided every time it is updated. The Contractor shall provide assistance to the Purchaser in determining the minimum required access permissions for the firewalls to allow functional yet secure operation of the SCADA/EMS, including normal, emergency, and required maintenance actions.

3. The Contractor shall provide users accessing the SCADA/EMS through interactive or maintenance access with an “Appropriate User Banner” on the user screen upon all interactive access attempts, the contents of which will be provided by the Purchaser.

4. The Purchaser will provide and implement the intrusion detection systems (IDSs) or intrusion prevention systems (IPSs) across all electronic security perimeters (e.g. IDS Palo Alto layers 3 through 7).

5. The Contractor shall propose a mechanism for determining what network traffic patterns constitute “normal” traffic.

6. The Contractor shall ensure that all interactive or user-driven data exchanges into electronic security perimeters from an external source use authentication of the sender and the receiver, as well as ensuring each party has the authorization to perform the requested action.
Authentication shall include methods that augment user names and passwords, such as two-factor authentication.

7. The Contractor shall ensure accountability of all data exchanges across electronic security perimeters through the logging of all significant actions with the ability to log at a debug level when necessary.

8. The Purchaser shall implement and document an electronic process for monitoring and logging access at access points to the electronic security perimeter(s) 24 (twenty-four) hours a day, 7 (seven) days a week.

9. Communications shall be designed so that the most trusted application or system shall initiate communications. Upon failed communications, the most trusted application or system shall re-start communications. This extends to control schemes, where the SCADA master shall initiate communications with RTU.

The electronic security perimeter of OT zone shall have the following characteristics as a minimum:

1. The Contractor shall provide mechanisms to define controls to ensure confidentiality and integrity of all external data communications to the SCADA/EMS.

2. The non-SCADA/EMS networks shall not have direct query or access capability to any data stores, such as maintained by the Historical Information System, or processes within the OT (SCADA/EMS) zone.

3. Management of access control devices shall be permitted only from a highly restricted subset of management devices.

The security monitoring processes, shall detect, alert, and log all attempts at actual authorized and unauthorized access including unauthorized attempts to access the security logs. These alerts shall provide for appropriate notification to the engineering workstations. The logging of attempts at or actual unauthorized accesses shall be kept for at least every past 90 (ninety) calendar days.

The Purchaser, in coordination with the Contractor, shall provide the perimeter protection, such as firewalls and IDS/IPSs to establish a clear demarcation between the protected SCADA/EMS network, Production Environment, and unprotected and untrusted external networks. The
Perimeter Protection hardware systems shall be implemented redundantly such that the overall reliability and redundancy of the SCADA/EMS is not contingent upon Perimeter Protection. The Contractor shall provide detailed information on all communications (including protocols) required through a firewall, whether inbound or outbound, and identify each network device initiating a communication. Additionally, the Contractor shall recommend firewall rule sets or other equivalent documentation.

All firewalls shall be implemented using a “default deny” philosophy, allowing only those users, nodes, ports, and services that are affirmatively identified. All supplied firewalls and associated routers shall be configured to generate log information on both attempted and successful access and forward logging data to a centralized logging server or service. The Contractor shall provide a list of all necessary and required ports, services, and addresses requiring access through all firewalls supporting normal, emergency, and ongoing maintenance functions. All access implemented during system development, Formal Acceptance Test, and Site Acceptance Test shall be documented and reviewed for removal prior to System acceptance.

4.2 Systems Security Management

All security functions included as part of these Technical Specifications shall be implemented in a non-interfering manner, such that authorized and legitimate use of the SCADA/EMS is not hampered. Thus, the ability to perform the required functions shall not be impeded by the security features.

4.3 BES Cyber Systems and Associated BES Cyber Assets

4.3.1 SCADA/EMS as BES Cyber System

The SCADA/EMS is considered a BES Cyber System. Therefore, notwithstanding any additional cyber security requirements specified herein, it is preferred that the Contractor’s processes and supplied systems support compliance with all applicable requirements of the latest versions of the Critical Infrastructure Protection (CIP) standards developed by the North American Reliability Council (NERC)\(^2\). The applicable standards are listed as follows:

\(^2\) [http://www.nerc.com/pa/Stand/Pages/CIPStandards.aspx](http://www.nerc.com/pa/Stand/Pages/CIPStandards.aspx)
1. CIP-002 BES Cyber System Categorization
2. CIP-003 Security Management Controls
3. CIP-004 Personnel & Training
4. CIP-005 Electronic Security Perimeter(s)
5. CIP-006 Physical Security of BES Cyber Systems
6. CIP-007 Systems Security Management
7. CIP-008 Incident Reporting and Response Planning
8. CIP-009 Recovery Plans for BES Cyber Systems
9. CIP-010 Configuration Change Management and Vulnerability Assessments
10. CIP-011 Information Protection.
11. CIP-013 Supply Chain Risk Management
12. CIP-014 Physical Security

The Contractor shall document which cyber security standards are incorporated in the SCADA/EMS, and where and how they are incorporated. The SCADA/EMS software shall be audited immediately prior to delivery to ensure that the cyber security initiatives described in the following sections are satisfied.

4.4 System Hardening

4.4.1 Removal of Unnecessary Services and Programs

The Contractor shall provide documentation detailing all applications, utilities, system services, scripts, configuration files, databases, and all other software required and their appropriate configurations, including revisions and/or patch levels for each of the computer systems associated with the SCADA/EMS.

The Contractor shall provide a listing of services required for any computer system running SCADA/EMS applications or required to interface with the SCADA/EMS applications.

The Contractor shall remove or disable all software artifacts that are not required for the operation and maintenance of the SCADA/EMS prior to Formal Acceptance Test. The software to be removed or disabled shall specifically include, but not be limited to:

1. Entertainment features
2. Unused Messaging services (e.g., MSN, AOL IM, WhatsApp, Viber, Skype, etc.)
3. Servers or clients for unused Internet services
4. Unused networking and communications protocols
5. Unused administrative utilities, diagnostics, network management, and system management functions
6. Backups of files, databases, and programs used only during system development
7. Programs and scripts used for development and testing, including sample programs and scripts.

4.4.2 Changes to File System and Operating System Permission

The Contractor shall configure hosts with least privilege file and account access.

The Contractor shall configure the necessary system services to execute at the least user privilege level possible for that service.

The Contractor shall document that changing or disabling access to such files and functions has been completed.

4.5 Free of “Electronic Self-Help” Enabled Software

The Contractor shall ensure that no SCADA/EMS software proposed contains any known embedded faults or back-door mechanisms that could allow the software Contractor, or any other party, to remotely disable some or all of the functions of the software, to affect their performance, or in any way to degrade its operation.

The software shall not contain any mechanism that automatically disables some or all of its functions or degrades their operation on a certain date or upon the occurrence of a specific event.

4.6 Host Based Firewall Protection

The Contractor shall enable and configure host based firewalls. Each firewall shall support the following features:

1. Access Control – The firewall shall provide access control through Access Control Lists (ACLs) and through limiting the number of open ports to only those required for
SCADA/EMS operation. Changes to ACLs shall only be implemented via authorized and authenticated means, and shall be logged.

2. IP Spoofing – The firewall shall guard against address spoofing or source-routing

3. Packet Filtering – The firewall shall implement filtering of both inbound and outbound traffic and shall restrict access based on both source and destination IP addresses.

4. Reject Unauthorized Traffic – The firewall shall reject packets originating from outside the local network that claim to originate from within.

5. Prevention of Denial of Service – The firewall shall protect against denial of service attacks by rapidly rejecting unauthorized packets that may overwhelm a port. The Contractor shall describe which types of denial of service attacks its firewall can prevent.

The Contractor shall be responsible for the configuration of the host based firewall. The following general access rules shall be implemented:

1. Access from the SCADA/EMS to systems and networks on the Corporate and other, external Networks shall be allowed only via a CSN DMZ.

2. Access to the SCADA/EMS from users and systems on the Security Network shall be limited by network address and user (or account) name.

3. Selected users at selected network nodes shall be permitted access to the IS&R/HIS databases. The access control facilities of the IS&R/HIS will be used to further limit access.

4. Selected users at selected network nodes shall be permitted access to the SCADA/EMS for SCADA/EMS user interface functions.

### 4.7 Hardware Configuration Protection

The Contractor shall disable, through software or physical disconnection, all unneeded communication ports and removable media interfaces, or provide engineered or electronic barriers. Where possible, logging of physical port use or modification shall be configured to send such logging information to centralized logging servers or services.

If technically feasible, the Purchaser shall password protect the BIOS from unauthorized changes. The capability for the Purchaser to password protect the BIOS shall be supported.
The Contractor shall configure the system to allow the system administrators the ability to re-enable devices if they are disabled by software.

The Contractor shall provide network and system management for monitoring the health of the networks and systems. The Simple Network Management Protocol (SNMP v3, IETF RFC 3411–RFC 3418) shall be used for common network devices such as routers and firewalls.

The Contractor shall identify heartbeat signals or protocols and recommend whether they should be included in network monitoring. If they are to be included in the network monitoring, the Contractor shall provide packet definitions of the heartbeat signals and examples of the heartbeat traffic.

All configuration changes shall be validated and logged.

### 4.8 Security Patch Management

The Contractor shall have a patch management and update process for operating systems, applications, and third-party software. Patch management shall not require direct connection of the production system to the Internet to facilitate patching.

The Contractor shall ensure all services are patched to current status.

The Contractor shall provide, within a pre-negotiated period, an updated list as upgrades or patches are made available to any of the items mentioned above.

The Contractor shall provide details on their patch management and update process. Procedures for installation and update of patches shall be provided and documented.

The Contractor shall provide notification of known vulnerabilities affecting Contractor-supplied or required OS, application, and third-party software including the notification of patches affecting security as identified in the patch management process. The Contractor shall apply, test, and validate the appropriate updates and/or workarounds on the Purchaser’s factory system before distribution. Testing shall have the goal of confirming that the patch indeed does not introduce any new errors and does not interfere with the SCADA/EMS. The security patch shall be tested and sent to the Purchaser by the Contractor in a secure fashion within 28 (twenty eight) days of its release by the software Contractor.
The Purchaser will test the patches on the QAS to simulate an operational environment.

The implementation and testing of all security patches shall follow the established configuration management and change control processes. This includes the execution of test procedures where the change is deemed “significant”.

If during testing on the QAS a patch is found to interfere with the operation of the SCADA/EMS software, the Purchaser will notify the Contractor and the Contractor shall initiate the resolution process with the third-party Contractor.

The SCADA/EMS shall include a Contractor-provided facility to enable the Purchaser to receive, test, install and distribute security patches throughout the system components.

This facility shall be located in the OT DMZ to protect the SCADA/EMS and shall provide all hardware and software required to accurately manage the patch process.

### 4.9 Notification of Security Vulnerabilities in Contractor-Provided Software

The Contractor shall within two business days of its knowledge, inform the Purchaser in a secure manner the discovery of an error in or a property of any software resident on the SCADA/EMS that makes the SCADA/EMS vulnerable to cyber-intrusion. The Contractor shall have a patch management and update process.

Responsibility for installation and update of patches shall be identified.

Post-contract award, the Contractor shall provide notification of known vulnerabilities affecting Contractor-provided or required OS, application, and third-party software within the two business days period after public disclosure. Post-contract award, the Contractor shall provide notification of patch(s) affecting security as identified in the patch management process.

The Contractor shall apply, test, and validate the appropriate updates and/or workarounds on the Purchaser’s factory system before distribution.

The Contractor shall provide within a negotiated period (pending the severity and risk of the vulnerability) appropriate software and service updates and/or workarounds to mitigate all...
vulnerabilities associated with the product and to maintain the established level of system security.

The Contractor shall diligently work to correct the error or modify the property to close the vulnerability. The correction shall be tested to the Purchaser’s complete satisfaction and made available to the Purchaser at no cost. Notification and closure of security-related vulnerabilities shall be taken as a Contractor obligation throughout project implementation and shall remain as such during warranty and as long as a Service Agreement is in place.

After warranty, but without a Service Agreement, the Contractor shall notify the Purchaser of security-related vulnerabilities. Closure of security-related vulnerabilities in the absence of a Service Agreement will be handled on an individual contract basis.

The Contractor shall provide the Purchaser with a process to submit problem reports as part of the system security process. Submitted reports shall be reviewed and an initial action plan generated within 48 (forty-eight) hours of submittal.

The Contractor shall protect problem reports of a security nature from public disclosure and when notifying other customers shall not release any information to indicate that the Purchaser identified the problem.

The Contractor shall verify and provide documentation that all services are patched to current status.

4.10 Malicious Software Prevention

Where technically feasible and where appropriate commercial products exist (e.g., in Microsoft Windows environments), the Contractor shall implement anti-virus, spyware, executable whitelisting, or other malware detection or prevention systems. These products shall be installed and running throughout the development, test, commissioning and acceptance of the system to ensure that the impact of these products on system performance is known and tested. If any products depend on signature or blacklist data, the Contractor shall provide procedures for the secure updating of configuration and signature files to ensure that the tools remain current with updates and releases. The updating of configuration and signature files shall be performed by a centralized server or service.
The Contractor shall meet one of two conditions:

1. Provide a host based malware detection or prevention scheme for the SCADA/EMS network. The Contractor shall ensure adequate system performance for host-based malware detection, quarantine suspected infected files instead of automatically deleting them, and provide an updating scheme for the signatures. The Contractor shall also test major updates to malware detection applications and provide performance measurement data on the impact of using the malware detection applications in an active system. Measurements shall include but not be limited to network usage, CPU usage, memory usage, and any other impact to normal communications processing.

2. If the Contractor is not providing the actual host-based anti-malware scheme, the Contractor shall propose malware detection products to be used, and they shall provide guidance on malware detection settings that will work with their products. The Contractor shall validate the Purchaser’s selection works with their system.

4.11 Account Management

4.11.1 Role-Based Access Control (RBAC)

The Contractor shall implement Role-Based Access Control (RBAC) in compliance with IEC 62351-8, NERC CIPS (1-9), NIST SP 800-53 (Access Control), NIST SP 800-82 (security standard for power grid control systems) and Smart Grid Cyber Security Requirements (Access Control – AC). Users (human, software applications, device) shall have individual user accounts, while roles shall be assigned to functional accounts with established rights and constraints. Software applications and devices that are used to interact with the SCADA/EMS shall also be considered as RBAC “users”. The authorization and privileges of each role shall be defined (reference IEC 62351-8):

1. Each user, shall be assigned to one or more of the roles - Authorization and privileges assigned to roles may include read data, write data, modify data, delete data, run invoke applications, issue commands

2. Some roles should be mutually exclusive if required (e.g. enforce the separation of duties, to eliminate conflicts of interest, and to ensure independence in the responsibilities)

3. Users may be assigned to multiple roles so long as they are not mutually exclusive.
4. Default roles/functional accounts shall be provided for basic operational and engineering activities including security management, with default privileges assigned down to the individual device and type of data. These default roles and their privileges shall be modifiable.

5. No user shall be able to access the SCADA/EMS without having their user account assigned to at least one role. That role shall determine what access privileges the user has.

6. The Contractor shall provide for user accounts with configurable access and permissions associated with the defined user role.

7. The Contractor shall adhere to least privilege permission schemes for all user accounts, and application-to-application communications.

8. The Contractor shall configure the system so that initiated communications shall start with the most trusted application controlling the communication. Upon failed communication, the most trusted side will restart communications.

9. The Contractor shall ensure that under no circumstances can a user escalate their privileges without logging into a security management role first.

10. The Contractor shall provide a mechanism for changing user-to-role associations.

4.11.2 **Disabling, Removing, or Modifying Well-Known or Guest Functional Accounts**

All user access to SCADA/EMS systems shall be through individual user accounts that are assigned to roles. These roles may be associated with functional accounts.

The Contractor shall recommend which functional accounts need to be active and those that can be disabled, removed, or modified. The Purchaser shall approve in writing the Contractor’s recommendation.

The Contractor shall disable or remove all unnecessary functional accounts, such as guest accounts, development accounts, factory maintenance accounts, and default accounts provided for hardware, operating system, database, application program, and other contractors pursuant to the approved recommendation prior to Formal Acceptance Testing. Where specific accounts cannot be removed, they shall be renamed or disabled to prevent unauthorized access and document it so that the Purchaser understands what the Contractor disabled and why. Once
changed, new accounts shall not be published except that new account information and passwords shall be provided by the Contractor via protected media. After Site Acceptance Testing the Contractor shall disable, remove, or modify all Contractor-owned user and functional accounts.

4.11.3  **Session Management**

Users shall be required to login to one of their assigned role-based functional accounts to start a session.

The Contractor shall not permit user login credentials to be transmitted in clear text. The Contractor shall provide the strongest encryption method commensurate with the technology platform and response time constraints.

In addition, where appropriate, the Contractor shall not allow the same user to log into multiple accounts concurrently, nor for applications to retain login information between sessions, nor provide any auto-fill functionality during login, nor allow anonymous logins.

The Contractor shall provide user account-based logout and timeout settings for all accounts and it shall be configurable by the Administrator by account.

4.11.4  **Secure Maintenance Access**

Secure maintenance access to the operating environment shall be provided for both remote and local users. The access shall provide authentication of valid users without transmitting plain-text passwords on the network. An encrypted access mechanism such as SSH shall be used for “command line” access to any nodes. Secure file copy features included in SSH shall be used to manually transmit files between nodes when using the network.

4.11.5  **Security of Remote Access for Maintenance by Contractor**

All access from the Contractor’s facilities or Contractor’s staff to the SCADA/EMS will be controlled by the Purchaser. All Contractor’s staff needing access to the Purchaser’s SCADA/EMS shall be required obtain and maintain an AE NERC CIP and AE Sensitive clearance prior to being granted access.
Access for the purpose of maintenance shall be permitted on an as-needed basis only to the QAS & PDS Environments, and not to any component of the on-line SCADA/EMS.

In emergency situations, Contractor staff may be allowed access to the on-line system(s) when authorized and initiated by the Purchaser.

Such access shall be subject to the security requirements for remote maintenance access as described in Section 2.3.4.7 Remote Access System.

All actions performed remotely shall be subject to audit-trail reporting and adhere to the Purchaser’s software version and configuration control procedures.

The Contractor’s diagnostic system used for remote maintenance of the SCADA/EMS is referred to here as the “Contractor’s remote diagnostic system”. The Contractor shall ensure security of the physical access to its remote diagnostic system. The Contractor’s remote diagnostic system shall be a stand-alone system, and shall not be connected to any Contractor or external network without explicit, written authorization from the Purchaser’s IT Security.

The Contractor shall recommend strict physical and electronic security procedures for access to its remote diagnostic system, such as having the system in a secure area and requiring two factor authentication or identification in addition to a password to gain access to the Contractor’s remote communications line.

Upon termination of the Maintenance Agreement, the Contractor’s remote diagnostic system shall be dismantled, and all paper and electronic media shall be securely erased or destroyed.

A certificate of erasure or destruction shall be provided as part of the contract termination documentation.

**4.11.6 User Account Password/Authentication Policy and Management**

The Contractor shall provide a configurable user account password management system that allows for selection of password length, frequency of change, setting of required password complexity, number of login attempts, inactive session logout, screen lock by application, and denial of repeated or recycled use of the same password. Passwords shall not be stored electronically or in Contractor supplied hardcopy documentation in clear text unless the media is
physically protected. The configuration interface to the account management system shall have controlled access.

The Contractor shall provide a mechanism for rollback of security authentication policies during emergency system recovery or other abnormal operations, where system availability would be negatively impacted by normal security procedures.

All accounts in the delivered SCADA/EMS shall use passwords assigned by the Purchaser. Passwords for maintenance access shall be constructed to maximize the amount of computer processing required to guess the password. A combination of upper and lower case English alphabetic, numeric, and special characters shall be used. The minimum password length shall be configurable by the Purchaser and must be able to accommodate up to 20-characters. The Purchaser would like to consider any additional password construction and usage restrictions available by the proposed operating system environment(s).

All accounts providing interactive or network access shall have passwords. Accounts that exist strictly for identification and ownership purposes shall be disabled from all interactive, networks, or other access.

### 4.11.7 Account Audit and Logging

The Contractor shall provide a centralized system whereby user and functional account activity is logged and is auditable both from a management (policy) and operational (account use activity) perspective. The audit trails and logging files shall be time stamped and access controlled as well as sent to the centralized logging system (Section 4.14). This includes:

1. All anomalous events shall be logged and timestamped
2. Alarms shall be assigned to one or more roles
3. User interactions with applications and systems shall be logged
4. The timestamps across all systems shall be synchronized via industry-standard mechanisms such as NTP.
5. Logs shall be archived for period of time defined by the Purchaser or at minimum 90 days.
6. All logs shall be viewable by security personnel using appropriate role-based access
7. Sort/search functionality for correlating different types of events shall be provided
4.11.8 Single Sign On

The Contractor shall implement the Single Sign On (SSO) procedure in the SCADA/EMS so that an authorized user can use a single login to have role-based access privileges to multiple systems across a network, or between different programs and systems, without requiring re-authenticating for each system or application.

The Contractor shall provide an SSO such that RBAC enforcement is equivalent to that enforced as a result of direct login.

The Contractor shall also provide documentation on configuring the role-based SSO procedure, and documentation showing equivalent results in running validation tests against the direct login and SSO. The SSO procedure shall resolve individual user logins to each application.

4.11.8.1 AE SPECIFIC REQUIREMENT

AE prefers MS Active Directory.

4.12 Web-Based Interfaces Toolbars

The Contractor shall remove or disable all software components and services that are not required for the operation and maintenance of the devices that run a secure HTTP (HTTPS) server and shall provide documentation on what is removed and/or disabled.

The Contractor shall provide, within a negotiated period (pending the severity and risk of the vulnerability), appropriate software and service updates and/or workarounds to mitigate all vulnerabilities associated with the product and to maintain the established level of system security.

The Contractor shall provide documentation on the actual process used for verification and validation of Web-based interface software.

The Contractor shall follow secure coding practices and reporting for all Web-based interface software. This requirement includes both Web applications and Web servers. Based on risk analysis, the Web applications shall be protected using best practices.
4.13 Security Status Monitoring

The SCADA/EMS shall log all access attempts at both the application and OT security perimeter. The SCADA/EMS shall maintain and forward logs of system events related to security in sufficient detail to create historical audit trails and enable a root-cause analysis for a period of at least 90 (ninety) calendar days. If required, it shall be possible to copy the system event data to an alternative storage medium as part of an investigation covering more than 90 (ninety) days. As a minimum, the logs shall capture the following user access requests:

1. All attempts to log on, both successful and unsuccessful.
2. Any RBAC privilege change requests, both successful and unsuccessful.
3. All user actions affecting security, such as changing passwords.
4. Attempts to perform an action not authorized by the security scheme.
5. Detecting unauthorized access (intrusions) and attempts at unauthorized access at the access points to the electronic security perimeter(s) twenty-four hours a day, seven days a week.
6. All attempts to modify logs, both successful and unsuccessful.

For the purposes of the above requirements, the term “user” shall refer both to human users and to applications requesting such actions.

All access records shall be stored within the SCADA/EMS on auxiliary memory. The format of these records shall be consistent with those provided by other log generating devices, such as network routers, firewalls, and intrusion detection systems. Files that record system activities shall be defined as “append-only”. That is, it shall not be possible to delete an entry from a log file once an entry has been made, although clarifying notes may be added. Access recording shall include a feature to archive the record file and to direct the records to a new, empty file.

The SCADA/EMS shall generate an alarm when access activity may be indicative of attempts to obtain unauthorized access to system services or data. This alarm shall notify security personnel. Initially, an alarm shall be generated when the system detects any of following activities:

1. Repeated attempts from a specific console or external port to log in
2. Repeated failed attempts at file access
3. Port scans (attempts to access closed ports or services)
4. Unusual levels of traffic on the local area network.

4.14 Centralized Logging System

All logs (e.g., application, security, error logs, syslogs, etc.) shall support being sent to a centralized logging server provided by the Purchaser. The Administrator shall be able to enable/disable which logs are sent to the central logging server.

4.15 Detection of Unauthorized Modifications to Software (Option)

As an option, the Contractor shall provide a mechanism for ensuring the integrity of the software on the SCADA/EMS disks to determine if unauthorized modifications to the software have been made. A tool, such as Tripwire or equivalent, may be used for this function. The process of making an authorized modification to the software shall include steps to update any sort of integrity database such that authorized changes are not flagged as unauthorized. Scanning software or other mechanisms shall be configurable to run manually or periodically and shall not interfere with the performance or operation of the SCADA/EMS or any application.

4.16 Authorization Process

The Contractor shall use a secure authorization process to grant Contractor’s personnel access to the SCADA/EMS while on site at the Contractor’s development site. Additionally, the Contractor shall continue to use the authorization process in the field during site start-up, commissioning, and ongoing maintenance of the SCADA/EMS.

The Contractor shall maintain lists of all authorized personnel with access to the SCADA/EMS while on site at the Contractor’s development site, including their specific electronic and physical rights to the systems, processors, or databases, and a date for which access will be terminated. The Purchaser shall be informed of all changes to the list.

4.17 Security Updating and Expandability Requirements

The system security management of the SCADA/EMS shall be able to update the latest threat signature and the latest security detection and protection in order to increase security and functionality without redesign or reengineering efforts. The security updates shall not detract from the reliability and availability of the SCADA/EMS.
The system security management shall be able to support multiple types of expansion without requiring major reengineering. This shall include, but shall not be limited to:

1. An increasing number of monitors hosts/workstations
2. An increasing number of monitors networks

**4.18 Recovery Plans for BES Cyber Assets**

The Contractor shall provide a comprehensive procedure for the restoration of all software and configuration such that a complete rebuild on replacement or substantially similar hardware can be achieved in the time specified in Section 3 Capacity and Performance. This procedure shall include: definitions of what information or system data is required to be backed up or copied to auxiliary storage; mechanisms for performing such backups or copies; mechanisms for verifying the integrity and completeness of backups or copies; methods or mechanisms to perform a restoration or recovery from those backups and copies; and training materials for performing these procedures.
5 SCADA Functions ................................................................................................................ 85

5.1 RTU Data Acquisition .................................................................................................. 85

5.1.1 RTU Protocols ................................................................................................. 85

5.1.2 Data Polling ....................................................................................................... 86

5.1.3 Report by Exception (RBE) ............................................................................. 87

5.1.4 Acquisition of Unsolicited Data ......................................................................... 87

5.1.5 Acquisition Data on Demand ........................................................................... 88

5.1.6 Listen Mode Capability ..................................................................................... 88

5.1.7 Uploading of Sequence of Events (SOE) Data ................................................ 89

5.1.8 Error Detection and Recovery ......................................................................... 90

5.1.9 RTU Test Mode ............................................................................................... 91

5.2 Data Organization ..................................................................................................... 91

5.2.1 Real Time Database (RTDB) .......................................................................... 91

5.2.2 Data Quality ..................................................................................................... 93

5.2.2.1 AE Specific Requirements (ICCP QUALITY CODES) .............................. 94

5.2.2.2 Telemetry Quality Report (AE Specific Report) ....................................... 96

5.2.3 Areas of Responsibility .................................................................................... 96

5.3 Data Processing ....................................................................................................... 96

5.3.1 Redundant Data Processing ............................................................................. 97

5.3.2 Analog Data Processing ................................................................................... 98

5.3.2.1 Data Conversion ......................................................................................... 98

5.3.2.2 Alarm Limit Checking ............................................................................... 98

5.3.2.3 Dynamic Limits – Transmission Lines and Transformers (AE Specific) .... 99

5.3.3 Status Data Processing .................................................................................... 100

5.3.3.1 Reporting of Multiple Status Changes .................................................... 101
5.3.3.2 Motor-Operated Switch Status Processing ..................................................... 102

5.3.4 Processing of Non-Telemetered Data ................................................................. 102

5.3.4.1 Manual Data Points ......................................................................................... 102

5.3.4.2 Calculated Data Points .................................................................................... 102

5.3.5 Pulse Accumulator Processing ......................................................................... 105

5.3.6 Processing of ICCP Data Received from Other Systems ................................. 107

5.4 Supervisory Control .............................................................................................. 107

5.4.1 Validation of Control Commands ...................................................................... 107

5.4.2 Control of Two-State and Three-State Devices ................................................. 108

5.4.3 Incremental Device Control (Jog Control) ....................................................... 109

5.4.4 Setpoint Control ............................................................................................... 109

5.4.5 Control Completion Check ............................................................................... 110

5.4.6 Network Status Processor ............................................................................... 110

5.4.6.1 Determination of Energization Status .......................................................... 110

5.4.6.2 Determination In-Service Status .................................................................. 111

5.5 Communications with Other Systems .................................................................... 112

5.5.1 AE Specific Requirement (Option) - Secure ICCP ............................................. 112

5.5.2 ICCP Interface Management ............................................................................. 112

5.5.3 ICCP Interface with the Network ...................................................................... 114

5.5.4 Data Set Management ...................................................................................... 114

5.5.5 Data Link to Other Utilities’ and ISO EMS ..................................................... 115

5.6 Sequential Control ............................................................................................... 115

5.7 Autotrip Function (AE Specific Requirement) ..................................................... 116

5.8 Voltage Reduction ............................................................................................... 116
5 SCADA FUNCTIONS

This section specifies the data acquisition, data processing, supervisory control, and related capabilities for the SCADA/EMS. These functions shall enable operators to monitor and control the Purchaser’s transmission and distribution system, and shall fully support the advanced applications specified elsewhere in the Technical Specifications.

5.1 RTU Data Acquisition

Real time data for the SCADA/EMS will be acquired from existing and/or new RTUs. In general, unless explicitly stated otherwise, the term “RTU,” as used in this specification, shall also be construed to include Substation Automation Systems.

5.1.1 RTU Protocols

AE’s current SCADA/EMS talks to RTUs through DNP3/IP as the primary channel and DNP3/Serial on the backup channel in most cases (uses DNP3/IP on both channels in some cases, but talking through the same IP cloud to both RTU ports).

AE does not want serial channels (not even using terminal servers) in the replacement SCADA/EMS. Rather, the Data Acquisition Front-End Processors (DAFEs) will talk on through two separate IP ports (primary RTU channel out of one port, secondary channel out of a different port). The primary channel will talk IP all the way to the RTUs through an AE IP cloud. The secondary channel will pass through a JPAX-based MPLS-TP network and at the RTU will either connect to an IP port or will pass through a serial/IP bi-directional converter so that the RTU sends/receives serial DNP3. The SCADA/EMS vendor’s RTU protocol implementation must support that the DAFE may need to send DNP3/IP or DNP3/Serial through IP.

1. DNP 3.0 IP and Serial over IP.
2. 61850 (Option) for future use

The Contractor shall provide their DNP conformance certificate and DNP device profile document as part of the bid.

Within this context, the Contractor shall meet the following requirements at minimum:

1. The Front-End subsystem shall support operations with all existing RTUs.
2. The Front End shall support the incorporation of additional protocols in new communication ports or for replacement of legacy protocols in existing communication ports. In particular, even for alternatives focusing on point-oriented protocols, the ability to add device-oriented protocols shall be included in the overall design of the Front-End subsystem.

3. The Front-End shall support operations with the Purchaser’s secure Backbone Communications Network.

4. The Front-End subsystem shall meet all other requirements as specified in the Technical Specifications.

5.1.2 Data Polling

The EMS shall make data scan requests to RTUs for the most current status, analog, and pulse accumulator data. Such requests shall be made on a parallel basis for RTUs on different serial channels and on a sequential basis when more than 1 (one) RTU shares the same serial communication channel. All IP protocol based RTU data requests shall be made on a parallel basis.

The capability to specify the frequency at which each data point is to be scanned by assigning it to a scan group shall be provided. The number of scan groups shall be configurable. The scanning frequency of each group shall be adjustable in increments of 1 (one) second in the range of at least 2 (two) to 300 (three hundred) seconds and in increments of 1 (one) minute in the range of 1 (one) minute to 60 (sixty) minutes. The capability to define a scan rate offset shall be provided.

Scanned points shall be initially assigned to the following scan rates:

<table>
<thead>
<tr>
<th>Point Types</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status points</td>
<td>2 seconds</td>
</tr>
<tr>
<td>Analog points</td>
<td>2 seconds</td>
</tr>
</tbody>
</table>
5.1.3 Report by Exception (RBE)

Data acquisition using report by exception (RBE) shall be supported for the retrieval of status and analog data. With RBE, the SCADA/EMS shall acquire the data changes that have been detected at the RTUs since the last scan. All analog values that have changed by more than a user-specified deadband shall be reported. All status changes shall be reported, together with the analog-point values in the same RTUs (the same RTUs with the status change or changes).

Deadbands for RBE reporting of analog values shall be specifiable on an individual point basis by a user at a Point-to-Point and Developer workstation. Deadbands shall be specified individually as percentages (a different percentage for each point) of the corresponding full-scale values. When an analog reporting deadband is set to 0 (zero), the analog value shall be reported at every scan whether or not it had changed from the previous scan.

With RBE, a full scan is required under the following conditions for data that is normally acquired by exception:

1. Periodic “integrity scans”. The period shall be 5 (five) minutes and shall be user adjustable for each scan group from 5 (five) minutes to 60 (sixty) minutes in 5 (five) minute increments.
2. Upon system startup and restarts.
3. When any individual RTU is returned into service after being off-line or experiencing a power failure.

5.1.4 Acquisition of Unsolicited Data

The SCADA/EMS shall have the capability to accept unsolicited data from RTUs if the communication protocol supports this capability. The SCADA/EMS shall always process an unsolicited response immediately, even if it arrives when the SCADA/EMS is expecting a response to a previously issued request by the SCADA/EMS. A confirmation of the unsolicited response shall be issued immediately if requested by the RTUs. When unsolicited reporting techniques are used, an integrity scan shall be performed at a frequency that shall be user programmable on a per-RTU basis. The handling and processing of unsolicited data shall be the same as for scanned data.
5.1.5 **Acquisition Data on Demand**

An operator, an application, or other authorized user shall be able to request immediate retrieval of specific data from one or more field devices by identifying the analog point, the status point, or preset groups of points. The Front-End subsystem shall request the specified data from the field devices and provide it to the requestor.

5.1.6 **Listen Mode Capability**

The System shall support RTU “Listen Mode” technology. The System shall be capable of monitoring data from any or all configured RTUs in parallel with the existing online systems. This capability shall not interfere with, or negatively affect, communications with the existing online systems. The use and processing of the acquired data while in the listen mode shall not be differentiated from normally scanned data. Changes as a result of supervisory controls initiated by the existing system shall be processed as events but not alarmed as if the controls were initiated by the System.

The EMS shall inhibit supervisory controls to an RTU that is in the listen mode.

When the Administrator puts an RTU into the listen mode, the EMS shall prompt the Administrator to enter a comment for the action (up to 60 (sixty) characters). The Administrator’s action including the comment shall be processed as an event. The same processing shall apply when the Administrator removes an RTU from the listen mode.

A Listen Mode Summary shall be available to list all RTUs that have been placed into listen mode. This summary shall contain an entry for each RTU that is currently in listen mode. Each entry shall include:

1. Date and time (at which listen mode was activated)
2. Administrator identification
3. RTU name
4. Location name
5. Administrator’s comment
The listen mode shall support all protocols as described in Section 5.1.1, RTU Protocols. The Contractor shall supply all the required hardware and software to support the listen mode function.

5.1.7 Uploading of Sequence of Events (SOE) Data

Whenever data (analog and digital) is acquired from RTUs that include an SOE function, the SCADA/EMS shall check for pending SOE data. SOE data shall be uploaded promptly to minimize the risk of SOE buffer overflows in the RTUs. Uploading of SOE data shall however be given lower communications priority than supervisory control and data scanning. If supported by the RTUs, SOE data shall be retrieved in segments as needed to avoid delays in supervisory control and data scanning activities. In RTUs that support this capability, the master station shall instruct RTUs to clear SOE data after it is successfully received and stored. SOE buffer overflows reported by RTUs shall be alarmed.

The master station shall store SOE messages in chronological order. The SOE messages shall identify the RTU, the data point, and include the time stamp received from the RTU. The SOE buffer shall be able to hold as defined in Section 3 Capacity and Performance. Users shall be able to select and sort SOE messages for viewing and printout by various search keys, such as a specific RTU, a particular period of time across all RTUs, or a particular type of event.

The system shall periodically synchronize the clocks of RTUs with SOE with a resolution of 1 (one) millisecond, except for RTUs which are equipped with a time standard; the time signal shall include compensation for signal propagation delays. The System shall check the round-trip time for communications with each RTU and assume that the outgoing delay equals one half of that time.

Administrators shall be able to clear all the SOE data for any specific RTU or the system-wide SOE data in the Master Station’s buffer. If a fixed length SOE buffer is used in the Master Station, an alarm shall be generated when the buffer is 80 (eighty) percent full. When the buffer overflows, new entries shall overwrite the oldest ones.

The system shall ignore and purge any SOE data coming from the RTUs that is not addressed in the SCADA/EMS database.
The system shall issue an alarm when a date or time is determined to be suspicious for an SOE event (e.g., the system receives a date or timestamp in the future).

The SOE data shall also be stored in the Information Storage and Retrieval system to let users outside the secure network access the SOE information.

5.1.8 Error Detection and Recovery

Data retrieved from RTUs shall be immediately checked for certain basic error conditions including incorrect response, data buffer overwrite error, invalid message security codes, etc. All detected errors shall be recorded for maintenance purposes. Attempts shall be made to recover from the error conditions by repeating the particular data scan for a predetermined number of times as defined by a configurable database parameter. If no more errors are detected in at least one of the retries, then the earlier error shall be considered as a recoverable error. Otherwise, it shall be considered as a non-recoverable error. Statistics (number of detected errors per predefined time period) shall be kept on recoverable errors by RTU and communications line. An RTU Communications Report shall be provided.

The detection of a non-recoverable error shall be considered to be an RTU failure, shall be alarmed, and shall result in the suspension of scanning for the particular RTU. All data associated with an RTU for which scanning has been suspended shall be marked with a data quality of “Failed.” The channel shall then be periodically tested to see if communications can be restored, and the RTU shall return to scanning after a configurable number of consecutive good scans. Appropriate alarm messages shall be generated when the channel initially fails and when it is returned to service. Unsuccessful retries on a failed channel shall not be alarmed.

An authorized user shall be able to manually attempt to restart the scanning of an RTU for which scanning had been suspended.

The detection of a high number of recoverable errors in a unit time (e.g., 30% per hour, configurable) shall result in the generation of an alarm, but the scanning of the RTU shall not be suspended. An alarm shall be generated only for the first occurrence of a high percentage of recoverable alarms, but no more alarms shall be generated as long as the error percentage remains above the limit.
Scanned data shall not be lost because of insufficient buffer size or insufficient time to service a data request. An alarm shall be generated when the buffer becomes 80 (eighty) percent full. If the data conversion and checking functions have not been completed for a certain data or data group before the new data values for the same data or data group are received in the next scan, appropriate event messages shall be generated. When the system detects an error, the system shall display the reasons for the error to the administrators or operators. Security-related errors shall notify the appropriate security personnel.

The SCADA/EMS shall determine and track the RTU failure minutes for any RTU that is failed and display that information. The RTU failure minutes shall also be stored in the historical database.

The SCADA/EMS shall include a stale data monitor function that determines if a value has become stale (i.e., show as valid telemetry but the value is not changing). A summary display of stale values shall be provided and the stale value quality code shall be set for any value determined as stale.

5.1.9 **RTU Test Mode**

The Administrator shall be able to put an RTU or individual points in the RTU in a test mode that will provide the capability to monitor transmit and receive messages on a communication channel, RTU, and individual point basis. When placed in test mode, the data in the RTDB shall be retained and the attributes set to “non-update”.

The capability to select any scan requests as well as to initiate a single, periodic, or continuous scan request shall be provided. The RTU test mode shall include displays to view the scan information transmitted and received in both raw format as well as scaled/converted values including their point names, IDs, and unit names shall be provided.

5.2 **Data Organization**

5.2.1 **Real Time Database (RTDB)**

All data acquired from the power system, all real time calculated values, and all manually entered data for non-telemetered points, as well as parameters to be output to field devices, and
parameters that control the operation of real-time application programs shall be stored in a comprehensive system real-time database (RTDB). The RTDB shall be the central interface between all elements of the SCADA/EMS including the data acquisition software and the user interface software for real time information.

The database may be distributed and/or duplicated for convenience and performance reasons between processors and storage devices, but the database shall be managed such that all data remains consistent in all locations. Data residency shall be transparent to the accessing functions. Each database item shall be defined in the SCADA/EMS only once; any propagation to other locations shall be performed automatically and transparently to the users.

As the common real-time data interface, the RTDB shall include all information necessary for proper operation of all application programs, including telemetered data, data which is calculated by applications or entered by operators, as well as data for logs and summaries, and all program constants. The system database shall be sized upon delivery to accommodate the Delivered Capacity sizing requirements specified in Section 3.1 System Sizing Requirements; i.e., no programming or system regeneration shall be required in order to add master station devices, RTUs, data points, etc., up to the specified Ultimate counts.

To facilitate development of future functions by the Purchaser, the structure and contents of the database elements shall be thoroughly documented, and well-documented non-proprietary database access routines shall be included in the System.

The real-time database shall have the following features:

1. Access through a single, well-defined real-time application program interface.
2. Values stored in engineering units.
3. Support for data quality flags and tags.
4. On-line database browsing and value modification of all database entries by authorized SCADA/EMS users. These SCADA/EMS users shall be given the capability of sorting, filtering, and searching the data by various criteria for display, including by substation, point ID, point name, etc.
5. On-line database modification capability (e.g., modify communication parameters, data conversion curves, etc.)
6. Automatic propagation of updates and changes, whether made manually or by program, to all copies of the source database. This process shall be able to handle the situation where added or deleted data might have shifted the data locations of the new data compared to the old data.

7. Automatic propagation of updates and changes to calculated values by triggering recalculations.

The physical reconfiguration of the data acquisition and control subsystem shall be transparent to interactive and programmatic database access (e.g., changing the position of a scanned quantity on an RTU or moving it to another RTU shall not affect retrieval of that quantity).

### 5.2.2 Data Quality

Data quality codes shall be maintained for all telemetered and calculated values, reflecting their reliability. The data quality codes that the SCADA/EMS and Historical System shall maintain are listed below. The letters in parentheses are the associated data quality indicators that shall be shown with the values in displays and reports.

1. Up-to-date (blank) – Data has been successfully received during the latest poll.
2. Uninitialized (U) – The point’s value has never been entered, neither by telemetry or calculation, or manually.
3. Unreasonable (R) – The point’s value is outside the reasonability limits for analog points.
4. Failed (F) – The System failed to receive valid data from the RTU for the point in the most recent poll.
5. Deactivated (D) – A user deactivated scan processing for a point, RTU, or communications channel. The last successfully retrieved value is shown. The deactivated points shall be shown on a Deactivated Points Summary display.
6. Manually Entered (M) – The point was deactivated, and the shown value was manually entered. The manually entered points shall be shown on a Manually Entered Points Summary display.
7. Limit Override (V) – The point’s limit has been overridden and shown on the Limit Override Summary.
8. State Estimated (E) – The point’s value is being estimated by the State Estimator. The State Estimated substituted points shall be shown on a State Estimator Substitution Summary display.

9. Calculated (C) – The point’s value is being calculated.

10. Questionable (Q) – The calculated point’s value is questionable such as a manually entered input point, etc.

11. Alarm (A) – The point’s value is in alarm.

12. Stale (S) – The point’s value has been detected to be stale (not updated over a pre-defined time).

The data quality codes are listed above in order of ascending precedence (i.e., “Up-to-date” has the lowest precedence). When more than one data quality applies to a value, the indicator for the highest precedence code shall be shown with the value at least in single-line displays and tabular displays when it is displayed or printed. A separate multi-quality code indicator shall appear when more than one quality code is on the point and the capability to hover over the symbol that results in all the quality codes on the point being shown. The highest priority quality code shall also be shown along with the multi-quality code indicator.

For calculated points, the data quality of the result shall be set to the highest precedence code associated with the elements of the calculation, i.e., to the quality code of the least reliable value used in the calculation.

No data quality indicator, except State Estimated, shall be shown for non-telemetered points.

5.2.2.1 **AE SPECIFIC REQUIREMENTS (ICCP QUALITY CODES)**

Some of the quality codes defined above shall distinguish the quality of the data received from ICCP from the quality received via local telemetry. For example, the system shall allow the operator to distinguish whether a value was manually entered by their ICCP partner or by AE. The following quality codes apply because they are passed by ICCP in some way. ICCP includes something called Data Validity, where ICCP provides four validity states: Valid, Held, Suspect, and Not Valid. Held shall map to Stale, though a value may also be held because it has been Manually Entered – but priorities of the quality codes shall be considered. ICCP also has Current Source as follows: Telemetered, Calculated, Manually Entered, and State Estimator. Finally,
ICCP passes something called Normal Value as follows: Normal or Abnormal. Timestamp quality is also passed – Valid or Invalid, which shall be mapped to the Questionable quality code (typically called Suspect, e.g. by ERCOT).

The following tables were extracted from the ERCOT ICCP document:

<table>
<thead>
<tr>
<th>Normal Provider</th>
<th>ICCP Normal Source Attribute</th>
<th>ICCP Current Source Attribute (Current Provider is Market Participant)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TELEMETERED</td>
<td>CALCULATED</td>
</tr>
<tr>
<td>MP</td>
<td>TELEMETERED (Field Telemetered)</td>
<td>REMOTE GOOD</td>
</tr>
<tr>
<td>MP</td>
<td>CALCULATED</td>
<td>n/a</td>
</tr>
<tr>
<td>MP</td>
<td>ESTIMATED (State Estimator)</td>
<td>n/a</td>
</tr>
<tr>
<td>MP</td>
<td>MANUAL (Operator Entered – Non-Field Telemetered)</td>
<td>REMOTE GOOD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Normal Provider</th>
<th>ICCP Normal Source Attribute</th>
<th>ICCP Current Source Attribute (Current Provider is ERCOT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CALCULATED</td>
<td>ESTIMATED</td>
</tr>
<tr>
<td>MP</td>
<td>TELEMETERED (Field Telemetered)</td>
<td>CALC_REPLACED</td>
</tr>
<tr>
<td>MP</td>
<td>CALCULATED</td>
<td>CALC_REPLACED</td>
</tr>
<tr>
<td>MP</td>
<td>ESTIMATED (State Estimator)</td>
<td>CALC_REPLACED</td>
</tr>
<tr>
<td>MP</td>
<td>MANUAL (Operator Entered – Non-Field Telemetered)</td>
<td>CALC_REPLACED</td>
</tr>
<tr>
<td>ERCOT</td>
<td>TELEMETERED (Field Telemetered)</td>
<td>CALC_REPLACED</td>
</tr>
<tr>
<td>ERCOT</td>
<td>CALCULATED</td>
<td>GOOD</td>
</tr>
<tr>
<td>ERCOT</td>
<td>ESTIMATED (State Estimator)</td>
<td>n/a</td>
</tr>
<tr>
<td>ERCOT</td>
<td>MANUAL (Operator Entered – Non-Field Telemetered)</td>
<td>CALC_REPLACED</td>
</tr>
<tr>
<td>Current Source</td>
<td>ICCP Validity</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>----------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NOT VALID</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HELD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SUSPECT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VALID</td>
<td></td>
</tr>
<tr>
<td>TELEMETERED</td>
<td>BAD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OLD (Stale)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OLD (Stale)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GOOD</td>
<td></td>
</tr>
<tr>
<td>CALCULATED</td>
<td>BAD</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OLD (Stale)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>OLD (Stale)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GOOD</td>
<td></td>
</tr>
<tr>
<td>ESTIMATED</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GOOD</td>
<td></td>
</tr>
<tr>
<td>MANUAL</td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(no SCADA translation)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n/a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GOOD</td>
<td></td>
</tr>
</tbody>
</table>

For situations where an EMS user issues controls (e.g., LTCs) that are passed through the AE ADMS, the ICCP shall support and return the success/failure of the control (quality code) back to the EMS. This requirement shall also support when the ADMS user issues control that are passed through the EMS.

### 5.2.2.2 Telemetry Quality Report (AE Specific Report)

The SCADA/EMS shall produce a report that shows telemetered points that are having issues due to communication problems (e.g., point showing in and out many times). In addition, the total time the point was in telemetry error shall be included in the report.

### 5.2.3 Areas of Responsibility

To facilitate flexible assignment of operational responsibilities to operators, the capability to associate the field devices with Areas of Responsibility (AOR) shall be provided. The capability to assign any point in the RTDB including control points to one or multiple AORs shall be provided. The AOR assignments will be used: (a) to allocate control privileges and operational responsibility for devices to specific users, (b) to determine which alarms to annunciate to the user, (c) to construct logs and summary displays for specific Areas of Responsibility, and (d) to control viewing of the points. Roles assigned in Role-based Access Control shall take AOR privileges and responsibilities into account. The capability to create AORs and AOR groups shall be provided.

### 5.3 Data Processing

Data acquired from RTUs as well as data received over data links to the other utilities’ EMS and other ICCP data shall be processed and placed in the RTDB as soon as it is received. All the data
shall be similarly processed and stored, in such a way that the source of the data, RTU or external system, is transparent to the users and the applications of the SCADA/EMS.

The capability to allow the Administrator to enable/disable alarming on any point (telemetered, non-telemetered, or calculated) shall be provided.

5.3.1 Redundant Data Processing

Any database points in the EMS database may be obtained from up to 5 (five) sources. Upon startup, the point shall use the primary source. If the primary source is deemed to be failed (Section 5.1.8, Error Detection and Recovery), the EMS shall automatically select an alternative source for the point. The function of choosing the best available source is called “redundant data processing.”

The possible sources used for redundant data processing are called “arguments”, and the chosen source is called the “resultant best value.” The arguments may include telemetered values, calculated values, and values generated by EMS functions. For each resultant best value, its value and all of the arguments shall be stored in the EMS. Redundant data processing shall be transparent to any system functions, such as displays, reports, and any applications. The functions shall use the resultant best value as if the value comes from the primary source.

When defining the calculation for a resultant best value, the Administrator will rank the arguments in a priority order. The resultant best value shall be determined by selecting the “best available” from among the arguments. The highest-ranking argument with a valid value (see Section 5.2.2 Data Quality) shall be stored as the result. If none of the arguments have a valid value, no alternative source shall be selected. The System shall allow the Administrator to define the ranking of arguments for each database point for redundant data processing.

Operators shall be able to override automatic selection and manually select any argument. Restoration of automatic redundant data processing shall require manual action by an Operator. Automatic and manual changes of the selected argument shall be reported as an event.

An Alternative RTU Summary list shall be available providing details of points whose primary source has been substituted. Each entry in this list must contain the date and time of occurrence, the point name, the identity of the current source, automatic or manual, the name of the Operator
who made this selection (if manual), as well as a short comment for the reason. The Operator’s action including the comment shall be processed as an event.

5.3.2 **Analog Data Processing**

5.3.2.1 **DATA CONVERSION**

Raw analog data shall be converted to engineering units by assuming a linear transducer characteristic throughout the range of the analog input. A conversion formula of \( Y = aX + b \) shall be used, where ‘a’ and ‘b’ are the coefficients defining the scaling of the analog point. If the value of an analog point differs from zero by less than a user-specified deadband, then the value shall be forced to zero.

5.3.2.2 **ALARM LIMIT CHECKING**

Every analog value shall be checked against 4 (four) sets of pre-defined high and low limits. However, lines and transformers shall be checked against the limits defined below in the dynamic limit function (Section 5.3.2.3). All the limits shall be individually specified for each individual analog point in the database. These limits shall be:

1. **High and Low Operational Limits**
   Readings beyond these limits indicate a deviation from normal operational guidelines.

2. **High and Low Emergency Limits**
   Readings beyond these limits indicate that the equipment is operating outside its design tolerance.

3. **High and Low Warning Limits**
   Readings that exceed a configurable parameter (initially 95%) of the operational limits.

4. **High and Low Reasonability Limits**
   Readings beyond these limits indicate failures of transducers or the A/D conversion equipment.

Detection of a limit crossing, in either direction, shall result in appropriate alarm reporting. Each of the limits shall be treated separately (e.g., when a point returns within an Emergency Limit it may still be out of an Operational Limit). An alarm deadband shall be applied to each of the limits to derive the return-to-normal level, so that repeated alarming does not occur for points
whose magnitude hovers around the limit. Individual alarm deadbands shall be specifiable in the
database for each individual point.

When analog data exceeds its reasonability limit, the last reasonable value shall be retained in the
database and shall be assigned the “Unreasonable” data quality. The alarm message shall
however state the actual value of the analog data. The new data shall not be updated in the
database or subject to further processing until it returns within the reasonability limits.

Authorized users shall be able to enter a new value to override the value of any limit except for
the reasonability limit. Overridden limits shall be marked with a “limit override” quality code
and shall be used in place of the initial limit value. The EMS shall log each limit change as an
event. The event shall include the initial limit value and the new limit value. When the
authorized user removes the override, the limit shall revert to its initial value and the “limit
override” quality code shall be removed. Limits (both initial and overridden limits) shall be
constrained to be within the reasonability limits of each analog point.

When overridden limits are replaced by an alternate limit set, the “limit override” shall be
removed automatically.

**AE Specific Requirements**

Transmission Line and Transformer MW values shall be checked against the dynamic limits
determined by the Dynamic Limit function (See 5.3.2.3).

**5.3.2.3  DYNAMIC LIMITS – TRANSMISSION LINES AND TRANSFORMERS (AE
SPECIFIC)**

The SCADA/EMS shall include dynamic limits. The dynamic limits shall be based on
temperature. The dynamic limits shall include twenty sets of ratings based on temperature: Temp
1 to Temp 20. Each set shall contain 5 limits: Normal, Emergency, Short Term Emergency 1,
Short Term Emergency 2, and Load Shed. In addition, readings that exceed a configurable
parameter (initially 95%) of the normal limits shall generate an alarm that the warning limit has
been exceeded. Alarms shall be generated when the value exceeds the limits. The capability to
define and store all the ratings shall be provided.
The Administrator shall be able to enable/disable dynamic limit processing on an individual piece of equipment basis (i.e., enable dynamic limit processing for selected lines and transformers).

Detection of a limit crossing, in either direction, shall result in appropriate alarm reporting. Each of the limits shall be treated separately (e.g., when a point returns within an Emergency Limit it may still be out of a Normal Limit). An alarm deadband shall be applied to each of the limits to derive the return-to-normal level, so that repeated alarming does not occur for points whose magnitude hovers around the limit. Individual alarm deadbands shall be specifiable in the database for each individual point.

Sources of temperature values are: manual entry, telemetered value, and forecasted temperature. To determine the current temperature to be used in dynamic limit calculation, the telemetered temperature shall be used if it is available and of good quality. The dynamic limit calculation shall use the default temperature if there is no manual temperature available and if the telemetered temperature is failed or unavailable. For the default temperature, the operator shall select which of the 20 temperature sets to use. The current temperature shall be used to determine which set of ratings shall be selected as the active limit set.

Once the active limit set is selected based on the current temperature, the SCADA/EMS shall use the limits applicable for that temperature.

The dynamic limits shall be used by the SCADA alarming function as well as the real-time and study power network applications.

The capability to calculate the load shed limits as a percentage of the normal limits shall be provided.

### 5.3.3 Status Data Processing

Status data shall be processed for every scan period when such data is received, to determine if changes have taken place. Changes of state shall be processed and alarms (uncommanded changes) issued based on the point definition or events (changes resulting from supervisory control). All status changes shall result in immediate update of displays and the Overview.
Display (see Section 3.2.6 Display Call-up Response Time). No change-of-status information shall be lost.

For each status point, the capability to define in the database the relationship between the RTU contact-input position and the state of the device. For instance, an open contact may represent "Tripped", or "Closed", "Open", "Alarm", "On", "Off", etc. shall be provided. The capability to define a particular "normal" position for each status point in the database shall be provided and a “no normal” state shall also be allowed. The system shall support defining processing types such as door open/door closed that shall be used in alarming as well as tabular and single line diagrams.

The Administrator shall be able to override the default normal state with a new definition of normal state, and to remove the override (return to the default normal state). Overriding the normal state designation shall establish a “normal state override” quality code on the point. The Administrator removal of the normal state override shall remove the “normal state override” quality code. Points that have the normal state override quality code shall be shown on a Normal State Override summary display.

5.3.3.1 REPORTING OF MULTIPLE STATUS CHANGES

To the extent that the RTU identifies multiple breaker operations that occur between scans, the SCADA/EMS shall identify and alarm the operations. The capability shall be provided to detect, identify, and alarm at least the following breaker operations which may occur between two consecutive status scans:

1. From close to trip
2. From close to trip to close
3. From close to trip to close to trip
4. From trip to close
5. From trip to close to trip
6. From trip to close to trip to close
5.3.3.2 **MOTOR-OPERATED SWITCH STATUS PROCESSING**

Motor-operated switches are monitored by contacts to indicate fully opened and fully closed positions. The software shall correctly interpret and show each switch position as being fully opened, fully closed, in-transit, or invalid (an error condition).

5.3.4 **Processing of Non-Telemetered Data**

Non-telemetered data points represent data which is not derived from RTUs and which is either manually entered or calculated based on telemetered or other non-telemetered points. The Contractor shall determine the number of non-telemetered points required to support all the specified functions, including the points that represent the results of specified calculations and points that correspond to dynamic data on the graphical displays, and shall size the database accordingly.

Whether a point is telemetered or non-telemetered shall be transparent to the accessing programs. Non-telemetered data points shall be definable in the database similarly to real-time data points. Additional requirements are given in the following sub-clauses.

5.3.4.1 **MANUAL DATA POINTS**

Manual (non-telemetered) status, analog, and energy (accumulator) data points shall represent power system data that is not monitored by RTUs and is not calculated. The values of these data points will be updated only by manual entry or by an application program such as State Estimator. Manual data shall be stored and accessed in the same manner as telemetered data, except that it shall not be associated with data quality flags. Analog values shall be limit checked when entered and displayed in the color that corresponds to their limit range, however the limit checking shall not result in the alarming of limit violations.

5.3.4.2 **CALCULATED DATA POINTS**

A calculated point is a data point whose value is a function of the value of one or more other data points (component points). All calculations shall be performed periodically; and the frequency of calculations shall be assignable in the database on an individual calculation basis. In addition, each calculated point shall have an Administrator configurable option to trigger its calculation
whenever any of its arguments have changed. Periodic and trigger calculations shall co-exist simultaneously.

The value of a calculated point shall be calculated by using a predefined algebraic equation dedicated to that particular point. The capability to use telemetered data, manually entered data, constants and other calculated data points as the component points in the calculation of a point shall be provided. Calculations shall not be limited to a maximum number of component points. The component points shall be definable as part of a calculated point's definition. (It shall not be necessary to define multiple calculated points as interim steps in processing the component points.) Newly calculated values shall immediately be limit checked, and subject to the same processing as telemetered points.

The Administrator shall have the capability to enable and disable the calculation of any calculated data point. The “calculation suspended” quality code shall be set for any point for which the calculation was disabled. For each suspended point, an entry shall be entered in the Suspended Calculation Summary (Section 6.11.7, Summary Displays).

The capability to use any value of any type from the database for arguments of the calculation, including other calculated points and values produced by EMS functions shall be provided.

The calculation function shall detect arithmetic exceptions such as division by zero and over-range results. Such conditions shall be marked with “failed data” quality code on the resultant calculated points. An event that states the cause of the failure shall be generated.

The Administrator shall be able to drag and drop points from displays or from the database into the calculation definition.

The EMS shall provide a facility to eliminate the need to enter common equations repetitively. The capability for the Administrator to define and save multiple equations as a function to a library shall be provided. To define a calculation, the Administrator shall be able to recall the saved function and enter the required arguments.

At a minimum, the following operations shall be available for calculations:

1. The 4 (four) arithmetic operators (+ - * /)
2. Exponent, log (base 10), natural log
3. Square root
4. Trigonometric operators (sin, cos, tan, cot, arc sin, arc cos, arc tan, arc cot)
5. Maximum, minimum, mean, and mode for a set of data
6. Absolute value
7. Running average over a defined period
8. Boolean operations (AND, OR, NOT, XOR) on status points.
9. Integrated value
10. Data conversion (HEX, Binary, Decimal, text to value)

The following capabilities are also required:

1. Resetting of counters and maximum or minimum values
2. Construction of statements with conditions such as IF, THEN, ELSE, Boolean operators
   (AND, OR, NOT, XOR, etc.), and comparison tests (>, ≥, =, ≠, ≤, <)
3. Automatic initiation of an application based on the results of a calculation.
4. The ability to use programming type constructs such as Do, For, and While.
5. The ability to read input files.
6. The ability to access (read/write) any data point and parameter (including data quality) in the database.
7. The ability to read and process XML files.
8. The ability to create menus and graphical user interface elements such as buttons, check boxes, control menus, etc.
9. The ability to issue SCADA controls, OTS controls, alarms, and events.
10. The ability to create output files.
11. The ability to utilize time as part of the calculation.
12. The ability to process arrays.

Calculations shall not cause system crashes (e.g., division by zero, √−1, etc.).

MVA shall be calculated using any of the formula specified below. The formula to be used shall be selected for each MVA calculation.
\[ MVA = \sqrt{MW^2 + M\, \text{var}^2} \quad \text{– sign always positive} \]

\[ MVA = \sqrt{MW^2 + M\, \text{var}^2} \quad \text{– sign the same as the sign of the MW} \]

\[ MVA = \frac{kV \times A \times \sqrt{3}}{1000} \quad \text{– sign always positive} \]

\[ MVA = \frac{kV \times A \times \sqrt{3}}{1000} \quad \text{– sign the same as the sign of the MW.} \]

The integration calculation will typically be used to produce MWh and MVArh values from MW and MVAr inputs respectively.

The SCADA/EMS shall include calculations applications that allow the users to define real-time calculations as those defined above as well as complex calculations and scripts that require more robust ways of defining the calculations.

**AE Specific Requirements**

AE has calculations that need to be migrated to the new SCADA/EMS. The calculations packages shall be used to migrate the needed calculations to the new system. During the calculations knowledge transfer workshop (see Section 17.4 Knowledge Transfer Workshops), AE and the Contractor shall review the calculations and determine the most appropriate approach to migrating the needed calculations.

The SCADA/EMS shall include phase imbalance calculations and monitor the imbalance to generate an alarm whenever the imbalance exceeds a tolerance.

**5.3.5 Pulse Accumulator Processing**

Pulse accumulator readings shall be retrieved at fixed periods of time, synchronized with the hour. The Purchaser shall be able to select one of the following periods for accumulator reading and processing: 5 (five) minutes, 15 (fifteen) minutes, 30 (thirty) minutes, and 1 (one) hour. Upon delivery, the pulse accumulator reading period shall be set to 1 (one) hour.

The system shall support both frozen and running accumulator types.
A freeze command (or equivalent time synchronization command) shall be sent exactly at the beginning of an accumulator reading period, simultaneously to all RTUs with accumulator points, to command them to save the current value of all their accumulators for subsequent retrieval. New RTUs may be equipped for local freezing based on GPS derived time, and will ignore the freeze command. The EMS shall retrieve the accumulator values from each RTU. In this respect, a selectable number of retries shall be made when accumulator values are not initially received successfully. If an accumulator read is missed, the system shall generate an alarm at a user defined priority or configured to generate an event only. Data quality processing requirements also apply to pulse accumulators.

The EMS shall calculate the difference between successive accumulator readings, automatically accounting for roll-over of the RTU register and for “long” reads (where one or more periodic reads was missed). It shall then convert the increment to engineering units.

The system shall display the last hour register reading, current hour register reading and the delta between the two. In addition, the display shall also show an intra-hour delta if you are reading the accumulator more than once an hour.

The accumulator reading shall be set to zero and flagged “Failed” for the first accumulator period after an RTU has experienced a power failure or was restarted. When communications problems prevent the acquisition of one or more period accumulations, or the RTU has not been polled by the system, the reading upon the restoration of accumulator processing shall include the sum of the missing readings. A “Long Period” quality code shall be associated with this reading.

Redundant information may be available for some metering points where, in addition to the MWh energy accumulator readings, the real-time MW reading is also measured. In such cases, the MW readings shall be integrated over the reading period and the result shall be compared with the corresponding MWh measurement. An alarm shall be generated if the absolute value of the difference between the accumulator reading and the calculated energy exceeds an operator-entered value.

The capability to define an accumulator scaling factor and a rollover value for each accumulator shall be provided.
AE Specific Requirement

Currently, AE does not have any accumulators being processed by the existing SCADA/EMS.

**5.3.6 Processing of ICCP Data Received from Other Systems**

Any data received from other systems through ICCP links (e.g., neighboring utility data) shall be processed using the same data processing methods as those used telemetered points, authenticated, and checked for reasonability as soon as it is received. The data quality flags assigned by the other system for all data exchanged shall be maintained in the RTDB database and historical database. The Contractor shall work with the Purchaser to define the mapping of the quality codes received from the other system to the quality codes in the Contractor’s system.

For each data point, the capability to specify in the database whether each specific change of its state shall be alarmed, not alarmed, or conditionally alarmed shall be provided. The capability to change the alarming conditions for each individual status point belonging to the EMS shall be provided.

**5.4 Supervisory Control**

Operators shall be able to control power system devices via messages transmitted from the SCADA/EMS to the RTUs. In addition, the SCADA/EMS shall be capable of automatically transmitting supervisory control messages when directed by application programs or as the result of calculations.

The backup arrangement between the 2 (two) control centers in Section 2.4 Redundant System Design Requirements, shall be taken into consideration by supervisory control.

Functional requirements for the various types of supervisory control are given below. The required operating procedures are specified in Section 6.7.3 Supervisory Control.

**5.4.1 Validation of Control Commands**

A supervisory control request shall be sent to an RTU only after the controlled point was checked for proper conditions. The request shall be rejected by the system if:

1. The device is not subject to supervisory control of the type being attempted.
2. The requested control operation is inhibited by a tag placed on the device.
3. An Uninitialized, Failed, Deactivated, Manually Entered, or Stale Data data quality indicator is shown for the device.
4. The user’s workstation is not assigned to the Area of Responsibility (AOR) of the device.
5. The user’s AOR does not permit this action.
6. The Operating Mode of the workstation attempting control does not permit supervisory control.
7. A control request for the same device from another workstation is still pending (i.e., the request is not yet executed or the commanded control is not yet completed).
8. A control request for a device is in a direction that is not allowed (i.e., single sided control where the device is defined to only be controlled in one direction).
9. Permissive control – the state of a separate point is checked to ensure the conditions allowing the control are valid prior to issuing the control. The Administrator shall define those points that are subject to permissive control.

Rejection of a control request shall occur before any transmission is made to the RTU for control purposes. A control rejection message shall be displayed to the operator. The point name and the reason for the refusal of the request shall be identified in the message displayed to the operator.

The system shall include the capability to define pre-operational checks (e.g., if a ground switch is closed, then the system prevents the breaker from closing in). In addition, the system shall support executing a power flow and contingency analysis to determine if closing or opening a device will create an adverse power system condition.

5.4.2 **Control of Two-State and Three-State Devices**

Select-before-operate (SBO) control shall be provided for two-state and three-state devices such as circuit breakers, switches, and motor operated switches.

If supported by the RTU, the capability to control the duration of closure of the controlled contact shall be provided. Control duration shall be adjustable, for individual points, in the range of at least 100 milliseconds to 60 (sixty) seconds.

**AE Specific Requirement**
The SCADA/EMS shall include the capability to issue controls to points that do not provide feedback. These controls are used to reset selected devices in the substation.

**5.4.3 Incremental Device Control (Jog Control)**

Incremental, open-loop, select-before-operate device control capabilities shall be provided to transmit RAISE or LOWER commands to devices. The capability to select the point once and then send any number of RAISE or LOWER commands without reselection shall be provided. The device selection shall automatically be canceled if neither an execution command nor a new operation selection was issued by the operator within a system-wide pre-specified control timeout period. A select-before-operate (SBO) control process shall be employed for the execution of each individual RAISE or LOWER command.

The duration of the contact closure for incremental control shall be selectable in the same way as for two and three state control points.

**5.4.4 Setpoint Control**

The SCADA/EMS shall support the supervisory control of devices, such as generators, voltage regulators and var compensators, where the supervisory control command specifies the desired operating point as a setpoint. The user command sequence shall allow the user to enter the desired operating point, typically in engineering units.

Control actions that would result in movement of the device beyond its defined operating range shall be rejected. The operating range shall be defined by the Purchaser individually for each device and shall be stored with the definition of the device. A message indicating that the requested control action exceeds the operating range shall be issued.

As part of the setpoint definition, the Administrator shall be able to define a periodic refresh (i.e., resend of the predefined setpoint value) automatically on a timed or triggered basis. A means to individually define a deadband value and a delay between successive controls shall also be provided for each setpoint.

An analog feedback for each setpoint shall also be able to be defined. An alarm will be issued if the feedback point does not match the setpoint output within a certain period of time after the
control has been sent and periodically thereafter. The timeout for the alarm shall be configurable per setpoint.

5.4.5 Control Completion Check

Control completion checks are required when devices whose state is monitored are controlled. After the successful conclusion of the exchange of control messages with an RTU, the master station shall begin to check for control completion by monitoring the state or position of the controlled device. If the expected reaction of the controlled device is not detected within the assigned completion period, a “control-failed-to-complete” alarm shall be generated, and if the command originated from an application then the application shall also be notified. Failure of controls to complete shall be declared:

1. For commands to switch the state of a device, if the expected state is not detected within the control completion time.
2. For incremental device control (Raise/Lower control), if the value of a related analog value does not change by a database-defined value within the control completion time.

The capability to define in the RTDB an individual control completion period for each controllable device, in seconds from 2 (two) seconds up to several minutes.

5.4.6 Network Status Processor

The Network Status Processor (NSP) shall determine the energization of power system equipment. The energized/de-energized state and in-service/out-of-service status of each generator, bus section, transmission line, transformer, load and capacitor defined in the Real-Time Network Model (Section 7 Network Analysis) shall be determined. These components shall be defined as circuit elements.

5.4.6.1 Determination of Energization Status

A circuit element (transmission line, bus section, or sub-transmission line segment) shall be considered energized if one of the following conditions exists:

1. There is a non-zero measurement of voltage associated with the element.
2. A breaker or switch at either end of the element is closed and the adjacent section is energized.

A power system device shall be considered energized if it is connected to an energized circuit element.

Energization state shall be an attribute of the associated circuit element and shall carry a data quality code as described in Section 6.7.7 Advanced Visualization Features.

If the System identifies a contradiction in calculating circuit energization (for example, a circuit element is isolated but is associated with a non-zero voltage measurement), it shall issue an alarm identifying the contradictory database points and shall be displayed distinctly from energized and de-energized elements.

The NSP algorithm shall be derived directly from the network model without additional Purchaser’s input. Any changes to the model shall be automatically reflected in the calculation of energization.

### 5.4.6.2 DETERMINATION IN-SERVICE STATUS

NSP shall also determine the In-Service Status (namely, “in-service” or “out-of-service”) of each NSP circuit element.

A circuit element shall be considered “in-service” if it is conducting power. Any circuit element that is energized and connected to a load shall be considered “in-service”. It is to be noted that an energized circuit element may still be “out-of-service”, as would be the case, for example, if one end were connected by a closed switch to another energized segment, but the switch at the other end were open.

The in-service status shall be an attribute of the associated the circuit element. The capability to display circuit elements (typically line segments) in different colors or shapes (e.g., dashed line) depending on the combination of the in-service status and the state of energization shall be provided. The system shall support coloring circuit elements in distinct colors corresponding to at least the following four combinations:

1. Energized and in-service
2. Energized and out-of-service
3. De-energized and out-of-service
4. Energization state unknown (invalid data quality).

### 5.5 Communications with Other Systems

The SCADA/EMS shall be designed for data exchanges with external and internal systems as specified below, and shall ensure that appropriate security measures are in place and that the correct security procedures are followed. The Contractor shall be responsible for the integration of these systems with the SCADA/EMS. The Purchaser will cooperate with the Contractor in this effort.

The SCADA/EMS shall exchange real-time data with other utilities’ and ISO’s Energy Management Systems. The communication for these data exchanges shall be IEC 60870-6 TASE.2 (informally known as the Inter-Control Center Communications Protocol – ICCP), and shall be in compliance with the ICCP security requirements in IEC 62351-3 and IEC 62351-4 for those external systems that also support ICCP security. The Contractor shall have submitted the ICCP TASE.2 Services Supported Table with the Contractor’s proposal.

The capability to pre-process the data (e.g., interpret status values, scale analog values) shall be provided.

#### 5.5.1 AE Specific Requirement (Option) - Secure ICCP

As an option, the Contractor shall provide Secure ICCP that can be enabled/disabled by an Administrator on a per link basis.

#### 5.5.2 ICCP Interface Management

The ICCP data exchange database shall be automatically generated by the database generation program. The bilateral tables shall be created and updated without difficulty and the links between the ICCP database and all other SCADA/EMS databases shall occur without manual intervention.

An interactive ICCP editing capability shall be permitted to add, expand, modify, and delete ICCP databases by the database administrator including the ability as follows:
1. To add, modify, and delete Bilateral Tables
2. To link the ICCP data points both transmitted data and received data to the database.
3. To create, modify, and delete the Data Sets for sending and receiving, including the ability to set how ICCP data quality flags are mapped into the SCADA/EMS data quality flags
4. To establish, enable, and disable Transfer Sets for transmitting Data Sets between the Purchaser and all external and internal systems.
5. To set parameters for Transfer Sets and other ICCP structures as needed to operate and manage ICCP communications, including periodicity of transfers, event triggers, integrity scan, sending and receiving control signals, etc.
6. To trap and screen ICCP traffic over the network for debugging and maintenance. In addition, the SISCO or Contractor equivalent log shall be saved and available for retrieval by the Administrator.
7. The capability to manage point permissions per site.
8. The capability to query/poll another system to determine which data points are available. The system shall show the points and the data type that are available and not in the current system as well as creating a text file that has all of the available points. The query shall return the ICCP object ID and the data type.
9. The capability to read data from an input file and write data to an output file shall be provided. The ability to consume the file and leave the file with an option to consume the file and delete it shall be provided. Once the file is consumed, the data shall be available for ICCP use.
10. The capability to define links as bi-directional or single directional shall be provided.

All user entries using the Database Management System (DBMS) editing system shall be checked for reasonability and validity before being accepted. It shall never be necessary to enter the same data value more than once, either for the redundant systems or for any other reason. Editing or expansion of the ICCP information shall not adversely impact or invalidate existing data structures or previously entered values.

The ability to enable/disable generation of detailed logging for model/database validation, bilateral agreement information, individual ICCP links, ICCP services, and ICCP datasets. The format of detailed logs shall be subject to Purchaser approval.
5.5.3 **ICCP Interface with the Network**

The SCADA/EMS shall include all necessary tools to manage the configuration and operation of the ICCP interfaces over the Purchaser’s communication network and Security Network.

The ICCP interface to the external systems will be composed of redundant communication channels. The status and performance statistics of each ICCP channel and the ICCP communications equipment shall be monitored and displayed, including:

1. Active/Standby
2. Enabled/Disabled
3. Functional/Failed
4. Number of errors/Rate of errors
5. A percentage of the data available per ICCP association.

As permitted by their access control roles, authorized Purchaser staff shall be allowed to enable, disable, and switch communication ports, and to set retry times and other communication parameters. All modifications to the configuration, and all link errors and failures shall be logged. ICCP link failures or loss of communications shall cause an alarm. For each link, an appropriately configured firewall as specified in Section 4.1.1 Management of Electronic Security Perimeters shall be provided.

The system shall provide displays that show the configured ICCP link and data set statuses. The displays shall be color coded to indicate which links and data sets are active, inactive, disabled or in error.

All data within the ICCP databases (including link statuses and percentage availability) shall be available to the EMS.

5.5.4 **Data Set Management**

The frequency of data exchange with other systems through ICCP links shall be configurable on each data point to be exchanged by assigning it to a data set. The exchange frequency of each data set shall be adjustable in increments of 1 (one) second in the range of at least 2 (two) to 300
(three hundred) seconds and in increments of 1 (one) minute in the range of 1 (one) minute to 60 (sixty) minutes.

The ability to enable/disable individual data sets shall be provided. The system shall support transferring partial or incomplete data sets.

The exchange frequency of the data sets shall be initially assigned to 30 (thirty) seconds.

5.5.5 Data Link to Other Utilities’ and ISO EMS

The SCADA/EMS shall support a real-time data exchange with the other SCADA/EMSs and other Purchaser systems (e.g., AE ADMS). For these data exchanges, both Non-Secure and Secure ICCP shall be supported. In this respect, the IEC 62351-3 and IEC 62351-4 security standards for IEC 60870-6 and Secure Sockets Layer/Transport Layer Security (SSL, TLS) authentication shall apply. The existing ICCP servers communicate with these EMSs by using non-secure ICCP. In the future, the other utilities will upgrade the ICCP links to be secure ICCP. All Conformance Blocks shall be supported.

The SCADA/EMS shall process all data received from the other EMSs. It shall also transmit data to the other systems.

The types of data to be exchanged with the other EMSs include the real-time analog measurements, status values, accumulator data, calculated data, and quality codes.

The system shall support true 32-bit values.

5.6 Sequential Control

The EMS shall include a sequential control function that allows users to create, edit, and schedule pre-defined sequences of control commands. These control commands shall be executed in a specified sequence. The sequences shall be able to be triggered to run automatically based upon monitored information, specific conditions, or on demand. Additional commands such as “Pause” a sequence, “Wait” until a command is completed, “Jump” a step, and “Manual Entry” (operator input needed) shall be provided. The capability to stop, continue, cancel and exit a sequence shall be provided. All supervisory control commands shall be eligible
to be used in the sequential control application. An alarm shall be issued if the sequence fails to complete successfully or if the sequence fails validation checks.

The Sequential Control function shall include user displays for defining sequences, executing the sequences, and monitoring the steps and results. The user displays for defining sequences shall include the capability to select points and drag and drop into the sequence. The sequences shall be able to include analog and status points, Boolean logic, limit values, conditional checks, arithmetic calculations, time delays, counters, supervisory control commands, operator notifications, and calls to other programs and sequences.

The Administrators shall be able to define the sequences.

5.7 **Autotrip Function (AE Specific Requirement)**

AE has a function that trips selected breakers under certain emergency conditions. The capability to define the emergency conditions and associated actions when the condition occurs shall be provided. An authorized user shall be able to define these conditions and actions interactively on-line. An easy to use interface shall be provided.

5.8 **Voltage Reduction**

The SCADA/EMS shall include a Voltage Reduction (VR) application. The VR application shall lower transformer taps to reach an operator entered MW reduction in the Purchaser’s system load.

The Operator shall be able to enable/disable transformers to be used during a Voltage Reduction. The application shall determine the change in tap position to achieve the desired MW reduction and issue tap controls. The VR application shall monitor the system load before and after the voltage reduction to determine the total MW change that occurred. The VR application shall not include transformers that are not under control or are not available for control in determining the control actions for VR.

Displays shall be provided to allow the operator to manage the inputs to the VR application as well as output displays showing the results.
5.9 Load Shedding and Restoration (LSR)

The ADMS shall include a load shed and restore application with the following capabilities:

1. Underfrequency Relay Monitoring/Restoration

5.9.1 Underfrequency Relay Monitoring/restoration

3. Overview of Purchaser’s Automatic UF Load Shed

3.1. Feeders selected by Purchaser for automatic UF load shedding are pre-determined based on Purchaser’s guideline for critical loads (Feeders with critical loads CL2 & CL3). Based on this guideline, UF relays out in the field are programmed to trip automatically at different steps or stages.

3.2. Purchaser manually maintains and tracks changes on loads (size, criticality, load switching) which affect the overall load composition of the feeders and, therefore, affecting the eligibility of these feeders to be use for manual or UF load shedding.

3.3. UF relays are installed throughout the entire Purchaser network on feeder breakers. UF relay settings (on/off, step/stage) are configured via SCADA or by field crews if telemetry is not available. Approximately 326 out of 418 total feeder breakers in-service are equipped with UF relays. Approximately, 128 out of 326 breakers with UF relays, have their UF capabilities active (on) to meet ERCOT’s requirements. Approximately 262 out of 316 breakers with UF relays, the UF capabilities can be turned on/off remotely via SCADA.

3.4. UF settings are set per ERCOT’s requirements and based on the frequency of ERCOT-Texas’ system wide power grid. The UF relays are set to provide load relief in three steps/stages/blocks:

3.4.1. UF Block1 (UF1) – 5% of Purchaser’s system load will be shed if Texas’ system wide frequency drops below 59.3 Hz.

3.4.2. UF Block2 (UF2) – 10% of Purchaser’s system load will be shed if Texas’ system wide frequency drops below 58.9 Hz.
3.4.3. UF Block3 (UF3) – 10% of Purchaser’s system load will be shed if Texas’ system wide frequency drops below 58.5 Hz.

3.4.4. For a total of at least 25% of Purchaser’s total system load active (on) for UF load shed at all times.

3.5. UF load shed happens automatically without operators’ involvement. Typically, the first indication to operators of an event is through SCADA alarms from opened feeder breakers. Purchaser currently relies on Excel spreadsheets to help us determine what feeders tripped and fail to tripped, and the amount of load shed.

3.6. Purchaser operators cannot restore the UF load shed until authorized by ERCOT. If restoration is authorized within a short period of time, operators will restore loads by closing feeder breakers one-by-one via SCADA. If the operators determine that the UF outage will extend for a longer period of time, they will make every reasonable attempt to replace the open UF-equipped distribution feeder breakers with similarly loaded non-critical load circuits by initiating the existing SCADA Manual Load Shed application. At this time, operators will initiate and use the Manual Load Shed application to maintain and rotate the shed amount until receiving notification from ERCOT to restore.

3.7. With exception of the automatic UF tripping of feeder breakers, all steps described above are currently performed and maintained manually.

4. UFR Monitoring

4.1. The underfrequency relay monitoring function shall be used to verify that the underfrequency relays trip at the correct pre-set frequency values in the relay. The application shall identify when an UF event occurs and its step/stage and notify the operators.

4.2. The underfrequency relay monitoring function shall monitor the load available to shed related to the circuits covered by the underfrequency relay and record those values when the underfrequency relay trips the circuits. The underfrequency relay monitoring function shall check if all the circuit breakers associated with the underfrequency relay trip when the relay trips and highlight circuit breakers that should have tripped but did not trip on the underfrequency relay monitoring displays.
In addition, the function shall generate alarms for load devices that should have tripped but remain closed. The function shall also track the total load shed by each underfrequency relay, by substation, and total load shed by the underfrequency relay.

4.3. The results of the UFR function shall be recorded and saved.

4.4. Displays shall be provided that show a list of loads shed per device, step/stage, substation, group, area, etc. including MW load shed, time of shedding and running timer counting outage duration for each category. The capability to sort, filter, search, and export the data shall be provided.

4.5. The capability to monitor 15 step/stages of UF relays shall be provided.

4.6. After an UF event, a summary display and report showing loads shed per device, step/stage, substation, group, area, etc. including MW load shed, time of shedding, time of restoration, duration of outage for each category shall be provided. Summary (per step/stage, substation, group, area) and detail (per device) reports shall be provided. The capability to sort, filter, search, and export the data shall be provided.

4.7. At any given time, a summary display and/or report showing load devices active and subject to UF load shedding per devices, step/stage, substation, group, area, etc. to include available MW loads for each category and Purchaser’s total system load for a specified date and time as entered by operators shall be provided. This display and report shall be used for spot verifications and audits of Purchaser’s UF obligations and historical reporting. The capability to sort, filter, search, and export the data shall be provided. (See UF & Manual Load Shed Master List Sample Spreadsheet).
Exhibit 5-2: UF and Manual Load Shed Master List Sample Spreadsheet

4.8. At any given time, a summary and detail report showing all feeders and its characteristics based on Purchaser’s pre-defined criteria such as critical customers (CL1, CL2, CL3), priorities, ATO, MT, key accounts, residential, spare, UF, Manual, dispatch area, etc. shall be provided. This report shall be used by Purchaser as reference when reporting, identifying, selecting, and implementing procedures for UF and Manual load shedding. (See Purchaser’s ALL Feeders Master List Sample Spreadsheet).
5. **UF Relay Available Load Monitor**

5.1. The UF Relay Available Load Monitor function shall periodically compute the total amount of load that is under the control of each UF relay. The operator shall be able to put in a required amount of load that is needed to be under UF relay control as a percentage of the total Purchaser system load.
5.2. The operator shall be able to enter an “X%” of that must be “wired” to trip at “Y” frequency to compute an UF relay required amount for each UF relay. The UF relay available load calculation shall compare the current load associated with each UF relay and compare it to the UF relay required amount and highlight (and alarm?) when the actual UF relay load is less than the required amount.

5.3. The UF relay available load shall also compare the total amount of load under UR relay control to the total required amount and highlight (and alarm?) when the amount is less than the required.

5.4. Displays shall be provided to enter the required input data and to view/monitor the calculations.

6. UF Load Restoration

6.1. The UF Restore function shall be used to allow and facilitate the operator to restore the loads that have been shed via UF relays. When initiated by an operator, the function shall execute a total or partial load restoration (per device, MW load, step/stage, substation, area, or group). The operator shall be allowed to input the amount of MWs to restore for a partial load restoration.

6.2. The operator shall have the capability to inhibit (exclude) any device from UF load restoration. Exclusions can consider critical loads or any other criteria to automatically exclude feeders as defined by customer. UF load restoration shall include only loads previously shed by UF relays, and that are not closed, inhibited (excluded) from restoration, tagged (for no control), manually entered or in bad telemetry.

5.9.2 Manual Load Shedding/Restoration

1. Overview of Purchaser’s Manual Load Shedding

1.1. In addition to using the SCADA Manual Load Shed application to replace loads shed via automatic UF relays, Purchaser will primarily execute Manual Load shedding when and as directed by ERCOT (Electric Reliability Council of Texas) during energy emergency alerts.
1.2. The feeders selected by Purchaser for Manual Load Shedding are pre-determined based on Purchaser’s guideline for critical loads (Feeders with no critical loads). The selection of feeders and order of list is currently a manual process. Purchaser manually maintains and tracks changes on loads (size, criticality, load switching) which affect the overall load composition of the feeders and, therefore, affecting the eligibility of these feeders to be use for manual or UF load shedding. Currently, 90 feeders are in the manual load shed list (approx. 22% of Purchaser’s load). Using the existing SCADA Manual Load Shed application, operators initiate and maintain the shedding, restoration and/or rotation of the loads.

2. MLS Application

2.1. The solution will provide an optimal list of shed candidates based on user specified/configurable criteria.

2.2. The ADMS shall include a Manual Load Shed (MLS) application that includes manual load shed blocks consisting of circuits and their associated switching devices (e.g. reclosers). The capability for the operator to manually configure load shed blocks shall be provided. The capability to perform individual load shedding or group load shedding shall be provided. The capability to enable/disable individual switching devices within the load block, set a priority order, and include delay timers shall be provided. Load shedding shall respect supervisory control checks (e.g., if the switching device is control inhibit, no control shall be issued, etc.).

2.3. The operator shall be able to identify, create and sort the list of candidate feeders to be used for manual load shed based on Purchaser’s pre-defined criteria such as, but not limited to: Feeder’s characteristic (critical customers, priorities, etc.), SCADA points status (tagged, open/closed, quality, inhibited, manually entered), etc. The displays shall allow the user to configure the load shed blocks, enable/disable switching devices participation and show any device conditions/tags, show timers, status, and show the individual loads MW, block MWs, and system MWs available for shed. The before and after shed MWs shall be recorded as well as the time of the shed action.
2.4. The MLS application shall be initiated by the operator. The operator shall have the option to specify the Target Load Shed amount (in MWs), the type of load shedding desired (Fixed and Rotational modes must be supported), and the maximum amount of time each load group is to be shed if rotation is required (rotational load shed time interval).

2.5. The application shall manage and maintain Target Load Shed and rotation of devices as selected and defined by operator. The operator shall be able to enter the Target Load Shed and change it at any time during a load shed event. The Target Load Shed is the minimum amount of MW load the user wants to shed and maintain at any given time.

2.6. The Actual Load Shed shall be computed as the sum of the MW load of feeders currently opened through the manual load shed program. The application shall be responsible for maintaining the Actual Load Shed amount always be equal or higher than the Target Load Shed amount during a load shed event, including during rotation of the devices but trying to maintain as close to the target MW as possible.

2.7. The Target and Actual Load Shed values shall be presented and visible to the user at all times without having to perform any additional actions to retrieve this information.

2.8. The operator shall have the option to shed and restore loads without having to rotate (Fixed Load Shedding and Restoration). The operator shall have the option to shed and restore loads while rotating (Rotational Load Shedding). The operator shall also be able to change, at any time during a rotation event, how often each load group will rotate (change rotational load shed time interval). The option to rotate load by maintaining a MW amount must also be supported.

2.9. After the initial shedding and at any given time during a load shed event, the operator shall have the capability to perform any of the following actions to change or maintain the Actual Load Shed amount:

2.9.1. Increase or decrease the Actual Load Shed amount by shedding or restoring additional loads in increments without having to rotate feeders

2.9.2. Increase or decrease the Actual Load Shed amount by shedding or restoring additional loads in increments while also rotating feeders
2.9.3. Rotate feeders with no changes to the Actual Load Shed amount.

2.10. When rotating feeders in conjunction with an increase or decrease of the Actual Load Shed amount, the program must shed or restore first to meet new Target and then proceed to rotate feeders. When rotating, additional “reasonable” load needs to be shed first before restoring previously opened breakers ("reasonable" is defined as Purchaser does not want to be shed double the amount required at any given time). This shall be done to make sure that the Actual Load Shed amount remains above the Target Load Shed at all time even during the rotations of feeders.

2.11. The shedding and rotation of feeders shall be performed by equally rotating non-critical loads throughout Purchaser’s entire territory (system wide), as much possible. Loads shed at any given time need to be equally spread, as much as possible, throughout Purchaser’s territory (not concentrated by substation or area) since this is done for public perception and fairness. Purchaser’s feeders can be tracked by Dispatch Areas (ex. North Central (NC), NW, NE, SC, SW, SE). This information can be found in Purchaser’s GIS. (See Dispatch Area Sample).

Exhibit 5-4: Dispatch Area Sample
2.12. The MLS application shall allow the option for the operator shed load by area, by substation or system wide (as selected by the operator) even though Purchaser currently only sheds on a system wide basis.

2.13. For Purchaser, rotation of feeders means opening new breakers to meet/maintain Target Load Shed and restoring all previously opened breakers (regardless of any increase in load due to cold load pickup).

2.14. The capability to perform to manual load shed by interrupting any device (ex. feeder breakers, telemetered load breaking switches) and not limit it to just feeder breakers shall be provided.

2.15. At any time, e.g. during and after a load shed event, the following summary and detailed reports shall be available (screen shots for illustrative purposes only) - showing list of all breakers used during the load shed event and details per breaker such as:
2.15.1. Time opened and time closed for every interruption
2.15.2. MW interrupted during every interruption
2.15.3. Total time opened and closed for the entire event
2.15.4. Total MW interrupted for the entire event
2.15.5. Dispatch area (ex. NC-north central), customer count, criterion function, etc.
2.15.6. Indication that differentiates a breaker opened by the load shed program vs. a field event

Exhibit 5-5: FeedersOutage Analysis Tool
Exhibit 5-6: Feeders Outage Summary Report

<table>
<thead>
<tr>
<th>Feeder</th>
<th>Total Outage Duration (H:M:S)</th>
<th>Average Shed MW</th>
<th>Ns. Outage</th>
</tr>
</thead>
<tbody>
<tr>
<td>FE-6</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-7</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-8</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-9</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-10</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-11</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-12</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-13</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-14</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-15</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-16</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-17</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-18</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-19</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-20</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-21</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-22</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-23</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-24</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-25</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-26</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-27</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-28</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-29</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-30</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-31</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-32</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-33</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-34</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-35</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-36</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-37</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-38</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-39</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-40</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-41</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-42</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-43</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-44</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-45</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-46</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-47</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-48</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-49</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-50</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-51</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-52</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-53</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-54</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-55</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-56</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-57</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-58</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-59</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-60</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-61</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-62</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-63</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-64</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-65</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-66</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-67</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-68</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-69</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-70</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-71</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-72</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-73</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-74</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-75</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-76</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-77</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-78</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-79</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-80</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-81</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-82</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-83</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-84</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-85</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-86</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-87</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-88</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-89</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-90</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-91</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-92</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-93</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-94</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-95</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-96</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-97</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-98</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-99</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>FE-100</td>
<td>0:00:00</td>
<td>0.00</td>
<td>0</td>
</tr>
</tbody>
</table>

Legend:
- **FE-##**: Feeder number
- **Total Outage Duration**: Duration of outage in hours:minutes:seconds
- **Average Shed MW**: Average reduction in megawatts during the outage
- **Ns. Outage**: Number of units affected by the outage
2.16. A user can run a report at any time by selecting date/time range (and be able to re-run and recreate the same report at a later time regardless of future changes on the list of feeders or topology).

2.17. All load shed reports shall be customizable by Purchaser. User shall be able to export, print and/or email report(s) at any given time.
6 User Interface Requirements........................................................................................................ 136

6.1 User Interface Guidelines .......................................................................................................... 136

6.1.1 Guidelines on User-System Interactions................................................................................ 136

6.1.2 Guidelines on Information Presentation ................................................................. 136

6.1.3 Look-and-Feel......................................................................................................................... 138

6.2 User Workstation Requirements ............................................................................................. 139

6.2.1 User Workstations.................................................................................................................. 139

6.2.2 Workstation Configurations ................................................................................................. 139

6.3 Display System Requirements ................................................................................................. 140

6.3.1 General Requirements ........................................................................................................... 140

6.3.2 World Map ............................................................................................................................ 140

6.3.2.1 World Map Sectors ........................................................................................................ 140

6.3.2.2 Zooming and Panning .................................................................................................. 140

6.3.2.3 Declutter Levels ........................................................................................................... 141

6.3.2.4 Font .................................................................................................................................. 142

6.3.3 Overlays and Data Sets ........................................................................................................... 142

6.3.4 Bit-Map “Picture” Displays .................................................................................................. 142

6.3.5 Queries-Based Displays ...................................................................................................... 143

6.3.5.1 Tabular and List Displays ............................................................................................. 143

6.3.5.2 Summary Displays ......................................................................................................... 144

6.3.6 Help Function ......................................................................................................................... 146

6.3.7 List Searching Capabilities .................................................................................................. 147

6.4 Screen and Windows Features .................................................................................................. 148

6.4.1 Windows .................................................................................................................................. 148

6.4.2 Date and System Time .......................................................................................................... 149
6.4.3 Pushbuttons (Soft Keys) ............................................................... 149
6.4.4 Keyboard Functions ................................................................. 149
6.4.5 Toolbars .................................................................................. 150
6.4.6 Dialog Boxes .......................................................................... 151
6.4.7 Information boxes ................................................................. 151

6.5 Data Representation ...................................................................... 151

6.5.1 Data Attribute Representation.................................................. 151

6.5.1.1 Numerical Data Display ....................................................... 152
6.5.1.2 Display of Point States ......................................................... 153
6.5.1.3 Display of State Names ....................................................... 153
6.5.1.4 Substitution of Estimated Values for Telemetered Data ......... 153
6.5.1.5 Displays Names ................................................................. 154

6.5.2 Graphical Data Representation ............................................... 155

6.5.2.1 Bar Charts and Dials ......................................................... 155
6.5.2.2 Pie Charts .......................................................................... 155
6.5.2.3 X-Y Plots ........................................................................... 156
6.5.2.4 Kiviat Charts ................................................................. 156

6.6 Trend Displays ............................................................................ 156

6.6.1 Trending Capabilities .............................................................. 156
6.6.2 Precise Reading of Curve Values ........................................... 158
6.6.3 Selection of Trending Data and Parameters ......................... 159

6.6.3.1 Pre-Selected Trending Points ........................................... 159
6.6.3.2 Presentation of Trending Curves ........................................ 159

6.7 Operator Functions ..................................................................... 160

6.7.1 Display Call-Up ...................................................................... 161
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.7.1.1</td>
<td>Call-Up Methods</td>
</tr>
<tr>
<td>6.7.1.2</td>
<td>Placement of Displays on Screens</td>
</tr>
<tr>
<td>6.7.1.3</td>
<td>Display Call-Up from Web Browsers</td>
</tr>
<tr>
<td>6.7.1.4</td>
<td>Display Viewing Restrictions</td>
</tr>
<tr>
<td>6.7.2</td>
<td>Control of Video Wall Overview Display</td>
</tr>
<tr>
<td>6.7.3</td>
<td>Supervisory Control</td>
</tr>
<tr>
<td>6.7.3.1</td>
<td>Device State Control</td>
</tr>
<tr>
<td>6.7.3.2</td>
<td>Incremental (Raise/Lower) Control</td>
</tr>
<tr>
<td>6.7.4</td>
<td>Deactivate/Activate RTUs</td>
</tr>
<tr>
<td>6.7.5</td>
<td>Deactivate/Activate Data Points</td>
</tr>
<tr>
<td>6.7.6</td>
<td>Manual Data Entry</td>
</tr>
<tr>
<td>6.7.6.1</td>
<td>RTDB Data Entry</td>
</tr>
<tr>
<td>6.7.6.2</td>
<td>Other Data Entry</td>
</tr>
<tr>
<td>6.7.7</td>
<td>Advanced Visualization Features</td>
</tr>
<tr>
<td>6.7.8</td>
<td>Export of Operational Data (Snapshots)</td>
</tr>
<tr>
<td>6.7.9</td>
<td>Video Recording (Option)</td>
</tr>
<tr>
<td>6.7.10</td>
<td>Printing of Information and Displays</td>
</tr>
<tr>
<td>6.7.11</td>
<td>Block Selection and Rubber Banding</td>
</tr>
<tr>
<td>6.7.12</td>
<td>SCADA/EMS Access Security</td>
</tr>
<tr>
<td>6.7.12.1</td>
<td>User Log-On</td>
</tr>
<tr>
<td>6.7.12.2</td>
<td>Remote Operating Access</td>
</tr>
<tr>
<td>6.7.13</td>
<td>Data Access Spreadsheet</td>
</tr>
<tr>
<td>6.8</td>
<td>Operator Modes and Areas of Responsibility</td>
</tr>
<tr>
<td>6.8.1</td>
<td>Modes of Operation</td>
</tr>
<tr>
<td>6.8.1.1</td>
<td>Operator Mode</td>
</tr>
</tbody>
</table>
6.8.1.2 Supervisor Mode ............................................................................................. 175
6.8.1.3 Maintenance Mode ...................................................................................... 175
6.8.1.4 Programmer Mode ........................................................................................ 175
6.8.1.5 OTS Trainee Mode ...................................................................................... 175
6.8.1.6 OTS Trainer Mode ...................................................................................... 176
6.8.1.7 Viewing Mode .............................................................................................. 176
6.8.1.8 Testing Mode ............................................................................................... 176
6.8.1.9 Analysis Mode .............................................................................................. 176
6.8.2 Modes Assigned for User Workstations ......................................................... 176
6.8.3 Areas of Responsibility (AORs) ....................................................................... 177
6.9 Tagging ................................................................................................................ 178
6.9.1 Tag Attributes ................................................................................................. 178
6.9.1.1 Control Inhibit ............................................................................................ 179
6.9.1.2 Alarm Inhibit .............................................................................................. 180
6.9.1.3 Event Inhibit ............................................................................................... 180
6.9.1.4 Limit Override ............................................................................................ 180
6.9.1.5 Normal State Override ............................................................................... 180
6.9.1.6 Scan Inhibit ............................................................................................... 180
6.9.2 Purchaser Tags ................................................................................................ 180
6.9.2.1 AE Specific Requirements (Inheritance tagging) ...................................... 181
6.9.2.2 AE Specific Requirements (ICCP to SCADA tagging) ............................... 181
6.9.3 Tag Groups ..................................................................................................... 181
6.9.4 Tag Summary .................................................................................................. 182
6.9.5 Tag Removal .................................................................................................... 182
6.10 Event and Alarm Management ........................................................................ 183
6.10.1 Events.................................................................................................................. 183
  6.10.1.1 AE Specific Requirement (email capability) .............................................. 183

6.10.2 Alarms................................................................................................................. 183
  6.10.2.1 Definition of Alarms................................................................................... 183
  6.10.2.2 “Return to Normal Alarm” Flag ................................................................. 184

6.10.3 Alarm and Event Processing............................................................................... 185
  6.10.3.1 Alarm Management Responsibilities...................................................... 185
  6.10.3.2 Alarm and Event Reporting ................................................................. 185
  6.10.3.3 Alarm Priorities...................................................................................... 185
  6.10.3.4 Conditional Alarms.................................................................................. 186
  6.10.3.5 Alarm Tone .............................................................................................. 186
  6.10.3.6 Alarm Inhibition........................................................................................ 187
  6.10.3.7 Acknowledgment and Deletion of Alarms ................................................. 187
  6.10.3.8 Alarm Locate ............................................................................................ 188

6.10.4 Alarm Summaries ............................................................................................... 188
  6.10.4.1 Summary Structure ................................................................................ 188
  6.10.4.2 Customization of the Summary ............................................................... 189
  6.10.4.3 Acknowledgement and Deletion of Alarms............................................... 189

6.10.5 Alarm and Event (A&E) Messages Format........................................................ 190

6.10.6 Alarm and Event (A&E) Records ....................................................................... 191
  6.10.6.1 Alarm and Event (A&E) File ................................................................. 191
  6.10.6.2 Selection of Alarms and Events for Viewing, Exporting, and Printing ...... 191

6.10.7 Enhanced Alarm Management............................................................................ 192

6.11 Display Types ............................................................................................................. 192
  6.11.1 Directories Displays...................................................................................... 193
6.11.2 Power System World Map Display .......................................................... 193
6.11.3 Substation Displays .................................................................................. 193
6.11.4 Point Profile Displays ............................................................................ 194
6.11.5 SOE Displays ......................................................................................... 194
6.11.6 Field Communications Statistics Display ............................................. 194
6.11.7 Summary Displays ................................................................................ 195
6.11.8 Bulletin Board Displays .......................................................................... 196
6.11.9 Memos .................................................................................................. 196
6.11.10 Station Comments Displays ............................................................... 197
6.11.11 Operator Log ....................................................................................... 197
6.11.12 System Displays .................................................................................. 197
  6.11.12.1 User Assignments Displays ............................................................... 197
  6.11.12.2 System Configuration Control Displays .......................................... 197
  6.11.12.3 Workstation Assignment Displays ................................................ 197
  6.11.12.4 Field Equipment Displays ............................................................... 197
  6.11.12.5 Communication Link Control Displays .......................................... 198
  6.11.12.6 System Maintenance Displays ........................................................ 198
6.11.13 Network Analysis Displays .................................................................. 198
6 USER INTERFACE REQUIREMENTS

The functional capabilities that shall be provided to the users of the SCADA/EMS are specified in this section. All of the specified user interface functionality shall be available to any user, except when certain functions for which access is deliberately restricted according to the user’s log-on privileges or console privileges.

6.1 User Interface Guidelines

6.1.1 Guidelines on User-System Interactions

The user procedures for interacting with the SCADA/EMS shall be simple, fast, and unambiguous, and shall be “fail-safe” to guard against inadvertent user errors.

The following design guidelines shall be followed in user-system interactions:

1. Single-step procedures (i.e., initiation of functions by clicking a pushbutton or a display symbol which is always shown in the appropriate application window) are required, whenever feasible, for frequently used functions and for critical functions.
2. Common and frequently employed actions shall be initiated from toolbars. One or more toolbars, specific to the particular application or function that is currently active, shall be shown in each window.
3. The use of pop-up dialog menus which overlay portions of one or more windows shall be kept to a minimum.
4. Multi-level menus shall be used only for the presentation of hierarchies of options and shall have the minimal number of levels needed.

6.1.2 Guidelines on Information Presentation

The following design guidelines shall be followed for information presentation:

1. Power system information shall be organized and presented to the user in a manner that allows the user to be immediately aware of any condition requiring urgent attention, to quickly grasp the most significant aspects of a situation, and to have fast access to related data for the investigation of details of the information presented.
2. Application programs shall not merely present the results of their calculations, but shall present in highlighted form, the significant results. For example, in addition to calculating the voltage at each bus and the real and reactive power of each line, the power flow program shall summarize significant results such as the following:
   2.1. Minimum voltage is xx% of nominal at (location)
   2.2. Maximum power flow is xx% of nominal at (location)
   2.3. Minimum power factor is xx at (location).

3. Displays built by the Contractor shall be constructed with systematic use of borders or frames to visually group information that logically belongs together. For example, displays for non-real time studies shall be shown in a color different than the real time studies.

4. Headers shall be placed on displays and reports using larger fonts and/or bold characters.

5. Color shall be used sparingly for the following purposes: to distinguish different dynamic states, for clarification purposes, and to highlight important information. Color shall not be used for decorative purposes.

6. On-line help shall be readily available on displays and shall be designed to present useful information and explanations to the inexperienced user. The SCADA/EMS shall conform, as much as possible to the Microsoft Windows standards for the on-line help function (e.g., pressing the F1 function key shall open the Help directory window).

7. Messages to operators shall be in plain English language and alphabet. Cryptic messages shall be avoided.

8. When requesting an input from the user, the SCADA/EMS shall, to the maximum extent possible, ensure that the user has on view all information needed to decide on the requested input.

9. Where possible, the system shall offer menu-selectable default entries for the most common or most likely data entries.

10. The SCADA/EMS shall not require the user to make repeated entries of the same data, but shall provide a means for quickly copying data from one set of entry fields to another through copy/paste and drag/drop techniques.

11. When a data entry must be one of a defined set of possibilities (e.g., a file name or substation name), the possible entries shall be presented to the user in a scrollable list, and selection of
the desired option shall be by clicking the desired entry. If a search engine is used, search shall be possible by keying in the first 2 or 3 characters.

12. A display shall be able to display any combinations of telemetered and calculated data types (e.g., analog values, status, IS&R data, etc.) and any combinations of display types (e.g., values, graphical symbols, trends, etc.).

The detailed design of the user interfaces, including navigation trees and menu bars, the format and contents of dialog menus, the colors of display features such as menu bars, window borders, display background, and the operational procedures, shall be selectable in the database definition process. The initial design to be included in the system upon delivery shall be subjected to approval by the Purchaser. These items shall be reviewed during the UI Configuration workshops (See Section 17.4 Knowledge Transfer Workshops). The capability for the Administrators to re-configure the menus and dialog boxes shall be provided.

6.1.3 **Look-and-Feel**

The Contractor shall provide a full-graphic user interface for the SCADA/EMS workstations, whose functionality and behavior shall conform to the norms of Microsoft Windows applications. The use of emulation of X-windows is not acceptable. A design which takes full advantage of the features of the Windows graphical user interface capabilities is required. The appearance of the user interface and the methodology of user interaction with the SCADA/EMS and all the applications shall follow the “look-and-feel” of the latest revisions of Microsoft Windows and the Office applications.

A consistent approach is required for the formatting of SCADA/EMS displays, the graphic presentation of power system devices, the use of color and of display features for highlighting events and exceptions, and for every other aspect of the display appearance. As mentioned earlier, the guidelines for the appearance, shape, color, background color, blinking, etc. of power system devices in displays, and for the use of fonts, color, etc. in display titles and other text, shall be submitted for approval by the Purchaser.
AE Specific Requirement

The user shall be able to adjust the theme of the displays and toolbars. The user shall be able to revert back to the default theme. This shall be part of the user preferences.

6.2 User Workstation Requirements

6.2.1 User Workstations

User workstations will be installed in several locations: in the Purchaser’s Transmission and Distribution Control Center rooms, in other locations within Purchaser’s offices, and in remote locations (e.g., Maintenance workstations). Local workstations shall be connected to the SCADA/EMS LAN. High-speed LAN connections between the two control centers, the Purchaser’s offices, and remote locations will be provided by the Purchaser.

The System shall provide a Web based remote user capability to display results on remote PCs without the need for non-standard software installation in the particular PCs. If required, the Contractor may use a Contractor-supported browser plug-in module or other Purchaser approved technology that does not require a manual installation of software at each user’s PC. The Contractor shall be responsible for the support and maintenance of this software with the same terms and conditions as applicable to the SCADA/EMS software.

6.2.2 Workstation Configurations

The SCADA/EMS shall support various workstation configurations, including workstations with a single monitor, dual-monitor workstations, triple-monitor workstations and 4-monitor. Each workstation shall have a single keyboard and mouse, and shall constitute a single logical entity that accommodates and supports only one user at a time through a single log-on process. The screens of a workstation with multiple monitors shall function in all respects as if they were one contiguous screen, except that it is not required for a window to be able to span more than one monitor. It shall, however, be possible to drag a window from one monitor and drop it on another monitor. When the screen pointer is moved beyond the edge of a monitor, it shall appear at the opposite edge of the adjacent monitor, if one exists. The pointer shall be programmable to wrap around or stop at the right or left edge of the monitor. The term “clicking” a location pertains to placing the screen pointer on that location and depressing the left mouse-button.
6.3 Display System Requirements

6.3.1 General Requirements

The user will operate from several major types of displays of the power system, including but not limited to:

1. Schematic one-line diagrams of power transmission and distribution lines and substations
2. Tabular displays many of which also include imbedded graphical data representations
3. Queries-based displays
4. Applications based displays including those supporting any functionality contained within Section 7 Network Analysis.

All the displays shall be dynamic, i.e., the appearance of objects displayed in these displays shall reflect the values and attributes in the Real-Time Database (RTDB), and they will be the operator’s main tool for monitoring and controlling the power system.

6.3.2 World Map

The SCADA/EMS shall include a “world map” schematic display of the Purchaser’s entire power system.

6.3.2.1 WORLD MAP SECTORS

The user shall be able to display a rectangular portion of a world map, referred to as a sector, in a window of a monitor. Different windows shall be able to display different sectors of a world map on the same monitor, and sectors shall be able to overlap one another. The capability to view map sectors of any size up to the entire world map and to assign a name to a map sector and to call a named sector for display by referencing its name shall be provided. Operators shall be able to define and name sectors for their own use.

6.3.2.2 ZOOMING AND PANNING

Zooming shall affect the magnification level of the data displayed. Panning shall move the viewed portion of a world map space. The size of the viewed portion of the map relative to the whole map shall be indicated by the width of the sliders in the scroll bars of the window displaying the sector. The position of the viewed sector within the world map shall be indicated
by the sliders’ positions. When a named sector is first called up in a window, it shall be automatically scaled so that the whole sector is in view within the window with its aspect ratio unchanged. The width or height of the window shall be adjusted to match the sector’s aspect ratio.

Both continuous and discrete panning and zooming control shall be provided. Continuous panning and zooming shall be done in a convenient, intuitive way using the mouse, and the resulting changes in the screen contents shall be “smooth” and instantaneous without any delay. Discrete panning and zooming in the larger steps shall be possible by dragging the mouse, using the keyboard, and clicking on pushbuttons on toolbars.

When the active window is a window which shows only a sector of a world map, the user shall be able to request a “navigation” window for orientation. This window shall show a small replica of the complete map in that window, with the displayed sector of the world map highlighted. This highlighting shall be updated continuously during panning and zooming in the world map display. The user shall be able to move the navigation window anywhere on the screen and shall be able to close it.

6.3.2.3 DECLUTTER LEVELS

A de-cluttering mechanism shall be provided that defines the visibility of a graphic construct as a function of its magnification. As the magnification of data displayed in a window is changed by zooming, decluttering shall cause levels of detail to be shown or suppressed.

At least 16 (sixteen) mutually exclusive declutter levels shall be provided. The magnification range corresponding to each declutter level shall be defined at system configuration.

Each static and dynamic element within a world space shall have associated with it a visibility designation for each level (“visible” or “not visible”), thereby defining a range of magnification levels where the construct is visible. The magnification range of visibility of each element shall be selected by the display builder at display edit time.
6.3.2.4 **FONT**

Any fonts that are included in the Windows system shall be available for use in any kind of SCADA/EMS displays. In addition, scalable fonts, which shall change in size with zooming maintaining the aspect ratio, as well as fixed-size fonts, which do not change in size with zooming, are also required.

The fonts to be used in a particular display shall be selectable at the time of display definition.

**AE Specific Requirement**

The user shall be able to change the font interactively for all items on a display.

### 6.3.3 Overlays and Data Sets

There will often be several related sets of information about a system entity, all of which cannot be displayed and made readable simultaneously without rendering the display to clutter. For this reason, the capability to create displays that have multiple data overlays consisting of a root overlay that is normally visible and one or more auxiliary overlays that are visible only under explicit overlay control by the user shall be provided. Each overlay shall include its own static and any number of dynamic data points. For example, a one-line diagram may have all status points in the root overlay, but have each type of analog measurement (MW, MVar, Volts, etc.) or values generated by an application in a separate overlay.

Overlays shall be independent of the de-cluttering levels. The same one-line diagram shall be used by both the SCADA and EMS functions. The users shall be able to select from a dialog menu any mix of overlays to be displayed.

### 6.3.4 Bit-Map “Picture” Displays

Many schematic diagrams and other graphic information that must be available for viewing on SCADA/EMS workstations are not, at least not initially, in digitized formats. The capability to import bit-map (or “raster”) pictures and photographs in JPG and GIF format and include them in the structure of user-callable displays shall be provided:

1. Call bit-map pictures for display through any of the call-up procedures
2. Link bit-map pictures to the world map display. Such pictures shall be represented on the world map by symbols, and shall be called up when the corresponding symbols are selected by the users.

3. Use a bit-map picture as a world map overlay

4. Place an overlay of dynamic display objects on top of a bit-map picture and link the dynamic objects to the RTDB. It shall be possible to select these objects for all the operations for which the user is authorized.

6.3.5 **Queries-Based Displays**

Queries-based displays are displays for which only a format template is created by means of the display editor and the contents of each instance of the display as called up are automatically determined and generated by the SCADA/EMS based on the real-time values of the specific data to be shown. Such queries-based displays shall automatically adapt to database changes, and it shall not be necessary to edit the underlying queries, nor to edit a template except in order to change its appearance or its contents. The format of such displays shall automatically adjust to the amount of data that is applicable and available for each call-up instance, i.e., their size shall vary as needed to show all the requested and available data, and they shall not include any unused data fields.

6.3.5.1 **TABULAR AND LIST DISPLAYS**

Queries-based capabilities are required for station and similar tabular displays, and for displays that present lists of devices, points, etc. from the RTDB:

1. Tabular Displays – Queries-based tabular displays shall be used for substation tabular displays. However, a general capability that can also be used to display other classes of tabular data is required. Tabular display templates shall define the appearance of the display (e.g., columns and their headers, fonts and their sizes, colors, etc.), the data to be shown (e.g., status data, analog values, etc.), and the order in which the data shall be presented. The capability to rearrange columns and save the view shall be provided.

2. The capability to include bar graphs and pie-charts in the definition of queries-based tabular displays shall be provided. When a tabular display is called, the system shall automatically link the template to the appropriate portion of the database and shall configure the display as
appropriate for the quantity of data that has to be shown for each specific instance of the display.

3. List Displays – Queries-based displays shall be used to show lists of devices according to user selection criteria. The user shall be able to request one or more fields in the RTDB to be displayed (for example, to show a list of all the breakers that are not in their normal state, and to present them by substation in alphabetical order). When a list display does not fit into the window, the capability to scroll through it shall be provided. The capability to sort and filter the display list displays shall be provided.

4. The capability for authorized users to control power system devices from entries in a List Display shall be provided.

Detailed capabilities for each type of queries-based displays prepared by the Contractor, including selection criteria for the contents of lists, shall be determined in consultation with Purchaser.

Self-structured displays shall comply with the display response times. For flexibility, queries-based displays shall be dynamically configured when they are called to the screen. However, in instances where this may preclude meeting the display response time requirements, as may be the case for list displays that require large amounts of system-wide data, such displays shall be pre-generated and kept up to date, ready to be output to the screen whenever it is called.

6.3.5.2 SUMMARY DISPLAYS

“Summary” displays shall be used to present lists of information that are derived from SCADA/EMS-created files (e.g., alarm summaries that are derived from the Alarm and Event file), or are based on the RTDB queries (e.g., a summary of all points with alarming inhibited, off-normal, etc.). Such displays (and printouts) shall be queries-based, in order to adapt to the specific categories of data that have to be shown for each instance (e.g., major alarms for specified substations) and to the quantity of data that is included in the applicable categories. When a summary display does not fit into a window, the capability to scroll through it shall be provided.
Selection of Summary Data

As a class of displays, summary displays shall provide a general capability for users to select specific subsets of data for viewing; the same selection capabilities shall also be available for the selection of summary data for printing. The selection mechanism shall use SQL queries. However, in order to enable users without SQL skills to make selections, pre-defined SQL scripts shall be available and invoked through dialog menus. These dialogs shall enable operators, through pointing and with the minimum possible typing, to select the desired summary and to specify its scope according to at least the following selection parameters (as applicable to each summary):

1. Time range (before T1; after T2; between T1 and T2)
2. Substation(s)/feeder(s)
3. Area of Responsibility
4. Point status (open, closed, in a given limits range, etc.)
5. Point attributes (tagged, abnormal state, alarming inhibited, alarmed, etc.)
6. The point’s data quality (deactivated, manually replaced, etc.)

For example, the SCADA/EMS shall support requests to view, export, or print all the points at “Substation A” and “Substation B” which are in an abnormal state. Where appropriate, the capability to include “wild card” characters in the search strings shall be provided.

Additional specific data selection capabilities to be included by the Contractor in the initial SCADA/EMS shall be determined during the development of the SCADA/EMS.

A fast method shall be provided for requesting summary displays (alarms, abnormal, etc.) for one specific substation by pointing to that substation.

Sorting of Summary Data

The "keys" provided for selecting summary data shall also be available for requests to sort and filter summary data. The capability to specify one or more keys, and the data shall be sorted or filtered by the order in which the keys are specified shall be provided. For instance, the capability to request the display of points in the (alphabetical) order of the substations to which
they belong, and, within each substation, to show abnormal state points before normal state points shall be provided.

The specific sorting and filtering capabilities for each type of summary (such as the ordering keys to be provided and the default ordering for attributes when not explicitly specified by the user) shall be defined in consultation with the Purchaser.

The capability to save views of the sorted and filtered shall be provided, including the capability to export the data.

### 6.3.6 Help Function

The SCADA/EMS shall include a “Help” function of sufficient scope to instruct users on normal operation of the SCADA/EMS and each of its applications without having to resort to a printed user manual. The appearance and capabilities of the Help function shall be like those of the Help function of Microsoft Office applications, including the feature by which selection topics are suggested based on a partial or complete search string entered by the user.

Users shall be able to call from any display, with a single mouse click, a Help window that explains every pushbutton (and associated pull down or dialog menu) and data field of that display. Error messages associated with the operations from that display shall also be explained. The Help window shall remain on the screen until closed by the user, or until the display from which it was called is replaced.

Access to Help shall also be available to persons who view SCADA/EMS displays over the SCADA/EMS Web Server System. Help shall be customized as appropriate for users on Web browsers.

The SCADA/EMS shall include tools for administrators to edit and add more screens for Help text. Both html and pdf shall be supported for calling up help. The system shall allow the administrators to add poke points that call up documents in pdf format or enter URLs to access additional help information.
6.3.7 List Searching Capabilities

Basic mechanisms to search for specific data in long lists shall be included in the SCADA/EMS. These mechanisms shall be like those provided in Microsoft Office applications for the selection of Help topics. They shall be available, for example, for the selection of displays from display directories, for searching an entry in a long list of selectable options, or for locating an entry in long lists of data such as a list of all the devices represented in the power system model.

The following search mechanisms are required:

1. “Index” Search – This method shall present an index window with two fields, an “Item name” entry field and an “Item index” field. As the user types the name of the desired display in the Name field, the Index field shall show a portion of an alphabetized index of all the items in the list, with items whose names match the characters entered so far appearing at the top of the Index field. The user shall be able to select any item that appears in the Index field by clicking it, i.e., this method of selection shall be like that of the Index tab of the Help function of Microsoft Office applications.

2. “Contents” Search – This search method shall be provided for lists which are organized by categories, such as a list of power system devices organized by substation or a list of all the SCADA/EMS displays organized by display type. A “Contents” pushbutton shall bring up a window showing the categories (e.g., the substation or the display types) in alphabetical order. Clicking a category shall bring up an alphabetized list of all the items belonging to the category, and the user shall be able to access an item by clicking it. This method of selection shall be like that of the “Contents” tab of the Help functions of Microsoft Office applications.

3. “Phonetic” Search – This method shall facilitate calling up of displays when the user does not know the exact spelling of their name. The Soundex or similar coding method shall be employed for the selection of groups of displays with similar sounding names. When the user enters a display name, the SCADA/EMS shall present a list of displays whose names sound like the entered name or are like it. The user shall then be able to select the desired display by clicking it. The search for matching names shall ignore predefined key words, such as “substation”, “feeder”, and “display”.

Austin Energy SCADA Replacement 0500-Scope of Work
Proprietary © Austin Energy 2017 – All Rights Reserved
6.4 Screen and Windows Features

6.4.1 Windows

Windows shall be provided to allow the partitioning of the monitor so that several displays and information from several programs can be viewed simultaneously. As delivered, the user workstations shall support up to at least 8 (eight) windows on each monitor, in addition to the dedicated window for information such as date and time.

At any time, there shall be only one window at a workstation, including multi-monitor workstations, which are designated as the "active” window. The active window shall be identified by highlighting its title bar, and it shall be the focus and conduit of (the intended and designated window for) all user interactions such as display call-up, navigation through displays, program execution, and dialog interactions. An implicit rule on active window shall be as follows: the window on which the pointer rests at the time shall become the active window without clicking in the window.

In general, all windows shall have the same basic structure and include:

1. Window border.
2. Title bar.
3. Maximize, Minimize, Restore, and Close buttons.
4. Scroll bars, when the display spans beyond the window. The magnitude and position of the slider of the scroll bar shall represent the size of portion of the display that is currently being shown relative to the full size of the display and the position of the shown portion within the display.
5. Mode/Case identification – The operational mode (real-time, study, OTS, etc.) of the function running in the window shall be shown very distinctly.
6. A Toolbar from which pull down menus can be called.
7. Application area – The main area of the window, from which the SCADA/EMS functions and applications are operated.

The capability to drag a border of a window to increase or decrease its size in one direction, or to drag a corner to increase or decrease the window size in the two adjacent directions shall be
provided. The capability to drag any window that does not fill the whole screen to any location, even when part of the window extends beyond the screen shall be provided. Any one window shall not be permitted to shrink to the point where the window title cannot be read, and window titles shall be designed so that the currently loaded windows can be identified on the task bar (for example “Alarm Summary” and not “Window 1”).

The capability for every user of the SCADA/EMS to define and save the user’s individual screen layout for each monitor of the user workstation, i.e., the preferred number of windows on each monitor of the user workstation; their size, position, color, text, and contents shall be provided. When a user logs on to a user workstation, the user’s pre-defined dedicated screen layouts shall appear. The capability for every user to define and save a layout that can be called up at any time by any user shall be provided.

Fully documented window management capabilities shall be provided to allow window creation, deletion, movement, re-sizing and re-naming.

6.4.2 Date and System Time

The date and system time shall be shown on each user workstation monitor. Date shall be presented in the format MM/DD/YYYY. Time shall be presented in the format HH:MM:SS with a resolution of 1 (one) second and shall be updated once per second.

The Administrator shall be able to select the time zone to be used as system time.

6.4.3 Pushbuttons (Soft Keys)

In the context of the specifications, the term push-button (or simply button) refers exclusively to symbols on a monitor from which functions can be initiated or displays can be called by clicking it. The term function key (or simply key) refers to a physical key on the keyboard.

6.4.4 Keyboard Functions

The Purchaser shall be able to assign and reassign combinations of keys of the user workstation keyboards (e.g., Control-Alt-P) to the activation of specific functions and calling up of frequently used displays. These assignments shall be allowed only from user workstations in the
Programmer mode and shall affect all the user workstations of the SCADA/EMS. The following keyboard selectable functions shall be included in the delivered System:

1. Silence – Silence the audible alarm.
2. Cancel – Has the same effect as a "cancel" button shown in a currently displayed menu.
3. Display – Call up a display by entering its mnemonic. See Section 6.7.1 Display Call-Up.
4. Alarm Summary – Display the All Alarms Summary for the calling user’s Area(s) of Responsibility.
5. Freeze – Toggles a display between “frozen” and “unfrozen”. When frozen, the automatic refreshing of a display shall be suspended, and a visual indication that the display is frozen shall be shown.
6. Help – Show a menu of topics related to the active display from which further information or instructions can be selected.
7. Acknowledge – Acknowledges the alarm.

6.4.5 Toolbars

Toolbars with pull down menus shall provide fast navigation to functions and displays. The capability to navigate to functions and displays by clicking the toolbars and entries on their pull-down menus shall be provided. The layout of toolbars and the rest of the navigation schemes shall be developed in consultation with Purchaser and shall be subject to Purchaser’s approval. Provisions are required for programmers to edit the toolbars and the navigation trees, and to construct new ones, through an interactive procedure and without programming.

1. A main toolbar shall appear near the top of each monitor. The main toolbar and pull-down menus initiated from it shall provide fast navigation to frequently used SCADA/EMS functions and displays, and to functions that have to be quickly accessible for the handling of emergencies.
2. One or more application toolbars shall be provided for application displays to facilitate navigation to functions and displays which belong to the application itself or are used in conjunction with it. Each application’s toolbar shall provide fast and convenient access to Help information associated with the specific application.
6.4.6 Dialog Boxes

Dialog boxes shall be displayed when it is necessary to present the user with further information, or to allow the user to choose among several alternatives or to enter data. Alternatives which are not currently valid shall be displayed in lower intensity and shall be inactive. Alternatives which the user workstation is not authorized to perform shall not be shown at all. A dialog box shall be placed close to the object from which it was initiated, but shall not cover it, and the capability for the user to drag a dialog box to any part of the window shall be provided. Dialog boxes shall be able to include static textual information, pushbuttons, data entry fields, and check boxes as appropriate.

The capability for the user to cancel a dialog at any time by selecting a Cancel push-button in the dialog box and also from a function key on the keyboard shall be provided.

6.4.7 Information boxes

Information boxes shall be used to annunciate occurrences that require user attention, such as failures to successfully complete a supervisory control request, receipt of a message from a substation, or errors reported by power system applications. Messages that are displayed in response to operator actions, such as notification of failure of supervisory control, shall be displayed in an information box that pops up on the screen from which the request was issued. Other messages, such as an error message from an application, shall be posted on a predefined monitor on all user workstations that are assigned to the function which is reporting the problem. Information boxes shall remain on the screen until they are closed by a user and shall not be overlaid by other windows. Several information boxes shall be able to exist on a monitor at the same time, and users shall be able to drag information boxes to another part of the screen.

6.5 Data Representation

6.5.1 Data Attribute Representation

Any attribute of any data point contained in any SCADA/EMS database, whether the point is telemetered, received over a data link, manually entered, calculated, historical, or produced by an application (e.g., by the State Estimator) shall be available for presentation at any screen location.
of any display. No restrictions as to the placement of data or the format of its presentation shall limit the way displays can be defined.

The capability to access every attribute of any point or object in any database of the SCADA/EMS to dynamically control its appearance in displays shall be provided. The presence, appearance, and location of quality indicators (and whether to show all applicable indicators or only the one with the highest precedence), tags, alarm inhibit indications, and any other indications and display features that depend on point attributes shall be defined via the Display Editor during display creation or modification.

Methods to display data attributes (such as state of a device, limit range of an analog value, alarm state, selection status of a point, etc.) shall include different object shapes, various object and background colors, flashing, intensity, animation, etc. The assignment of display features to data attributes shall be table-driven, and shall be defined system-wide. The capability for Administrators to globally re-assign the colors (or other display features) associated with any attribute shall be provided. Through similar methods, they shall also be able to designate a point as being telemetered and non-controllable, telemetered and controllable, or non-telemetered (pseudo-point).

6.5.1.1 **NUMERICAL DATA DISPLAY**

Every numerical field on any display shall allow selection of the following features:

1. The number of integer and fractional digits displayed may be different for each analog data item. Tap positions shall be shown as integer values.
2. The number of integer and fractional digits may be different for the same data point when this data point is shown on different displays or at different locations on the same display.
3. The algebraic sign of a value may be expressed as such or may be expressed as one of a pair of alphanumeric or graphic indications (up/down, in/out, arrow symbols, etc.) located anywhere in the display.
4. The capability to show or suppress leading zeros, plus signs and minus signs for all numerical data.
5. Any data field may be defined as being protected (against user entry) via the display generation procedure.
6. When the value of a data point cannot be represented completely by the preformatted number of digits on a particular display, the value shall be shown as asterisks.

7. Data values may be shown numerically in any character size; left, right, or center justified; lined up by decimal point (in lists); vertically or horizontally positioned, or rotated up to +45 degrees or -45 degrees.

6.5.1.2 DISPLAY OF POINT STATES

The capability to specify arbitrary sets of symbols, with up to at least 16 (sixteen) different symbols for each device, to represent the states of multi-state devices on displays shall be provided. The symbols shall be built by the Display Editor and shall be maintained in a library from which they can be selected. There shall be no limit to the number of symbol sets that may be built. The capability to use various display attributes (color, flashing, inverse video, etc.) to represent the database attributes of a point or object shall be provided.

A single symbol shall be able to use more than one color (e.g., the symbol for a transformer between two voltage levels can show one side in the color associated with the first voltage level, and the other side in the other color).

The state of three-state devices shall be represented by one of a set of four symbols, including a symbol for the invalid state.

6.5.1.3 DISPLAY OF STATE NAMES

The capability to specify arbitrary text strings, with up to at least 16 different text strings, to represent the states of multi-state points shall be provided.

6.5.1.4 SUBSTITUTION OF ESTIMATED VALUES FOR TELEMETERED DATA

The values of analog points shown in displays shall be replaced on all workstations with the corresponding values from the State Estimator under any of the following circumstances:

1. Any of the following data quality flags is set for the point: Unreasonable (U), Bypassed (B), or Deactivated (D) and authorized by the user.
2. When the State Estimator detects that the estimated value for the point deviates from the RTDB value by more than a deadband as defined in the RTDB on an individual point basis.
3. Upon request by an authorized user.

In order to avoid replacing analog values with old estimates that may no longer be valid, such replacement of telemetered values shall be suspended if more than a pre-defined time period has elapsed since a State Estimator solution has successfully converged.

Selection of estimated values for display shall not affect the value stored in the RTDB nor its data quality flags.

The data quality indicator for the point whose RTDB value was replaced shall continue to be shown (it may be blank if the value was up-to-date), and an indicator ‘E’ (Estimated) shall be shown adjacent to it. The data quality indicator and the ‘E’ indicator shall be propagated into calculated points and into historical and repository data.

When estimated data is automatically displayed, the display shall revert to the RTDB values as soon as satisfactory data is available again. For operator requested displays, the estimated value shall continue to be shown until return to RTDB values is requested by an operator.

An Estimated Points Summary shall show all the points for which substitution by estimated values was either manually requested or (in a different color) automatically made. Operators shall be able to revert to an RTDB value for a point either through selection of the point in the summary or through selecting the point on other displays. Operators shall also be able to completely disable such substitution of RTDB values. A symbol, shown on the main toolbar of all user workstations, shall indicate if substitution of estimated values is enabled or disabled.

6.5.1.5 DISPLAYS NAMES

The capability to assign to each display (or named segment of a world map) a name of up to at least 48 (forty-eight) alphanumeric characters shall be provided. The names of a display shall be shown on any list that includes the display, and shall be available for use with all the methods of calling displays by name. When a new display is named, the SCADA/EMS shall reject attempts to reuse an existing name.
6.5.2 Graphical Data Representation

Graphic data displays presenting bar charts, dials, pie charts, and X-Y plots and Kiviat charts shall be fully supported. Any numerical database value shall be representable in graphics format on any kind of display. All charts and plots shall also be capable of being displayed in a 3D format.

The capability to graphically represent time based data (e.g., forecast data such as time zero, t+5, t+10, t+15, etc.) shall be supported.

6.5.2.1 BAR CHARTS AND DIALS

A bar chart shall provide a simple pictorial method of showing the magnitude of a data value. The capability to define a bar chart to extend either horizontally or vertically shall be provided. The location, maximum length, width, and nominal color shall also be defined at display definition time. The length of the bar shall represent the value of the data point. The capability to split the background of the bar chart into regions corresponding to the limits of an analog point and to assign a different color to the portion of the bar that appears in each region shall be provided. The capability to display bars in a flashing mode to represent the value of data points with unacknowledged alarms shall be provided.

Dials shall include a circle, or an arc of a circle, with a pointer whose position represents the value of the data displayed. Like bar charts, the background color of the dials can be used to define regions of limits.

6.5.2.2 PIE CHARTS

The capability to show the relative percentages of a set of related data by means of pie charts shall be supported. A pie chart shall appear as a circle divided into wedge segments, each a different color and representing a different database variable. The size of each wedge shall be proportional to the value of the variable in relation to the total of all variables. The circle origin and radius, as well as the number, identity, order, and displayed color of variables shall be definable at display definition time.
6.5.2.3 **X-Y PLOTS**

A means of graphically displaying X-Y plots of data from the RTDB and from the historical database shall be provided. An X-Y plot shall show the relationship between two arrays of data whose structure is such that the ordinates (x values) of a set of points are contained in one array and the abscissas (y values) are contained in the other. The color, data point symbol, location and extent of both axes shall be individually assignable to each plot. Multiple plots shall be allowed within an area defined by one pair of plot axes.

6.5.2.4 **KIVIAT CHARTS**

Kiviat charts or radar charts display multivariate data in the form of a two-dimensional chart of three or more variables represented on axes starting from the same point. The chart consists of a sequence of equally angled spokes, with each spoke representing a variable. The data length of a spoke is proportional to the magnitude of the variable. A line also connects the data values for each spoke giving the appearance of a star.

The color, data point symbol, location and extent of both axes shall be individually assignable to each plot. Multiple plots shall be allowed within an area defined by one pair of plot axes.

6.6 **Trend Displays**

Trend displays shall provide the capability to view telemetered and calculated real-time data plotted against time in a horizontally or vertically oriented graph. In the trend displays, 1 (one) axis shall be time and the other axis shall be the value of one or more selected points as they vary with time.

6.6.1 **Trending Capabilities**

The system shall allow the user to select any point, analog and digital, for temporary real-time trending and to assign any point, analog and digital, to permanent trending via simple user actions such as drag and drop. The values of permanently trended points shall be available in the historical database at time intervals that are commensurate with the scaling of the trending curve in such a way that at least 1 (one) value is saved for each pixel of the curve. For such points, (1) all the data needed for the curve shall be available whenever their trending is requested, and a
complete curve shall immediately be displayed, and (2) it shall be possible to request trending of historical data for any period for which it is on-line.

The following trending capabilities shall be provided:

1. Define, separately for each trend display, horizontal or vertical orientation of the trending curves. For horizontally oriented curves, the value of time shall increase to the right (i.e., the oldest data shall be on the left and the most recent data on the right.) For vertically oriented curves, the value of time shall increase downward.

2. Plot at least 8 (eight) curves, corresponding to 8 (eight) separate data values, together on the same set of axes, and to define different scaling for each curve. All curves shown simultaneously on the same axes shall have the same time scale.

3. Select time scaling so that the complete (full-scale) time axis represents any user-selected time period, such as:
   3.1. 1 (one) second
   3.2. 10 (ten) seconds
   3.3. 15 (fifteen) minutes
   3.4. 12 (twelve) hours
   3.5. 24 (twenty-four) hours

4. When several values from a trending file correspond to a single point on the trending curve, then the average trending file values shall be used to construct a point on the curve.

5. Select different time and value scaling for curves in different windows.

6. Define a unique color for each curve.

7. Using different colors, the capability to identify portions of a curve which represent values marked with a “Failed” or “Deactivated” data quality, and manually entered values shall be provided.

8. Assign a pair of limits for each curve and to select shading to emphasize the areas inside and outside the limits. For real time values, the limits shall be linked, as a default, to the first, innermost, pair of operational limits of the trended point, but it shall also be possible to assign them to the point’s other pairs of operational limits, or to assign to each limit a value within the range of values of the trending curves. Only the last option is required for
historical trends. The limits shall be shown as lines on the curve, and their numerical values shall also be shown.

9. Superimpose trend curves where 1 (one) curve represents historical data from a given time period and the other curve represents the real-time data of the corresponding current time period. (For example, a window might present two curves, one showing the load of a transformer on the day of the peak, and the other showing the current day's load, updated in real-time)

10. Trend curves for real-time data shall automatically be updated when a new value becomes available. When historical data for a corresponding period is superimposed on real time data, it shall be updated too in synchronism with the real-time data.

11. For trend curves showing real-time data, the position of the axes shall remain fixed, and the curves, time axis markers and the grid shall move with the addition of newly acquired data.

12. Use a pre-existing trend curve as a template for a new trend curve by calling it up and then saving it under a new name or ID. This new trend curve can be modified by selecting different data points or other parameters.

13. Select historical data to be displayed in two ways: (1) static display of data for a user-specified time period, or (2) dynamic display of as many of the most recent values as can be accommodated in the trend curve. Dynamic historical trends shall be automatically updated as new values are received.

14. Select a mixed plot type (i.e., line plot for one data item with fill area plot for another data item).

15. Capability to hide legends.

6.6.2 Precise Reading of Curve Values

Users shall obtain a precise reading of values of each curve within the set of axis, at any point along the time axis, by placing a hairline cursor at the desired point. The time for which the accurate values are shown, and the engineering values of the curves corresponding to this time shall be shown. The user shall be able to quickly place the hairline cursor at any point on the curve and then move it slowly to precisely select the desired point.

When a new trending display is shown, the hairline cursor shall be placed at the end of the curve, so that the value of each curve is shown.
6.6.3 Selection of Trending Data and Parameters

The system shall allow the user to select any telemetered (analog, status and digital) or calculated value for trending. For the selection of data for trending, a procedure is required which is based on pointing the cursor to the desired point; it shall not be necessary to enter a point name or ID to select a point for trending.

6.6.3.1 PRE-SELECTED TRENDING POINTS

The user shall be able to pre-select points for trending. The momentary values of such pre-selected trending points shall be saved in the historical database at time intervals that are commensurate with the scaling of the trending curve in such a way that at least one value is saved for each point. For such points, all the data needed for the curve will therefore be available whenever their trending is requested, and a complete curve shall immediately be displayed. The user shall be able to trend historical data points from the data repository. In this respect, the requirements below for displaying historical curves and overlays apply.

Trending data shall be transferred into the data repository for long term keeping and archiving. Historical and restored archived trending data shall be accessible to the trending function from the repository.

Pre-select trending is also referred to as “permanent trending.”

6.6.3.2 PRESENTATION OF TRENDING CURVES

The following basic capabilities for the presentation of trending curves shall be provided:

1. When trending is requested for a point that is not assigned to permanent trending, the trend shall appear with system-wide, predefined, default trending parameters, including time and value scaling (values will be dynamically determined based on point attributes such as point limits), and default shading attributes.

2. User shall be able to change all the trending parameters (scaling, limits, etc.) from within the display. This customized version shall apply only at the workstation at which it was prepared. A “Restore” function shall enable the user to request restoration of a permanent trend display to its assigned parameters or of a non-permanent trend to the default parameters.
3. A capability to save a user customized version for later recall is required for each trend display.

4. The capability to select up to 8 (eight) points for trending within the same set of axes and to mix permanent trending points with non-permanent trending points shall be provided.

5. For permanent trending points the user shall be able to request a curve of historical data to be overlaid on top of a curve of real-time data. The overlay shall be white with transparent shading through which the underlying curve is visible. The user shall be able to specify a date, whereupon data for the same hours of the day shall be shown in the overlay. When real time curves get updated, the overlay curves shall likewise be updated with the corresponding values for the overlay date. The user shall be notified when historical data for the requested dates is not available.

6.7 Operator Functions

In this section, the following required operator functions are specified:

1. Display Call-up
2. Control of Overview Display
3. Supervisory Control
4. Device Tagging
5. Deactivate/Activate RTUs
6. Deactivate/Activate Data Points
7. Manual Data Entry
8. Printing of Information and Displays
9. Block Selection and Rubber Banding
10. SCADA/EMS Access Security
11. Data Access Spreadsheet
12. Alarm Inhibit individual data points and entire RTUs

Other operator functions are specified elsewhere in the context of the required applications.

Messages shall be displayed to advise the operator of the disposition of the request after each action. Appropriate dialog menus or pushbuttons shall automatically be displayed to guide the
operators through operating procedures. Error messages shall explicitly identify the encountered problem or reason for which a user’s request was rejected.

User operations on power system points, such as supervisory control, tagging, and acknowledgement of alarms, shall be permitted only for points that belong to areas of responsibility to which the workstation is assigned.

User’s requests shall be validated and shall be rejected if the user is not authorized to issue the request or if parameters or other data that the user entered for the request are not valid or are unreasonable. The user shall be notified of the rejection of requests through an information box with a message that states the reason for the rejection.

Several operator functions, such as supervisory control and deactivation of points, require a point to be selected. Point selection shall automatically be canceled when the last step of an activity with respect to a point is completed. Point selection shall also be canceled for multi-step procedures if the time between two consecutive steps of the procedure exceeds a pre-defined system-wide selection timeout period. The selection timeout period shall be adjustable by programmers in the range of 10 (ten) seconds to 120 (one hundred and twenty) seconds for each individual point in the system. It shall also be a global default selection timeout value (adjustable in the range of 10 (ten) seconds to 120 (one hundred and twenty) seconds), and shall be used for points for which an individual timeout period is not specified in the RTDB. A user configurable timeout value shall be provided for menus, dialog boxes, etc.

6.7.1 Display Call-Up

The capability to call up any display or named segment of the world map, at any time, to any window of any monitor of any user workstation shall be provided. The capability to call the same display to any number of windows, on any number of monitors, at any number of user workstations, at the same time shall be provided.

6.7.1.1 CALL-UP METHODS

Display call up methods provided by the SCADA/EMS shall include:
1. **Display Directory** – A list of displays from which a display can be called by clicking its name. The directory shall include individual displays as well as named sectors of the world map. Only displays belonging to classes that the user is authorized to see shall appear in the directory.

2. The two search tools, Index search and Contents search, shall be provided for locating displays in the directory. The display categories for the Contents search will be defined by the Purchaser during the preparation of the Purchaser’s displays.

3. **Pushbuttons** – The capability to define pushbuttons which, when selected, call up a designated display or designated sector of a world map shall be provided. Specifically:
   3.1. The capability to call up the schematic diagram for any substation that is shown on a schematic world map display by clicking on the symbol representing the substation. The diagram shall be displayed at such a magnification level that the entire substation one-line is visible within the window.
   3.2. In addition, when the user clicks a pre-defined button in the schematic diagram of a substation, the system shall call up a sector of the world map at an appropriate magnification (defined by an Administrator) with the substation at its center.

4. **Function Keys/Keyboard Shortcuts** – Administrators shall be able to assign function keys and keyboards shortcuts to displays so that, when a user presses the key(s), the corresponding display is called up in the active window.

5. **Display Name and Alias** – Users shall be able to call a display by entering any of the names of the display or a display name alias in a data entry field that shall be provided for this purpose on each monitor. The name entry shall not be case sensitive (i.e., the case of the typed letters shall be ignored).

6. **Equipment Name** – Users shall be able to call up a particular view from the world map display by referring to a substation name, circuit name, device ID, or location.

7. **Device ID** – Users shall be able to enter point IDs consisting of area, substation, and device number. The SCADA/EMS shall list all the displays (including named sectors of the world map) in which the specified point appears, and which the user is authorized to view. Clicking a display name on the list shall call that display to the screen.

8. **Recall** – The system shall maintain a circular buffer with the identity of at least the last 20 (twenty) displays (including named sectors of the world map) that were viewed at each
workstation; toggling back and forth between two displays shall not result in repeated entries into the buffer. The capability to go to the next or previous display either by typing a “Recall” shortcut or by clicking “Recall Next/Previous” pushbuttons in a toolbar shall be provided. To call other displays from the Recall buffer without repeatedly clicking the Next/Previous pushbuttons, the user shall be able to initiate a Recall dialog menu. The dialog menu shall list all the recallable displays, and the user shall be able to directly recall any listed display by clicking it. Recalled displays shall appear in the active window, which shall not necessarily be the window on which they had last been shown.

9. Hierarchy – Hierarchical displays shall include pushbuttons for calling the next/previous (child/parent) level of the display. Where operationally desirable, additional pushbuttons shall provide direct access to other levels of the display rather than just to the next/previous level.

10. The capability to call an Alarm Summary display by clicking a point on a world map or substation display shall be provided. If there is an entry for the selected point in an alarm summary, the portion of the summary that includes the entry shall be shown. The point’s entry shall be highlighted, e.g. by placing it on the top of the display or by other means subjected to Purchaser’s approval.

11. In addition, Alarm Summary displays shall include functionality to navigate to the schematic display/world map and the location or device where the active alarm is present, or to highlight the alarm generating feature in some other way acceptable to the Purchaser.

6.7.1.2 PLACEMENT OF DISPLAYS ON SCREENS

Several options shall be available for the placement of a display when it is called. These shall include:

1. The new display replaces the display in the currently active window.
2. The new display replaces the current display only when called from a pushbutton within that display.
3. The new display appears in a new window. For multi-screen workstations, the user shall be able to select the destination screen on which the next window shall be created.
The capability to select a default method, between those listed above, for each display shall be provided. However, users shall be able to override the default, and choose a different method whenever they call a display.

**6.7.1.3 DISPLAY CALL-UP FROM WEB BROWSERS**

The SCADA/EMS shall accept requests for displays, including sectors of the world map, from the SCADA/EMS Web Server located in the CEU Environment.

The System shall provide the capability to authorized non-System users to view a pre-defined list of displays and reports via the Purchaser’s standard Web browsers. The Web browser will run on computers that are connected to the CEU via the Purchaser’s internal network. The Web browser interface shall ensure that authorized users are authenticated and that the jurisdiction requirements are met.

All Web browser users shall be classified by the System as non-System users, so they shall have a strictly limited set of capabilities, roles, and jurisdictions.

The Contractor shall include tools for the creation, management and publishing of the pre-defined list of displays and reports by the Purchaser.

The Web browser user interface shall meet the following design guidelines:

1. Pages shall load quickly (i.e., the general display response requirements of Section 3.2.6 Display Call-up Response Time for Web Browser User Interface shall apply).
2. Displays shall have a consistent look and style. Use of colors and fonts shall be applied consistently. Control buttons, navigation aids, message windows, etc. shall have consistent appearance and location.
3. Navigation aids shall be provided to enable users to easily determine which display is being viewed and to facilitate movement around the current display and to other displays.
4. Users shall be provided with positive, visual feedback when they make a selection, which shall remain visible until the request is completed or until they make a new selection.
5. Dynamic information on the displays shall refresh at a rate configurable by the user, from 2 (two) seconds to 1 (one) minute.
The Contractor shall supply all required software and licensing to support this Web browser user interface. The Purchaser would prefer an implementation that is not dependent on use of a specific Web browser.

6.7.1.4 DISPLAY VIEWING RESTRICTIONS

In order to restrict the viewing of privileged data the capability to assign displays for viewing only at workstations that are authorized for viewing them and to assign individual data fields within displays for viewing only by “unrestricted” users shall be provided.

The capability to assign each display, including the world map and queries-based displays, to a class and to define specific classes of displays that may be viewed on workstations of each of the functional areas shall be provided. One of the classes shall be “Unrestricted”. Viewing of “Unrestricted” displays shall be permitted on workstations of any functional area.

Displays shall be assigned to one class when they are built, and the capability to change assignment from the Engineering workstations shall be provided. In order to prevent inadvertent wrong display assignments, it shall be required to explicitly specify a class for each display (i.e., the class shall not be “inherited” when one display is used as a template for the construction of another display). If a display has no class assignment at all, it shall be viewable only on the Engineering workstations.

The capability to assign RTDB data fields and historical data records to “restricted” viewing shall be provided. Restricted data shall be shown only on workstations whose logged-on user has “unrestricted” viewing rights.

6.7.2 Control of Video Wall Overview Display

The multi-panel Overview Display on the video wall in the control center shall be treated as one contiguous screen without showing the menus, tile box, etc. From an Overview Display control interface, users on their specific workstation shall be able to call displays and open and manage windows. The procedures for display call up and manipulation (including panning and zooming) shall be the same as those for the user workstation.

The Overview Display shall provide capabilities for control of both shared and local windows.
A Shared window shall remain selected on the Overview until an operator removes or changes the window and shall be treated as per a window on a workstation that is in Viewing mode (i.e., where only viewing and no other activity shall be supported). Selection of displays for the overview shared window shall not affect the displays that are shown on the screens of the workstation from which the selection is made.

Local display windows shall be assigned and controlled from an individual operator’s workstation. Operators shall be able to open windows on the Overview Display screens that shall have no restriction on the display types or on the operations that can be performed. These windows shall be used to extend the display capabilities of the operator’s workstation. These display windows when initially opened shall be superimposed on the overview windows. Users shall be able to hide and unhide their local windows behind the overview shared windows.

The SCADA/EMS shall have a user interface to manage the Overview Display shared and local window operations.

### 6.7.3 Supervisory Control

This section specifies the operator procedures for supervisory control. Operators shall be able to control two-state devices such as breakers and switches, three-state devices such as motor-operated switches, and multi-state devices.

Only 1 (one) user at a time shall be able to select a device for control, or for any other point-oriented operations such as tagging. If the user does not perform the next step of a control procedure (or other point-oriented procedure) within the selection time-out period, the point’s selection shall automatically be canceled. A system-wide time-out period shall be adjustable by programmers.

Rejection of a control request shall occur at the procedure step at which it is detected, and in any event before the request is sent to the RTU. The user shall be notified of the rejection and of its reason.

The backup arrangement for the 2 (two) control centers specified in Section 2.4.1 Real Time Data Management shall be taken into consideration.
6.7.3.1 **DEVICE STATE CONTROL**

Supervisory control of two state devices and three-state devices such as breakers and switches shall involve the following consecutive actions:

1. The operator selects the device for control by clicking the dynamic presentation of a control point.
2. When the device is selected, the device symbol shall flash and a pop-up menu with the device name and available operations shall be displayed. Operations that are not applicable under current circumstances or at this time shall be dim and inactive. This menu shall not obscure the selected device.
3. The operator selects a control operation (TRIP, CLOSE, etc.). Users shall be permitted to control devices into any state, including the current state of the device.
4. A message is placed in the pop-up menu identifying the device and the selected control operation. The pushbuttons EXECUTE and CANCEL are placed in the window.
5. The operator initiates the control action by selecting the EXECUTE function.

The operator shall be notified when a control cannot be issued due to a permissive control validation check failure. Successful completion of the control request shall be recorded as an event. Request failures shall be annunciated by displaying an information box that identifies the controlled device and the specific problem that was encountered (such as failure to communicate with the RTU or an error condition reported by the RTU).

Control requests shall be cancelled and the selection of the point shall be terminated when the user cancels a request, does not perform the next step of the control procedure within the selection time-out period from the previous step, or the request is rejected.

6.7.3.2 **INCREMENTAL (RAISE/LOWER) CONTROL**

Supervisory control of Raise/Lower control devices shall involve the same set of consecutive actions as specified above for device state control except that:

1. Only RAISE and LOWER control operations may be selected.
2. The command shall be issued as soon as RAISE or LOWER is selected, without an EXECUTE step. The capability for operator to initiate control repeatedly without reselection
of the controlled point, provided that the execution of the previous control command has been completed successfully shall be provided.

3. A separate timeout period, different from that specified above in this Section 6.7 Operator Functions, shall be provided for incremental control. The selection timeout period for incremental control shall also be adjustable by programmers in the range of 10 (ten) seconds to 120 (one hundred and twenty) seconds. The timer shall be reset and start counting again whenever a RAISE or LOWER command is issued.

6.7.4 **Deactivate/Activate RTUs**

The capability to deactivate and activate processing for any RTU, manually from field communications control displays and also from Purchaser written applications shall be provided. When an RTU is deactivated, the SCADA/EMS shall stop processing all data for the RTU and shall mark all the points belonging to the RTU as “Deactivated”, except for points with “Manually Entered” data quality. Supervisory control requests, issued by operators or applications, shall be rejected for deactivated RTUs, and the reason for the rejection shall be noted in a message displayed to the operator or reported to the requesting application. When the RTU is reactivated, the "Deactivated" quality codes shall be replaced with the "Bypassed" quality code until up-to-date data is received from the RTU. However, points that have been deactivated individually, or for which data has been entered manually either before or after the RTU was deactivated, shall remain in the "Deactivated" or “Manually Entered” state.

A user deactivating an RTU shall be prompted to enter a comment of up to at least 50 (fifty) characters. The comment shall appear in a comment box when the deactivated RTU is pointed to in the field communications control displays. The comment field shall also be shown in the Deactivated Summary.

6.7.5 **Deactivate/Activate Data Points**

Operators shall be able to deactivate individual telemetered data points. The incoming data for a deactivated point shall not be processed by the SCADA/EMS. A deactivated point shall retain the last value or state that was successfully retrieved before being deactivated, and shall be assigned a "Deactivated" quality code. Upon reactivation, the system shall resume processing of
data reported for the point from the field. The data quality of the point shall be set to "Bypassed" until up-to-date data is successfully retrieved for it.

When deactivating a data point, the operator shall be prompted to enter a comment, whose length may be at least 50 (fifty) characters. The comment shall be shown in a comment box when the pointer rests on the point. The comment field shall also be shown in the Deactivated Summary.

6.7.6 Manual Data Entry

The capability to manually enter data into the RTDB, into the historical database, and into data tables shall be provided.

Attempts by more than 1 (one) user to enter values into the same point or set of data at the same time shall be rejected, and an explanatory information box shall be displayed for the user.

6.7.6.1 RTDB DATA ENTRY

The capability to manually alter the state or value of a telemetered or non-telemetered data point including limits shall be provided. Data entry requests shall be validated and unreasonable requests shall be rejected. For successful entries, an event shall be generated; the old state or value and new state or value and the user entering the data shall be shown in the event message. The “Manually Entered” data quality shall be assigned to such points from the moment that data is manually entered until it is replaced with telemetered data, and the point shall not be updated until it is manually activated.

Limit checking shall be performed when values are entered for analog points. The entered value shall be displayed in the appropriate color, but no alarms shall be generated if the data entry results in a limit violation.

A procedure like that used for supervisory control shall be employed for manually changing the state of a status point. Manual requests to change the state of a device shall be subject to the same restrictions imposed by tagging as apply to supervisory control commands, and the same operator notification is required when an attempt to manually change the state of a device is rejected by the SCADA/EMS.

Manual data entered points shall be displayed on the Manual Entry Summary.
6.7.6.2 OTHER DATA ENTRY

The capability to enter data that is not associated with points in the RTDB, in order to enter parameters and operating conditions for the application functions, and to edit historical data and information in the data repository shall be provided including entering values into several fields at the same time. All enterable fields shall be highlighted. The new values shall be processed, validated, and accepted only when a “Manual Entry” pushbutton is clicked. If one or more of the new values failed checking and is rejected, the invalid values shall be highlighted, and none of the newly entered values shall be accepted until all invalid values have been corrected and “Manual Entry” has been clicked again.

Each Data entry shall be recorded as an event. The event message shall identify the data structure (e.g., historical data for a certain day or outage scheduler parameters) into which the data has been entered, the previous value, the new value, and the user who entered the data.

Where applicable, such as when data is entered into the historical database, the “Manually Entered” data quality flag shall be set.

Manual data entered points shall be displayed on the Manual Entry Summary.

6.7.7 Advanced Visualization Features

Advanced Visualization tools shall be provided to enhance situational awareness. These features shall include dynamic dashboards, dynamic color contouring, 3D objects, and animated objects.

Dynamic color contouring shall be configurable to show variations in color or intensity to depict menu driven system values or limit conditions from real-time data, State Estimator, Contingency Analysis, and network applications savecases. Contouring techniques shall be capable of being applied to voltage levels, line real and reactive power flows, MVAr reserves and power flow injection and withdrawal points, specifically, for generation and load.

Dynamic dashboards shall be provided. Dashboard displays shall represent a configurable window by each user representing a simultaneous view of data and displays from multiple sources in the system including real-time, state estimation, study or historical data as well as alarms and alarm counts. Displays shall be user configurable with drag and drop techniques from
any existing graphic, tabular or trend display. Dashboards shall be user configurable by the operator. They shall have the capability to drill down, provide the ability to use hyperlinks and pop-ups, and can include animated objects.

Display objects including cylinders, cones etc. shall enable the user to depict system conditions of interest on select 3D displays.

Display objects including animated arrows or other graphic symbols shall be configurable by the user to depict specific conditions for individual system elements of interest. Animation features shall enable the user to define dynamic sizing, direction, color and object speed for individual value conditions such as showing arrows to show real and reactive power flow, halos for violations, increasing line size for limit violations, etc. The user shall be capable of disabling and enabling any animation feature via on-screen menus.

Dynamic characteristics from the NOM and RTDB shall be capable of being displayed with coloring and gradient effects to reflect the dynamic state of the network. As violations occur, the coloring shall identify this.

All groupings, colors, and dynamic behavior related to the presentation of the above features shall be configurable by the Purchaser and will not require any customization on the part of the Contractor.

The stated visualization tools shall be available for use in both the real time and study contexts.

6.7.8 Export of Operational Data (Snapshots)

Users require the capability to export any data from the Production Environment user interface to the CEU, where it can be accessed in a read only (i.e., PDF) or editable format for further analysis. This functionality shall be provided through integrated features of the user interface (i.e., without the need for the user to run scripts or separate applications from their workstation) in a secure method, consistent with the Architectural Security Principles defined in Section 2 System Requirements and Architecture and Section 4 System Security. The capability shall be provided within this feature to easily identify the originator of the file generated, the time of generation, and the contents of the file (such as State Estimator results, SCADA alarms at a substation, etc.).
6.7.9 **Video Recording (Option)**

As an option, the Operator shall be able to put the screen in record mode that captures all the Operator actions and entries until the recording is stopped. The recording shall be saved to a user configurable storage area and available to review. The system shall ensure that if the recording is stopped prior to running out of space and causing a failure.

6.7.10 **Printing of Information and Displays**

Users shall be able to request the printing of copies of any display, including the world map display, trend displays, and other printable data and reports. The user shall be able to choose to print either only the active window or the complete monitor screen. Copies shall be printed in color when directed to color printers and in gray tone otherwise. The capability for the user to change the background color prior to printing (e.g., color on white) shall be provided. Copy requests shall be buffered so that the user workstations are not tied up until the display is printed.

The capability to request the printing of any display to file format, i.e. PDF format, etc. shall be provided. The capability to use the standard workstation Windows print function shall be provided.

The capability to direct printing requested on a workstation to network printers (printers that are connected to a SCADA/EMS LAN or WAN or to a local LAN or network) to which the workstation has access, and to local printers that may be connected directly to a workstation. For workstations that have access to more than one printer, users shall be able to select the desired printer.

6.7.11 **Block Selection and Rubber Banding**

The various selection methods included in Windows shall be available for selecting text and objects for processing by SCADA/EMS functions. This includes selecting blocks of text by dragging the mouse pointer through the block or clicking the block’s beginning and end points with the Shift key depressed.

In addition, a simple means shall be provided for the user to easily and quickly select a multiple of entities on any schematic display, map-display, or other world-map display, for further user
actions. For example, the operator should be able to select several busses, several substations, several breakers, and the connecting lines/busses, etc., from a schematic diagram, in one action. To indicate such multiple selection, the user shall be able to use the mouse to draw one or more closed curves on the schematic diagrams to indicate that all the entities within the curves are either selected or excluded for a subsequent user action (such as a switching study, a count of interrupted customers, disable scanning, etc.). The user shall be able to designate additional entities outside (or inside) the curves as being also selected in case the enclosed curves cannot include all such entities.

6.7.12 SCADA/EMS Access Security

A mechanism for defining and controlling user access to the SCADA/EMS including accessing from the SCADA/EMS Web Server System shall be provided. This security scheme shall be in addition to that included with the operating system. That is, even though a user has logged onto the SCADA/EMS network or a processor, access to the SCADA/EMS functionality shall be subject to additional security checks.

6.7.12.1 USER LOG-ON

Users shall be required to log-on to gain access to the SCADA/EMS. Single sign-on access shall be provided. A list of authorized users shall be maintained, and a default workstation mode shall be assigned to each user. Upon logging on, the workstation shall be put into the user’s default mode. Prior to logging on, however, any person already logged on must log off, a procedure that would apply for example during an operator change of shift.

Logging on and off shall be recorded as events. When nobody is logged on to a user workstation, logging on shall be the only function allowed at a workstation.

The delivered SCADA/EMS shall not include any guest accounts or default administrator or maintenance accounts providing user access. It shall not include any accounts that do not require an interactive log in. All accounts in the delivered SCADA/EMS shall use passwords assigned by the Purchaser. The Contractor shall provide a user management document for the Purchaser’s approval.
6.7.12.2 REMOTE OPERATING ACCESS

Access to the SCADA/EMS for users inside and outside the corporate environment shall be made according to the Security requirements in Section 4 System Security. All local access control procedures shall apply once the remote access requirements have been met.

6.7.13 Data Access Spreadsheet

A spreadsheet application shall be included in the SCADA/EMS to enable users to perform ad-hoc calculations and to define more permanent calculations and format them for viewing and printing. In addition to manually entering variables into the spreadsheet, the capability to copy values from the databases of the SCADA/EMS and from the data repository shall be provided. The methods to do so shall include drag/drop and copy/paste techniques. Clicking a Refresh button shall cause all the values derived from databases to be updated and a recalculation to be performed.

Incorporation of a commercially available spreadsheet such as Excel is preferred.

The following capabilities are required:

1. Interfaces and methods for easy retrieval of historical data into spreadsheet.
2. Linking of spreadsheet to the RTDB.

This is intended to allow the Purchaser to use spreadsheets as SCADA/EMS displays to present user-specific calculated information.

6.8 Operator Modes and Areas of Responsibility

6.8.1 Modes of Operation

In order to control the scope of functions that users are authorized to operate, the capability to assign user workstations to modes of operation shall be provided. The functions permitted for each mode shall be defined in a table. Purchaser’s Administrators shall be able to edit this table in order to change the authorizations of existing modes and to define new modes.

Initial modes that shall be implemented by the Contractor are tentatively defined below. Final definition shall be developed in consultation with Purchaser during the development of the
SCADA/EMS. The Contractor and Purchaser shall define the modes of operation during the User Interface Configuration workshop.

6.8.1.1 OPERATOR MODE

Operators shall be authorized to perform all the SCADA and Network Analysis applications functions.

6.8.1.2 SUPERVISOR MODE

Supervisors shall be able to perform all the functions permitted in the Operator mode. In addition, the supervisors shall be able to manage the configuration of the SCADA/EMS, change the operating mode and areas of responsibility, change the assignments of workstations, set system-wide operating parameters, choose another set of seasonal limits, restart the system, request fail-over, manage communications interfaces, etc.

6.8.1.3 MAINTENANCE MODE

This mode shall provide access to the database and display editors. Users shall be able to build, edit, integrate, and test database and display changes, but shall not be permitted to perform any power system operations. In this mode, all activities that change databases and displays shall be logged.

6.8.1.4 PROGRAMMER MODE

Programmers and software developers shall be able to perform software development, debugging, integration, and configuration activities from their workstations. Programmers shall also be authorized to perform all the Maintenance mode functions. All activities that result in software changes shall be logged.

6.8.1.5 OTS TRAINEE MODE

Workstations in this mode shall have access to all the trainee functions of the OTS, but no access to other SCADA/EMS functions.
6.8.1.6 **OTS TRAINER MODE**

Workstations in this mode shall be authorized to use all the functions of the OTS. They shall have no access to other SCADA/EMS functions.

6.8.1.7 **VIEWING MODE**

In this mode users shall only be allowed to call displays for viewing including alarms, tags (i.e., a read-only mode).

6.8.1.8 **TESTING MODE**

Users shall be authorized to perform all the SCADA application functions in the Quality Assurance System (QAS) and Program Development System (PDS) Environments.

6.8.1.9 **ANALYSIS MODE**

Users shall be authorized to perform all the Network Analysis applications functions.

### 6.8.2 **Modes Assigned for User Workstations**

The following table describes the authorized modes attributed to the user workstations of both control centers. The modes assigned to user workstations shall be configurable.

**Exhibit 6-1: Modes Assigned for User Workstations**

<table>
<thead>
<tr>
<th>Access to</th>
<th>Mode</th>
<th>Operator</th>
<th>Engineering</th>
<th>Point to Point and Developer</th>
<th>OTS Trainer</th>
<th>OTS Trainee</th>
<th>Analysis</th>
<th>Portable</th>
<th>Corporate (Web-accessed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real-time SCADA/EMS Application</td>
<td>Viewing Mode</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Operator Mode</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Supervisor Mode</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EMS Application</td>
<td>Analysis Mode</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>OTS Application</td>
<td>OTS Trainer Mode</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Access to</td>
<td>Mode</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operator</td>
<td>Engineering</td>
<td>Point to Point and Developer</td>
<td>OTS Trainer</td>
<td>OTS Trainee</td>
<td>Analysis</td>
<td>Portable</td>
<td>Corporate (Web-accessed)</td>
<td></td>
</tr>
<tr>
<td>OTS Trainee Mode</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Quality Assurance System (QAS) and Program Development System Environments (PDS)</td>
<td>Testing Mode</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Maintenance Mode</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Programmer Mode</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Notes:

1. “✓” means the mode shall be authorized on the workstation according to user assignments.
2. In emergency situations, the Purchaser shall have the capability to use OTS Trainer and OTS Trainee workstations to monitor and control the power system in Operator mode.
3. It shall not be possible to change the modes assigned to a workstation by changing some configuration file local to the console. Modes and authorities must only be changeable by a system administrator from a central point.

**6.8.3 Areas of Responsibility (AORs)**

The capability to assign from 1 (one) to at least 64 (sixty-four) Areas of Responsibility (AORs) to users shall be provided. The AORs will be defined during the database workshop. Default AORs shall be defined for each person in the list of authorized users and assigned to the workstation when a user logs on. Supervisors and Administrators shall be able to change the current AORs for functions, users, and workstations via display; such changes shall be logged as events. The AORs assigned to functions, users, and consoles shall be viewable and changeable via display.

It is required that every active AOR be assigned to at least 1 (one) operator or supervisor workstation at all times. An Administrator shall be able to enable/disable this capability. Log-on
attempts and requests for reassignment of AORs that violate this rule shall be rejected as long as
the capability is enabled. When this rule is violated due to deactivation or failure of equipment, a
major alarm shall be generated.

Alarms shall be annunciated on workstations that have audible alarming enabled and user is
assigned to an alarmed point’s AOR. Point related operations (including those listed below) shall
be permitted only for points that belong to an AOR assigned to the authorized user and
workstation:

1. Supervisory control
2. Alarm acknowledgement and deletion
3. Alarm inhibition
4. Tagging and removal of a tag
5. Deactivation and activation of points and RTUs
6. Data entry (e.g., limit changes, manual entry, etc.).

6.9 Tagging

The user shall be able to apply a tag to a single point, group of points, or all points in an RTU or
in a Substation (except for “limit override” and “normal state override” tags), to non-telemetered
points, and to calculation points. When a tag has been applied to a point, a tag symbol separate
from the quality code symbol shall be presented next to the tagged point on any display or report
where the point is presented.

All tag information for a point shall be accessible by any System functions and applications
including the calculation function.

6.9.1 Tag Attributes

Each tag type shall have a set of attributes. The administrator shall be able to enable/disable
individual attributes associated with each tag type. As a minimum, the System shall support the
following tag attributes:

1. Inhibit all controls
2. Inhibited close control
3. Inhibited open control
4. Alarm inhibit
5. Event inhibit
6. Limit override
7. Normal state override
8. Scan inhibit

In addition, the administrator shall be able to define the following for each tag type:

9. The tag symbol to be presented
10. The tag precedence

As a minimum, the System shall support up to 16 (sixteen) tag types. There shall be no limit on the number of tags per point. When a point carries multiple tags, the two highest priority tags shall be presented. Any combination of tags shall be supported, including multiple tags of the same type. The combined effect of multiple tags shall be to inhibit a type of function (or multiple types of functions) if it is inhibited by any of the applied tags. The capability for multiple tags shall be provided. The system shall be able to show at least 2 tags on displays. In the case of more than 2 tags on a point, the user shall be able to hover over the tag and see all the tags that are currently on the point.

The System shall provide a facility to allow the administrator to map 3 (three) TASE.2 tags to any of the 16 (sixteen) tags.

The System shall support inheritance tags as follows:

1. Inhibit alarms on child points
2. If the user untags the point and the point is in the off-normal state, issue an alarm for the point and the child points if the child points are in the off-normal state as well.

6.9.1.1 CONTROL INHIBIT

The control inhibit action shall apply to operator supervisory controls as well as controls initiated by a System function. When an operator attempts a supervisory control action on a tagged point in a direction prohibited by the tag type, the System shall block the control and inform the
operator of the inhibit condition. When a System function attempts a prohibited supervisory control action on a tagged point, the System shall block the control and return an error indication to the function.

6.9.1.2 **ALARM INHIBIT**

The capability for the operator to tag “alarm inhibit” of any alarm limit for any analog points and any integrated accumulation points. When an alarm limit is inhibited, the System shall not raise an alarm for this limit violation. When a status point is tagged “alarm inhibit”, the System shall not raise an alarm for any spontaneous changes in state.

6.9.1.3 **EVENT INHIBIT**

The capability for the administrator to inhibit any event logging for any types of points shall be provided. When a tag with an “event inhibit” attribute is placed on a point, the System shall not raise events for this point. However, the administrator action for putting on and removal of the “event inhibit” attribute must be logged in the Event Summary as a record.

6.9.1.4 **LIMIT OVERRIDE**

The “Limit override” tag is described in Section 5.3.2.2 Alarm Limit Checking.

6.9.1.5 **NORMAL STATE OVERRIDE**

The “Normal state override” tag is described in Section 5.3.3 Status Data Processing.

6.9.1.6 **SCAN INHIBIT**

The operator shall be able to “scan inhibit” an individual point and all the points in an RTU with a single RTU scan inhibit tag.

6.9.2 **Purchaser Tags**

An operator shall be able to place on any controllable device a combination of up to at least 10 (ten) tags of different types of tags. During the user interface configuration knowledge transfer workshop, the Purchaser and Contractor will configure the Purchaser’s tags including the attributes and symbols. The system shall include information tags that shall not impose any
control restrictions on devices, but a comment box with a standard warning message or information shall be displayed when it is selected for controls.

The Purchaser shall be able to define and use graphic icons in lieu of these textual symbols. For devices with several tags, the symbol for the most severe type of tag that presently applies to the device shall be shown.

The capability to place tags on a device from any schematic or tabular display in which it is shown. The operator shall be prompted to enter a comment of up to 1 (one) line that will be shown in the tag summary entry; the operator shall also be able to enter and edit comments later. The capability to remove individual tags from the tag summary displays, station displays, and the world map display shall be provided. The placing and removal of tags shall be permitted only for the devices belonging to categories to which the user is assigned, and these activities shall be recorded as events.

6.9.2.1 AE SPECIFIC REQUIREMENTS (INHERITANCE TAGGING)

The SCADA/EMS shall include inheritance tagging. The user shall be able to place a tag on the parent device and it shall be copied to the child devices.

6.9.2.2 AE SPECIFIC REQUIREMENTS (ICCP TO SCADA TAGGING)

The capability to map tags from ICCP to the SCADA tagging shall be provided.

The capability to transfer and map tags from the SCADA/EMS to the existing ADMS shall be provided.

6.9.3 Tag Groups

Each tag is associated with a tag group. The capability to tag multiple points (or a single point) of different tag types and associate them with one tag group shall be provided. When a tag group is first created, the System shall allow the Operator to enter the tag group name or number and prompt the operator to select tag points, tag types and enter a free form comment of up to 60 (sixty) characters in length. The operation to select points and tag types shall be simple and convenient. The capability for the operator to add or remove a tag, remove tag groups, or modify
the comment after the tag group has been created shall be provided. The operator’s action including the operator’s comment shall be logged in the Event Summary.

### 6.9.4 Tag Summary

A Tag Summary of all active tags on a point shall be conveniently accessible to the operator. The Tag Summary shall indicate for each active tag the date and time the tag was placed on the point, the point identification, operator identification, tag type, and comment. A display of tagged point entries shall be selectable based upon the following sort or search parameters and combinations of these parameters:

1. Tag group number range
2. Tag type
3. Location
4. Point
5. Time period - Both specific time periods and relative time periods (for example, twelve hours prior to the current time) shall be supported.
6. General text.

For any text search, the System shall support wildcard matching.

The capability for the Administrator to create pre-configured filtered Tag Summary displays to show all entries of a specific tag type, for example Alarm Inhibit Summary shall be provided. These displays shall be called up in one single action.

### 6.9.5 Tag Removal

Tag removals for a point or points in a tag group shall be permitted, one at a time, from the Tag Summary or any display showing that tag. When the last tag in a tag group is removed, the tag group shall also be removed. The operator’s action shall be logged in the Event Summary.

Upon a database maintenance operation or regeneration, or a system restart, all tag information shall remain unchanged.
6.10 Event and Alarm Management

6.10.1 Events

The following occurrences shall be processed as events:

1. All changes of status points resulting from supervisory control commands from the SCADA/EMS.
2. Operator’s actions including, but not limited to, the following:
   2.1. User and workstation log on/off
   2.2. Changing of user and workstation modes and AORs
   2.3. Supervisory control
   2.4. Tagging and removal of tags
   2.5. Alarm acknowledgement and deletion
   2.6. Data entry in the real-time or historical database
   2.7. Deactivation and activation of points, RTUs, data links, and audible alarming
   2.8. Alarm inhibition and enabling
   2.9. Manual fail-over or restart
3. Events declared by application programs
4. Other conditions that may be specifically called out in these specifications.

When an event occurs, an entry shall be made in an Alarms and Events (A&E) Summary and file.

6.10.1.1 AE SPECIFIC REQUIREMENT (EMAIL CAPABILITY)

1. The system shall include an email capability that allows an Administrator or user to define conditions which will send an email when the conditions occur.
2. Any analog violation or status point change event shall be emailed through this mechanism.

6.10.2 Alarms

6.10.2.1 DEFINITION OF ALARMS

The following occurrences shall be processed as alarms:

1. Un-commanded changes of state of status points.
2. Limit crossing by analog values.
3. Failures of a device to respond to a supervisory control command.
4. When any SCADA/EMS device or major component such as a server, processor software processes, disk drive, or workstation or printer fails, becomes unavailable, or experiences a high rate of unrecoverable errors.
5. Failures of communications with RTUs, with the Purchaser’s SCADA/EMS, or with another external computer system via ICCP failures.
6. When an alarm is declared by an application program.
7. When a numerical value (calculated or telemetered) exceeds a limit in either direction. When processing of a value reveals that several limits have been exceeded since the value had previously been reported, only one alarm shall be reported, and the final limit range shall be shown in the event message. Dead bands shall be provided to eliminate alarms caused by a value fluctuating about a limit.
8. When the utilization of a SCADA/EMS resource exceeds a pre-assigned limit.
9. Other conditions specifically called out elsewhere in these specifications.

The Purchaser shall be permitted to add, delete, or redefine conditions for alarming at any time before the entire Contractor's design documents are approved. The alarm workshop shall be used to define the conditions for alarming.

The capability to assign points and specific alarm conditions to major and minor alarms shall be provided. So, for instance, the capability to define the excursion of a value of an analog value outside the operational limits as a minor alarm and exceeding of the emergency limits as major alarms shall be provided.

6.10.2.2 “RETURN TO NORMAL ALARM” FLAG

Each database point shall have a Return to Normal Alarm flag. When this flag is set, then all un-commanded changes (state changes for status points, and limit crossings for analog points) shall be alarmed. When the flag is not set, then return to a normal state (when a status point returns to the state defined in the RTDB defined as Normal, or when an analog value returns within the first set of limits) shall always be processed as an event. For status points for which no Normal state is defined, all un-commanded changes shall always be processed as alarms.
6.10.3 **Alarm and Event Processing**

6.10.3.1 **ALARM MANAGEMENT RESPONSIBILITIES**

Alarms shall be annunciated and their handling (acknowledgement, deletion, etc.) shall be permitted only by users and workstations that have the assigned AOR of the alarmed point.

6.10.3.2 **ALARM AND EVENT REPORTING**

The following shall occur when an alarm is detected:

1. An audible tone shall sound at user’s workstations that are assigned to the point’s AOR or to the alarming application. The Administrator shall be able to define which alarm priorities have audible alarms as well as the workstations have audible alarming enabled.
2. The visual representation of the point in alarm (the status symbol, or the numerical value) shall flash at user’s workstations that are assigned to the point’s AOR or to the alarming application.
3. If the point going into or out of alarm is represented on the user’s workstations, then the Overview Displays shall be changed accordingly.
4. An entry for the point shall appear on appropriate Alarm Summary displays.
5. An entry shall be made in the Alarm and Event (A&E) summary and file.
6. Alarm messages according to the power system shall be copied, when they are entered into the A&E file, to the SCADA/EMS Web Server System.
7. Only one alarm per point shall be shown on the Alarm Summary which shows the latest alarm (e.g., if a breaker closes and generates an alarm and then it trips again, only the trip alarm shall be shown in the Alarm Summary but both alarms shall be in the Events Summary).
8. Different and customizable alarm tones shall be provided.

6.10.3.3 **ALARM PRIORITIES**

The capability to assign up to 16 alarm priorities shall be provided. For the sake of flexibility in altering the alarm priorities that are assigned to various types of occurrences the following scheme shall be provided: Using database generating and editing procedures, it shall be possible to assign one of 16 alarm priorities to every un-commanded change of state of a status point.
(e.g., different levels to a breaker opening and closing), to each crossing of every analog value out of or back into limit range, and to every alarm condition including alarms generated by application programs. From a supervisor or maintenance workstation, the capability to assign a priority from which and the alarms below the priority can be suppressed shall be provided. Such reassignment of alarm priorities shall be recorded as events, with the range of non-suppressed alarm levels shown in the event message. The capability to assign different audible tones and colors by priority shall be provided.

6.10.3.4 CONDITIONAL ALARMS

The capability to define in the RTDB alarms as being conditional on the value (state or limit range) of other points or on the logical relationship among several other points shall be provided. This is illustrated by the following examples.

“Conditional” alarms shall be evaluated and declared only after up-to-date data has been retrieved for all the points on which the alarms depend. Evaluation of conditional alarms shall be designed for asynchronous data acquisition, i.e., the evaluation shall not rely on the data used for the evaluation being received in a particular order.

In addition, when manual supervisory control action is taken which affects a primary device, dependent alarms shall be suppressed. For example, if the operator commands a breaker to open, then alarms shall not be generated when the directly dependent analog quantities (such as line current, real power, and reactive power) go below their low limits.

Disabling/enabling of conditional alarming shall be permitted from authorized types of workstations. A Conditional Alarming Disabled indicator shall appear in the Chronological Alarm Summary displays when conditional alarming is disabled.

6.10.3.5 ALARM TONE

When an alarm occurs, an audible tone shall sound at each workstation that has the permissions to handle the condition. A tone generation function shall provide a variety of tones:
1. A distinct tone shall be assigned to each alarm priority but every alarm priority shall not be required to have a tone. If an audible alarm is already sounding when a higher priority alarm is generated for the same point, the tone shall change to that of the higher priority alarm.

2. The capability to choose different sets of tones for each workstation or function (e.g., one tone for a Transmission Operator priority 1 alarm and a different tone for a Distribution Operator priority 1 alarm).

The tones for each priority at each workstation as well as the number of times that an audible alarm is repeated and the periodicity of its repeat shall be selectable from supervisor and maintenance workstations.

Users shall be able to silence the tone on their workstation by clicking a “Silence” pushbutton in the main toolbar or by pressing a “Silence” keyboard shortcut. That workstation’s alarm tone shall be silenced until the next new alarm is received.

**6.10.3.6 ALARM INHIBITION**

Operators shall be able to inhibit alarm processing for any point. When a point is alarm-inhibited it shall be processed as usual, and analog points shall continue to be shown in the color (or other characteristic) that corresponds to their limits range, however no alarm conditions associated with the point shall be reported. This capability is intended primarily to prevent nuisance alarms from points which are under maintenance or intermittent. The points that are alarm inhibited shall be shown on the Alarm Inhibit Summary. The capability to enter a comment when alarm-inhibiting the point shall be provided.

**6.10.3.7 ACKNOWLEDGMENT AND DELETION OF ALARMS**

Operators shall be able to acknowledge alarms that are associated with their AORs. The capability to acknowledge individual alarms from any display on which the alarmed point is shown shall be provided. On Alarm Summary displays, the capability to use the mouse or keyboard to select individual alarms or blocks of alarms for acknowledgement and for deletion from the summary shall be provided. Deletion shall be permitted only for previously acknowledged alarms. When an alarm is acknowledged, its visual representation shall no longer flash at user workstations and the Overview Displays shall be changed accordingly.
For points that have multiple AORs, each user with an assigned AOR for the point shall need to acknowledge the alarm before it stops flashing and before it can be deleted.

6.10.3.8 **ALARM LOCATE**

The user shall be able to navigate from the Alarm Summary Display to:

1. The schematic display that presents the point, in the case of alarms on electrical network points.
2. A display that is associated with the alarm condition, in the case of non-point associated alarms. For example, “locating” an alarm indicating that the State Estimator failed to converge would call up a State Estimator display that presents State Estimator convergence information.

6.10.4 **Alarm Summaries**

Operators shall be able to call up an Alarm Summary display. The capability to sort, search, and filter the alarm summary display at least by substation, RTU, AOR, point names/descriptions, message, time, and priorities shall be provided. Alarm display attributes such as the color of the alarm priority shall be configurable. The capability to use wildcards when searching the Alarm Summary displays shall be provided.

Each of these summary displays shall include a toolbar with pushbuttons from which the other summaries can be called. In addition, each of these summary displays will include functionality to navigate to the schematic display and position to the location (or device) where the active alarm is present.

The capability to export the alarms shall be provided.

6.10.4.1 **SUMMARY STRUCTURE**

Alarm Summary displays shall be queries-based. Entries in the alarm summaries shall be in inverse-chronological order, with the most recent alarms appearing at the top of the summary. When an Alarm Summary display is called, the start of the list, which includes the most recent alarms, shall be shown, and it shall be possible to reach any part of the display using the scroll
bar and/or Page Up/Down buttons. An Alarm Summary display shall show only one entry for any point in alarm, with the latest alarm state and the time that the point entered that state.

The number of display pages shall vary depending on the number required to hold all the entries to be displayed. The alarm record shall flash in entries for unacknowledged alarms on Alarm Summary displays. When the operator acknowledges alarms, the alarm record shall stop flashing.

6.10.4.2 CUSTOMIZATION OF THE SUMMARY

By default, when a user calls up an Alarm Summary display, it shall show only those alarms that belong to the categories that are assigned to the user and workstation. These shall be shown system-wide. Fast procedures shall however be provided for the user to request alarm summaries for:

1. Any combination of categories and functions – Such customization shall be accomplished through selection from a list of categories and functions (pre-defined filters), and shall not require typing.
2. A specific substation – Such customization of Alarm Summary displays shall be accomplished through selection of the summary by any of the following methods:
   2.1. Clicking the symbol of that substation on a world map
   2.2. Pressing a pushbutton in a schematic diagram of the substation
   2.3. When a station name entered before the Alarm Summary key or a corresponding pushbutton is pushed/clicked by the operator.

Users shall also be able to request customization of alarm summaries by means of the selection capabilities.

6.10.4.3 ACKNOWLEDGEMENT AND DELETION OF ALARMS

A user shall be able to select single alarms or blocks of alarms for acknowledgment. Deletion shall be permitted only after an alarm has been acknowledged.
6.10.5  **Alarm and Event (A&E) Messages Format**

All entries in alarm summaries and in the Alarm and Event (A&E) file shall be a maximum 1 (one) monitor line in length and shall be identical in both the monitor display version and when printed. No unduly cryptic abbreviations shall be used in alarm and A&E messages. An alarm and event message shall contain the following information, as applicable:

1. Class (required only for A&E messages) – a one-letter designation defining the category of alarm or event:
   1.1. “A” for alarm
   1.2. “O” for operator initiated event
   1.3. “N” for return to normal event
   1.4. “M” (Message) for “Text Events”

2. Alarm Priority (for alarm message), indicated through color and a symbol

3. Date and time of the detection of the condition, or of the user’s action
   3.1. Date shall be in the format MM/DD/YYYY
   3.2. Time shall be in the format HH:MM:SS

4. The operator ID and workstation ID (for user-initiated events)

5. Location (e.g., substation ID, “Control Center”) or application

6. Point Name

7. Point Descriptor

8. AOR

9. Alarm or event text.

The following requirements shall be met:

10. For analog limit violations, both alarm and return to normal, the alarm text shall also include the measurement and the name of the limit that was crossed, and in which direction.

11. For status changes, in direction, the alarm or event text shall include the new state. For alarms/events of multiple state transitions, the alarm text shall include all transient states as well as the final state (e.g., for a reclosing operation followed by a lock-out, the text shall be “TRIP-CLOSE-TRIP”.)
12. The normal and abnormal state names shall be shown in different colors for each type of point.

13. For operator generated text events, the event message shall include operator ID, date and time, and free format text.

The exact format of the alarm and event messages shall be subject to approval by the Purchaser.

6.10.6 **Alarm and Event (A&E) Records**

Alarms and events shall be recorded in an Alarm and Event (A&E) file, and shall be available for viewing, exporting, and printing on demand.

6.10.6.1 **ALARM AND EVENT (A&E) FILE**

An entry shall be made for every alarm and every event in a chronologically ordered A&E file. Occurrences, such as un-commanded status changes and limit violations, which would normally be annunciated as alarms shall be recorded as events if alarming is suppressed due to alarm inhibition, or any other reason. In contrast to the Alarm Summary, the A&E file shall have a time-tagged entry for every occurrence, rather than just the most recent alarm or event for a point or function.

The A&E file shall be part of the historical database, and entries shall be kept on-line for the period specified for historical data.

The operator shall be able to view and export the A&E file and to print it in whole or in part.

6.10.6.2 **SELECTION OF ALARMS AND EVENTS FOR VIEWING, EXPORTING, AND PRINTING**

By default, only alarms and events belonging to the user’s assigned AORs shall be shown when the alarm and event list is viewed. The most recent entries shall be shown when an A&E display is requested, and the rest of the list shall be accessible through scrolling. It shall, however, also be possible to select specific data from the alarms and events list for viewing, exporting, and printing. As a minimum, the selection mechanism shall be by means of SQL queries.

To enable the operator without SQL skills to select alarm and event data for viewing, exporting, and printing, the Contractor shall include in the system pre-defined SQL scripts and an operator
oriented interface for them. The Operator shall be able to select data through pointing and minimal typing, according to the following criteria and combinations thereof:

1. Date and/or time range (before T1; after T2; between T1 and T2; All)
2. Functional areas
3. AORs
4. Alarm priority
5. Alarm substation(s)/locations
6. Point name
7. Point attribute, including limit violation, open state, etc.

6.10.7 Enhanced Alarm Management

Additional features for alarm management shall be provided. Desirable features of the enhanced alarm management function include:

1. Minimization of nuisance alarm messages (for example, repetitive alarms for the same alarm condition)
2. Combining of related alarm messages
3. Highlighting of the most urgent messages
4. Suppression of alarms based on related alarm conditions
5. Evaluation of related alarm conditions to determine the true alarm condition.
6. The capability to define and use parent-child alarming.
7. The capability to enable/disable enhanced alarm management features on a global or individual point basis.

6.11 Display Types

The Contractor shall be responsible for providing all SCADA/EMS displays. The various network diagrams shall include all dynamic linkages to the network elements and devices in the NOM that they represent and shall also include dynamic linkages for the seamless display of SCADA and application data that relates to the relevant elements and devices.
The format and content of each type of display shall be subject to review and approval by the Purchaser, to that end the displays shall be the subject of a specific design task including targeted workshops that shall engage the Purchaser’s input.

As a minimum, the display types and their inherent capabilities described within this section shall be provided. This is not an exhaustive list and the Contractor shall prepare all the displays necessary for the required functions. The Purchaser shall derive the world map and schematic displays from Purchaser’s existing SCADA/EMS display with Contractor’s participation in the display workshop and assistance when Purchaser has technical questions regarding the user interface capabilities and features. The Contractor shall autogenerated the substation one-lines from the network model. The Contractor shall be responsible for the integration of all displays, including those prepared by Purchaser, into the SCADA/EMS.

6.11.1 **Directories Displays**

A hierarchically organized set of lists of displays from which those displays can be selected by clicking on the list shall be provided.

6.11.2 **Power System World Map Display**

At its least magnification (fully zoomed out), the world map shall show all the substations interconnected by the transmission lines. The capability to see the one-line schematic diagram for any substation by zooming in to the substation shall be provided. The capability to get to the lowest magnification level at which the schematic diagram is shown for a substation by selecting the substation shall be provided. Further zooming within the schematic diagrams shall then be possible.

The world maps display shall be scaled to fit the Overview Display on the video wall taking into account resolution and dimensions of the wall board such that the best outcome is achieved.

6.11.3 **Substation Displays**

Substation displays shall consist of one-line diagrams and tabular displays. The substation one-line diagrams shall be auto-generated from the network model or converted from the existing displays. An easy means to link the displays to the SCADA database shall be provided.
Substation tabular displays shall be automatically created by the SCADA/EMS. They shall list all the telemetered and non-telemetered status, analog, and pulse accumulator data points associated with the substation. In the tabular displays, the users are able to search any points by the following conditions: Device name, Type of telemetered or non-telemetered data points (status, analog and pulse accumulator), etc. The capability to sort and filter the substation tabulars shall be provided (e.g., filter telemetered points by numerical order where the numerical order is the scan address). The values of the limits that are currently in use shall be shown, and operators shall be able to change the operational and emergency limits from these displays.

**6.11.4  Point Profile Displays**

An individual display for each RTDB point shall show all the fields of the point, including those that define its attributes, all the limits for all the seasons and temperatures, and current data for the point.

**6.11.5  SOE Displays**

An SOE summary display for each RTDB point associated with each AOR shall be available. The operator shall be able to sort and filter SOE data by substation ID, device name, and time duration occurrence.

**6.11.6  Field Communications Statistics Display**

This display shall show all the communications statistics in such a way that this information is suitable for use for maintenance of the field communications equipment and channels.

At least the following information shall be listed for each RTU and for each communications channel:

1. The total number of scans (or transmissions of unsolicited messages)
2. The number of unsuccessful scans; no reply or replies with checksum errors
3. The percent of good scans = \([(\text{Total Scans} – \text{Failed Scans})/\text{Total Scans}] * 100
4. The number of CRC errors
5. The number of times the RTUs fails.
6. Percent communications load
6.11.7 **Summary Displays**

A set of summary displays, including those listed below shall be provided to list alarms and events as well as data points that are in alarm or in an abnormal state, or have been placed in a special condition by the operator.

1. **Alarm Summaries** – See Section 6.10.4 Alarm Summaries.
2. **Alarm and Event (A&E) Summaries** – For viewing of alarm and event entries; see Section 6.10.6 Alarm and Event (A&E) Records.
3. **Abnormal Summary** – This summary shall be a list of analog points that are outside of the operational limits, and of status points that are not in the state defined as “normal” in the RTDB.
4. **SOE Summary** – This summary shall be a list of Sequence of Event (SOE) information.
5. **Tag Summary** – A list of tagged devices. Each entry shall show the date and time that the tag was placed, the log-on ID of the operator placing the tag, the substation and point name of the tagged device, the type of the tag, and an operator-entered comment. The entries in the Tag Summary shall be ordered chronologically in each substation. Additionally, the Tag Summary display grouped by AOR shall be provided.
6. **Alarm Inhibited Summary** – A list of points for which alarming has been inhibited by users. The entries in the Alarm Inhibited Summary shall be ordered chronologically in each substation.
7. **Suspended Calculation Summary** – A list of calculations for which processing has been suspended.
8. **Estimated Points Summary** – Shows all points for which substitution by estimated values was manually selected. See Section 6.5.1.4 Substitution of Estimated Values for Telemetered Data.
9. **Off-Normal Summary** – This summary shall be a list of devices and values that are not in their normal state. Telemetered, calculated, manually entered value, status, analog, and accumulator data point shall be included. The displays shall show the off-normal data points in the following groups:
10. Status points for which the present telemetered state is different from the normal state stored in the database.
Analog and accumulator points that present telemetered values exceeding alarm limits.

The off-normal status displays shall use dynamic coloring facilities to identify the different conditions associated with the points

1. Off-Scan Summary – This summary shall be a list of points that have been suspended/deactivated from acquisition.
2. Manual Entry Summary – This summary shall be a list of points that have been manually overridden.
3. Limit Override Summary – This summary shall show the points that have their limits overridden.
4. Device Comment Summary – This summary shows the comments for the device.
5. Memo Summary – This summary shows the memos in the system.

Users shall be able to select entries from summaries for viewing and for printing according to the following search keys (as appropriate for each type of summary) and combination thereof: (1) time range, (2) substation, and (3) area(s) of responsibility.

6.11.8 Bulletin Board Displays

A textual display shall be included on which any user may make multi-line textual entries. The display will be used to convey information among users, and from one shift to another. The entries on the Bulletin Board shall be ordered chronologically. When a user makes an entry, or updates an entry, the system shall automatically enter the time, date, and user ID. An entry made by a user may be modified or deleted only by that user or by a supervisor. The Bulletin Board shall be separated by each AOR.

6.11.9 Memos

The capability to add memos (“post-it” type notes) shall be provided. The capability to view the memo by hovering over the memo shall be provided. The user who entered the memo and the date the memo was entered shall be included in the memo.
6.11.10  **Station Comments Displays**

The capability to add comments related to station shall be provided. A visual indication shall be provided on the station displays to indicate that station comments are available for the station.

6.11.11  **Operator Log**

The system shall include an Operator Log.

6.11.12  **System Displays**

The following System displays shall be included as a minimum.

6.11.12.1  **USER ASSIGNMENTS DISPLAYS**

This display shall allow an authorized user to view and temporarily assign the functional areas for each user. The capability to view and make all the assignments for a user from one display without paging shall be provided. This display is used for the management of user AORs.

6.11.12.2  **SYSTEM CONFIGURATION CONTROL DISPLAYS**

This display shall make it possible to view and control the configuration and status (on-line/backup and on/failed) of the various components of the SCADA/EMS. The system shall prevent a user from taking the action of turning the primary system from active to off-line. A graphic presentation of SCADA/EMS configurations and status is required, and it shall be possible to control the configuration and manually initiate equipment and SCADA/EMS failover from this display. This display shall show all the components in the SCADA/EMS configuration.

6.11.12.3  **WORKSTATION ASSIGNMENT DISPLAYS**

This display shall be provided to allow the Administrators to enable/disable the audible alarms by priority for the workstations.

6.11.12.4  **FIELD EQUIPMENT DISPLAYS**

Displays shall be provided to monitor the status and performance and to manage the RTUs and other field devices, including devices and subsystems that are provided by the Purchaser. In
addition, the RTU Communication display shall be provided as associated with the overall Purchaser network configuration.

6.11.12.5 **COMMUNICATION LINK CONTROL DISPLAYS**

These displays shall be provided for each SCADA/EMS link to external systems. These displays shall allow the users to: (1) view the status of the link and (2) view available link communications statistics such as downtime, link availability, and data availability. The Administrators and authorized users shall be able to (1) deactivate and activate the link, (2) set operational parameters for the link, and (3) run diagnostics that are available for the link. Moreover, the backup of controls, monitoring of devices and measurement between 2 (two) control centers in Section 2.4 Redundant System Design Requirements, shall be taken into consideration.

6.11.12.6 **SYSTEM MAINTENANCE DISPLAYS**

System maintenance displays shall show information that is needed for maintenance and troubleshooting of the SCADA/EMS, such as the disk usage, network usage, system memory, utilization for each processor, system I/O statistics, subsystem status (which device is processing which subsystem), database errors, etc. In particular, information which is unavailable from the OEM diagnostic and resource monitoring tools shall be included.

6.11.13 **Network Analysis Displays**

Displays shall be supplied to support the use of the Network Analysis Applications. These displays shall have a common look and feel from one application to the next such that they apply consistent logic in the configuration, execution, and display of results.

6.12 **Switching Order Management**

The EMS shall have the same Switching Management functionality as described for the optional ADMS, Section 19.7.1 Switching Order Management, with the exception that the customer related functionality described in Section 19.7.6 Planned Customer Outages – Distribution.
7 Network Analysis .................................................................................................................. 201

7.1 Network Operations Model .............................................................................................. 201

7.1.1 NOM Overview ......................................................................................................... 202

7.1.2 NOM Related Features ............................................................................................ 205

7.1.3 Modeling Terminology .............................................................................................. 206

7.1.4 Database Conversion ................................................................................................. 207

7.2 Network Analysis User Interface ..................................................................................... 207

7.3 Required Features .......................................................................................................... 212

7.4 Real-Time Network Analysis .......................................................................................... 212

7.4.1 RTS Execution Control ............................................................................................ 213

7.4.2 RTS Display .............................................................................................................. 214

7.4.3 Real-Time Model Update ......................................................................................... 216

7.5 Study Network Analysis .................................................................................................. 218

7.5.1 Study Model Update ............................................................................................... 219

7.5.2 Study MU Sub-Functions ......................................................................................... 220

7.6 Generation Forecast (Option) ......................................................................................... 221

7.7 Bus Load Forecast ......................................................................................................... 222

7.7.1 Functional Requirements .......................................................................................... 222

7.7.1.1 AE Specific requirements (Load forecast retrieval) ............................................ 224

7.7.2 Input Data ................................................................................................................ 224

7.7.3 BLF User Interface .................................................................................................... 224

7.8 State Estimator .............................................................................................................. 225

7.8.1 Pre-processing Consistency Checks ......................................................................... 225

7.8.2 Functional Requirements .......................................................................................... 225

7.8.3 Input Data ................................................................................................................ 226
7.8.4  Output Data ........................................................................................................ 227
7.8.5  SE Quality Indexes .......................................................................................... 227
7.8.6  SE User Interface ............................................................................................. 228
7.9   Network Parameter Adaptation (NPA) ................................................................. 228
      7.9.1  Functional Requirements ........................................................................... 229
      7.9.2  NPA User Interface .................................................................................... 230
7.10  Power Flow (PF) ............................................................................................... 230
      7.10.1 Capabilities ................................................................................................ 231
      7.10.2 Calculations ................................................................................................ 232
      7.10.3 PF User Interface ....................................................................................... 232
      7.10.4 Execution Procedures ............................................................................... 233
      7.10.5 Power Flow Study Comparisons ............................................................... 234
      7.10.6 Pre-Switching Power Flow ......................................................................... 234
7.11  Contingency Analysis ....................................................................................... 235
      7.11.1 Dynamic Contingency Case Re-definition ................................................ 236
      7.11.2 Remedial Action Scheme Simulation ......................................................... 237
      7.11.3 Contingency Screening .............................................................................. 238
      7.11.4 Ranking ..................................................................................................... 239
      7.11.5 Full Contingency Analysis ........................................................................ 240
      7.11.6 Limit Set ..................................................................................................... 241
      7.11.7 CA User Interface ...................................................................................... 241
      7.11.8 Remedial Action (Option) ......................................................................... 242
7.12  Short-Circuit Analysis (Option) ......................................................................... 242
7.13  Voltage Stability Analysis (Option) .................................................................. 243
7  NETWORK ANALYSIS

The Contractor shall provide a suite of real-time and study Network Analysis functions fully integrated with other System functions as necessary to support the Purchaser’s power system operations and planning. The Network Analysis functions shall meet the performance requirements and accommodate the power system sizing details specified in Section 3.1 System Sizing Requirements.

The EMS users will be the primary users of the real-time and study Network Analysis functions. Other users supporting daily operational planning and analysis may also utilize the study Network Analysis functions.

The Network Analysis functions shall allow users to visualize the state of the power system in real-time and study mode and take whatever corrective and preventive actions may be necessary to ensure that all individual elements of the power system are operated within the Purchaser’s overall reliability criteria. Some of the Purchaser’s criteria for reliable operation are listed as follows:

1. Equipment loading must respect continuous thermal limits.
2. Voltage on equipment must respect corresponding voltage limits.
3. Loading of equipment following credible contingencies must lie within time-limited thermal limits.
4. Voltage on equipment following credible contingencies must lie within specified limits.

All Network Analysis functions shall be developed from mature baseline software as may be necessary to meet the Purchaser’s specific requirements. Both SCADA functions and all Network Analysis functions shall use the same one-line diagrams.

7.1  Network Operations Model

To support the Network Analysis functions, the EMS shall include a Network Operations Model (NOM) built and maintained from the Purchaser’s power system data using Contractor software tools provided with the EMS.
The necessary software shall convert the Purchaser’s power system data into a common NOM format that can be accessed by the EMS applications and other third-party power system analysis products.

The NOM shall serve as a central interface and information resource by representing the installed and operating state of the power system, i.e., the Purchaser’s power system augmented by relevant parts of other utility power systems. Thus, the network that will be analyzed by the Network Analysis functions shall consist of:

1. The Purchaser’s power system and reliability footprint.
2. Those parts of the external power system owned and operated by other utilities that must be modelled to ensure the results from execution of the Network Analysis functions can be fully trusted as a true representation of the power system’s behavior under all feasible operating conditions. This shall include very accurate actual or equivalent modelling of external generation plants.

The NOM shall be closely integrated with, or shall incorporate, the EMS Real Time Data Base (RTDB). The source of data shall be transparent to EMS users. All Network Analysis functions shall share common alarm and event generation interfaces and systems with specific behavior being configured via the NOM. The NOM shall support the concept of assignment of data to areas of responsibility in an identical manner to that described for the RTDB in Section 5.2.3 Areas of Responsibility.

7.1.1 NOM Overview

As a minimum, the NOM shall provide:

1. A core connectivity model of the electrically connected elements of the power system and its associated generating units and loads.
2. Models of generating units having characteristics defined by their capability curves and their Automatic Voltage Regulator (AVR) actions. The MVAr limits at each MW value shall be calculated from the MVAr capability curves. The MVAr capability characteristics (MVAr limit versus MW output) shall be modeled with piecewise linear curves. Unit auxiliary load
shall be modeled as a function of unit outputs. Selected generators shall be switched between voltage control and fixed var control to maintain voltage or var limits.

3. Equivalent units at the end of the network model acting as a source or a sink.

4. Synchronous condenser models, both dedicated and generator motoring. Selected synchronous condensers shall be switched between voltage control and fixed var control to maintain voltage or var limits.

5. Models of Independent Power Producer (IPP) plant including Small Power Producer (SPP) and Very Small Power Producer (VSPP) distributed generation resources such as PV-solar and wind-turbine renewable energy plant.

6. Data related to the nature of loads including their load type, such as conforming or non-conforming, and their daily load profiles. Conforming loads shall be scalable to Control Area loads. Where necessary, fixed loads shall be enterable.

7. Modelling information for electrical devices and loads such as impedance and admittance values. This shall include the data used to represent power system elements such as generators, substation buses, power transformers including load tap changing (LTC) transformers, phase shifters, reactors, circuit breakers, disconnecting switches, overhead lines, underground cables, voltage regulators, var controllers, switched capacitor banks, loads (with parameterized voltage dependencies), and automatic transfer switches. In this respect, the data shall also include the unit capability curves as used to represent generators and the impedances corresponding to changes in transformer tap positions.

8. Support for temporal attributes allowing elements of the model to be represented in a planned, decommissioned, or in-service state.

9. AC transmission line models (including low and zero-impedance connectors). These lines shall be modeled as unbalanced pi-models or other means to handle separate series and shunt devices at either or both ends of a line. Sectionalized lines, with each section as a separate line or line segment. Lines with R/X ratios over a range of 0 to 2.5.

10. Explicit models of zero-impedance lines. Flows through zero impedance connections shall be calculated and included in the solution output with associated flows and voltages.

11. Transformer, including two and three winding transformer, models. Load tap changers (LTC) may be included with any winding.
12. A parallel LTC control model, where the tap position of the “follower” transformer is set the same as the “master” transformer tap position. Parallel operation shall be enabled and disabled by user action for each transformer.

13. Phase shifter transformers.

14. Shunt capacitors and reactors, series capacitors and reactors, and FACTS devices such as Static Var Compensators (SVCs) and STATCOMs. The capability to model a voltage setpoint for SVCs shall be provided.

15. Support for modeling based on Siemens Power Technologies International (PTI) names and numbers for buses, loads, generators, transformers, zones, and areas even though the PSS/E bus names and numbers may be different than the bus names defined in the network model database in the EMS.

16. Ability to represent network islanding conditions.

17. Support for configuration of remedial action schemes and special protection schemes.


19. Power system measurements and results values. The power system model shall correctly map field “measurements” and results (such as State Estimator results) to corresponding branches, buses, and devices. As a minimum, mapping shall be provided for the following values:

   19.1. Branch real and reactive power flows, where these values can be associated with any terminal of the branch.

   19.2. Bus voltages and phase angles. Buses may have more than one voltage measurement. Where a bus consists of multiple segments with bus tie breakers connecting the segments, the model shall identify each voltage measurement with a specific segment such that the voltage measurement is mapped to a specific segment when the bus splits.

   19.3. Switching device status, i.e., open or closed.

   19.4. Transformer tap positions.

   19.5. Device voltage or reactive setpoints, such as SVC setpoints.

   19.6. Generator real and reactive powers as well as terminal voltage. If generator values are gross, station load shall be computed as a function of the generator gross output, on which basis generator net values shall also be computed and mapped.

   19.7. Reactor and capacitor voltage setpoints.
19.8. Total area loads.

7.1.2 **NOM Related Features**

The Network Analysis functions shall use the NOM as a database employing a common approach for data structures, database access, data editing, data area population, database maintenance, data validation, and error reporting. Information and data that is common among EMS functions shall only be entered once.

In this respect, the following requirements shall be satisfied:

1. When a new database is generated or an existing database is modified, previous savecases (those created prior to the modification) shall not be invalidated or deleted unless requested.
2. Application data that is smoothed over time, such as parameter adaptation data, shall not be lost after a database modification. Upon a database modification, this data shall be processed automatically to make it consistent with the new network model.
3. Any data manually entered by the user shall be viewable via display to allow the user to select which data shall be processed after a change in the network model or the parameters themselves in such a way that these data entries are not lost.
4. The capability to create savecases from both real-time or study Network Analysis executions shall be provided. The user shall be provided with the capability to protect savecases from other users.
5. The capability for multiple users to simultaneously and independently set up savecases and run the study Network Analysis functions shall be provided.
6. The capability to retrieve real-time savecases, to copy them to study savecases, to copy savecases to permanent storage medium, and to reload savecases from permanent storage medium shall be provided.
7. The capability to retain study working areas shall be preserved in the event of a failover.
8. The capability, with appropriate authority, to interactively modify individual network model parameters through displays without requiring a complete database generation shall be provided.
9. The capability to generate and export to other parties the PTI PSS/E data formats from any savecase by means of user interface commands shall be provided. In this respect, the most
recent PSS/E format prior to Pre-FAT along with at least 2 backwards compatible versions shall be supported. The capability to export the contingency database in PTI format shall be provided.

10. The capability to export the network model data including topology information via the Common Information Model (CIM) shall be provided.

11. The capability to generate a network model database from PSS/E power flow formats as well as the CIM for initial database entry shall be provided. The EMS shall also support the capability to import subsequent network model updates from data files in the CIM format. In this respect, the CIM format shall be fully compatible with the latest version utilized by ERCOT.

12. A toolkit for maintenance of the CIM-compliant NOM shall be provided. For details, refer to Section 9 Model and Display Development.

Modifications to the network model shall be applied initially to the QAS for testing purposes. Modifications to the network model will include the associated tabular and one-line diagram displays. After successful completion of the modification process, the Administrator shall be able to import the network model modifications resulting from the QAS to the Production Environment. This shall in no way impact the periodic execution of the Network Analysis Real-Time Sequence (refer to Section 7.4 Real-Time Network Analysis).

7.1.3 **Modeling Terminology**

Within the context of the power system and the Network Analysis functions, the following modeling terminology shall apply:

1. **Internal Network** – Purchaser’s power system.
2. **External Network** – Other utilities’ power systems.
3. **Observable Network or Island** – A portion of the power system for which there are sufficient measurements (actual or pseudo-measurements) available allowing the State Estimator to solve for the island’s voltages and hence power flows. There can be more than one observable island.
4. Unobservable Network or Island – A portion of the power system for which sufficient measurements or pseudo-measurements are not available to make it observable. There can be more than one unobservable island.

Boundaries of observable islands and unobservable islands shall be able to change dynamically depending on the availability of measurements.

In general, all iterative Network Analysis functions shall converge and find a solution for every condition that is physically plausible, even if prolonged power system operation in some conditions, such as overload conditions, is not viable.

7.1.4 Database Conversion

The Contractor shall be responsible for converting/migrating the Purchaser’s existing databases to the Contractor’s system. To support conversion, the Purchaser can provide the network database in CIM or PSS/E format along with SCADA and ICCP mapping details. The input format for all other database items shall be determined during the project’s database workshop. The tools used to import and transform the CIM or PSS/E file from the existing Purchaser system into the new system shall also be provided for Purchaser utilization.

7.2 Network Analysis User Interface

The Network Analysis functions require a highly interactive user interface that shall provide extensive user support. For the functions to be useful, the user interface shall be logical, convenient, and simple to use. The user interface shall include configurable dashboards that enhance the situational awareness for the operators. These dashboards shall show information regarding the power system security as well as the potential contingencies that can create a power system security problem. Additional wide area overview displays shall be provided for enhanced situational awareness and wide area monitoring. The dashboards and wide area overview displays shall take advantage of visualization techniques to show the power system conditions and status.

The user interface for all real-time and study Network Analysis functions shall conform to the user interface requirements in Section 6 User Interface Requirements. Within this context, the general requirements of the user interface are summarized as follows:
1. The Contractor shall provide a full set of displays to support all specified Network Analysis functions.

2. The capability to sort, filter, and search network analysis displays shall be provided as well as the general display capabilities defined in Section 6 User Interface Requirements.

3. The capability to display real-time SCADA and Network Analysis results data simultaneously on the same display shall be provided; however, they shall be distinguished from each other via Purchaser-approved means.

4. Displays shall clearly differentiate between Network Analysis real-time and study modes through color, display heading, and dynamic field indicators. For study mode, the indicators shall clearly identify the individual study case that is being displayed.

5. The Purchaser shall have review rights with respect to the Network Analysis user interface, including all displays, logs, printed outputs, messages, and alarms for baseline displays.

6. Displays shall be available to support all functional capabilities in a convenient manner.

7. The user interface shall allow results to be printed in PDF, bitmaps, png, generic screen shots as well as exported in Excel format to the CEU Environment.

8. There shall be a high degree of consistency among the Network Analysis user interface displays with respect to naming convention, layout, appearance, look and feel, presentation, and user dialogue. Simple execution control procedures shall be provided.

9. Disconnected and open-ended power system equipment shall be identified on all displays and print output.

10. Multiple islands, when they exist, shall be easily identified on one-line diagrams and tabular displays by different attributes associated with the related elements (buses, generators, branches, etc.)

11. All displays, error messages, alarms, logs, and reports shall be designed for use by users and, in this respect, shall be clear and concise. The on-line user help shall be provided for user call-up. The documentation shall show the user the information for the meaning of error messages. Context sensitive help shall be provided.

12. The capability to present Network Analysis input and output details on one-line diagrams and overview displays shall be provided. The capability to provide this capability by using the static and dynamic definitions of the one-line diagrams shall be provided.
13. All input and output shall be in engineering units. The option to display voltages in per unit shall be provided.

14. Displays shall be provided allowing users to easily modify any data, whether telemetered, non-telemetered, calculated, or obtained from a savecase, prior to the execution of any of the Network Analysis functions.

15. Information for schematic displays of the electrical facilities, showing individual elements and interconnections, along with the operating state and other related details.

16. Operations data such as network element status indications, associated statistics, tags, operating limits, set points, power flows, voltages, currents, transformer tap positions, quality codes, alarms.

17. Facility and equipment information such as status, alarms, location and site details, electrical and mechanical design parameters, photographs, contact replacement indices, operating instructions, and maintenance procedures. This information shall be made available by equipment point and click operations on relevant displays and presentation of a drop-down menu allowing the user to select the information of interest.

18. Setup and execution of all Network Analysis functions shall be made as simple as possible through the utilization of interactive, menu-driven execution control displays. The capability to execute individual study Network Analysis functions in an interactive mode with a minimum amount of user input required shall be provided as well as the capability to execute a series of study Network Analysis functions with a single command.

19. The System shall provide the capability to execute study functions without switching the console to a dedicated study mode. The console shall have the ability to operate in both the real-time and study modes simultaneously. Only one mode will be active at any given time. Switching between the two modes through windowing is acceptable.

20. All execution control and output displays of the real-time Network Analysis functions sequence shall show when the real-time data was collected.

21. All functions shall provide indications of execution progress and completion.

22. Each function shall provide messages of error conditions, inconsistent data, or significant events that may occur during execution. For messages related to real-time mode, the messages shall be sent to those consoles with the appropriate assigned area of responsibility. For messages generated from functions running in study mode, the messages shall be sent to
the console from which execution of the function was requested. The messages shall be
understandable by the user and shall be “actionable”, meaning that they shall indicate clearly
what action needs to be taken given the circumstance encountered.

23. Data entry capability shall be provided via both tabular displays and one-line diagrams. Users
shall be able to enter typical power flow inputs, such as individual loads, generation values,
device status values, transformer tap positions, and desired voltages on one-line diagrams for
use by the Network Analysis functions. The user shall also have the capability to change
power system operating limits in study mode. All modified data shall be saved with the
savecase.

24. All displays shall clearly differentiate between metered data and data calculated by the
Network Analysis functions or any other function.

25. Where identical one-line diagrams and tabular displays are used for different functions (e.g.,
Operator Power Flow, State Estimator), it shall only be necessary to build these displays and
specify linkage names once.

26. All equipment shall be displayed via a consistent alphanumeric naming convention used
throughout the EMS. Leading numbers in the names shall be allowed.

27. User-oriented messages related to equipment shall refer to the equipment by substation and
equipment name.

28. Maintenance displays shall be available to provide control of convergence tolerances, step
sizes, and all other parameters affecting execution of the Network Analysis functions.

29. All solution results must be limit checked and violations highlighted by providing separate
tabular displays for each type of violation using standard conventions described in Section 6
User Interface Requirements.

30. Control and monitoring of the Network Analysis functions shall occur at consoles with
appropriate authorization as determined by their operational responsibility assignments.

31. A convergence summary display shall be provided for all iterative functions (e.g., State
Estimator, Contingency Analysis, and Operator Power Flow). Each iteration, this display
shall identify the buses with the largest MW and MVAr mismatches and/or voltage angle and
magnitude changes. In case of a divergent solution, the display shall also provide information
regarding the network area (or buses) where the calculation process is encountering
divergence (or difficulty in solving) to help the user correct the problem.
32. Detailed debug information on an iteration basis shall show, for example, matrix values, bus voltages, and generation outputs. This information shall be available to the user in a readable format for investigating divergent cases and other solution problems. Debug information shall only be generated when specifically requested by the user.

33. The displays associated with the Network Analysis functions, whether tabular displays or one-line diagrams, shall provide context-sensitive help. This feature shall allow access to power system operational procedures and equipment details as well as to information with respect to the Network Analysis functions and their execution.

34. Other specific information shall be provided such as:
   34.1. Summary of split buses, open-ended branches, and de-energized equipment
   34.2. List of equipment in each network island
   34.3. Graphical presentation of islands, split buses, open-ended branches, and de-energized equipment on overview displays and network analysis one-line diagrams.

35. In addition to specifying switch configurations, the capability to place equipment in or out of service or apply contingencies for study purposes without having to operate, for example, the breakers that may connect equipment to a bus shall be provided. Hence, in this respect, it shall be possible to select equipment (e.g., lines, transformers, and generators) by the symbols used to represent them on power system one-line diagrams. The selections shall be executed by operating the appropriate switching devices.

36. Dynamic creation of the bus/branch model displays on a per substation basis. The Dynamic Bus Branch Injection display shall show the following:
   36.1. Real-time and estimated branch flows
   36.2. Real-time and estimated bus voltages
   36.3. Real-time and estimated transformer flows and tap position
   36.4. Real-time and estimated unit generation
   36.5. Real-time and estimated shunt MVar
   36.6. Net Load/Generation Injection at the bus
   36.7. Denote on the display if measurements are disabled or rejected by the applications
   36.8. If a line is in a base-case overload, it shall be dynamically colored to indicate this state.
37. The user shall navigate from bus to bus through hot buttons based on the network model.

7.3 Required Features

The Contractor’s Network Analysis functions shall be designed and integrated for fast and reliable execution and shall support the following specific features:

1. Data checking and verification shall be available beyond the rudimentary reasonability and format checks provided by user interface software.
2. All Network Analysis functions shall provide voltage and var solutions for the open ends of any energized power system branches.
3. For the real-time Network Analysis functions, the same limits used for the limit monitoring of real-time measurements shall apply including their dynamic ratings (refer to Section 5.3.2.3 Dynamic Limits – Transmission Lines and Transformers (AE Specific)). These limits shall also be the default limits for study mode. Otherwise, the user shall have the on-line ability to change such limits when in study mode. This shall include the ability to reset the study mode limits to the real-time limits.
4. All solution constraints shall be user definable.

7.4 Real-Time Network Analysis

In the real-time mode, the Network Analysis functions shall execute in a sequence referred to as the Real-Time Sequence (RTS). The RTS results shall allow the user to visualize the current state of the power system, the potential effect of contingencies, and thereby determine if corrective or preventive control action is necessary. During execution of the RTS, data shall also be generated to support the Network Analysis functions that execute in study mode (refer to Section 7.5, Study Network Analysis).

The real-time Network Analysis functions are named as follows, where they are listed in the order in which they normally execute as a part of the RTS:

1. Real-Time Model Update (MU)
2. State Estimator (SE)
3. Network Parameter Adaptation (NPA)
4. Penalty Factor Calculation (PF)
5. Contingency Analysis (CA)
6. Voltage Stability Analysis (VSA), if option selected by the Purchaser

The capability shall be provided to execute these Network Analysis functions cyclically one after the other. A data set shall be gathered at the start of each RTS so that all functions in the sequence are using a consistent set of input information (e.g., for a given sequence, CA shall use the same network model used by SE).

**7.4.1 RTS Execution Control**

Three methods shall be provided to control the execution of the Real-Time Sequence:

1. Time Triggers – The RTS shall be scheduled for periodic initiation using time triggers. Separate time triggers shall be provided for each application. Time triggers shall be monitored. Missed periodic triggers shall be recorded as events except when reset by event or demand triggers. The Administrator shall be capable of changing the time triggers.

2. Event Triggers – When a status change event is detected by the System, the RTS shall be initiated after a short delay (typically 10-20 seconds, adjustable). This delay shall allow acquisition of status and analog data corresponding to the post-event power system conditions. The capability to define event triggers as a logical function of one or more user-defined switching elements and analog points exceeding a pre-specified threshold shall be provided. Event triggers shall be recorded as events.

3. Demand Triggers – A manual trigger shall cause any sequence in progress to stop and a new sequence to start. No other triggers shall be initiated if a Real-Time Sequence initiated by a demand trigger is already active. Demand triggers shall be recorded as events.

The initial periodicity requirements for the real-time Network Analysis functions are defined in the performance tables of Section 3 Capacity and Performance. The capability for the Administrator to change the periodicity of any RTS Network Analysis function on-line using a user-oriented display shall be provided.

Users shall have the ability to initiate or cancel executions of the Real-Time Sequence at any time. A Real-Time Sequence execution control display shall be provided, which shall show which function is executing, which has completed, and what error may have been encountered. If
the RTS is canceled, the execution shall stop as soon as possible and all network data that is displayed in tabular or single line displays shall remain at the values of the last valid solution. No database areas shall be corrupted with inconsistent data.

The capability to enable/disable individual applications within the sequence shall be provided.

The sequence shall execute downstream applications including CA when the SE solves but does not meet the tolerances set by the user. In addition, in a multiple island situation, if one or more of the islands fails to converge then the downstream applications shall execute on the island(s) that converged.

Alarm and event processing for state estimated data shall be the same as for real-time data. Alarms for state estimated data, however, shall not be repeated. Alarms related to state estimated data shall be distinguished on Alarm Summaries with a different attribute. The capability to inhibit alarming for state estimated data, both globally and on a per-point basis shall be provided.

The capability to automatically collect data after every execution of a Network Analysis function for which collection is defined shall be provided. Results from the real-time Network Analysis functions shall be reconstructed using the telemetered data stored by the Information Storage and Retrieval function (refer to Section 3 Capacity and Performance) for a specific collection period. Databases and displays for old network models shall be archived with the time in use and retrievable for result reconstruction. The capability to extract results shall be provided via SQL, ODBC, or an API.

The RTS shall have a savecase capability. In this respect, savecases and cases for export in PSS/E format shall be saved automatically at an Administrator defined periodic interval (initially, as defined in Section 3 Capacity and Performance). If the RTS aborts, the valid models of the last run shall be stored as the savecase.

**7.4.2 RTS Display**

A display shall provide user control over the execution frequency of all functions comprising the Real-Time Sequence.
The RTS display shall allow the user to see the run-time status of each function comprising a Real-Time Sequence (e.g., ACTIVE, DONE, ABORTED).

The following RTS summary information shall also be displayed:

1. Start and finish time of the most recent RTS execution.
2. Start and finish time of the most recent real-time execution of all enabled applications.
3. Next scheduled execution time for each application.
4. The application and solution status for each application. Visual indication shall be provided to show the state of each application (e.g., disabled, running, canceled, etc.).
5. The number of power system branch overloads detected by the most recent SE execution shown in descending order of percent overload. Navigation to power system branch overload displays directly from this display shall be supported.
6. The number of bus voltage violations detected by the execution of SE shown in descending order of percent voltage violation. Navigation to bus voltage violation displays directly from this display shall be supported.
7. The number of generator units at or beyond their MVAr limits. Navigation to generator unit displays directly from this display shall be supported.
8. The number of new abnormal measurements pending since the last execution of SE. Navigation to abnormal measurement pending displays directly from this display shall be supported.
9. The number of extremely anomalous measurements detected by the last execution of SE, i.e., all anomalous measurements beyond a $\pm 3\sigma$ standard deviation. Navigation to anomalous displays directly from this display shall be supported.
10. The number of power system islands corresponding to the current real-time conditions. Navigation to power system island displays directly from this display shall be supported.
11. The number of devices with a change in status since the previous execution of the Real-Time Sequence. Navigation to device change displays from this display shall be supported.
12. Total power system load and losses.

Display entry of all relevant RTS control parameters as well as selection of RTS execution control points (e.g., demand triggers, periodic triggers, etc.) shall be provided.
RTS information pertaining to its last periodic run and last event run shall be displayed.

7.4.3 **Real-Time Model Update**

The Real-Time Model Update (MU) function shall be responsible for establishing the bus-oriented model of the power system and all other data used by the real-time Network Analysis functions. Thus, as a minimum, the function shall result in completion of the following steps:

1. Retrieval of telemetered, calculated, default, and manually entered status data from NOM, and use of this data to build the real-time bus-oriented model of the power system.
2. Retrieval of telemetered, calculated, and manually entered analog data from NOM for use by the State Estimator function.

Within this context, the user shall be able to enable or disable retrieval of the calculated values as well as override the status and analog values retrieved.

The function shall also determine the availability of controlling devices and associated schemes such as:

1. Switchable reactive elements (e.g., capacitor banks)
2. LTC voltage controllers
3. LTC blocking schemes (e.g., the blocking of voltage regulation when voltage falls outside a specified limit)

Such availability information shall be determined from control tag status, mode of operation data, and user entered availability status.

In addition, the function shall be capable of providing power system data for the RTS functions. For example, if switch positions are not determined from telemetry, they shall be determined from calculations based on:

1. The reactive support that the bus requires to maintain voltage within the allowable bus voltage range.
2. The results of tracking the changes of the reactive power flow for each station in which the locally controlled reactive devices are located.
To determine these positions, the following information may be used:

1. Bus voltage high and low limits (user-adjustable)
2. Solved bus voltages from the previous execution of the State Estimator
3. Telemetered reactive power flows.

For use by the other real-time Network Analysis functions comprising the RTS, the estimated switch positions shall overwrite database default positions, but only when telemetered positions are unavailable.

As another example, if the position of an LTC is not defined based on telemetry, it shall be calculated based on the following data:

1. Telemetered voltages, power flow, and transformer parameters
2. LTC controller settings and tags
3. Desired bus voltage

When a status has changed in a particular station, the real-time bus model shall be reconstructed for that station.

The status retrieved by the Real-Time MU function shall be compared with the previous real-time status on a station-by-station basis and a list of those stations where differences occur shall be displayed.

The function shall process each station independently. The resulting station model shall be stored in the real-time NOM, replacing the old model for that station.

There shall be the capability to manually configure the station topology. This shall include the ability to change the status of the following devices where applicable:

1. Circuit breakers
2. Capacitors
3. Lines
4. Loads
5. Phase-shifters
6. Transformers
7. LTC positions

7.5 Study Network Analysis

In study mode, the following Network Analysis functions shall be executed on user demand to analyze current, past, and future power system conditions:

1. Study Model Update (MU)
2. Power Flow (PF)
3. State Estimator (SE)
4. Contingency Analysis (CA)
5. Voltage Stability Analysis (VSA) option, if selected by Purchaser
6. Short Circuit Analysis option, if selected by Purchaser.

The study Network Analysis functions shall work together as an integrated set of functions. It shall be possible to execute a sequence of study functions with a single command. The exchange of data among functions in a study sequence shall be transparent to the user. General-purpose tools shall be available for sequencing and executing the study functions.

Users shall have the capability to easily initiate or cancel studies at any time. A study sequence execution control display shall be provided, which shall allow the user to control study setup, sequencing, and execution, and which shall show study completion indications as well as the occurrence of error conditions. If a study is canceled, the execution shall stop as soon as possible and no database areas shall be corrupted with inconsistent data. A canceled study shall be re-executable with no adverse effect on the results.

All study Network Analysis functions that provide functionality similar to the real-time Network Analysis functions shall be based on the same algorithms, provide the same features, and use an identical user interface as the real-time versions, except where noted otherwise. The control of each study function, however, shall be totally independent of the real-time version, and each study function shall have execution and tuning parameters that can be adjusted independently. The study Network Analysis functions shall not generate any alarms due to detected violations or solution failures; these types of conditions shall be available as solution results and diagnostic displays.
Multiple users shall be capable of executing the study Network Analysis functions simultaneously and independently. Each user shall have an individual working area, which shall be used as a temporary location to gather information needed to run a study, modify the data as needed to represent the desired study conditions, and temporarily hold the study results. Each working area shall be able to support multiple temporary savecases. Modifications made by a user in the user's working area shall not affect the source of data or any other user's working area. Interaction between users shall only be through permanent savecases. The capability for multiple users to simultaneously prepare input cases, execute functions, and examine the output data shall be provided. Local temporary savecases shall be saved to or retrieved from permanent savecases.

Savecases shall contain all information needed to describe the power system at the time it is being studied. This includes not only data normally considered as dynamic, such as system load, switching device status, and generating unit limits, but also the full definition of the network model such as power system connectivity and electrical characteristics. Savecase information shall be sufficient to execute a study for a previous network model and generation schedule even after a database change of any of this data.

Savecases shall be accessible by all users. A locking mechanism shall be provided to prevent users from inadvertently purging, overwriting, or modifying specific savecases.

7.5.1  **Study Model Update**

The Study Model Update (MU) function shall build a bus-oriented model of the power system to support the study Network Analysis functions. Study MU shall also be used for power system connectivity presentations on study Network Analysis one-line and overview diagrams and other displays.

The capability shall be provided for Study MU to build the bus-oriented model from a base case made available from:

1. Most recent State Estimator solution
2. Operator Power Flow (PF) savecases
3. State Estimator savecases
4. Real-time SCADA data 
5. Historical SCADA data

The Study MU function shall be executed as part of an Operator Power Flow execution. A mode of operation shall be available in which Study MU simply checks a retrieved study case to ensure that all network model processing needed to execute a study has been completed.

7.5.2 Study MU Sub-Functions

For studies that are initialized from current real-time conditions or State Estimator results and conducted for the current date and time, or initialized from a State Estimator savecase and then conducted for the savecase date and time, all data shall normally be left unchanged.

Otherwise, in building the required bus-oriented model for a user specified date and time, the Study MU shall be supported by data derived from the Generation Forecast, Bus Load Forecast, and Network Parameter Adaptation functions (refer below to Section 7.6 Generation Forecast (Option), Section 7.7 Bus Load Forecast, and Section 7.9 Network Parameter Adaptation (NPA)) as well as sub-functions such as follows:

1. Configuration Scheduler – Providing the ability to schedule the open/closed status of breakers and disconnecting switches.
2. Generation Scheduler – Providing the ability to establish generating unit schedules including their real and reactive power limits.
3. Regulating Equipment Scheduler – Providing the ability to schedule regulated voltage set points, transformer tap positions, and capacitor and reactor settings for studies that take place at a future or past time or for a different load level as based on Parameter Adaptation values.
4. Equipment Outage Scheduler – Providing the ability to schedule equipment outages for Network Analysis studies that take place at a future time. The user shall be notified via display of all such outages. The capability to manually override the equipment outages before beginning each study Network Analysis shall also be provided. The outages/inages shall be imported from the existing Sunnet TOA application for use in future studies.
7.6 **Generation Forecast (Option)**

The Generation Forecast (GF) function is specified as optional. The intent is for the function to provide forecasts corresponding to the individual and total real and reactive power outputs from VSPP and SPP distributed generation resources such as PV-solar and wind-turbine renewable energy plant. The power output values shall be capable of being used to support the Network Analysis functions.

GF shall forecast power output values by accounting for the statistical dependency of distributed generation on weather data such as intermittent solar irradiation, cloud cover, and wind speed statistics on an area by area and/or voltage connection level basis throughout the Purchaser’s service territory. The areas considered shall be based on those that statistically are exposed to similar weather patterns. GF shall also consider any available information that may be known about the nominal and/or current capacity of the plant and their status, such as whether or not they are or will be connected to the Purchaser’s power system during the generation forecast period.

Within this context, key functional requirements include:

1. Capability to forecast individual and total distributed generation output on demand at 15-minute intervals covering periods from 1 (one) hour ahead to 1 (day) ahead.
2. Capability to generate the historical data it needs for statistical sampling and reference and for tuning the generation forecast model through a learning process.
3. Use of an adaptive statistical forecast model to compute distributed generation forecasts from inputs such as weather conditions, generation plant type, nominal or current rating, and online/offline status.
4. Ability of user to modify the forecast by entering data for any time slot.
5. Capability of comparing the forecast result with any actual distributed generation output (as may be known) by trending, for example, on an interval of 15 minutes.
6. Capability of GF to continuously update itself over time. Provision shall be provided for the user to initiate a learning process by considering the forecasts as well as the actual forecasts and weather information.
7. Capability of the adaptive model to be tuned easily by modifying the appropriate parameters of the model.
7.7 **Bus Load Forecast**

To support the study Network Analysis functions, the Bus Load Forecast (BLF) function shall provide the capability to calculate bus real and reactive loads based on characteristics dependent on current, past, and future states of the power system. This shall include the capability to:

1. Utilize load profile characteristics derived from data available from the Purchaser’s Historian.
2. Forecast the real and reactive load-to-voltage dependencies for two modes of operation:
   2.1. Normal operating conditions (linear dependencies can be used)
   2.2. Emergency operating conditions (second power polynomial dependencies)
3. Adapt bus load values based on characteristics associated with:
   3.1. Substation reactive devices
   3.2. LTC transformers
   3.3. MVAr reserves under normal and emergency voltage limits
   3.4. Bus voltage limits
   3.5. P-Q load curves for SPP and VSPP generation units

In addition, the Bus Load Forecast function shall provide the capability to generate a forecast for load groups and their associated characteristics. A load group can contain more than 1 (one) bus or more than 1 (one) substation. Load groups shall correspond to those defined for use by the applicable Network Analysis function such as the State Estimator.

7.7.1 **Functional Requirements**

As a forecast function, the BLF shall be in accord with the Purchaser’s existing Load Forecast function with respect to time intervals (minutes, hours, days) and day types.

The BLF shall be executed periodically or on demand:

1. When run periodically, the function shall generate a 24-hour look-ahead forecast of all load elements. Each subsequent run of the BLF function shall consider the actual historical load parameters of the current day and shall update the look-ahead forecast.
2. When run on demand, the function shall generate a 24-hour forecast of all load elements for a specified time period.
3. The Bus Load Forecast function shall use the power system load retrieved from the Purchaser’s Load Forecast results and the corresponding adapted Bus Load Forecast parameters and load percentage values.

In using distribution factors and power factors to derive bus load forecasts, the BLF function shall allow for:

1. Different distribution and power factor schedules for different times and days.
2. Multiple regression equations where the bus load or distribution factors are dependent on several other loads.

The forecasted states of station capacitors, reactors, and LTC transformers shall be determined based on the following principles:

1. Station capacitor and reactor devices connected to a bus that is not an HV bus shall be represented by equivalent devices on the HV side of the power system such that associated transformer losses are also considered. If applicable, their behavior may be described by algebraic and Boolean equations to account for any analog and/or status dependencies.
2. With respect to LTC transformers, load forecasts shall reflect the different load-to-voltage dependencies when: (a) the voltage is within its LTC controlled range and (b) when the voltage lies outside this range. The forecasted LTC position within its available range may be determined using algebraic and Boolean equations to account for any analog and/or status dependencies that apply.

Group load forecasts shall combine the characteristics of their individual loads.

The bus load forecast for non-monitored buses shall be derived as may be applicable from:

1. Data received via data links with neighboring utilities and ERCOT.
2. Calculations using algebraic or Boolean equations to reflect possible dependencies on other data that is available.

All forecasted bus and group loads shall be subjected to a validity check:

1. If the forecast does not pass the validity check, the user shall be informed and the abnormality shall be recorded.
2. If a bus or group load parameter is detected as abnormal then its previous value shall be retained.

The total of the bus load forecasts shall not differ from the load forecast less losses by more than 2 (two) percent of the system peak load.

### 7.7.1.1 AE SPECIFIC REQUIREMENTS (LOAD FORECAST RETRIEVAL)

The SCADA/EMS shall import the load forecast from the Purchaser’s Load Forecast program.

### 7.7.2 Input Data

In addition to any other input data required by the Contractor’s BLF function, the following input data shall be adopted:

1. Tap positions of substation LTC transformers
2. LTC voltage regulation ranges
3. Substation shunt capacitor/reactor status
4. Available capacity of the reactive devices
5. P-V and Q-V load curves
6. Voltage controller settings and bandwidth

### 7.7.3 BLF User Interface

Bus Load Forecast displays shall be available for each substation. In this respect:

1. The forecasted MW and MVAr of each bus of a substation and the forecasted substation MVA shall be available for each run of the Real-Time Sequence.
2. The corresponding actual data for past times of the current day and for the past seven days shall also be available for display and comparison.
3. The default and adapted parameters shall be displayable.

A Current Violation Display shall be available to show load forecast inconsistencies. The information displayed shall include:

1. Time and type of violation (e.g., MW or MVAr beyond the ± 3σ interval)
2. Deviation from normal (both absolute and percentage)
3. Average and maximum deviations with time of occurrence

For accessing the display, the user shall be provided with a user-friendly navigation sub-function.

### 7.8 State Estimator

The State Estimator (SE) function shall provide consistent, updated, reliable, and most probable power flow solutions using the current network model of the power system along with real-time status and analog measurements, forecasted and scheduled values, and user entries. Solutions for all observable and unobservable portions of the power system shall be provided.

#### 7.8.1 Pre-processing Consistency Checks

The State Estimator shall perform consistency checks to identify potential problems between the network topology and the measurement set. For example, a non-zero power flow on a line that is open at one end. Identified inconsistencies shall be presented to the user.

#### 7.8.2 Functional Requirements

The following modes of execution shall be provided:

1. Real-time mode where redundant real-time, forecasted, scheduled, and entered data is used.
2. Study mode where a Real-Time Sequence input or savecase is used.

The network solution shall include the following values:

1. Bus voltages (magnitude and angle)
2. Node MW, MVar, and Ampere injections
3. Branch MW, MVar, and Ampere flows
4. LTC and phase shifter tap positions for telemetered transformers
5. Circuit breaker states
6. Network parameters, if included in the validation process (e.g., impedance and admittance of circuit elements)

SE shall provide a solution for the entire power system. The solution for the observable portion of the network shall be based on whatever sufficiently redundant real-time measurements are
available. The solution for the unobservable portion shall be based on forecasted and scheduled data as well as on scattered telemetry and user entered data. Within this context, the following capabilities and features shall be supported:

1. Ability to solve multiple electrical islands whether observable or unobservable.
2. Ability to provide results based on expanded equipment limits if the solution is outside normal limits.
3. The solution for the entire power system shall not in any way degrade the solution for the observable portion of the power system.
4. SE shall perform an analysis at each execution to assess the boundaries of observability as dependent on the availability of data that is both reliable and redundant.
5. Ability to detect and identify bad analog measurements including any manual entries. Bad measurements shall be replaced by estimates based on their individually specified anomaly thresholds.
6. Ability to detect and identify biased analog measurements. This shall include the situation where minor yet consistent and persistent differences between measurements and estimates occur because of metering errors, or network modeling problems associated, for example, with power system topology, impedance, transformer ratio, and device capacity errors.
7. Ability to examine branch and bus injection telemetry and identify those branches and buses where inconsistencies occur (e.g., where MW or MVar values do not sum to zero).

7.8.3 Input Data

The SE function shall be capable of using the following input data from real-time measurements, database entries, forecasted values, and user entries in combination:

1. Power system’s circuit-breaker oriented topological model
2. Power system’s bus-oriented topological model
3. Electrical characteristics of the network components
4. Paired or unpaired bus real and reactive power injections
5. Paired or unpaired real and reactive power flows
6. Bus voltage magnitudes from one or more power transformers on the same bus
7. Branch ampere values from one or more current transformers on the same branch.
8. Transformer and phase shifter tap positions
9. Thresholds for bad data detection
10. Accuracy parameters for measurement, forecast, and scheduled data (e.g., percent of maximal deviations or standard deviations)
11. User-enterable as well as database-definable weighting coefficients for specific measurements
12. Bus synchrophasor measurements such as voltage angles from Phasor Measurement Units (PMUs)

7.8.4 Output Data

SE output shall include the following types of information:

1. Power flow results such as:
   1.1. Bus real and reactive power injections
   1.2. Real and reactive power flows and amperes at both ends of branches
   1.3. Bus voltage magnitudes and angles
   1.4. Transformer and phase shifter tap positions
   1.5. Switch open/close status indications such as for circuit breakers, disconnecting switches, and capacitor banks
   1.6. Losses by voltage level as well as for each network component ordered by equipment type, and loss totals for Purchaser defined zones as well as for the power system as a whole.
2. Pending as well as historical anomaly and abnormal measurement data
3. Measurement bias data
4. SE execution data including performance details

7.8.5 SE Quality Indexes

The SE shall compute solution quality indexes that track the quality of the SE solution over time. The EMS shall determine the quality of the SE solutions including amount of bad data, number of iterations run, solution deviations, data availability, etc. The SE Quality Indexes shall be shown on displays.
7.8.6  **SE User Interface**

The user interface shall include displays showing input and output details along with parameters and settings used to control execution of the SE function. In this respect:

1. Results shall be displayed on both tabular and one-line displays.
2. Outputs shall use colors to differentiate between power system islands, measured and estimated values, anomalies, violations, etc.
3. One-line station displays shall show all voltages, flows, and injections.
4. All other relevant schematic diagrams available in SCADA shall also be available for displaying SE results.

The System shall maintain the anomaly (measurement error) list of the last execution. Current and historical anomaly, abnormal measurement, and bias data shall be displayed and, on request, the user shall be able to send this data for printing.

At each execution, the anomaly list shall be passed to SCADA to process as analog alarms.

When data is removed from the current anomaly list, information shall be displayed in the historical list. In addition to measured and estimated data values, these displays shall contain detection information (when detected, how many times, etc.).

An SE execution summary display shall include number of iterations to converge, number of measurements, number of observable and unobservable islands, number of generation units with expanded limits, and all other relevant information.

There shall be an Execution Control Display for the user to enter parameters controlling the execution of SE.

7.9  **Network Parameter Adaptation (NPA)**

The Network Parameter Adaptation (NPA) function shall provide and maintain parameters that are not directly monitored, but are required by the Network Analysis functions.
7.9.1 **Functional Requirements**

The Network Parameter Adaptation function shall adapt parameters for estimating and forecasting network conditions.

The forecasting parameters shall be adapted from the following information sources:

1. State Estimator solutions.
2. Circuit breaker status time and/or load dependencies.
5. System Load Forecast solutions.
6. User adjusted parameters via an interface that allows the on-line tuning of power system results by making changes to network characteristics such as those associated with lines and transformers.

The adapted parameters, such as those that follow, shall be filtered when an old data point is replaced with a new one:

1. System MW load
2. Load and load group MW and MVAr values for both conforming and non-conforming loads
3. Load and load group distribution factors
4. Logical device positions as in capacitor and reactor switches
5. Transformer tap positions
6. Generator desired voltages
7. Other pseudo-measurements needed to replace telemetry in non-observable areas or in case of telemetry failures

If the adaptation involves time-dependent relationships, then the following features shall be supported:

1. User ability to define, if needed, the day-type and each of the 24 hours within the day-type over which each parameter set should be updated.
2. Parameter distribution over the available day types on a 24-hour day basis.
Two statistics shall be kept for each adapted parameter:

1. The average deviation from a predefined normal
2. The maximum deviation from a predefined normal

Reasonability checks shall be provided for the adapted parameters.

### 7.9.2 NPA User Interface

The NPA function shall include an execution control display. This display shall be used to control the execution of the function including the associated initialization of parameters and the function’s linkage to other displays.

Displays for comparing actual and default parameters with adapted parameters shall be provided. Such displays shall support comparisons corresponding to the current day and the past seven days.

A Current Violation display shall be available to display parameter violations. This shall present details such as:

1. Time and type of violation
2. Average and maximum deviations with time of occurrence

The Contractor shall provide additional displays as may be necessary to provide convenient access by the user to all other input and output data corresponding to the Contractor’s NPA function.

### 7.10 Power Flow (PF)

The Contractor shall provide a Power Flow (PF) function. The PF shall be used to perform power flow studies that include loss of power system equipment, changes in generation, changes in bus load, and any other changes in system or area quantities and settings such as buses, loads, generators, and voltages.

The PF user interface shall be structured to require the minimum amount of user input for execution. Equipment outage, loss-of-generation, and loss-of-load studies shall simply require that the user change the status of the appropriate switching devices on a one-line display or by
clicking only the appropriate equipment symbol (line, generator, etc.) on a one-line or tabular display.

The capability to perform a full PF execution for a selected contingency from the Contingency Analysis function starting from any savecase shall be provided. The capability to accurately reproduce the results of Contingency Analysis for the selected contingency when starting from the same base case shall be provided. Execution of the PF function for a selected contingency shall be possible through a simple execution control procedure.

7.10.1 Capabilities

The PF shall be capable of providing solutions for existing, past, and future states of the power system. This shall include the use of loads generated from the BLF function to provide a look-ahead function.

The PF solution algorithm shall be efficient, accurate, and robust. Fast-decoupled solution techniques are acceptable. The Contractor, however, shall also provide more robust algorithms such as those based on the Newton or Newton-Raphson method. The capability to manually select from the available solution algorithms shall be provided, but it shall not be required to make the selection for every study that is run. The study shall default to one of the algorithms, according to a tuning parameter setting.

The following power flow controls shall be implemented in the PF function subject to appropriate limits such as those imposed by generator P-Q and P-V capability constraints:

1. Transformer tap voltage or MVAr flow control
2. Generator voltage control
3. Shunt capacitor voltage control
4. Shunt reactor voltage control
5. Generator MVAr control

Implementation of these controls shall not degrade the efficiency, accuracy, or robustness of the basic power flow algorithm.
The user shall be able to select either the distributed generation slack or the distributed load slack option to adjust for changes in losses. In the distributed generation slack mode, selected unit outputs shall be adjusted. In the load slack mode, all load elements shall be adjusted.

For maintenance and debugging purposes, the capability to provide display output for non-converged cases shall be provided. This shall include output on one-line diagrams and tabular displays. In addition, tabular summaries shall be available that provide details about the nature of the convergence problem including a list of substations where the most severe convergence problem occurred and solution statistics such as number of iterations, number of control actions such as tap changes, MVAr limiting instances, bus mismatches, etc.

7.10.2 Calculations

The PF function shall calculate:

1. Generation, load, and losses for the overall power system and for its areas and islands
2. Bus generation MW and MVAr values
3. Bus voltage magnitudes and angles
4. Line and transformer flows (MW, MVAr, Amperes, and MVA)
5. Flow of power in and/or out of shunt devices.

7.10.3 PF User Interface

The PF and its user interface shall be designed to anticipate all events and problems that could reasonably be expected to occur during the PF setup and execution and aid the user to avoid or recover from these problems. All PF displays shall be specifically designed to provide an efficient and user-friendly interface. The user interface shall provide all the flexibility to set-up input cases while minimizing the amount of manual entry. To perform studies with the minimal amount of manual entry, the PF user interface shall support the following:

1. Information access by specified date and time
2. Use of default values
3. Use of automatic execution of subtasks
4. Use of default initialization sequences
5. Input of equipment status, limits, set points, and target values from one-line diagrams and tabular displays.

6. Display features that include the following:
   6.1. PF execution control displays
   6.2. Ability to choose slack bus
   6.3. Initialization control
   6.4. Output of scheduler sub-functions on tabular displays and one-line diagrams
   6.5. Generation summary by substation and distributed generation location providing MW, MVAr, voltage, MVAr limit, etc.
   6.6. Summary of distributed generation by zone and voltage level
   6.7. Summary of bus loads by substation and voltage level
   6.8. Transformer summary by substation and by voltage level providing tap position, controlled voltage, MW, MVAr flow, etc.
   6.9. Summary of bus voltage limit violations
   6.10. Summary of line and transformer flow limit violations
   6.11. Summary of statistics including totals of load, generation, losses, etc.
   6.12. Summary of any network islanding and generation isolation that may occur
   6.13. PF execution summary such as iteration statistics and problems
   6.14. Displays to enable/disable power flow controls by type or for individual devices
   6.15. Power flow solutions shall be displayed on one-line diagrams.

### 7.10.4 Execution Procedures

For the majority of PF studies, it shall be necessary to perform only the following procedural steps:

1. Enter the date and time for which the study is to be performed or request initialization from the most recent SE solution or from a SE saved case.
2. Alter equipment status or limits, if desired, using one-line diagrams and tabular displays.
3. Request execution.

For studies in which the user must modify selected bus loads, bus generations, voltages, or topology, displays shall be provided for the following reasons as a minimum:
1. Initialization  
2. Configuration scheduling  
3. Capacitor/reactor scheduling  
4. Load scheduling  
5. Bus voltage scheduling  
6. Transformer tap scheduling  
7. Generation scheduling  
8. Enabling/disabling control variables individually or globally  

7.10.5  **Power Flow Study Comparisons**  
A PF sub-function shall provide a summary of significant differences in input as well as output between two power flow cases. Whether the PF is initialized from the most recent SE solution, from a savecase, or from the current working area, the user shall be able to request that the PF automatically execute and present a summary of differences between a reference case and a new PF solution. The capability to use this PF sub-function to analyze the differences between two selected SE and PF savecases or between a savecase and the working area shall be provided. As a minimum, the following differences shall be reported, based on thresholds defined by the user:  
1. Total power system load  
2. Equipment out of service  
3. Capacitor status  
4. Branch status  
5. Generating unit status  
6. Limit violations  
7. Differences in flows, generator outputs, bus voltages, transformer taps, and system losses  
8. Differences in bus names, control area names, and topology including identification of any facilities not included in one of the cases being compared.  

7.10.6  **Pre-Switching Power Flow**  
The EMS shall include the capability for the Operator to execute a power flow and contingency analysis prior to opening or closing a device and report if the control action will result in an adverse operating condition. The results shall be presented to the Operator via a simple pop-up
dialog that indicates the result. The capability for the Administrator to enable/disable this functionality shall be provided.

### 7.11 Contingency Analysis

The Contractor shall provide a Contingency Analysis (CA) function that shall be used to assess the security of the power system under specified contingency conditions. The Contingency Analysis function shall consist of:

1. Contingency definition
2. Contingency screening
3. Full contingency analysis

Contingency Analysis shall use the latest State Estimator solution for real-time security assessment of the power system or a saved Operator Power Flow solution for assessing power system security in study mode. Contingencies shall be applied to either of these solutions serving as the Contingency Analysis base case. Each contingency may consist of single or multiple outages of power system components. Power flow solutions shall be used to analyze the effects of these contingencies.

Contingency Analysis shall provide the capability to evaluate a contingency involving increase or loss of generation or increase or loss of load by generation reallocation in the external network. Generating unit limits shall not be violated by generation reallocation. In this respect, Contingency Analysis shall apply the same unit limits as used by the other Network Analysis functions.

The CA function shall include the capability to define, edit, validate, and maintain contingency cases for real-time and study Contingency Analysis. In this respect, it shall have two components involving: (a) a base contingency case definition process and (b) a dynamic contingency case re-definition process.

1. Contingency case sizing requirements are presented in Section 3 Capacity and Performance.
2. Base Contingency Case Definition
3. The capability to define contingencies as a combination of outages and/or the placing in service of one or more power system elements shall be provided. This may include the
opening or closing of one or more associated switching devices. The user shall be able to modify contingencies via user interface displays.

4. Contingency definition shall also include the following capabilities:

5. Load Transfer – The capability to define automatic load transfer in any specified percent load or MW amount to model the effect of the outage of a distribution transformer.

6. Contingency List Augmentation – The capability to augment the active contingency list automatically with equipment that reaches a user-defined percentage of a base case limit. Users shall be able to disable this feature.

The capability to organize the contingencies into groups shall be provided. A contingency can be assigned to any number of groups and the assignments can be modified interactively. The capability for the user to enable/disable any or all contingencies of a group shall be provided.

In addition, the user shall be able to perform contingency case list updates, as necessary, to reflect equipment additions, deletions, or modifications to power system equipment.

Checks shall be performed to ensure a valid contingency definition.

7.11.1  **Dynamic Contingency Case Re-definition**

Dynamic contingency case re-definition shall apply in real-time whenever the state of an element changes such that the connectivity of the power system is altered or the arming selection for a remedial action (special protection) scheme is changed. Examples of a contingency re-definition scenario include: (a) arming of a remedial action scheme when flows on a given power system branch exceeds a pre-defined flow level and (b) arming of a generator tripping scheme when a series capacitor is removed from service.

The dynamic contingency case re-definition function shall modify each base contingency definition affected by the element or arming pattern changes to ensure the post contingency configuration remains accurate. The identification of the re-definition scenario triggering events, contingencies, element changes, and companion outages shall be completed prior to execution of the contingency case re-definition function and shall not be edited when the function is active.
7.11.2 Remedial Action Scheme Simulation

A Remedial Action Scheme (RAS) is an automated set of actions that adjusts the power system in response to a given contingency. A RAS may be “armed” to activate only under certain system conditions on a pre-contingency, mid-contingency, and/or post-contingency basis.

The Contingency Analysis function shall provide for incorporation of an RAS Simulation function that can be accessed as part of a contingency definition. As a minimum, the RAS Simulation function shall model the Purchaser’s Bus Throw-Over (BTO), Coupler Throw-Over (CTO), Line Throw-Over (LTO), and Line Transfer Function (LTF) schemes.

The PF shall be capable of accessing and running any contingency from the contingency definition file including any calls to the RAS Simulation function. The simulated RAS shall be identified to the user in the reporting of contingency results. This shall include the capability of the user to view the schemes that were triggered and implemented for a particular contingency.

The RAS Simulation function shall exhibit the following characteristics:

1. Initial usage of RAS will be within real-time Contingency Analysis and the study Network Analysis functions as well as the Operator Training Simulator (OTS).
2. The user shall be able to construct and edit schemes in real-time or study functions using common logic and simple interfaces.
3. The schemes must be successfully validated before being eligible for use. A validation process shall ensure that the equipment defined in the schemes represent equipment in the network database. Each scheme shall be independently validated so that one invalid scheme shall not prevent other valid schemes from being processed by Contingency Analysis.
4. Each scheme shall be archived separately. The capability to save multiple RAS files on the System shall be provided.
5. Schemes shall support the basic logical testing of Boolean functions including (=, >, <, ≤, ≥, ≠, AND, OR, NOT) and mathematical functions including (+, -, *, /, **, SQRT) in combinations of the following:
   5.1. Switching device status (open/closed)
   5.2. Branch energization (either end of branch open or both ends opened)
   5.3. Path flow (a set of branches defined as an interface)
5.4. Node voltage
5.5. SCADA point – arming status

6. Cumulative Boolean logic shall be used to test the RAS conditions. The set of conditions that make up the scheme shall be evaluated from the top down, one condition at a time.

7. Arming information, either for a scheme or for a particular action within a scheme, shall come from SCADA for real-time use. Study functions can use real-time arming statuses or modified arming statuses.

8. The user shall be able to manually override the arming statuses from the RAS definition displays in both real-time and study functions.

9. Scheme conditions shall be recognized during Contingency Analysis processing. Before a solution for a particular contingency is started, a pre-processor shall take the pre-contingent state of the system and add in any remedial actions defined for that contingency. Each scheme shall then be analyzed. If the conditions from the pre-contingent case are met, the resulting actions shall be implemented and Contingency Analysis shall solve by taking into account these actions. The actions supported by the schemes shall include:

   9.1. Breaker open/close actions if a detailed station breaker model is available.

   9.2. Equipment (lines, transformers, shunt reactors, shunt capacitors, series capacitors, etc.) in/out of service actions if only a simplified station breaker model is available.

   9.3. Generator actions such as moving to a particular MW output.

   9.4. There may be more than one resultant action for a particular scheme.

   9.5. If a triggered scheme causes a generation outage, it shall be possible for the user to reallocate the generation to one or more other generators.

### 7.11.3 Contingency Screening

A contingency screening capability shall be provided to screen a large number of pre-defined contingencies for critical cases. The goal of contingency screening shall be to identify as quickly as possible the most critical contingencies, thereby reducing the number of contingencies that must be analyzed in full for greater accuracy. The contingency screening function shall be capable of handling contingency cases of any complexity, including cases that cause bus splits. Any contingencies leading to bus splits, isolated equipment, or changes in network islands shall be reported as such on results displays.
Contingency screening shall process the specified list of contingencies and rank the contingencies from the perspective of how severely they violate the power system’s reliability criteria. The ranking shall be tunable by using weighting factors. Based on this ranking, a reduced contingency list shall be constructed for Contingency Analysis processing in full.

The capability to specify how many of the highest ranked contingencies shall be analyzed in full shall be provided. As an alternative, the capability to specify that all contingencies resulting in violations during the screening process be analyzed fully and completely shall be provided.

The user shall have the additional ability to specify that particular contingencies or all contingencies be processed in full regardless of the contingency screening’s ranking, thereby ensuring that these contingencies will be accurately analyzed. Furthermore, in real-time mode, contingencies that caused a violation in the previous execution of the Contingency Analysis function shall be added to the contingency list requiring more accurate processing.

The Contractor shall tune contingency screening so that any contingency that may result in significant overloads or voltage violations will be captured by the screening process. This may be achieved by tuning weighting factors used for contingency ranking, placing contingencies on the reduced contingency list without screening, changing limits used for violation checking, or by changing the selection algorithm itself (e.g., adding an additional iteration). After tuning, performance requirements shall still be satisfied.

### 7.11.4 Ranking

Ranking of contingencies shall be performed to:

1. Select contingencies to be analyzed in full
2. Display contingencies in order of severity after the full Contingency Analysis.

Ranking shall be based on the following categories of contingency violations or base case deviations:

1. Branch flow limit violations
2. Bus voltage limit violations
3. Reactive power generation limit violations

For ranking purposes, the CA shall compute two severity indexes, one to be used for flow related violations and one for voltage related violations. Both rankings shall be based on a weighted sum of contingency violations and base case deviations, where different weights can be defined for each of the two severity indexes. The capability to assign weights for a whole category (e.g., bus voltage limit violations), for individual violations, or base case deviations shall be provided. Default values for the weights shall be available for each category. Weights of zero shall be allowed to disable consideration of the associated violation type.

For tuning and validation purposes, the capability to compare, for all contingencies, the ranking obtained from the contingency screening with the ranking obtained from full Contingency Analysis shall be provided. The capability to compare these rankings side by side such that the accuracy of the contingency screening and its ranking criteria can be tuned shall be provided. In addition, the capability to produce a solution output based on the results obtained from the contingency screening for any specified contingency shall be provided.

7.11.5 Full Contingency Analysis

Full Contingency Analysis shall be executed automatically after contingency screening. However, the capability to bypass contingency screening and execute a full Contingency Analysis on all contingencies shall be provided. The objective of full Contingency Analysis shall be fast yet accurate analysis of the contingencies in the reduced contingency list (unless full analysis for all contingencies is selected) from the perspective of power flow and bus voltage limit violations. A robust power flow solution shall be used. It shall not be acceptable that cases that can be solved by the Operator Power Flow function do not converge in the full Contingency Analysis process.

The capability to enable or disable power flow controls, such as MVAr limiting for generators, generator voltage control, shunt reactor and capacitor voltage control, and transformer LTC voltage control on a system-wide basis, type basis, or on an individual device basis shall be provided.
Contingency cases that fail to converge shall be reported. To investigate non-convergence, the capability to obtain iteration and convergence records for a Contingency Analysis execution, similar to the ones that can be obtained for an Operator Power Flow execution, shall be provided.

7.11.6 Limit Set

The limit set used for monitoring by the Contingency Analysis function shall be capable of comprising any and all limits including dynamic ratings that are available to the System and shall be configurable to meet the specific requirements of the Purchaser.

7.11.7 CA User Interface

User interface functions shall be provided to facilitate definition, editing, and validation of contingency cases. The contingency definition and editing shall be made as simple as possible through interactive and menu-driven procedures.

Within this context, the capability shall be provided to pre-define a class of contingencies that by default are automatically created when a new substation is commissioned and modeled as part of the power system’s NOM. This shall include, for example, the automatic creation of contingencies that entail loss of substation incoming lines and/or power transformers.

The capability to identify equipment to be included in a contingency by selecting equipment from a one-line diagram as well as from a tabular display shall be provided. In addition, the capability to enter or edit equipment names for inclusion in contingencies shall be provided.

Through simple interactive procedures, the capability to assign or reassign contingencies to groups and specify which groups are included in either the real-time or study mode analysis shall be provided.

The primary output of the Contingency Analysis process shall be provided by the full Contingency Analysis function. Displays shall be provided to show contingencies with their violations. The presentation of these contingencies shall be ordered according to the severity of their associated violations. Within a contingency, the presentation of individual violations shall be ordered according to their severity.
For each violation that is presented, pre-contingency and post-contingency values as well as the violated limits shall be displayed.

The user shall be able to distinguish between new violations and violations that have already been detected in the previous execution of the full Contingency Analysis function.

In addition, summaries shall be provided for:

1. Contingency cases that did not converge or that have non-converged islands
2. Contingency cases that cause islanding or isolated equipment
3. Contingency cases that caused bus splits.

Displays shall also be available in order to:

1. Enter weighting factors either by category or for individual violations or base case deviations
2. Enable/disable power flow controls by type or individual device
3. Enter tolerances of limit values for which warning violations will be reported. It shall be possible to enter these tolerances by category or voltage level.
4. Define contingencies and the grouping of contingencies.

7.11.8 **Remedial Action (Option)**

The System shall include a Remedial Action function that will recommend corrective actions for a user-selected contingency case. The corrective actions shall be presented to the user in an advisory capacity. That is, the corrective actions will advise the user on the actions that should be taken to alleviate the violations if the contingency occurs.

The remedial action function shall use generation real and reactive power, bus load real and reactive power, and load shedding blocks as primary control variables. In addition, the capability to control shunts and transformer tap positions shall be included as control variables. The remedial action function shall observe branch overload and bus voltage violations as the primary constraints.

7.12 **Short-Circuit Analysis (Option)**

The Short-Circuit Analysis function shall be designed to analyze the Purchaser’s power system such that one or more users may request the execution of independent studies that calculate
three-phase voltages and currents due to a postulated fault condition. The function shall include the capability to calculate and compare fault currents against applicable transformer, line, and circuit-breaker operating limits.

The function shall perform these studies starting from a “savecase”, including the savecase that corresponds to an SE or PF solution. This feature shall be supported by the ability to also save and retrieve base cases created by the Short-Circuit Analysis function itself. Prior to executing a study, Short-Circuit Analysis shall allow the user to modify the savecase input conditions.

Selected study conditions shall include phase-to-ground, phase-to-phase, and three-phase faults. The ability of the user to specify bus section faults, line section faults, and fault impedance values shall be provided. The user shall also be capable of specifying a study based on zero pre-fault current (flat voltage) conditions or actual pre-fault current conditions.

Voltages and currents at all system wide buses for each specified fault condition shall be calculated per phase. Results shall be shown on the one-line displays of the power system. In particular, fault currents that exceed acceptable fault-current levels shall be highlighted.

7.13 Voltage Stability Analysis (Option)

As an option, the EMS shall include Voltage Stability Analysis function to provide the capability to analyze/assess the Purchaser’s transmission reliability area for potential stability problems such as system voltage collapse and electrical islanding. The stability analysis program shall be executable in both real-time as part of the real-time sequence as well as the study mode.

The SCADA/EMS shall include a Voltage Stability Analysis (VSA) application that includes the following features:

1. Screening and ranking of contingencies according to their likelihood of causing voltage problems, with detailed analysis of the highest ranked contingencies.
2. Identification of secure regions in which the operating point is voltage-secure with sufficient voltage security margin when contingencies occur.
3. Identification of preventive control actions when the power system lacks an adequate voltage security margin to withstand contingencies, or corrective control actions in cases when contingencies are pushing the power system toward voltage collapse.
4. Fast time-domain simulations of proposed preventive or corrective measures to validate the
desired effect.
5. Support of regional P V analysis to pinpoint the local point of collapse and the critical
contingency in each region.
6. Interface with generation control and scheduling applications for selectable use of stability
limits.
7. Capability to monitor selected 345kV elements.
8. Capability to specify power factor within the case/region where loads are being scaled up.
9. Capability to identify and display the weakest BES bus(es) within the region.
10. Capability to model power transfers across Purchaser’s system (e.g., south-to-north).
11. Capability to group areas into reactive reserve regions based on pre-defined system topology.
12. Capability to display PV curves.
8 Operator Training Simulator ................................................................. 246

8.1 Simulator Functional Requirements .................................................. 247

8.2 OTS Modes of Operation ................................................................. 247

8.3 Dynamic Power System Model ......................................................... 248

8.4 Modelling Requirements ................................................................. 250

8.5 SCADA/EMS Functionality .............................................................. 252

8.6 Scenario Builder ............................................................................. 253

8.7 Simulation Management Capabilities .............................................. 255

8.8 Playback ......................................................................................... 256

8.8.1 AE Specific Requirement (Two Simultaneous Playbacks) ............... 256
8 OPERATOR TRAINING SIMULATOR

The Contractor’s Operator Training Simulator (OTS) shall provide an environment in which the Purchaser’s personnel can be trained to operate the on-line SCADA/EMS (i.e., the Production System component of the SCADA/EMS) without impact on its actual use for day-to-day power system operations. Conversely, the on-line SCADA/EMS shall not impact execution and performance of the OTS. In addition, the OTS shall serve as a facility for testing software, testing application and database changes, developing and validating operating procedures, and for replicating and investigating power system behavior as observed and recorded on the on-line SCADA/EMS.

Within this context, the OTS shall be capable of simulating the power system’s normal, emergency, and restorative conditions and of monitoring and controlling the power system with the same fidelity as the on-line SCADA/EMS.

The OTS shall also provide convenient to use features that will help the user, such as an instructor, to set up and manage simulation scenarios, provide simulation oversight and control, replay simulations, and review trainee performance during training sessions.

To support the OTS functional requirements as specified herein, its components shall include as a minimum:

1. A power system simulator capable of replicating the behavior of the power system during execution of dynamic time-dependent and conditional criteria scenarios.
2. A replica of the on-line SCADA/EMS from the perspective of its functionality, databases, and user interfaces, but one that interoperates not with the actual power system, but with the power system simulator. This shall include simulation of the on-line SCADA/EMS functionality from the perspective of its interoperation with external systems.
3. A scenario builder that can be used to set up dynamic simulation scenarios based on power system conditions and events derived from SCADA/EMS data sources as well as from OTS manually entered data. This shall be supported by an interface between the OTS and on-line SCADA/EMS.
4. An interface with the PDS/QAS that can be used to establish and maintain an up-to-date OTS replication of the on-line SCADA/EMS software and database including its Network Operations Model (NOM).

5. User interfaces for simulation setup, management, and review as well as those that replicate the user interfaces of the on-line SCADA/EMS.

6. The capability to run multiple OTS sessions (up to 4 sessions) simultaneously shall be provided.

8.1 Simulator Functional Requirements

The OTS shall reproduce the behavior of the actual power system in a discrete time-step manner (as opposed to a continuous manner) in response to specified scenarios and simulations representing control actions performed by Operators, the power system’s autonomously operating devices, and the SCADA/EMS functions as installed and running on the OTS platform.

At each time step, the simulation shall produce a complete power system solution for the voltage at each bus and for the real and reactive power flows through each and every branch. This voltage and power flow solution shall be used as a basis for OTS simulation of the telemetered data normally accessed by the on-line SCADA/EMS.

Simulations shall run within such time constraints that the response of the simulated power system and the response of the OTS monitoring and control functions are consistent with the real-time operations perceived by Operators and other users of the on-line SCADA/EMS. For specific OTS capacity and performance requirements refer to Section 3 Capacity and Performance, of these specifications.

The OTS shall be able to recover from a diverged solution by going back to the last previous converged solution.

8.2 OTS Modes of Operation

The OTS shall be capable of operating in 2 (two) modes:

1. Supervised – In the supervised mode, the instructor shall control the training session. The actions of the trainee shall be replicated on the Instructor workstation.
2. Non-supervised – In this mode, the trainee (or other personnel using the OTS for test or other purposes) controls the training session based on a pre-defined scenario. A capability shall be provided for the trainee to start and stop the simulations and to back track to a defined state for analyzing different power system control solutions.

Within this context, the capability to connect any designated workstation to the OTS as well as any number of workstations at the same time up to the maximum available on the System shall be provided. The difference between a Trainee or Instructor workstation shall be based on log-on security. All real-time operational log-on authorities and restrictions shall apply within the OTS as governed by the log-on security system.

The Trainee workstation shall be able to take on the functionality of the different Operator positions in the Purchaser’s control rooms. The instructor shall be able to designate the desired Trainee workstation operating position at the start of a training session.

8.3 Dynamic Power System Model

The power system simulator shall be supported by a dynamic power system model that shall be an extended form of the Network Operations Model (NOM) used by the on-line SCADA/EMS.

The NOM used by the OTS shall provide an on-line SCADA/EMS database model from the perspective of data acquisition and, in this respect, shall include all relevant database values and their attributes, whether or not these values are linked to power system model data. Changes to the NOM in the on-line SCADA/EMS shall be capable of being exported via the SCADA/EMS/OTS interface so that the OTS can populate corresponding entries in the OTS NOM without the need to enter database values manually using the on-line SCADA/EMS data entry facilities as also replicated on the OTS.

For data included in the SCADA/EMS database model but not included in the power system model, facilities for the user to simulate telemetry by changing the value or attributes of any data point shall be provided.

As a minimum, the extended NOM shall include settings, parameters, and all other modelling details as necessary to support:
1. Simulations consistent with modelling the behavior of the power system from a static, dynamic, and transient stability perspective.

2. Creation of scenarios from pre-stored load curves and event groups, where event groups consist of one or more events that occur at the same time, at different times, or in accordance with other events and power system conditions. The pre-stored load curves shall include those that vary on an area-by-area basis.

3. Definition of events such as change of bus load, change of system load, loss of generation, circuit breaker trip/close operations (including, for example, those corresponding to sustained line faults that result in breaker lockout and those corresponding to momentary faults that are cleared by breaker reclose action), fault indications at one or more remote controlled switches, loss of RTU data, equipment alarms, etc.

4. Initialization of the dynamic power system model from on-line SCADA/EMS savecases, snapshots of the real-time state of the actual power system, and from IS&R historical data.

5. Initialization of the dynamic power system model from OTS savecases and snapshots of the current state of the simulated power system derived, for example, from the result of executing the OTS State Estimator.

6. Simulation starts, pauses, restarts, and stops.

7. Creation, application, and omission of events during an on-going simulation.

8. Periodic and demand snapshot savecases. At user discretion, periodic snapshots shall be saved automatically at a specified time interval throughout the simulation, where a snapshot is all data required to initialize the simulation to the conditions prevailing at the time of the snapshot. Periodic and demand snapshots shall not cause the simulation to pause.

9. Recording of scenario events so that these events together with a corresponding snapshot may be used to replay and review the simulation session.

10. The capability to create and save different instances of the OTS power system model, database, and associated displays shall be provided. The Instructor shall be able to select and run scenarios against the particular instance of the OTS power system model, database (parameters), and associated displays (e.g., one-lines). That is, the instructor or others may want to use not only the current power system model (as in the on-line SCADA/EMS), but also a power system model that corresponds to a past or future power system. A future
system, for example, may be one that includes one or more new substations, transmission lines, relay types, etc.

8.4 Modelling Requirements

The power system simulator’s modelling requirements shall extend to all equipment and devices comprising the power system as modelled in the on-line SCADA/EMS. It shall also extend to equipment and devices that are not included in this model but, as part of the power system infrastructure, affect the dynamic behavior of the power system.

The power system model as used by the OTS shall also be capable of being modified in any way to represent the addition and/or removal of equipment and devices, as for example to study the impact of new substation construction.

Within this context, as a minimum, the power system simulator shall include models that can represent:

1. Time-dependent changes in bus loads as derived, for example, from the profiles of conforming and non-conforming loads for each effective season and day type by area. Users of the OTS shall be able to modify such profiles, e.g., by defining a new peak value that scales the entire load profile, or by changing one or more individual load values. This shall include the capability to define and save load profiles manually for each area.

2. Generating units with defined characteristics in the form of capability curves, generator frequency dynamics resulting from governor and prime mover response to changes in load, and unit Automatic Voltage Regulator (AVR) actions for the different unit types.

3. SPP and VSPP distributed generation such as PV-solar and wind-turbine renewable energy plant. The capability to input distributed generation schedules to model the DER output in the simulation.

4. Power system frequency and/or voltage dynamics such as those that control the behavior of:
   4.1. Loads defined as functions of frequency and/or voltage.
   4.2. Overvoltage and undervoltage relays.
   4.3. Overfrequency and underfrequency relays.
   4.4. LTC transformers and generator AVRs. Whereas LTC transformer dynamics (and phase-shifter dynamics) shall allow for controller time delays, generator AVR dynamics can be
considered instantaneous. Simulate manual operation of an AVR (i.e., setting the AVR in manual mode so it doesn’t respond to voltage changes).

5. SCADA functionality as, for example, opening and closing circuit breakers and disconnecting switches, sending set points and tap positions to control the power system’s LTC transformers and phase-shifters, sending commands to reset underfrequency and lockout relays.

6. Overcurrent, automatic recloser, lockout, and synchronism check relays in addition to the above referenced voltage and frequency relays. Each relay and associated field device shall be modeled with an enable/disable flag. When set to disable, the relay or device shall not operate. When set to enable, the relay or device shall operate as normal. Selected relays or devices may be implemented for supervisory control of the enable/disable flag. For these devices, the OTS shall map the supervisory control command to the enable/disable flag. Underfrequency and lockout relays shall inhibit operation of the device it controls until a reset command is sent.

7. Load Shedding in response to underfrequency relay operations.

8. Purchaser’s substation automation functions as implemented via Voltage Selection, Breaker Failure Protection, Bus Throw-Over (BTO), Coupler Throw-Over (CTO), Line Throw-Over (LTO), Line Transfer Function (LTF), Load Shedding, Automatic Transformer Restoration, and Capacitor Control schemes.

9. Generation output from simulated Automatic Generation Control (AGC) and Economic Dispatch (ED) functions as well as from manually defined dispatch schedules. The ability to change the AGC and ED parameters shall be provided.

10. Power system configurations consisting of multiple islands with individual frequencies having different excursion characteristics.

11. Synchronization of live islands.

12. Conditions leading to power system voltage collapse.

13. Black start conditions in which the user shall be able to place specific generating units in and out of isochronous mode of operation and change specific load values to facilitate partial load pickup at designated substations.

14. Cold Load pickup based on the time that the load is de-energized. The instructor shall be able to enable/disable the cold load pickup modeling.
15. Static Var Compensator and Synchronous Condenser Modeling.

8.5 SCADA/EMS Functionality

The functionality of the OTS from the perspective of monitoring and controlling the simulated power system shall be a replica of the on-line SCADA/EMS functionality (including its User Interface functionality), as described elsewhere in the Technical Specifications, with the following exceptions:

1. The data acquisition functionality shall be provided by the power system simulator with the simulated telemetered data appearing to originate from the same data sources with which the on-line SCADA/EMS communicates. This specifically includes data telemetered from the Purchaser’s RTU data sources.

2. A short-term historical information function shall be included with the OTS, i.e., a full and complete replica of the Historical Information System serving the on-line SCADA/EMS is not required. In contrast, as a minimum, the OTS historical information function shall allow for one month of data storage to cover the needs of a complete training session. This shall include sufficient capacity to store the training session’s savecases.

Otherwise, the SCADA/EMS functionality of the OTS in particular shall include:

1. Supervisory control, including tags, such that
   1.1. Where a supervisory control is linked to a switching device in the power system model, the power system simulator shall reflect the changed network topology.
   1.2. Where the supervisory control is linked to equipment without its switching device being included in the power system model, the control action shall change the state of the equipment, e.g., to in or out of service.

2. Identical data entry facilities.

3. Identical messages and alarms.

4. Identical Network Analysis functions.

5. Identical applicable displays such as:
   5.1. Overview displays
   5.2. Tabular displays
   5.3. Overload summaries
5.4. Alarm and Event summary displays
5.5. Trend control and summary displays
5.6. Resource schedule displays
5.7. Equipment outage summaries
5.8. Memo displays
5.9. RTU and device monitoring and control displays
5.10. One-Line Displays
5.11. Application displays
5.12. Short-Term Historical Data access and reporting
5.13. Control displays to allow the instructor to change device status.

8.6 Scenario Builder

Scenario definition and building to prepare for a training session or any other OTS session shall be supported by comprehensive and convenient user interface facilities. In this respect, a Scenario Builder shall be provided that can be used to define scenarios that are up to 48 (forty-eight) hours long. A provision shall be made to define multiple training scenarios. Scenarios shall include a record of all instructor and trainee actions.

Each training scenario shall be described by defining events. This shall include the capability to define conditional and probabilistic events. Within this context, as a minimum, it shall be possible to create scenarios based on the following specifically defined events:

2. Trip or Trip/Close on a Breaker
3. Failure of a Breaker to Operate
4. Relay Malfunction
5. Local Control Malfunction (Load Tap Changers, Load Shedding, Generation Control)
6. Limit Violations (all types)
7. Temporary and Permanent Loss of Equipment (including ICCP and RTU data sources)
8. Loss of Generation
9. Change in MW and MVAr Generator Outputs
10. Single Bus Load Change
11. Area Load Change
12. System Load Noise, individual load noise, or both
13. Fault Occurrence (i.e., the tripping action resulting from a fault)
14. Loss of a Line or Transformer
15. Islanded Operation
16. Receipt of Operational Alarm

In addition to the above, the scenario builder shall support the merging of information available from the on-line SCADA/EMS to generate a scenario. For example, a scenario may be developed starting from an OTS scenario and subsequently merging IS&R data and a power flow savecase from the on-line SCADA/EMS. That is the OTS shall be able to be initialized by the IS&R. With each merge action, some data may be overwritten. The capability to create events from the IS&R shall be provided.

The OTS User Interface (UI) shall support scenario development using simplified techniques such as selecting and dragging and dropping equipment from one-line diagrams.

The OTS shall allow the instructor to define the following types of training scenarios:

1. Transmission Operations
   1.1. Disturbance exercises such as transmission line outages (faults), bus outages, and transformer bank faults
   1.2. Voltage control
   1.3. Normal transmission system switching
   1.4. Manual load sheds
   1.5. Island management including synchronization
   1.6. Paralleling operations – phase angle differences across a breaker
2. Balancing and Interchange
   2.1. AGC operation and control
   2.2. Meter failures
   2.3. Startup generators
3. Power System Restoration (including black start)
8.7 Simulation Management Capabilities

In addition to the capabilities and features of the Scenario Builder, the OTS user interface shall provide the capabilities and features that are identical to those of the user interface associated with the on-line SCADA/EMS.

As a minimum, the OTS user interface shall also support all necessary simulation management capabilities. These capabilities, for example, shall be designed to facilitate OTS training session setup and control by the instructor. The OTS simulation management capabilities shall include:

1. Training sequence start, stop, pause, and resume at any time within a scenario.
2. Replay of a session from an earlier state including all Operator actions.
3. Variable real-time speed selection (fast, normal, slow)
4. Base case initialization from any of the following sources:
   4.1. Real-time snapshots from the on-line SCADA/EMS
   4.2. Measurement data and savecases as existing on the on-line SCADA/EMS
   4.3. Snapshots and savecases as created by the OTS
   4.4. Historic event data from the IS&R function
5. Scaling of power system load for different operating conditions
6. Saving multiple OTS savecases
7. Scenario and associated initialization data storing in the OTS database. Scenario recall shall be preserved through power system model changes to the greatest possible extent.

To help the instructor, all operations during a training session, including the trainee and instructor operations, shall be logged automatically and shall be available for review by the instructor.

In addition, the instructor shall be able to:

1. Create a library of training scenarios.
2. Initialize the OTS with a snapshot saved during a training session.
3. After a snapshot has been loaded, call up displays and examine any data normally available during a session as, for example, to discuss specific details with the trainee.
4. Resume the simulation from a snapshot in the same manner as it would resume from a pause.
Reports for each training session shall also be provided for use by the instructor. As a minimum, these reports shall include the training session log, trainee comments, and instructor comments. All complete reports shall be capable of being saved on the OTS, printed, and exported in a suitable format to other Purchaser computer systems.

8.8 Playback

The OTS shall include a playback mode that allows the user to select a time, date, and duration to playback exactly what occurred during that time. In the playback mode, there is no simulation. The data and alarms/events are retrieved from the IS&R system and played back to the operator. The user shall be able to stop the playback at any point in time and start a simulation from that point in time.

8.8.1 AE Specific Requirement (Two Simultaneous Playbacks)

The capability to run two playbacks simultaneously where each playback is the result, for example, of two different trainees operating and controlling the power system under the same scenario applied to the same initial power system conditions. On this basis, the instructor and trainees shall be able to compare the playbacks and therefore compare how well or how differently the trainees handled the same training session.
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Model and Display Development</td>
<td>258</td>
</tr>
<tr>
<td>9.1</td>
<td>Modeling Requirements</td>
<td>258</td>
</tr>
<tr>
<td>9.1.1</td>
<td>Model Management System (MMS) Requirements</td>
<td>258</td>
</tr>
<tr>
<td>9.1.1.1</td>
<td>AE Specific Requirement (MMS PI and ICCP)</td>
<td>261</td>
</tr>
<tr>
<td>9.1.2</td>
<td>Toolkit for Maintenance of CIM-Compliant NOM</td>
<td>261</td>
</tr>
<tr>
<td>9.1.2.1</td>
<td>AE Specific requirement (ERCOT CIM Model Imports)</td>
<td>262</td>
</tr>
<tr>
<td>9.1.3</td>
<td>Design Conventions</td>
<td>262</td>
</tr>
<tr>
<td>9.1.4</td>
<td>Database Model</td>
<td>263</td>
</tr>
<tr>
<td>9.1.5</td>
<td>Relational Database Requirements</td>
<td>263</td>
</tr>
<tr>
<td>9.1.5.1</td>
<td>Non-Real-Time Database Requirements</td>
<td>263</td>
</tr>
<tr>
<td>9.1.5.2</td>
<td>Multi-User Database Integrity</td>
<td>263</td>
</tr>
<tr>
<td>9.2</td>
<td>Database Generation and Maintenance</td>
<td>265</td>
</tr>
<tr>
<td>9.2.1</td>
<td>Database Generation Requirements</td>
<td>265</td>
</tr>
<tr>
<td>9.2.1.1</td>
<td>Database Generation Tasks</td>
<td>266</td>
</tr>
<tr>
<td>9.2.1.2</td>
<td>Input Validation</td>
<td>267</td>
</tr>
<tr>
<td>9.2.2</td>
<td>Database Conversion</td>
<td>268</td>
</tr>
<tr>
<td>9.2.3</td>
<td>Database Maintenance</td>
<td>268</td>
</tr>
<tr>
<td>9.3</td>
<td>Display Generation and Maintenance</td>
<td>270</td>
</tr>
<tr>
<td>9.3.1</td>
<td>Display Generation Capabilities</td>
<td>271</td>
</tr>
<tr>
<td>9.3.2</td>
<td>Display Generation and Modification Procedure</td>
<td>274</td>
</tr>
<tr>
<td>9.3.3</td>
<td>Display Migration (Option)</td>
<td>275</td>
</tr>
<tr>
<td>9.4</td>
<td>Additional Tools</td>
<td>275</td>
</tr>
<tr>
<td>9.5</td>
<td>Report Generation and Maintenance</td>
<td>276</td>
</tr>
<tr>
<td>9.5.1</td>
<td>Creation of Reports</td>
<td>276</td>
</tr>
<tr>
<td>9.5.2</td>
<td>Printing of Reports</td>
<td>277</td>
</tr>
</tbody>
</table>
MODEL AND DISPLAY DEVELOPMENT

This section specifies requirements for modelling, database, and display development of the SCADA/EMS including the corresponding generation and maintenance tools. Development shall include both the real-time and historical databases. The requirements below apply to these databases and to other databases, such as those associated with the models supporting SCADA and the Network Operations Model (NOM) supporting the power system analysis applications.

9.1 Modeling Requirements

9.1.1 Model Management System (MMS) Requirements

In distributed and networked systems, the major requirements are efficient database design, secure database access, standard database access methods, and management of data consistency and data exchanges across multiple network nodes. In this respect, the MMS component of the SCADA/EMS shall meet the following requirements as a minimum:

1. A single source shall be established for each type of data, although copies of data may be propagated to other databases for reasons of performance and ease of use. The user shall not be required to enter the same data more than once.

2. There is a preference for unified display and database modeling tools such that modeling of the network (NOM) is performed visually and the resulting network connection diagrams can be used within the Production Environment for operational purposes. In addition, such an approach must allow for the association of assets represented on those diagrams (and in the NOM) with their associated parameters.
3. Speed of access to each database shall match the type of access required, e.g., the real-time database may use high-speed access methods such as compiled linking, while the historical database shall use relational database access methods to permit standard access by users.

4. Any modifications to any modeling database shall be recorded in a transaction log for troubleshooting and auditing. The transaction log shall record the user that made the change, the database and database table or tables that were changed, the data points changed with the corresponding data changes and the date and time when the changes occurred.

5. The MMS shall include data entry validation and shall achieve database integrity using comprehensive error checking and reporting features. Databases shall be secure from:
   5.1. Unauthorized access (read-only, read-write, create-delete)
   5.2. "Write" access by multiple users simultaneously (the system shall ensure that only one user at a time has write access to any single database item)
   5.3. The lockup of databases due to mismanagement of resources or the lack of necessary resources
   5.4. The storage of invalid data
   5.5. The propagation of corrupted data
   5.6. Failures that cause the permanent loss of critical data.

6. Data communications and data formats shall use international and utility standards in all cases unless otherwise approved by the Purchaser.

7. Data shall be consistent across all nodes of the network, unless implicit or explicit time stamping permits users to be aware of and to handle data inconsistencies.

8. Management of database generation and modifications shall be consistent, easy, modular, and rapid. Any generation and modification shall be able to keep track of what data was changed and who changed it.

9. The file system shall be scalable, i.e., increasing the size of the databases or changing to a larger drive shall not require rebuilding the SCADA/EMS and losing data.

10. Modifying portions of the database shall not require the entire database to be recreated, but only those portions that have changed. No data shall be lost or require manual re-entry during this process.
11. Modifying portions of the database shall not require the recompilation or relinking of application software, except if the application software has been changed to reflect the modification of the database.

12. The database shall be redundant to maintain system availability in the event of a hardware or software failure. All data in the primary and backup databases shall be kept synchronized and consistent.

13. On-line database edits and display modifications shall not require system restarts and changes shall be incorporated into the MMS.

14. The MMS shall support on-line backups of the database, which shall not affect on-line operations. It shall not be required to take equipment out of service or perform a failover to back up any component of the system database.

15. The MMS shall support the import-export of data from/to external systems. The IEC 61970 standard shall be followed. For example, the SCADA/EMS shall support the exchange of CIM profiles (refer to Section 2.3.3.3 CIM Compliant Adapters) with external systems using such means as FTP as well as interoperation with applications running on other CIM-compliant systems via direct information exchange using the IEC 61970 standards.

16. The MMS shall deploy data to multiple environments including PDS, QAS, Production, and Operator Training Simulator.

17. Database updates for each environment of the SCADA/EMS, such as the QAS or Production Environment, shall be performed such that corresponding environments at both control centers remain synchronized.

18. The database modeling tool shall support the use of templates where the user can define the required attributes.

19. The capability for simultaneous users to be editing, merging, committing, and/or installing database changes shall be provided.

20. The MMS shall include time-based model versioning capabilities.

21. The MMS shall support incremental model updates such that system failovers are not required to implement the changes.

22. The user shall have the ability to do mass imports and exports of any information in the database. For example, the ability to export information to a spreadsheet and manage ODBC connections.
9.1.1.1 \textit{AE SPECIFIC REQUIREMENT (MMS PI AND ICCP)}

The MMS shall be used to identify the points to be stored to PI historian(s) and/or transferred over ICCP links.

9.1.2 \textit{Toolkit for Maintenance of CIM-Compliant NOM}

In the case of a CIM-compliant NOM, the CIM input as well as the CIM-compliant NOM will change and evolve over time along with the on-going changes to the actual power system. Thus, the Contractor shall provide a tool set for maintenance of the CIM-compliant NOM.

The functionality of the tool set shall include, but shall not be limited to the following capabilities:

1. Capability to extend a current CIM-compliant NOM to include other CIM packages.
2. Capability to extend the current CIM-compliant NOM to include other classes, attributes, types, and relationships.
4. Capability to update any element in the CIM-compliant NOM using stream data file(s) in XML format.
5. Capability to incrementally edit/maintain data in the current CIM-compliant NOM while implementing a new network model without requiring a system failover or interruption to the real-time sequence.
6. Capability to export/import instances of the CIM-compliant NOM.
7. Capability to support graphic modeling using drag and drop functionality.
8. Capability to support the use of customizable templates for all elements of the model.
9. Capability to support modeling through tabular displays. All tabular displays shall be customizable on a user basis.
10. Capability to support multiple independent users.
11. Capability to support auto-generation of one-line and overview displays based on the network connectivity.
12. Capability that allows the displays built within the modeling tool to be used by the online system.
13. Capability to support SQL queries (or similar database technologies).
14. Capability to support the building and maintenance of contingency cases including remedial action schemes.
15. Capability to support time-based modeling (e.g., models with different in-service dates, capability to select different models).
16. Capability to provide an audit trail of changes and installations. The audit trail shall include the user, date, time, and what changed (including what it changed from to what it was changed to).
17. Capability to support different levels of permission for different types of changes.

9.1.2.1 **AE SPECIFIC REQUIREMENT (ERCOT CIM MODEL IMPORTS)**

The capability to import not only entire CIM models from ERCOT, but also portions of these models.

9.1.3 **Design Conventions**

1. The databases shall be defined and maintained by a set of interactive, English language editors. The editors shall use a consistent style, fill-in-the-blank format, or shall use a library of standard defaults based on point type, and shall be supported by warnings that shall appear automatically to alert the user to inappropriate entries.
2. The system database shall be documented in a complete database manual that shall be available on-line, and which explains the interrelationship of all databases and explains the database tables, attributes, etc. The database manual shall provide both visual samples and text descriptions of the entry format and purpose of all fields in all the system databases.
3. The database foundation shall include both the schemas (logical descriptions of the databases) and the instances (run time databases) of the real-time, historical, and relational data structures. It shall also encompass all aspects of database management across a distributed architecture composed of dispersed processors connected in a peer-to-peer network.
4. The software shall provide for “Global Naming Conventions” to be used in conjunction with display and database point definition. This global naming shall provide for unique names throughout the system.
9.1.4 Database Model

1. While the dispersed architecture dictates that multiple physical databases will be implemented, and while some databases may be structured for fast access (e.g., the real-time database and some of the application program databases), and others may be structured to provide easy and standard access (e.g., the historical and archival databases), from an operational point of view there shall be a single, integrated system-wide “logical” database that encompasses all SCADA/EMS functions.

2. The MMS shall make use of templates and other mechanisms to facilitate database development and maintenance. For example, AE has a duplicate RTU template that includes all the data characteristics associated with the RTU.

3. The user shall interact with the database via a graphical user interface. The user shall also have the capability to interact directly with the database source via ANSI SQL-compatible queries.

4. Report generation and other non-real-time applications shall have access to the data via ANSI SQL-compliant calls to the historical and real-time databases.

9.1.5 Relational Database Requirements

The non-real-time database shall be a relational or objected-oriented database.

9.1.5.1 NON-REAL-TIME DATABASE REQUIREMENTS

The relational databases shall support ANSI SQL-compliant queries. These databases shall have the following additional features:

1. An object-oriented structure and the use of standard object-oriented techniques in general.

2. The use of the Common Information Model (CIM) compliant constructs and CIM import/export facilities, where feasible.

9.1.5.2 MULTI-USER DATABASE INTEGRITY

As a minimum, the following requirements shall be met to ensure the integrity of the database while accessed by multiple users:
1. Individual records within a table shall be lockable such that other records within that table are still accessible.

2. Deadlocks in database access shall be prevented. If a deadlock is detected, the server shall choose a transaction to abort and return a specific error code to allow the application to take alternative action.

3. Within a non-real-time database, the capability to treat a single step change request as a transaction with automatic commit shall be provided. Multiple change requests may be treated as transactions with explicit commit commands.

4. Database access methods shall support the following capabilities:
   4.1. Queries shall be definable and executable from menu-driven screens.
   4.2. Menu-defined queries shall be stored for future execution either on-line or in batch mode.
   4.3. Selection criteria for previously defined queries shall be capable of parameterization, thus alterable upon each execution.
   4.4. All programming language compilers shall support SQL database access via library functions and embedded SQL commands and stored procedures.
   4.5. Access to all values associated with a single component shall be retrievable by specifying only the component (e.g., all variables associated with a transformer shall be retrievable by identifying the transformer). Direct access to specific variables shall also be supported.

5. Security measures shall ensure only authorized access to the databases.

6. Authorization granularity shall be supported by database, by table, by item, and by record for all relational databases.

7. The different authorization levels shall include no-access, read-only, read-write, create, and delete.

8. For critical and sensitive data, unauthorized access attempts shall be logged. Successive access failures larger than a programmer-entered number shall cause an alarm.

9. The databases (real-time as well as non-real-time) shall support time stamping of data entries.
9.2 Database Generation and Maintenance

The requirements below apply to the databases and to any additional databases, such as applications, modeling, and connectivity databases, if implemented separately. Database generation and maintenance shall take place in the PDS Environment and, prior to deployment in the Production Environment, be tested in the QAS Environment (also refer to Section 2 System Requirements and Architecture).

9.2.1 Database Generation Requirements

Databases shall be generated and maintained for the SCADA/EMS at both control centers. Database generation or update for any environment at 1 (one) SCADA/EMS shall be automatically transmitted to and incorporated in the database of the corresponding environment at the other SCADA/EMS (see Section 2.3 SCADA/EMS System Configuration). The generation of any replicas of required portions of databases on processors for local usage at each SCADA/EMS shall be done automatically either as part of the system generation process or the database generation process. Parameters shall be entered only once even if used by many applications or replicated in more than 1 (one) database. Data that can be derived from other data shall not have to be re-entered.

The database generator, using the source information, shall size the database, create the necessary files and indices, and initiate them to the appropriate values. Partial generation of unrelated portions of the database shall be possible. If, because of a change in database sizing, it is necessary to re-dimension application programs, database generation shall automatically create dimension parameters for all application programs. The application programs shall either pick up or use these parameters at execution time or alternatively, if recompilation is required, the dimension parameters shall be incorporated automatically during compilation of the application software.

Database generation functionality shall provide the capability to automatically generate the complete system database based on sources (internal files and external systems) that completely identify all the information needed to build the database. The database generation function shall automatically generate the databases required for the real-time SCADA and Network Analysis functions, ICCP data exchanges, and the Operator Training Simulator (OTS) as well as the data
for the rest of the SCADA/EMS. In addition, it shall automatically update the tag definitions on all OSI PI historians to reflect new, modified or deleted tag definitions (note: the format of the tag names for different types of points are included in Section 10 Information Storage and Retrieval (IS&R) of these specifications). If any parameters are needed during the database generation process, they shall be entered at the initiation of the generation process. No interaction shall be required during the generation process other than recovery from error conditions. Sizing parameters shall as much as possible be derived from the input data.

The database generation process shall log/record all activity and capture errors for detailed review.

Many of the substations and points in the database have already been defined in the Purchaser’s existing SCADA/EMS systems. Consequently, portions of the database for the new System can be derived from the existing SCADA/EMS database files. The database generator shall be able to accept, as input, files derived from the Purchaser’s existing systems and defined during the database workshop.

When a new point is defined, unless specified by the user, certain database point information (e.g., alarm category, priority, description, initial state, priority, flag for automatic entry into the historical database, etc.) shall automatically default to values based on the point’s voltage, RTU type, AOR, point name, etc. The Purchaser will collaborate with the Contractor during the project to define the rules and guidelines for the assignment of default values.

The capability to define a SCADA point to also be available for ICCP shall be provided.

9.2.1.1 DATABASE GENERATION TASKS

The database generation function shall perform the following tasks as a minimum:

1. Validate the input data, confirm that the values of all entries are valid, and flag all conflicts among input sources, all logical and electrical errors and inconsistencies, and all missing data fields. Power equipment parameters shall also be checked for reasonability.
2. Build and maintain database schemas sufficient to fully describe the database.
3. Build databases that include structures for storing of telemetered data, calculated and other non-telemetered data, parameters, and flags. The structures shall also allow room for spare points.

4. Transmit a replica of the database to all servers where it is stored as well as to the Operator Training Simulator (OTS) and backup system.

5. Output databases and directories to bulk memory in a format usable as an input in regenerating and/or reloading the entire database system.

6. Have the capability of importing and exporting database information to and from a commonly used custom database formats in a user-friendly way, in addition to CIM.

7. As an option, have the capability of exporting data to the PI Asset Framework.

**9.2.1.2 INPUT VALIDATION**

Input data shall be validated. It shall, however, be possible to mark specific input data entries as exempt from data validity checking. For instance, if a valid range of impedances has been specified for a class of transformers and the impedance of a specific transformer is known to fall outside this range, it shall be possible to mark that impedance as “exempt” from validation.

All data shall be validated before it is loaded into the on-line system. The validation process shall include checks on the following:

1. Uniqueness of the object identifiers
2. Plausibility of the equipment data
3. Plausibility of the network topology
4. Plausibility of the network hierarchy
5. Validation of data formats.

The validation shall be performed as soon as possible. The plausibility of equipment data shall, for instance, be checked whenever changes are applied.

All validation errors for database generation shall be posted in a single run of the database generation process. The process shall not stop when a non-critical error is detected. The error messages shall identify the problems. They shall direct the user to the source of the problem and require no reference to other documentation. The capability to correct errors during the
generation process without re-starting the database generation process from the beginning shall be provided.

Telemetered and calculated data, applications adaptive data, and user entered data must be retained and remain correctly linked through database generation, even when addition or deletion of substations, generating units, or other entities shifts the location of the data.

Where CIM data is imported, the System shall validate the source file against the system schema to ensure valid structures and elements exist. All errors shall identify the problem and location within the file.

9.2.2 Database Conversion

The Contractor shall be responsible for converting the Purchaser’s existing databases to the Contractor’s database. The Contractor shall be responsible for identifying data items that are needed for its system that are not in the existing databases. The Data Engineering workshop shall be used to define the mapping between the existing databases and the Contractor’s databases. Multiple database conversions shall be provided. The Contractor shall provide the tools used to convert/migrate the databases to the Purchaser.

9.2.3 Database Maintenance

The System shall provide for on-line interactive database maintenance, off-line interactive database maintenance, and off-line batch database maintenance. Procedures for change control of the database shall be like the ones used for programming control.

Database maintenance functions shall include the capability to add, delete, or change database parameters associated with telemetered data, control of communications and data links, manually entered data, application program calculated data and, in general, all database parameters that affect system operation.

All entries shall be checked for validity before being accepted. It shall not be necessary to enter the same data more than one time. After the update entries or modifications have been verified and accepted at 1 (one) processing resource or workstation, the SCADA/EMS shall, on command, propagate the changes to all other processing resources or workstations that are
relevant including the corresponding processing resources and workstations comprising the other
SCADA/EMS and, if applicable and required, those comprising the OTS. The capability to
to control the propagation of changes manually shall also be provided. Database changes made at 1
(one) processing resource or workstation shall not require changes to be made manually at other
processing resource or workstations.

Tools shall be provided to allow for flexible and easy definition of new objects along with their
attributes, presentation of attributes, alarming, and user dialogs. Additions or modifications shall
include, but shall not be limited to:

1. Addition, deletion, and redefinition of RTUs
2. Addition, deletion, and redefinition of points
3. Addition, deletion, and redefinition of RTU communications channels
4. Addition, deletion, and redefinition of data link points and sets of points
5. Reassignment of workstation areas of responsibility
6. Redefinition of substation data retrieval frequencies
7. Redefinition of functions and capabilities to be assigned the workstation modes
8. Addition, deletion, and redefinition of models and parameters for network analysis as well as
   other existing or future applications of the SCADA/EMS.

References to each data point or to an array of data by the user shall be by variable name, not by
address location or index. Wherever possible, such references shall be through dragging and
dropping or, at the user’s option, copying and pasting.

No modification to program logic, automatically or otherwise accomplished, shall be required
when performing database maintenance. Further, the update servicing software itself shall be
table-driven in so far as possible and shall be modular in structure, thus allowing easy
modification for the incorporation of new data types or conventions.

Modified portions of the database, especially those applicable to data acquisition definition and
driving tables, shall be buffered and shall not be utilized until a single command is given by the
user. Changes shall be archived with the time and date and the identification of the user making
the changes. The old copy of modified information shall be retained on protected bulk memory
until a subsequent user command indicates that the new data is acceptable. At any time during
the “temporary” use of the new data, the user shall be able to command the SCADA/EMS to revert to operation using the previous unmodified data.

The capability to add a new substation, RTU, or other entity to the database by copying an existing similar entity, and then renaming it and changing the attributes that are different shall be provided.

The deletion of a substation, RTU, or any other entity shall be “cascading” (i.e., all points at the entity shall be deleted). The scope of the pending deletions shall be shown, at the user’s option, for approval before the deletion occurs.

During any modification of the database, all manually entered data or any program calculated data from the current real-time operating database shall automatically merge or carry over into the newly built database. Examples of manually entered data are: limits, telemetered points which are manually overwritten, manually entered status points, tags associated with equipment, calculated analogs which are manually overridden, limits, application data and parameters, etc. The user shall not be required to re-enter any manually entered data because of any database modifications or software modification that causes the restructuring of the database (even if recompiling the software is required).

Authorized users shall be able to perform database maintenance as described above on-line, interactively, without affecting normal system operation on other non-affected SCADA/EMS data. When data is modified, the old values shall be displayed in conjunction with the request for new values. All modifications or updates made shall be recorded with user information for audit purposes. The interactive database maintenance editor shall allow the user to query information about the database structure definitions to assist with the modification process. This feature shall at minimum support ANSI SQL-compliant queries of the database definitions. The editor shall be structured so that access to information can be menu-driven with sufficient text messages available to assist the user with the operation of the editor.

9.3 Display Generation and Maintenance

An interactive display generation and maintenance function shall be available at workstations in the appropriate mode. It shall be designed for use by non-programming personnel, and support
all displays, including the world map and application program displays. As for database
generation and maintenance, display generation and maintenance shall take place in the PDS
Environment and, prior to deployment in the Production Environment, be tested in the QAS
Environment.

Individual dynamic data fields or data arrays in defined displays shall be logically identified by
the user during the interactive definition process. All linkages to the database necessary for
ensuring the proper retrieval and output of the dynamic data or data arrays during actual use of
the display shall be automatically established according to this identification. Further, the
linkages between the displays and the database shall be solely by logical identification and shall
be designed in such a way that any database modifications (even those resulting in insertions into
tables and changes in table sizes) do not require the redefinition of existing displays.

9.3.1   Display Generation Capabilities

The following specific capabilities shall be included within the display generation and
modification function:

1. The Contractor shall provide a tool for auto-generation of displays (one-line and overview
displays) from the NOM based on the network topology and connectivity found in the NOM.
2. The auto-generation of displays tool shall allow the user to pre-define the spatial orientation
   of the displays to be built as follows:
   2.1. Portrait – a north to south or vertical profile
   2.2. Landscape – an east to west or horizontal profile
3. The auto-generation of displays tool shall allow the user to set x-y coordinates for the main
elements of the one-line and substations displays (busses, breakers, switches, line connectors,
etc.)
4. Displays built with the auto-generation displays tool shall be compatible with the
   requirements in Sec. 9.1.2, Toolkit for Maintenance of CIM-Compliant NOM.
5. The Display Editor shall support the building of a library of device representations of all
   Purchaser’s power system devices such that the representation on a display of a specific
device may be made by first referring to the appropriate entry in the library and then entering
   the device-specific information (e.g., substation ID and point ID).
6. Symbols may utilize more than 1 (one) color.

7. Dynamic data fields may be selectively added or deleted on existing displays. There shall be no artificial limit to the number of dynamic data fields that may be included.

8. Displays may be created, modified, and deleted without requiring changes to any software or firmware.

9. Complete support shall be offered for all advanced display capabilities of the user workstations, such as world maps, overlays, windows, menus, de-clutter, pan and zoom, etc.

10. User interface hardware shall be fully compatible with the Display Generation and Maintenance function.

11. The capability shall be provided to create, modify, store, and retrieve display skeletons and display symbols (or macro generators) from a library.

12. The display characteristics (color, intensity, and blink) of any symbol on the display may be made dependent on the value or the quality code of a database point. The user shall be able to specify the relationship between the database value or quality code and the display characteristics of the associated symbol.

13. Different symbols (e.g., up arrow or down arrow) may be displayed depending on the sign of a numerical point.

14. Data fields and pushbuttons may be selectively added or deleted on existing displays.

15. Color may be associated with individual pixels when defining the fixed portion of displays.

16. Backgrounds may be imported from external sources (e.g., as .bmp, .jpg, .png, .dxf, and .kml files), particularly for displaying geographic maps.

17. Different conventions may be utilized for the same data point on different displays or on different portions of the same display. Several examples of the conventions include:

17.1. Number of significant digits in a numerical value

17.2. Number of decimal digits in a numerical value

17.3. Choice of displaying status pair indications symbols or text

17.4. Choice of whether to display all data quality indicators that are associated with a point or a value, only the “worst” quality indicator, or no data quality indicators at all.

17.5. Choice of whether to display tag symbols.
18. Any display may contain fields with dynamic data acquired from any number of sources (RTUs, data links, non-telemetered, calculated, estimated, historical, and so forth).
19. The number of integer and fractional digits displayed may be different for each analog data point on a display.
20. The number of integer and fractional digits may be different for the same data point when this data point is shown on different displays.
21. Any data field may be defined as being protected against user entry.
22. Display call up parameters may be defined (display name, etc.)
23. Pushbuttons may be defined for either display call up or program execution at any location on the screen.
24. A list of all displays in the SCADA/EMS, ordered by display ID or categorized by Group, shall be maintained. The list shall be displayable.
25. The capability to build displays showing all applicable database elements and linkages to other system elements shall be provided.
26. The capability for mass batch edits shall be provided. That is, a user shall be able to change the symbol for a device and then apply it to all devices of the same type.
27. There shall be no limitations on the number of devices that can be included on a single display.

A major feature of the display generation and maintenance software shall be its ability to support application programs. The ability to link to any data, not just real-time data, shall allow interactive graphic displays to be constructed for application programs. The capability to have input to and output from these programs using graphic displays shall be provided.

The full interactive and responsive nature of the human-machine interface subsystem shall be applied to the application programs while the application program itself remains independent of the details of the user interface.

The display generation and maintenance software shall provide for listing, dumping, reloading, and validating of the display files. The capability to list all or any part of the display file shall be provided. The dumping and reloading of the display file shall allow all, or any part of the display file, to be archived to and reloaded from archival storage. A “compare” function shall allow for the archived file to be compared with the current display file or another archived file.
The display generation and maintenance software shall log/record the display changes for auditing purposes.

**AE Specific Requirement**

The capability to export a schematic diagram in OSIsoft PI vision format with database references modified to be the PI tag corresponding to EMS database point.

### 9.3.2 Display Generation and Modification Procedure

In addition to the auto-generation tool, the System shall allow the user to generate and modify displays manually. This shall include the capability of the user to modify existing displays that have been generated manually or automatically.

In generating a display, the user shall be able to format or import the static portion of a display and indicate the locations of the various dynamic display fields by “drawing” the display symbols directly on the monitor, using drawing capabilities included in the display editor and by dragging and copying symbols from the Purchaser’s power system device symbols library.

The capability of the user to specify the linkage of a display’s dynamic display field to the database shall be provided. In this respect, the user shall be able to identify the dynamic data by using its database name. All linkages between the database and the dynamic data to be shown on the display shall be automatically established according to this identification.

Linkages between a display and the database shall only be by variable names and shall be designed in such a way that no database modifications (even those modifications resulting in insertions into tables or files and changes in table file sizes) requires display redefinition.

A tool shall be provided that grabs the database points for the substation and allows the user to easily identify and link the database points to the appropriate location on the display.

After verifying the display and its linkages, the user will commit the display. At this time, the System shall replace the existing display with the new one, activate the foreground database linkages, and propagate the new display to all workstations of both SCADA/EMS systems. The capability to revert back to a previous version of the display shall be provided.
If the old display happens to be on view at a workstation, the display shall not be automatically replaced. Instead, the user shall be informed by a message that the display has been updated. When requested, the user shall then be capable of using the replacement display in place of the previously existing display.

9.3.3 Display Migration (Option)

As an option, the Contractor shall migrate the Purchaser’s substation one-line displays to the new system. The Contractor shall assist the Purchaser during the display design and prototyping workshop to finalize the display prototypes to identify any changes to the existing displays (e.g., connectivity for dynamic coloring). The Purchaser can provide the existing displays in SVG format. The Contractor shall make any changes resulting from the prototyping workshops as part of the display migration. The Purchaser will review and validate the migrated displays. The Contractor shall be responsible for correcting any problems with the migrated displays.

9.4 Additional Tools

The System shall include the following tools, utilization of which shall be included along with all other tools in the UI knowledge transfer workshops and used by Administrators to maintain and support the System:

1. Tool to output the database structure and contents in an easy-to-read format.
2. Tool that identifies points on displays or set of displays that do not exist in the real-time database.
3. Tool that identifies invalid display calls (e.g., a hyperlink to another display and the display no longer exists) and linkages.
4. Tool that lists all the symbols used on a particular display or set of displays.
5. Tool that lists all text strings associated with status point states (e.g., 0 = “open” and 1 = ‘close”) on a particular display or set of displays.
6. Tool that lists dialog/control/popup boxes associated with all points on a display or set of displays. The capability to customize the dialog/control/popup boxes shall be provided.
7. Tool to dump display definitions in an ASCII format, including database references and locations on the display, for ease of comparing displays over time.
9.5 Report Generation and Maintenance

The Report Generation and Maintenance system shall be capable of defining reports and scheduling their automatic generation at predetermined times. The Report Generation and Maintenance system shall include full support for the English language.

The capability to create reports based on data stored in all databases shall be provided. Authorized users shall be able to view, edit, and format reports, schedule their target saving location and specify the network location or locations for printing along with the printing devices to use. The capability shall also be provided to save and print reports on user demand. The user shall be able to format operational reports for saving and printing (on any printing device) or to output reports to a named file. Each individual report shall be stored to a distinct file. The file name standard shall be configurable and shall include the date and the report title.

The capability to create and test reports in the PDS and QAS Environment before execution in the Production Environment shall be provided.

Report generations shall not adversely affect System performance or availability. Report generation activities shall be included in the scenarios used to test the performance of the System (refer to Section 14 Quality Assurance and System Testing).

A facility to generate ad-hoc reports shall be provided.

9.5.1 Creation of Reports

The Report Generation and Maintenance system shall support the creation, modification, scheduling, and deletion of system reports. All data stored in the real-time and historical databases shall be available for inclusion in reports. Report definition capabilities shall include the following:

1. Text definition
2. Formatting (layout, color, bolding, fonts and font size, background, titles, page breaks etc. for displays and color printers)
3. Selecting if data quality codes shall be shown
4. Data definitions
5. Definition of calculations
6. Output of date and time of report generation and the date and time each item was saved in the database

7. Assignment of output printing devices, including the assignment of a report to a file or to a socket connection to an external system

8. Ability to generate a report in various formats, including .txt, .csv, .docx, .xls, .pdf, and HTML

9. Full support for the English language.

The capability to format reports for printing on black-and-white and color laser and ink-jet printers in either landscape or portrait mode shall be provided. Font sizes and styles shall be easily selectable.

The Report Generation and Maintenance system as a software package shall be easy to learn and use with minimal programming required to define new reports. The creating of new reports should not involve specialized reports programming knowledge or extensive reports building training.

If a general-purpose IT reports package, such as Oracle Reports, Crystal Reports, etc., is proposed, the Contractor shall describe how the package shall be augmented to make it easier for users to create reports. The Contractor shall include these augmentation features with the Report Generation and Maintenance system.

A Report Generation and Maintenance system that meets all the specification requirements using a PC configured with the Microsoft Office Suite can be proposed. The Contractor shall describe the user interface, the Microsoft Office Suite components used, the database access methods and standards (e.g., SQL, ODBC, etc.) employed, the control interface to schedule report execution, and all other custom software that may be required for report formatting and printing.

**9.5.2 Printing of Reports**

All reports shall always start printing at the top of a new page and each page shall have a specifically designed header identifying pertinent data, including time and date. Once started a report shall not be interrupted until it is completed unless cancelled by the user. At no time shall a page of printed output contain any information other than for the specific report.
If the designated printing device is unavailable or becomes unavailable before printout is completed, the entire report shall automatically be re-routed to a backup device previously selected by the user. If no backup device has been selected or none is available, the entire report shall be saved for later printing. The report shall be automatically printed as soon as a printing device becomes available.

The following capabilities are required for the scheduling of reports:

1. Scheduled Printing – The capability shall be provided to specify, as part of the report generation process, whether the report is to be printed automatically and when it is to be printed. Printout scheduling capabilities shall include hourly printout, daily printout, printout on a given day of the week, printout on a given day of the month, and printout at given time intervals. The capability to specify the time of day for printout shall be provided.

2. Manual Printing – The capability to request the printout of any report at any time shall be provided. If the time range of the report is not completed by the time of the request, data available up to that point shall be printed.

3. Event Triggered Printing – The capability to trigger the printout of a predefined report upon the detection of a specific event (e.g., when a telemetered or calculated point goes into alarm) shall be provided. Application programs shall also be able to request the printing of reports.

### Viewing and Editing of Reports

Authorized users shall be able to view reports on their workstations. The methods used to select the reports shall be the same as for manual selection of a report for printout. To the extent that the report does not physically fit on the display, the user shall be able to scroll vertically and horizontally to view the entire report.

Reports results shall also be made available to authorized PC users for display using standard Web browsers.

For reports of historical data, the user shall be able to step forward or backward in time to view reports for different time periods.
For reports on specific data, the user shall have the capability of producing reports where the
data is sorted by any key logically appropriate to the report (e.g., by AOR, substation, point type,
point description, equipment, alarm categories, special calculations, etc.).

Authorized users shall be able to edit historical data from automatically formatted reports that
can be displayed. Whenever a database point is edited, all calculated points using the modified
data shall be recalculated, preferably automatically. If recalculation must be manually initiated, a
clear warning shall be shown, both on the display and on all affected printouts.

9.5.4  **Required Reports**

Reports to be prepared by the Contractor include those that are listed below. The design of these reports shall be subject to approval by the Purchaser.

All required reports shall be retained consistent with the retention period defined for the Production Environment IS&R as defined in Section 3 Capacity and Performance.

9.5.4.1  **POWER SYSTEM REPORTS**

The system shall include appropriate reports as specified in Section 6 User Interface Requirements.

9.5.4.2  **RTU COMMUNICATIONS REPORT**

This report shall provide hourly performance statistics by communication link or channel and by RTU. The statistic shall indicate the number and type of error (e.g., checksum error, loss of carrier, illegal function code, etc.), and the overall bit error rate, for the reporting period. The report shall include hourly communications statistics. In this respect, it shall be designed to enable supervisors and maintenance engineers to monitor the performance of the communication links and channels, and to identify the problems and their date and time of occurrence associated with specific links and channels, to facilitate maintenance of good communications. The retention period of the report is specified in Exhibit 3-6, Information Storage and Retrieval Sizing.
10 Information Storage and Retrieval (IS&R) ................................................................. 281

10.1 AE Specific Requirements (AE Provided OSIsoft PI) ............................................. 282

10.2 Server Support Requirements ............................................................................. 282

10.3 Client Capabilities ............................................................................................... 282

10.3.1 User Access .................................................................................................... 282

10.3.2 Function Access ............................................................................................. 283

10.3.3 Automated Data Capture .............................................................................. 284

10.3.4 Data Quality Codes ......................................................................................... 285

10.3.5 System Message Log Storage and Retrieval ............................................... 285

10.4 Historical Databases ............................................................................................ 286

10.4.1 SCADA Historian Integration (AE Specific Requirement) .............................. 287

10.4.2 Capabilities of the Historical Databases ......................................................... 288

10.4.3 Historical Points ............................................................................................. 289

10.4.4 Manual Entry of Historical Data .................................................................... 290

10.4.5 Required Historical Data .............................................................................. 291

10.4.6 Off-Line Archiving and Transfer of Data ...................................................... 292

10.5 Information Delivery ............................................................................................ 293

10.5.1 Reports .......................................................................................................... 293

10.5.2 Ad Hoc Reporting Functions .......................................................................... 294

10.6 Historical Information Applications ...................................................................... 294

10.7 Historical Playback .............................................................................................. 295
10 INFORMATION STORAGE AND RETRIEVAL (IS&R)

The Purchaser prefers IS&R to be a logically separate node(s) within the System environment running on separate, redundant, processors. The IS&R shall service many concurrent System and non-System users. Servicing non-System users shall not affect the security and performance of the System from the perspective of the System users. The IS&R shall also accommodate long term archival storage and retrieval of information produced by the System.

The IS&R shall consist of a data historian (OSIsoft PI) and a Database Management System (DBMS) capable of supporting a two or three tier, i.e., client/server or client/application/server, architecture through the TCP/IP protocol. Open Database Connectivity (ODBC) is required with documented and demonstrable compatibility with Microsoft Access, Microsoft Excel, and other common front-end software. The DBMS must be accessible by Structured Query Language (SQL) and Dynamic Data Exchange (DDE) based data management tools.

Any data value in the SCADA/EMS shall be available for collection, calculation, retention, and archiving by IS&R. This includes scanned data, data received via data exchange such as ICCP, SCADA/EMS calculated data, and data used and produced by EMS applications such as SE. In addition, logging information from the Network Management System and Authentication Services shall also be stored within the IS&R for audit purposes.

Any authorized, designated SCADA/EMS user shall be able to access all IS&R functions, review scheduling and historical information, and edit selected (non-PI) information from any SCADA/EMS console in the Control Secure Network (CSN). IS&R shall also be accessible from the corporate WAN for non-system users. The Contractor shall ensure that the architecture supports the users on the CSN as well as those users who are on the corporate network.

The SCADA/EMS shall capture (for future analysis and/or replay) all changes of real-time data in OSIsoft PI. This data in the data historian shall not be editable.

Any third-party license(s) provided to support these functions must allow the Purchaser “full-use” of the software. It shall provide for Purchaser use all databases and applications delivered with the system by the Contractor as well as permit the Purchaser to develop additional applications and/or databases generally related to the functionality of the System.
10.1 AE Specific Requirements (AE Provided OSIsoft PI)

The SCADA/EMS shall provide data to an AE-provided OSIsoft PI data historian product on the Control Secure Network and the corporate network.

10.2 Server Support Requirements

For the purposes of server and memory sizing, the System shall be capable of storing the information listed in Exhibits 3-2 through 3-6 for the retention periods defined in Exhibit 3-6, Information Storage and Retrieval Sizes.

The System shall also be provided with the capability and capacity to extract and store the data needed for a query when the query covers the maximum number of retention days for the highest periodicity data retained. Within this context, “on-line” storage is defined as the set of data that is available to users within the response times defined in Section 3.2.6 Display Call-up Response Time.

In addition, the System shall support the archiving that is described in Section 10.4.6, Off-Line Archiving and Transfer of Data.

10.3 Client Capabilities

IS&R shall provide data access to the IS&R database by System and non-System users (Section 2.3.1 Definition of Users) using all of the data retrieval capabilities of the DBMS and PI. The PCs or workstation consoles shall be connected either to the SCADA/EMS LAN (CSN) or the Purchaser’s Corporate Network based on the security requirements of the Purchaser. Data retrieval shall meet the latest SQL standard. Remote data retrieval shall be subject to appropriate security measures but shall not be dependent upon Purchaser’s staff help or intervention. The Contractor shall provide the database client software and any additional Contractor-developed client software needed to utilize the IS&R capabilities.

10.3.1 User Access

The user access function shall incorporate the following features as a minimum:

1. Menu driven data selection process.
2. Pre-formatted sets of data retrieval request displays built via the IS&R user interface.
3. Sets of generic access routines for typical types of access, such as all analog points at a specific time and the average, maximum, and minimum of a value over a user nominated time period, etc.

4. Capability to define ad hoc queries to call for any specific values that have specified similar characteristics over specified periods of time.

5. Capability to transparently deliver interpolated data for a specific time or period of time and associated periodicity, where the source is stored by exception.

6. Capability to display data graphically.

7. Capability to edit select data (non-PI data) by authorized users.

8. Restrictions on access to confidential information based on user access control.

9. Seamlessly integrated with typical Web browsers for user retrieval of IS&R data and for the presentation of reports.

10. Capability to retrieve any quality code, tag, or data value stored for any IS&R data value.

For retrieval purposes, it shall be transparent to requesting users or applications whether the requested information is stored on-line or on archival storage, or spans across both storage types. The IS&R shall satisfy a retrieval request of any time period and any time span. Sufficient relationships shall be maintained between the IS&R data and the System’s Real Time Data Base (RTDB) to ensure that selections can be made based on comparisons between stored IS&R values (such as a periodically saved bus voltage value) and any related, fixed System value (such as the bus voltage limit). In addition, the displays shall be captured so that the data context can be maintained. That is, savecases shall include the model and displays.

10.3.2 Function Access

The Contractor shall provide a library of programming interfaces to allow any function added by the Purchaser to access IS&R for information storage and retrieval. For example, the capability to initialize a power network analysis study case or OTS from IS&R for any date and time within the data retention period or the archived period shall be provided. The data storage times closest to the date and time specified by the user shall be used to select values from the IS&R database.
The IS&R database shall also provide an interface to PC-based applications such as Microsoft Office applications (e.g., WORD, EXCEL, etc.), report generators, and other RDBMS and DBMS products via the latest standard SQL data requests or ODBC drivers.

### 10.3.3 Automated Data Capture

The capability to capture any analog, calculated, or status value defined in the SCADA/EMS database either upon detection of its change (with associated data quality codes and time tags) or periodically in sets of associated data shall be provided. Automated capture of alarms and events, user entries (including control, tag and flag requests, manual data entries including limit changes) and system maintenance log entries shall be provided. All alarms and events shall be captured upon occurrence and forwarded to the IS&R facility for storage and future access.

The alarms and events shall be stored in a DBMS. The Contractor shall provide user-friendly forms that allow the user to build ad hoc queries of any combination of the individual fields stored with each entry. These fields include date, time, substation name, point name, alarm category, AOR, alarm priority, alarm type, data type, and message text. Queries may be saved and query results may be viewed, printed or written to a file in a format such CSV, xlsx, txt, etc. In addition, each entry may have a user-entered comment.

Data shall be recorded in such a manner that it is possible to retrieve a complete picture of the power system from any date and time specified by a user (i.e., a “snapshot”). This snapshot shall include all power system telemetered and derived measurements and statuses (including quality codes, analog limits in effect at the time, etc.) as well as system alarm and events. The Contractor shall provide all tools necessary to retrieve this data using SQL and ODBC-compliant applications.

In addition to the above, the following types of data shall be stored and made available for user access:

1. Sequence of Events (SOE) messages.
2. Communications statistics and errors.
3. Transmission Operator standards-related data.
4. Environmental (e.g., weather, hydrological, etc.) data.
5. System processor and application status.
6. Power application solution status for the different applications such as SE, CA, etc.
7. The contingency analysis results and state estimator results. The Administrator shall be able to select the results data to be saved.

10.3.4 **Data Quality Codes**

The IS&R database shall include all of the quality codes associated with each point. In addition, a distinct quality code shall be provided to denote that a correction has been made to a point’s value while in the IS&R database.

10.3.5 **System Message Log Storage and Retrieval**

The system message log storage and retrieval function shall consist of a chronological listing of all SCADA/EMS alarm messages and event messages. Each entry shall consist of the same time tag, dynamic information, user identification, and text that is displayed on the SCADA/EMS alarm summaries and event summaries. The capability to add comments to each entry shall be provided. System message log data shall be stored in IS&R and transferred to archival storage.

Facilities to sort, filter, search, selectively display, export, and print the contents of the system message log shall be provided through the IS&R user interface. A user shall be able to select the display of system message log entries based on the following sort or search parameters and combinations of these parameters:

1. Alarms – Select a set of alarms based on alarm partitioning, AOR, or severity level.
2. Events – Select a subset of events based on user action (including specific users) and application function-detected condition (including specific applications).
3. User log messages – Select a subset of log messages based on specific or all users.
4. Substations – Select a subset of alarms or events based on specific or all substations.
5. RTUs – Select a subset of alarms or events based on specific or all RTUs.
6. Device types – Select a subset of alarms or events based on specific device types.
7. Devices – Select a subset of alarms or events based on specific devices.
8. Time periods – Select message log entries based on specific time periods.
A display shall be provided to permit the user to define the selection criteria for sorting, filtering, exporting, or searching. When a user calls up the display, the user may select an existing selection criteria (queries) previously defined by the user. The capability to save queries on a private (just for that user) or public (accessible by all users) basis shall be provided.

10.4 Historical Databases

Data collected or calculated by the SCADA/EMS shall be saved in a historical database (HIS). Historical data shall be available for viewing and editing (non-PI data) by authorized users, inclusion in printed reports, exporting, archiving for long term storage, and transmission to external systems. The selection of data for inclusion in the historical database including data to be stored in PI shall be controllable by the Purchaser, shall be defined in the RTDB, and shall not require separate IS&R definition. The default enabling/disabling status of each point will be defined during the “existing-to-new” SCADA/EMS database conversion.

The stored data, including archived data, shall contain sufficient information to enable the retrieval of the data value, its quality codes, and the time and date that the data was collected at any time in the future. Access to the stored data shall not be affected by computer system failure recovery, time change, or changes to the computer system configuration.

All stored data shall be accessible from any time period regardless of any RTDB or IS&R database changes that may be made after storage of the data. For example, the capability to retrieve stored data for a variable that no longer exists in the System and initialize study-mode network analysis functions with stored data although the power system model has changed shall be provided.

Database changes shall not require stored data to be re-built (e.g., changing the IS&R database structure shall not require archived media to be re-built). This shall also apply to a retrieval request that may span across multiple database changes.

The addition, deletion, or modification of data to be collected and processed shall not result in loss of any previously stored data during the transition of data collection and processing to the revised database.
10.4.1 **SCADA Historian Integration (AE Specific Requirement)**

The Purchaser will provide all required OSIsoft PI server and client licenses, but requires the following integration of the SCADA/EMS with PI:

1. Any data value in the real-time database shall be available for collection and storage without limitation into PI.
2. All events shall be stored in PI.
3. The interface API shall be a direct connection to PI.
4. The Data Engineering tool shall allow the user to indicate which historian(s) a given value should be sent to each time it changes and the Data Engineering tool will define the required tag(s) in all specified PI historians.
5. The PI tag naming convention shall be identical to that of the existing SCADA/EMS as specified below:
   5.1. Analog Point Values – SubstationName.PointName.AV
   5.2. Analog Point Quality Flags – SubstationName.PointName.AQ
   5.3. Status Point Values – SubstationName.PointName.SV
   5.4. Status Point Quality Flags – SubstationName.PointName.SQ
   5.5. Accumulator Point Values - None Currently
   5.6. Accumulator Point Flags - None Currently
   5.7. Application Values - Stored in Analog or Status Points
   5.8. Integrated Database Values – tablename.fieldname.primarykey
   5.9. Real-time RTU Communication – tablename.fieldname.primarykey
6. The SCADA/EMS shall support the identification of users and groups for each data point for data security purposes (i.e. a given point may be viewable by some users and not others).
7. The SCADA/EMS shall automatically synchronize access permissions for all real-time data and their corresponding SCADA Historian data.
8. The SCADA/EMS shall send point values or quality flags to each identified PI historian upon change.
9. The values shall be stored in PI with the most accurate time value available for the value. For example, if the RTU or peer ICCP node sends a time stamp with the value that time stamp
shall be stored. If the RTU doesn't send a time stamp, the Data Acquisition front-end processor shall store a time stamp for the value.

10. SOE data shall be stored in PI, with the millisecond resolution timestamps that are sent with the data from the RTU.

11. If the SCADA/EMS cannot communicate with a given PI server it shall "queue" the updates for that historian until it re-establishes communication with the historian, then shall "de-queue" all stored data to that historian.

12. When a point is removed from the real-time database, or when a point is removed from a collection set definition, a record shall be added to the audit trail such that it can be determined that the data point is no longer being collected by IS&R.

13. If a data item has been removed from the real-time database, the capability shall be provided to recreate the data item, with the same name, and to again collect and store the data in IS&R, appending new data to the previously stored data.

14. The SCADA/EMS Historian data definitions shall include information relating the historian point to its real-time database source such that the historian data presentation functions can, given the historian point name, retrieve information on the point from the real-time database.

15. When a SCADA point is renamed, the name change shall be reflected in the PI database.

All existing PI data shall be preserved. The Contractor is responsible for mapping the existing the PI tag IDs to the SCADA points in the new SCADA/EMS system.

The Purchaser has developed a number of downstream applications, spreadsheets, and ProcessBook displays that retrieve data from their PI historians and they require that those applications/spreadsheets/displays not be impacted by the replacement of the SCADA/EMS. The Contractor shall be responsible for ensuring that all existing Contractor developed ProcessBook displays work the same with the new SCADA/EMS as with the existing SCADA/EMS.

10.4.2 Capabilities of the Historical Databases

All the historical data collected by the SCADA/EMS shall be stored in the PI and DBMS database. All the data needed for the preparation of SCADA/EMS reports shall be derived from this database. Users shall be able to select from this database any part, or all, of the historical data collected or processed by the system for viewing and editing (non-PI data only), printing,
exporting, and archiving to magnetic or other suitable media that may be added to the system. To do so, user-oriented procedures that do not require familiarity with database querying techniques shall be provided for the display and printing of on-line historical data for specific points or predefined groups of points and for user-specified time periods. Procedures based on selection by pointing, with minimal data entry, are required for the selection of historical data for display, archiving, or any other purpose.

The historical database shall consist of historical points and blocks thereof. A historical point is a set of values collected for 1 (one) variable at pre-specified time periods. Such variables can be telemetered or non-telemetered values from the real-time database or variables calculated periodically from other historical points. Examples are bus voltage readings, which may be saved hourly from the real-time database, or hourly minimum and maximum values calculated daily for sets of historical points. The arithmetic precision of real-time data shall not be reduced when stored in the historical database. Historical data shall be stored in such a way that it will be possible to identify and display the date and time of each entry and request specific data for specified time periods. Historical data shall be saved together with the associated data quality codes.

On delivery, the historical database shall be configured to store historical data at the storage rates for the period of time and delivered capacity sizes given in Exhibit 3-3, Exhibit 3-4, and Exhibit 3-5 for the retention periods defined in Exhibit 3-6. However, the size of the historical database shall be constrained only by the capacity of the disks. The capability to increase the number of data points stored at each time, or the number of data periods for which data is stored, while the database is on-line and without using export and import procedures shall be provided. The database shall be expandable beyond the delivered configuration by assigning added physical storage.

10.4.3 Historical Points

The capability to create a historical point for any telemetered or non-telemetered status, analog, or accumulator data point including limits in the real-time database and to create calculated points based on these and other historical points shall be provided. The value of a data point shall automatically be saved in the historical database together with its quality codes at configurable
time intervals or by exception. Within this context, it shall be possible without requiring any
programming skills to:

1. Create new historical points by selecting real-time data to be saved.
2. Create calculated historical points through definition of the calculations.
3. Delete a calculated historical point.
4. Specify the time periods at which the data is to be saved or calculated.
5. Stop historizing a data point.

As a minimum, selection for data saving and calculation shall be possible for an individual point
on a daily, weekly, and monthly basis for periods of 1 (one) minute, 5 (five) minutes, 15 (fifteen)
minutes, 30 (thirty) minutes, and 60 (sixty) minutes synchronized with the hour. Daily, weekly,
and monthly processing shall occur shortly after midnight. The SCADA data shall be saved in
the PI data historian at the scan rate.

The calculations specified in Section 5.3.4.2 Calculated Data Points, shall be provided as
applicable to historical data. Additional operations as required for historical data include:

1. Calculation of maximum, minimum, sum, average, and standard deviation over a set of data
   saved at one time.
2. Calculation of maximum, minimum, sum, average, and standard deviation of the values of a
   historical point over a pre-specified time period.

Every calculated data point in the historical database shall carry a quality code, which shall be
set as specified in Section 5.2.2 Data Quality.

10.4.4 Manual Entry of Historical Data

The user shall be permitted to edit some of the values (non-PI data) in the historical database.
Edited data shall be given a data quality of “Manually entered”. If the user manually edits any
one or more of the component points of a calculation, the system shall re-compute the calculated
value and its data quality. User-oriented manual entry procedures shall be provided that do not
require programming skills. All manual entry actions shall be logged. The system shall maintain
a change log of who edits the data for audit purposes. The selection of editable data in the
historical database shall be controllable by the Purchaser.
10.4.5  **Required Historical Data**

1. As a minimum, historical data to be collected by each SCADA/EMS upon delivery shall include all data shown in Exhibit 3-3, Exhibit 3-4, and Exhibit 3-5. More explicitly, some of the required historical data shall include:

2. All status and analog values including limits upon change.

3. Hourly snapshots of all analog values in the real-time database (RTDB). The capability to define a snapshot periodicity (e.g., scan rate, 5 min, 15 min, etc.)

4. Value of line current (Ampere) or MW flow prior to a breaker trip.

5. Data saved at the time of the Daily System Peak.

6. Data placed in the historical database by Power Network Analysis functions such as contingency analysis and state estimator results.

7. Alarm & Event Log. For this historical table, it shall be easy to select the entries to be displayed, exported, or printed based on the following sort and filter parameters and any combinations of these parameters:
   7.1. Alarm – Select a set of alarms based on alarm category and alarm priority.
   7.2. Events – Select a set of events based on user action and application detected condition.
   7.3. Station – Select a subset of alarms or events based on one or several stations.
   7.4. RTU – Select a subset of alarms or events based on one or more RTUs.
   7.5. Device type – Select a subset of alarms or events based on specific device types.
   7.6. Device – Select a subset of alarms or events based on specific devices.
   7.7. AOR – Select a subset of alarms or events based on specific areas of responsibility.
   7.8. Time period – Select a specific time period of interest.
   7.9. Text string – Select a subset of alarms or events based on text strings within the messages.

8. SOE Log. For this historical table, it shall be easy to select the entries to be displayed, exported, or printed based on the following sort and filter parameters and any combinations of these parameters:
   8.1. Station – Select a subset of alarms or events based on one or several stations.
   8.2. Device type – Select a subset of alarms or events based on specific device types.
8.3. Device – Select a subset of alarms or events based on specific devices.
8.4. AOR – Select a subset of alarms or events based on specific areas of responsibility.
8.5. Text string – Select a subset of alarms or events based on text strings within the messages.
8.6. Time period – Select a specific time period of interest.

9. RTU failures. For this historical table, it shall be easy to select the entries to be displayed, exported, or printed based on the following sort and filter parameters and any combinations of these parameters:

9.1. RTU – Select a subset of RTUs based on one or more RTUs.
9.2. Time period – Select a specific time period of interest.

Any other data that has not been explicitly identified above but is needed for the preparation of specified reports shall also be collected.

The SCADA/EMS shall provide storage that extends to 3 (three) years on-line before the user needs to access archived data. When the requested online data is not available, the System shall display an appropriate message to the requesting user.

10.4.6 Off-Line Archiving and Transfer of Data

The system shall be able to copy historical data periodically from the database to any removable storage medium for long term archiving and for file transfer to other systems. A capability to restore archival data to the historical database for viewing and editing (non-PI data) is required. When archived historical data is restored to the SCADA/EMS it shall be placed in a “reconstructed” history file, and this data shall be used in the same way as regular historical data. All archived historical data shall be stored for the retention periods defined in Exhibit 3-6 online before being archived. User-oriented procedures, which do not require programming, or database querying skills, shall be provided to select the desired data and the particular time period data.

Selection of historical data for archiving shall be initiated by an authorized user from any of the SCADA/EMS consoles. Pre-defined sets of historical points and time periods to be copied and the destination device (if there is more than one) shall be selectable. More flexible selection of
points shall also be possible. A user-oriented procedure is also required to delete reconstructed history files when they are no longer needed.

Data shall be archived in a format that is supported by commercial databases such as SQL.

10.5 Information Delivery

The Contractor shall provide enterprise information delivery tools that support ad hoc data retrieval reports as well as the creation and maintenance of periodic and on demand reports. The tools shall be highly interactive and preferably Web-based, allowing the user to see representative output from the report during the building procedures. The reporting software shall have full read-only access to the IS&R database and shall support sorting, filtering, algebraic, logical, and arithmetic functions such as spreadsheet calculations, to allow for creation of reports. The software provided shall be a commercially available package capable of generating complex reports. The IS&R shall provide the capability for Purchaser’s users to configure report formats. The Administrator shall be able to select version control of report definitions to be integrated with the source control system established for the Program Development System on a report by report basis. Any report may be displayed on the screen, sent to any printer, exported, or sent through an industry standard messaging system (e.g., email) to any destination.

10.5.1 Reports

Any authorized SCADA/EMS user shall be able to schedule the generation of IS&R reports by time and date or on demand. In addition, the user shall have the capability to specify conditions detected by the SCADA/EMS where designated reports are automatically initiated. Reports shall have the capability of being regenerated if a value in the report is adjusted and all dependent values are re-calculated.

The facility shall be able to securely publish these reports in any format (including HTML, XML, PDF, delimited text, Postscript, and RTF) to any destination (including email, Web browser, and file system). The user shall be able to designate the format and destination to which reports are generated. If the destination is a hard copy printing device, the system shall use available (i.e., base operating system) print file spooling logic. This shall include automatic
redirection to a compatible output device and notification to the system administrator and to the report requestor of the redirection. The report shall not have to be rebuilt to send it to additional destinations. The IS&R shall track successful report distribution and receipt and shall generate a notification for any delivery failures.

10.5.2 Ad Hoc Reporting Functions

The IS&R database tool set shall include a method for extracting data using industry standard SQL or ODBC. The System shall allow a less sophisticated user a means of constructing database queries. The Purchaser prefers a tool such as Query by Example (QBE) to be available with the System for such a purpose.

The provided simple query tool may generate complex SQL. It is desirable that the simple query tool shall optionally display the SQL that it generates, so that the more sophisticated user can view and edit the SQL required to execute the query.

10.6 Historical Information Applications

The SCADA/EMS shall have the capability to create a picture of the state of the power system at given points in the past. This picture requires not only a snapshot of the power system telemetered and derived measurements and statuses, but also the results of various application programs (e.g., limits and associated existing conditions) and prevailing alarms as well as display snapshots and power network applications.

Historical information shall be used to support control room activities in the current day/hour operating timeframe. The IS&R shall record historical information in a manner that can be accessed quickly for control room functions. Outside of the control room operating timeframe, performance requirements are less stringent, but the ability to access data through ad hoc queries becomes more important.

Historical snapshots of the power system are required to support the following processes:

1. Historical data required by Purchaser to support business processes and decision support. For example, various forecasting activities are based on past history.
2. Disturbance analysis by Purchaser to analyze and report on power system events defined by operating policy. The system shall include disturbance analysis reports that show the pre- and post-disturbance conditions and values.

3. The Operator Training Simulator.

4. Power network analysis applications.

10.7 Historical Playback

The System shall include an historical playback feature, which shall be available to multiple users simultaneously and independently. The user shall be able to select a start date and time from PI or the historical alarm and event file or nominate a start date and time. The System shall display the historical values and alarms on the displays (including Alarm Summary and Event Summary and one-lines/tabulars) that are normally used for displaying real-time data. The user shall be able to initiate the historical playback from a one-line diagram.

The user shall be able to move forward and backward through a set of control buttons on a console, or through PI data or historical alarm and event file, and the corresponding values and alarms shall be shown on the displays as they occurred at that time. In addition, the user shall be able to put the displays into fast forward or backward mode to replay the history at a user nominated rate.

An indicator shall appear on each display that is in historical playback mode. The indicator shall always be visible.

Operator actions related to historical playback shall not be processed as events.
11 System Software Requirements .......................................................................................... 298

11.1 Operating System Software ........................................................................................ 298

11.1.1 AE Specific Requirements (AE Preferences) ..................................................... 299

11.2 System Software Requirements .................................................................................. 299

11.2.1 Software Development and Integration .............................................................. 299

11.2.1.1 Programming Tools .................................................................................... 300

11.2.2 Time and Calendar Synchronization Service ...................................................... 301

11.2.3 System and Network Management Software ...................................................... 302

11.2.3.1 System Resource Monitoring and Management ........................................ 302

11.2.3.2 Diagnostics .................................................................................................. 303

11.2.3.2.1 Online diagnostics ................................................................................... 303

11.2.3.2.2 Offline Diagnostics ................................................................................. 304

11.2.3.3 Performance Tuning Capabilities ............................................................... 305

11.2.4 Virus and Malware Protection Software ................................................................ 305

11.2.4.1 AE Specific Requirement (Option) – Heat Endpoint management and security Suite ................................................................................................................... 305

11.2.5 Operating System Security Patch Update System .............................................. 306

11.2.6 SCADA/EMS Patch Update System .................................................................. 306

11.2.7 Automatic System and Data Backup .................................................................. 307

11.2.7.1 Austin Energy Specific Requirement (AE Provided backup software)..... 308

11.2.7.2 Austin Energy Specific Requirement (Contractor Provided backup software Option) 308

11.2.8 Remote Maintenance Access ........................................................................... 308

11.2.9 Third Party Software Interface Requirements .................................................. 309

11.3 Video Wall Display Workstation Software .............................................................. 309

11.4 Protocol Analysis Software ...................................................................................... 310
10 Information Storage and Retrieval (IS&R)........................................................................................................ 281
  10.1 AE Specific Requirements (AE Provided OSIsoft PI) ................................................................. 282
  10.2 Server Support Requirements ................................................................................................. 282
  10.3 Client Capabilities .................................................................................................................. 282
    10.3.1 User Access.................................................................................................................. 282
    10.3.2 Function Access ........................................................................................................ 283
    10.3.3 Automated Data Capture ............................................................................................ 284
    10.3.4 Data Quality Codes .................................................................................................... 285
    10.3.5 System Message Log Storage and Retrieval ............................................................ 285
  10.4 Historical Databases ............................................................................................................... 286
    10.4.1 SCADA Historian Integration (AE Specific Requirement) ........................................... 287
    10.4.2 Capabilities of the Historical Databases ................................................................. 288
    10.4.3 Historical Points .......................................................................................................... 289
    10.4.4 Manual Entry of Historical Data ............................................................................... 290
    10.4.5 Required Historical Data............................................................................................ 291
    10.4.6 Off-Line Archiving and Transfer of Data .................................................................... 292
  10.5 Information Delivery .............................................................................................................. 293
    10.5.1 Reports ........................................................................................................................ 293
    10.5.2 Ad Hoc Reporting Functions ..................................................................................... 294
  10.6 Historical Information Applications ..................................................................................... 294
  10.7 Historical Playback ................................................................................................................ 295
11 SYSTEM SOFTWARE REQUIREMENTS

This section specifies requirements for the software platform of the SCADA/EMS system and for SCADA/EMS system management and maintenance tools. This includes the operating system, basic software, resource monitoring capabilities, compilers, system and network management tools, and software development tools.

All software written by the Contractor shall be written in an industry standard high level language such as C++ or C#. Software sources shall include clear and unambiguous comments written in grammatically correct English, and each program shall include a comprehensive description of its purpose, functions, inputs, outputs, and resources operating system software.

11.1 Operating System Software

An operating system with long term support shall be supplied by the manufacturer of the processors and shall be used in all general-purpose processors (servers) of the SCADA/EMS. In this respect, the Contractor shall provide the latest version of Windows Server or Linux Enterprise operating system certified on the vendor software and included in the vendor long-term support program (also refer to Section 2.2 Architectural Principles).

All workstations shall use a latest version of the Windows operating system from Microsoft certified on the vendor software and included in the vendor long-term support program. The SCADA/EMS user interface shall be native to Microsoft Windows such that it is not necessary to remotely login to a console server or require use of X emulation or something similar.

The most recent release of MS Office Professional compatible with the delivered SCADA/EMS workstations’ Operating System shall be provided.

The same standard unmodified version of the operating systems shall be used throughout the SCADA/EMS. They shall be the latest revisions released up to at least 6 (six) months before FAT. The operating systems shall be patched to the latest version recommended by the OS supplier and provide robust security features.

Original Equipment Manufacturer (OEM) Operating Systems are not acceptable to the Purchaser and will not be specified.
All operating systems of network equipment shall use the latest revisions released up to at least 6 (six) months before FAT and certified on the vendor software and included in the vendor long term support program.

In order to facilitate operating system upgrades, the operating system directories shall not include any files that are irrelevant to the operating system. In addition, the operating system and data files shall be placed in different disk partitions.

The Contractor shall be responsible for service and support of the installation and the validation of update security patches during the warranty period.

11.1.1 **AE Specific Requirements (AE Preferences)**

AE prefers Microsoft Windows or Linux for all servers and Microsoft Windows for all clients. They require that Virtual Machines be utilized to the full extent possible, with a preference for Nutanix hyper-converged infrastructure. The Nutanix provides native convergence of compute, memory, and storage resources in a single appliance. In addition, AE plans to utilize CISCO ACI (Application Centric Infrastructure) to administer the Local Area Network for the SCADA/EMS. The SCADA/EMS solution must be compatible with both the Nutanix and CISCO ACI products.

These requirements are based on the AE preference for Nutanix hyper-converged infrastructure that hosts Virtual Machines (VMs) in the form of guest software dedicated to specific SCADA/EMS functions and tasks. Use of Nutanix HCI along with CISCO ACI including their detailed configuration design shall be proposed by the Contractor for the express purpose of satisfying in the best possible way the AE SCADA/EMS capacity, performance, availability, and security requirements.

11.2 **System Software Requirements**

The following requirements shall apply to the System’s software.

11.2.1 **Software Development and Integration**

Software management shall be based on the concept of a master source code repository for centralized management of source code. Procedures shall be established for checking out source code for development or compilation and for submittal of new or revised source code. No source
code shall be kept in run-time environments, and source handling procedures shall be established to avoid the spread of source code outside the source code repository. A single repository shall exist at all times.

A hierarchically organized programming development environment shall be established for all software. Programs and data files shall be placed in different disk directories, and programs belonging to different subsystems shall be placed in different directories. A consistent naming convention shall be enforced to distinguish programs in different subsystems and to distinguish between program source files, parameter source files, object files, command files, libraries, executable code, and program documentation. Software that is under development and software released for the operational system shall be maintained in completely different directory structures. The time and date of the last update and the log-in identification of the programmer submitting modified code shall be kept in the code repository.

Revision control software capabilities, such as Visual Source Safe, etc., shall be provided to manage software maintenance and update processes for all aspects of the SCADA/EMS.

Revision control tools shall be provided to allow individual users to maintain control over an item such as a source file while they implement and test changes to it. During the period that the file is "checked out," no other user shall be allowed to modify it. When the user is satisfied that the changes have been implemented successfully, the file shall be "checked in" to the baseline database for use by everyone.

An audit trail shall be maintained of modifications to each program’s source code to allow the sequence of changes to be automatically reconstructed, starting with the latest version of the program that was released for integration into the SCADA/EMS. The SCADA/EMS software generation process, unless explicitly directed otherwise, shall use the latest version of all inputs. Tools and procedures are required that use the audit trail to restore the SCADA/EMS software to a previous known source code version.

11.2.1.1 PROGRAMMING TOOLS

The system software shall include a comprehensive set of programming tools and aids, including:
1. Assembly and Compilation Facilities – Compilers and assemblers, programming tools, and programming services shall provide facilities for assembling or compiling all the delivered programs. This shall include compilers for all the languages in which the delivered software was written.

2. On-line Interactive Debugging Tools.

3. Utility functions, such as editors, file comparison, library maintenance, etc.

4. Program Loading – Object modules produced by the compiler shall be temporarily stored on the disk and upon command by the programmer shall be loaded and linked for execution in the system. The program loading module may consist of 1 (one) or more programs, written in 1 (one) or more languages, from more than 1 (one) input medium with necessary linkages, in any combination.

5. The capability shall be provided to create, modify, and execute batch files for program linking.

### 11.2.2 Time and Calendar Synchronization Service

Each system and application throughout the SCADA/EMS shall have the capability of being time synchronized using Coordinated Universal Time (UTC) over Network Time Protocol (NTP) to provide accurate time stamped information.

This system service shall automatically adjust System time in accord with the input from the GPS synchronized clock without the need for centralized time synchronization software to avoid a Single Point of Failure (SPOF).

In addition, a time monitoring service shall be provided through the system management services to ensure that all systems are correctly synchronized. An Administrator shall be alerted if an application or device has demonstrated a loss of synchronization. Historical data that had been scheduled to be stored during the time gap shall be marked with an appropriate quality flag.

When time is not automatically synchronized from the time and frequency standard, an event shall be recorded and an alarm shall be issued to the assigned authorized users. An authorized user at an authorized console shall be able to set the time and/or to correct the time by entering a time increment or decrement. The updated date and time shall be used to immediately update the system clock and calendar at all servers and user workstations, and to reschedule the initiation of
programs and scheduled functions. If the clock is moved forward, or moves forward as a result of resynchronization with the time standard, all functions (such as printing of reports) that were scheduled for execution in the time gap shall be immediately executed.

The event log of synchronization for all servers, all workstations, and all network equipment shall be stored in the centralized logging server and shall be accessed via the Engineering console.

11.2.3 System and Network Management Software

The Local Area Network equipment and monitoring/administration tools will be provided by AE. As mentioned, they plan to use CISCO ACI to define/maintain the network. The SCADA/EMS vendor shall identify any LAN requirements of their system in their response to the RFP. In addition, the SCADA/EMS vendor shall be responsible for resolving any problems their SCADA/EMS has working within the LAN if the problem is due to LAN requirements not identified by the vendor.

11.2.3.1 SYSTEM RESOURCE MONITORING AND MANAGEMENT

The SCADA/EMS shall include functionality to monitor and record the utilization and queuing of requests for resources on the various components of the System, including the following:

1. Utilization (i.e., percentage of processor or channel time being used) of the following resources:
   1.1. Servers, workstations, and data storage systems
   1.2. LANs, routers, and switches
   1.3. Communications servers and data links
2. Queue lengths and average wait-times for the following queues:
   2.1. I/O queues for disks and mass-storage devices
   2.2. I/O queues for access to the LAN and wide-area network
   2.3. Processing queues for major tasks, such as database access, alarm generation, scan data processing, etc.

The utilization/performance information shall be sufficient for the following objectives:
1. Enable Purchaser’s staff to track the system usage, determine bottlenecks, and plan system upgrades
2. Verify compliance with the specified performance requirements during System Acceptance Tests
3. Perform basic analytics on system cyber security, system traffic patterns, usage, and other configurable parameters

Appropriately authenticated users shall be able to use any Engineering workstation for viewing and to request reports of SCADA/EMS System utilization and other performance information. The utilization parameters shall be accessible to Purchaser-written or commercial network management statistical analysis programs.

In addition, System resource monitoring and management shall allow authenticated users to manage all network devices within the SCADA/EMS. This includes the administration of accounts and the configuration of devices.

The Contractor shall provide tools to monitor the RTU communications as defined in Section 11.4 Protocol Analysis Software.

11.2.3.2 DIAGNOSTICS

Both on-line and off-line diagnostic programs shall be provided for all hardware components of the system supplied by the Contractor.

11.2.3.2.1 Online diagnostics

On-line diagnostics shall operate initially when power is first applied to the device. At start up, the diagnostics shall report error messages on the Engineering workstations. Errors detected during startup shall be logged to a SCADA/EMS Errors log. Start-up diagnostics shall detect and report such problems as configuration and security errors, corrupted disks, failures to access memory, failures to access the LAN, or failures to access a required peripheral device.

After the device has been powered up, self-check capabilities incorporated in the equipment controllers and monitoring software shall provide continuously active error detection while the device is in operation. All detected errors, including non-critical and automatically corrected
errors, shall be logged into the SCADA/EMS Errors log. Equipment failures and possible security breach indications shall also generate alarms.

The on-line diagnostic programs shall be provided to monitor the loading and performance of every system processor, server, and LAN. The LAN diagnostic shall be able to scan for a preset pattern (e.g., source address, destination address, specific data field, etc.), store all messages that include the pattern in a circular buffer, and display the messages on user request in a documented and easy to interpret format. The LAN diagnostic shall be able to generate LAN traffic to simulate the loading that may be imposed by any device on any LAN of the SCADA/EMS. LAN diagnostics shall also allow system analysts to configure devices on the LAN for test purposes (e.g., block messages from being received or sent by certain devices).

### 11.2.3.2.2 Offline Diagnostics

Off-line equipment diagnostics shall be performed while the SCADA/EMS is fully operational, with only the equipment being tested placed off-line. The off-line diagnostics shall also be executable in the backup units of redundant configurations while the backup unit remains available for failover. The off-line diagnostics shall be automatically terminated in the event of a failover. Administrators shall be able to use SCADA/EMS Configuration Control displays to declare equipment to be off-line and unavailable and to perform the appropriate diagnostics under interactive control.

Off-line diagnostic programs shall test and evaluate the performance and shall analyze the failures, errors, or possible security breaches of all the processors, peripherals, and other devices of the SCADA/EMS. These off-line diagnostics shall provide extensive facilities for reporting and user interaction from maintenance consoles. The off-line diagnostic programs shall comprise a complete analysis and diagnostic tool for verifying the correct operation and for detecting and analyzing problems in each piece of equipment.

A complete set of off-line executable diagnostic program files shall be installed in the SCADA/EMS and included in the SCADA/EMS software delivered on read-only portable media or another medium supported by the SCADA/EMS.
11.2.3.3 **PERFORMANCE TUNING CAPABILITIES**

An Administrator shall be able to access and modify performance tuning parameters, such as:

1. Execution priority for all programs and processes
2. Program access priority to resources such as disks and communication channels
3. Program event notification priority
4. Program use of non-restricted and restricted operating system functions.

11.2.4 **Virus and Malware Protection Software**

All servers and workstations shall include virus and malware protection software that shall run at startup, when initiated by an authorized user such as Administrator, and whenever data or programs are loaded into any server and workstation in the SCADA/EMS. The virus and malware protection software shall search for and report the existence of software viruses in RAM and on associated disk devices. A server or user console shall be disconnected or not be allowed to connect to the SCADA/EMS if it has been found to harbor a virus or other malicious software.

An update service shall be available for the virus and malware protection software, with updates for new known viruses provided to the Purchaser as soon as they become available. The Contractor shall be responsible for this service and shall support the installation of updates during the warranty period. Updating shall be required only on one server, with the updated version distributed as appropriate to similar servers in the rest of the SCADA/EMS.

The virus and malware protection software shall provide centralized installation, configuration, reporting, monitoring, updates and group management for all servers and workstations in accordance with the System Security requirements.

11.2.4.1 **AE SPECIFIC REQUIREMENT (OPTION) – HEAT ENDPOINT MANAGEMENT AND SECURITY SUITE**

Currently, AE is using the Heat Endpoint Management and Security Suite. As an option, the Contractor shall support use of this software or offer an alternative.
11.2.5  **Operating System Security Patch Update System**

A system shall exist to manage and deploy OS patch updates for both servers and workstations in accordance with the System Security requirements. The system shall present new patch updates as they are supplied by the OS vendor such that all available patches can be viewed. Using this system, the capability to view a summary of each of the servers and workstations to determine the version of software running (for security audit purposes) against that available shall be provided.

Adequate processes and the necessary infrastructure shall also exist such that patch updates can be securely deployed to all systems in a managed way, first within the support environments and then, once proven successful, to the Production Environment.

This system shall provide centralized management of this function using the appropriate Operating System update service such that minimal human intervention is required to perform the patch update deployment. It should also be noted that deployment of patches to the Production Environment should not be restricted to a scheduled task, but shall be “semi-automated” to allow strategic deployment in concert with Purchaser’s software change management procedures.

The patch update system shall be able to report which patches are applicable to which computers, and then report which patches are subsequently installed on which computers. In addition, third party patches shall also be supported.

11.2.6  **SCADA/EMS Patch Update System**

A system shall exist to manage and deploy SCADA/EMS patch updates for servers and workstations in accordance with the System Security requirements. The principles and mechanism employed shall be the same as for the Operating System Security Patch Update System.

The patch update system shall be able to report which patches are applicable to which computers, and then report which patches are subsequently installed on which computers.
The Operating System Security Patch Update System and the SCADA/EMS Patch Update System are not required to be a single system.

11.2.7  **Automatic System and Data Backup**

Once per day, shortly after midnight, the system shall automatically back-up the database to the Backup & Archiving Environment (BAE), which will contain online backup and removable media. The data saved shall include the entire real-time database, NOM, historical database, all displays, all source codes and all report definitions. In addition, the saved data shall include any configuration files (e.g., hardware definitions, definitions of parameters and calculations, script files, etc.) necessary for a complete “bare-metal” restoration of the software system from a catastrophic failure (see Section 4.18, Recovery Plans for BES Cyber Assets).

An authorized Administrator shall also be able to execute a system data back-up at any time.

Tools within the management system shall format the data in blocks and transmit them to the BAE unit at low priority to ensure that the system performance requirements as specified in Section 3.2, System Performance Requirements, continue to be met even while the system is performing the daily backup. This data transfer shall be performed without interruption to operational data, and should it be necessary to achieve this, a maintenance VLAN shall be used.

In addition to full backups, the Contractor shall propose an incremental backup, where the entire system is saved less frequently (e.g. once per month) and, on a daily basis, only those files that have changed are backed up.

The capability to back-up a complete image shall be provided.

In the event of a disk corruption or other problem affecting all redundant disks, the capability to restore an operational system, current as of the time of the most recent back-up, by loading system programs and then restoring the database and the configuration files from an unaffected source shall be provided.

All backup data contents shall be documented to include identification of the backup data and backup schedule and details concerning the restoration procedure. The Contractor shall develop,
document and test the restoration procedures for applicable use cases (full system restoration, incremental system restoration, “black start” system restoration, etc.).

11.2.7.1 **AUSTIN ENERGY SPECIFIC REQUIREMENT (AE PROVIDED BACKUP SOFTWARE)**

AE will provide the backup software and the Contractor’s system shall work with the AE provided backup product.

11.2.7.2 **AUSTIN ENERGY SPECIFIC REQUIREMENT (CONTRACTOR PROVIDED BACKUP SOFTWARE OPTION)**

As an option, the Contractor shall provide the backup software.

11.2.8 **Remote Maintenance Access**

The SCADA/EMS shall include remote maintenance access capabilities for authorized and authenticated users outside the Production Environment to access the SCADA/EMS for monitoring, analyzing, and maintaining the SCADA/EMS. The Purchaser shall provide the infrastructure for remote maintenance access.

Access over these facilities shall be tightly controlled and include strong access restrictions and encryption, including Virtual Private Network (VPN) technology between the remote system and the SCADA/EMS. The remote maintenance access shall have the minimum following characteristics:

1. The VPN access point at each control center shall be a resource dedicated to the VPN. All VPN traffic shall be routed through this access point. The access point shall enforce user authentication and security policies; access to the SCADA/EMS shall not be possible until the user has been authenticated.
2. A client shall be installed on each remote PC console that will be allowed to access the SCADA/EMS. The client shall be proprietary to the VPN technology supplier; it shall not be a client supplied with the PC operating system.
3. Administrators shall be able to disable remote maintenance access with a single action and to physically disconnect the SCADA/EMS from the access point.
4. Any VPN session shall be logged in the centralized server.
The Contractor is encouraged to propose additional security measures for remote maintenance. These may include but shall not be limited to technologies that abstract the SCADA/EMS support environment from the Contractor’s environment (such as CITRIX, WebEx, etc.) or prevent any in-bound connections, or require Purchaser additional steps to initiate the connection to the Contractor or other external user. The use of these technologies shall be subject to approval from the Purchaser and does not diminish any of the other security requirements.

The Contractor shall be able to inspect and solve any SCADA/EMS problems throughout the warranty period; therefore, it shall be the Contractor’s responsibility to prepare all necessary equipment used to link the Contractor’s remote workstations to the Purchaser’s SCADA/EMS. The network connection shall require the authentication of users and software, the encryption for any significant information, e.g., username, password, etc., and the logging of all remote session transactions. Any cost accorded to initial network connection setup and on-going network connection costs during the warranty support period shall be covered by the warranty.

11.2.9   Third Party Software Interface Requirements

Provisions are required for the Purchaser to add applications to the SCADA/EMS such as those developed in-house or by a third party. The capability of high-level language programs to access the databases by referencing unique variable names shall be provided. The residency (main memory versus disk memory or the identity of the applications processor) for the referenced variables shall be transparent to the programmer. In addition, the SCADA/EMS shall include well-documented non-proprietary application program interfaces (APIs) which may, at no cost and with no restriction, be used by the Purchaser or provided to a third party engaged by the Purchaser for development of applications for the SCADA/EMS. The APIs and database documentation shall be sufficient to allow the Purchaser or a third party to successfully integrate new programs with the SCADA/EMS. The APIs shall allow selectable read/write access to all database tables, records, and any descriptive fields and quality codes.

11.3   Video Wall Display Workstation Software

Purchaser plans to continue using their existing Primate Technologies servers to drive the Barco Video Wall, transitioning to native EMS Video Wall management functionality over time. The
only interface requirement to the Primate system is to use a provided API to send status and analog values, along with their quality codes, to the Primate server.

In order to prepare to transition, all Video Wall display workstations shall be delivered with the same Microsoft Windows operating system as provided for the SCADA/EMS workstations. In addition, the following software shall be delivered and installed on these workstations:

1. The most recent release of MS Office Professional compatible with the delivered SCADA/EMS workstations’ Operating System.
2. Utilities such as Adobe PDF viewer and PDF creator software
3. The same anti-virus and malware protection software and services used in the other SCADA/EMS workstations.

11.4 Protocol Analysis Software

The Contractor shall supply the necessary software to allow the Administrator to monitor, analyze, and capture SCADA protocol exchanges. The software shall be used by an authorized Administrator for connection to the SCADA/EMS and for RTU SCADA protocol testing.

The SCADA protocols test sets shall be capable of emulating both the master station and the SCADA RTU for all defined protocols such as DNP and ICCP.

This SCADA protocol test set software shall support multiple frame message processing and the full range of objects, variations and options for Extended WISP-Plus and DNP3 Subset Levels 1, 2, 3, and 4, including DNP3 security.

Software that enables the user to monitor and analyze both secure and non-secure ICCP and network protocols shall be provided.

The test set software shall provide dynamic data display during monitoring and simulation mode test sessions. It shall be capable of continuously monitoring communications without interfering with normal operation. The message data shall be displayed in a format that can be easily interpreted by the user. Selection of number base (decimal, hexadecimal, octal, and binary) shall be also available.
In addition, software shall be supplied to perform network utilization and performance monitoring, and LAN sniffing that will enable users to capture full TCP/IP packets in real-time and organize them by TCP connections to reconstruct communications. The sniffer shall support sorting and filtering of messages and saving the captured data to a file for future analysis. The sniffer will not interfere with any communications it is monitoring.
12 Hardware Requirements ........................................................................................................ 314
  12.1 AE Specific Requirements (Hardware Procurement) ................................................ 314
  12.2 Computer and Peripheral Devices .............................................................................. 314
    12.2.1 Servers ............................................................................................................... 314
      12.2.1.1 AE Specific Requirement (hardware procurement) ........................................ 317
      12.2.1.2 AE Specific Requirement (Nutanix) ............................................................. 317
      12.2.1.3 AE Specific Requirement (ae preferences) ..................................................... 317
    12.2.2 Workstations ...................................................................................................... 317
      12.2.2.1 AE Specific Requirement (hardware procurement) ........................................ 318
      12.2.2.2 AE Specific Requirement (VDI Environment Option) ................................. 318
    12.2.3 Time Standard Unit ............................................................................................ 318
    12.2.4 IS&R, Backup, and Archiving Storage .............................................................. 318
      12.2.4.1 AE Specific Requirement (hardware procurement) ........................................ 319
    12.2.5 Off-Site Backup ................................................................................................. 319
      12.2.5.1 AE Specific Requirement (hardware procurement) ........................................ 319
  12.3 System LAN/WAN Connectivity ............................................................................... 320
    12.3.1.1 AE Specific Requirement (hardware procurement) ........................................ 320
    12.3.2 Local Area Network (LAN) ............................................................................... 320
      12.3.2.1 AE Specific Requirement (hardware procurement) ........................................ 321
    12.3.3 Wide Area Network (WAN) ............................................................................ 321
    12.3.4 LAN/WAN Security Equipment ........................................................................ 321
  12.4 RTU Communications ............................................................................................... 322
    12.4.1 Front End Processors (FEPs) Functions ............................................................ 322
    12.4.2 RTU Communications Ports (AE Specific Requirements) ................................ 322
    12.4.3 Redundancy Requirements ............................................................................... 323
12.4.4 Protocol Communications Monitoring Facility ........................................... 323
12.5 SCADA/EMS Equipment Operating and Construction Requirements ................. 324
12.6 Video Wall Graphic Display Servers ................................................................ 324
  12.6.1 AE BARCO Video Wall ............................................................................. 326
    12.6.1.1 BARCO Video Wall: ......................................................................... 326
    12.6.1.2 Current Video Wall Sources: ............................................................. 326
    12.6.1.3 Video Wall Sources Future ................................................................. 327
12.7 Spare Parts ................................................................................................... 327
12 HARDWARE REQUIREMENTS

This section specifies requirements for the capabilities and construction of System hardware. Requirements for SCADA/EMS architecture and sizing can be found in Section 2 System Requirements and Architecture and Section 3 Capacity and Performance.

The hardware infrastructure shall be able to support the specified functional, performance, maintenance, availability, and expansion requirements for the SCADA/EMS. Printers, removable backup media, and other peripherals shall be included as needed for efficient and secure operation and maintenance of each function and element of the SCADA/EMS. Certain specific hardware requirements are given in the following sections. Detailed hardware specifications shall be established during Contract negotiations, based on the proposed hardware infrastructure.

The Contractor shall be solely responsible for the design and integration of the SCADA/EMS hardware infrastructure.

All hardware shall have been accredited to quality standard ISO 9001.

12.1 AE Specific Requirements (Hardware Procurement)

AE will be procuring most of the hardware based on the Contractor’s recommendations. AE will have the hardware directly shipped to AE facilities where it will be staged in a similar manner as the intended approach to be used with the final SCADA/EMS delivery environments at AE. AE will provide sufficient hardware at the Contractor’s facility to allow the Contractor to perform its design, implementation, and testing activities. AE will make a hardware infrastructure available to Contractor as a maintenance support system that will be used by the Contractor’s staff to support AE during warranty and maintenance.

The Contractor shall be responsible for any additional hardware modifications based on underspecifying the recommended hardware at no cost to the Purchaser.

12.2 Computer and Peripheral Devices

12.2.1 Servers

The Purchaser requires use of Virtual Machines (VM) as solution for all environments and prefers Nutanix hyper-converged technology for the VM implementation. Different functional
subsystems may incorporate different model processing resources as the most cost-effective design; however, except for user workstations (See Section 12.2.2 Workstations) all processing resources shall be members of a single family of processing resources, manufactured by a single manufacturer, and conforming to the same architectural design. The capability to replace or upgrade each processing resource with future compatible processing resources offerings without changing other components of the system or applications software shall be provided.

Workstations notwithstanding, the SCADA/EMS servers and their application software shall be implemented on the same revision of a widely accepted and latest version of the Windows Server operating system certified on the vendor proposed software and included in the Windows long-term support program (Linux operating system such as Red Hat Enterprise Linux or SUSE Linux Enterprise Server may be an acceptable alternative). The latest version of Server Operating System certified on the vendor proposed software shall be used so that, whenever a hardware upgrade is required, the SCADA/EMS software shall be portable to an infrastructure that offers the best price/performance ratio at that time. In addition, the operating system software shall be a standard product and shall not be modified by the Contractor.

The following requirements shall be met for each rack:

1. Rack mount keyboard and 17-inch TFT monitor.
2. Server Console Switch (KVM) which can manage all servers in each rack.
3. Where the supplied model of equipment has the option for redundant power supplies, then the equipment shall be supplied with this option.
4. All physical systems shall be equipped with two network switching modules that shall be configured as a functional team to support No Single-Point of Failure (NSPOF). Switches shall have minimum 1 Gbps speed interfaces.
5. Server disks and storages shall be configured using SSD RAID technology using either hardware or software means, with “hot swap” maintenance capability. A hot spare disk shall be included within any logical group of disks.
6. The servers shall have warning lights that indicate and help identify the equipment component or subsystem faults.
7. Redundant processing resources shall be housed in separate rack cabinets to enhance NSPOF capability.
8. The Purchaser shall be able to replace or upgrade the server processing resources with future compatible processor offerings to obtain increased computational power and system expansion with no required system or application software changes. To this end the backplanes specified shall be capable of multi-vendor support or have a minimum 10 (ten) year chassis architecture support arrangement. The Contractor shall provide written evidence of this arrangement.

9. All component functionality shall be maintained if either or both NICs are connected to the network.

The general-purpose processing resources shall be state-of-the-art with the following minimum characteristics:

1. 64-bit, multi-core Intel architecture.
2. Latest version of Operating System (as described above in this section) including installed latest release of security patches that are certified by the Contractor on its software as approved by the Purchaser and with Client Access Licenses that meet the Design sizing figures as specified in Section 3.1 System Sizing Requirements.
3. Auto-restart hardware and firmware.
4. Direct memory accesses controllers for high speed I/O operations to disk drives, DVD-RW, monitors, and backup processors.
5. Real time clock, calendar with battery backup, with synchronization from a NTP time standard.
6. Virtual memory management architecture.

These characteristics are only the minimum requirements for each server. The Contractor shall provide any needed hardware and software to achieve the system performance and availability requirements (as specified in Section 3.2 System Performance Requirements and Section 2.6 System Availability).

Single-function processing resources, such as gateways and routers, may be provided by other manufacturers and are exempt from the requirement of conforming to the general architectural design.
12.2.1.1 AE SPECIFIC REQUIREMENT (HARDWARE PROCUREMENT)

AE will procure the servers and racks based on the Contractor’s recommendations consistent with the AE standards. The Contractor shall provide a hardware list of deliverables that identifies all recommended hardware. The Contractor shall identify any Contractor-provided hardware and associated spare parts in the list of deliverables. AE shall review and approve the recommendations. In addition, the Contractor shall provide the date that the hardware needs to be ordered by to ensure that the project schedule is maintained.

12.2.1.2 AE SPECIFIC REQUIREMENT (NUITANIX)

The software shall work with Nutanix hyper-converged technology (VM infrastructure, storage aggregation).

12.2.1.3 AE SPECIFIC REQUIREMENT (AE PREFERENCES)

AE prefers Windows operating system for both Servers and Workstations. At a minimum, Windows Server 2016 and Windows 10 Professional shall be recommended.

12.2.2 Workstations

Full-graphics PC-based user workstations and engineering workstations shall be the primary user interface. The required quantities of local and remote workstations and the number of monitors for each workstation are specified in Section 3.1 System Sizing Requirements. If the workstation is dedicated entirely to the GUI, it shall include sufficient capacity to satisfy the user interface performance and capacity requirements of Section 3 Capacity and Performance.

Each workstation shall include the following characteristics:

1. Pre-installed with a latest long-term supported Windows operating system that is certified by the Contractor. The installation shall include all the latest release of security patches.
2. Pre-installed 2 (two) Gigabit Ethernet NICs (10/100/1000 Mbps).
3. Graphics card that supports multiple displays as required by Section 3.1 System Sizing Requirements, to the specified resolution of the monitors provided.
4. Monitors with high definition (HD) resolution of no less than 1920 by 1200 pixels (number supplied as appropriate to the function).
5. The monitors shall be supplied with tilt and swivel bases, including a mounting plate for desktop stand.

6. The monitors shall be designed for 24 hours per day, 7 days per week, continuous operation. Nominal backlight life under these conditions shall be 50,000 hours.

7. The Contractor shall provide recommendations for monitor size and resolution should there be an alternative optimal solution.

8. 1 (one) keyboard.

9. 1 (one) optical wired mouse with 2 (two) buttons and a scroll-wheel.

10. A loudspeaker for audible alarming and use with future functions.

These characteristics are only the minimum requirements for each workstation. The Contractor shall provide any needed hardware and software to achieve the system performance requirements as specified in Section 3.2 System Performance Requirements.

12.2.2.1 AE SPECIFIC REQUIREMENT (HARDWARE PROCUREMENT)

AE will procure the workstations based on the Contractor’s recommendations. AE prefers HP workstations. The user interface software shall not require high end graphics cards to meet performance.

12.2.2.2 AE SPECIFIC REQUIREMENT (VDI ENVIRONMENT OPTION)

As an option, AE is open to consideration of a Virtual Desktop Infrastructure (VDI) environment.

12.2.3 Time Standard Unit

AE will re-use its existing time standard units.

12.2.4 IS&R, Backup, and Archiving Storage

The SCADA/EMS shall include historical data storage configured to store any historical data for supporting the Delivered Capacity historical data sizing as specified in Section 3.1 System Sizing Requirements.

Each Historical Data Storage shall comply with the following minimum requirements:
1. Supports Nutanix Hyper-Converged Infrastructure technology.
2. In the case of the IS&R, the capacity to retain up to 5 (five) years of stored data is required.
3. In the case of the Backup and Archiving system, the capacity to retain both the 5 years plus current year of stored data as well as 5 (five) years plus current years of model and configuration data is required.
4. All Archive Storage hardware shall support the necessary throughput, capacity and redundancy to meet overall system performance requirements in Section 3 Capacity and Performance. This includes a recommendation to implement at least 2 (two) ports of fiber channel host interface.
5. Has redundant Hot Pluggable power supply.
6. Has redundant cooling system.
7. Supports local data replication and remote data replication.
8. Supports Mirrored Write-Back Cache.
10. Includes Controller Password Protection for Configuration Control.
11. Includes monitoring and controlling units and software with respect to health, performance, and storage utilization and reporting the status of storage.

12.2.4.1 AE SPECIFIC REQUIREMENT (HARDWARE PROCUREMENT)

AE will procure the storage devices as part of Nutanix Hyper-Converged Infrastructure, based on the Contractor’s recommendations as approved by AE.

12.2.5 Off-Site Backup

In addition to the on-line backup storage requirements, writable removable media and associated management system shall be provided for the offsite storage of archive data. Enough writable media hardware shall exist to support periodic offsite backups to meet the recovery policies of the Purchaser.

12.2.5.1 AE SPECIFIC REQUIREMENT (HARDWARE PROCUREMENT)

AE will procure the off-site backup based on the Contractor’s recommendations.
12.3 System LAN/WAN Connectivity

The Purchaser shall be responsible for implementing all networking for the combined
SCADA/EMS environments. This includes provision of all associated equipment and devices
allowing the SCADA/EMS to connect with the Purchaser’s Corporate LAN and WAN facilities.
It also includes all equipment that will be necessary to interface the SCADA/EMS with external
systems.

The Purchaser, with assistance as needed by the Contractor, shall be responsible for design,
configuration, and implementation of the security requirements specified in Section 4 System
Security. With Contractor assistance during the System development phase, this shall include
consideration of the Purchaser’s security policy as may apply to SCADA/EMS network
equipment.

12.3.1.1 AE SPECIFIC REQUIREMENT (HARDWARE PROCUREMENT)

AE prefers use of Cisco ACI as software-defined networking (SDN) solution along with Nutanix
Hyper-Converged Infrastructure.

12.3.2 Local Area Network (LAN)

The system shall connect all general servers and workstations at each of the 2 (two) control
centers via a dual redundant Local Area Network which shall be based on IEEE 802.3 standards
and TCP/IP. The network infrastructure supplied shall be managed Level 2 devices.
Communications shall use a minimum of 1000 Base-T redundant switches to implement
redundant LAN configurations and to meet system performance requirements. Each LAN shall
be implemented with separate hardware, including chassis and power supply, and LAN cabling
shall be Category 6 UTP. Where modular network hardware is supplied, the circuit board shall
be “hot” swappable, such that it is not necessary to power down the entire chassis to replace a
single card. The network design shall provide dedicated bandwidth for each LAN segment
.switched technology) and facilitate the addition of future LAN segments.

The failure of any piece of equipment connected to a LAN shall not disrupt LAN operations.
Similarly, on/off powering or connection/removal of equipment shall not be disruptive.
12.3.2.1 **AE SPECIFIC REQUIREMENT (HARDWARE PROCUREMENT)**

AE will procure the LAN equipment and material based on the Contractor’s recommendations.

12.3.3 **Wide Area Network (WAN)**

Each communication link between the 2 (two) control centers shall be based on the IEEE 802.3 standard.

The Purchaser shall supply routers, securely configured firewalls, and cabinets for housing the equipment to interface with the Purchaser’s STM-4 equipment at each site such that ICCP data exchange can be successfully and securely established.

The SCADA/EMS shall support remote maintenance from outside the System. In this respect, remote access shall meet all security requirements specified in Section 4 System Security, as relate to remote system interconnections.

12.3.4 **LAN/WAN Security Equipment**

The Purchaser will provide hardware firewalls to restrict access to the SCADA/EMS from the Corporate LAN or WAN to authorized users or computers.

The Purchaser will provide dedicated and redundant hardware modules for firewalls and firewall management. Where the network design has cascaded firewalls, the Purchaser may utilize firewalls that are from different vendors to maximize security.

All SCADA/EMS network devices shall support the necessary throughput and redundancy to meet overall system performance requirements.

All SCADA/EMS system components shall gracefully and automatically re-establish required IP connections as needed and in compliance with secure connection establishment procedures.

The Purchaser shall supply all network equipment including routers, switches and firewalls to implement the SCADA/EMS network.

The Contractor shall supply a list, in Microsoft Excel form, detailing the interface ports and services required for full functionality of the SCADA/EMS as defined herein. This list shall
include all information required to define the firewall rules including direction, protocol, interface port number, associated service, etc. for each network connection.

12.4 RTU Communications

The System shall support communications with RTUs over a Purchaser-provided communication network. Contractor shall be responsible for establishing end-to-end communication with the RTUs, which may employ a variety of communications media, including fiber optic cables.

12.4.1 Front End Processors (FEPs) Functions

The functions of the FEPs shall include, but not be limited to the following:

1. Communication controller interface processing, including signal level conversion, block (word) recognition, transfer control and data buffering. Buffering of block or multiple blocks of data shall be provided to minimize CPU time required for RTU I/O processing.
2. Synchronization pattern generation and recognition.
3. Error-checking for received data.
4. Serial-to-Parallel conversion of received data.
5. Parallel-to-Serial conversion of sent when sending data.
6. IP transmission and receiving of data.
7. Error-checking code generation when sending data.
8. Bit counting and timing on data clocked into and out of the lines shall be provided.
10. Security for communications establishment, authentication, security alarming, security key management for sessions, etc.

In order to offload the central processors, and to make their loading largely independent of system expansions, the FEPs shall be responsible for scan scheduling and pre-processing of received data.

12.4.2 RTU Communications Ports (AE Specific Requirements)

The Purchaser currently uses the following communication channels for the RTUs:

1. DNP3 IP.
2. Autonomously owned (i.e. by AE) IP network, optically-based to all substations. The Purchaser has SONET connectivity to all substations also through that network.
3. IP communications as primary channel and as backup channel to all RTUs.
4. Use DNP exclusively.

AE plans to change the serial RTU communications prior to cutting over to the new SCADA/EMS. Deploying a JPAX-based replacement for the current JMUX-based SONET. Some of the RTUs will still have to be communicated to through a serial port, but will be connected to a serial/IP converter which will connect to a JPAX server at the RTU’s substation. That JPAX will pass the encapsulate and encrypt the message and pass it to a JPAX at the control center(s) which will un-encrypt the message and pass it as IP into a second IP port of the Data Acquisition Front-End (i.e. a different port than being used for primary port DNP/IP communications)

12.4.3 Redundancy Requirements

RTU communications is a critical function. Therefore, a redundant design is required for the FEPs. Failover to backup equipment in the communications subsystem shall be automatic, and shall not require failover of central processing equipment. Communications must automatically resume after failover; manual adjustment and tuning of interface equipment is not acceptable. The user shall be able to manually switch all the RTUs to an alternate FEP for maintenance or other uses.

The system shall automatically rotate, on a periodic basis, the use of equipment for on-line operation to make sure that latent hardware failures of backup equipment will not go undetected. Authorized users shall also be able to manually assign and configure communications subsystem hardware.

12.4.4 Protocol Communications Monitoring Facility

An RTU and ICCP communications monitoring facility shall be supplied that can emulate RTUs, external entities and the SCADA/EMS. All RTU protocols and RTU communication channel interfaces supplied with the SCADA/EMS shall be supported by the RTU communications monitoring facility, including the capability to monitor secure RTU communications. This
facility shall capture and display selected messages or portions of messages between the selected RTU or RTUs and the SCADA/EMS. Communication traffic shall be monitored without interfering with its normal flow.

A test mode shall permit manual simulation of messages from the SCADA/EMS to an RTU and from an RTU to the SCADA/EMS.

The ICCP communications monitoring capability shall provide equivalent features to allow full monitoring and decoding of both non-secured and secured traffic.

12.5 SCADA/EMS Equipment Operating and Construction Requirements

Any Contractor specific connectivity requirements shall be provided by the Contractor to the Purchaser to ensure that the Purchaser can connect the equipment correctly.

12.6 Video Wall Graphic Display Servers

The Contractor shall recommend multi-screen graphic display servers that shall provide HD and 4K HD high-definition display signals to the Purchaser’s Video Wall Displays (VWDs) and enable users to control how graphic images from a variety of sources are presented on each of the VWDs. Within this context, the Contractor shall recommend measures that can be used to avoid system security issues. Otherwise, users shall be able to select any combinations of images from the following sources for display on either VWD array:

1. Displays created by the SCADA/EMS
2. IP-encoded video acquired from the Purchaser’s CCTV WAN
3. Standard (NTSC) video images from equipment provided by the Purchaser.

The graphic display servers shall be capable of displaying any full graphics Windows and standard video images on any VWD. The graphic display servers shall be connected to the SCADA/EMS servers and to the CCTV system through redundant LANs.

For all graphics applications, the graphic display servers shall be capable of displaying and configuring a single image across multiple video wall screens and displaying multiple graphic
images from different sources on a single screen, including implanted windowed data, graphics, and/or live video displays.

Authorized users shall have the capability of positioning a window of any size and aspect ratio anywhere within the VWD, including across screen boundaries.

The graphic display servers shall support the display of any SCADA/EMS displays, including displays that were not specifically designed for the VWDs, on any screen or group of screens within the VWDs (e.g., SCADA/EMS text, graphic, and tabular displays).

Up to 8 (eight) standard (NTSC) video signals shall be simultaneously displayed on an VWD. These video signals will be available from outside broadcast or cable sources, or discrete CCTV sources, and will be provided as composite video signals. The graphic display servers shall be capable of displaying the video sources as multiple separate windows anywhere within the VWDs.

The graphic display servers shall be controlled through a secure, Windows based, user interface that allows authorized user at any SCADA/EMS workstation to control all capabilities of the graphic display server through a network application, including:

1. Opening or closing VWD applications
2. Defining, editing, and saving VWD display configurations
3. Controlling individual screens

The graphic display server output to each screen shall be through a direct digital link conforming to the latest version of the HDMI (High Definition Multimedia Interface) standard.

The Contractor’s cable routing shall consider the recommended maximum cable lengths, and in no case, shall the installed cabling exceed the recommended lengths. If the physical configuration and placement of the equipment requires longer cable lengths, the Contractor shall provide an alternative connection such as HDMI boosters for longer than recommended HDMI cables.
The graphic display servers shall be configured with dual power supplies, RAID redundant disc configurations, and dual network interface ports that shall provide for automatic failover of the network interface in the event of a network or port failure.

12.6.1  **AE BARCO Video Wall**

AE currently uses a Barco Video Wall as described below:

12.6.1.1 **BARCO VIDEO WALL:**

1. Video Wall Integrator – AVI-SPL
2. Video Wall Vendor – BARCO
3. AE Administrator – William Hunter King
4. TransForm ECU-200
5. 4 (four) BARCO ECU-200 Controllers -3 (three) Production 1 (one) QAS.
6. Wall 4x17 Total cubes, (4x4/4x9/4x4)
7. Divided into 3 sections controlled from each of the front operator stations with secure km switches.
8. TRANSMISSION Center Wall – Res: 4200x12,600
9. Left/Right Sections – Res: 4200x9,600

12.6.1.2 **CURRENT VIDEO WALL SOURCES:**

1. DVI Connection-ADMS Console: Distribution management dispatch. ADMS Off Norm Alarms
2. DVI Connection-SCADA Console: EMS Off Norm Alarms
3. DVI Connection-Security Console: DVI Connection: Substation Cameras
4. DVI Connection-Weather TV: Local Cable News
5. DVI Connection-Corporate Console: ERCOT Available Dispatch, ERCOT PRC, ERCOT DATA, LCRA Flood Data
7. BARCO Controller-Clock App.
8. BARCO Controller-PRIMATE Distribution Display, Wall and SCADA Console.
12.6.1.3 VIDEO WALL SOURCES FUTURE

1. BARCO Controller-SCADA/EMS Transmission Schematic Display.
3. BARCO Controller-SCADA/EMS/ADMS Information Displays based on all available outside sourced data.
4. The described Single System must have data available from all systems and sources.

12.7 Spare Parts

The Contractor shall provide sufficient spare parts for achieving the specified system availability for Contractor-provided equipment, if any. Spare parts shall include all recommended maintenance parts. The recommended spare parts list shall include a shelf stock of 10% of all Field Replacement Units.

All spare parts used in support of warranty repairs shall be replaced by the Contractor within 30 (thirty) days at no additional cost to the Purchaser. Any System parts or spare parts which are added or modified due to design changes made after the Contract award and during the warranty period, or to meet the specified system requirements (including system availability and performance requirements), shall be provided to the Purchaser at no extra cost.

The Contractor shall provide a list of recommended SCADA/EMS equipment and spare parts, parts with the original manufacturer’s part numbers, and serial numbers of all equipment. Sufficient information shall be provided for Purchaser to buy the equipment directly from the manufacturers. The list shall indicate the quantities of each type of equipment and modules that are included in the delivered System.
## 13 Documentation Requirements

### 13.1 Documentation Submittal Requirements

#### 13.1.1 Categories of Documentation Required

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1.1</td>
<td>332</td>
</tr>
</tbody>
</table>

#### 13.1.2 Documentation Plan and Directory

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.1.2</td>
<td>333</td>
</tr>
</tbody>
</table>

### 13.2 Documentation Preparation Requirements

#### 13.2.1 Language

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.2.1</td>
<td>334</td>
</tr>
</tbody>
</table>

#### 13.2.2 Paper and Electronic Copies

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.2.2</td>
<td>334</td>
</tr>
</tbody>
</table>

#### 13.2.3 Drawings

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.2.3</td>
<td>335</td>
</tr>
</tbody>
</table>

#### 13.2.4 Documents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.2.4</td>
<td>335</td>
</tr>
</tbody>
</table>

#### 13.2.5 Proprietary Documents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.2.5</td>
<td>336</td>
</tr>
</tbody>
</table>

### 13.3 Documentation Review and Approval

#### 13.3.1 Review and Approval Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.3.1</td>
<td>336</td>
</tr>
</tbody>
</table>

#### 13.3.2 Document Management

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.3.2</td>
<td>338</td>
</tr>
</tbody>
</table>

#### 13.3.3 Approval Process of Documents and Drawings

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.3.3</td>
<td>338</td>
</tr>
</tbody>
</table>

#### 13.3.4 Contractor’s Responsibility

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.3.4</td>
<td>339</td>
</tr>
</tbody>
</table>

### 13.4 Documentation Contents

#### 13.4.1 System Overview Documentation

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.4.1</td>
<td>339</td>
</tr>
</tbody>
</table>

#### 13.4.2 Hardware Functional Design Documentation

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.4.2</td>
<td>340</td>
</tr>
</tbody>
</table>

#### 13.4.3 Software Functional Design Documentation

##### 13.4.3.1 General Requirements

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.4.3.1</td>
<td>340</td>
</tr>
</tbody>
</table>

##### 13.4.3.2 Documentation of Application Functions

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.4.3.2</td>
<td>341</td>
</tr>
</tbody>
</table>

#### 13.4.4 Detailed Hardware Design Documentation

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.4.4</td>
<td>342</td>
</tr>
</tbody>
</table>

#### 13.4.5 Detailed Software Design Documentation

##### 13.4.5.1 Application Programs Design

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.4.5.1</td>
<td>343</td>
</tr>
</tbody>
</table>

##### 13.4.5.2 Databases

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.4.5.2</td>
<td>344</td>
</tr>
<tr>
<td>13.4.5.3</td>
<td>System Software</td>
</tr>
<tr>
<td>13.4.6</td>
<td>Power System Models Documentation</td>
</tr>
<tr>
<td>13.4.6.1</td>
<td>Power Network Applications Tuning and Diagnostics</td>
</tr>
<tr>
<td>13.4.7</td>
<td>Display Models Documentation</td>
</tr>
<tr>
<td>13.4.8</td>
<td>Interface Control Documentation</td>
</tr>
<tr>
<td>13.4.9</td>
<td>Cyber Security Documentation</td>
</tr>
<tr>
<td>13.4.10</td>
<td>Hardware Maintenance Manuals</td>
</tr>
<tr>
<td>13.4.11</td>
<td>Software Maintenance Manuals</td>
</tr>
<tr>
<td>13.4.11.1</td>
<td>Standard Software Manuals</td>
</tr>
<tr>
<td>13.4.11.2</td>
<td>Custom Software Manuals</td>
</tr>
<tr>
<td>13.4.12</td>
<td>System Administrator Manual</td>
</tr>
<tr>
<td>13.4.13</td>
<td>Development and Debugging Tools Manuals</td>
</tr>
<tr>
<td>13.4.14</td>
<td>User Manuals</td>
</tr>
<tr>
<td>13.4.14.1</td>
<td>Information Presentation Requirements</td>
</tr>
<tr>
<td>13.4.14.2</td>
<td>Contents and Structure</td>
</tr>
<tr>
<td>13.4.15</td>
<td>System Installation and Cutover Manual</td>
</tr>
<tr>
<td>13.4.15.1</td>
<td>AE Specific Requirements (system installation manual)</td>
</tr>
<tr>
<td>13.4.16</td>
<td>Formal Acceptance Test (FAT) Plan</td>
</tr>
<tr>
<td>13.4.16.1</td>
<td>AE Specific Requirement (Formal Acceptance test on-site at AE)</td>
</tr>
<tr>
<td>13.4.17</td>
<td>Formal Acceptance Test Procedures</td>
</tr>
<tr>
<td>13.4.17.1</td>
<td>Viewing of Manuals on User Workstations</td>
</tr>
<tr>
<td>13.4.18</td>
<td>Site Acceptance Test (SAT) Plan and Procedures</td>
</tr>
<tr>
<td>13.4.19</td>
<td>Availability Test Procedures</td>
</tr>
<tr>
<td>13.4.20</td>
<td>Operator Training Simulator Documents</td>
</tr>
<tr>
<td>13.5</td>
<td>As-Built Documentation and Software</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>13.5.1</td>
<td>Final System Documentation</td>
</tr>
<tr>
<td>13.5.2</td>
<td>Final Software</td>
</tr>
<tr>
<td>13.5.2.1</td>
<td>Source Code</td>
</tr>
<tr>
<td>13.5.2.2</td>
<td>Software Package</td>
</tr>
<tr>
<td>13.5.3</td>
<td>Master Document Directory</td>
</tr>
</tbody>
</table>
13 DOCUMENTATION REQUIREMENTS

The Contractor shall provide full documentation including design, operation, maintenance, and testing documentation, as well as training materials and other documents needed for the operation, maintenance, enhancement, and expansion of the SCADA/EMS and all other deliverables. All equipment within the scope of supply shall include documentation.

All the Contractor-generated documents shall be provided both in electronic format and as hard copies. Electronic and hard copies are also required for all the drawings prepared by the Contractor. Original Equipment Manufacturer (OEM) documentation and drawings shall also be provided in electronic form, in addition to hard copies. The requirement to provide hard and electronic copies applies to all revisions of the documentation, i.e., initial and interim revisions that are delivered for review as well as final documentation.

It is Purchaser’s intent to maintain the system documentation primarily in electronic format, and Purchaser shall have the right to edit the electronic documentation files and print the original and revised documents for in-house use and for use by parties hired to assist Purchaser in the maintenance and upgrading of the SCADA/EMS. Purchaser shall also have the right to produce, for the same purposes, additional copies from the hard copies furnished by the Contractor.

Documentation shall be available for presentation within the System as described elsewhere in these Technical Specifications. All documentation shall have an electronic copy and shall be suitable for integration in a Web portal. All documentation shall be structured and have a common root with indexes per subject (master document). This shall include OEM documents as well. System shall include documentation control tools including search, version management, and update control.

The intent of the Documentation and the ensuing Review and Approval process is to ensure that it is of a standard and coverage that, when coupled with the delivered Training, will ensure that the Purchaser will be self-sufficient in maintenance of the System. Where it is deemed by the Purchaser that the documentation fails to fulfill this intent, the Contractor shall make good and shall deliver additional documentation as directed by the Purchaser.
13.1 Documentation Submittal Requirements

13.1.1 Categories of Documentation Required

The categories of documentation furnished under the Contract shall include the following:

1. System Overview Documents
2. Hardware Functional Design Documents (including diagrams)
3. Software Functional Design Documents
4. Detailed Hardware Design Documents (including diagrams)
5. Detailed Software Design Documents
6. Interface Control Documents
7. Power System Models Documents
8. Display Models Documents
9. Cyber Security Documents
10. Hardware and Software Maintenance Manuals (including OEM manuals)
11. System Administrator Manuals
12. Development and Debugging Tools Manuals
13. User Manuals
15. Formal Acceptance Test (FAT) Plan and FAT Procedures
16. Site Acceptance Test (SAT) Plan and Procedures
17. Availability Test Procedures.
18. Master Documents Directory
19. Application Tuning Documents

The Contractor shall provide hard-copies of all documents in quantities stated below. In addition, except for documents supplied by the original equipment manufacturers, the Contractor shall provide word processor files of these documents, and Purchaser shall be permitted to edit these files and generate from them printed documents for in-house use.

Exhibit 13-1 Minimum Deliverable Documentation and Desirable Delivery Date, lists the minimum documentation to be delivered, the quantities to be delivered, and the desirable
delivery dates for first submission of the review and approval copies. Purchaser shall establish the distribution list for the copies after Contract award.

All documentation submitted by the Contractor to Purchaser shall be accompanied by a letter of transmittal. Each document shall be identified by the Contract number, document number, drawing number, revision or issue number, date of release, and revision.

13.1.2 Documentation Plan and Directory

A complete Documentation Plan shall be finalized and submitted for approval by Purchaser together with the first submittal of the project schedule. The documentation plan shall be generated and maintained to be compatible with the project schedule. To facilitate review by Purchaser, submittal of documents shall be sequenced to enable Purchaser to become familiar with prerequisite information before a document is submitted for review. For instance, the user manual shall be presented in time for review and approval before the FAT Procedures. Gradual delivery of documents is prerequisite for Purchaser to review the documents within the time frames to which it will commit.

The Documentation Plan shall comprise a list of all the deliverable documents, grouped by subsystem or other logical grouping. Documentation, such as software functional design or detailed design documentation is expected to consist of many documents, and each individual document shall be represented in the list. The list shall be structured to support documentation submittal and review activities. To this end it shall include for each document:

1. Document name
2. Document number
3. Document’s Subsystem (SCADA, Network Analysis, etc.)
4. Document class (i.e., Functional Design, Detailed Design, Test Procedure, etc.)
5. Scheduled date of submittal and actual date of submittal for the original revision
6. Current revision and status (pending, Purchaser’s Review, Approved, etc.), and date for next action (date pending revision will be submitted, date the review is due, approval date, etc.).
The scheduling of the individual document submittals shall be compatible with the project schedule, and shall allow reasonable time for Purchaser to meet its objective of completing document reviews within 20 (twenty) business days.

The Documentation Plan shall serve as a checklist throughout the project and shall be revised and resubmitted by the Contractor with each project progress report. Before System acceptance the plan shall be revised into a Documentation Directory for the “as-built” documentation, by removing scheduling information and any other information that is no longer relevant.

13.2 Documentation Preparation Requirements

13.2.1 Language

To facilitate the design and documentation reviews by all the parties that may be involved in the development of the SCADA/EMS, all documentation shall be prepared in English.

13.2.2 Paper and Electronic Copies

All Contractor documents shall be prepared on the latest revision of Microsoft Office, i.e. Microsoft Word, Microsoft Excel, where appropriate, or PDF format. All text materials shall be printed and available in electronic format, including all revisions, mathematical equations, notes, and corrections. Handwritten texts are not acceptable. Illustrative materials and drawings shall be included in electronic format and whenever practical printed; the use of fold-out sheets shall be minimized.

Both hard copies and electronic files of each document and drawing shall be provided to Purchaser. This applies not only to the final documents and drawings, but also to all revisions that are submitted for review. Pictures and diagrams that are incorporated or inserted in documents shall be included with the electronic versions of the documents. Electronic versions of OEM manuals shall be provided to Purchaser where available.

Purchaser shall have the right to copy and to edit Contractor (including OEM) documents for in-house use.
13.2.3 **Drawings**

Drawings, including hardware configuration and cabling drawings shall be prepared using AutoCAD or Visio.

“Typical”, “standard,” or “off-the-shelf” drawings are unacceptable unless they are fully applicable to the system. If such drawings are used, all non-applicable sections shall be either removed or explicitly noted on the drawings. Any drawings which contain options shall clearly show which options apply to the system furnished, and non-applicable options shall be marked out.

Individual drawings shall be submitted for each unit of different design. It is not acceptable to submit a single multi-purpose drawing (one drawing title and one drawing number) to show a “typical” design, with exceptions noted for equipment or software modules having various deviations.

When a drawing is revised, revision numbers shall be clearly legible, easily distinguishable from the drawing number, and shall be located as close as possible to the title box. A short description of the revision shall be included and the affected areas on the drawing shall be circled and identified with a revision number.

13.2.4 **Documents**

All documents shall be written clearly and unambiguously in grammatically correct English. Manuals and other written documents shall be legibly printed on sheets of standard letter size paper arranged in binders. Desktop publishing quality printing produced by high resolution laser printers is required for both review and final documents. Large documents shall be arranged into separate volumes such that each volume will be less than 3 inches thick. High quality plain-paper copying, offset printing, or other approved printing process shall be used to produce the required documents. The binders shall be labeled with permanent labels as to set and volume number on the spine of the binder.

A complete table of contents, listing all numbered sections and the corresponding starting page numbers, shall be included for each document. A complete identical table of contents shall be provided in each volume of a multi-volume document. A complete list of exhibits shall follow
the table of contents. A glossary of acronym terms shall be included with each set of documents. An index shall also be included with each document.

Where a manual is revised to reflect a change in design, or a change for any other reason, each such revision shall be noted by a revision number, date, subject, and a brief description of the change in a revision block. Indication of official approval by the Contractor’s project manager shall also be included. To permit rapid location of the revisions, all changes shall be highlighted by revision marks and sidebars on the revised pages of the manual. These highlights shall be removed from the final documents.

13.2.5 **Proprietary Documents**

Documents or technical information that the Contractor considers to be proprietary shall be clearly marked as such. The documentation of the database structure, Interface Control Documents (ICDs), and of all protocols and interfaces on the system LAN, to the FEPs, to external systems, and among the computer subsystems shall not be proprietary.

13.3 **Documentation Review and Approval**

All deliverable documents, including specifically the documents listed in Section 13.1.1 Categories of Documentation Required, shall be submitted by the Contractor to Purchaser for review and approval no later than specified in the Documentation Plan after its approval by the Purchaser. The Purchaser intends to complete the review of each document within 20 (twenty) business days. It is to be noted that the Purchaser may not be able to promptly review documents that are not delivered on schedule.

13.3.1 **Review and Approval Requirements**

For purposes of documentation review and approval, 2 (two) classes of documentation are hereby defined:

1. Standard documentation – Third party vendor documents, and Contractor documents that have been produced and used prior to the award of Contract, and that do not require any changes to accurately describe the SCADA/EMS.

   1.1. Whenever standard third-party vendor documentation is supplied, each document shall include a preface indicating which portions of the document, if any, do not apply to the
SCADA/EMS being furnished and hence do not constitute parts of the SCADA/EMS documentation. All drawings and illustrations contained therein shall apply specifically to the SCADA/EMS furnished to Purchaser, with all non-applicable information properly identified.

1.2. All standard documentation written by the Contractor must fully apply to the SCADA/EMS. If previously written documentation does not completely apply to the SCADA/EMS, or is inaccurate or incomplete or if amendments are necessary, then such documentation shall be made complete and correct and shall be considered as custom documentation.

2. Custom documentation – All other documents associated with functions and hardware that are specially prepared for Purchaser or that were customized or changed for Purchaser.

Purchaser shall have review and approval rights on all standard documentation where the approval will be focused on ensuring that the documentation is complete, correct, legible, and fit for the purposes intended as determined by Purchaser. In addition, any Consultant employed by the Purchaser shall have the right to review and provide comment on the standard documentation delivered.

For the custom documentation, including standard documents that were changed for the Purchaser, Purchaser shall also have complete review and approval rights on the contents of the documents. Purchaser shall determine not only whether the custom documentation is complete, correct, legible, and fit for its intended purpose, but also whether it clearly describes the functions, and whether the proposed functionality meets the requirements of the Contract.

Purchaser reserves the right to reject any documentation (standard or custom) which is incomplete, incorrect, illegible, does not properly cover the subject matter, or when the writing or translation is not up to acceptable standards. Any documentation so rejected shall be corrected and resubmitted within 20 (twenty) business days to Purchaser for further review and approval.

In the execution of the Contract, the Contractor shall fulfill the following requirements:

1. The Contractor’s authorized representatives shall scrutinize all documents, drawings, etc. prior to submission to Purchaser for approval.
2. The Contractor’s authorized representatives shall verify all documents, drawings, etc. sent to Purchaser for approval.

3. Design, drawings, reports, and other documents have to be certified by Contractor’s authorized representatives

If the above mentioned requirements are not fulfilled, the documents, drawings, etc. sent to Purchaser for approval shall not be processed.

**13.3.2 Document Management**

The Purchaser prefers the use of a secure, Web-based document management system such as SharePoint for the version control and transmittal of all deliverable documents that require review and approval. The document management system shall manage the work flow of the document review and approval process such that email alerts and notifications are transmitted to the responsible parties when a given document is uploaded or changes status in the work flow and the current state of progress for any of the documents can be ascertained using a reporting function.

The Contractor shall supply such a system to facilitate the review and approval process.

**13.3.3 Approval Process of Documents and Drawings**

The approval process shall proceed as follows:

1. The Contractor shall transmit documents subject to the approval process to Purchaser. The transmittal cover shall identify the document as requiring approval and shall identify the date by which Purchaser should respond. The Contractor shall allow at least 20 (twenty) business days for the Purchaser’s reading, reviewing and submitting the review result of the document.

2. Purchaser will return comments to the Contractor within 20 (twenty) business days. The transmittal cover for the comments shall clearly indicate that the document is:
   2.1. Approved – If approved, the Contractor shall proceed with the work covered by the document. No further approval action is required.
2.2. Approved with Comments – If approved with comments, the Contractor shall promptly revise the document or drawing in accordance with the comments and submit another set of copies for approval within 30 (thirty) business days of the date of notification.

2.3. Not Approved – If not approved, the Contractor shall correct the document or drawing and resubmit another set of copies for approval within 20 (twenty) business days of the date of notification.

3. All changes made to documents or drawings to reflect approval comments shall be clearly highlighted and the revision record shall be updated to reflect the changes. Purchaser prefers the use of the “Track Changes” feature of the Microsoft Word used to produce the document.

4. The review and comment process shall be repeated until the document is accepted. After the document is accepted, the Contractor shall deliver the required number of final copies free of highlighting due to tracking of changes.

13.3.4 Contractor’s Responsibility

Approval of any of the Contractor documents or drawings by Purchaser shall not relieve the Contractor of the responsibility for the correctness of the documents nor of the responsibility to meet all of the requirements of the Contract. The Contractor shall have no claim for additional costs or extension of time because of delays due to revisions of the documents that may be necessary for ensuring compliance with the Contract. In case of later discovery of error, omission, or inconsistencies within a Contractor document, the Contractor shall promptly submit the revised document to Purchaser for approval within 20 (twenty) business days after the date of notification.

13.4 Documentation Contents

The content required for the various categories of documentation is briefly described below. The sections below describe the types of documentation required to be delivered.

13.4.1 System Overview Documentation

The system overview document shall introduce the reader to the purpose and function of the system. This document shall provide a basic description of the system and its functions, the relationship between the functions including the data flow between them, and the local and wide
area communications networks used by the SCADA/EMS. Therefore, this document shall include, but shall not be limited to, the following items:

1. Description of the system architecture
2. Description of all functions with respect to
   2.1. SCADA
   2.2. User Interface
   2.3. Historical Information System/Information Storage and Retrieval System/PI Interface and Integration
   2.4. Power Network Analysis Applications
   2.5. Operator Training Simulator
   2.6. Database
   2.7. Database Manager/Network Model Manager
   2.8. Interface with AE Applications and External Systems
3. Description of associated local and wide area networks.
4. Description of the interface to the existing AE Video Wall

13.4.2 Hardware Functional Design Documentation

The hardware functional design documentation shall address all the SCADA/EMS hardware, and shall include, but shall not be limited to, the following:

1. Complete System block diagrams showing the interconnections between the major hardware components of the SCADA/EMS
2. A network diagram showing all the ports and services that are interconnected between hardware components
3. A drawing, to scale, of the physical layout of the SCADA/EMS equipment at each control center.

13.4.3 Software Functional Design Documentation

13.4.3.1 GENERAL REQUIREMENTS

The software functional design documentation shall provide a complete description of the functions of the system in such a way that they can be clearly understood without understanding
the detailed design of each software module, and without detailed knowledge of software engineering. It shall also describe, in detail, what functions are to be performed by each software subsystem.

The software functional design documentation shall include, but shall not be limited to, the following items for each subsystem:

1. A brief overview of the subsystem, in which each application and its major functions shall be described.
2. A description, from a user’s standpoint, of all functions to be performed by the subsystem. Related displays, dialog menus, and report formats shall be included.
3. An overview of major algorithms
4. Diagrams and descriptions pertinent to the manner in which the subsystem interfaces with other subsystems
5. A detailed description of all interfaces between the subsystem and the user. Related display formats shall be shown, and user operating procedures shall be explained. Relevant sections of the user manual may be used in the functional design document to describe user interaction aspects of functions and applications.
6. Statements on the performance that will be delivered by the subsystem. This shall include response times and wall-clock execution times that control or limit the capabilities of the software.

A description of the handling of power failure, system failover, restarts, and other anomalies that may be encountered by the subsystem.

13.4.3.2 DOCUMENTATION OF APPLICATION FUNCTIONS

The functionality of the application functions is of special concern to the Purchaser, and therefore detailed functional design documents shall be provided for review and approval by the Purchaser. The functional design documents shall describe each function from the user’s point of view. They shall include the detailed layout of all relevant displays with explanations of each field and its range of valid values, and descriptions of the operating procedures along with copies and explanations of the associated dialog menus and pushbuttons. It is desired for relevant chapters of the user manual to be used as the functional design document if they cover all
functional aspects and considerations. Alternatively, user manual chapters may be included in functional design documents, or functional design documents may reference previously delivered chapters of the user manual.

13.4.4 Detailed Hardware Design Documentation

The detailed hardware design documentation shall contain hardware reference manuals and complete sets of reduced drawings. Part lists shall be furnished with reference manuals for each piece of equipment.

The design document shall include electrical schematic drawings and logic diagrams for Contractor-built equipment and, if available, for third party vendor equipment. Detailed wiring diagrams for each hardware functional module, the interconnection of all modules, plug-in circuit boards, and the connections to the terminals used for external wiring shall be furnished.

The detailed hardware design documentation shall include, but shall not be limited to, the following drawing and diagrams:

1. System equipment power distribution drawing
2. Wiring lists and connection diagrams
3. Interface terminal block drawings
4. Complete Bill of Materials (BOM) spare parts list for each piece of hardware supplied, or typical for several pieces of hardware if they are the same (such as operator workstations), assembly drawings and parts lists
5. Module and network (IP) address assignments
6. For Contractor-built functional modules and cards and as available for third party vendor equipment:
   6.1. Block Diagram
   6.2. Schematic diagrams
   6.3. Logic diagrams
   6.4. Firmware charts and descriptions
13.4.5 **Detailed Software Design Documentation**

The detailed software design documentation shall provide a detailed description of the design of the functions described in the software functional documentation. The detailed software design documentation shall be organized on a subsystem basis. For each subsystem it shall include, but shall not be limited to, the following items:

1. An overview of the purpose and operation of each subsystem
2. An overall block diagram of the subsystem, showing its modules or programs, and the data flows among them
3. A description of each program or module of the subsystem, its purpose, and the functions that it performs
4. Detailed descriptions and explanations of algorithms
5. Descriptions of data structure
6. A list of software parameters, with a description of the meaning of each parameter and the options or values that can be selected for it.

**13.4.5.1 APPLICATION PROGRAMS DESIGN**

For each software module, the software design document shall include, but shall not be limited to, the following items:

1. A program abstract
2. A description of the program
3. A pseudo code description of the program. The pseudo code shall describe the module’s logic, selection and processing of various states and modes, algorithms, software interfaces, and major error checking.
4. All external interfaces to the program including calling sequences and output to other programs
5. All error messages produced by the module, with an explanation of the reason for their occurrence and remedial measures
6. Initialization considerations
7. Identification of any data referenced or modified
8. Instruction for the compilation, linking, loading, and scheduling of the application and its programs. Explanation of program parameters and considerations that have to be taken into account in the generation and activation of programs shall be included.

13.4.5.2 DATABASES

The database documentation shall describe the structure of each database, provide both visual examples and text descriptions of the entry format and purpose of all the fields, including all relevant attributes, and explain the interrelationships between the data and the SCADA/EMS databases. In case of RDBMS documentation, for example, its Entity Relationship (E-R) diagram shall be included. Every element of the database shall be defined as follows:

1. The name of the element
2. Format, e.g., 64-bit floating point, 2-bit digital, variable length text, etc.
3. Definition of the element including, where appropriate, the meaning of each state of a variable
4. A description of each field of each data item
5. Dimensions of arrays and ranges of indexes.

The database documentation shall include a discussion of the database access routines and instructions for their use.

13.4.5.3 SYSTEM SOFTWARE

All detailed documentation that is available for the operating system, utilities, diagnostics, and other software associated with the computing equipment of the system shall be furnished to Purchaser.

13.4.6 Power System Models Documentation

Documentation of power system models shall include a description of the models used by the applications including power network analysis, voltage stability analysis (if purchased), short circuit analysis (if purchased) and OTS. As a minimum, the required information shall include:

1. The features of the model, the applications that use the model, and the features of the model that qualify it for use by these applications
2. Description and explanation of the model by device and feature
3. Explanation and justification of equivalents (e.g., use of a shunt to present core losses) used in the model
4. Model parameters and tuning parameters
5. Inputs for the generation and updating of the model
6. Default model examples.

13.4.6.1 POWER NETWORK APPLICATIONS TUNING AND DIAGNOSTICS

The Contractor shall provide tuning and diagnostics documents for the power network applications such as State Estimator that describe the use of different application tuning parameters and their impact on the application results. In addition, diagnostics shall be provided that show the user steps on how to track the cause of solution divergence (e.g., what should the user do when SE or PF diverges to identify the issues causing the problem).

13.4.7 Display Models Documentation

The display models document shall describe the discretionary aspects of display design and implementation. It shall take into consideration Purchaser’s existing display conventions and standards and shall be used by the Contractor and Purchaser to develop all displays supplied with the SCADA/EMS. This document shall include descriptions on defining and using advanced visualization techniques for enhanced situation awareness as well as the creation of custom dashboards.

13.4.8 Interface Control Documentation

The Interface Control Document (ICD) shall describe in detail all communication interfaces and data exchanges between the SCADA/EMS, Purchaser-furnished subsystem and network, and all external systems and applications.

The Interface Control Document shall include, but shall not be limited to, the following aspects:

1. Description of the hardware interface
2. Description of the communication protocols, including the lower level network protocols, the upper level session, presentation, and application protocols, and the options and parameters selected

3. Description of the database access methods and capabilities, including specific displays, commands, and access and authorization requirements

4. Description of relevant database models, structures, and contents for these databases

5. Data exchange requirements including timing, priority, volume, and security requirements. A specific list of data to be exchanged during formal and site testing shall also be included.

6. Description of the performance requirements

7. Exception (for example, error) processing

8. Failover/backup processing

9. Alarm conditions

10. Archiving requirements.

13.4.9 Cyber Security Documentation

The cyber security documentation shall include all network configurations, and network access control rules implemented in firewalls used to secure the electronic security perimeter(s) surrounding the component systems of the SCADA/EMS. The documents shall include a description of all systems that interact electronically with the SCADA/EMS and describe the purpose and justification for all interconnections, including whether or not they are required for core operations, business information needs, or maintenance. This document shall include the network address, protocol service, ports and services, and cyber security measures for each documented access. Documentation to support the Purchaser’s compliance to the NERC CIP standards shall be provided.

13.4.10 Hardware Maintenance Manuals

The hardware maintenance manuals shall describe in detail preventive and restorative procedures required to keep the system in good operating condition. Maintenance manuals shall make reference to appropriate diagnostics, and all necessary settings and adjustments shall be documented. Maintenance manuals shall be furnished for all delivered hardware, including third party vendor equipment.
The hardware maintenance manual shall include, but shall not be limited to, the following information:

1. Operation Information

   This information shall include a detailed description of how the equipment operates, and a block diagram illustrating each major assembly in the equipment. Descriptions of external data transfers with other equipment shall be included. The operational sequence of major assemblies within the equipment shall be described and illustrated by functional block diagrams and timing diagrams. Detailed logic diagrams shall also be provided as necessary for troubleshooting, analysis, and field repair actions.

2. Preventive Maintenance Instructions

   These instructions shall include all applicable visual examinations, hardware testing and diagnostic routines, and the adjustments necessary for periodic preventive maintenance of the SCADA/EMS. Instructions on how to load and use test and diagnostic programs and any special or standard test equipment shall be an integral part of the maintenance instructions.

3. Corrective Maintenance Instructions

   These instructions shall include procedures for locating malfunctions down to the level specified in training requirements. These guides shall include adequate details for quickly and efficiently locating the source of an equipment malfunction.

   The corrective maintenance instructions shall also include explanations of the adjustment or replacement of all subsystems, including printed circuit cards. Schematic diagrams of electrical, mechanical, and electronic circuits and illustrations of the location of parts, photographs, cable routing diagrams, and sectional views giving details of mechanical assemblies shall be provided as necessary to replace faulty equipment. Information on the loading and use of special off-line diagnostic programs, tools, and test equipment, as well as any cautions or warnings which must be observed for equipment protection.

4. Safety Information

   Warnings on hazards, such as high voltage, and safety instructions on how to avoid injury shall be included.

5. Parts Information

   This information shall include the identification of each replaceable part, with a level of
detail sufficient for procuring any replaceable part. Cross-references between the Contractor's part numbers and manufacturer's part numbers shall be provided where applicable.

13.4.11 **Software Maintenance Manuals**

The software maintenance manuals shall cover all the features and functions as implemented. Supplementary documents or appendices to cover the maintenance of recently introduced software are not acceptable. To the largest extent practical, maintenance manuals shall include all explanations and information needed by the maintenance personnel so that references to other documents are kept to a minimum. On-line documents shall include links to the references.

13.4.11.1 **STANDARD SOFTWARE MANUALS**

The Contractor shall deliver to Purchaser software maintenance manuals for the processors, servers, workstations, the user consoles and other programmable equipment furnished by the Contractor. They shall include, as applicable, the following:

1. Operating system manuals
2. High-level language compiler manuals, including instructions and examples on the calling of executive services in the operating system
3. Software system generation and configuration manuals
4. Programming tools manuals
5. Software utilities manuals
6. Diagnostic software manuals
7. Database generation and modification manuals
8. Database access manuals (real-time, historical, and application databases)
9. Display generation and modification manuals, including importing displays from all external systems and their incorporation in displays
10. Report generation manuals
11. Manuals for the maintenance of the SCADA/EMS application programs
12. User manuals for commercial application programs included in the SCADA/EMS, such as word-processor, spreadsheet, browser, etc.
13. APIs
If standard software has been modified or supplemented for the SCADA/EMS, the corresponding manuals shall be treated as custom documents.

13.4.11.2 CUSTOM SOFTWARE MANUALS

Custom software manuals shall be provided to cover all the maintenance areas not covered by the standard software maintenance manuals. This shall include all the above standard software manual subjects from the perspective of the software that has been modified for the SCADA/EMS, and the following:

1. Custom functions developed for the SCADA/EMS
2. Customized application software
3. Customization of databases to support system applications
4. Special diagnostics prepared for the SCADA/EMS

The custom software documentation shall include an explanation of the redundancy and failover scheme of the SCADA/EMS including the site-to-site switchover, instructions for the tuning of backup and failover parameters, and instructions for extending the failover scheme to new equipment at least up to the Delivered Capacity configuration.

13.4.12 System Administrator Manual

The system administrator manual shall include all information needed for maintenance of the configuration, performance, and proper operation of the SCADA/EMS and of its interfaces to external systems. This includes information and instructions for

1. Generation and configuration of software
2. Installation, configuration and setting-up of system hardware and software
3. Screening and tuning of system performance
4. Use of diagnostics and troubleshooting
5. Maintaining system security
6. Implementation of system upgrades issued by the Contractor, the supplier(s) of servers and workstations, and other OEM suppliers
7. Instructions on how to expand any elements of the system
8. Recovery from a critical failure to perform a bare-metal restoration
9. Installing cybersecurity and system patches. In addition, computer firmware upgrade
   procedures including versioning, version dependencies, update procedure, and other related
   requirements.

10. Configuring active directory.

11. List and description of all group policies installed by the Contractor

12. List and description of all user accounts installed by the Contractor

13. System backup and recovery methods used by the Contractor

The system administrator manual shall include step-by-step procedures for building parts or all
of the SCADA/EMS software, including the applications, databases, and also console software.
The step-by-step procedure shall include SCADA/EMS startup, shutdown, replacement of old
parts of the software with new revisions, and installation of new applications and database. These
procedures shall include screen shots of the displays that they use.

The system administrator manual shall include an explanation of the redundancy and failover
scheme of the SCADA/EMS, with instructions on tuning of backup and failover parameters and
extending the failover scheme when new equipment is added to the system. Instruction for the
setup, supervision, and control of routers, firewalls, front end processors and interfaces to critical
external equipment such as the RTUs, other utility SCADA/EMS, and the Web Server System
shall be included.

Within this context, the system administrator manual shall include the administration of the
SCADA/EMS at the primary and backup control centers.

The Contractor, with Purchaser’s assistance, shall verify the accuracy of the documentation when
installing and configuring the hardware at Purchaser’s site. The Contractor shall correct any
mistakes in the documentation and submit the corrected documents to the Purchaser.

**13.4.13 Development and Debugging Tools Manuals**

The development and debugging tools manuals shall be provided for each of the software
development, testing, and debugging tools that are required. This applies to OEM manuals as
well as to software development, testing, and debugging tool manuals developed by the
Contractor.
### 13.4.14 User Manuals

The user manuals shall cover operating procedures for all standard and custom functions of the system. They shall comprise a set of integrated manuals, organized by areas of applications (e.g., SCADA, Network Control, etc.), and by functions within each area, for all the SCADA/EMS functions. The user manuals shall be custom documentation, written or edited specifically for Purchaser in non-technical language. The capability to go directly to the part of the user manual related to the Help request shall be provided.

The user manuals shall not include system maintenance and administration information. Such information shall be included in the system administrator manual and software maintenance manuals.

#### 13.4.14.1 INFORMATION PRESENTATION REQUIREMENTS

Displays associated with each function shall serve as the main means of explaining user procedures; toolbars and dialog menus shall be included. Actual and up-to-date copies of displays from Purchaser’s SCADA/EMS shall be used in conjunction with the descriptive text. Color reproductions shall be incorporated where the use of color is essential for the presentation of the information. User instructions for each function shall start with a brief overview of the purpose and capabilities of the function. This shall include, but shall not be limited to, the following information:

1. Replicas of all relevant displays and dialog menus
2. The purpose of each pushbutton
3. A description of each displayed data field. Valid ranges of values or the set of possible legends shall be described.
4. A description of all data entry fields or selectable entries with the valid possible set of entries that may be made for each field.
5. The purpose of each pushbutton or data field in dialog menus
6. Operating procedures and sequences
7. User messages and their interpretation
8. Error recovery procedures.
13.4.14.2 CONTENTS AND STRUCTURE

The functional areas listed below, as well as any other areas involved in the operation of the SCADA/EMS shall be covered by the user manuals:

1. Overview of User Operations
   1.1. Basic operational procedures – Keyboard, mouse, logging on and off, management of windows, toolbars, dialog menus, Help function, etc.
   1.2. User access privileges – user modes of operation, console modes, and AORs
   1.3. Display call-up methods
   1.4. World-map, zooming and panning, and navigation tool concepts
   1.5. Recovery from errors and equipment failures

2. SCADA Functions
   2.1. Power system monitoring and control functions
   2.2. Alarm handling, alarm filtering, enhanced alarm management, and Alarm and Event messages
   2.3. Data entry
   2.4. Tagging
   2.5. Summary displays
   2.6. Situational Awareness

3. Power Network Analysis Applications
   Separate sections of the manual shall be provided for each Network Analysis application, explaining operator inputs, modes of sequencing and operation, and interpretation of the output for each of its functions including any custom features.

4. Historical Information and Reports
   4.1. Review and editing of historical data
   4.2. Scheduling and requesting reports
   4.3. Archiving of data and retrieval of archived data

5. Operator Training Simulator:
   5.1. Preparation of training scenarios
   5.2. Training instructor functions
   5.3. Modeling and use of relays and special protection schemes in training scenarios
5.4. Modeling and use of power system models such as load models including cold load
pickup, frequency models, generator models, and external AGC models in training
scenarios.

13.4.15 System Installation and Cutover Manual

The Contractor shall provide an informational manual to allow Purchaser to plan SCADA/EMS
installation and power system operation cutover activities from the Purchaser’s existing systems
to the new SCADA/EMS. This document shall be scheduled for delivery in time for Purchaser to
complete the preparation of facilities for the SCADA/EMS by the time that it is shipped.

This manual shall address all the site preparation, system installation, parallel operation, and
cutover activities, including but not limited to:

1. Preparation of facilities, including air conditioning and power supply for the SCADA/EMS.
2. Instructions for the installation of the SCADA/EMS equipment in the computer room and
   control centers.
3. Instructions for labeling and cabling from the SCADA/EMS to all relevant external systems,
   communications equipment, and network(s).
4. Plans and procedures for parallel operations of the existing system with the new
   SCADA/EMS.
5. Plans and procedures for transferring power system operations from the existing systems to
   the new SCADA/EMS without disrupting operations.

This manual shall include drawings, to scale, of the layout of SCADA/EMS equipment in the
computer room and control center. The drawings shall include sufficient information for the
design of raised floors, conduits, cabling, signaling and power wiring, and air-conditioning that
are to be prepared by Contractor. In addition, the manual will take into consideration any other
dependent projects the Purchaser may be undertaking in parallel such that there is seamless
coordination and consideration given to these activities.

13.4.15.1 AE SPECIFIC REQUIREMENTS (SYSTEM INSTALLATION MANUAL)

Hardware shall be delivered directly to AE facilities with the exception of a factory test system
that will be sent to the Contractor’s facilities for Contractor development and integration. The
system installation manual shall be delivered prior to the equipment being received at AE. The system installation manual shall be used by the Purchaser and Contractor staff to install and configure the system.

13.4.16 Formal Acceptance Test (FAT) Plan

This document shall describe the Formal Acceptance Test plans for the system, including:

1. Testing philosophy, rules, and guidelines
2. Functions to be tested
3. Test bed descriptions for the FAT – block diagram showing all major components of the system being tested, simulation hardware, test equipment, and associated interconnection, etc.
4. Scenarios for testing SCADA/EMS performance and response
5. Methods, including simulations, used to verify the performance and response of the system in the Design configuration.
6. Methods for monitoring and recording results
7. Procedures to report and correct variances
8. Day-by-day test schedule, with enough detail to manage the FAT and to estimate its duration including time for unstructured testing.

To ensure a realistic and accurate schedule is available for the FAT, the test schedule shall be verified and updated during the Pre-FAT. The actual duration of each test shall be recorded in the test form whenever a test is completed and used to refine the final test plan for the FAT.

13.4.16.1 AE SPECIFIC REQUIREMENT (FORMAL ACCEPTANCE TEST ON-SITE AT AE)

Since most of the equipment will be shipped directly to AE’s facilities, the FAT will be conducted on AE’s equipment at AE’s facilities. The use of the term “FAT” in these specifications shall be for the formal acceptance test that is typically performed in the Contractor’s factory but shall be performed at AE facilities instead.
13.4.17  Formal Acceptance Test Procedures

Detailed procedures designed to meet the FAT requirements described in Section 14.6.4 Formal Acceptance Test (FAT), shall be presented in a Formal Acceptance Test Procedures document. The procedures shall comprise detailed guides for tests to verify that:

1. The development of each SCADA/EMS function is complete.
2. The hardware and software, including that furnished by Purchaser, is fully integrated.
3. All the functional, performance, security, and sizing requirements of the Contract are met.
4. Each function included in the SCADA/EMS, regardless of whether or not required by the Contract, operates correctly.
5. The development of interfaces and functions for operation with Purchaser provided video wall Overview Display and applications and all relevant external systems is complete.

Supplemental test procedures may be supplied by Purchaser. The supplemental tests shall be incorporated by the Contractor into the Acceptance Test procedures document.

The test procedures shall be organized by functional area and, where applicable, grouped for assignment to more than one test team for concurrent testing. Tests which require collection of data under controlled conditions (such as testing of historical data and reports) shall be carefully planned with data collection procedures scheduled as needed before the tests themselves.

The test procedures shall be prepared in the form of detailed step-by-step test guides. Detailed test conditions, inputs, and expected results must be explicitly stated in the procedures. The procedures shall be designed to test the behavior of each function under normal and abnormal conditions, and their handling of user errors. The goal is to rigorously test the system by strictly following carefully pre-planned procedures without reliance on informal, unstructured testing.

Test procedures shall be broken into short segments. Each segment shall include:

1. Test identification numbers
2. Statement of the purpose of the test
3. A complete list of initial conditions. It shall not be necessary to refer to previous tests to determine the requirements for the initial condition.
4. Detailed procedure steps
5. Expected responses and results. These must be described immediately following the last step that generates them. Explicit expected test results are required; terms such as "verify reasonable results" are not acceptable. The test results shall be confirmed and refined during Pre-FAT.

6. Space for recording test results
7. Space to record, during Pre-FAT, the duration of the test
8. Space to enter references to variance reports for failed tests
9. Space for test sign-off by both the Contractor and Purchaser.

Detailed test conditions, inputs, and expected results must be explicitly stated in the procedures. The goal is to avoid spending time on calculations and documentation searches during FAT, to achieve consistency between the Pre-FAT and the FAT, and to allow tests to be accurately repeated when necessary.

All the information needed to conduct the FAT shall be included in the FAT Procedure documents. When appropriate, such information may be included in appendices; references to other documents shall be avoided.

13.4.17.1 VIEWING OF MANUALS ON USER WORKSTATIONS

Users are expected to rely largely on “Help” screens for fast assistance; however, they shall be able to refer to the user manuals for more comprehensive information and to look up information on functions that involve displays which do not appear on their screens at the time. Therefore, the user manuals shall be easily accessible for on-line viewing. User-oriented procedures, which do not require familiarity with the word processor, shall enable users to search for and access information. Fast information selection methods, which do not require extensive scrolling through text, are required for locating and accessing information in the on-line version. If access is by pointing to a table of contents, then a single table of contents is required and not several table of contents (for various volumes).

13.4.18 Site Acceptance Test (SAT) Plan and Procedures

The SAT procedures shall verify that all hardware and software perform as required and that the system performs satisfactorily under real operating conditions from end-to-end. These
procedures shall comprise tests that verify the end-to-end testing of the functionality and data flows.

13.4.19 Availability Test Procedures

The Contractor shall submit for review and approval a System Availability Test Procedure document. The Procedure shall include:

1. Instructions for conducting the Availability Test
2. Contacts and arrangements for Contractor support during the test
3. Forms and procedures for documenting and reporting test problems and results.

13.4.20 Operator Training Simulator Documents

The Contractor shall submit OTS documents that includes descriptions on how to establish the OTS environment, set up scenarios, savecase management and use, starting the simulations, and OTS data modeling.

13.5 As-Built Documentation and Software

Prior to system acceptance, the Contractor shall provide as-built documentation and software for the SCADA/EMS.

13.5.1 Final System Documentation

The Contractor shall submit the final “as-built” System documentation to Purchaser for review and approval. This documentation shall include all deliverable documentation, in English, which has been revised to reflect the as-built System. Any modifications to the System resulting from the Formal Acceptance Test, the Site Acceptance Test, or Availability Test shall be reflected in the “as built” documentation.

All other previously submitted documents that have been changed because of engineering changes, Contract changes, or errors or omissions shall be resubmitted for approval.

When the “as built” documents and other revised documents are approved by Purchaser, the final documents shall be provided to Purchaser in the quantities indicated in the approved documentation plan. In addition, the word processing files and AutoCAD/Visio files of all the
documents and drawings that were prepared by the Contractor shall be furnished to Purchaser. Purchaser shall be permitted to edit these files and generate from them documents for in-house use.

The Contractor shall update incorrect custom documentation, without charge, as required by Purchaser, even after final payment.

13.5.2 Final Software

13.5.2.1 SOURCE CODE

One set of “as-built” program source code shall be furnished for the delivered software and firmware, except for the operating system and related standard software maintenance and development tools. The source code shall be in electronic form and shall be easily accessible for viewing on SCADA/EMS consoles and for printing. Source code shall be in a format that can be used as input for program compilation. The source code shall include clear and comprehensive comments.

Source code shall include, but shall not be limited to, the following:

1. Command files and scripts associated with the system generation and software configuration.
2. Source code for all SCADA/EMS databases, displays, and reports.
3. Source code for all Contractor-developed software including user interface, SCADA, Network Analysis applications, Historical Information application, and all other applications.
4. Source code for any Contractor-developed firmware.
5. Source code for any custom developed functionality.

These listings shall include all changes made prior to the acceptance of the SCADA/EMS by Purchaser.

AE Specific Requirement

If the Contractor does not provide the source code, then a copy of the source code shall be maintained in an escrow account.
13.5.2.2 SOFTWARE PACKAGE

The Contractor shall provide 2 (two) sets of the following as-built software package in machine readable format:

1. The entire set of software ready to mount and execute on the system
2. Object files for all the Contractor-developed programs suitable for generation of the entire software system
3. Well-commented source code for the Network Analysis applications, the OTS, and for any other function that was developed or modified for Purchaser
4. Operating system software
5. Command files to configure the operating system and build the Contractor’s system software
6. “Make files” as needed to construct the software system
7. All program test environments, test drivers, and informal programs (for which written documentation is not required) used by the Contractor in the development of the system’s software.

Loadable software shall be 100% compatible with the software sources furnished in response to Section 13.5.2.1 Source Code, at the time of SCADA/EMS acceptance.

13.5.3 Master Document Directory

A comprehensive master documents directory, covering all the SCADA/EMS documents, shall be provided. It shall list all the documents by such categories as software documents, hardware documents, user and maintenance manuals, schematic diagrams, parts lists, etc. Each entry shall include document title, volume number, sequence within volume, Contractor document ID, and the latest revision number and release date as the minimum information provided. The Directory shall cover all SCADA/EMS documents.
# Exhibit 13-1: Minimum Deliverable Documentation and Desirable Delivery Date

<table>
<thead>
<tr>
<th>Document</th>
<th>Quantity</th>
<th></th>
<th></th>
<th>Delivery Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Review and Approval</td>
<td>Final</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard Copy</td>
<td>Soft Copy</td>
<td>Hard Copy</td>
<td>Soft Copy</td>
</tr>
<tr>
<td>1. System Overview Documentation</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2. Hardware Functional Design Documentation</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>3. Software Functional Design Documentation</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4. Detailed Hardware Design Documentation</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>5. Detailed Software Design Documentation</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>6. Power System Models Documentation</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7. Display Models Documentation</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>8. Interface Control Documentation</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>9. Cyber Security Documentation</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>10. Hardware Maintenance Manuals</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>11. Software Maintenance Manuals</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>12. System Administration Manuals</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>13. Development and Debugging Tools Manuals</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>14. User Manuals</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>15. System Installation and Cutover Manual</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>16. Formal Acceptance Test (FAT) Plan</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>17. Formal Acceptance Test Procedures</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>18. Site Acceptance Test (SAT) Plan and Procedures</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>19. Availability Test Procedures</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Document</td>
<td>Review and Approval</td>
<td>Final</td>
<td>Delivery Date</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>---------------------</td>
<td>-------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quantity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hard Copy</td>
<td>Soft Copy</td>
<td>Hard Copy</td>
<td>Soft Copy</td>
</tr>
<tr>
<td>20. As-Built Documentation and Drawings</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
14 Quality Assurance and System Testing ................................................................. 364
14.1 ISO-9001 Certification ..................................................................................... 364
14.2 Test and Inspection .......................................................................................... 364
14.3 Test Responsibilities ....................................................................................... 365
  14.3.1 AE Specific Requirements (Formal Acceptance Test Location) ................. 365
  14.3.2 Automated Test Progress Tracking (AE Specific Requirement) ................ 366
14.4 Configuration Control ..................................................................................... 366
14.5 Tracking of Problems and Variances ............................................................ 366
  14.5.1 System Problems Log ................................................................................ 366
  14.5.2 Variance Recording and Resolution ............................................................ 367
  14.5.3 Processing of Variances .......................................................................... 368
14.6 System Testing Requirements ....................................................................... 369
  14.6.1 Early Delivery PDS, OTS, and QAS Confidence Test ............................... 369
  14.6.2 Early Validation Architecture Test (AE Specific Requirement) ................ 370
  14.6.3 Hardware Tests ......................................................................................... 370
    14.6.3.1 AE Specific Requirements (test location) ........................................... 371
  14.6.4 Formal Acceptance Test (FAT) ................................................................ 371
    14.6.4.1 FAT Guidelines ................................................................................ 372
    14.6.4.2 Preliminary Formal Acceptance Test (Pre-FAT) ................................. 373
    14.6.4.3 System Generation Prior to FAT Commencement .............................. 373
    14.6.4.4 System Functional Tests ................................................................... 374
    14.6.4.5 Unstructured Test ............................................................................... 376
    14.6.4.6 Cyber Security Audit ......................................................................... 376
    14.6.4.7 System Performance Tests ................................................................. 377
    14.6.4.8 System Stability Test (100-Hour Test) ............................................... 378
14.6.4.9 Management of Variances ................................................................. 378
14.6.5 Installation and Startup ............................................................................ 379
  14.6.5.1 Inspection of Facilities ................................................................. 379
  14.6.5.2 System Installation ....................................................................... 379
  14.6.5.3 System Startup ............................................................................ 380
14.6.6 System Readiness .................................................................................. 380
  14.6.6.1 Points Test ................................................................................... 381
14.6.7 Site Acceptance Test (SAT) ................................................................. 381
14.6.8 Availability Test .................................................................................... 382
  14.6.8.1 Facility and Maintenance .............................................................. 382
  14.6.8.2 Availability Calculation ............................................................... 383
  14.6.8.3 Duration and Failure of the Availability Test ............................... 383
14 QUALITY ASSURANCE AND SYSTEM TESTING

This section specifies requirements for quality assurance (QA) and system testing to ensure that the Contractor produces a well-engineered and contractually compliant SCADA/EMS.

14.1 ISO-9001 Certification

The Contractor shall have ISO-9001 certification remaining valid through completion of the Contract and shall adhere to ISO-9001 rules for the preparation of all Contract deliverables, including documentation, hardware, firmware, and software.

14.2 Test and Inspection

The Contractor shall allow the Purchaser to access the Contractor’s facilities during System design, manufacturing, and testing and any other facility where hardware or software is being produced. The Contractor shall provide office facilities, equipment, and documentation as necessary for Purchaser staff to complete all inspection and test activities and thereby verify that the SCADA/EMS is being fabricated and maintained in accordance with the Technical Specifications.

The Purchaser shall be allowed to review and verify the functional implementation of System software informally in conjunction with scheduled project meetings at the Contractor’s facilities. No test plans, procedures, or reports are required to support these informal software demonstrations.

The Contractor shall allow the Purchaser to inspect the Contractor’s hardware and software quality assurance standards, procedures, and records. Documents identified in the approved software quality assurance plan will be inspected to verify that the Contractor has performed the required quality assurance activities.

The inspection rights described above shall not apply to subcontractors supplying standard computer or peripheral equipment and third-party software products. Inspection rights, however, shall apply to subcontractors that are developing new software for integration in the SCADA/EMS.
The Contractor at its own expense shall carry out, at the place of manufacture and/or any other applicable site, all tests and inspections of the SCADA/EMS as specified in the Contract.

The Purchaser shall be allowed to informally test the Contractor’s baseline software using the early delivery QAS and OTS. The Contractor shall provide its baseline test procedures and user guides to allow the Purchaser to use them to informally test and gain familiarity with the System.

14.3 **Test Responsibilities**

Both the Purchaser and the Contractor shall designate, in writing and prior to the start of the formal acceptance test, a test coordinator. Each coordinator shall be responsible for ensuring that the tests are conducted in accordance with the requirements of this Contract. The coordinators shall each have the authority to make binding commitments for their employer such as approvals of test results and schedules for variance corrections or, as a minimum, to cause such commitments to be made expeditiously.

Unless otherwise stated in this specification, the Contractor shall be responsible for all formal acceptance tests. This responsibility shall include supporting the tests, all record keeping, and producing all associated documentation. The Purchaser will execute the formal testing by supplying staff to execute the test procedures under the Contractor’s supervision.

The Contractor shall be responsible for all site tests. This responsibility shall include supporting the tests and producing all associated documentation. The Purchaser shall support the site testing by supplying staff to execute the tests. The Purchaser expects that at least one fully qualified and experienced member of the Contractor’s staff will be on-site during these tests.

14.3.1 **AE Specific Requirements (Formal Acceptance Test Location)**

Since all the hardware will be shipped directly to AE facilities and the SCADA/EMS will be staged on-site at AE, the Formal Acceptance Test (FAT) will be conducted on-site in Austin instead of the Contractor’s facilities. Therefore, the term FAT in these specifications shall mean the conduct of the formal acceptance tests at AE facilities.
14.3.2 Automated Test Progress Tracking (AE Specific Requirement)

The Contractor shall provide an automated test process tracking system (such as TestLink from Testlink.org) that keeps track of the number of test steps that have been completed successfully and the number of test steps that have failed. The tracking shall be done on a test procedure basis (e.g., State Estimator - 25 test steps completed and 15 test steps failed in each test section). A daily report shall be produced prior to the end of the day for review by Purchaser.

14.4 Configuration Control

Control of software sources and configuration of the SCADA/EMS shall be centralized and uniform for all functional packages of the SCADA/EMS. The Contractor shall prepare procedures for the release-control of software programs and subsystems during their development, integration, and maintenance. This shall include revision control for released software that relates to the incorporation of security patches, software backup, and the tracking and correction of variances as specified below in Section 14.5 Tracking of Problems and Variances. The Contractor’s project manager shall ensure that the system developers adhere to the configuration control procedures. In this respect, at the time of acceptance by the Purchaser, only the latest software releases shall be included in the system. In addition, the final software documentation and source codes (if delivered) that are delivered to the Purchaser (see Section 13.5.2 Final Software) shall correspond exactly to the software actually installed in the SCADA/EMS.

14.5 Tracking of Problems and Variances

14.5.1 System Problems Log

From the time that SCADA/EMS equipment staging or software integration begins, the Contractor shall maintain a System Problems Log. This log shall be used to record all hardware, operating system, and Contractor and third-party application software problems. The System Problems Log shall continue to be maintained until the end of the warranty period. The Purchaser shall always have access to this log.
14.5.2 Variance Recording and Resolution

The Contractor shall provide access to a variance tracking system that will be placed in service no later than 1 (one) month before the start of Pre-FAT and shall remain in use through completion of the System warranty. Both the Contractor and Purchaser may initiate variances. In this respect, variances may be used to record system deficiencies at any time, even if the system is not undergoing testing.

The variance tracking system shall record and track variances for:

1. Documentation deficiencies.
2. Functional deficiencies.
3. Performance deficiencies.
4. Procedural deficiencies (as when deviations from contractually required QA procedures are observed).
5. Test deficiencies (as when the system cannot satisfactorily complete a test procedure due to a problem with the test).

The capability to use the variance tracking system to produce reports on all variance information shall be provided. In addition, the capability to produce reports on subsets of this information by searching variance parameters singly or in combination shall be provided. Variance reports shall be available to the Purchaser at all times. In addition, the Contractor shall periodically distribute a variance summary that lists for each variance the report number, a brief overview of the variance, its category, and its priority.

The record of each variance shall be subject to the Purchaser’s review and approval. The record shall be open to discussion with the Contractor. As to variance content or priority, however, the final decision shall be made by the Purchaser.

The variance tracking tool and all its databases and recorded data shall be made available to the Purchaser at the time of System acceptance.

The Contractor shall take all reasonable steps to verify that the correction has resolved the variance and the Contractor shall update the variance record to reflect the corrective action taken.
prior to submitting the corrected variance for acceptance by the Purchaser. The Purchaser shall then schedule any testing to be performed in conjunction with the Contractor.

A variance shall be deemed accepted only after the Purchaser has tested the corrected variance to its satisfaction or the Contractor’s proposed resolution meets the Purchaser’s satisfaction. Written acceptance by Purchaser may be handled as an entry into the variance tracking system by Purchaser or an email to the Contractor’s project manager. The Contractor shall support any and all testing deemed necessary by the Purchaser to verify the corrections.

14.5.3 Processing of Variances

Variances are system deficiencies that prevent the SCADA/EMS from meeting Contract requirements or from properly performing any function that is included in the SCADA/EMS regardless of whether that function is contractually required. A variance report shall be written for every problem (as outlined in Section 14.5.2 Variance Recording and Resolution) that the SCADA/EMS has in meeting the requirements of the Contract, complying with the approved QA requirements, and in general when any SCADA/EMS function fails to operate as intended or documented. The variance reports shall be included in the System Problems Log.

The variance reporting process shall be subject to the Purchaser’s approval and shall include:

1. Methods to ensure that variances are identified, documented, reported, corrected, and closed.
   A variance shall be considered closed only when its correction or resolution has been approved by the Purchaser.

2. Procedures and forms for the reporting of variances. The forms shall include the following:
   2.1. The application or subsystem responsible for the observed problem. The variances shall be organized by application and subsystem.
   2.2. Name of the initiator of the variance.
   2.3. Name of the person responsible for correcting the variance.
   2.4. A unique identifier for tracking the correction of the variance.
   2.5. Identification of the non-conforming item and the specific non-conforming characteristics.
   2.6. Variance severity level (Section 16, Exhibit 16-1).
2.7. Identification of the specifications and documents that provide the acceptance criteria involved with the variance.

2.8. The Contractor’s proposed action plan and timetable for correcting the variance.

2.9. Description of the action taken to solve the problem, the results of tests to verify its successful correction, and identification of the person documenting and confirming the solution, his/her signature, and date.

2.10. Purchaser approval and signoff for each resolved variance.

A complete and up-to-date collection of all variances, including closed variances, shall always be available for inspection by the Purchaser. A variance status summary shall be included in the Contractor’s monthly project progress reports.

### 14.6 System Testing Requirements

To ensure that the system is well engineered by the Contractor and complies with Contract requirements, the following testing shall be performed at Austin Energy:

1. Early delivery PDS, OTS, and QAS Confidence Test.
2. Early Validation Architecture Test.
3. Hardware Tests.
5. Site Acceptance Test (SAT).
6. Availability Test.

#### 14.6.1 Early Delivery PDS, OTS, and QAS Confidence Test

The purpose of the PDS, OTS, and QAS Confidence Test is to validate that, on early delivery, the PDS, OTS, and QAS environments have been verified as stable and in compliance with their functional requirements specified in Section 2.3.3.5 Quality Assurance System Environment (QAS), 2.3.3.6 Early Delivery of the PDS Environment, and Section 2.3.3.7 Early Delivery of the QAS Environment. The Contractor shall provide its baseline test procedures with the early delivery systems.

The functions to be tested include but shall not be limited to the following:
1. Field communications to verify proper operation of data acquisition and supervisory control with all types of RTUs. This shall include protocol testing.
2. Verification of basic SCADA functions sufficient to perform point end-to-end testing with all types of RTUs.
3. Verification of network model management and database and display generation capabilities including Contractor software and support tools sufficient to support database and display development activities, including the Contractor’s database and display conversions from the existing SCADA/EMS.
4. Verification of the report generation capabilities including the Contractor’s software and support tools sufficient to perform the report development activities.
5. Verification of data exchange with external systems through ICCP links
6. Verification that all baseline software is executing and producing results using the Contractor’s standard models.
7. Verification of the Purchaser’s power network model for power network applications.

14.6.2 Early Validation Architecture Test (AE Specific Requirement)

The Contractor shall demonstrate that its baseline software works in the Nutanix environment. This test shall be performed at the Purchaser’s facility using the Contractor’s baseline software and database. The Contractor shall prepare a test procedure for this test and submit it to the Purchaser for review and approval. The Contractor shall participate in this test on-site at AE. The Purchaser shall support the Contractor’s on-site resource in setting up the environment.

14.6.3 Hardware Tests

Before commencing with the FAT, the SCADA/EMS shall pass hardware tests to verify that the approved list of hardware to be used during the performance of the FAT meets all the requirements of the Contract.

The Contractor shall notify the Purchaser at least 30 (thirty) days in advance of the scheduled start date for the hardware tests. In addition, the Contractor shall submit a Hardware Test plan providing a day-by-day schedule with enough details to enable management of the Purchaser’s team that will witness the hardware tests.
The Purchaser’s witness team will include Purchaser’s Consultant staff as well as Purchaser staff.

The System hardware tests shall include:

1. Visual Test - Verification that the SCADA/EMS includes all required equipment and is properly configured. Visual inspection shall verify proper workmanship and check that all equipment, including cables and connectors, is properly labeled.
2. Upgrade and Expansion Capabilities Test - Verification that provisions for SCADA/EMS upgrading and expanding are furnished as required by the Contract.
3. Hardware Diagnostic Test – Verification that Contractor’s hardware diagnostic programs are provided and can be used to run individual tests on all System hardware. These shall include any special programs as well as the standard programs used by the Contractor.

14.6.3.1 AE SPECIFIC REQUIREMENTS (TEST LOCATION)

Since most the hardware will be staged on-site at AE, the hardware tests shall be conducted at AE’s facilities. The Contractor shall schedule the hardware tests prior to the start of the FAT or at a mutually agreed time at AE’s site.

14.6.4 Formal Acceptance Test (FAT)

Preceded by a Preliminary Formal Acceptance Test (Pre-FAT), the Formal Acceptance Test (FAT) shall be successfully completed with no deviation. Successful completion of the FAT shall be certified in writing by the Purchaser.

The Contractor shall assign a QA test team for both the Pre-FAT and FAT. The Purchaser will assign a test witness team that shall include Purchaser’s staff and Purchaser’s Consultant staff (see Section 15.1.3 Consultants). This team will participate in the FAT activities and, in this respect, work closely with the Contractor’s QA test team. On the other hand, Pre-FAT attendance will be at Purchaser’s option and, if attended, shall provide the Purchaser’s witness team with the opportunity to make comments aimed at ensuring the System is ready for the FAT.

The Contractor shall notify the Purchaser at least 30 (thirty) calendar days in advance of the scheduled starting date of the Pre-FAT and FAT. SCADA/EMS documentation shall be
completed, reviewed, and approved by the Purchaser before the Pre-FAT starts. This documentation shall include all design documents, maintenance documents, user manuals, and the FAT Test Plan and Test Procedures. With respect to the FAT, the Contractor shall submit a day-by-day schedule with enough details to allow the Purchaser’s witness team to properly manage its participation throughout all of the FAT activities.

### 14.6.4.1 FAT GUIDELINES

The purpose of the FAT is to verify that the System is fully developed and meets all configuration, architectural, functional, performance, security, and interface requirements as per Contract. The tests shall verify the performance and functional integrity of the individual subsystems, including active interfaces between subsystems, and shall demonstrate the operation of the SCADA/EMS as an integrated system. All required functions shall be shown to be fully implemented. System maintenance tools and functions shall be verified. This shall include database, display, and report generation tools. System performance and response times shall be verified by testing user interface responses and the alarm handling and processing capabilities of the System. In this respect, the required utilization and expansion capacity of processors, memory, disks, and communications channels shall also be verified. All Pre-FAT and FAT tests shall be conducted using the Purchaser’s databases. If no Purchaser data is available for specific tests, the Contractor shall provide test data in order to run the test and validate the functionality.

All interfaces with external equipment and systems shall either be connected to the System during FAT or simulated by the Contractor. It is a goal of the Purchaser to perform the FAT on a configuration that is as close as possible to the configuration of the SCADA/EMS in its intended go-live configuration, and under the most realistic operating conditions possible. All software shall be sized to the Delivered capacity (Section 3 Capacity and Performance) and the Contractor shall show the parameter sizing configuration to the Purchaser prior to starting FAT.

The Formal Acceptance Test shall be conducted according to the Purchaser-approved Test Plan and Test Procedure documents, and shall cover all the tests described in the following sections. In the testing of SCADA and all applications, each function shall be tested for correct operation and performance under all reasonable conditions, including user errors, invalid data, hardware and communication failures, system overload state, and other system conditions.
The Purchaser shall carry out all tests of FAT according to the approved FAT procedures with support from the Contractor. In addition to conducting the FAT, the Purchaser shall have the right to perform unstructured testing, identify variances, assign priorities for variance resolution, and make notes for incorporation into all FAT reports.

14.6.4.2 PRELIMINARY FORMAL ACCEPTANCE TEST (PRE-FAT)

To ensure that it will be expeditiously and successfully completed, the FAT shall commence only after successful completion of the Preliminary Formal Acceptance Test (Pre-FAT). The purpose of the Pre-FAT is to qualify the SCADA/EMS as well as the test plan and procedures as ready for FAT. The Pre-FAT shall be a complete dry-run of the FAT, strictly following the Purchaser-approved FAT plan and FAT procedures. The intent is for the Contractor to detect and correct all SCADA/EMS design, integration, database, display, and performance problems before the Purchaser’s personnel are committed to participate in FAT. The Pre-FAT shall be supervised by the person designated to serve later as the Contractor’s Director for FAT. The Director shall be required to formally sign-off on each Pre-FAT test.

A copy of the FAT procedure with the Pre-FAT test results fully documented and formally signed-off, as well as a copy of the recorded variances with resolution and retest details, shall be provided for inspection by the Purchaser to determine if the SCADA/EMS is indeed ready for FAT. The FAT shall not be started until all the Pre-FAT variances are cleared and all failed tests have been repeated and passed. Subsequent to successful completion of the Pre-FAT, a minimum of 30 (thirty) days shall be allowed so that all necessary arrangements can be made for the Purchaser’s test team to participate in the FAT.

14.6.4.3 SYSTEM GENERATION PRIOR TO FAT COMMENCEMENT

The System shall be isolated from any of the Contractor systems or networks prior to the commencement of the System generation activities until the conclusion of all FAT activities unless approved by the Purchaser to allow the Contractor to keep it connected to the Contractor’s network.

A complete system software generation, including compilation and linking of all software modules, shall be performed just prior to the FAT to ensure full compatibility with up-to-date, formally controlled, system sources. The test configuration shall include only code derived from
the latest release of controlled sources. Computer produced system generation records shall be provided for inspection by the Purchaser and shall be included in the official records of the FAT. The Purchaser shall get early notice of the system generation activities and have the option to witness them.

The system generation procedure that is required in the system administrator manual, including step-by-step configuration and installation instructions, shall be followed and shall constitute part of the acceptance procedures to start FAT. Only deliverable software tools shall be used in the system generation process. Moreover, the FAT shall not be started until the following apply:

1. Pre-FAT has been concluded successfully.
2. Successful operation with all the supported protocols has been implemented in the updated PDS and QAS at the Purchaser’s site.

**14.6.4.4 SYSTEM FUNCTIONAL TESTS**

The purpose of this testing is to rigorously exercise all the system functions, both individually and collectively, to verify the correct functional behavior of all hardware and software. The functions to be tested include, but are not limited to, the following:

1. Field communications to verify proper operation of data acquisition and supervisory control as applicable to all types of RTU with which the SCADA/EMS is required to work.
2. Verification of SCADA functions, including:
   2.1. Data acquisition and processing.
   2.2. Alarm handling.
   2.3. All SCADA applications.
   2.4. Calculations.
   2.5. Limit management.
   2.6. Historical data storage and archiving.
3. Verification of all User Interface functions.
4. Verification of all Network Analysis functions including Stability Analysis (if required).
5. Verification of all Operator Training Simulator (OTS) functions, including creation of training scenarios and conducting of training sessions for users of the SCADA/EMS.
6. Data exchanges with other utility SCADA/EMS systems.
7. Data exchange with other Purchaser applications.
8. Verification of system software functions.
9. Verification that system sizing has met the Purchaser’s requirements as specified in Section 3.1 System Sizing Requirements, Section 7 Network Analysis, and Section 8 Operator Training Simulator.
10. Proper System handling of abnormal conditions such as communication errors, loss and restoration of communications with RTUs, loss and restoration of communications with external systems, loss and restoration of input power, alarm bursts, and user errors.
11. Verification of the redundancy and failover scheme of the System, including correct updating of backup equipment and all proper operation of possible failover modes including verification of failover/restart times.
12. Verification of the SCADA/EMS switchover facility, i.e., from primary to backup System and from backup to primary System including verification of the switchover time. If the Contractor’s System architecture includes the capability to switch over FEPs independently, this capability shall also be tested. The tests shall be performed as applicable to the scope of the backup (standby) system. This shall include verification of all relevant primary and backup System coordination (e.g., Database and Display synchronization) as well as transfer of control from primary to backup and vice versa.
13. Verification of data replication times to the backup system.
14. Verification of the software update and maintenance capabilities.
15. Verification that all required software development, debugging, and installation tools, software libraries, diagnostics, and utilities are included in the System.
16. Verification of system security. A cyber security audit including vulnerability assessment and verification of the Contractor’s system hardening manual shall be included to verify compliance with the requirements specified in Section 4 System Security.
17. Verification of all IS&R functionality.
18. For system configurations that are “hot-hot” (both systems receiving data simultaneously), verification that the applications are producing identical results.
14.6.4.5 UNSTRUCTURED TEST

The FAT schedule shall allow time throughout functional testing of the System for unstructured testing by the Purchaser. At least 2 (two) hours shall be reserved for unstructured testing for each 6 (six) hours of structured testing. The Purchaser shall be allowed to schedule unstructured testing at any time, including time during the structured tests.

Unstructured testing is intended solely for use by the Purchaser to perform additional tests and investigate potential problems as may be detected during tests. Unstructured testing is not intended for, and shall not be used as, a substitute for completing the formal pre-planned test procedures. Detailed tests procedures shall cover all aspects of system functionality, performance, and management. Variances found during unstructured testing shall be added to the formal Variance List for correction by the Contractor.

14.6.4.6 CYBER SECURITY AUDIT

The cyber security audit shall verify that the security requirements of Section 4 System Security and others have been satisfied. Within this context, as a minimum, the following cyber security test, verification, and review activities shall be included:

1. Review of permissions and configurations to ensure that the deliverable security configuration of the System is accurately documented.
2. Verification that network traffic recording and access recording have been enabled and are functioning.
3. Verification that unused services have been removed.
4. Verification that all software has been updated with the latest security patches.
5. System virus and malware scans to verify that all virus and malware scanning tools are enabled.
6. Verification that there are no unused as well as default accounts.
7. Verification that all access authorization methods are properly configured.
8. Verification that all system authentications and the Single Sign-On function are properly implemented.
9. Verification that all account activities are logged.
10. Generation of a full backup of software and databases.
11. Verification that all capabilities included in the system for NERC CIP are provided.

14.6.4.7 SYSTEM PERFORMANCE TESTS

System performance Tests shall verify that the system performance requirements, as specified in Section 2 System Requirements and Architecture, and Section 3 Capacity and Performance, are met for the System’s intended Go-Live configuration. In this respect, the software shall be sized to accommodate the System’s Delivered Capacity configuration.

Simulation shall be used to create any operating conditions that are required for the test but which are not supported by the test configuration, or which do not exist under the required test conditions. Such simulation may include additional processor execution, disk access, processor and disk utilization (allocation) as imposed on the SCADA/EMS using simulation software or hardware. Data acquisition for the intended go-live number of RTUs shall be simulated using status and analog values changes, and rates of alarms, as needed to generate the activity levels specified for performance testing. The Contractor may use extrapolation of system utilization to provide the expected utilization for the RTUs at the Delivered Capacity configuration. The simulation and extrapolation methods shall be subject to approval by the Purchaser.

Performance testing shall include verification that all performance requirements specified in Section 3.2 System Performance Requirements, and elsewhere in the specifications are met.

As a minimum, performance testing shall include verification of System compliance with Purchaser requirements such as:

1. Data retrieval and processing times.
2. Control command execution times.
3. Display response times.
4. Alarm processing times.
5. Response time to all user requests.
6. Utilization of computing resources and memory of processors.
7. Disk memory space and time utilization.
8. Loading of the LANs.
9. Wall-clock time for application program executions.
10. Response and processing times for interfaces with other systems.
11. “Stress tests” in which the SCADA/EMS shall be overloaded to levels chosen by the Purchaser.

**14.6.4.8 SYSTEM STABILITY TEST (100-HOUR TEST)**

A 100-hour continuous run of the SCADA/EMS shall be performed, after successful completion of the Functional Test and Performance Test, to ensure that the software is robust and that the hardware system is reliable and stable. This test will be considered successful if no critical function is lost, no restart of a critical function occurs, no automatic failover or switchover occurs, and no major hardware failure occurs within a continuous 100-hour period. Major hardware failures are defined for the purpose of this test as the loss of a major piece of hardware supplied, recommended, or approved by the Contractor (such as a processor, disk system, interface to any console, data link, etc.).

During the 100-Hour Test, the SCADA/EMS shall be exercised (with simulated inputs, events, and conditions) in a manner that approximates normal power system operations. Unstructured user activities may be performed by the Purchaser’s representatives during this test.

No ad-hoc software “fixes,” modifications, or changes shall be allowed to bypass failed modules during the 100-Hour Test. If a module fails, the failed module shall be corrected, those portions of the Functional Test affected by the change shall be repeated, and the 100-Hour Test shall be rerun in its entirety.

**14.6.4.9 MANAGEMENT OF VARIANCES**

A variance processing tool shall be provided for managing the correction of all SCADA/EMS problems discovered from the beginning of the Pre-FAT. This includes problems discovered subsequently during the FAT, System readiness (refer to Section 14.6.6 System Readiness), and the SAT (refer to Section 14.6.7 Site Acceptance Test (SAT)).

When a test fails, a separate variance report shall be created for each problem that prevented successful completion of the test procedure. Tracking numbers for variance reports shall be noted in the test procedures of failed tests, and a test shall not be signed off until all variances against it
are cleared to the satisfaction of the Purchaser. Tracking numbers shall include a designation identifying the point in the life cycle of the System that the variances were recorded.

The presence of major discrepancies such as frequent processor failover, excessive delay in System response, major or non-recoverable database errors (where wrong values are accessed or stored), and incorrect operation of major functions may, at the discretion of the Purchaser’s Project Manager or designated representative, be cause for suspension of an entire sequence of tests pending correction of the discrepancy. After correction of a major discrepancy, the entire sequence of tests to which the failed test belongs shall be started again (i.e., tests that had been completed before the discrepancy was found shall be repeated). The Purchaser shall have the right to request that other hardware and/or software modules, which may be affected by the correction, be re-tested. Minor discrepancies may, at the Purchaser’s option, be corrected and re-tested without suspending or repeating the entire sequence of tests.

14.6.5 Installation and Startup

14.6.5.1 INSPECTION OF FACILITIES

Prior to shipping the SCADA/EMS, the Purchaser will notify the Contractor that it has completed the preparation of facilities for the SCADA/EMS installation. The Contractor shall inspect the facilities to verify that they conform to the requirements of the facilities and installation manuals submitted by the Contractor.

14.6.5.2 SYSTEM INSTALLATION

The Purchaser shall be responsible for the installation of the SCADA/EMS equipment, including all intra and inter-system signal and power cabling, with support from the Contractor. The Purchaser, with support from the Contractor, shall also be responsible for the installation of all cables external to the system. This shall include wiring to the communications equipment and electrical power supply termination points in the Purchaser’s facilities. The Purchaser will provide all site-specific information regarding the locations where the various SCADA/EMS elements and Purchaser-furnished equipment will be installed.

The Contractor shall visit the system installation sites prior to System delivery to inspect the facilities and verify that they conform to the requirements of the System Installation Manual.
The Purchaser shall be responsible for the orderly removal of the existing systems including cables and servers at the control centers. All demolished equipment shall be delivered to a suitable location within the Purchaser’s local facility and all care shall be taken to preserve the equipment in its existing state.

The Purchaser shall be responsible for transferring and integrating all Purchaser-furnished equipment with the new SCADA/EMS for both control centers with support from the Contractor.

14.6.5.3 **SYSTEM STARTUP**

The Purchaser shall be responsible for the startup of the SCADA/EMS after its installation with support from the Contractor. The activities shall include:

1. Contractor shall inspect the SCADA/EMS for proper installation.
2. The Purchaser shall power up the SCADA/EMS and run diagnostics to verify the proper operation of all system hardware.
3. The Purchaser shall start the SCADA/EMS up and initialize the applications.
4. The Contractor shall check the on-site operation of the SCADA/EMS and ensure that it is ready for implementation and testing.
5. The Purchaser shall activate communications with RTUs and all other relevant devices and external systems.

14.6.6 **System Readiness**

System readiness shall be carried out by the Purchaser, with the Contractor’s assistance, following the completion of pre-commissioning and formal acceptance testing.

System Readiness activities shall include but shall not be limited to checking that the on-site operation of the System, including its communications interfaces to all relevant field devices and external systems, are ready for site acceptance testing and commercial operation. Specific tasks include:

1. Verification of all System interfaces with Purchaser-provided data sources and systems.
2. Verification of all System interfaces with Contractor-provided data sources and systems.
3. Verification that the System is protected against cyber intrusion whether originating with intruders outside or within the System’s electronic security perimeter. This shall include verification that the System is protected from attacks by intruders having access to the Corporate WAN or, for example, to unsecured remote equipment or communication lines.

4. Validation of System databases, displays, and reports using field data.

5. Validation that all software is free of contaminants, is purged of all sample scripts and sample code, and has had all default accounts and passwords removed or disabled.

6. Validation of the output of System functions using field data.

7. Verification that the SCADA/EMS is working with the Quality Assurance System (QAS), Operator Training System (OTS), and Program Development System (PDS) regarding the deployment process of new databases, displays, and code, i.e., from initiation on the PDS to testing it on the QAS and OTS, as well as then deploying it in the System production (on-line operation) environment.

8. Verification that power networks applications are producing quality solutions.

14.6.6.1 POINTS TEST

The Points Test shall be performed after the QAS has been updated with verified code from the completion of the FAT and shall be completed before the Site Acceptance Test (SAT) is performed. The Points Test may be separated from System commissioning.

The Points Test (end-to-end test) shall be carried out by the Purchaser with the Contractor’s assistance. This test shall be performed to verify the validity of the database and displays. This test shall be performed on the Quality Assurance System (QAS) and shall not impact the on-line operation environment.

The capability to perform the Points Test earlier in the project shall be provided.

14.6.7 Site Acceptance Test (SAT)

The purpose of the Site Acceptance Test (SAT) is to confirm that the SCADA/EMS has been properly updated, tested, and is ready for operational use. The SAT shall be performed by the Purchaser after the SCADA/EMS has been installed in the designated facilities and SCADA/EMS startup and system readiness activities has been completed successfully.
The SAT shall be performed according to written procedures prepared by the Contractor and approved by the Purchaser. The SAT shall include most of the tests performed in the FAT, modified as needed for testing the SCADA/EMS in the control center environment and supplemented by new procedures for tests that were not possible with the System configuration and test environment of the FAT. Functions and performance requirements that could not be fully verified in the environment of the FAT shall be exhaustively tested in the SAT.

The required cyber security audit at site shall be performed and reported in a similar manner as the required audit during the FAT. The Purchaser has the right to use a third-party or the Purchaser’s cyber security team to conduct independent vulnerability assessment and penetration tests as part of the SAT.

Unstructured tests will be employed, as deemed necessary by the Purchaser, to verify correct overall SCADA/EMS operation under typical operating conditions. In this respect, business processes related to the SCADA/EMS will also be tested.

Any system defects or design errors discovered during the SAT shall be corrected by the Contractor. The variance reporting and processing procedures shall be used to manage the correction of problems discovered during the SAT.

14.6.8 Availability Test

The purpose of the Availability Test is to verify the reliability of the SCADA/EMS hardware and the robustness of the SCADA/EMS software. The Availability Test shall constitute the final acceptance test of the SCADA/EMS. It shall commence after parallel operation of the SCADA/EMS and Purchaser present systems has been completed and final cutover to the SCADA/EMS has taken place. Within this context, the Availability Test will be completed at a time mutually agreed upon by the Contractor and the Purchaser. It shall be performed under actual operating conditions.

14.6.8.1 FACILITY AND MAINTENANCE

During the Availability Test period, the following maintenance and support requirements shall apply:
1. The Purchaser will maintain the facilities in which the SCADA/EMS equipment is installed. This shall include temperature and humidity, which (for all test periods applicable to the Availability Test) will be maintained within the limits specified by the Contractor.

2. The Contractor shall bear responsibility for all corrective maintenance on the System. The Purchaser may correct problems under direction of the Contractor.

3. The Purchaser will be responsible for system restarts, notification to the Contractor of problems and service requirements, and for preventive maintenance.

4. The Contractor shall have qualified support personnel on call for emergency support at all times during the Availability Test.

### 14.6.8.2 AVAILABILITY CALCULATION

During the Availability Tests, downtime and operational time will be recorded by the Purchaser. The System’s availability shall be computed based on these records.

If the SCADA/EMS is down because of failures of equipment or communications provided by the Purchaser, the Availability Test shall be suspended until that failed equipment becomes available. Neither downtime nor operating time shall be accrued while the test is suspended.

### 14.6.8.3 DURATION AND FAILURE OF THE AVAILABILITY TEST

The Availability Test shall be run for a total operating time of 1,000 (one thousand) hours (approximately three months). Should the guaranteed availability not be demonstrated at the end of 1,000 hours, the Contractor may continue the test by moving the starting time of the test forward and continuing the test until 1,000 consecutive hours have been accumulated and the guaranteed availability has been demonstrated. The entire 1,000-hour test must be rerun when any hardware or software changes are made to the SCADA/EMS to correct problems with the Contractor’s software, hardware, or firmware. However, database or display changes and updates to reflect power system changes will be allowed without invalidating the on-going test.

The SCADA/EMS shall be deemed to have failed the Availability Test if more than 3 (three) redefinitions of starting time are required to demonstrate the guaranteed availability or if the test is not completed within 180 (one hundred and eighty) days from the original starting date.
If the SCADA/EMS fails the Availability Test, the Contractor shall make all hardware and software corrections necessary to make the SCADA/EMS conform to the availability requirements. This effort shall be given high priority by the Contractor, and a weekly progress report shall be sent to the Purchaser’s project manager and the project Consultant. The report shall identify the people working on the problems and the progress made. The Availability Test shall then be rerun. This process of making corrections to the SCADA/EMS and re-running the Availability Test shall be repeated until the test proves successful. All Contractor costs for such corrections and test reruns shall be borne by the Contractor.
15 Project Implementation

15.1 Project Responsibilities

15.1.1 Responsibilities of Contractor

15.1.2 Responsibilities of Purchaser

15.1.3 Consultants

15.1.4 Third-Party Software

15.1.5 SCADA/EMS Quality Assurance System (QAS) and Program Development System (PDS) Environments

15.1.6 Operator Training Simulator

15.2 Project Organization

15.2.1 Purchaser’s Program Manager

15.2.2 Contractor’s Key Project Personnel

15.2.2.1 Project Manager

15.2.2.2 Team Leaders

15.2.3 On-Site Offices

15.3 Project Schedule

15.3.1 Detailed Project Schedule

15.3.2 Schedule of Training and Knowledge Transfer Activities

15.4 Project Documents

15.4.1 Documentation Plan

15.4.2 Project Milestones

15.5 Project Procedures

15.5.1 Project Correspondence

15.5.2 Project Progress Reports

15.5.3 Project Meetings and Minutes
15.5.4 Weekly Project Status Calls ................................................................. 404
15.5.5 Project Change Order Procedures ...................................................... 404
15.6 System Testing, Installation, Parallel Operation, and Cutover .............. 405
15.6.1 Formal Acceptance Test Sequence ...................................................... 406
15.6.2 System Installation and Start-up ......................................................... 406
15.6.2.1 AE Specific Requirements (hardware order and installation) .......... 407
15.6.3 System Readiness .............................................................................. 407
15.6.4 Site Acceptance Test .......................................................................... 407
15.6.5 Parallel Operation ................................................................................ 408
15.6.6 Cutover .............................................................................................. 408
15.6.7 Availability Test ................................................................................... 408
15.7 Support Services ..................................................................................... 408
15.7.1 Site Implementation Plan .................................................................... 408
15.7.2 Change Notification and Patching Service ......................................... 409
15 PROJECT IMPLEMENTATION

This section specifies project implementation responsibilities and requirements with respect to project management, project schedule, project procedure, maintenance support, and training.

15.1 Project Responsibilities

The general implementation responsibilities of Purchaser and Contractor are presented below.

Other sections in the specifications may also present implementation responsibilities.

If the requirements of any other sections conflict with the implementation responsibilities of this section, the responsibilities of the other sections shall take precedence.

15.1.1 Responsibilities of Contractor

Except for the activities specifically assigned to the Purchaser in the next section, the Contractor shall assume full responsibility for the design, assembly, development, configuration, integration, delivery, installation, and commissioning of the SCADA/EMS within the context of its meeting fully and completely all of Purchaser’s operational performance requirements.

No attempts have been made to include all items of work to be done in the list below. Only the work which is significant and for which the scope and boundary can be clearly illustrated is covered. Other responsibilities to complete the installation up to test and full operational performance are detailed in other parts of the specifications and shall also be the responsibility of the Contractor except where noted.

The Contractor specific responsibilities shall include:

1. System engineering, including the qualification of all hardware and software components for the functions to which they are assigned, and modification of the SCADA/EMS components as necessary to achieve system performance, security, and availability requirements as a single, fully integrated system.

2. Integration of the Contract deliverables with equipment and software that may be supplied by the Purchaser, including the existing and new Purchaser RTUs. It shall be the Contractor’s responsibility to meet all the specified functional, security, and performance requirements of the Contract with the equipment furnished by the Purchaser included in the SCADA/EMS.
3. Verification of the functional capabilities and performance of the Purchaser-furnished equipment and subsystems including any interfacing with the Purchaser’s communication systems, which will be provided to the Contractor by the Purchaser in good faith and with its best effort. The Contractor shall promptly notify the Purchaser of the discovery of limitations in or problems with equipment and software furnished by the Purchaser, which may prevent any Contract requirements from being met. The Contractor shall cooperate with the Purchaser expeditiously in solving such problems, and it shall be the Contractor’s responsibility to modify or replace all interface parts without any charge to the Purchaser.

4. Hardware and software development engineering, as may be required to develop and configure all the EMS functions and User Interface (UI) options, and interfaces to the existing Purchaser provided applications as well as external systems that are required under the Contract.

5. Recommendation for all SCADA/EMS equipment to be procured by the Purchaser, including processors, servers, workstations, LANs, data storage devices, communications gateways, and related support material, except for equipment, if any, that is explicitly designated by the Contract to be furnished by the Contractor. The Contractor recommended equipment shall be compatible with the Purchaser supplied equipment.

6. Supply of hardware interfaces to the external systems and applications as required by the Contract.

7. Integration of the system with the external equipment and systems as required by the Contract.

8. Supply of system software to satisfy all the Contract requirements. This shall include SCADA, user interface, power system applications, information storage and retrieval, database and network management, operator training simulator, and all other necessary software.

9. Recommendation of spare parts for use by the Purchaser’s personnel for the operation of the SCADA/EMS and its maintenance until the end of the warranty period.

10. Furnishing and installing of all interconnecting cables and wiring, including power wiring, among all Contractor-furnished equipment. The Contractor shall document the manufacturer type and catalog number for the power plugs being furnished and for communication interface connectors and any other connectors to external equipment.
11. Delivery of Contractor’s display style guide outlying the principles of the display design and defining all discretionary display parameters used by the Contractor when developing displays and reports to support the Purchaser’s development of its display standards. The Contractor shall review the Purchaser’s display standards and prototypes to ensure that the Purchaser is building the prototype displays in the most optimal way. The Contractor shall participate in the display building workshop. The Contractor shall identify any database conversion configuration options that facilitate the building and maintenance of the displays.

12. In consultation with the Purchaser, defining operator roles, establishing logins and security requirements, and designing areas of responsibility that align with the Purchaser’s operating vision.

13. Conducting an “alarms” workshop to facilitate Purchaser’s understanding of the alarm model and configuration of the system alarms to enhance the Purchaser’s situation awareness. The results of the alarms workshop shall be included in the database conversion effort in configuring how the points will be alarmed.

14. Conducting the required training and knowledge transfer courses and workshops.

15. Review of the display naming conventions that are developed by the Purchaser to ensure that the Contractor UI supports the Purchaser’s approach.

16. Preparation, with Purchaser’s participation, of the complete EMS database including the SCADA, RTU, network, and OTS models (connectivity, characteristics, etc.) by converting and integrating all existing databases into the new SCADA/EMS. This shall include identification of the information needed in the Contractor’s database but not in the existing Purchaser’s database.

17. Integration of any database and displays prepared by the Purchaser into the SCADA/EMS system.

18. Defining, documenting, and coordinating a software and database management methodology that shall ensure synchronization of SCADA/EMS databases and applications software, between the Contractor's factory and Purchaser’s site, until final shipment of all SCADA/EMS components.

19. Support for Purchaser’s generation of all required reports, excluding standard reports provided in the Contractor’s standard software.
20. Preparation and delivery of a Documentation Plan for Purchaser approval and subsequent supply of all documentation listed therein. This shall include system design, configuration, testing, maintenance, upgrading, and operation, and any other required documentation such as data sheets and technical documentation for OEM equipment.

21. Furnishing of the required software packages specified in Section 11 System Software Requirements.

22. Transferring knowledge to the Purchaser’s staff so that they will be self-sufficient and able to configure, operate, maintain, and upgrade the complete SCADA/EMS. This includes formal tutorial classes as well as and on-the-job workshops for Purchaser’s personnel, according to Section 17 Training and Knowledge Transfer, and providing the necessary means and services for Purchaser’s personnel when performing workshops at the Purchaser’s facilities.

23. Ensuring knowledge transfer to the Purchaser’s personnel on system operation through formal courses and hands-on workshops.

24. Ensuring knowledge transfer to the Purchaser’s personnel on database and display preparation and maintenance and management of the power system network model. This shall include the automatic generation of displays based on information, such as power system connectivity details, in the Network Model Management software.

25. Ensuring knowledge transfer to the Purchaser’s personnel on system maintenance, expansion, configuration, and upgrading through formal courses and workshops. In addition, at the Purchaser’s discretion, its staff will participate with the Contractor staff in loading and configuring the software at the Purchaser site using configuration and installation software prepared and used by the Contractor.

26. At the Purchaser’s option, inclusion of the Purchaser’s personnel in the SCADA/EMS development and/or configuration and installation team for project activities on-site at Purchaser’s locations, and Contractor responsibility to direct and supervise their work.

27. Provision and maintenance of the EMS Quality Assurance System (QAS) and Program Development System (PDS) Environment, as specified in Section 15.1.5, for use by the Purchaser’s personnel.

28. Successful completion of the Pre-Formal Acceptance Test (Pre-FAT) according to FAT procedures approved by the Purchaser, including all cybersecurity testing required, and submittal of detailed results for approval by the Purchaser.
29. Providing adequate resources for formal testing and performing the tests on-site at Purchaser’s location in accordance with the Quality Assurance and System Testing section within these specifications.

30. Providing an environment that allows reproducible execution of all SCADA/EMS functional performance tests conducted during formal testing.

31. Successful completion of the Formal Acceptance Test (FAT) according to FAT procedures approved by the Purchaser, and ensuring its successful completion prior to system shipment, in accordance with the contracted schedules.

32. Ensuring that the requisite security measures have been incorporated in the SCADA/EMS and all software, upon delivery, is free of viruses, worms, trapdoors, and other software contaminants, contains no software enabled with “electronic self-help”, is purged of all sample scripts and sample code, and has had all default accounts and passwords removed or disabled. In addition, all security patches are up to date and installed.

33. Shipment of project deliverables including transportation and delivery of all Contractor-provided equipment and materials to Purchaser’s sites.

34. Support installation of SCADA/EMS equipment.

35. Pre-Commissioning, Commissioning, and startup of the SCADA/EMS after its installation at the Purchaser’s facilities.

36. Assistance (i.e., provision of labor and materials) and testing, such as the Site Acceptance Test, and correction of defects discovered during all such testing.

37. Assistance (i.e., provision of labor and materials) during the Availability Test and correction of defects discovered during this test.

38. Provision of maintenance support and site services during the Availability Tests.

39. Full system backup of all installed software for all servers and workstations.

40. Maintenance of an up-to-date version of the Contract documents to reflect all agreed-upon change orders (if any).

41. Migration from the Purchaser’s present systems to the new SCADA/EMS with minimal disruption to real-time operations. In consultation with the Purchaser, this shall include review of a parallel operations plan and a cutover plan. The plan shall consider parallel operation of the new and present systems so that all operations with the new SCADA/EMS can be compared and validated as its communication with External Entities, internal
Purchaser applications, and RTUs takes place. In this transition, the listening mode shall be utilized with the present control systems to ensure maximum success in the cutover. The Contractor shall also be responsible for supplying the equipment, materials, and installation services to allow connections with existing RTUs and control center systems to be individually switched and shared between the present system and the new system during the transition period.

42. Performing, with Purchaser oversight, system start-up after satisfactory system installation. This shall include powering up the system, configuring environments, loading correct versions of all software and databases, activating data links and interfaces, verifying correct operation of the system, checking databases and displays, and turning over to Purchaser an operational system ready for site testing.

43. Performing, with Purchaser oversight, after delivery and start-up of the System, but prior to any site testing, the setting up of all functions for proper operation (system and function “tuning”). This includes having the power applications producing high quality solutions and solved power flow as well as a valid OTS solution.

44. Participating in testing at Purchaser’s site including the correction of all reported variances.

45. Ensuring and periodically demonstrating that the work is progressing according to the approved schedule.

46. Providing office space and services including telephone and wideband internet connections for Purchaser’s staff and personnel participating in the activities at the Contractor's site.

47. Providing secure remote computer access from the Contractor's factory to support the field-installed systems. This access shall be based on Purchaser’s authorized procedures including exclusive use of double factor authentication. The Contractor shall also provide the communications channels necessary for remote support in case this support cannot be done through the Internet.

48. Correction of all defects covered by the Warranty.

49. Preparation of meeting minutes for the Purchaser’s review and approval including preparation of project progress reports.

50. Provision and maintenance of secure remote computer/network access from the Contractor’s factory to support and maintain the installed SCADA/EMS until the end of warranty period.
51. Managing, coordinating, and scheduling the activities of all Subcontractors employed by the Contractor for this project. This shall include the resolution of all problems that may arise in connection with the hardware, software, and services supplied by the Subcontractors.

52. Supplying final (“as built”) documentation that is accurate and complete prior to final acceptance.

53. Supplying and completing all interconnection wiring between external communications terminals and communications interface panels supplied by the Contractor.

54. Supplying and installing the SCADA/EMS and the associated cabling and wiring to all supplied equipment, including connection to input power at the Purchaser’s delivery points within the buildings, and delivery of all necessary installation documents in advance of and in accordance with the anticipated start-up of the SCADA/EMS.

55. Providing proper site planning information such as power supply, air conditioning, power grounding, EMI, seismic protection, dust protection, fire protection, equipment sizing, and other site requirements as necessary for the proper environmental control and operation of all SCADA/EMS equipment.

56. Ensuring that the SCADA/EMS works in the Nutanix and CISCO ACI environment including proof of concept.

57. Providing on-site resources to support the cutover and post-cutover/stabilization support (4 - 6 weeks).

58. Providing meals and refreshments for FAT, SAT, and any meetings that require working through lunch.

15.1.2 Responsibilities of Purchaser

The Purchaser shall be responsible for the following:

1. Procuring the hardware based on Contractor recommendations that ensure the SCADA/EMS meets the performance, capacity, availability, redundancy, and security requirements. Once Purchaser has ordered the hardware based on the Contractor’s recommendations, the Contractor shall be responsible for providing any additional hardware in order to meet the performance, capacity, availability, redundancy, and security requirements at no cost to the Purchaser.

2. Preparation of facilities for the SCADA/EMS equipment.
3. Provision of power supply for the SCADA/EMS to receptacles according to the Contractor’s specifications.

4. Provision of communications channels (excluding interfaces) to the SCADA/EMS at the Primary and Backup control centers and external systems.

5. Participation in the physical installation of the SCADA/EMS equipment with the Contractor.

6. Review and approval of custom documentation, including software and hardware functional and design documentation, user guides, drawings, progress reports, acceptance tests plan and procedures, and as-built documentation of the system.

7. Review of Contractor standard documentation to ensure adequacy, completeness, and accuracy.

8. Preparation of Purchaser displays including video wall displays and station one-lines. If the optional Contractor converted displays is selected, then Purchaser will review the substation one-lines and overviews generated by the Contractor. Review of the Contractor’s auto-tabular and auto-display generation capabilities. The Contractor, in consultation with the Purchaser, shall determine if these capabilities can be used to support the display building process. The Contractor and Purchaser shall work together to determine any changes required to the auto-tabular/display process to meet its needs, in which case the Contractor shall update the auto-tabular software.

9. Furnishing of information required by the Contractor for preparation of Contractor-built databases, displays, and reports.

10. Preparation of customized power system database input under Contractor’s direction and for integration by the Contractor.

11. Consultation on Contractor-built displays and reports and review and approval of same.

12. Furnishing, upon request by the Contractor, necessary documentation, interface information, engineering drawings, and schematic diagrams for Purchaser equipment that will be directly interfaced with Contractor equipment.

13. Coordination of project work at the Purchaser’s facilities, such as connections to external equipment, testing of SCADA/EMS interaction with external systems and other Purchaser applications, and integration of equipment and software into the SCADA/EMS.

14. Attending and participating in the early PDS and QAS Functional Readiness Test. Reviewing and approving the test results.
15. Attending and participating in the Hardware Tests. Reviewing and approving the test results.
16. Attending and participating in the Formal Acceptance Test (FAT). Reviewing and approving the test results.
17. Attending and participating in the Site Acceptance Test (SAT). Reviewing and approving the test results.
18. Conducting the Availability Test with the Contractor’s support.
20. Reviewing variance reports, approving variance priorities assigned by the Contractor, resolving variance issues, and approving corrected variances and resolutions.
21. Determining if the Contractor’s work is progressing in accordance with the schedule.
22. Verifying that all Contractor materials, installation practices, and workmanship conform to requirements.
23. Providing media to allow remote access to the field-installed System from an external Contractor’s site.
24. Providing facilities for on-site workshops, formal on-site courses, and Contractor offices.

15.1.3 Consultants

No limitations shall be imposed on the Purchaser’s use of Consultants in any activity related to the project. The Consultants, at the direction of the Purchaser’s program manager, shall be accorded the same access to facilities and participation in project activities as any member of the Purchaser’s project team. Involvement of Consultants may include, but shall not be limited to, progress and technical meetings, workshop participation, conference calls, document review, and system testing.

The Purchaser shall have the option of adding Consultants to the distribution list to receive all correspondence initiated by the Contractor. The Purchaser shall also be able to add Consultants to the distribution list to receive all or selected system documents. The Consultants will be bound by the same confidentiality restrictions imposed on the Purchaser’s personnel.

15.1.4 Third-Party Software

Where any Contractor-provided applications software or software modules developed by a third-party are integrated into the System, the Contractor shall be responsible for integrating, testing,
and meeting the functional, security, patching, and performance requirements of this software in
the System environment.

15.1.5 SCADA/EMS Quality Assurance System (QAS) and Program Development System (PDS) Environments

The Contractor shall supply the Purchaser with system environments for use in the development
and integration tasks at each control center for which the Purchaser is responsible, including:

1. Preparation of databases and displays for which the Purchaser is responsible.
2. Review by the Purchaser of Contractor-furnished displays.
3. Testing of RTU communications interfaces with the SCADA/EMS.
4. Points testing to verify the validity of the database and displays through communications
   between the SCADA/EMS and its RTUs.
5. Early testing of Contractor baseline software.

The PDS and QAS from the beginning shall support on-line file exchanges with the Contractor.
Also, from the beginning, the PDS shall support the database and display work for which the
Purchaser is responsible, and shall be able to show displays that the Contractor provides for
review by the Purchaser. This requires the inclusion of the specified database and display
generation and maintenance functions in the PDS.

The QAS shall provide for points testing and shall be able to use all of the Purchaser’s existing
RTUs and all of the communications protocols supported by the SCADA/EMS. The QAS shall
provide for security patch testing independent from the production system.

The PDS and QAS shall be separated from the on-line system servers to ensure that development
and testing are in an isolated environment without affecting the on-line system.

To enable the Purchaser to perform its development and testing work in a timely fashion, the
PDS and QAS shall be delivered and ready for use by the Purchaser early in the project. Initially
one PDS with associated Point-to-Point and Developer workstations shall be installed and used
for database, display, and reports generation including point testing. The Contractor shall
complete the points testing by using this QAS before the Site Acceptance Test. Finally, the
Contractor shall upgrade all PDS and QAS equipment, including all Point-to-Point and
Developer workstations, to meet the full and complete functional and performance requirements of the QAS in its final configuration at the time of integration at site.

15.1.6 Operator Training Simulator

The Contractor shall provide the Operator Training Simulator software with its baseline software upon completion of the initial conversion of the power system network model, which includes converging operator power flow solutions using the Purchaser’s network model. The OTS shall be updated prior to FAT.

15.2 Project Organization

15.2.1 Purchaser’s Program Manager

All project contacts and coordination with the Purchaser shall be through the person designated by the Purchaser as its program manager. The Purchaser’s program manager will, from time to time, authorize other staff to act in this regard for specific tasks. The program manager will also change such assignments from time to time.

All Contractor’s correspondence shall be addressed to the Purchaser’s program manager. In this respect, scheduling the review and approval of documents, project meetings, Purchaser’s participation in the project, training, system testing, and other project activities shall be coordinated through the Purchaser’s program manager.

15.2.2 Contractor’s Key Project Personnel

15.2.2.1 PROJECT MANAGER

The Contractor shall designate a project manager who shall be the single-point of contact for coordination of all the project work and for all formal communications between the Contractor and the Purchaser. The Contractor project manager shall be involved in the Statement of Work development activities during Contract Negotiations. The Purchaser shall have approval rights on the selection of the project manager. The project manager shall not be changed or substituted by another person without express written consent by the Purchaser's project manager. If the Purchaser, in its sole opinion, determines that the Contractor’s project manager is not meeting...
the Purchaser’s requirements, the Contractor shall provide the resumes of potential project managers for the Purchaser to select a new project manager.

15.2.2.2 TEAM LEADERS

The Contractor shall nominate team leaders for the development and integration of the platform/SCADA functions and for each major applications area. The Purchaser shall have approval rights on the selection of the team leaders. They shall not be changed or substituted without the Purchaser’s express written consent. If the Purchaser determines that a team leader does not perform in a fashion that is acceptable to the Purchaser, the Contractor shall provide the resumes of potential team leaders for the Purchaser to select as a replacement.

15.2.3 On-Site Offices

Both the Purchaser and the Contractor shall make available office facilities for use by the other party. Office space, furniture, and reasonable office services such as telephone, facsimile, copying, printing, mail and courier services, internet access, access to meeting rooms, and secretarial assistance shall be provided. Such cost caused by the Contractor at the Purchaser’s location shall be at the Contractor’s expense.

The Purchaser will provide office space for up to two Contractor staff members at the Purchaser’s offices throughout the project. Office space for an additional four members of Contractor’s staff will be made upon delivery of the equipment to site until completion of the site testing.

The Contractor shall provide offices dedicated to the Purchaser’s use suitable for two staff members. These offices shall be contiguously located and shall be kept available for the exclusive use of the Purchaser throughout the duration of the project such that confidential documents, personal effects, and other materials may be stored safely and securely.

15.3 Project Schedule

A detailed project schedule showing all tasks shall be submitted by the Contractor for review and approval by the Purchaser within 15 (fifteen) business days of the signing of the Contract Agreement. The schedule shall be compatible with the preliminary schedule included in the Contractor’s proposal.
15.3.1  **Detailed Project Schedule**

The project schedule shall be prepared using the Microsoft Project program, which shall continue to be used throughout the project. This project management program shall be used to plan and schedule project activities including requirements analysis and custom reviews, design, configuration, integration, testing, shipment, installation, and site availability testing, from the inception of the project until the Purchaser’s acceptance of the SCADA/EMS.

Project activities for which the Purchaser is responsible, and which impact the schedule, shall be explicitly included in the schedule. These activities include the review and approval of documents, preparation of inputs for database migration/conversion, preparation of displays, supplying technical information to the Contractor, assistance to the Contractor with the configuration of the SCADA/EMS servers and workstations, integration of the SCADA/EMS with the RTUs and other systems, etc. The activities of subcontractors who may be involved in the SCADA/EMS project shall be shown to the extent that these activities affect the schedule for the SCADA/EMS. In addition, the schedule shall specifically include:

1. Identification of tasks in the critical path.
2. The amount of contingency time (float) remaining in the schedule.
3. Information on each task including:
   3.1. Estimated start and finish dates and their change since the last reporting period.
   3.2. Estimated total number of calendar-days and person-days.
   3.3. Percent of task completed, computed as person-days expended divided by total person-days expended plus currently estimated person-days to complete (or other similar measure of actual progress).
   3.4. An indication of whether the start date was manually entered or computed.
4. Total project resources including person-days used, person-days estimated to complete, and person-days assigned.
5. The tasks to begin in the next two reporting periods.
6. The tasks to be completed in the next two reporting periods.
7. The tasks completed in the last two reporting periods.
Payment milestones shall be shown in the schedule and linked to the prerequisite milestone tasks.

Training and knowledge transfer tasks and documentation schedules may be maintained outside the implementation schedule. However, the implementation schedule shall include all the dependencies of tasks contingent on the documentation and knowledge transfer tasks.

The project schedule shall be updated at least bi-weekly by the Contractor’s project manager. An up-to-date hardcopy and electronic copy of the schedule shall be included in the monthly project report sent to the Purchaser.

The content and format of the project schedule shall be subject to the Purchaser’s approval.

15.3.2 Schedule of Training and Knowledge Transfer Activities

The schedule of training and knowledge transfer activities shall identify the dates of the activities included in the training and knowledge transfer program including all required workshops (configuration, alarms, situational awareness, etc.), all structured courses defined in Section 17 Training and Knowledge Transfer, and any other activities that are required to meet the Purchaser’s training and knowledge transfer objectives. The schedule shall also identify the Purchaser’s personnel to attend each structured course and on-site workshops. The Contractor shall work with the Purchaser to determine the schedule of training and knowledge transfer activities. The content and format of the schedule for training and knowledge transfer activities shall be subject to the Purchaser’s approval.

15.4 Project Documents

Project documents shall specifically include those in the following Exhibit 15-1, which shall be delivered to the Purchaser by the dates indicated in the sections that are referenced in the exhibit and where, as below, document details are provided. Project Documents are all subject to Purchaser review and approval.
Exhibit 15-1: Project Documentation

<table>
<thead>
<tr>
<th>Document</th>
<th>Reference Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Documentation Plan</td>
<td>Per Section 15.4.1 Documentation Plan</td>
</tr>
<tr>
<td>Project Progress Report</td>
<td>Per Section 15.5.2 Project Progress Reports</td>
</tr>
<tr>
<td>Project Meetings, Agendas, and Minutes</td>
<td>Per Section 15.5.3 Project Meetings and Minutes</td>
</tr>
<tr>
<td>Project Correspondence</td>
<td>Per Section 15.5.1 Project Correspondence</td>
</tr>
<tr>
<td>Detailed Project Schedule</td>
<td>Per Section 15.3.1 Detailed Project Schedule</td>
</tr>
<tr>
<td>Test Documents</td>
<td>Per Section 14 Quality Assurance and System Testing</td>
</tr>
<tr>
<td>Training and Knowledge Transfer Documents</td>
<td>Per Section 17 Training and Knowledge Transfer</td>
</tr>
</tbody>
</table>

15.4.1 Documentation Plan

A documentation plan shall be submitted to the Purchaser within 20 (twenty) business days after Contract award. The documentation plan shall describe, in detail, the Contractor’s plan for the submittal of all subsequent documentation. It is expected that certain major documents, such as the detailed hardware and software design documentation, will consist of a series of submittals made over a period of time. The documentation plan shall address this by including a detailed list of all individual documentation submittals for the project. This list shall include, but shall not be limited to, the following information for each document:

1. Document name.
2. Document number based on the Purchaser’s File Plan.
3. Document type (such as functional design, detailed design, listing, or user guide).
4. Estimated and actual date of submittal.
5. Document status (such as submitted for review, submitted for approval, returned for correction, or approved).

The plan shall serve as a checklist throughout the project and shall be revised and resubmitted by the Contractor as necessary.

Documents shall be submitted in a sequence that allows the Purchaser to have all information necessary to review or approve each document at the time of its submittal. Documentation shall be submitted in a manner that allows for a reasonably paced review effort. The documentation plan shall be subject to Purchaser’s approval.
15.4.2  *Project Milestones*

To facilitate the review of the Contractor’s progress, a list of important project milestones shall be prepared and maintained as part of the schedule. Delivery dates of interim and final project deliverables shall be included in the milestones. Milestones shall be listed in chronological order with the expected completion date shown for each milestone. Completed milestones shall be marked whenever the schedule is updated. The list shall include 2 (two) sets of milestone completion dates. The original dates, entered when the list is first submitted, shall always be retained. In addition, actual completion dates shall be shown for completed tasks, and presently expected completion dates shall be shown for the remaining milestones.

15.5  *Project Procedures*

15.5.1  *Project Correspondence*

Correspondence between the Purchaser and the Contractor shall adhere to the following rules:

1. All formal correspondence, including email transmittals, shall be dated and numbered in sequence. The sequence number shall be accompanied by a Contractor ID code indicating the source and destination of the correspondence. CON-PUR-001, for example, would indicate the first correspondence from the Contractor to the Purchaser.

2. For clarity, each transmittal shall be limited to one topic.

3. The topic of each transmittal shall be described in a “subject” line that precedes the text. The description shall be specific (e.g., Project Report for June 2018). General, non-descriptive, subject lines (e.g., “Contract XXXX” or “UTILITY EMS/SCADA Project”) shall be avoided.

4. The recipient of each item of correspondence shall confirm the continuity of the sequential numbering and, in the event of a gap, shall inform the sender of the discrepancy, whereupon the sender shall retransmit the missing item(s).

The Contractor shall address all project correspondence to the Purchaser’s program manager. Email shall normally be used for correspondence, with attachments that are in electronic format supported by Microsoft Office applications and other formats acceptable to the Purchaser. Courier service or other fast delivery services may be required by the Purchaser when necessary.
to avoid unnecessary delays, especially when hardcopies are needed or requested by the Purchaser.

15.5.2 **Project Progress Reports**

A Project Progress Report shall be prepared by the Contractor and received by the Purchaser by the sixth calendar day of each month through the start of the warranty period. The report shall cover the project from the start of the Contract through the last working day of the previous month.

The monthly progress report shall include:

1. A description of work completed in the reporting period.
2. Work expected to be completed in the next reporting period.
3. Actual progress relative to the schedule.
4. Major outstanding problems as identified by either the Contractor or the Purchaser.
5. Procedures in place or efforts being undertaken to resolve outstanding problems.
6. Open action items, both for the Contractor and Purchaser, with the dates due for their resolution.
7. Action items completed since the last project meeting with a reference to their closing (e.g., “Utility Action #5 of Meeting #4”, or a correspondence number) and date of closing.
8. Unresolved contractual issues.
9. Log of Contractor and Purchaser correspondence.
10. An electronic copy of the most recent revision of the project schedule and milestones updated to the end of the reporting period.

A shorter weekly progress report shall be prepared and emailed at the end of each week that includes the work completed for the week, upcoming activities scheduled for the following week, and any issues/concerns that are holding up progress.

15.5.3 **Project Meetings and Minutes**

Project meetings shall be held to review project status, to ensure correct interpretation of the Contract, to review new designs, and to maintain general coordination between the Purchaser and Contractor’s project personnel. The Contractor’s project manager and team leader shall
attend all the meetings, as will the Purchaser’s program manager, or an appointed substitute and technical lead. Software and applications developers shall attend meetings concerning functions for which they are responsible. The elapsed time between in-person project meetings shall be quarterly. The meetings shall take place at the Purchaser’s office.

The Contractor’s project manager shall prepare an agenda for each in-person meeting and deliver it to the Purchaser’s program manager by email at least 10 (ten) calendar days in advance of the meeting for review and approval by the Purchaser. The Purchaser’s program manager shall have the right to add agenda items and change the order in which agenda items are to be discussed.

Review and closing of action items that have been completed since the last project meeting shall be included in the agenda of the project meetings. Completed action items shall be closed only after review in a project meeting.

The Contractor shall prepare minutes of the meetings and submit them within 5 (five) calendar days of the end of the meeting for review and comment by the Purchaser. Any disagreements about the minutes of a meeting shall be resolved within 5 (five) calendar days of submittal, and the minutes shall be approved in the next meeting. The final minutes as approved shall become the official minutes for the given meeting.

15.5.4 Weekly Project Status Calls

Weekly project status calls shall be conducted to review the status of project activities that were planned for the week and the upcoming activities. Any issues/concerns that are delaying progress shall be discussed. The project schedule shall be reviewed on the call and updates submitted to the Purchaser after completion of the call.

15.5.5 Project Change Order Procedures

The Contractor shall establish a Project Change Order Procedure to control project changes. The purpose of the Project Change Order Procedure shall be to control:

1. Deviations from the Contract including specifically changes to the project schedule
2. Deviations from the Contractor designs after their approval by the Purchaser.
The Project Change Order Procedure shall be subject to review and approval by the Purchaser and shall conform to the terms and conditions of the Contract (see Section 0300, item number 46 Modifications).

The Project Change Order Procedure shall include the instructions to be followed by the Contractor in requesting and seeking authorization for any project changes. As a minimum, the following information shall be included in any change order:

1. Reason for the proposed change.
2. Description of the proposed change.
3. Definition of the scope of the proposed change.
4. Discussion of the merits and disadvantages of the proposed change and the alternatives considered.
5. Supporting documentation suitable for evaluation by the Purchaser.

It is the Purchaser’s intent to process change orders within 4 (four) business weeks after presentation and to expedite the decision on change requests that are small in scope and have no cost or schedule impacts. A change order shall not be considered accepted until written approval by the Purchaser’s program manager has been provided. The acceptance or rejection of a change order is a prerogative to be exercised at the Purchaser’s sole discretion. Acceptance of a change order by the Purchaser shall not relieve the Contractor from responsibility for accuracy, adequacy, and suitability of the delivered System.

When a change order is approved, all the affected documents, including design documents, test procedures, Contract, and project schedule, shall be updated.

15.6 System Testing, Installation, Parallel Operation, and Cutover

The transition of activities from the implementation of the system through installation, testing, startup, parallel operation, and cutover is crucial to the success of the project. This section sets out the sequence of these activities and expands on the responsibilities of the Purchaser and the Contractor for these activities.
15.6.1  **Formal Acceptance Test Sequence**

Formal tests are described in Section 14 Quality Assurance and System Testing, along with conditions for test initiation and completion. These tests include a Preliminary Formal Acceptance Test (Pre-FAT), a Formal Acceptance Test (FAT), and a stability test. These tests shall be executed in the following sequence:

1. Preliminary Formal Acceptance Test – Successful completion of Pre-FAT is a prerequisite for FAT. This activity shall be scheduled as necessary to maintain the overall project schedule.
2. Formal Acceptance Test – The FAT including the Performance Test shall be started as soon as possible after successful completion of Pre-FAT.
3. System Stability test – The 100-hour system stability test shall be started immediately after successful completion of the FAT.

15.6.2  **System Installation and Start-up**

The Purchaser will be ordering the equipment using the Contractor’s recommended list at an agreed upon time in the project. After the equipment is delivered to the Purchaser’s site and received by the Purchaser, the system installation and start-up activities shall commence. These activities include:

1. Movement and placement of the equipment.
2. Unpacking, installation, removal of shipping brackets, reconnection of cables, powering up, verification of proper operation of the hardware, and all other start-up procedures, such as those as may be required to follow OEM recommendations.
3. Interconnection of the equipment including interconnection with previously delivered equipment.
4. The installation test (refer to Section 14 Quality Assurance and System Testing).

The Contractor shall support these tasks using labor provided by the Purchaser. Prior to delivery to the Purchaser’s site the Contractor shall become familiar with the Purchaser’s labor and safety rules governing the installation work and shall design the installation work in accordance with these rules.
The Purchaser, with assistance from the Contractor, shall be responsible for the start-up of the System and shall continue to support and maintain the System through successful completion of the warranty period.

15.6.2.1 **AE SPECIFIC REQUIREMENTS (HARDWARE ORDER AND INSTALLATION)**

AE and the Contractor shall determine the appropriate time to order most of the hardware and have it delivered to AE’s facilities. This should occur as late as practical to take advantage of the latest versions of the hardware and still meet the overall project schedule. The Contractor shall provide on-site resources to support AE’s resources configuring and installing hardware and software. The objective is to use the Contractor’s documentation to configure and install servers and workstations so that AE can be better positioned to perform this work once the system is operational. The Contractor shall put together a plan for installing and configuring the hardware at AE facilities like the approach many utilities use during hardware and software upgrades.

15.6.3 **System Readiness**

System readiness activities shall start after the Site Acceptance Test activities are concluded satisfactorily. System readiness activities shall include but shall not be limited to checking that the on-site operation of the System, including its communications interfaces to all relevant field devices, and external systems are ready for parallel operation. Specific tasks are specified in Section 14.6.6 System Readiness.

The Purchaser shall be responsible for this activity with support from the Contractor. The project schedule shall allow a minimum of two months for this activity. The Contractor shall allocate a minimum of two people full-time at the Purchaser’s site throughout this activity.

15.6.4 **Site Acceptance Test**

The Site Acceptance Test (SAT) shall be started after System Readiness activities are complete to formally confirm for the Purchaser that the SCADA/EMS is in fact ready for parallel operation. For further details refer to Section 14.6.6 System Readiness.
15.6.5 **Parallel Operation**

Parallel Operation shall be started after completion of the Site Acceptance Test and consist of operating the new SCADA/EMS in parallel with the existing systems. Parallel operation shall consist for a length of time that the Purchaser deems necessary to validate the system and to ensure that the users and support personnel are well prepared to use and maintain the system. During parallel operation, controls will still be performed primarily via the existing systems, however, the Purchaser may cut over the RTUs for selected time intervals.

15.6.6 **Cutover**

Cutover shall be started after the Purchaser has determined that the system is ready for operational use as determined by the results of the parallel operations period. Cutover will consist of the new SCADA/EMS taking over the full operation and control of the power system.

15.6.7 **Availability Test**

The Availability Test shall be started after parallel operation and cutover is successfully completed and the Availability Test prerequisites (Section 14 Quality Assurance and System Testing) have been satisfied.

15.7 **Support Services**

Throughout design, implementation, and testing, the Contractor shall supply engineering data and services, as required by the Purchaser, regarding the necessary site preparations, communication facilities, site installation of equipment, and solutions to technical problems related to the System. These support services shall apply to System hardware, software, and operational needs. Services that are not described elsewhere in these specifications are covered in this section as follows.

15.7.1 **Site Implementation Plan**

The Contractor shall develop the Site Implementation Plan so that a smooth and secure transition between the existing computer systems and the System can be achieved with effectively no loss of monitoring and control of the electric power system. This plan will allow for an interim period of parallel operation of the existing computer system and the new System.
To assist the Contractor, the Purchaser will provide information about the existing computer system equipment, building facilities, building expansion and renovation plans, operational requirements, and schedule requirements in as timely a manner as possible.

15.7.2 Change Notification and Patching Service

The Purchaser shall be informed of all alterations or improvements to the hardware and software supplied under the Contract. The Purchaser shall be placed on the Contractor’s mailing list to receive announcements of the discovery, documentation, and solution of hardware and software problems as well as other improvements that could be made to hardware and software provided with the System. The service shall begin at the time of Contract award and shall continue for 15 (fifteen) years after final acceptance of the System. The Contractor shall also include a subscription to any OEM and/or subcontractor hardware and software change notification services from the time of Contract award through the warranty period with a Purchaser-renewable option for extended periods.

These services, which may include System patches, shall be provided at the Contractor’s expense through to the successful completion of the warranty period. System patches shall be available to the Purchaser within 30 (thirty) calendar days of release. Installation of patches shall be scheduled in consultation with the Purchaser to avoid any operational disruption.
16 Maintenance, Support, and Upgrade Program ................................................................. 412
  16.1 Definitions .................................................................................................................. 413
  16.2 Deliverable Version ................................................................................................. 413
    16.2.1 AE Specific Requirements (Hardware Procurement) ....................................... 414
  16.3 Maintenance Responsibilities up to End of Warranty .............................................. 415
    16.3.1 Hardware Maintenance ..................................................................................... 415
      16.3.1.1 General Principles .................................................................................... 415
      16.3.1.2 Response Time ....................................................................................... 415
      16.3.1.3 Spare Parts, Tools, and Test Equipment .................................................. 415
    16.3.2 Software Maintenance ...................................................................................... 416
      16.3.2.1 General Principles .................................................................................... 416
      16.3.2.2 Pre-Delivery Maintenance ......................................................................... 417
      16.3.2.3 Maintenance during System Readiness and Parallel Operation ................. 417
      16.3.2.4 Maintenance during Availability Test ...................................................... 417
      16.3.2.5 Maintenance under Warranty .................................................................. 417
      16.3.2.6 Software Minimum Support Period .......................................................... 418
      16.3.2.7 AE Specific requirement (Software backwards compatibility) .................... 418
  16.4 General Requirements for Maintenance and Support Program .................................. 418
    16.4.1 General Principles ............................................................................................ 418
    16.4.2 Problem Reporting ........................................................................................... 420
      16.4.2.1 Problem Severity Levels .......................................................................... 420
      16.4.2.2 Problem Escalation ................................................................................... 420
      16.4.2.3 Problem Determination and Resolution Process ....................................... 421
      16.4.2.4 Response Times ....................................................................................... 421
    16.4.3 System Security for Maintenance ...................................................................... 422
16.4.3.1 Remote Access

16.4.3.2 Patch Management

16.4.3.3 Obligation for Notification of Security Vulnerabilities

16.4.3.4 Disposition of Sensitive Information

16.4.4 Loaner Licenses for Testing Purposes

16.5 Post Warranty Maintenance and Upgrade Options

16.5.1 Post-Warranty Software Maintenance
16 MAINTENANCE, SUPPORT, AND UPGRADE PROGRAM

This section specifies the requirements for System hardware and software maintenance and support until the end of the warranty period. It also includes options for hardware and software maintenance, support, and upgrade after the warranty period.

Within this context, the Purchaser will consider the adoption of a tailored maintenance, support, and upgrade (“Evergreen”) program that guarantees hardware and software capable of meeting the Purchaser’s needs throughout the SCADA/EMS lifecycle considering possible additional needs in the future and the continuous evolution of applicable information and supervisory and control system technologies.

The complete or partial adoption of the Evergreen program and the specific options that are selected by the Purchaser will be subject to negotiation.

The Evergreen objectives can be described broadly as follows:

1. Establish a strategy, conditions, and directives for a continuous long-term relationship between the Purchaser and the Contractor.
2. Determine responsibilities for System hardware and software maintenance that will vary depending on the time frame, i.e., before and after the end of the warranty period.
3. Maintain the system as close as practical to the Contractor baseline offering and future evolutions.
4. Maintain third-party software such as Operating System, data base management system, historical information system software up to date.
5. Maintain the SCADA/EMS in optimal operating condition and free of known errors, defects, and security vulnerabilities via preventive and corrective maintenance both from factory and local support.
6. Maintain the SCADA/EMS appropriately sized in relation to the performance needs of the Purchaser to ensure that the System is permanently available to perform its functions.
7. Supply the Purchaser access to updated tools and enhancements.
8. Avoid obsolescence of the hardware and software platform.
9. Maintain Purchaser personnel at an adequate level of knowledge for reliable system maintenance and system operation by providing yearly refresher training.
10. Take advantage of the constant evolution of software and hardware for keeping the system “state of the art”.

11. Optimize (reduce) the total cost of ownership over long term operation.

12. The Contractor shall propose an upgrade program that includes a software upgrade to the latest release 3 years after the previous upgrade went live.

13. Apply a preventive rather than corrective approach to maintenance.

14. Ensure adequate response times to the Purchaser’s requests for maximizing availability of its mission critical real-time platform.

15. Allow the Purchaser to develop and integrate into the SCADA/EMS future applications developed by the Purchaser or third parties.

16. Allow the Purchaser to influence the product evolution of the Contractor.

16.1 Definitions

So that changes in maintenance responsibilities can be determined for different time frames, the following definitions shall be used:

1. Delivery – Delivery of any item shall be interpreted as receipt of the item at the Purchaser’s facility.

2. Commissioning – Commissioning of any item shall be interpreted as receipt of the item at the Purchaser’s facility, installation on-site, successful completion of associated site tests, and correction of all variances from the tests.

16.2 Deliverable Version

The delivered hardware shall be the manufacturer’s latest version of the required hardware. Prior to the procurement of hardware, the Contractor shall submit to the Purchaser a complete updated list of all proposed hardware with a statement of the respective equipment lifecycle supporting this requirement.

The delivered software shall be the latest version certified to execute on the Contractor’s platform. Prior to the procurement of software, the Contractor shall provide the Purchaser with a complete updated list of all third-party software with a statement of the respective software lifecycle supporting this requirement.
If it becomes necessary to upgrade some hardware or software to meet the requirements specified above, the cost and time shall be borne by the Contractor. All modifications performed after FAT shall be retested. All design modifications of any part of the SCADA/EMS shall be approved by the Purchaser.

In no event shall any delivered third-party software be more than one version behind the current version unless approved by the Purchaser. All hardware and software shall be of compatible versions. The Contractor shall be responsible to ensure that all delivered hardware and software versions will interoperate successfully. If it becomes necessary to upgrade some hardware or software to meet this requirement, the cost and time shall be borne by the Contractor.

If it is necessary to revert to a previous version of any hardware or software to overcome incompatibilities among the hardware or software, the Contractor shall bear the cost and time of the "downgrade" and shall present a plan to correct the problems with the newer release. Such corrections shall also be at the Contractor’s sole expense.

The Contractor shall investigate and inform the Purchaser of all hardware and software patches or available upgrades with security or stability implications prior to the start of the Hardware Test and again prior to the start of the Site Acceptance Test.

16.2.1 **AE Specific Requirements (Hardware Procurement)**

Independently of any special hardware that the Contractor must provide as part of the Contract with AE, the System’s server and workstation hardware will be procured by AE. However, the Contractor shall retain the responsibility for ensuring that it provides AE with hardware specifications for equipment that meets the System’s performance and capacity requirements.

Within this context, AE will agree to have a minimal set of hardware staged in the factory, with the remainder of the hardware staged directly at AE. It is AE’s intent to ensure that sufficient hardware is provided at the Contractor’s facility to perform the design, integration, and testing activities. This hardware shall remain in the Contractor’s facility after completion of FAT to allow the Contractor to have an AE platform to support the Contractor’s maintenance obligations to AE.
16.3  Maintenance Responsibilities up to End of Warranty

16.3.1  Hardware Maintenance

16.3.1.1  GENERAL PRINCIPLES

The Contractor shall be responsible for providing maintenance for any special vendor-provided hardware supplied under the Contract required by its System through the end of the warranty period. Regarding any hardware provided by Vendor, AE may elect to contract with the equipment OEM or a third party to provide hardware maintenance service.

The transfer of any hardware support contract from the Contractor to the Purchaser shall be the responsibility of the Contractor and at no cost to the Purchaser.

Specific AE Requirements

AE will be responsible for providing hardware maintenance services for the servers and workstations. The Contractor shall be responsible for providing hardware maintenance services for vendor-provided hardware, if any.

16.3.1.2  RESPONSE TIME

Once the System is installed at the Purchaser’s facilities, the Contractor shall correct any vendor-provided equipment failure within 24 (twenty-four) hours of being notified by the Purchaser of a failure.

Beginning with the start of the Availability Test through the end of the warranty period, Contractor shall provide a hardware Maintenance Agreement or provide spare parts for vendor provided hardware.

16.3.1.3  SPARE PARTS, TOOLS, AND TEST EQUIPMENT

The Contractor shall recommend on-site spare parts for field-replaceable and repairable modules as part of the list of deliverable hardware (refer to Section 12 Hardware Requirements) for vendor provided hardware.

The spare parts to be supplied shall be adjusted by the Contractor during the project so that the delivered set is consistent with the delivered System configuration.
The recommended spare parts shall include any special tools and test equipment that the Contractor and the OEM use and which are applicable for the Purchaser’s maintenance.

If, at any time up to the end of warranty, the Contractor’s set of spares proves insufficient to meet the Contractor’s maintenance and warranty obligations, the Contractor shall provide additional spare parts at the Contractor’s cost.

16.3.2 Software Maintenance

16.3.2.1 GENERAL PRINCIPLES

The term “software” shall include all firmware and software delivered under this Contract, as well as the associated configuration files, installation kits, release media, documentation, and support media such as on-line help facilities and maintenance tools.

The transfer of any license from the Contractor to the Purchaser shall be the responsibility of the Contractor and at no cost to the Purchaser.

The project schedule shall include an allowance for software maintenance prior to the Availability Test (refer to Section 14.6.8 Availability Test). The Contractor will not be granted any relief for project delays caused by maintenance problems prior to the Availability Test.

Maintenance delays during the Availability Test will be addressed as presented in Section 14.6.8 Availability Test.

Should it be found necessary, the Purchaser shall have the right to request the Contractor to alter, modify, edit, and add to the software code provided with the System. This right shall begin with early delivery of the PDS and QAS and the Contractor’s baseline software. This requirement is necessary to facilitate development of the Purchaser-supplied software and the SCADA/EMS interfaces to the Purchaser’s other computer systems.

The Purchaser agrees to discuss any changes to be made to software no less than 48 (forty-eight) hours in advance of the implementation of the change.
16.3.2.2 **PRE-DELIVERY MAINTENANCE**

The Contractor shall have the responsibility for maintenance for all software prior to delivery. This maintenance may be affected by a Maintenance Agreement with OEMs or other parties or by Contractor’s staff.

16.3.2.3 **MAINTENANCE DURING SYSTEM READINESS AND PARALLEL OPERATION**

The Contractor shall have the responsibility for maintenance of all software after delivery and prior to commencement of the Availability Test. This maintenance may be performed by a Maintenance Agreement with OEMs or other parties or by Contractor’s staff.

During the System Readiness and Parallel Operations periods, the Purchaser may make changes to databases, displays, and reports as necessary to meet the Purchaser’s operational needs. The Purchaser shall be under no obligation to inform the Contractor of such changes.

16.3.2.4 **MAINTENANCE DURING AVAILABILITY TEST**

The responsibilities for maintenance of the software during the Availability Test shall be as for Maintenance under Warranty (Section 16.3.2.5 Maintenance under Warranty).

16.3.2.5 **MAINTENANCE UNDER WARRANTY**

Maintenance during the warranty shall be in conformance with the terms of the warranty sections of this Contract. The Contractor shall have the responsibility for maintenance of all software during the warranty period. This maintenance may be performed by a Maintenance Agreement with OEMs or other parties or by Contractor’s staff.

The System software will likely be composed of Contractor’s standard system elements, customized or specially developed elements, and several third-party products. To facilitate efficient maintenance of the System software, the Contractor shall follow the general principle that software specific to the Purchaser shall be implemented in specific libraries which are properly identified. This principle shall ensure that changes and upgrades to the Contractor’s standard system software, applications, or third-party products can be implemented without affecting or interfering with the software specific to the Purchaser.
During the warranty period, the Purchaser may make changes to databases, displays, and reports as necessary to meet the Purchaser’s operational needs. The Purchaser shall be under no obligation to inform the Contractor of such changes.

The Contractor shall provide summaries of all changes made to software, including but not limited to security updates, performed during the maintenance under the warranty phase of support. These summaries shall describe the problem and solution for any maintenance action performed.

The Contractor shall monitor all updates to third party software that are released during the warranty period, and shall advise the Purchaser as to the applicability of the updates to the delivered SCADA/EMS.

16.3.2.6 SOFTWARE MINIMUM SUPPORT PERIOD

The Contractor shall guarantee the availability of upgrades, technical support for all System software, and announcements of software and hardware releases applicable to the system for a period of 10 (ten) years after the expiration of the warranty.

16.3.2.7 AE SPECIFIC REQUIREMENT (SOFTWARE BACKWARDS COMPATIBILITY)

The software shall be backwards compatible with the hardware and Operating System for up to 7 years.

16.4 General Requirements for Maintenance and Support Program

16.4.1 General Principles

The Contractor shall have the following basic maintenance support program components:

1. System Patches – The Purchaser shall be able to receive periodic patches that correct variances, especially significant issues.
2. An 8x5 Help Desk - The Purchaser shall be able to request on-call support during normal business hours.
3. Software Problem Reporting (SPR) Tool – The Purchaser shall be able to submit, review, and track the Contractor’s progress of all SPRs that are associated with the System.
4. Support Hours with Rollover Provision – The Purchaser shall be able to purchase person-hour support from the Contractor on an as-needed basis. The Contractor shall provide 100 hours of support per year to be used at Purchaser’s discretion in the base support contract. Any support hours remaining at the end of the calendar year shall be rolled over into the following year.

5. Access to Contractor’s Customer Bulletin Board – The Contractor shall maintain an electronic bulletin board for the posting of information by the Contractor and the Contractor’s customer base. The Purchaser shall be granted access to read and post to the Contractor’s customer bulletin board.

The Purchaser shall also evaluate additional services including:

1. Unlimited Support – An option that provides unlimited support on a 24 x 7, on-call basis.
2. A 24x7 Help Desk – The Purchaser shall be able to submit System problems by calling them in and by submitting them via a Web-based software problem reporting tool.
3. Annual Software Updates – The option to receive software updates on an annual basis.
4. On-site Support Services – The option to have on-site support with maintenance and security patch installations, configurations, and installations of software.
5. Yearly Refresher Training – The option to include refresher training as part of the maintenance and support contract shall be provided. That is, an allocation of training courses (assume 5 on-site refresher courses per year) shall be included in the contract. Any training courses not used in a current year will be carried forward into the next maintenance year. The Contractor shall track the use of the training courses given per year and the remaining balance, including rollover, and report them to the Purchaser on a periodic basis.

The Contractor’s Help Desk support team shall be staffed with experienced and trained personnel. The staff shall possess adequate technical competencies so that any aspect of a system failure can be investigated and corrected.

The following minimum response times shall be supported:

1. The Contractor shall respond to a request for service within 15 (fifteen) minutes during normal business hours (8:00 am to 5:00 pm central time at the Purchaser’s facility).
2. The Contractor shall provide 24x7 phone support for all other times.
3. The Contractor shall respond to a support call within 30 (thirty) minutes of the service request.
4. A set of service levels will be finalized during the negotiation of the Contract.
5. A rebate scheme will apply if the Contractor fails to meet agreed service levels in any support program provided.

16.4.2 Problem Reporting

16.4.2.1 PROBLEM SEVERITY LEVELS

The Purchaser shall state the severity level for any problem that it submits for correction.

Problems will be categorized according to severity. The definition of each severity level is included in Exhibit 16-1, Problem Severity Levels, as below. Refer to Section 2.5.1 Critical Functions for critical functions definition.

### Exhibit 16-1: Problem Severity Levels

<table>
<thead>
<tr>
<th>Category</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severity 1 – Critical</td>
<td>Critical functions or equipment non-operational or unusable with critical or material impact on normal operations.</td>
</tr>
<tr>
<td>Severity 2 – High</td>
<td>Critical functions operational but without redundancy, and there are no possible circumventing actions.</td>
</tr>
<tr>
<td>Severity 3 – Medium</td>
<td>Functions are operational but with limited functionality. There are no possible circumventing actions to prevent impact to normal operation.</td>
</tr>
<tr>
<td>Severity 4 – Low</td>
<td>Functions are operational but there are some identified problems that need correction. There is no impact on normal operation.</td>
</tr>
</tbody>
</table>

16.4.2.2 PROBLEM ESCALATION

The Contractor’s maintenance and support program shall include a problem escalation that can be triggered automatically (e.g., “X” amount of time has elapsed for a high severity problem, etc.) as well as manually by the Purchaser.

Non-Emergency Cases (Medium/Low)

The Purchaser may elect to escalate a support request for the following reasons:

1. Contractor’s proposed action plan or solution to a problem is unsatisfactory.
2. The reported severity of a problem has changed.
3. Contractor has not provided a response within the stated response time.
Emergency Cases (Critical/High)

A severity of Critical or High, as described in Section 16.4.2.1 Problem Severity Levels, shall be considered an emergency.

If the problem is not resolved within the time identified in Exhibit 16-2 Response Time, the Contractor shall immediately begin to make arrangement for on-site assistance. On-site support shall be maintained until the problem is resolved. The Contractor shall continue to work on the problem remotely while the on-site support persons are in transit.

16.4.2.3 PROBLEM DETERMINATION AND RESOLUTION PROCESS

The Contractor shall work with the Purchaser to understand, isolate, and resolve the reported problem. During problem evaluation, the Contractor shall work with the Purchaser’s support staff to identify any additional support that may be required to resolve the problem.

16.4.2.4 RESPONSE TIMES

This section describes the required response times within which the Contractor shall respond to support requests for each category of severity.

1. Maximum Response Time – This time includes the initial notification of the problem, assignment of the problem to a qualified technician, and initiation of problem resolution efforts by the technician.

2. Maximum Solution Time – This is the maximum time for the problem to be corrected or, at a minimum, implementation of an acceptable workaround.

Exhibit 16-2: Response Time

<table>
<thead>
<tr>
<th>Variance Priority Level</th>
<th>Maximum Response Time</th>
<th>Maximum Solution Time</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>30 minutes</td>
<td>6 hours</td>
<td>A schedule for the correction of critical priority variances shall be informed within 30 (thirty) minutes and it shall be fixed within 6 (six) hours after the Purchaser’s request. After this period, the Contractor shall assign dedicated resources until the problem is fixed or a workaround implemented.</td>
</tr>
<tr>
<td>Variance Priority Level</td>
<td>Maximum Response Time</td>
<td>Maximum Solution Time</td>
<td>Guidelines</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------</td>
<td>-----------------------</td>
<td>------------</td>
</tr>
<tr>
<td>High</td>
<td>2 hours</td>
<td>12 hours</td>
<td>A schedule for the correction of high priority variances shall be informed within 2 (two) hours and it shall be fixed within 12 (twelve) hours after the Purchaser’s request. After this period, the Contractor shall assign dedicated resources until the problem is fixed or a workaround implemented.</td>
</tr>
<tr>
<td>Medium</td>
<td>8 hours</td>
<td>5 work days</td>
<td>A schedule for the correction of medium priority variances shall be informed within 8 (eight) hours and it shall be fixed or a schedule for correction presented to the Purchaser for approval within 5 (five) working days.</td>
</tr>
<tr>
<td>Low</td>
<td>2 work days</td>
<td>10 work days</td>
<td>The schedule for correction of all low variances shall be replied within 2 (two) working days and it shall be fixed or a schedule for correction presented to the Purchaser for approval within 10 (ten) working days of the Purchaser’s request.</td>
</tr>
<tr>
<td>Spare Part Replenishment</td>
<td>1 work day</td>
<td>3 weeks</td>
<td>Contractor shall initiate the provisions to replenish the spare parts for Contractor provided equipment, if any, in the following working day after the Purchaser’s notification and shall deliver the spare part to the Purchaser’s site within 3 (three) weeks.</td>
</tr>
</tbody>
</table>

**16.4.3 System Security for Maintenance**

This section describes the cyber security requirements. The proposed solution must comply with the relevant security standards and measures specified in Section 4 System Security.

**16.4.3.1 REMOTE ACCESS**

All access from Contractor’s facilities or Contractor’s staff to the Purchaser’s SCADA/EMS for the purpose of maintenance shall be permitted only to the Quality Assurance System (QAS) and Program Development System (PDS), if not directly connected to the SCADA/EMS LAN, and not to any component of the on-line SCADA/EMS. Such access shall be subject to the security requirements for remote maintenance access as described in Section 4.11.5 Security of Remote Access for Maintenance by Contractor.
All actions performed remotely shall be subject to audit trail reporting and adhere to the Purchaser’s software version and configuration control procedures. The Contractor’s diagnostic system used for remote maintenance of the Purchaser’s SCADA/EMS is referred to here as the “Contractor’s remote diagnostic system”.

The Contractor shall ensure security of the physical access to its remote diagnostic system. The remote diagnostic system shall be a stand-alone system and shall not be connected to any Contractor or external network.

The Contractor shall enforce strict physical and electronic security procedures for access to its remote diagnostic system such as having the system in a secure area and requiring a smart card or biometric identification as well as a password to gain access to the Contractor’s remote communications line.

The Contractor shall ask permission for any remote access connection requiring authorization by the Purchaser. The Contractor shall inform the Purchaser of its plan on what work will be performed, which processing resources they will connect to, and what needs to be changed/installed/deleted, etc. The Purchaser will have the right to block remote access to the Contractor without previous advice if so necessary.

Upon termination of the Maintenance Agreement, the Contractor’s remote diagnostic system shall be dismantled, and all paper and electronic media shall be securely erased or destroyed as described in Section 4 System Security. A certificate of erasure or destruction shall be provided as part of the contract termination documentation.

16.4.3.2 PATCH MANAGEMENT

Whenever a software supplier, including the SCADA/EMS Contractor, OS provider, and suppliers of third-party software to the SCADA/EMS Contractor, releases a software change (“upgrade”, “update”, “modification”, “release”, or “patch”) to correct a security-related error in the code or to close a vulnerability, the Contractor shall take immediate steps to test, confirm, and install the software change on the SCADA/EMS in order to ensure that the Purchaser can stay in NERC CIP compliance.
The Contractor shall develop and test security related software changes against a “base line” software environment in order to minimize the testing time required on the Purchaser’s System.

The Contractor shall notify the Purchaser as soon as practical that a security software change is forthcoming, in order to allow the Purchaser to allocate resources to implement the software change when it is released.

The initial testing for the Purchaser’s configuration shall be done on the Purchaser’s factory testbed by the Contractor. Testing shall have the goal of confirming that the patch indeed corrects the published error and does not introduce any new errors.

The Purchaser will test the patch on its QAS for the purpose of testing the security patch in an operational environment. The implementation and testing of all security patches shall follow the established configuration management and change control processes. This includes the execution of test procedures where the change is deemed “significant”.

16.4.3.3 OBLIGATION FOR NOTIFICATION OF SECURITY VULNERABILITIES

The Contractor shall immediately inform the Purchaser upon the discovery of an error in or a property of any software resident on the SCADA/EMS that makes the SCADA/EMS vulnerable to cyber-intrusion. The Contractor shall diligently work to correct the error or modify the property to close the vulnerability, and shall make the correction available to the Purchaser at no cost.

This obligation for notification and closure of security-related vulnerabilities shall not expire upon the completion of warranty or other Contract obligations, but shall remain in effect for the lifetime of the SCADA/EMS or until the Purchaser informs the Contractor in writing that the obligation for notification has been waived.

16.4.3.4 DISPOSITION OF SENSITIVE INFORMATION

Any hardware, documentation, or other material replaced during maintenance shall be discarded in such a manner as to protect sensitive information such that all paper and electronic media shall be securely erased or destroyed as described in Section 4 System Security to ensure that the sensitive information is protected. A certificate of erasure or destruction shall be provided as part of the contract termination documentation.
This includes maintenance actions performed on the SCADA/EMS as well as the Contractor’s remote diagnostic system.

### 16.4.4 Loaner Licenses for Testing Purposes

The Contractor shall provide, at no additional charge, licenses adequate to support any system staging and testing during the project implementation; additionally the Contractor will provide, at no additional charge, licenses adequate to support all testing environment(s) during post cutover operations.

### 16.5 Post Warranty Maintenance and Upgrade Options

#### 16.5.1 Post-Warranty Software Maintenance

Post-warranty software maintenance services shall include:

1. Change notification services of all SCADA/EMS component software. This shall include transmission of service bulletins and notices of the availability of corrections, modifications, upgrades, revisions, and new releases. These bulletins and notices shall describe:
   1.1. The release or version of the previous software to which the upgrade may be applied.
   1.2. Prerequisites for the upgrades, including a complete list of the minimum release or version of all other software necessary to support the new software.
   1.3. Problems with the previous releases corrected by the upgrade.
   1.4. New features available with the upgrade.
   1.5. As part of these services, the Contractor shall maintain and periodically publish a list of the current release of their standard products and the compatible releases of all software supplied by subcontractors.

2. Upgrade services for the software. The Contractor shall provide software maintenance releases to the Purchaser for installation. These incremental software maintenance releases shall include the fixes for the software problems reported by the Purchaser and correct all other known software problems at the time of the release.

   The services shall include the change notification services as described above, as well as a copy of the new software, appropriate licenses for the new software, installation instructions, and a reasonable amount of support for the installation of the upgrade.
3. A contract for upgrades to be performed. This contract shall include the software upgrade services described above, plus the on-site testing and installation services to be provided. The contract is referred to here as the “Software Maintenance Agreement.” The Software Maintenance Agreement is intended to ensure the SCADA/EMS is maintained at the current release version of all software. The current release version is defined as the most recent supported release of the Contractor or Contractor’s sub-contractor software. Current version does not include test, trial, or advance “Beta” releases of software. Upgrades are to be completed within 12 (twelve) months of the release of the Contractor or Contractor’s sub-contractor software. Extensions to this 12-month requirement shall be acceptable only if approved by the Purchaser.

4. Provision of technical guidance, analysis, and diagnosis towards the resolution of all software problems. This is referred to here as Technical Support. The Contractor or other parties under contract to the Contractor shall be available to provide Technical Support by telephone 24 (twenty-four) hours per day, 7 (seven) days a week. The Contractor’s staff providing Technical Support by telephone shall be able to communicate effectively in English, have access to all documentation relevant to the Purchaser’s system, and be capable of providing effective diagnosis and guidance towards the resolution of problems reported by the Purchaser or the Purchaser’s support contractor. The Contractor’s diagnostic system used for remote maintenance of the Purchaser’s SCADA/EMS is referred to here as the “Contractor’s remote diagnostic system”. When requested, the Contractor shall provide Technical Support by remote diagnostic system via a secure connection on the first working day following receipt of a remote support request. Working day is defined as 7:00 am to 5:00 pm Central Standard Time, Monday to Friday. Security is of paramount importance when using a remote diagnostic system. The Purchaser acknowledges the physical distance between the Purchaser and Contractor’s facilities may make it impractical for the Contractor’s Technical Support staff to travel to site at short notice to undertake analysis and diagnosis of problems. The Contractor shall comply with the requirements defined in Section 4.11.4 Secure Maintenance Access.

5. A security notification service. The security notification service shall include notification of the discovery of security problems or the subsequent release of any mitigation of the security problems, including new releases, patches, service packs, “work-around”, or parameter
changes within 2 (two) weeks of the discovery or release. The Contractor shall discuss with
the Purchaser any potential installation issues that software releases or patches may cause
when installed.
The notification shall include a discussion by the Contractor of the specific vulnerability of
the supplied software and the results of any compatibility testing performed by the
Contractor.

Normal field service rates shall also be provided.

Any variations on the number of hours or level of support to be supplied under the support
contract will be charged at the hourly rate specified in the Unit Price Schedule. Personnel
dispatched under these rates shall be subject to prior and ongoing approval by the Purchaser.

The support contract and associated KPIs will be reviewed annually.
17 Training and Knowledge Transfer ................................................................. 430

17.1 Training and Knowledge Transfer Objectives ............................................. 430

17.2 Training and Knowledge Transfer Plan and Schedule ............................... 431

17.3 Structured Course Requirements ............................................................... 432

17.3.1 Self-Study Courses ................................................................................. 433

17.3.2 Recording of Courses ........................................................................... 433

17.4 Knowledge Transfer Workshops ............................................................... 433

17.5 Training and Workshop Locations (AE Specific Requirement) ................... 435

17.6 Structured Course Documents .................................................................. 435

17.6.1 Course and Workshop Descriptions ........................................................ 435

17.6.2 Course Material ..................................................................................... 436

17.7 Instructor and On-site Staff Qualifications .................................................. 436

17.8 Structured Classes ...................................................................................... 436

17.8.1 System Overview .................................................................................... 437

17.8.1.1 System Overview for Technical Support Group ..................................... 438

17.8.1.2 System Overview for Executives .......................................................... 438

17.8.2 Database, Display, and Reports Building ................................................ 438

17.8.3 Data Engineering Workshops ................................................................. 440

17.8.4 Calculations Course ................................................................................ 440

17.8.5 System Level Course on Computing Equipment ..................................... 441

17.8.6 System Administration ......................................................................... 441

17.8.6.1 Administration at System Level ............................................................. 441

17.8.6.2 Administration at Operating System Level ........................................... 442

17.8.7 Application Software ............................................................................. 442

17.8.8 Communications Software ..................................................................... 443
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.8.9</td>
<td>System Software</td>
<td>444</td>
</tr>
<tr>
<td>17.8.10</td>
<td>Programming in System Environment</td>
<td>444</td>
</tr>
<tr>
<td>17.8.11</td>
<td>Information Storage and Retrieval System and Reports</td>
<td>445</td>
</tr>
<tr>
<td>17.8.12</td>
<td>Courses for Operators and Users</td>
<td>445</td>
</tr>
<tr>
<td></td>
<td>Operator Course</td>
<td>446</td>
</tr>
<tr>
<td></td>
<td>OTS Instructor Course</td>
<td>446</td>
</tr>
<tr>
<td>17.9</td>
<td>Training and Knowledge Transfer Budget</td>
<td>446</td>
</tr>
<tr>
<td>17.10</td>
<td>No Additional Charges</td>
<td>446</td>
</tr>
</tbody>
</table>
17 TRAINING AND KNOWLEDGE TRANSFER

The Contractor shall prepare and deliver a comprehensive training and knowledge transfer program on the configuration, operation, and maintenance of the System. The training and knowledge transfer program shall also include knowledge transfer of the Purchaser’s requirements and operations to the Contractor for better Contractor understanding of Purchaser’s needs. The training and knowledge transfer program shall include structured courses, workshops, and on-site Contractor services to support Purchaser staff in selected activities such as showing them the best way to perform certain operation or maintenance tasks. The Contractor’s training and knowledge transfer program shall teach Purchaser personnel the skills required for System configuration, software and hardware installation, applications configuration, network model management and database management, maintenance and expansion, and preparation and integration of new functions.

17.1 Training and Knowledge Transfer Objectives

The objective of the training and knowledge transfer program from the Contractor to the Purchaser shall ensure that the Purchaser is operationally ready to take primary responsibility for the maintenance of the SCADA/EMS. The Purchaser will maintain the database and displays; will implement system expansions; rebuild environments; install system patches, upgrades and enhancements; and plans to develop additional functionality and applications for the SCADA/EMS. The Purchaser will perform preventive maintenance of SCADA/EMS hardware, will upgrade the system’s hardware by replacing units such as processors, servers, routers, etc., and will troubleshoot and replace failed SCADA/EMS equipment down to the level of plug-in boards and modules. The Contractor shall provide the Purchaser with tools and knowledge for the Purchaser to assume this range of responsibilities.

The objective of the knowledge transfer from the Purchaser to the Contractor is to ensure that the Contractor has a strong understanding of how the Purchaser operates its power system as it relates to any custom features included in the system as well as the best way to configure the Contractor’s UI and applications to meet the Purchaser’s needs without the need to include customs in the Contractor’s baseline software.
17.2 Training and Knowledge Transfer Plan and Schedule

A training and knowledge transfer plan and schedule tailored to the Purchaser’s needs shall be developed in cooperation with the Purchaser. The training and knowledge transfer plan and schedule shall be compatible with the proposed project schedule such that appropriate activities are provided prior to the need to start each activity (e.g., display workshop and display tool courses prior to the display building activity, customs workshop prior to developing the functional requirements specification document) and shall be designed to prepare the Purchaser’s personnel to assume their responsibilities in a timely fashion.

The training and knowledge transfer plan shall list the following:

1. Each structured course to be taken and the expected number of participants to attend.
2. Each workshop to be conducted and the objectives of the workshop.
3. The on-site activities (e.g., services to support using the network model management system) to be supported by the Contractor during design, development, configuration, and installation of the System.

The training and knowledge transfer plan shall be defined in a logical manner such that the training and knowledge transfer activities build upon themselves (e.g., course on the layout of the network model followed in sequence by a course on the network model manager tool, a workshop on network model maintenance using the tool, and on-site support from a Contractor field person with network model management experience who can work with Purchaser staff to use the tool to maintain the model).

It is the Purchaser’s desire that all structured courses, except for the Operators course, be completed prior to the start of the Formal Acceptance Test.

The training and knowledge transfer plan and schedule shall include the following:

1. The course, workshop, and on-site activity name.
2. The objectives of the course, workshop or on-site activity.
3. A summary of the contents of the class, workshop, or on-site activity.
4. All courses and workshops shall be conducted at AE.
5. Class, workshop, or on-site activity dates and duration.
6. A list of any prerequisite courses, workshops, or experience expected of the Purchaser participants.

17.3 **Structured Course Requirements**

The structured courses shall be conducted at Contractor or Purchaser facilities in accordance with the approved Training and Knowledge Transfer plan and schedule. The key requirements are as follows:

1. Structured courses shall be conducted by personnel who: (1) are experienced in instruction, (2) have a good command of English, (3) have expertise in the course subject, and (4) are familiar with the SCADA/EMS being developed for the Purchaser. The Contractor shall submit a list of instructors and their experience records with course documents for Purchaser approval at least 1 (one) month before the scheduled commencement of the particular course.

2. For all courses on the subcontractor/third-party software products used in the System, suitably qualified personnel of the software subcontractor or certified center shall be used as instructors wherever possible. These courses shall cover the theory of design and operation, use, maintenance, and installation of upgrades or new releases of these software products.

3. The Contractor shall provide extensions to all subcontractor-provided courses to cover how the subcontractor/third-party software products are used in the System, the specific product features that are implemented, and the features that cannot be used if any.

4. All necessary course material shall be provided by the Contractor.

5. Each participant shall receive individual copies of the technical manuals and pertinent documents. These shall be sent to the participants at least 1 (one) month before the scheduled commencement of a course. Electronic files of the manuals and documents shall also be provided to the Purchaser when available to the Contractor.

6. Class materials, including documents sent before the classes and class handouts, shall become the property of the Purchaser. The Purchaser shall be given the right to copy such material for in-house use.

7. Copies of course material presentations, including electronic files of the presentation in original format such as Microsoft Word and PowerPoint, shall be provided to the Purchaser, and the Purchaser shall be permitted to use them for in-house use by the Purchaser’s personnel.
8. Courses shall provide a proper balance of classroom lectures and hands-on work to ensure a thorough understanding of the subject matter by the participants.

9. The Contractor shall provide suitable tools and equipment for the course such that each participant has their own, dedicated equipment for use during the course.

10. The Contractor shall bear all expenses for the courses, including airfare, instructor's living expenses, documentation, and any third-party course fees. However, the Purchaser will provide classroom facilities for all on-site courses.

17.3.1 **Self-Study Courses**

The Purchaser prefers classroom style courses for all courses. Self-study courses using books, computer-aided instruction (CAI), or computer-based courses (CBC) may be used to supplement structured courses. A copy of any DVD, CAI program, or CBC program used shall be provided to the Purchaser as part of the knowledge transfer documents.

17.3.2 **Recording of Courses**

The Contractor shall make video and audio recordings of all classes for Purchaser in-house use. The Purchaser will use these recordings solely for internal instruction purposes and will not release the recordings to third parties.

17.4 **Knowledge Transfer Workshops**

SCADA/EMS systems contain a plethora of configuration options to provide greater flexibility for the Purchaser to configure the system to meet their needs. Consequently, the Contractor shall design and conduct workshops that allow the Contractor and Purchaser to work together and thereby set the System configuration options to those acceptable to the Purchaser. These workshops shall be conducted on-site at the Purchaser’s facilities. To this end, a series of Knowledge Transfer workshops shall be conducted such as follows:

1. Configuration workshop for:
   1.1. Configuring the alarms to behave the way the Purchaser desires, including any special configuration requirements for enhanced or intelligent alarm processing.
   1.2. Configuring the tags to meet Purchaser requirements.
1.3. Configuring the execution and feedback features associated with SCADA control commands to behave the way the Purchaser desires.

1.4. Configuring UI menus and pull-downs to meet Purchaser requirements.

1.5. Configuring AORs and permissions to meet Purchaser requirements.

1.6. The OTS shall be used to verify that the alarming is working to the Purchaser’s specification as part of the workshop.

2. Situational Awareness workshop to discuss and demonstrate the capabilities of the System from the perspective of its advanced power system visualization features (e.g., use of contours, dynamics, network coloring, etc.). The workshop shall take into account the maintenance aspects of using different situational awareness features as well as the use of situational awareness on the Purchaser’s video wall.

3. Calculations workshop to discuss the Purchaser’s required calculations and the best way to implement them using Contractor calculation engines.

4. Network Model Management workshops and on-site support. These workshops shall ensure that Purchaser personnel fully understand the best way to use the model management tool. One workshop shall be used to discuss and demonstrate the options available to define the model. Other workshops shall be provided where experienced Contractor personnel will be on-site to coach the Purchaser’s personnel on how to configure and use the tool.

5. OTS Modeling workshop to discuss and demonstrate the modeling required to support the Contractor’s OTS as well as the different ways to create OTS training scenarios. In addition, the workshop shall also include instruction on how to model and set up training scenario support activities such as modeling the hydro, schedule creation, and use of calculations in the OTS.

6. Security workshop for the Contractor to understand the Purchaser’s security environment. Discussions shall focus on the System capabilities and tools that will be required to meet the CIP standards, including security monitoring and logging, and the best way for the System to meet the Purchaser’s overarching security requirements during all phases of project implementation.

7. Customs requirements workshop to discuss Purchaser’s SCADA/EMS customs in detail. The goal of this workshop is to ensure that the Contractor fully understands how the System must meet the Purchaser’s special needs. It is the intent to have these workshops, one for each
major area (SCADA, Network applications, OTS) prior to the Contractor starting the custom functional design activities.

8. Power Network applications workshop to discuss modeling requirements, parameters, setup and configuration, tuning, review input and output displays, and the interaction of applications.

17.5 Training and Workshop Locations (AE Specific Requirement)
All training courses and knowledge transfer workshops shall be conducted on-site in Austin Energy’s training facilities.

17.6 Structured Course Documents
The Contractor shall be responsible for the preparation and production of all course material. Course documents shall be subject to the review and approval process of Section 13.3 Documentation Review and Approval.

17.6.1 Course and Workshop Descriptions
Course and workshop descriptions shall be included with the training and knowledge transfer plan (also refer to Section 17.2 Training and Knowledge Transfer Plan and Schedule). The information provided shall include:

1. The course or workshop name (and number if applicable).
2. A brief description of the course or workshop.
3. A description of the intended audience for the course or workshop.
4. A description of the relationship of the course to others in the knowledge transfer plan.
5. The duration of the course or workshop.
6. A breakdown of the course with respect to identifying classroom, laboratory, and hands-on periods or a breakdown of the workshop with respect to identifying the necessary resources (classroom, PDS workstation, etc.).
7. A list of the materials to be supplied.
8. A list of reference material to be used in the course or workshop.
9. A list of any prerequisite courses or experience expected of the participants.
17.6.2 **Course Material**

The Contractor shall provide all necessary materials, including course manuals and reference materials. For relevant requirements, refer to Section 17.3 Structured Course Requirements.

17.7 **Instructor and On-site Staff Qualifications**

As in Section 17.3 Structured Course Requirements, course instructors shall have demonstrated technical competence in the subject and previous instructing experience.

The Purchaser prefers instructors who specialize in course presentation, as opposed to hardware or software developers who only occasionally present courses. However, for System elements produced specifically for this Contract, the Contractor may use the developer as the instructor. The developer shall use appropriate staff as resources when developing the course and materials.

Workshop facilitators shall have demonstrated technical competence and a deep understanding of the configuration and modeling capabilities for the topics to be covered in each of the workshops.

Where practical, subcontractors shall deliver courses on their products directly. However, the Contractor shall remain responsible for selecting these courses, coordinating their delivery, and ensuring that all knowledge transfer objectives are met.

17.8 **Structured Classes**

The following sub-section describes the types of structured classes required and shall be used as a guideline for the preparation of the knowledge transfer plan and courses for each of the roles below. A System Overview (refer to Section 17.8.1 System Overview) shall be included in the knowledge transfer plan for all roles. Additional classes may be offered by the Contractor.

In developing the knowledge transfer plan, the Contractor shall include recommended sets of structured classes for the following expected Purchaser roles:

1. Executive
2. Operator
3. System Administrator
4. Cybersecurity personnel
5. Software Engineer
6. Power Network Applications Engineer
7. SCADA Engineer and Communications Technician
8. Database Administrator
9. Display Builder
10. OTS Instructor
11. Operator Instructor

The number of Purchaser staff in each role is listed in **Exhibit 17-1, Staff Roles.** For each staff role, the Contractor shall develop a recommended course of study including course names, timing for when the staff should take the courses, and the recommended location of the courses. The capability to hold courses more than once shall be provided.

After completing the recommended courses by staff role, the Contractor shall develop a matrix that has the course name in the rows and the number of participants for each role along the columns so that the Purchaser can see the number of participants recommended to attend each course. In addition, the last column shall show the recommended location to take the course.

To establish a baseline cost, the Contractor shall list the assumptions regarding the courses and workshops to be taken.

### 17.8.1 System Overview

The System Overview course shall be planned to serve two purposes:

1. It shall constitute an introductory class for the Purchaser’s personnel who are designated to attend specific courses and workshops later. As a minimum, it shall provide a general understanding of all aspects of the Contractor’s SCADA/EMS.
2. It shall familiarize managerial personnel with the capabilities, configuration, operation, and maintenance of the system, and provide them with an overview of the system development process and the Purchaser resources as required to implement and maintain the System.

The Contractor shall separate the class into 2 (two) sessions, one for the Purchaser’s Technical Support Group and the other for the Purchaser’s Executives.
17.8.1.1 SYSTEM OVERVIEW FOR TECHNICAL SUPPORT GROUP

The System Overview shall be the first class in the knowledge transfer sequence. The course shall constitute an introductory course for Purchaser’s personnel who typically will participate in the project as members of the project team or as managers with a special interest in the project. Most of the attendees will also attend subsequent Contractor courses and workshops. Thus, the System Overview for Technical Support Group shall present not only a general overview of the project, but also details related to understanding the SCADA/EMS architecture, its functions and technology, the project schedule and its various phases, how the project will be implemented, and the role to be played by the Purchaser’s personnel.

17.8.1.2 SYSTEM OVERVIEW FOR EXECUTIVES

The System Overview for Executives shall be scheduled after Contract Award. The course shall provide ample opportunity for free interchange between the Contractor and Purchaser’s personnel. Many of the attendees will include managers concerned with system operations. Thus, the course shall provide a high-level overview of the SCADA/EMS functions and technology with particular emphasis on the project’s objectives, the results to be achieved, and how the SCADA/EMS should be operated and managed.

17.8.2 Database, Display, and Reports Building

This course shall be designed for people without programming skills, and shall show them how to prepare and maintain the system database, displays, and reports. This course shall show Purchaser staff the mechanics of using all relevant tools provided with the System.

This course shall be provided early in the project, i.e., in time to enable the Purchaser to fulfill its obligations for supporting the preparation of database, displays, and reports for integration by the Contractor into the system. This class will be held at the Purchaser’s site and shall focus on hands-on activities during which the participants shall start the development of database, displays, and reports for the SCADA/EMS. After completing this class, the attendees shall be able to use the Contractor-supplied PDS (see Section 2.3.3.6 Early Delivery of the PDS Environment) for verify the Contractor’s database conversions and displays for which the Contractor is responsible.
The course shall be scheduled to coincide with the delivery of the Quality Assurance System (QAS) and Program Development System (PDS). The course shall teach Purchaser staff how to prepare the input data to define the SCADA/EMS operating environment, and build the SCADA/EMS database and displays. It shall also prepare the database administrator to maintain and modify the database and its structure. The course shall include classroom instruction reinforced by the appropriate configuration workshops (refer to Section 17.4 Knowledge Transfer Workshops) making full use of the Quality Assurance System and Program Development System facilities.

Typical topics to be covered shall include:

1. How to set up a SCADA/EMS database and display building environment.
2. How to identify database fields, entries, records, tables, and contexts.
3. How to structure data source table definitions.
4. How to build tables and arrays.
5. How to build application models, such as Network Analysis and OTS models.
6. How to verify power system network model connectivity.
7. How to interpret validation errors.
8. How to build and link displays.
9. How to use macros, pictures, symbols, templates, etc. to build displays efficiently.
10. How to use visualization techniques for highlighting abnormal power system conditions.
11. How to perform database maintenance.
12. How to generate the database from source materials including data imported from the Purchaser’s data.
13. How to prepare data to be sent to/received from other computer systems.
14. How to maintain symbol libraries and other display constructs.
15. How to autogenerate displays from the database model.
16. How to use the graphical model editor.
17. How to develop calculations that are model driven.
18. How to build reports.
17.8.3 Data Engineering Workshops

The objectives of these workshops are to bridge the gap between the formal courses on the mechanics of database and display building and understanding practical design and conceptual issues. The workshops shall discuss any database configuration needs to support display design and build in the best way to facilitate the maintenance of the displays by Purchaser staff. Scheduled after the database and display building courses, they shall utilize the Purchaser’s actual data, displays, and models along with the PDS to ensure that the Purchaser is properly engaged in database and display building activities.

Topics to be covered in the data engineering workshops include the following:

1. The most effective and expeditious way to input the data from the existing system to the new system:
   1.1. Mapping between data in the existing system to the new system.
   1.2. The identification of data that is not in the existing system that needs to be collected for input to the new system.
   1.3. Procedures to transmit data between the PDS or QAS and the system staged on the factory floor.
2. Display building design issues
3. Discussion of application-specific modeling techniques.
4. Discussions of the different approaches to storing and retrieving historical data.
5. Development of a program for data and display development activities.

Separate workshop sessions shall be conducted for the following major topics:

6. SCADA database generation and conversion.
7. Information Management database development.
8. Display design and prototyping.

17.8.4 Calculations Course

This course shall teach the participants how to use the tools to define and implement different types of simple and complex calculations.
17.8.5 System Level Course on Computing Equipment

This course for the computing equipment shall give the Purchaser’s hardware personnel sufficient knowledge of the overall design, configuration, and operation of the system to be able to identify all System components, correct obvious problems, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. This course shall include procedures on system expansion and upgrading techniques and procedures to add equipment such as servers, workstations, network equipment and screens, and communication channels, and to replace old equipment.

17.8.6 System Administration

The system administration course shall familiarize participants with the procedures necessary to operate the system as an integrated entity, to recognize and respond to malfunctions, and to perform maintenance functions. The only prerequisite for this course shall be familiarity with the overall functionality and architecture of the System.

This system administration shall consist of several components to ensure that Purchaser’s personnel, as software engineers, are able to perform all system administration tasks. These components are described in the following sub-sections.

17.8.6.1 ADMINISTRATION AT SYSTEM LEVEL

This component of the system administration course shall familiarize the participants with the procedures necessary to operate the system as an integrated entity, to recognize and respond to system malfunctions, and to perform system level maintenance functions. At the end of this course, participants shall be able to:

1. Start up the System and its components.
2. Shut down the System and its components.
3. Switch functions to backup equipment.
4. Take equipment out of service.
5. Restore equipment to service.
6. Interpret and react to messages generated by error-monitoring functions.
7. Test field device and communication links.
8. Implement procedures for installing new or modified applications for operations use.
9. Use procedures for altering and replacing the operations database.
10. Identify procedures for using diagnostics.
11. Describe the backup functions required for normal maintenance.
12. Use the system’s procedures to generate the System from source code or distribution media.

**17.8.6.2 ADMINISTRATION AT OPERATING SYSTEM LEVEL**

This component of the system administration course shall prepare the participants to manage and maintain the SCADA/EMS at the operating system level so that, as a minimum, the participant shall be able to:

1. Manage and maintain the system administration database and files.
3. Shutdown and restart the SCADA/EMS from different media, such as disk, tape, CD-ROM, and over the network.
4. Backup and restore all programs and data.
5. Add processors and peripherals to the SCADA/EMS.
6. Add users to the SCADA/EMS including Active Directory design, configuration, and administration.
7. Update the operating system software.
8. Access Contractor and subcontractor system level programming interfaces to facilitate the development of software by the Purchaser.

**17.8.7 Application Software**

The application software course shall be provided on the SCADA, Network Analysis, Information Storage and Retrieval System, and all other application software such as the OTS software. The software courses shall include:

1. **Overview** - Block diagram of the application software and data flows and the associated programming standards and program interface conventions.
2. **Application Functions** - Functional capabilities, design, and major algorithms including maintenance and expansion techniques.
3. **Software Development** - Techniques and conventions to be used for the preparation and integration of new software functions.

4. **Software Generation** - Generation of the applications software from source and setting of performance and sizing parameters for the applications functions.

5. **Software Documentation** - Orientation in organization and use of the Contractor’s functional and detailed design documentation and the corresponding programmer and user manuals.

Each application course shall be organized to be responsive to the Purchaser’s specific requirements and shall be regarded as an extension to the standard courses that are provided. Each course shall cover the following topics:

6. Functional design of the specific application program (using the approved functional specification and hard-copies of all associated displays).

7. Algorithms and models used by the application program.

8. Programming techniques for the algorithms.

9. Software implementation aspects, including each module’s calling parameters and its interfaces with other modules as determined by these parameters and the data flags described.

10. Database implementation aspects, including those portions of the database used by an application relative to content, structure, meaning, origin, and usage.

11. Application program command language structure and common techniques.

12. Application program procedures, including a review of standard procedures used to modify source code and compile, load, and install programs.

### 17.8.8 Communications Software

The Contractor shall provide a course on the communications among data sources, the communications software used for the System local and wide area networks, and the interfaces or communications links (e.g., ICCP links) with external subsystems and networks. The course shall include Contractor and subcontractor-supplied communications software and products.

At the end of this course, participants shall be able to:

1. Understand the basic communications theory behind all communications software used by the System.
2. Understand the communications software from design and implementation perspectives.
3. Understand the protocol implementation.
4. Install, startup, and test the initial configuration.
5. Expand the communications.
6. Perform diagnostic and maintenance procedures.
7. Install communication software upgrades.

17.8.9 System Software

A system software course shall provide detailed instruction on the generation, configuration, tuning, and diagnostic features of the SCADA/EMS software, including third-party software. This course shall include the activities required to perform a complete generation of the SCADA/EMS software. The activities that relate to a partial system regeneration shall be included.

The course shall be designed to meet the following goals:

1. Demonstration of all tools and procedures applicable to System builds.
2. Demonstration that a full system build is possible using only the delivered software libraries, tools, and procedures.
3. Verification that the Purchaser’s staff has the skills necessary for complete and partial System builds without assistance by the Contractor.

17.8.10 Programming in System Environment

The Contractor shall instruct Purchaser staff on the skills needed to program in the System software environment. This course shall be designed for Purchaser staff responsible for maintaining, expanding, or adding new functions. At the end of this course, the participant shall be able to:

1. Plan the implementation of a new software function.
2. Describe the directory structure and locate applications and all supporting functions and software structures.
3. Design and implement program data structures.
4. Add new attributes to existing data structures.
5. Write and test programs.
6. Use Contractor and subcontractor-provided programming interfaces.
7. Configure the failover and restart functions for Contractor and Purchaser-provided software.
8. Generate error messages.
9. Use the trace and debug utilities.
10. Extract code and check code using the source code utility.
11. Describe the inter-program communication processes.

17.8.11 Information Storage and Retrieval System and Reports

This course shall provide instruction on the preparation and maintenance of the SCADA/EMS historical databases, historical data displays, Web displays, and reports. The course shall ensure that the Purchaser’s personnel are proficient in the use of the tools provided by the Contractor for this purpose.

The course shall include the development of historical databases based on such activities as defining points for historical storage, using techniques for gaining access to the historical databases and retrieving data, and creating and using historical data displays and reports even though these activities initially are the responsibility of the Contractor.

As a minimum, the participants at the end of the course shall be able to:

1. Create and maintain the historical databases.
2. Understand SQL features and functions.
3. Construct SQL queries to retrieve, sort, summarize, and change data.
4. Develop strategies for writing efficient applications.
5. Define and develop interfaces to systems such as the Historical IS&R processor.
6. Understand how to create and maintain reports using the SCADA/EMS facilities.

17.8.12 Courses for Operators and Users

These courses shall be designed for users of the System such as operators and OTS instructors. The Operator course shall be conducted at the Purchaser’s site immediately after the Site Acceptance Test is completed. The OTS Instructor course shall be conducted earlier since the Purchaser requires the OTS to be delivered in advance of the on-line System.
17.8.12.1 **OPERATOR COURSE**

This course shall include hands-on activities using the OTS. Otherwise, it shall consist of three parts as follows:

1. **Basic Procedures and SCADA Functions** – Teach participants on the user interface features and procedures followed by operation of the SCADA functions.
2. **Power System Operation Functions** – Teach participants on the use of the Network Analysis applications. A sequence of courses such as one course for each application shall be provided.

17.8.12.2 **OTS INSTRUCTOR COURSE**

This course shall include activities and procedures on the construction of OTS training scenarios and on conducting OTS sessions.

17.9 **Training and Knowledge Transfer Budget**

The Purchaser expects that the courses to be taken and the number of participants attending each course will change over the course of the Contract. The Purchaser expects that the training courses and knowledge transfer workshops will be conducted on-site at Purchaser locations. Therefore, the total cost for all training and knowledge transfer included in this Contract shall be considered as an allocation, and the Purchaser, in consultation with the Contractor, will revise the training and knowledge transfer activities including the number of workshops and courses as well as the participants at each course and workshop. Any assumptions regarding the cost of the training and knowledge transfer program shall be clearly identified in the proposal so that the changes to the training and knowledge transfer program can be accounted for correctly. The Contractor shall provide the per course cost to conduct the courses at the Purchaser’s site. The per-workshop cost to conduct each workshop at the Purchaser’s site shall be provided. Any remaining funds left in the training and knowledge transfer allocation shall be carried forward for Purchaser use in the warranty and post-warranty period.

17.10 **No Additional Charges**

Payment for any additional courses and workshops conducted beyond the courses and workshops defined in the proposal shall be the responsibility of the Purchaser. The Contractor, however,
shall be responsible for the cost of any additional courses that participants may need to take because of the following conditions:

1. Inadequate or poor quality courses that fail to meet the Purchaser’s requirements for quality, content, or timeliness.
2. Contractor changes to any hardware or software deemed necessary during the project to meet the requirements of this Contract.
3. Any major change in the scope of this Contract, unless the cost of the additional courses is included in the cost of the change.
### Exhibit 17-1: Staff Roles

<table>
<thead>
<tr>
<th>Item</th>
<th>Role</th>
<th>Number of Staff in Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Executive</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Operator</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>System Administrator</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Cybersecurity (and NERC CIP) personnel</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Software Engineer</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Power Network Applications Engineer</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>SCADA Engineer and Communication Technician</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Database Administrator</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Display Builder</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>OTS Instructor</td>
<td>2</td>
</tr>
</tbody>
</table>
# 18 SCADA/EMS PROJECT MILESTONE PAYMENT SCHEDULE

<table>
<thead>
<tr>
<th>Payment Milestone</th>
<th>Milestone Deliverables</th>
<th>Completion Date (Months ARO)</th>
<th>% of Total Cost</th>
</tr>
</thead>
</table>
| 1                 | **EMS Vendor kick-off + Finalize SOW**  
  - Completion of Statement of Work (SOW) and agreement on all contract prices – Project Start  
  - List of Software Deliverables – Approved  
  - Recommended List of Hardware Deliverables - Approved  
  - Configuration Drawings – Approved  
  - Detailed Project Schedule – Approved  
  - Conduct early training courses at Contractor site identified in the SOW immediately after award including all system administration and database/display generation tools (no later than 8 weeks after contract award) | 2                            | 5%              |
| 2                 | **Operational PDS + Baseline System Overview**  
  - Delivery and Installation of an Operational PDS  
  - Conduct the database engineering workshop #1 at Purchaser’s site regarding the SCADA/RTU database with on-site Contractor staff  
  - Submittal/review/approval of formal training schedule  
  - Delivery of database design documentation on the PDS  
  - Submittal of the Documentation Plan  
  - Submittal of baseline System Overview Document | 3                            | 10%             |
| 3                 | **Finalize Hardware + Custom Software Design (if any)**  
  - Submittal and approval of the software requirements specifications for custom designs  
  - Approval of the Documentation Plan  
  - Conducting Data Engineering Workshops #2 regarding display/report generation activities with on-site Contractor staff  
  - Recommended Hardware LOD reviewed and finalized  
  - Demonstration that the Contractor’s SCADA/EMS solution is compatible with both the Nutanix and CISCO ACI products | 5                            | 5%              |
| 4                 | **Onsite and Factory Test Hardware staged + Knowledge Transfer/Training**  
  - Submittal and approval of preliminary draft of all pertinent environmental specifications  
  - Approval of custom feature designs (Software Functional Design Documents)  
  - Submittal of Purchaser-specific System Overview Document | 7                            | 10%             |
<table>
<thead>
<tr>
<th>Payment Milestone</th>
<th>Milestone Deliverables</th>
<th>Completion Date (Months ARO)</th>
<th>% of Total Cost</th>
</tr>
</thead>
</table>
| 5                 |  ▪ All knowledge transfer workshops completed as defined in the Training and Knowledge Transfer plan  
▪ Factory system hardware staged at Contractor’s facility  
▪ Production and backup system hardware installed at Purchaser’s facility  
▪ Installation of Standard Baseline System  
  ▪ Complete installation of all Contractor standard baseline system and application software as well as converted database and displays within the on-site PDS, OTS, and QAS  
  ▪ Submittal of:  
    – All on site factory test plans & procedures  
    – Draft Operator’s User’s Manual  | 10 | 10% |
| 6                 |  ▪ Test Plans  
  ▪ Approval of:  
    – All factory test plans and procedures  
    – Site Preparation Plan  
    – Operator’s User’s Manual  | 13 | 5% |
| 7                 |  ▪ Pre-FAT Acceptance Testing  
  ▪ Successful completion of Pre-FAT evidenced by:  
    – Completely signed-off test procedures  
    – Resolution of Pre-FAT variances to Purchaser’s satisfaction  | 15 | 5% |
| 8                 |  ▪ FAT Acceptance  
  ▪ Successful completion of FAT and resolution of all variances to Purchaser’s satisfaction  
  ▪ Resolution of FAT variances to Purchaser’s satisfaction  | 19 | 10% |
| 9                 |  ▪ SAT Acceptance Testing  
  ▪ Successful completion of the SAT  | 23 | 5% |
| 10                |  ▪ Parallel Operations  
  ▪ Parallel Operations Completed  
  ▪ All final documentation delivered  
  ▪ Power Network Applications Tuning complete  
  ▪ All System Tuning complete  
  ▪ System is ready for operation  | 27 | 5% |
| 11                |  ▪ Cutover to new EMS  
  ▪ Successful cutover completed  | 30 | 10% |
| 12                |  ▪ Availability Test  
  ▪ Availability Test completed successfully  | 32 | 5% |
<table>
<thead>
<tr>
<th>Payment Milestone</th>
<th>Milestone Deliverables</th>
<th>Completion Date (Months ARO)</th>
<th>% of Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 Retainage</td>
<td>- Final Acceptance/ Warranty Period Completed</td>
<td>44</td>
<td>15%</td>
</tr>
</tbody>
</table>
Advanced Distribution Management System (ADMS) - Option

19.1 ADMS Architecture

19.1.1 Stand-alone ADMS

19.1.2 Integrated EMS/ADMS

19.1.3 Substation Equipment

19.1.4 Remote Field Devices and Communication

19.1.5 Critical and Non-Critical Functions

19.1.5.1 Critical Functions

19.1.5.2 Non-Critical Functions

19.2 ADMS Data Conversion

19.3 Database & Display Construction

19.3.1 Distribution Network Model

19.3.1.1 Distribution System Operations Model (DSOM)

19.3.1.2 Dynamic Power System Model

19.3.1.3 Distribution Planning Applications

19.3.1.4 Displays That Represent the Distribution Network State

19.3.1.5 Tools that serve to create and maintain the model and displays

19.4 ADMS User Interface

19.4.1 Distribution Network Displays

19.4.2 Purchaser-Provided Displays

19.4.3 Contractor-Provided Displays

19.4.3.1 Distribution Displays

19.4.3.2 Tabular Displays

19.4.3.3 ADMS Schematic Auto-Generation Functionality

19.5 ADMS SCADA

Austin Energy SCADA Replacement 0500-Scope of Work
Proprietary © Austin Energy 2017 – All Rights Reserved
19.5.1 Operations Device Monitoring ................................................................. 509

19.6 Distribution Management System (DMS) ......................................................... 510

19.6.1 Operating Modes and Execution Modes ..................................................... 511

19.6.2 Network Topology .................................................................................... 513

19.6.2.1 Cuts, Jumpers and Grounds ................................................................. 514

19.6.2.2 Feeder Tracing ..................................................................................... 515

19.6.2.3 Feeder Focus ....................................................................................... 517

19.6.3 Distribution Load Forecast ....................................................................... 517

19.6.4 Load Shedding and Restoration (LSR) ...................................................... 519

19.6.5 Distribution State Estimation (DSE) .......................................................... 519

19.6.6 Distribution Unbalanced Power Flow (DPF) ............................................. 520

19.6.6.1 Required Characteristics ..................................................................... 522

19.6.6.2 User Input .......................................................................................... 524

19.6.6.3 Results ............................................................................................... 525

19.6.7 Pre-Switching Validation (PSV) ................................................................. 526

19.6.8 Optimal Feeder Reconfiguration (OFR) .................................................... 528

19.6.9 Fault Level Analysis (FLA) ....................................................................... 530

19.6.10 Distribution Circuit Fault Location (DCFL) ............................................. 530

19.6.11 Safety Tagging ....................................................................................... 532

19.6.11.1 Safety Tag Application ....................................................................... 532

19.6.12 Fault Location, Isolation and Service Restoration (FLISR) ...................... 533

19.6.13 Location of Open Conductor Faults ........................................................ 539

19.6.14 Location of Downed Conductors ............................................................ 539

19.6.15 Model-based Integrated Volt/Var Control (IVVC) ..................................... 540

19.6.16 Rule-based IVVC .................................................................................... 542
19.6.17 Closed Loop Readiness ................................................................. 543
19.6.18 Protection Coordination ................................................................. 543
19.6.19 Under-Load Switching ................................................................. 543
19.6.20 Energy Losses (EL) ................................................................. 544
19.6.21 Large Area Restoration (LAR) .................................................. 545
19.6.22 Operational Losses (OL) ............................................................. 545
19.6.23 Distributed Energy Resource Management ............................... 546
19.6.24 Phase Balancing ................................................................. 547
19.6.25 DMS User Interface ................................................................. 548
  19.6.25.1 General Functionality ............................................................. 548
19.6.26 DMS Study Mode ................................................................. 551
  19.6.26.1 Study Analysis Execution Mode ......................................... 551
  19.6.26.2 Study Working Areas .......................................................... 552
  19.6.26.3 SaveCases ........................................................................ 553
19.7 Switching Management System (SMS) ............................................. 554
  19.7.1 Switching Order Management .................................................. 554
  19.7.2 Switching Order Life Cycle ....................................................... 555
  19.7.3 Content of a Switching Order ................................................... 556
  19.7.4 Manual Preparation of Switching Orders ................................. 560
  19.7.5 Automatic Preparation of Switching Orders – Distribution .......... 561
  19.7.6 Planned Customer Outages – Distribution ............................... 562
  19.7.7 Automatic Generation of Back-out Switching Steps .................... 563
  19.7.8 Management of Switching Orders .......................................... 564
  19.7.9 Switching Order Validation ..................................................... 564
  19.7.10 Automated Validation of Switching Orders .............................. 564
19.7.11 Switching Order Execution ................................................................. 565
19.7.12 SMS User Interface .............................................................................. 566
19.8 Outage Management System (OMS) ........................................................... 566
19.8.1 General ................................................................................................ 566
19.8.2 Incident Creation .................................................................................. 568
19.8.3 Incident Life-Cycle ............................................................................... 569
19.8.4 OMS Key Components ........................................................................ 572
   19.8.4.1 Incident management .................................................................... 573
   19.8.4.2 Outage Notification Management ................................................ 587
   19.8.4.3 Outage Grouping and Analysis ..................................................... 590
   19.8.4.4 Estimated Time of Restoration (ETR) ............................................ 592
19.8.5 Planned Outages .................................................................................. 593
19.8.6 Customer Information ........................................................................ 593
19.8.7 Customer Browser ............................................................................... 594
19.8.8 Reports ................................................................................................ 595
19.8.9 Performance Indices ......................................................................... 596
19.8.10 Crew Management ........................................................................... 597
    19.8.10.1 Crew Definition ........................................................................ 598
    19.8.10.2 Operation of Crews .................................................................... 599
    19.8.10.3 Hours tracking ........................................................................... 602
    19.8.10.4 Crew Statistics .......................................................................... 602
19.8.11 OMS User Interface Requirements .................................................... 602
    19.8.11.1 Information related to a device .................................................. 603
    19.8.11.2 Information related to a customer .............................................. 603
19.8.12 Field Client ....................................................................................... 604
19.8.13 Automatic Vehicle Location ................................................................. 607

19.9 Distribution Operator Training Simulator (DOTS) ........................................ 608

19.9.1 OMS Simulator ....................................................................................... 609

19.9.1.1 Call initiation .......................................................................................... 610

19.9.1.2 Call Creation ........................................................................................... 610

19.9.2 Control System Simulator ............................................................................ 610

19.9.3 Scenario Builder .......................................................................................... 611

19.9.4 DOTS Execution Management ................................................................... 614

19.9.5 Distribution System Simulator .................................................................... 614

19.9.6 The Operator Training Simulator model ..................................................... 615

19.9.6.1 Customer Calls Associations ................................................................. 616

19.9.6.2 SCADA Telemetry Model ...................................................................... 616

19.9.6.3 Relay and Field Logic Modeling ............................................................... 617

19.9.6.4 Load Allocation Modeling ...................................................................... 618

19.9.6.5 The Outage Management Database Model ........................................... 618

19.9.6.6 The ADMS database model. ................................................................. 619

19.9.7 DOTS Synchronization Process ................................................................. 619

19.10 ADMS Interfaces ....................................................................................... 620

19.10.1 Customer Care & Billing (CC&B) ............................................................. 620

19.10.2 Solar Size – manual import ...................................................................... 621

19.10.3 AECall ...................................................................................................... 621

19.10.4 21st Century High Volume Call Application (HVCA). ............................... 622

19.10.5 Automatic Vehicle Locator (AVL) (COA managed) ................................ 622

19.10.6 Advanced Metering Infrastructure (AMI) Real Time Meter Status .......... 622

19.10.7 Load Profile ............................................................................................. 623
19.10.8 GIS interface, including landbase and other layers ............................................. 623
19.10.9 Storm Center ........................................................................................................ 626
19.10.10 Weather Service .............................................................................................. 627
19.10.11 Transmission Outage Application (TOA) ....................................................... 627
19.10.12 Work and Asset Management System (WAMS) (requirement for future use) 627
19.10.13 Other interfaces that are managed by control Engineering: ......................... 628
19.11 ADMS Capacity and Performance ........................................................................... 630
19.11.1 ADMS Sizing ...................................................................................................... 631
19.11.2 ADMS Capacity .............................................................................................. 632
19.11.3 ADMS Performance .......................................................................................... 632
19.11.4 ADMS Activity Scenarios .................................................................................. 633
19.11.4.1 Base Conditions .................................................................................. 633
19.11.4.2 Steady-State Scenario ................................................................................. 634
19.11.4.3 High-Activity Scenario ............................................................................... 636
19.11.4.4 Degraded Operation .................................................................................... 639
19.11.5 Resource Utilization .......................................................................................... 639
19.11.6 User Interface Response ..................................................................................... 639
19.11.6.1 Display Request .......................................................................................... 640
19.11.6.2 User Requests .............................................................................................. 640
19.11.7 Resource Monitoring .......................................................................................... 640
19.12 Information Storage and Retrieval ........................................................................ 644
19.13 System Software .................................................................................................... 644
19.14 ADMS Hardware ................................................................................................... 644
19.15 ADMS Knowledge Transfer and Training ............................................................ 645
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.16</td>
<td>ADMS Documentation</td>
<td>645</td>
</tr>
<tr>
<td>19.17</td>
<td>ADMS System Security</td>
<td>646</td>
</tr>
<tr>
<td>19.18</td>
<td>Quality Assurance and System Testing</td>
<td>646</td>
</tr>
<tr>
<td>19.19</td>
<td>ADMS Project Implementation</td>
<td>647</td>
</tr>
<tr>
<td>19.20</td>
<td>ADMS Maintenance, Support, and Upgrade Program</td>
<td>648</td>
</tr>
<tr>
<td>19.21</td>
<td>ADMS PROJECT MILESTONE PAYMENT SCHEDULE</td>
<td>649</td>
</tr>
</tbody>
</table>
19 ADVANCED DISTRIBUTION MANAGEMENT SYSTEM (ADMS) - OPTION

1. As an option, the Contractor shall propose Advanced Distribution Management System (ADMS) functionality that includes SCADA, Distribution Management System (DMS) functionality, Switching Order Management System functionality (SMS), and Outage Management System (OMS) functionality in a single integrated platform.

2. ADMS shall be bid in two ways, 1) as a stand-alone ADMS and 2) with the ADMS functionality integrated within the EMS system.

19.1 ADMS Architecture

19.1.1 Stand-alone ADMS

1. For the stand-alone ADMS, the architecture and behavior of the ADMS shall be as similar to the EMS as possible.

2. It shall follow the Architectural Principals, System Configuration, Redundancy, Availability, etc. requirements described in Section 2 System Requirements and Architecture. For example, there shall be a Production ADMS, an ADMS QAS, an ADMS PDS, an ADMS DOTS – and some components shall be available at both the primary and backup sites while others are installed at only one site.

3. The level of redundancy of the ADMS components shall be equivalent to the level of redundancy of EMS components to meet the availability requirements in Section 2 System Requirements and Architecture.

4. Failover within a site and switchover between sites shall work the same as for the EMS (requiring no post-switchover verification by the user).

5. The availability (reliability) requirements of the ADMS shall be the same as for the EMS.

6. The communications network shall be equivalent to that of the EMS LAN.

7. The ADMS communicates with RTUs at substations over an IP network similar to the one used by the EMS, using DNP/IP.

8. The ADMS shall have its own historian and shall leverage Austin Energy’s existing OSIsoft PI historian for storage of real-time data (analog, status, and calculated data).

9. The ADMS shall have its own Data Acquisition and ICCP front-end servers.
10. The interfaces to other Austin Energy applications are described in Section 19.10 ADMS Interfaces.

11. Cyber and user security shall be equivalent to that of the EMS.

12. Remote maintenance access shall be equivalent to that for the EMS.

13. The Contractor shall provide Purchaser with proposed diagrams and List of Deliverables (LOD) for the architecture necessary to satisfy the requirements described.

14. The overall ADMS architecture must be flexible and scalable to support the future migration of the system hardware and software. The ADMS component architectures shall be expandable to support new application software as Purchaser’s functional requirements evolve and to support future expansion.

### 19.1.2 Integrated EMS/ADMS

1. For the case where the ADMS functionality is delivered integrated within the EMS system, the overall architecture shall be NERC CIP compliant but shall minimize the number of servers within the Electronic Security Perimeter (ESP). ADMS servers/clients shall be added to the EMS architecture in a manner that does not unnecessarily pull components that are not required to be under NERC CIP into the ESP. The Contractor shall ensure that any issues related to the ADMS do not have an impact on the SCADA/EMS functionality.

2. The interfaces to other Austin Energy applications are described in Section 19.10 ADMS Interfaces.

### 19.1.3 Substation Equipment

1. AE has 80 distribution substations with approximately 500 feeders (including spare and dedicated feeds).

2. Many of the feeder breakers have solid-state relays that support fault magnitude measurements and analogs per phase.

### 19.1.4 Remote Field Devices and Communication

1. AE currently has 250 DA devices including 40 remotely controlled gang operated air-switches, 150 remotely controlled capacitor banks, 24 remotely controlled reclosers, some distribution switchgear and some fault indicators.
2. The DA field devices communicate using the Landis+Gyr mesh radio network, cellular radios and fiber connections – using DNP3 for all communications.

3. The L+G mesh radio network uses a proprietary protocol and interfaces with the Intelligent Communication Gateway (ICG) product by DC Systems hosted locally on AE servers.

4. The OMS/DMS will poll the ICG using standard DNP3 for all DA device communication and control.

19.1.5 Critical and Non-Critical Functions

1. All ADMS functions shall be considered Critical unless explicitly shown as Non-Critical in Section 19.1.5.2 Non-Critical Functions.

2. Critical functions shall explicitly include those listed in the following Section 19.1.5.1 Critical Functions.

19.1.5.1 CRITICAL FUNCTIONS

1. Critical functions are defined as functions that shall not be lost as the result of any single failure. Component systems within the Production Environment and Distribution Operator Training Simulator environment will meet this requirement in addition to the requirements in Section 2 System Requirements and Architecture. Thus, functions running on critical component systems are also critical. Within this context, the following ADMS functions are explicitly defined as Critical:

1.1. Data acquisition and supervisory control via RTUs

1.2. Data exchange between the ADMS systems at the Primary and Backup control centers

1.3. Data exchange including ICCP with EMS

1.4. Pushing network model changes into the real-time model

1.5. Processing of acquired data (including alarming, refreshing displays, updating the database, calculations, etc.)

1.6. All real-time and study DMS Applications (Section 19.6 Distribution Management System (DMS))

1.7. All Switching Order functionality (Section 19.7 Switching Management System (SMS))
1.8. All Outage Management functionality (Section 19.8 Outage Management System (OMS))

1.9. User interface functions

1.10. Interfaces to other Purchaser applications (e.g. AECall, MDMS, etc.)

1.11. Historical data processing

1.12. System failover and system restart without loss of any data

1.13. Transmission and monitoring of exchange of heartbeat signal with the other ADMS

1.14. System configuration control

1.15. On-line diagnostics

1.16. Information Storage and Retrieval

19.1.5.2 NON-CRITICAL FUNCTIONS

1. The following major SCADA/EMS functions are defined as Non-Critical, in that automatic failover is not required to keep them available. It is acceptable to require manual switching or reassignment of processing resources to make them available for use.

1.1. Access to on-line documentation (except for the Help function)

1.2. Database, display, and report generation and maintenance

1.3. Software development.

1.4. Model Management System

1.4.1. Other than pushing changes into real-time

19.2 ADMS Data Conversion

1. Whether the ADMS is delivered as a stand-alone system or integrated within the EMS, the Contractor shall be responsible for loading the following existing data into the system:

1.1. SCADA parameters – the Contractor shall load the SCADA parameters from Purchaser’s current ADMS, will be supplied in a mutually agreed format.

1.2. Distribution System Model – the Contractor shall load the Purchaser circuit information from Purchaser’s Smallworld GIS database. Other data sources may include engineering planning tools such as Milsoft and/or ABB FeederAll.

1.3. Distribution Equipment Parameters
1.4. Historical Switching Orders

1.5. Historical outage information – Purchaser operates an existing outage management system. The outage information on this system must be remapped and loaded in the ADMS archive database. Once imported, the historical database must allow editing of operations in history, perform replication of the historical database and product Calls historical reports.

2. The conversion tools shall include features to facilitate the conversion of similar, but not identical attributes, and to generate default attributes for items not found in the existing databases.

19.3 Database & Display Construction

1. To the extent possible, the database and display maintenance tools shall be the same for EMS and ADMS, especially in the case of an integrated EMS/ADMS.

2. The Contractor shall provide a database and display development environment on the Production, QAS, and PDS systems.

3. The development environment shall be able to manage the database and display construction and maintenance work required to support the ADMS and shall satisfy the performance requirements of Exhibit 19-5: User Interface Response of Section 19.11 ADMS Capacity and Performance

19.3.1 Distribution Network Model

The Distribution Network Model shall include the following:

1. A Distribution System Operations Model (DSOM) which represents the as-connected state of the Purchaser power system, i.e., the system that falls within the area of jurisdiction of the DMS

2. A Dynamic Power System Model, which includes dynamic network information

3. Displays that represent the Distribution Network state

4. Tools that serve to create and maintain the model and displays.

19.3.1.1 DISTRIBUTION SYSTEM OPERATIONS MODEL (DSOM)

1. The DSOM shall include the following capabilities and features:
1.1. Models of electrically connected elements of the Purchaser MV distribution network. These models shall extend from the HV interconnections that supply the network’s MV feeders, to the MV feeders themselves, and to the MV loads that are fed by the MV feeders. Otherwise, considering the MV/LV distribution transformers and their associated LV loads, the Purchaser’s initial intent is to model these in the form of MV equivalent loads only.

1.2. Modeling information for electrical devices and loads. This shall include the ability to represent power system elements such as generators, substation buses, on-load tap changing transformers, reactors, breakers, reclosers, overhead lines, underground cables, voltage regulators, Var controllers, load break switches, fuses, switched capacitor banks, distribution transformers, loads (with parameterized voltage dependencies), and automatic transfer switches. Generation modeling shall take unit capability curves into consideration.

1.3. To support fault level calculations, the model shall include positive, negative, and zero sequence impedances of the network elements.

1.4. Meshed and radial power system configurations: The Purchaser shall provide impedance and admittance parameters, either directly or else line configuration detailed information such as conductor spacing and type, line length, and ground resistivity.

1.5. Facility and equipment information such as location and site details, electrical and mechanical design parameters, photographs, contact replacement indices, operating instructions, and maintenance procedures. This information shall be made available by equipment point and click operations on relevant displays and presentation of a drop-down menu allowing the operator to select the information of interest.

1.6. Substation electric equipment parameters (such as source impedance or relay protection parameters) – imported from Excel, or copy-paste from Excel into a table view, to populate the device parameters

1.7. SCADA parameters – imported from Excel, or copy-paste from Excel into a table view, to populate the SCADA parameters

1.8. Historical feeder values in Load Forecast – imported via a Feeder Head Data (FHD) Import Tool
2. By default, the DSOM shall be identical in real-time mode and any of the various study sessions in operation on the Production site. However, the capability shall be provided to retrieve into a study session a historical snapshot; in that case, the DSOM shall be that which was in effect at the time that the historical snapshot was taken.

19.3.1.2 DYNAMIC POWER SYSTEM MODEL

1. The dynamic power system model shall be an extension of DSOM that includes dynamic network information and supports the execution of DMS applications. The Dynamic Power System Model shall include the following capabilities and features:

   1.1. Operations data such as feeder and device status indications, associated statistics, tags, quality codes, alarms, set points, power flows, voltages, currents, transformer tap positions, and outage locations. System shall provide alarms for hazards and large outages.

   1.2. Dynamic Power System Model data may be SCADA-sourced, manually entered, received from an external source or calculated by the DMS applications.

   1.3. Models of temporary jumpers, grounds, cuts, and generators. The feature shall support single-phase as well as three-phase changes, and all such changes shall be made without the need for a formal editing session to modify the DMS database. Phase-to-phase jumpers that link different phases (e.g. Phase A of Feeder X to Phase B of Feeder Y) shall be supported.

2. The dynamic power system model shall be able to vary from real-time mode to any of the various study sessions.

3. All DMS applications which analyze the network shall analyze the dynamic power system model unless specified otherwise.

19.3.1.3 DISTRIBUTION PLANNING APPLICATIONS

1. The following applications shall be executable from within the Network Model / Database Editor. The intent is to replace the FeederAll and Milsoft applications Purchaser uses for distribution planning with these applications.
2. The functionality associated with Study Mode shall be available within this environment, with the added capability of modifying the connectivity model (i.e. adding/removing devices from the network).

3. At a minimum, Power Flow and Transient Stability Analysis applications shall be executable within this environment.

4. If a user has made edits to the model/database, the model/database used by the application will be their edited version (i.e. their changes superimposed on the master model/database).

4.1. Optimal Capacitor Placement

4.1.1. The ADMS shall include a study mode Optimal Capacitor Placement application that shall be used for planning network development and simulation studies. The user shall be able to define placement options (e.g. number of capacitors available to be added to the feeder) and perform a request to execute the optimal capacitor placement analysis. Upon completion, the user shall be able to view the results, apply the suggested capacitor placement, and continue to analyze or further optimize network state. The OCP application shall have two modes of execution:

4.1.1.1. Calculation mode – application’s proposal of locations for placement

4.1.1.2. Manual mode – analysis of user selected locations for placement

4.1.2. In the calculation mode, OCP shall search for the best locations for capacitors on the selected network considering the defined objectives and constraints, listed below:

4.1.2.1. Objectives:

4.1.2.1.1. Minimize voltage deviation

4.1.2.1.2. Improve Power Factor

4.1.2.1.3. Minimize active power losses

4.1.2.2. Constraints:
4.1.2.2.1. Overloads
4.1.2.2.2. Voltage
4.1.2.2.3. Power Factor at Feeder Head
4.1.2.2.4. Voltage Imbalance at user defined location
   (e.g. Feeder Heads, Cap Banks, Voltage Regulators)

4.1.3. In manual mode, the user selects the location of the capacitor placement and
the application analyzes the benefits. In automatic mode, the application
determines the optimal placement of the capacitor(s) and analyzes the
benefits. In both modes, the benefits shall be presented in a report that
shows final, initial, benefit, and benefit percentage for the performance
indices listed below:

4.1.3.1. Performance Indices

4.1.3.1.1. Injected active power
4.1.3.1.2. Injected reactive power
4.1.3.1.3. Power Factor
4.1.3.1.4. Active power losses
4.1.3.1.5. Reactive power generation
4.1.3.1.6. Voltage deviation
4.1.3.1.7. Minimal voltage
4.1.3.1.8. Maximal voltage
4.1.3.1.9. Voltage balance
4.1.3.1.10. Maximal loading

4.2. Optimal Voltage Regulator Placement

4.2.1. The ADMS shall include an Optimal Voltage Regulator Placement (OCP)
function that can be applied on arbitrarily selected parts of the network:
single or several feeders, area of one or more supply substations, etc. The
optimization algorithm shall be based on cost–benefit analysis. The overall
shall include investments, installation and maintenance of capacitor banks, while benefits depend on user’s specified criteria.

4.2.2. These criteria shall include:

4.2.2.1. Reduction of active (MW) power, and
4.2.2.2. Minimization of active power losses.

4.2.3. The OCP application shall optimize costs for the planning period, i.e. it maximizes the savings obtained by the installation of capacitor banks. The DPF application shall provide calculation of network state which presents the basis for OCP optimization.

4.3. Optimal Remote Switching Device Placement

4.3.1. ADMS shall have an application to propose the optimal locations to add remote switching devices for the purposes of gaining the most reliability indices benefit while using FLISR.

4.4. Reconductoring

4.4.1. The ADMS shall have an application that analyzes conductor overloading conditions and makes recommendations on reconductoring for the purpose of load relief.

4.4.2. ADMS shall provide easy to navigate (very few user clicks) functionality for users to perform offline simulation, study reconductoring, and simulation model version transparency (transparent information regarding whether the applied model version is synched with the time stamp of the dynamic data).

4.4.3. Additionally, the user shall have the ability to add new customers and see a report based on their effect on the system.

4.5. Motor Start Studies

4.5.1. The ADMS shall have a study mode Motor Start application. Large motor starts can introduce high currents (several times normal full load current)
lasting for as long as it takes for the motor to get up to normal speed. This can give rise to:

4.5.1.1. Failures to start
4.5.1.2. Unwanted operation of under voltage relays
4.5.1.3. Stalling of other online motors
4.5.1.4. Voltage dips and lighting flicker

4.5.2. Motor starting studies, performed on secondaries, can help determine the best method of starting as well as proper motor and system design to minimize the impact of starting. The application shall support the following types of studies:

4.5.2.1. Cold-start pickup studies - pre-switching studies to ensure there are no overloads prior to restoring load following an outage.
4.5.2.2. Studies of a large motor's starting impedance (if known) in a distribution-circuit power flow study.
4.5.2.3. Flicker - Application shall indicate the amount of voltage flicker that will be seen by adding different sizes of motors.
4.5.2.4. Studies, during large motor starting, if associated feeder breakers have appropriate interrupting capacity in a similar way that a short-circuit analysis would be performed.
4.5.2.5. To check whether the feeder network has the capacity to supply the inrush current when a large motor starts up. The motor’s start up impedance gives rise to a high current, but if an even higher current can be supplied under a much worse loading condition then this is not a problem. In this respect, the worst case occurs if the impedance is zero. Consequently, a short-circuit analysis can be undertaken to find the current that would flow if a three-phase zero impedance fault were to occur on the LV side of the distribution transformer serving the motor. If the owner of
the motor is an industrial customer connected to the MV feeder, then the owner’s transformer has to be modeled.

4.6. Customer Connections

4.6.1. The ADMS shall have a planning mode Customer Connections application.

4.6.2. User shall have the ability to add loads, Distributed Generation (DG), and EV charging stations to the model (primaries and secondaries) for the purposes of analyzing their effects on the distribution network.

4.6.3. When adding the devices, the user shall be able to specify the following:

   4.6.3.1. Number of units of each type
   4.6.3.2. Active phases
   4.6.3.3. Connected active and reactive power

4.6.4. Optionally, the catalog for the generator or the load group for the consumer shall be user specifiable.

19.3.1.4 DISPLAYS THAT REPRESENT THE DISTRIBUTION NETWORK STATE

1. The ADMS shall include three representative network display types as follows (see Section 19.4.3.1 Distribution Displays for more details about network displays):

   1.1. Geographically oriented Distribution Circuit Displays
   1.2. Geo-schematic feeder displays that are geographically relevant, but are not generated to scale for clarified presentation to system operations.
   1.3. Device Internal Views – Auto-generated, on-the-fly within the ADMS user interface, to show the details of a composite device (e.g. a recloser with a bypass switch) – with the “template” configurable by Purchaser (e.g. adding controllable poke points to the device internal view). At a minimum, the internal view templates below shall be supported:

   1.3.1. Internal view for Capacitors
   1.3.2. Internal view for Transformer banks
   1.3.3. Internal view for Reclosers
1.3.4. Internal view for Switching Kiosks
1.3.5. Internal view for Power Plant
1.3.6. Internal view for Voltage Regulator

19.3.1.5 **TOOLS THAT SERVE TO CREATE AND MAINTAIN THE MODEL AND DISPLAYS.**

1. Distribution Network Model Maintenance

   1.1. Database construction refers to the definition of the initial database structure, population of the structure with its initial contents, and revision of the structure when necessary.

   1.2. Database maintenance refers to the subsequent addition of new database contents and the modification of existing contents.

   1.3. The DMS Model Maintenance tools shall support the following:

      1.3.1. Ability to export the distribution network model in IEC CIM 61968 format version 15 from the GIS. The system shall support both full exports and incremental exports. Full exports shall support both the export of the entire network and the export of selected substations and their feeders and export of selected feeders.

      1.3.2. For DSOM device attributes that are not available directly from the GIS but are available from other systems, the Contractor-supplied tools shall be able to import that data from those other systems. Purchaser currently maintains some such data in Excel spreadsheets. Use of the Contractor’s equipment catalog database solution, or if not available, then use of a Distribution Equipment Database (DEQDB) - an Excel workbook, that is exported to CSV for the DEQDB to be used during CIM transformation. Validation checks shall automatically be performed.

      1.3.2.1. The automatic validation shall include a report of the transformation errors. One file will include the errors for all the feeders including circuit ID as a prefix of each line or section.
1.3.3. Ability to import the distribution network model of the feeders (starting from the feeder head-end breaker) in IEC CIM 61968 format version 15 from the GIS. The system shall support both full import and incremental import of the model. The time to perform a full import of Purchaser’s Distribution Network shall not exceed the limits specified in Exhibit 19-5: User Interface Response in Section 19.11 ADMS Capacity and Performance. Purchaser plans to import incremental changes on demand as often as several times per day.

1.3.4. The GIS importer shall be capable of handling PV (solar) devices:

   1.3.4.1. The GIS profile that defines the way GIS data is imported shall include the capability of defining an annual schedule for a solar panel. This would be tied to the solar panel switch device.

   1.3.4.2. The GIS importer, in accordance with GIS profile update, shall create the Load-Break Switch (LBS) and appropriate annual schedule, upstream of the defined distribution generators.

1.3.5. Purchaser shall be able to specify the information to include on each landbase layer (e.g. name, shape file name, type of shape, min and max zoom, outlines and colors, visible attributes and their colors, search attributes, etc.).

1.3.6. Purchaser shall be able to import aerial photography from a third party (ex. Google Maps).

1.3.7. Purchaser shall be able to create additional landbase layers. Polygon outlines are helpful for territory boundaries. Point layers are helpful when bringing in Proposed Installs and Proposed Removed Poles. The additional point layers are to overlay, for example, all the Svc Pt IDs that were out during a storm which would be sourced from the SHP from GIS.

1.3.8. Purchaser requires the following spare layers for their use (in addition to the ~25 layers allocated to the standard geographic display definition):
1.3.8.1. Purchaser_line1 - spare
1.3.8.2. Purchaser_line2 - spare
1.3.8.3. Purchaser_poly1 – spare for Zip Codes
1.3.8.4. Purchaser_poly2 – spare for Council Districts
1.3.8.5. Purchaser_poly3 – spare
1.3.8.6. Purchaser_poly4 – spare
1.3.8.7. Purchaser_poly5 - spare
1.3.8.8. Purchaser_point1 – spare for Zip Codes search
1.3.8.9. Purchaser_point2 – spare for Council Districts search
1.3.8.10. Purchaser_point3 – spare for Proposed Install & Proposed Replace Poles
1.3.8.11. Purchaser_point4 – spare for Proposed Remove Poles
1.3.8.12. Purchaser_point5 – spare
1.3.8.13. Purchaser Service Territory – Polygon unchecked, Line width 3-5
1.3.8.14. Purchaser Dual Service Territory - Polygon unchecked, Line width 3-5
1.3.8.15. Purchaser City Limits - Polygon unchecked, Line width 3-5
1.3.8.16. Poles Proposed Install – Points, a new symbol will be submitted to the Contractor
1.3.8.17. Poles Proposed Remove – Points, a new symbol will be submitted to the Contractor

1.3.9. Contractor will be required to import extracts and determine deltas (inserts, deletes, and updates). User shall be able to export from the changeset database by user specified parameters (e.g. date range, by feeder, by device, etc.).

1.3.10. The user shall have the ability to import daily deltas as determined in the above step.

1.3.11. The user shall have the ability for full feeder import even if it exists in the model. The process will consist of deleting the entire feeder from the model and importing it in its entirety on demand.
1.3.12. The execution time requirements for the import of the entire distribution network model, and for incremental imports, from the GIS shall be as specified in Section 19.11 ADMS Capacity and Performance.

1.3.13. The capability to generate a schematic representation of the Purchaser’s Distribution Network from the geographic representation shall be provided.

1.3.14. The ADMS shall include a single logical repository for all on-line data needed for applications to model the historical, current, and future state of the power system and ADMS- SCADA applications – the Source Database (SDB).

1.3.15. The tools used by the Contractor for the development and maintenance of the Source Database (SDB) shall be delivered with the ADMS.

1.3.16. All information needed to describe the models and database configuration parameters on which the ADMS operates shall be defined once in the centralized, fully integrated SDB and made available to all ADMS applications, real-time database, and user interface maintenance tools that need the information.

1.3.17. The SDB database and display maintenance tools shall support the import of GIS data from Purchaser’s Smallworld GIS into layers of displays as configured by Purchaser (e.g. Purchaser could configure the system to import poles into one layer, which they could name Poles, and import the network connectivity model into another layer named Connectivity).

1.3.18. The SDB, its associated tools, audit logs, and code management systems shall fully support the following four major data database definition components:

   1.3.18.1. Global ADMS Database Parameters
   1.3.18.2. SCADA/ICCP Data Definitions
   1.3.18.3. Network Analysis (NA) Data Model Definitions
   1.3.18.4. Distribution System Operations Model

1.3.19. The SDB shall also include parameters controlling execution of ADMS functions.
1.3.20. Under normal conditions, the SDB shall be maintained on the Quality Assurance System (QAS). From the QAS the user shall be able to selectively export edits to the Production System, the Development System(s), or the Training Simulator. When exporting updates to a given system, the user shall not be required to specify each redundant component of the system (e.g. when exporting from the QAS to Production, all servers at both the Primary and Backup Production sites will be updated). If necessary, an extra step of accepting those changes onto the receiving system and incorporating them into the operational database is acceptable.

1.3.21. Under some failure scenarios, Purchaser shall be able to utilize data engineering tools on another system component (e.g. the Development System or the Production System) to perform/distribute edits.

1.3.22. All edits shall be time-stamped (e.g. when a capacitor bank is added) to support the capability of querying by, or viewing, data based on the time-stamp in both the data engineering and operations user interfaces. The tools shall support the capability of sorting all feeders based on the last time they were imported from the GIS, with the timestamp for when the feeder was last imported visible to the user.

1.3.23. Within the data engineering tools, a user shall be able to compare pre- and post- edit values of parameters and graphics.

1.3.24. The tools shall provide the ability to export updates to just a changed portion of the database (Incremental Update) or perform a Complete Database Regeneration.

1.3.25. The SDB shall also accept interactive user commands and scripted SQL statements to provide at least the following functions:

1.3.25.1. Storage of the database data definitions, including schemas, relational tables, views, and fields.

1.3.25.2. An active repository component that provides the capability to organize, manage, and control information about users, applications, and programs that access the data.
1.3.25.3. On-line access to review the structure of the database and its data definitions.

1.3.25.4. On-line access to all SCADA data to allow updates and additions to the on-line database without requiring a system restart or failover to make the changes operational. This feature shall also create database change transactions to reflect the on-line changes back into the maintenance version of the SDB.

1.3.25.5. Development of new databases including batch-load capability from external database sources (e.g., Access databases, text files).

1.3.25.6. Comparison of the on-line “production” database with a new database to identify previous on-line database changes that might not have been incorporated into the new database.

1.3.25.7. Copying of existing database structures.

1.3.25.8. Modification of the database definition without unloading/loading the database.

1.3.25.9. Modifying existing databases, such as adding attributes ("columns" in a table-row-column structure). The addition of attributes shall not disrupt access to existing attributes.

1.3.25.10. Listing of all information on database parameters, attributes, etc.

1.3.25.11. For a given relation or table, a list of relations referencing this relation table and a list of relations referenced by this relation or table. Preferably, these relationships shall be shown graphically.

1.3.25.12. Support for command lists or catalogued procedure input.

1.3.25.13. Automatic time and date stamp on output (when promoted)

1.3.25.14. Name-change utilities that identify all uses of an entity name throughout the ADMS databases and facilitate selective and global changes to an entity's name.
1.3.25.15. The ADMS shall enforce naming standards based on the Purchaser naming conventions (to be provided during project discovery phase). The process for integrating and finalizing the initial set of naming conventions into the Contractor’s standard SDB structure shall be demonstrated as part of the data engineering workshop described in Section 17.8.3 Data Engineering Workshops.

1.3.25.16. Revise naming convention of Catalog names to improve usability (i.e. Conductor Catalog Name includes the conductor size)

1.3.25.17. Processing of the SDB into the data structures used by the ADMS for on-line applications – the “run-time” databases.

1.3.25.18. If a point name has been changed or deleted, the database generator shall identify the displays and reports that are affected by the change, and at a user request, update the point names in the affected displays and reports.

1.3.25.19. Initiate the CIM import/export process for exchanging power system modeling information with other computer systems.

1.3.25.20. All entries to the SDB shall be checked for validity, both syntactic and semantic. Effective use shall be made of menu selections, dialog boxes, list boxes, text boxes, and selection entries. Old values shall be displayed in conjunction with the request for new values during database modifications. All database modifications, including detailed listings of old and new data values shall be maintained in a time-stamped searchable audit log along with the user identification. The log shall be displayed on a workstation and exported upon demand.

1.3.25.21. Data not modified when a database is maintained, including run-time data, shall not be changed or reset to default
values. The current items in the run-time database shall be
retained in the modified database, except for those specific
items modified. This requirement specifically applies, but is
not limited to:

1.3.25.21.1. Values and attributes of telemetered and
calculated points
1.3.25.21.2. Models and execution parameters for
applications
1.3.25.21.3. Savecases (refer to Section 19.6.26.3
Savecases)
1.3.25.21.4. Data entered manually by users

1.3.26. Modified portions of the ADMS databases shall be buffered and shall not be
used until commanded by a user.

1.3.27. A user shall be able to schedule the model promotion batch jobs (batch will
define sequence of edits to be processed) using time of day scheduling for
all Approved edits.

1.3.28. A copy of the pre-modification database shall be retained until a subsequent
user command indicates that the new database is acceptable.

1.3.29. At any time during the "temporary" use of the new database, the user shall
be able to command the ADMS to rollback to using the previous unmodified
database (even after it has already been applied to Production).

1.3.30. The ADMS shall support multiple files ("work areas" or “projects”) of in-
progress modifications, such that several users can be preparing database
modifications at any time. Editing “projects” can be organized into multiple
related subprojects. A user within a project views the changes made within
that project superimposed on the master model/database (or their parent
project if one exists). If a user wants to execute a distribution planning
application, the model/database used by the application will be the same
version they’re viewing (i.e. their changes superimposed on the master
model/database).
1.3.31. In addition, the ADMS shall include the capability to separately undo recent individual database changes and rollback to the pre-modified state (even after it has already been applied to Production.

2. Display Construction and Maintenance

2.1. An interactive tool shall be provided for creating the operational displays and interfaces associated with each application.

2.2. With this tool, the user shall draw the contents of application windows, define dynamic linkages to any ADMS data, and sensitize display elements to respond to user input actions (such sensitized elements are typically referred to as cursor targets and function keys).

2.3. The ability to link to any ADMS data, not only real-time data, shall allow interactive graphic displays to be constructed for all applications in the ADMS via the display building tool.

2.3.1. The user shall logically identify individual dynamic data fields and data arrays in defined displays.

2.3.2. All linkages to the database necessary for ensuring the proper retrieval and output of the dynamic data or data arrays during actual use of the display shall be automatically established according to this identification.

2.3.3. The linkages between the displays and the database shall be by logical identification and shall be designed such that any database modifications do not require redefinition of existing displays.

2.3.4. Displays shall include a time tag indicating the time of last update of data on the display.

2.3.5. Data fields shall reference all supported formats.

2.3.6. These formats shall include programming language-equivalent data-to-ASCII conversions, plus all general GUI style elements (for example, radio boxes, menus, and sliders) and a special set of formats appropriate to the ADMS context.

2.3.7. Formats shall be conveniently definable and modifiable.

2.3.8. It shall be possible to present any item in the database on any display.
2.3.9. Database items shall be displayable anywhere on the screen, excluding dedicated screen areas such as the display heading.

2.3.10. There shall be no limitation on the number of data items presented on any display, up to the physical limitations of the window or screen.

2.3.11. Similarly, screen locations for cursor targets shall be unrestricted.

2.3.12. The User Interface shall be designed to allow data stored in the historian to be displayed on ADMS workstations and integrated into any ADMS display.

2.3.13. Easy to use user interface techniques such as pop-up menus with default data request values shall be provided to make it simple to display historical data on ADMS displays.

2.3.14. The ADMS shall allow the operator to call up historical data with these techniques from on-line displays without having to redefine the historical data request at display build time.

2.3.15. Database items shall be presented in the following formats as appropriate:

2.3.15.1. Numerical text that presents analog and accumulator values; the format definition of the text shall include the number of characters, number of decimal places, and the use of sign or flow direction arrows.

2.3.15.2. Symbols, including alphanumeric text strings for a single item, based upon the item’s state for all defined states.

2.3.15.3. Symbols, including alphanumeric text strings for multi-state items, based on flag fields where each flag represents a condition or a state and where multiple states may be true at any time; for example, data quality flag fields for both telemetry failure and alarm inhibit may be simultaneously set for an item.

2.3.15.4. X-Y and X-t point relationships with vectors connecting the points; for example, trending and Kiviat plots.

2.3.15.5. Bar charts – display of value in a bar showing alarm conditions with changes in bar color.
2.3.15.6. Filled polygons (x or y axis inside the polygon showing the percent of full scale of the variable); for example, bar charts.

2.3.15.7. Filled arcs; for example, pie charts or simulations of meter movements.

2.3.15.8. Colors, textures, and blink conditions based upon state or value changes or a change of data quality, for example, alarm limits.

2.3.15.9. Combinations of the actions listed above; for example, change a bar chart color when the data value exceeds the limit.

2.4. Display Style

2.4.1. All displays provided by the Contractor shall have a consistent “look and feel” and be consistent in its use of graphics, commands, menus, colors, poke procedures, and data entry such that data similar in appearance shall have a consistent meaning throughout the ADMS.

2.4.2. This requirement shall apply to displays provided from the Contractor’s standard offering and displays developed specifically for Purchaser.

2.4.3. The Contractor shall submit to Purchaser a display style guide for displays produced by the Contractor.

2.4.4. Any displays produced by the Contractor as part of their standard product shall comply with this display style guide.

2.4.5. Purchaser will develop a style guide for displays produced by Purchaser.

2.4.6. Any displays produced by the Contractor for this project, excluding displays to be incorporated into the Contractor’s standard product, shall be produced in compliance with this style guide.

2.5. Display Elements

2.5.1. Displays elements shall be based on the GIS symbology and exhibit similar behavior as that within the GIS, plus additional functionality required by ADMS.
2.5.2. A method of linking raster images; vector design files; jpeg, bitmap or gif files; operating procedures, and other documents to specific objects shall be included to allow an operator to select the object to display the associated document, image or file.

2.6. The display tool shall include an automatically generated Hierarchical Display Menu Directory as described 19.4.3 Contractor-Provided Displays.

2.7. The editor shall support displays constructed as world coordinate spaces and displays constructed as fixed spaces and shall allow XML based editing.

2.8. The display editor shall be fully compatible with the database generation and editing function.

2.9. The display editor shall be fully interactive and shall provide "What You See Is What You Get" (WYSIWYG) capabilities.

2.10. The display editor shall maintain a complete audit trail of edit activity as part of software configuration management.

2.11. New displays shall be constructed beginning from a blank display, from an existing display definition, or from display templates within a library.

2.12. The editor shall support the creation of libraries of standard and custom symbols or components to be created, modified, and used to facilitate the editing process. Symbols for the geographic display shall be capable of fully utilizing all data for the devices represented. The editor shall support the use of logic equations to define the symbol behavior. For example, a recloser symbol on the geographic display shall indicate the state of the underlying breaker and bypass switch in a manner that the user doesn’t have to open the device to see the open/close status of the individual devices. Tag and quality conditions of the child devices shall pass through so the user can tell the condition of individual devices without opening the symbol to see more detail. Similarly, meter attributes shall pass through to the service location symbol on the geographic display.

2.13. All edited displays shall be checked for validity. Effective use shall be made of menu selections, dialog boxes, list boxes, text boxes, and selection entries. Old layouts shall be displayed in conjunction with the request for new layouts during display modification. All display modifications shall be maintained in a time-
stamped searchable audit log along with the user identification. The log shall be displayed on a workstation and exported upon demand.

2.14. The display editor shall support the listing, dumping, reloading, and validating of display definitions.

2.15. The list function shall provide for partial and full summaries (directories) of displays cross-referenced to their use in applications.

2.16. The list function shall also produce detailed documentation of the contents of any display showing all elements and provide tools to find on which displays a given piece of data is referenced.

2.17. Dumping and reloading of displays shall be provided for individual displays, display libraries, individual applications, or an entire application system.

2.18. The display editor shall produce displays compatible with every workstation of the ADMS. Purchaser shall not have to develop multiple versions of displays for each type of workstation or for different GUI products included with the ADMS.

2.19. The display editor shall support, as a minimum, the following construction features:

2.19.1. Editing features to copy, move, paste, rotate, delete, and modify selected groups of information and to undo/redo the previous actions.

2.19.2. Building a display at any scale (zoom) level.

2.19.3. Custom summaries showing data for any/all applications

2.19.4. Dashboards, with a simplified “thumbnail” (that gives a very high level indication of the status of the function being dashboarded) that can be selected to open a summary display that contains graphical and/or tabular data. For example, an IVVC dashboard could have a thumbnail that indicates if IVVC has any problems or not – clicking on the thumbnail calls up the IVVC Summary dashboard that could show information such as the current status of setpoints and cap bank switch positions.

2.19.5. Sort and filter functionality must be available for all columns


2.19.7. Various font sizes, line types, and line thickness.

2.19.8. Linking of any defined graphics symbol to any database point.
2.19.9. Pop-up menus for selection of points for linkages by default. The points shall be those in a user-defined substation for which the display is being built. The user, however, shall be able to request a menu list of all available points.

2.19.10. Ability to establish different symbol or display conventions for the same database point on the same or on different displays.

2.19.11. Ability to display the short or long name for a database point.


2.19.13. Building and modification of display icons and store them in an easily accessible library.

2.19.14. Protection of any data field on any display against user entry based on log-on Area of Responsibility (AOR) identifiers, reference Section 6.8.3 Areas of Responsibility (AORs).

2.19.15. Activation of displays within any application system or across all application systems by a simple procedure that does not require a failover and that causes no noticeable interruption of on-line ADMS activity.

2.19.16. A scripting tool to facilitate the modification of displays to incorporate Purchaser changes on top of any Contractor product upgrades and to port existing Purchaser displays and third-party products into the Contractor’s system.

2.19.17. Using drawing files in .dxf format as input.

2.19.18. The ability to import or export ADMS display definitions, including database references and graphics, using a DXF or SVG file format.

2.19.19. The ability to link applications data on scrollable, list-based displays.

2.20. Quality Code and Safety Tag Presentation

2.20.1. When more than one quality-code condition applies to the data (refer to Section 5.2.2 Data Quality), the highest priority condition, as determined by a Purchaser-defined priority sequence shall be displayed.
2.20.2. Purchaser shall determine the presentation of each quality code. Color, flash, appended symbols, and other display features shall be selectable during display build time.

2.20.3. It shall be possible to construct multiple representations for a data item and its quality codes such that the presentation of data may be optimized for a particular display and to define different representations on a per point basis.

2.20.4. A separate indicator shall be used to reflect the safety tag status of a database point.

2.20.5. When more than one safety tag applies to a point, the highest priority safety tag, as determined by a Purchaser defined priority sequence, shall be displayed.

2.20.6. Purchaser shall determine the presentation of each safety tag.

2.20.7. Color, appended symbols, and other display features shall be selectable for safety tag presentation.

2.20.8. It shall be possible to construct multiple representations for a data item and its safety tags such that the presentation of data may be optimized for a particular display.

2.20.9. Please refer to Section 19.6.11 Safety Tagging for a complete description of the safety tag capability.

2.21. Data Sets

2.21.1. Selected displays will be defined with the intent of presenting data from different “data sets” defined as a collection of data produced by an application representing the state of the power system. It shall also be possible to simultaneously display data from the real-time data set and data from any of the other data sets on the same display.

2.21.2. Data sets from different applications include data for the same power system devices. For example, the ADMS includes the following applications that will each produce a data set for the power system:

2.21.2.1. Data acquisition and processing (the real-time data set).

2.21.2.2. Distribution state estimator (the current solution).
2.21.2.3. Distribution system network analysis savecases and working areas.

2.21.2.3.1. Where save-case data is presented on a display, it shall be possible to present the save-case identification on the same display.

2.21.2.3.2. It shall be possible to change the savecase presented by entering a new savecase identification.

2.21.2.4. Unbalanced load flow results

2.21.2.5. Outage Management function

2.21.2.6. Purchaser shall be not required to create multiple displays to allow data from multiple data sets to be viewed.

2.21.2.7. Purchaser shall be able to define each display once and to link the data elements to the real-time data set. All other processing necessary to link to other data sets shall be transparent to the display developer and to users.

2.21.2.8. At Purchaser’s discretion, they might create individual displays that show only a particular set of data.

2.21.2.9. The user interface shall include features such that data presented on displays can be highlighted to indicate the data set presented. It shall be possible to uniquely highlight data items for data generated by real-time state estimator solution and data from a network analysis savecases and working areas.

2.21.2.10. Called displays shall default to the real-time data set.

2.21.2.11. However, the display request mechanisms shall include features to facilitate the immediate presentation of other data sets when the display is called and to change datasets after the display has been presented.
2.21.2.12. Displays defined to present multiple data sets shall clearly indicate the data being presented (e.g., different background color of data).

2.21.2.13. Data set identification shall be unambiguous, obvious, and visible always.

2.22. Display Layers

2.22.1. World coordinate displays shall be constructed in layers.

2.22.2. Each layer shall be a self-contained world co-ordinate space onto which display elements, including data, shall be placed.

2.22.3. Layers shall be displayed in a defined order, with higher-order layers overlaying lower-order layers.

2.22.4. Where displayable elements of a multiple layers occupy the same space, the higher-order layer elements shall be displayed.

2.22.5. The selective presentation of layers – “decluttering” – shall be controlled by the scale (zoom) level and by user selection.

2.22.6. Each layer shall be visible over a range of scale level set defined as the display is built.

2.22.7. It shall also be possible for the user to override the automatic selection of layers and to select those layers presented at any time.

2.22.8. This layer capability shall be used to support the display of the geographic background for Distribution Circuit Displays.

2.22.9. Purchaser shall be able to define the mapping of GIS elements to specific layers such that the GIS interface pulls data, landbase object, etc. into the desired layer.

2.22.10. Purchaser shall be able to name the layers (e.g. Poles, Distribution Topology, etc.)

2.23. User Interaction
2.23.1. Cursor targets shall send a message to an application or issue a command when events occur. The ADMS shall support the following commands via user interaction:

2.23.1.1. Call a display. Page forward and backward commands shall be considered special cases of display call interaction, where the sequence of displays shall be part of the display definition.

2.23.1.2. Initiate a program. (Programs may be either an ADMS application, operating system, utility, or third-party program.)

2.23.2. Such commands shall convey both fixed and contextual data. As a minimum, supported contextual information shall include:

2.23.2.1. Record identities linked to the cursor target.
2.23.2.2. Cursor position on the screen and within the display.
2.23.2.3. Database, application, and application system associated with the display.
2.23.2.4. List position (for lists).
2.23.2.5. Workstation identification and any associated parameters, such as permissions.

2.23.3. Conditional attribute values shall be attached to any display element, primitive, or macro and shall be able to make a particular display item valid or invalid depending on whether the referenced data or display context is in a specified state.

2.23.4. Multiple cases shall be supported so that, for example, a data item may appear in one color if it is in range, another color if it is below range, and a third color if it is above range.

2.23.5. The ADMS shall support “pop-up” and “pull-down” menus for user interaction.
Those menus supplied with the ADMS shall be extensible by Purchaser to incorporate new features and applications developed by Purchaser. For example, user can right-click to display a user defined context menu.

It shall be possible to add additional items to existing menus, to define entirely new menus, and to link the call-up of new menus to specific user actions.

The menu items, when selected, shall pass messages to applications including fixed and contextual data as described above.

If a display definition is stored in multiple locations (for example, a copy in each workstation), a validation function shall be provided to ensure that all definitions over all workstations in all systems are consistent and up-to-date.

Modified portions of the ADMS displays shall be buffered and shall not be used until commanded by a user.

A user shall be able to schedule the display promotion batch jobs (batch will define sequence of display edits to be processed) using time of day scheduling for all Approved edits.

A copy of the pre-modification displays shall be retained until a subsequent user command indicates that the new database is acceptable.

At any time during the "temporary" use of the new displays, the user shall be able to command the ADMS to rollback to using the previous unmodified displays (even after they have already been applied to Production).

The ADMS shall support multiple files ("work areas") of in-progress display modifications, such that several users can be preparing display modifications at any time.

In addition, the ADMS shall include the capability to separately undo recent individual display changes and rollback to the pre-modified state (even after it has already been applied to Production).

19.4 ADMS User Interface

In addition to the requirements in Section 6 User Interface Requirements, the ADMS shall support the following functionality.
1. Top level toolbars and menu bar shall be configurable per role.

19.4.1  Distribution Network Displays

1. The DMS shall support the capability to display the Distribution Network and allow the operator to interact with it.

2. For the purposes of displaying the network, the DMS shall include the following:

   2.1. Information for schematic displays of the electrical facilities, showing individual elements and interconnections, along with the operating state and related information.

   2.2. Information for geographically oriented displays of the distribution network showing the same information as schematic displays plus associated land based information, facilities, equipment, locations of field crews, and other related information.

   2.3. Both schematic displays and geographically-oriented displays shall display cuts jumpers and grounds.

   2.4. Land-based information such as street maps, buildings, waterways, and other landmark details.

19.4.2  Purchaser-Provided Displays

1. Purchaser will provide the displays described below. Initially, the Contractor will assist Purchaser in the creation of these displays. Once proficient, Purchaser will take over the creation of these displays.

   1.1. Substation One-Lines – These displays show the interconnected elements of individual substations including buses, incoming and outgoing lines, transformer banks, circuit breakers, capacitor banks, and disconnects.

      1.1.1. The displays shall present telemetered, manual, and calculated data, including all alarm conditions.

      1.1.2. Highlighting and colors shall be used to distinguish the operating states of the different substation elements and shall be consistent with all other one-line displays.
1.1.3. The user shall be able to interact with the substation one-line displays to perform any associated user interactions such as data entry and supervisory control.

1.2. Tabular Displays – These displays will contain telemetered data and calculated data.

1.2.1. They may be associated with either Contractor-provided application programs or Purchaser-provided application programs.

1.2.2. The user shall be able to interact with these tabular displays to perform user interactions such as data entry, application function execution, and display call-up.

1.3. One-Line Menu – These displays shall provide one-line menus for substations.

1.3.1. Each entry in these lists shall allow selection of the associated one-line diagram.

19.4.3 Contractor-Provided Displays

1. The Contractor shall provide the displays described below. All Contractor-provided displays shall present data using data names defined by Purchaser.

2. Geographically oriented Distribution Circuit Display – See Section 19.4.3.1 Distribution Displays.

3. Geo-schematic feeder displays - See Section 19.4.3.1 Distribution Displays.

4. ADMS Auto-Schematic Displays – These displays are auto-generated and shall show the distribution circuits in a pseudo-geographic form that maintains the relative geographic orientation of devices but compresses the distance between devices to show a schematic view of the circuits. Please refer to Section 19.3.1.4 Displays That Represent the Distribution Network State for additional details.

5. Device Internal Views – Auto-generated, on-the-fly within the ADMS user interface, to show the details of a composite device (e.g. a recloser with a bypass switch) – with the “template” configurable by Purchaser (e.g. adding controllable poke points to the device internal view)
6. Access Control Display – This display shall allow a designated authority to control user access to the ADMS. The display shall enable the designated authority to enter, modify, and delete user IDs and passwords and to assign workstation jurisdiction and operating modes.

7. Menu Directory Display – This display shall list all menu displays in alphanumerical order. Each entry in the list shall have a cursor target for menu selection.

8. Hierarchical Display Menu Directory (popup window that presents displays in tree format) – This display shall list all displays in a hierarchical order based on the structure and organization of the display library, by application category, transmission, distribution, voltage level and display type (e.g., control input, output results). This display shall be generated automatically on call-up. Each entry in the list shall have a cursor target for display selection.

9. ADMS Directory Display – This display shall list all ADMS displays in alphanumerical order. Each entry in the list shall have a cursor target for display selection.

10. RTU Menu Display – This display shall list all RTUs (including devices that provide RTU like functions) in the ADMS in logical groupings/front-end order or alphanumerical order, selectable by the user. Each entry in the list shall have a cursor target to access an RTU detailed display, showing the configuration and composition of the selected RTU.

11. ADMS Configuration System Monitoring and Control – These displays shall allow the user to monitor and control the ADMS configuration. The displays shall:

   11.1. Present all equipment status and associated equipment alarms.

   11.2. Provide menus or cursor targets for performing actions such as failover, switching local and remote devices (such as workstations, servers, and RTUs), switching communication channels, controlling the ADMS resource monitoring function.

   11.3. Present processor and communication channel loading and error statistics.

   11.4. These displays shall graphically show the interconnected elements of the ADMS including communication paths and Contractor-provided channel interface equipment such as modems, transceivers, and multiplexors.

      11.4.1. The data sources communicating over each path shall be shown.

   11.5. An RTU In/Out of Service display shall be provided to show the state of the RTUs in the system.
12. RTU Tabular – These displays list the RTU protocol, whether the RTU has SOE, value of telemetered and calculated data associated with each RTU as well as related information such as alarm limits.

12.1. The user shall be able to interact with the RTU tabular displays to perform any associated user interactions such as data entry and supervisory control.

12.2. The user shall be able to call-up the associated substation one-line display from a poke point located on the tabular display.

12.3. These displays shall be generated automatically by the ADMS upon call up and shall be based on the current contents of the database.

12.4. Purchaser shall have approval over the format of these displays.

12.5. Points displayed shall be all database points within the substation:

12.5.1. For status points – The information displayed for each point shall include: name descriptors, all data attributes, an indication of whether the point has an associated output point, whether the point is telemetered, current status, normal status, quality codes, controllable and safety tags.

12.5.2. For analog points – Information displayed for each point shall include: name descriptors, all data attributes, current value, all limit values, quality codes.

12.5.3. For accumulator points – Information displayed for each point shall include: name descriptors, all data attributes, current value, quality codes.

12.5.4. For control points – The information displayed for each point shall include: name descriptors, all data attributes, type of control point, current status, normal status, quality codes and safety tags.

12.6. The types of points shall be displayed separately (i.e., using separate pages) from each other and telemetered data displayed separately from calculated data.

12.7. As many display pages as needed to show all points at a substation shall be provided.

12.8. For substations with multiple data sources, the points shall be ordered according to data source. It shall be possible to perform any allowed point function from the station tabular page.
13. Device Information Displays – Single displays shall be provided that will display all of the attributes for an individual data item on a per point basis, current state, alarm condition, all active quality codes, etc., when the data item is selected on another display.

13.1. These displays shall be provided for all telemetered (analog, status, SOE, accumulator, ICCP), calculated, control, pseudo/manual, distribution system devices (transformers, lines, etc.), substations, RTUs and other ADMS devices.

13.2. These displays shall be generated automatically by the ADMS upon call up and shall be based on the current contents of the database. Purchaser shall have approval over the format of these displays.

13.3. The types of devices shall be displayed separately (e.g. using separate pages) from each other. As many display pages as needed to show all devices shall be provided.

14. Summary Displays – Summary displays are list displays presenting power system and ADMS conditions to the users.

14.1. These displays shall be automatically dynamically updated when on view on a workstation.

14.2. User interaction with the displays shall include filtering and sorting of the data presented in the displays, including defining a primary and secondary sort key.

14.3. The ADMS shall support sorting and filtering by:

14.3.1. AOR.

14.3.2. Location (substation, generating plant).

14.3.3. RTU.

14.3.4. Point name.

14.3.5. Alarm class.

14.3.6. Date and time.

14.3.7. It shall be possible to define default filters and sorting for each summary, to be applied when the display is called to view:

14.3.7.1. Alarm, event, and SOE summaries – sorted by date and time, with the most recent entries in view when the display is called. The summaries shall be filtered to present only
those entries of those AORs assigned to the calling workstation.

14.3.7.2. All other summaries – sorted by date and time and then location (alphanumeric). No filter shall be applied at call up; however, the summaries shall be filtered to present only those entries of those jurisdictions assigned to the calling workstation and be selectable by RTU.

14.4. Summary Displays shall support the export of their contents (e.g., memos, manual entries, safety tags, etc.) to external files (Excel, Access, Word) for external processing and reports.

14.5. Summary displays shall include:

14.5.1. Alarm Summary – The ADMS shall include Alarm Summary displays that operate as follows:

14.5.1.1. A single user action shall be used to call an alarm summary that presents only those alarms for the AORs assigned to the workstation from which the display is called.

14.5.1.1.1. All alarms in all classes shall be presented.

14.5.1.1.2. The ADMS shall also include facilities to call a general alarm summary that will present all alarms in all AORs.

14.5.1.2. The ADMS shall also support alarm summary displays that show a distinct set of AORs.

14.5.1.2.1. The AORs assigned to an alarm summary display are distinct and may allow a user alarm and event access different than a user’s other permitted AOR’s. In addition, the ADMS shall support an alarm summary
That shows all AORs, all alarms regardless of AOR.

14.5.1.2.2. The operator shall be able to use filtering on this display to select specific AOR’s based on alarms assigned to the operator.

14.5.1.3. The summary shall have a system configurable option to display the alarms in chronological or reverse-chronological order.

14.5.1.4. Alarm summaries shall show power system and ADMS alarms.

14.5.1.4.1. The user shall be able to acknowledge and delete messages on the display.

14.5.1.4.2. Flashing shall identify unacknowledged alarms.

14.5.1.5. If the capacity of the alarm summaries is limited and an alarm summary display becomes full, the oldest messages shall be automatically deleted and the newest messages shall be added.

14.5.1.5.1. It shall be possible to perform any alarm interaction from the alarm summary displays.

14.5.1.5.2. This condition shall be annunciated to the operator as this limit is being approached (i.e., configurable percentage of total amount allowed).

14.5.1.6. The Alarm Summary display shall have the capability to filter and sort the contents based on the alarm priority and all other alarm message fields.
The operator shall be able to select one, multiple, or all priorities for viewing.

The operator shall be able to define default views that use the filter and sort capabilities to quickly access a preferred priority based summary view, showing the hierarchy of priorities.

When performing a filter or sort, the display shall keep a selected point visible in the same relative position in the window.

Event Summary - The event summary shall have the same functionality as the alarm summary with the exception that all alarms and events shall be listed.

The oldest events shall be removed from the event summary only when the capacity of the display is exceeded.

The Event Summary displays shall operate as follows:

A single user action shall be used to call an event summary that presents only those alarms for the AORs assigned to the workstation from which the display is called. All events in all classes shall be presented.

The ADMS shall also support event summary displays that show a distinct set of AORs. The AORs assigned to an event summary display are distinct and may allow a user alarm and event access different than a user’s other permitted AOR’s.

The summary shall have a system configurable option to display the events in
chronological or reverse-chronological order.

The Event Summary display shall have the capability to filter and sort the contents based on the various component fields of the event or alarm messages (e.g., user name, alarm priority, user id, workstation, etc.). The operator shall be able to define default views that use the filter and sort capabilities to quickly access a preferred summary view.

14.5.3. Off-Normal Summary – This display shall list devices and values that are not in their normal state.

14.5.3.1. Telemetered, calculated, and manually entered status, analog, and accumulator data points shall be included.

14.5.3.2. For analog points, this summary shall provide information representing the overloaded equipment.

14.5.3.3. Devices shall be removed from the list when those devices are returned to normal.

14.5.3.4. In a case when the capacity of the display is exceeded, the oldest Off-Normal devices shall be removed from the Off-Normal Summary.

14.5.3.5. The Off-Normal Summary displays shall operate as follows:

14.5.3.5.1. A single user action shall be used to call an off-normal summary that presents only those off normal devices for the AORs assigned to the user. All off-normal devices shall be presented.

14.5.3.5.2. The ADMS shall also support off-normal summary displays that show a distinct set of AORs. The AORs assigned to an off-normal
summary display are distinct and may allow a user off-normal access, different than a user’s other permitted AOR’s.

14.5.3.5.3. The summary shall have a system configurable option to display the off-normal in chronological or reverse-chronological order of when the devices were placed off-normal.

14.5.3.5.4. If the capacity of the off-normal summaries is limited and an off-normal summary display becomes full, the oldest messages shall be automatically deleted and the newest messages shall be added.

14.5.3.6. The Off-Normal Summary display shall have the capability to filter and sort the contents based on the various component fields of the off-normal device record (e.g., user name, device ID, device name, user id, etc.).

14.5.3.7. The operator shall be able to define default views that use the filter and sort capabilities to quickly access a preferred summary view.

14.6. Off-Scan Summary – This display shall list all points that have been suspended from acquisition.

14.7. SOE Summary – This display shall list SOE information.

14.8. Alarm Inhibit – This display shall list devices and data values for which the user has inhibited alarm processing.

14.8.1. Controls to enable sorting by substation and by date and time of the entry of the inhibit shall be included on the display.

14.9. Limit Override Summary – This display shall list devices and data values for which the user has overridden limits.
14.9.1. The entries for overridden limits shall show the database (non-overridden) value of the limit as well as the overriding value.

14.9.2. Controls to enable sorting by substation and by date and time of the entry override shall be included on the display.

14.10. Safety Tag Summary – This display shall list and describe all active safety tags for all devices.

14.10.1. The user shall be able to place and remove safety tags from this summary. Information on this display shall list each device safety tagged and shall include: date and time of safety tag placement, user who placed the safety tag, safety tag level, station identifier, device identifier, and comment field.

14.10.2. The display shall include the ability to sort the safety tag information according to safety tag type.

14.11. Manual Replace Summary – This display shall list all points that have been replaced by manual entries.

14.11.1. Separate displays shall be provided for telemetered and manual/pseudo points for SCADA data.

14.11.2. For each point, there shall be facilities for fast access to the display containing the point, such that the user can further modify the value or return the point to automatic data acquisition.

14.12. Carried by summary – this summary shall list if any portions of feeders are being served by a source that is not their normal source. This summary shall also list the amount of load that has been transferred to a new source.

15. Communication Maintenance Displays – Communications with data sources and other computer systems shall be managed via these displays.

15.1. Communications management displays shall show the current status of the communication channels.

15.2. Communication error counts, and tabulations of all types of errors and shall enable control and diagnosis of communications devices.
16. Areas of Responsibility Management Displays – The ADMS shall include displays to allow the supervisor or administrator to manage and assign AORs/permissions based on current user responsibilities.

16.1. The responsibility (and access to) for this function shall be configurable to divide this function among the Purchaser Operating regions (based on AORs) between users (refer to Section 6.8.3 Areas of Responsibility (AORs)).

17. Application Program Displays – The Contractor shall provide all displays associated with all specified application programs and functions.

17.1. Displays that allow the user to interact with ADMS application programs shall use a common look-and-feel approach.

18. Other Displays – Specific display requirements for other ADMS functions are described throughout this RFP.

18.1. The Contractor shall be responsible for the supply of all displays necessary to support the specified functions, in addition to any other ADMS displays required to control and monitor the ADMS itself.

19.4.3.1 DISTRIBUTION DISPLAYS

1. The ADMS shall include three representative network display types as follows:

1.1. Geographically oriented Distribution Circuit Displays

1.2. Geo-schematic feeder displays that are geographically relevant, but are not generated to scale for clarified presentation to system operations.

1.3. Device Internal Views – Auto-generated, on-the-fly within the ADMS user interface, to show the details of a composite device (e.g. a recloser with a bypass switch) – with the “template” configurable by Purchaser (e.g. adding controllable poke points to the device internal view)

2. Both sets of feeder displays shall be created from information that is imported from Purchaser’s Smallworld GIS and other asset data sources. The scaled view shall present world-map views of Purchaser’s Distribution System within the context of geographical
landmarks such as streets, buildings, and hydrology. The displays shall include landmark and facility names and all associated information to properly locate the Distribution System elements such as poles, customer service drops, distribution transformers, capacitor banks, reclosers, switches, fuses, feeder circuits, substations, RTUs and all other field equipment. The schematic view will include only those elements which are necessary to support operating the system.

3. The system shall provide the user with a seamless view of the company’s complete set of maps. That is, the user will not have to manually load map sheets or map files for display, but that the system will keep the physical storage structure invisible to the user’s navigation and display functions.

4. It shall be possible to “playback” historical data, including outages and AMI historical data such as sag/swell/power down flags and see the geographical diagram responding, including heat map coloring (e.g. based on number of outages and/or number of AMI events during a user-defined timeframe).

5. The displays shall show current in-service, out-of-service, alarm conditions, crew locations, outages and their extent. Highlighting and the colors used to distinguish the operating states of the different system elements shall be consistent with the Purchaser’s system overview display. The assigned colors should be Purchaser configurable (36 concurrent colors out of a pallet of at least 128), e.g. voltage colors, outage colors, etc., and a legend of the assigned colors shall be available (at least 10 feeder colors shall be available in the legend and the legend shall be dynamic based on the user view). Graphical depiction of outages will include highlighting that distinguishes predicted and confirmed. The user shall be able to zoom and pan to navigate the displays and to present different levels of detail for any selected portion by selecting the desired view using the scroll key or a “rubber banding” technique. De-cluttering of symbols, devices, data values, and text shall occur at selected zoom factors. Specific characteristics and conditions that shall be color-configurable include (but not limited to) the following, with the incident/outage subset coloring superimposed on the network coloring options:

5.1. Energization (De-energized, Energized, Energized by generator, Meshed, Partially energized, Unknown, Grounded, Bidirectional, Faulted, Abnormally Switched - Carried, Looped - from a palette of at least 256, through a user interface dialog)
5.2. Feeder (at least 36 colors possible, from a palette of at least 256, through a user interface dialog)

5.3. Phase (user definable color for each phase, from a palette of at least 256, through a dialog)

5.4. Rated current (user definable ranges, from a palette of at least 256, through a dialog)

5.5. Wire size (all wire sizes in DB can be assigned a color from a palette of at least 256, through a dialog, when coloring by wire size user can select which wire sizes to show through a dialog)

5.6. Substation (at least 36 colors possible, from a palette of at least 256, through a dialog with a warning when re-using a color)

5.7. Transformer Area (color each feeder driven by a transformer within the currently visible network from a color palette of at least 256, legend will show colors associated with transformers and will dynamically update as user zooms in/out to change the transformers included in the presented network)

5.8. Voltage Level (configured in DB from a palette of at least 256,)

5.9. Relative Voltage (Scaled to 120v, then colored by ranges of 5 volt increments – user assigns from palette of at least 256 colors through a dialog)

5.10. Relative Load (percentage of wire capacity, user assigns from palette of at least 256 colors through a dialog)

5.11. Relative Power Factor (range of percentages away from 1, e.g. 2% above, 5% above, 10% above, 2% below, 5% below, 10% below - user assigns from palette of at least 256 colors through a dialog)

5.12. Phase Angle (12 ranges – 0-30, 30-60, etc. - user assigns from palette of at least 256 colors through a dialog)

5.13. Abnormal (Off-normal) – User can pick normal and off-normal colors from a palette of at least 256 colors through a dialog

5.14. Load Flow Quality – Good, Bad, Questionable, Unknown, De-energized, Partially Energized, Grounded - User can pick colors from a palette of at least 256 colors through a dialog
5.15. State Estimation Quality - Good, Bad, Questionable, Unknown, De-energized, Partially Energized, Grounded - User can pick colors from a palette of at least 256 colors through a dialog

5.16. Visualization/symbology for AMI meters showing under and over voltage on the geographic view

5.17. Hosting capacity - User defined “color by” displays – User shall be able color the network/devices based on any query they can perform (e.g. color by percentage of PV so can tell percentage of renewable on feeders, etc.)

5.18. Incident/Outage coloring

5.18.1. Incident confirmation (confirmed, not confirmed)
5.18.2. Problem existence (incident has a problem, incident has no problem)
5.18.3. Incident type (unplanned outage, work location, hazard, work location outage, load shedding)
5.18.4. Incident sub-type (sustained, unknown, momentary)
5.18.5. Outage time range (0-120 minutes, 120-180 minutes, 180+ minutes)
5.18.6. Incident Status (dispatched, new, archived, cancelled, field completed, follow up required)
5.18.7. Incident priority (1-2, 2-5)
5.18.8. Nested incident (incident is nested, incident is not nested)

6. Symbols shall be dynamically resizable and colorable, based on data real-time or historical values (e.g. make a fuse bigger if it has downstream devices out, or resize and color (different sizes/colors based on percentages of conductors’ rated current) conductor segments based on maximum loading during a user-specified time period).

7. For all possible views, the user shall be able to interact with the geographic displays to perform any of the associated user interactions such as data entry and supervisory control. These displays shall also present relevant electrical, mechanical, and operational factors (e.g., maintenance, outage, and operating history) for individual elements of Purchaser’s Distribution Systems. Features of the system will include:

7.1. An advanced graphical user interface (GUI) with a geographic map display capability. It shall include normal pan, zoom, and locate functionality.
7.2. The user shall be able to save the extents of the currently displayed graphics window as a named area.

7.3. The user shall be able to bookmark numerous geographic locations, preserving the extents.

7.4. A method of linking raster images; vector design files; jpeg, bitmap gif or PDF files; operating procedures, and other documents such as MS Word or Excel to specific objects shall be included to allow an operator to select the object to display the associated document, image or file.

7.5. The user shall be able to select a landbase or network element and add a note to be sent to the GIS (through the GIS interface) so that object can be updated in the GIS.

8. The system shall support the notion of navigation aids. These navigational aids shall be based on the information operators use to find locations. System shall zoom and center on the entity searched device. For example, if the user searches on a meter the system will center on the service location or if the user searches on a transformer, it will center on the transformer.

Sample subsets of potential navigation aids include:

8.1. Facility Ids – switch number, breaker number
8.2. Alarm ID
8.3. Pole number
8.4. Customer info – name, address, meter number, account number
8.5. Street address or cross street (street 1, street 2)
8.6. Circuit Name
8.7. Line Name
8.8. Substation Name
8.9. Outage Event ID
8.10. Crew Name
8.11. Switching Order

9. Control Operation may be initiated from any representation of the device (object) on either the geographic or schematic views of the distribution system. The user shall be able to select a device on any graphics display and be able to toggle/cycle through all of the views that the device is graphically depicted on. This shall include the device’s representation on its geo-
reference view, on its single circuit view, on its 3-phase schematic backbone view, and for substation equipment, on its substation one-line view. Support using different symbols for differentiating equipment status, different types of crews and outages shall be provided. This geographic map display shall support user-defined settings for display of various layers (Purchaser requires a minimum of 64 layers, with the capability for Purchaser to assign names to each layer) of graphical data (land, roads, poles, switches, all outages, predicted locations, etc.) at various scale factors along with polygon/line colors. The symbols on the geographic display shall be able to represent the composite status of groups of equipment, e.g. a recloser with a bypass switch would be represented in full detail on a schematic view (i.e. both the recloser and the bypass switch would be shown) but on the geographic view a single symbol that indicates whether power can flow through the recloser/bypass will be shown (e.g. the symbol will show one state if both the recloser and the bypass are open or will show a different status if either the recloser or bypass are closed). In addition, the symbol can indicate whether the device is remotely controllable, telemetered, etc.

10. The user shall be able to locate a customer from the customer list (that can be called up by right clicking on a section of line). The customer incident history shall also be available in this customer list.

11. The user must be able to configure from the user interface the color of the text displayed by the length tool (a tool for measuring distances, e.g. from pole to pole or substation to pole, initiated from an icon on the menu bar, which displays the distance in feet above the line you draw between start and end points – supports multiple segments through multi-click).

12. The user shall be able to view the list of critical customers and/or key accounts served by the selected facility by phase. The advanced GUI will provide the ability to suppress the display of lower priority information such as low priority calls or alarms – for example, the ability to suppress alarms for low voltage network devices (but not medium voltage network devices).

13. When Commanding -Open Control Window for unmapped remote points, the user must be able to issue a command for unmapped remote points using the standard control window.

14. The incident shall be able to be merged, have crews assigned, taken over, and opened from the geographical view.
19.4.3.2 TABULAR DISPLAYS

1. Tabular displays shall be provided for displaying non-geographical/schematic data such as alarm information, device status, trouble call entry, crew dispatching, outage analysis results, trouble call status, customer information, outage resolution information, etc. Tabular displays shall be able to show data from one or more application simultaneously.

2. All display views shall be automatically refreshed whenever any information that affects the real-time accuracy of the display data has changed, unless refresh is explicitly suppressed by the user.

3. A user shall be able to “Locate” a device on the geographic display from an alarm or any other tabular list that includes the device.

4. All tabular displays shall support the export of their contents (e.g., incident browser, customer list, application reports, etc.) to external files (Excel, Access, Word) for external processing and reports.

5. Filtering, Sorting, and Searching

   5.1. All tabular displays shall be filterable, sortable, and searchable with functionality like that of MS-Excel.

   5.2. All tabular displays shall be sortable with at least three levels.

   5.3. User shall be able to save, load, and delete all filters-sort combinations with a 16-character name using Windows Explorer style of saving files (i.e. existing names shall be displayed, etc.)

6. The capability shall be provided to utilize these criteria in any combination, both in predefined displays created by the Purchaser using the Contractor’s furnished display tools and for ad hoc queries. Some examples, but not a complete list, of tabular displays is included below:

   6.1. List of alarms

   6.2. List of AMI events (such as sag, swell, and voltage measurement messages)

   6.3. List of telemetered devices

   6.4. Select list of trouble orders by substation, feeder, lateral, fuse, or transformer

   6.5. Select all customers on a feeder, lateral, fuse, or transformer
6.6. Select all customers on a portion of the distribution system demarcated by a user-specified set of controlling devices (fuses and/or switches)

6.7. Identify all customers affected by an outage, regardless of whether a trouble call was received from the customer

6.8. Select trouble orders by priority level or priority level range

6.9. Select trouble orders by creation time or range

6.10. Select trouble orders by Area of Responsibility or Region

6.11. Select trouble orders by type

6.12. Select trouble orders by facility code

6.13. Select trouble orders for key accounts and critical load accounts

6.14. Select dispatched trouble orders by crew assignment

6.15. Select un-dispatched trouble orders

6.16. Select single trouble order by customer name, address, telephone number, or account number


7. A report of all available electrical equipment for the entire system, selectable by device type (i.e. select a device type from a dropdown list and get a report for all devices of that type). User shall be able to filter the report by any attribute associated with the device. The columns shall be configurable by the user.

19.4.3.3 **ADMS SCHEMATIC AUTO-GENERATION FUNCTIONALITY**

1. The Contractor shall provide “on-the-fly” Schematic Auto-generation functionality. This function shall create pseudo-geographic displays that maintain the geographic orientation of devices, but compress the distances between devices to allow a more compact display for use by the operators. Regeneration of the schematic will not substantially alter the orientation of devices from their placement in the previously generated schematic.

2. This function shall be configurable to allow the Purchaser to create rules and standard layouts that are then used by the Schematic Auto-generation function during its display creation process.

3. The Schematic Auto-Generation function shall also allow the operator/user to take the output of the generation and make modifications to the display (e.g., via display generation tools) to
allow the Purchaser to create displays that adhere to their conventions and standards and shall be of high quality for use by operations. The ADMS shall enable these displays and the current system conditions to be saved for continued use by real-time operations.

4. This facility shall maintain a record of the manually initiated changes so that if the underlying circuit is revised and a new schematic is automatically generated, these changes can be applied to the new display.

19.5 ADMS SCADA

1. Please refer to Section 5 SCADA Functions for the general requirements for SCADA. In response to this ADMS section, the Contractor shall provide the same SCADA functionality as described for the SCADA/EMS with the following additions:

1.1. As an option – The OpenADR protocol
1.2. The Load Shed is considered a DMS application, within the DMS. Refer to Section 19.6.4 Load Shedding and Restoration (LSR).
1.3. SCADA Complex Triggering

1.3.1. The Complex Triggering application is an enhanced version of Alarm Notification. It includes an editor that allows users to define complex conditions (i.e. conditions that include Boolean logic and/or programming language style definitions of conditions) under which emails are sent to selected users (or to group of users). During condition definition, the user will specify a list of users which should be notified after condition fulfilment.

19.5.1 Operations Device Monitoring

1. The Operations Device Monitoring function shall track the number of operations made by every breaker, capacitor switch, recloser, and load-break switch that is monitored by the ADMS.
2. Devices shall be identified by area of responsibility, substation, feeder, and device ID to provide the necessary information for condition-based maintenance of these devices.
3. This identification shall continue to track operations when a device is switched temporarily from one feeder to another to restore customers during a circuit-switching process.

4. For each monitored device, the following counters shall be maintained:

   4.1. Operations – not associated with DMS control functions
   4.2. Operations – initiated by DMS functionality (automation and operator remote control actions)
   4.3. Operations – total

5. When multiple changes (such as a trip-close-trip sequence) are reported by an RTU, each operation shall be registered.

6. The date and time of the last operation shall be saved for each device.

7. An operator with proper authorization shall be able to edit any and all counters.

8. For each counter, an “operator definable” limit may be entered. The ADMS shall calculate the present number of operations expressed as a percent (which may exceed 100%) of its corresponding limit.

9. An operator with proper authorization shall be able to inhibit operations counting for individual devices.

10. Such devices shall be included in summaries based on areas of responsibility.

11. Resetting and inhibiting counters shall be permitted only for devices that belong to the areas of responsibility to which the user is assigned, and resetting shall require the user to be assigned to an appropriate mode of authority.

12. The date and time when each counter was last reset shall be saved.

13. The counters and other related information shall be available for display and inclusion in reports.

14. The user shall be able to view the date and time of a device’s last operation together with its accumulated operations data by simply selecting the device on any display where it appears.

**19.6 Distribution Management System (DMS)**

This section specifies the Distribution Management System (DMS) functions.
1. The Purchaser operators shall use the Contractor-provided DMS functions to monitor and control Purchaser’s power distribution system within the Purchaser’s regional administrative area.

19.6.1 **Operating Modes and Execution Modes**

1. The DMS shall support the following operating modes:

   1.1. **Real-Time Mode** – This is a mode in which an application performs its function by using real-time data and producing information immediately applicable to real-time operations. For example:

       1.1.1. When triggered by an actual feeder fault, the Fault Location, Isolation, and Service Restoration (FLISR) application shall make use of current real-time data as a basis for recommending actions.

       1.1.2. Distribution State Estimation shall use available real-time data to produce the equivalent of a power flow solution that represents a “best” estimate of the current real-time state of the power system.

   1.2. **Study Mode** – This is a mode in which an application uses modified real-time data, saved data or forecast data to produce a starting point that can be used to examine alternative hypothetical or postulated operating scenarios. Time is fixed in study mode, although certain applications, such as Optimal Feeder Reconfiguration, can execute over a period of time in study mode.

       1.2.1. **Load snapshot** – In study mode, the user shall be able to load the model topology, telemetry, and all other dynamic data, within 60 seconds, for a user specified moment in time. For example, this action shall take no more than a minute to load data from a year prior.

       1.2.2. **Historical playback** – In study mode, the user shall be able to replay history including the model topology, telemetry, and all other dynamic data, within 60 seconds, for a user specified time frame of events. For example, this action shall take no more than a minute to load data from a year prior and the time frame will be over the course of 24 hours. In addition to seeing the
data playback on the geographic diagram, user shall be able to view switching actions, events, and alarms and shall be able to “locate” them.

1.2.3. Savecases – In study mode, the user shall be able to create a savecase at any point in time. The data to be collected in the savecase includes the model topology, telemetry, and all other dynamic data. The user shall be able to load the savecase within 60 seconds.

2. Depending on the application and depending on the operating mode, each DMS application may be triggered in one or more of the following execution modes:

   2.1. On demand
   2.2. Periodically
   2.3. Event-triggered

3. Transitioning from real-time into study mode, when interested in performing studies based on the current network conditions, shall be a single-step operation. If the user wants to perform studies based on different network conditions they shall be able to load savecases with the desired network model. There shall be some clear indication to the user to show them when they’re in study mode versus real-time (e.g. display background color or border color).

**Exhibit 19-1** below summarizes the DMS applications and the mode(s) they operate in

<table>
<thead>
<tr>
<th>DMS Function</th>
<th>Real-Time</th>
<th>Study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Demand</td>
<td>Periodic</td>
</tr>
<tr>
<td>Network Topology</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Distribution Load Forecast (DLF)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Load Shedding and Restoration (LSR)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Distribution State Estimation (DSE)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Distribution Unbalanced Power Flow (DPF)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Pre-Switching Validation (PSV)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Optimal Feeder Reconfiguration (OFR)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fault Level Analysis (FLA)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Distribution Circuit Fault Location (DCFL)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Safety Tagging</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fault Location, Isolation, and Service Restoration (FLISR)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DMS Function</td>
<td>Real-Time Demand</td>
<td>Real-Time Periodic</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Location of Open Conductor Faults</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Location of Downed Conductor</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Model-based Integrated Volt/VAR Control (IVVC)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Rule-based IVVC</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Closed Loop Readiness</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Protection Coordination</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Under-Load Switching</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Energy Losses (EL)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Large Area Restoration (LAR)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Operational Losses (OL)</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Distributed Energy Resource Management (DERM)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Phase Balancing</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

The performance requirements associated with each of the DMS applications are presented in Section 19.11 ADMS Capacity and Performance.

19.6.2 Network Topology

1. The DMS shall include a Network Topology function. This function shall analyze the open/closed status of power system switching devices to determine the electrical connectivity and the energized, de-energized, looped or grounded status of power system components such as overhead lines and underground cables, transformers, capacitor banks, MV-connected DER and generators.

2. The status of the switching devices shall be obtained from SCADA, manually-entered data or externally sourced data. Switching devices shall include all relevant power system elements such as circuit breakers, gang-operated switches as well as non-gang-operated switches, line reclosers, load break switches, and capacitor bank switches. The Network Topology function shall take into consideration temporary jumpers, grounds, and cuts applied to the power system when determining electrical connectivity.

3. A circuit element, such as a bus section or distribution line segment, shall be considered energized if any of the following conditions are met:

   3.1. A breaker or switch at either end of the element is closed and the adjacent section is energized.

   3.2. It is connected to an energized circuit element.
3.3. There is a non-zero measurement of voltage associated with the element.

4. Energization shall be treated as a calculated status attribute, and as such, the data quality of the arguments shall be propagated to the result. If the Network Topology function identifies a contradiction in calculating circuit energization (e.g., a circuit element is isolated but is associated with a non-zero voltage measurement), it shall issue an alarm and the status shall be displayed distinctly from energized and de-energized elements.

5. The Network Topology function shall result in an updated Dynamic Power System Model that can be used by the other applications such as Distribution Unbalanced Power Flow which depend on the model to analyze the network.

6. The Network Topology function shall be triggered automatically by the following events:

   6.1. Whenever a switching device status change is detected
   6.2. Following the introduction of or removal of a cut, jumper or ground
   6.3. Whenever the static connectivity of the network changes following an update to the DSOM (e.g. as a result of an incremental import from the GIS)

7. The user shall also be able to execute Network Topology on demand.

**19.6.2.1 CUTS, JUMPERS AND GROUNDS**

1. The operator shall be able to place, via point and click operations on the geographic and schematic displays, temporary devices, such as cuts, jumpers, switches, grounds and temporary generators, in the network. These changes shall be accomplished easily using special symbols. Once installed, jumpers, cuts and grounds shall be considered devices that can have safety tags added and deleted from them.

   1.1. Operator shall have the option of sending the temporary element to the GIS to be made permanent.

2. The operator shall be able to attach a feeder to another feeder or the same feeder, by phase, with a jumper regardless of phasing (with an override of validation, if necessary). Each jumper shall include a switch. When the jumper is first applied, the switch shall be in the “closed” state, as if the jumper is present - causing the two feeders to be electrically connected. The operator shall be able to open or close the switch repeatedly.
3. The operator shall be able to place a cut along a feeder section or an underground cable. The cut shall include a switch. When the cut is first applied, the switch shall be in the “opened” state, as if the cut is present. The operator shall then open or close the switch repeatedly.

4. The operator shall be able to add a ground to an end of any device. The ground shall include a switch. When the ground is first applied, the switch shall be in the “closed” state, as if the ground were present. The operator shall then open or close the switch repeatedly.

5. When the repair is completed, the capability shall be provided to back out the temporary changes in a simple manner and quickly return the system display to its original state.

6. The placement of any temporary element shall be logged, including a timestamp and the ID of the user that placed the temporary element.

7. There shall be a summary list of all temporary elements, including timestamp and ID of the user that placed the temporary element. There shall also be a separate summary that includes the historical information of all temporary elements placed, opened, closed, and/or removed. Both reports shall be filterable by feeder, device, etc.

19.6.2.2 FEEDER TRACING

Feeder Tracing is a user interface function that shall allow users to request distinctive traces on one-line and feeder diagrams that can quickly highlight electrically connected elements of the power system through simple point-and-click operations.

1. User-requested tracing results shall be displayed only at the console where the request is issued; multiple users at different consoles shall be able to request and view different tracing actions in parallel.

2. A user shall be able to trace the network connectivity of any selected element on geographic or schematic displays in a unique and distinctive manner (e.g., by color) in both an upstream and downstream direction. They shall be able to specify, through a dialog box, which devices should be flagged in the trace. All electrical elements should be available in the dialog box. Examples of required tracing are:

   2.1. The user shall be able to select a device or segment of circuit and trace from the selection to the injection point, highlighting load break switches, line reclosers,
circuit breakers, and cap banks in the path. If cap bank switches are open, they shall still be highlighted.

2.2. Trace to the next open point.

2.3. Trace to the next load-break switch.

2.4. Trace all feeder sections downstream of the user-selected device.

2.5. The user shall be able to select a device or segment of circuit and trace from the selection downstream to the next protective or sectionalizing device, its distribution transformers, open points and tie switches.

2.6. The user shall be able to select a device or segment of circuit and trace from the selection upstream to the previous protective or sectionalizing device.

2.7. The user shall be able to select a device or segment of circuit and generate a trace set from the selection upstream to its source.

2.8. The user shall be able to select a device or line segment within a URD loop and manually trace to its open point.

2.9. The user shall be able to select a device and trace to nearest SCADA controllable device.

2.10. The user shall be able to select a device or segment of circuit and generate a highlighted trace from the selection to the next occurrence of a specific device type: fuse, switch, etc.

2.11. The system shall keep all trace sets highlighted while the user pans and zooms until the user deactivates the highlighted trace set.

2.12. The user shall be able to select a device or segment of circuit and generate a highlighted trace from the selection to its set of sources.

2.13. The user shall be able to select a device or segment of a circuit and get the calculated impedance from that point to the source, per phase.

2.14. The user shall be able to select a device or segment of a circuit and get the calculated downstream connected KVA, per phase.

2.15. The user shall be able to select a device or segment of a circuit and get the downstream customer count, including customer information/priority, per phase.

3. The tracing function shall be available and shall operate identically on geographic and schematic displays. The tracing function shall be able to trace both the static as-connected
model (assuming that all normally open switches are open and all normally closed switches are closed) and the dynamic as-operated model.

19.6.2.3 FEEDER FOCUS

The user shall be able to select a device or segment on a single or on multiple feeders to gray out all unselected feeders. The intent is to enable the user to focus visibility on the selected feeder(s).

19.6.3 Distribution Load Forecast

1. To support operations planning and analysis, area loads (15 minute intervals at a minimum) shall be forecast for up to eight days in the future and back cast at least 8 days in the past.
2. To support distribution planning and analysis, area loads shall be forecast daily for two years and yearly for eight more years.
3. The user shall be able to save forecasts in any of a user selectable number of savecases, one of which shall contain the active forecast that shall be available for study functions such as DPF.
4. Ability to create, edit, save, apply or un-apply planning projects through the user interface in simulation contexts shall be provided. A simplified user experience for creating and editing network for planning purposes shall be provided.
5. A Load history import tool shall be provided to enable Purchaser to perform initial load profile population as well as an initial ‘estimated’ history for new substations.
6. Purchaser will subscribe to a weather service, if required, for the forecasting application(s) and the forecast application(s) must interface to that service. If the forecasting application determines the weather data is suspicious or bad, a user shall be able to put the system in manual override and manually enter the corrected values through the user interface (by weather region); temperature and humidity data that is input shall be stored in history.
7. Reactive power (Q, measured in MVAR) will be provided for each forecast interval.
8. A trend line shall be included in the load forecast graphic view/report.
9. In the graphical and tabular views, users shall be able to input a % value via display to manipulate load scaling of the area load forecasts.
10. The user shall be able to filter the results by day, week, month, and year.
11. The user shall have the ability to select multiple substation(s) of interest for which the forecasted data for those substations will be shown, organized by substation.

12. Load forecast in batch mode, by substation for selected substations only.

13. UI for load forecast must allow for future substation modelling.

14. The Load scaling option shall provide scaling for the graphical and tabular overviews.

15. The DLF shall forecast the peak power.

16. The user shall be able to adjust the active forecast. In addition, Distribution Load Forecast shall adjust future load forecasts automatically. This shall be based on the amount of mismatch between the forecasted loads and the actual loads of previous periods as they become known.

17. The user shall be able to import weather data from various sources such as weather services, the generation QSE load forecasting spreadsheet, etc. These conditions can include: temperature, barometric pressure, relative humidity, precipitation level, wind speed, wind direction, and luminosity.

18. A similar-day forecast shall be used that is based on the normalized load values stored for each of seven-day types. Provision shall be made for storing day types for the last 25 months. The storage shall be updated each day by replacing the oldest of the same day type with the most current actual load curve. The similar-day forecast shall search the 25-month file for the same day type whose weather conditions best match those entered by the user. It shall then present the user-entered and best-matched conditions, for user comparison, together with the chosen day's loads as the suggested forecast.

19. The user shall be able to modify any of the forecast's loads manually. In addition, the user shall be able to scale the entire forecast by simply specifying an appropriate peak load value.

20. Multi-day forecasts shall be constructed by permitting the user to define the input data for each forecast day.

21. The user shall be able to print and display the forecasts in both tabular and graphical form. This shall include the ability to display the active forecast with the actual loads of current and past days superimposed.

22. The user shall be able to export the forecasts.

23. The load-forecasting tool shall be able to interface to a relational database (e.g. MS-SQL) that contains historical information for locations without telemetry. When executing the load
forecast, if the application can’t find all historical data it needs to function it shall indicate to the user what gaps (timeframe) are missing in the historical data.

19.6.4 **Load Shedding and Restoration (LSR)**

Refer to Section 5.9 Load Shedding and Restoration (LSR).

19.6.5 **Distribution State Estimation (DSE)**

1. Distribution State Estimation (DSE) shall provide a complete and consistent power flow solution of the MV power system that best fits all available power system SCADA measurements and/or pseudo-measurements associated with the relevant power system model in DSOM. It shall execute on demand, periodically (initially every 15 minutes but as frequently as 10 minutes), and when triggered by a power system event that creates a change in network topology.

2. In addition to the DSOM, the inputs to the Distribution State Estimator shall include the following on-line data as well Distribution transformer loads calculated by Distribution Power Flow (DPF):

   2.1. Actual topology (including cuts, jumpers and grounds), transformer tap changer positions, etc.

   2.2. Voltage magnitude and phase angle, flows (current and active/reactive power) at supply points (high-side of feeder breaker)

   2.3. Current magnitudes (active and reactive power) from downstream distribution line devices (when they are provided by SCADA system).

3. The measurements at the feeder breaker shall be provided by SCADA or imported from the EMS State Estimator.

4. The results of the Distribution State Estimation function shall include:

   4.1. Estimated measurements of current, real and reactive power, apparent power, power factor, voltage magnitude and voltage angle,

   4.2. Voltages (magnitude and angle per each phase) at the injection,

   4.3. Network state – complex voltages (voltage magnitudes and phase angles for all nodes); as well as other state variable – magnitudes of current and power factors,
real and reactive power flows for all sections, transformers and shunts (consumers, generators, motors and capacitors),

4.4. Estimated set-points of voltage regulators and generators,

4.5. Estimated status of regulated capacitors,

4.6. Estimated tap changer position of regulating transformers,

4.7. Statistical analysis of execution and quality of measurements.

5. The outputs of the DSE application shall also be available in a tabular manner that can be displayed, printed, and exported. The results shall contain the following information:

5.1. Minimal and maximal expected values of measurement,

5.2. Quality of estimated value of measurements (e.g. normalized residual),

5.3. Discrepancies between actual and estimated values of measurements,

5.4. Deviation of measured values from estimated and expected (pre-estimated) ones,

5.5. Time stamp of results,

5.6. Trust factor of measurement used during calculation

19.6.6 Distribution Unbalanced Power Flow (DPF)

1. The Distribution Unbalanced Power Flow (DPF) shall calculate the state of the distribution system based on (a) real-time measurements at substations and of locations along the feeders, (b) manually-entered input, (c) facilities data imported from the various Purchaser sources into the DSOM, (d) a model of the operation of automatic devices such as reclosers, ATOs, LTCs, voltage regulators, and capacitor banks, etc. (e) a model of the loads along the feeder and (f) modelled distributed generation.

2. The DPF shall be based upon a robust three-phase, unbalanced distribution system model typical of North America that includes solving single phase laterals. Common points represented in the EMS power system model and ADMS model shall be accommodated.

3. The computed voltage magnitude and angle from the Distribution State Estimator shall be used as the input values of the source for the DPF or a study power flow.

4. A DPF study shall be able to be initiated on demand from a historical data snapshot from the Historian.
5. The DPF shall have the ability to analyze looped systems, but is restricted to the distribution model defined in the DSOM.

6. The DPF shall run periodically at the frequency (a user-definable parameter) as well as when triggered by an event (whenever a change in the topology of the distribution system or predefined change in status or analog data is detected).

7. The operator shall be able to execute DPF on demand for an operator-specified feeder or all feeders associated with a substation via the graphical User Interface and see the results on the same display.

8. A DPF study shall be triggered on topology change in Study Mode (i.e. shall execute each time a user changes a device state).

9. A DPF study shall also be triggered by an update of weather information.

10. The output of solar (PV) devices shall influence the DPF. Estimates of the output of solar shall be determined by the size of the solar array and the manufacturer estimates of output based on insolation values obtained through the weather integration.

11. DPF shall also run in study mode in conjunction with other application programs, such as the IVVC and FLISR functions.

12. The DPF shall also allow the user to execute power flow studies in study mode on selected areas within the distribution power system to determine, for example, the effects of feeder configuration and/or voltage adjustments on feeder load balancing, voltage drops, and losses.

13. Study mode will be used to run “What If” scenarios.

14. The application must provide the capability for storage, retrieval and playback of the number of “Savecases” for study purposes.

15. The operator shall have the capability to modify the parameters such as connectivity, device parameters and other operational parameters before running a “What If” scenario.

16. Study mode operation shall be distinguished by a unique background color for the window or such other means so that it is not confused with real-time windows.

17. Distribution systems operated by Purchaser are primarily radial, but on occasion, loads may be fed from parallel sources.

18. Distribution (Medium) voltage lines operate at nominal 34.5 kV, 12.47 kV.

18.1. The distribution system may be constructed as overhead, underground, or “mesh network”
19. Secondary (Low) voltage lines operate at nominal 480V, 277 V, 240 V, 216 V, 208 V, 125 and 120 V.

20. The DPF shall include models of the distribution transformers and approximate models of the secondary voltage lines.

21. Most loads are supplied at secondary voltages, but some large industrial and commercial customers are supplied at distribution voltage.

22. User ability to perform motor-start studies, and capture the results for analysis. This must also be exportable.

19.6.6.1 REQUIRED CHARACTERISTICS

1. The DPF shall include the following characteristics:

2. The discrete transformer tap positions of LTCs and line voltage regulators shall be adjusted to maintain specified voltages while complying with prescribed ranges on voltages and tap positions.

   2.1. The switching deadband shall also be modeled

3. Line charging effects shall be modeled, including the insulation losses of underground cables where applicable

4. Provision shall be made to accommodate capacitor banks that are switched on and off based on locally measured parameters.

   4.1. As a minimum, DPF shall model capacitor banks that switch according to day of week, holidays, time of day, temperature, voltage measurements, or Var measurements with voltage override. Deadbands shall also be modeled.

   4.2. Automatic switching shall be enabled or disabled, as determined by the user or associated local/remote status points.

5. Automatic transfer switch positions shall be modified according to associated line energization status values.

6. The capability shall be provided to model each load as proportional to a pre-specified normalized load profile. These shall be produced based on the historical meter data available from the Meter Data Management System. The Contractor shall be responsible for initial
production of load profiles for the entire Purchaser network based on meter data, up to DMS entry into service. The Contractor shall provide a tool to allow Purchaser to re-calculate load profiles based on meter data following DMS entry into service.

6.1. Daily load profiles (current magnitude and power factor, and/or active and reactive power) for a variety of load types (e.g. industrial, commercial, residential) and sub-types, for all pre-specified year’s periods (e.g. seasons: winter, spring, summer, autumn), for pre-specified types of days (e.g. weekday, Saturday, Sunday and holiday).

6.2. Peak load for each distribution transformer and/or consumer (peak currents and/or peak powers) and/or monthly electric energy transfers across distribution transformers (consumers).

6.3. Each load profile shall be defined (at a minimum) as a set of 24 hourly values of real and reactive load for a minimum of seven day-types and four seasons.

6.4. The DPF shall also allow for individual telemetered loads whose values are acquired through direct telemetry or through an interface with a Meter Data Management System.

7. The system topology, connectivity, symbology, attribute data and location of the loads shall be derived from input from the Smallworld GIS and other Purchaser sources. Changes in any of these, including symbology, will be reflected in the DPF.

8. The system shall support modeling discontinuities in feeder construction, where a feeder may be a single phase (say A phase) and may transition to multiple phases for a short distance, for example where a line that crosses a freeway is constructed with 3 phases for efficiency purposes, even though only one of the phases is being used.

9. The variation of load with voltage shall be modeled using separate expressions for real and reactive power.

9.1. Loads shall be adjusted to account for the changes in voltage that occur during the iterative power flow solution process.

10. Transformers shall be modeled by explicitly considering their copper losses, core losses, and voltage dependence.
11. Voltage drops on secondary voltage lines may be calculated with a simplified model that assumes that the secondary voltage drop is proportional to the transformer loading of the distribution transformer and that the maximum designed secondary voltage drop (a parameter initially set to 5%) occurs when the transformer load is at the nominal loading. Purchaser shall have the ability to turn off voltage drop calculations on the secondary voltage lines globally.

12. The DPF must interface with customer loading information stored in a third-party relational database (e.g. MDMS).

12.1. Both load allocation and spot loads can derive their measurement from billed energy (specified as either kWh or kVA) that originates from Purchaser’s Customer systems.

12.2. User shall have the ability to add spot loads to the run-time environment by selecting a primary or secondary line segment and adding a temporary load.

19.6.6.2 USER INPUT

1. The DPF function shall be designed to run in periodic or event trigger mode without user intervention and shall be extremely user-friendly requiring very little operator input when run on demand.

2. This input shall largely be limited to identifying the base case for the study and then making all desired changes prior to execution.

3. Line-out, re-sectionalizing, or other configuration change studies shall simply require the user to change the status of the appropriate switching devices on the associated geographic or schematic display in study mode.

4. Other changes shall only require simple numerical entries and, where appropriate, the selection of any relevant solution option available.

5. The user shall be able to execute the DPF function for a particular circuit, a particular substation, or a particular "area" (that is, combination of substations and/or circuits) selected by the user, using current base case or postulated load conditions.
19.6.6.3 RESULTS

1. Multiple independent users shall be able to execute the DPF function concurrently, starting from the last execution or a selected savecase. In these “what if” studies, limit violations generated by DPF shall not be treated as real-time violations, but shall be retained for display at the workstation on which the function was run.

2. In modifying the base case prior to execution, the user shall be able to scale loads, specify loads individually, modify bus voltages, and change device status values.

3. As a minimum, DPF shall calculate the following quantities:
   
   3.1. Real power, reactive power, and current for all circuit elements
   3.2. Voltage on each phase at all nodes, including secondaries of distribution transformers
   3.3. Total real and reactive losses, line losses (load and no load), and transformer losses (load and no load), both in kWh and kVARh, and in percent
   3.4. Monthly accumulated losses, in kWh and kVARh, and in percent by “total system”, substation, power bank, or feeder.
   3.5. Tap positions for substation transformers and line voltage regulators
   3.6. Switch positions for capacitors and automatic transfer switches
   3.7. Feeder voltage drops along distribution voltage and secondary voltage lines but user shall be able to globally zero out impedances for the secondary conductors.
   3.8. Phase imbalance of 3-phase circuits calculated by percent imbalance (e.g., average phase current minus largest individual phase difference from the average, divided by the average current)
   3.9. Voltage imbalance of 3-phase buses (e.g., average voltage minus largest individual phase difference from average, divided by the average voltage).
   3.10. Identify overloaded equipment (in amps or percentage of rating).

4. The DPF results shall be presented on the graphical displays used for real-time dispatching as well as in tabular form on dedicated displays.

5. The user shall also be able to right click a conductor section and get a load profile of the previous 24 hours from the loading calculated downstream of that section. A voltage profile of the entire feeder shall also be available.
6. The results of the DPF calculation shall be subject to the same limit checking as other calculated data, i.e., each calculated variable shall be tested against three pairs of limits, and a limit violation shall be generated when an overload is detected.

7. Limit violations determined by DPF shall be indicated to the user simply and clearly.

8. All line sections that are overloaded and all buses that have voltage violations shall be highlighted in color. All loops and parallel-fed loads shall be highlighted in a distinct manner.

9. The power flow results shall be made available in tabular form and on one-line diagrams.

19.6.7 **Pre-Switching Validation (PSV)**

1. The DMS shall offer a Pre-Switching Validation capability which will allow the operator to verify the impact of a switching action immediately prior to switching. Validations shall be configurable by Purchaser, allowing them to define whether each validation is blocking, warning, or information-only. Blocking validations cannot be overridden. Warning or Information validations can be overridden by operator interaction. Validations shall only require user action, e.g. validation popup window, if a configured validation is triggered. Validations shall include, but not be limited to, the following and Purchaser shall be able to edit the wording of each validation:

1.1. Topology Validations

1.2. (Opening) action will result in de-energization of XXX customers, or de-energized of priority YYY customer

1.3. (Closing) action will introduce a loop or parallel

1.4. (Closing) action will connect a live portion of network to a grounded portion of network

1.5. (Closing) action will cause a cross phasing between phase x and phase y

1.6. Regulators should be locked out at 124 volts before tying circuits

1.7. Recloser should be turned off before tying circuits

1.8. Action will separate section or loops

1.9. Recloser should be turned off before separating circuits

2. Violations
2.1. Action will cause an overload on line YY, …etc.
2.2. Action will result in an under-voltage condition
2.3. (Closing) action will connect portions of network where the calculated phase angle difference exceeds a threshold

3. Protection Violation
   3.1. Current ### will exceed overcurrent protection settings on device xxx

4. Tag Validation
   4.1. The action cannot be executed because the device has a xxxx tag (e.g. a DO NOT OPERATE tag)

5. Temporary Element Validation
   5.1. Jumper may not be placed on elements of different phases or voltages
   5.2. Ground may not be placed on energized portion of the network

6. The capability to configure individual conditions so that the authorized operator can go ahead with the action anyway shall be provided. Other actions, such as closing a switch between a live section of network and a grounded section of network, shall be blocked regardless.

7. The operator shall be able to execute Pre-Switching Validation prior to opening or closing a switch or breaker, and prior to introducing or removing a cut, jumper or ground.

8. The operator shall be able to invoke the Pre-Switching Validation function from within the context of the geographic diagrams, schematic diagrams, or substation one-line diagrams and from within the context of the Switching Order Management displays.

9. Purchaser requires the ability to develop custom validations for specific devices (not device types, just devices that have special considerations). For example, before opening a recloser with a key customer behind it the operator is triggered to verify that customer is notified (e.g. via a message in a dialog that appears when the operator attempts to operate the device). Purchaser does not want to use notes or tags for this functionality.
19.6.8 **Optimal Feeder Reconfiguration (OFR)**

1. The DMS shall include a fully integrated Optimal Feeder Reconfiguration (OFR) application that can be used to determine how the electrical connectivity between a user-selected set of radial feeders could be modified, by closing or opening tie switches and sectionalizers, in order to improve feeder performance. OFR shall automatically validate possible switching actions by using the Distribution Unbalanced Power Flow to solve the new configuration without changing the initial load conditions, and shall report any feasibility problems.

2. OFR shall allow both “instantaneous” solutions (e.g. that minimize the real power (kW) loss at a point in time) and “time period” solutions (e.g. that minimize the total energy (kWh) loss over a user-selectable period of interest that may extend over a few hours or up to one week).

3. The OFR application shall be available in:
   
   3.1. Real-time mode, to make instantaneous recommendations or for the next hour starting with the current network topology and expected loading
   
   3.2. Study mode for longer periods of time and for future network topologies and expected loading.

4. The OFR application shall support several user-selectable objectives including, as a minimum, the following:
   
   4.1. Minimize the real (technical) instantaneous power or energy over the period selected by the user
   
   4.2. Maximize the spare capacity of the feeders by minimizing the highest device loading as a percentage of the operational limit of that device for all devices in the network; for feeders with similar construction this will generally be the same as balancing the feeder peak loading
   
   4.3. Remove of specific constraint violations
   
   4.4. Balance the load among supply substation transformers.

5. The user may select either one of the objectives or a combination of the load balancing and loss minimization objectives with a weighting factor for each. OFR shall run in real-time mode or study mode.
6. The OFR application shall allow the user to specify, for “time period” solutions, the time-step size that OFR shall use when evaluating network losses over the period.

7. OFR shall also support user-specified solution parameters for the minimum power/energy savings or the minimum percentage spare capacity gained from reconfiguration. Individual close/open switching pairs that produce less than the specified minimum gains shall be automatically excluded from the recommended list.

8. OFR shall be capable of satisfying the following constraints:

   8.1. Voltages within operating limits
   8.2. Feeder currents within operating limits
   8.3. No operation for switches in the control-inhibit state
   8.4. Transformer variables within operating limits
   8.5. No de-energization of Purchaser load.

9. OFR shall produce a series of switching pairs (Close X and Open Y) and shall present this information along with the impact (e.g. expected power or energy gained compared to the current configuration) to the operator.

10. OFR shall consider only remotely controllable switching devices. OFR shall not consider controlling devices if they are otherwise not available for control (e.g. if the corresponding point has bad data or in the presence of a Do-Not-Operate tag).

11. OFR shall execute automatically on a selected set of substation or feeders; the set of substations and feeders shall be selectable by the authorized operator.

12. The operator shall be able to request that the selected switching pairs be executed directly via the SCADA. Alternatively, a formal switching order (comprising one or several switching pairs) shall be generated by the OFR function; the plan shall be viewable via the Switching Management User Interface. The switching order shall be executed automatically or step-by-step following the procedures of the Switching Management function (refer to Section 19.7 Switching Management System (SMS)).
19.6.9  **Fault Level Analysis (FLA)**

1. The Fault Level Analysis (FLA) application shall analyze the Purchaser’s MV power system and calculate the three-phase voltages and currents that would result in the event of a postulated fault condition.
2. An individual user shall select the location where the fault shall be introduced. The user shall be able to select whether to introduce a phase-to-ground, phase-to-phase, or three-phase fault. The user shall also be able to specify a zero pre-fault current (flat voltage) condition or actual pre-fault current conditions.
3. When executed in study mode, the capability to present the results of an FLA execution (in terms of flows and voltages) on the geographic of schematic displays shall be provided.
4. The FLA function shall calculate and compare fault currents against applicable transformer, feeder, and switch operating limits and produce a list of violations.
5. Ability to perform fault calculation for all types of faults. Calculations for all types of faults shall be run for a user specified location within the same execution.
6. All types of fault calculations for all segments of selected feeders.
7. User ability to select which standard to be used in calculations (ANSI or IEC); Purchaser will select ANSI/IEEE
8. User ability to select a function to calculate impedance on the fault location.
9. User ability to configure distributed generation to exclude fault contributions from fault calculations by specifying a minimum kW threshold.
10. The system must display fault currents on the geographic view

19.6.10  **Distribution Circuit Fault Location (DCFL)**

1. The Distribution Circuit Fault Location (DCFL) function shall have the ability to detect, in an expeditious and reasonably accurate manner, the presence of feeder faults. DCFL shall be designed to react appropriately to “looped” distribution circuits (fed from multiple sources).
2. The ability of DCFL to recognize a fault condition shall not depend on the particular type of fault that has occurred, such as phase-to-ground or phase-to-phase. Nor shall DCFL be restricted in the event that faults occur on one or more feeders within a short period of time. The ability to handle multiple nearly simultaneous faults of different types, on multiple feeders, shall be provided.
3. Fault location(s) shall be predicted based on the following general concepts:

3.1. When a fault occurs, the fault current per phase shall be measured and reported to the system for processing. Alternatively, the fault currents may be entered manually.

3.2. The DMS shall perform an “appropriately scoped” short circuit study to determine all possible locations that could result in the measured fault current. This “short list” of potential locations (based on fault current) shall be represented visually on the circuit display(s) and ranked by probability (most likely first).

3.3. DCFL shall be capable of checking the fault indication points from Fault Indicators and relay trip indications to determine the line section where the fault has occurred. When there are multiple fault indications they shall be checked for consistency, i.e. all indications upstream of a fault shall be set and all downstream indications shall not be set. Any inconsistencies shall be reported to the operator as an alarm and no further analysis or recommendation shall be performed. After the faulted section has been located, DCFL shall issue an event message that identifies the faulted feeder section and the faulted section shall be distinctively highlighted on network displays. Field reports of manual FCIs.

3.4. Where it is available, DCFL shall be able to use telemetered positive and zero sequence fault impedance data from digital relays. DCFL shall determine the likely location of the fault on the feeder based on the feeder impedance model in the DMS, considering possible non-uniform feeder construction along its length. When there are multiple possibilities on different branches of the feeder DCFL shall identify all possibilities, and highlight them on graphical displays of the feeder. When both telemetered fault passage detector data and relay impedance data are available, DCFL shall advise the operators of inconsistencies between the two sources of data.

4. DCFL functionality shall not be dependent on any status change experienced by the substation feeder breaker, but can be triggered by FLISR to perform fault location when a device status changes. The objective is to help the Purchaser reduce event analysis and location time. The DCFL shall be able to be performed at all feeder circuits.

5. It is anticipated that the DCFL will identify multiple locations that meet a given data profile. Fault analysis shall be done internal to the DCFL. The fault location shall use the DOMS
data model. This model includes connectivity, switching devices, switch status, and power system parameters required to execute the fault analysis.

6. Users shall be able to disable the DCFL (i.e. stop sending/receiving fault data) with a single action when conditions warrant.

**19.6.11 Safety Tagging**

Safety tags are conditions applied to database values in order to call the users’ attention to exception conditions for field devices and to inhibit supervisory control actions.

1. The system shall support 32 safety tag types and 16 safety tags to be set on an individual point. The safety tag types shall be ordered by the Purchaser to indicate its relative priority to other types. The safety tag types and all of their characteristics shall be defined by the Purchaser to correspond with the field device-safety tagging scheme.

2. Examples of Purchaser safety tag names are as follows:

   2.1. Danger/ Hold (do not operate)
   2.2. Information
   2.3. Damaged
   2.4. Ground

**19.6.11.1 SAFETY TAG APPLICATION**

1. The user shall be able to create a safety tag on system one-line displays and tag summary displays for any SCADA data point, both telemetered and calculated/pseudo. The selected device shall be highlighted on the display. The user shall be required to enter, for each safety tag, the following information:

   1.1. Mandatory – Safety tag type (defaulted to “Do Not Operate”, but selectable from a pull-down list)
   1.2. Mandatory – Order number/Clearance number
   1.3. Optional – Comment - As part of the safety tag placement process, the system shall prompt the user to enter alphanumeric comment information to be stored with the safety tag (80 characters). The comment field shall be included in the event messages recording the addition or removal of a safety tag.
2. And the system will automatically fill in the following information:
   
   2.1. Date and time of safety tag placement, supplied by the system at time of operator entry
   2.2. Point identification (supplied by the SCADA)
   2.3. The user ID of the user applying the safety tag, supplied by the system

3. Tag Summary shall include Clearance Number

4. The system shall retain a copy of all changed data so that the data can be retained on a cold start or incorporated into a new database at the option of the user.

5. Each safety tag shall be presented on a safety tag summary display listed by AOR with an alphabetical sort.

6. The capability shall be provided to edit and delete safety tags from this display.

7. Safety tag application, all safety tag changes (e.g., safety tag comments), and removal shall be recorded as events.

8. An indication shall be provided that multiple safety tags are associated with the device.

9. Selection of the device safety tag shall bring up the safety tag summary display. There shall also be a separate summary, or a separate tab, that includes the historical information of all tags placed or removed. Both summaries shall be searchable and filterable by Order number/Clearance number, feeder, device, comment, user, date, etc.

10. The system shall include the capability to enter and edit multiple safety tags simultaneously by selecting the data points and entering the data common to the set of safety tags.

### 19.6.12 Fault Location, Isolation and Service Restoration (FLISR)

The objective of the Fault Location, Isolation and Service Restoration (FLISR) application is to improve Purchaser service to its customers by minimizing the duration and extent of forced outages due to faults in the MV network.

1. FLISR shall automatically detect the presence of faults and propose actions to isolate such faults and to restore service to as much of the affected load as possible.

2. It is Austin Energy’s intention to use FLISR in an “open loop” operation initially. However, the system proposed shall be delivered fully capable of “closed loop” operation. Because initial configuration will be for “open-loop” operation, this specification’s requirements are
generally written in that context. Where applicable, all requirements listed shall apply to 
“closed loop” operation as well.

3. FLISR shall have the ability to detect the presence of permanent (vs momentary) substation 
and MV feeder fault conditions (via DCFL). DCFL shall make use of telemetered data from 
circuit breakers, line reclosers, and associated relays and from fault indicators at feeder 
remote-controlled switches to determine fault location. FLISR shall be capable of monitoring 
circuit breaker and line recloser operations. This shall include discrimination between 
authorized open commands and unauthorized trip commands and the determination of 
lockout conditions. If the tripped breaker has an automatic reclosing relay, but the lockout 
state is not telemetered, FLISR shall wait for a pre-programmed delay to ensure lockout has 
occurred. The pre-programmed delay shall be a device attribute.

4. In the case of a permanent fault on an MV feeder section, FLISR shall automatically analyze 
the available data, determine alternative power source availability based on current load 
conditions, protection parameters, historical information, etc., and recommend the actions to 
take in order to:

4.1. Develop both “upstream” and “downstream”, tiered restoration solutions (switching 
instructions) as follows:

4.1.1. Tier 1 - a solution that involves only the currently available, telemetry 
(remotely) controlled devices

4.1.2. Tier 2 - a solution that involves all switchable components – both local 
(manual) and remote

4.2. Once restoration solutions have been developed they shall be either:

4.2.1. Presented to the operator for review / modification and subsequent manual 
execution (open loop operation). The operator may select individual 
switching steps or the presented order in whole as desired for execution.

4.2.2. Automatically executed (closed loop operation).

5. In this way, the long-term effect of the outage shall be limited to only those customers on the 
faulted section.

6. The results of FLISR execution for a given fault shall be provided to the operator including:
6.1. The list of actions to isolate the fault, including switching and tagging
6.2. The list of actions to restore the un-faulted portion of network, including switching and tagging
6.3. An estimate of the amount of load (pre-fault) that will be restored should the recommended restoration action be implemented
6.4. When initiated by operator, execute total or partial load restoration (per device, MW load, step/stage, substation, area, or group)
6.5. If a FLISR load transfer recommendation would cause a line recloser or line/recloser regulator to be “back-fed”, the report shall include a special warning message.

7. FLISR shall produce a series of switching operations (Open X, Close Y, Close Z, …etc.) and shall present this information along with the impact (e.g. expected power or energy gained compared to the current configuration) to the operator.

8. FLISR shall not consider controlling devices if they are otherwise not available for control (e.g. if the corresponding point has bad data or in the presence of a Do-Not-Operate tag).

9. FLISR shall execute manually or automatically. The set of substations and feeders on which FLISR is to execute automatically shall be selectable by the authorized operator.

10. The operator shall be able to select whether FLISR considers only SCADA-controllable devices or a mix of SCADA-controllable and manually operated devices. By default, FLISR shall consider a mix of automated and manual devices. The set of substations and feeders on which FLISR is to consider only SCADA-controllable devices shall be selectable by the authorized operator. The operator shall also be able to trigger initial execution of FLISR such that it considers only SCADA-controllable devices in a first pass, in order to isolate and restore as quickly as possible; the operator shall then be able to trigger a second-pass execution of FLISR to consider a mix of devices in order to further isolate the faulted device and further restore de-energized customers.

11. In the case of substations/feeders where SCADA-only control has been selected, the operator shall be able to request that the selected switching sequence be executed directly via the SCADA. In the case of both SCADA-only and mixed-device control, the operator shall be able to request that FLISR generate a formal switching order; the plan shall be viewable via the Switching Management User Interface. The capability to configure, on a substation/feeder basis, whether the switching order should be executed automatically
available only if the switching recommendation contains only SCADA-controllable devices) or manually step-by-step, following the procedures of the Switching Management function shall be provided.

12. FLISR shall be composed of sub-functions as follows: 1) Fault Location, 2) Isolation, and 3) Service Restoration. The operator shall be able to define profiles, enabling or disabling each sub-function, then assign the appropriate profile to each feeder. For example, they could develop a profile for feeders with no remotely controllable devices that only has the Fault Location sub-function enabled and assign it to all such feeders.

13. The FLISR Fault Location sub-function relies on the Distribution Circuit Fault Location (DCFL) function to locate faults.

14. The FLISR Fault Isolation and Service Restoration sub-functions (two separate sub-functions) shall include the following characteristics:

14.1. FLISR shall isolate line faults by opening any available line recloser or load break switches that may be necessary.

14.2. FLISR shall take into account:

14.2.1. Consideration of future loading (minimum of 6-hour window) of the network as well as current loading when analyzing the impact of switching operations.

14.2.2. Equipment ratings

14.2.3. Protective equipment settings

14.2.4. Alternative protective equipment settings (where available)

14.2.5. Current tags placed

14.2.6. Not dropping customer load

14.2.7. Limiting overloads

14.2.8. Secondary transfers to non-adjacent feeders when there is insufficient capacity

14.2.9. Minimizing switching actions

14.2.10. Taking into consideration priority when determining which loads can be de-energized
14.3. All tiered restoration solutions shall be ranked (based on “expected results”) and presented to the operator. The system shall rank “expected results” based on individually weighted factors such as:

14.3.1. Quantity of meters restored
14.3.2. Quantity of load (as modeled) restored
14.3.3. Designated critical loads

14.4. FLISR shall be capable of determining the switching actions that can be used to restore power to all healthy feeder sections that are de-energized by the power system’s protective devices. The following factors and priorities shall be considered when FLISR determines the "best" load restoration strategy:

14.4.1. FLISR shall not cause any new overloads or voltage limit violations beyond a percentage tolerance specified by the operator. Each restoration strategy shall be tested via a load flow execution to check for resulting limit violations. The operator shall be able to select which SCADA limit set (operating, long term emergency, or short-term emergency) should be used by FLISR.

14.4.2. Where possible, FLISR shall propose switching to restore an entire de-energized island. If not, FLISR shall propose switching to split the island into two or more smaller islands and restore each via a different tie-switch. When only partial restoration is possible, FLISR shall first try to restore all high priority loads, followed by restoring as much load as possible.

14.4.3. FLISR shall try to use a minimum number of switching actions.

14.4.4. If possible, FLISR shall transfer the load to a feeder from the same substation. If not, it shall then consider load transfers to feeders from other substations.

14.4.5. FLISR shall normally search for switching actions that will transfer load to only immediately adjacent feeders. However, if this is not possible without overloading the adjacent feeders, the operator shall be able to request FLISR to also consider possible load transfers to more distant feeders.
14.4.6. FLISR shall normally determine recommended switching actions independently for each de-energized island. However, when multiple simultaneous de-energized islands exist, the operator shall be able to request FLISR to find switching actions that will restore several islands at the same time.

14.5. Suspension of Automation - At all times, the operator shall have the ability to suspend (block) any and all automated execution of telemetry based control actions through minimal UI interaction. The operator shall be able to activate or de-activate automated controls in defined areas as follows: 1) System wide, 2) Per Substation, 3) Per Feeder, and 4) Per Device. The operator shall also be able to apply SCADA tags on switch devices to prevent FLISR from considering switching those switches.

14.6. FLISR shall be capable of estimating and displaying the total load and load points that are expected to be restored following each recommended control action.

14.7. The operator shall have access to an interactive environment (Study Mode) to investigate the impact of alternative restoration strategies prior to the operator's actual execution of a final restoration control sequence. This shall include comparisons such as line loadings, voltage profiles, load restoration levels, system losses, and number of affected customers, as well as modification of FLISR parameters, application or removal of tags on switching devices followed by a re-execution of FLISR to determine a different recommendation.

15. The operator shall be able to request FLISR to recommend actions to restore an outage. After field crews have repaired the faulted section, the operator shall be able to request FLISR to determine the switching actions to return the network to its pre-fault or normal state. If there were load transfers to adjacent feeders, the operator shall have the option of returning those loads back to their pre-fault feeder without de-energizing them (close first, then open) or allowing a temporary de-energized state (open first, then close) to avoid potentially dangerous loop flows. When FLISR determines the return to pre-fault condition switching actions, it shall check that none of the switches was operated by a different FLISR fault condition. If so, an alarm shall be issued and the operator shall be requested to approve the proposed switching or to manually perform alternative switching.
16. To avoid potential difficulties during severe storm conditions, the operator shall be able to suspend FLISR restoration capabilities by activating a single control point.

16.1. Otherwise, FLISR shall continue to operate for fault detection and isolation purposes.

16.2. The operator shall be able to resume FLISR's normal operation by deactivating the “storm-mode” control point.

16.3. When this occurs, FLISR shall be ready to detect and make recommendations for isolating faults following the next outage event.

17. FLISR shall be capable of distinguishing substation and/or transmission related faults (that cause loss of outgoing feeder voltage) from distribution faults.

18. If FLISR monitors a continuous loss of feeder supply beyond an operator - adjustable time interval, FLISR shall determine the switching orders that can be used to reconfigure available tie-switches to connect the de-energized feeders to alternative energy sources, such as other substations and/or feeders.

19.6.13 Location of Open Conductor Faults

1. The basic algorithm shall involve searching for a combination of zero current values and unbalanced non-zero voltages.

2. Once an open conductor fault is detected, an event message shall be issued to notify the operator, it shall be identified in the incident list, and the presence of the open conductor shall be clearly identified on relevant sections of the associated feeder as shown on one-line power system displays.

19.6.14 Location of Downed Conductors

1. The ADMS shall include an application that tries to predict the location of downed conductors based on outage information and having ADMS initiate pings of the closest downstream meters on two different transformers on each phase.

2. If the AMI meter downstream from a predicted device shows voltage, an event message shall be issued to notify the operator, it shall be identified in the incident list, and the presence of
the downed conductor shall be clearly identified on relevant sections of the associated feeder as shown on geographic and schematic displays.

3. This check would occur only for above ground circuits.

19.6.15  **Model-based Integrated Volt/Var Control (IVVC)**

1. The Contractor shall provide an integrated Volt/Var Control (VVC) application. VVC shall determine the control actions to be taken in order to achieve better network operations. Specifically, IVVC shall support the following objectives and IVVC can be scheduled to run on the same feeder with different objectives at different times (e.g. configure by user to run with a minimize power consumption objective from 4:00p to 6:00p and minimize losses from 10:00p to 6:00a):

   1.1. Minimization of MW losses
   1.2. Maximize Penalty Factor
   1.3. Emergency Voltage Reduction
   1.4. Minimize Power consumption
   1.5. Minimization of total Mvar demand (emergency var support)
   1.6. Minimize voltage deviation
   1.7. Minimize medium voltage deviation

2. Possible control actions shall include the following (these devices shall utilize a heartbeat concept of sending timer override signals periodically):

   2.1. Shunt capacitor bank switching
   2.2. Adjustments to transformer tap positions (via set points)
   2.3. Adjustments to line recloser/regulator tap positions
   2.4. Line recloser/regulator automatic voltage regulation (AVR) set points
   2.5. VAR support from smart inverters (via set points)

3. IVVC shall consider only SCADA-controllable devices.

4. IVVC shall be capable of satisfying the following constraints (individually or a combination of the constraints):
4.1. Maximum and minimum limits on voltage magnitudes at the secondary side of MV/LV distribution transformers.

4.2. Maximum and minimum limits on voltage magnitudes at the primary side of the MV/LV distribution transformers.

4.3. Maximum current or KVA flow limits on HV/MV transformers, line recloser/regulators, overhead and underground feeder sections, and switches.

4.4. Maximum and minimum limits on Power Factor at the high side of the substation transformer.

4.5. Voltage Imbalance within a user-defined percentage.

5. IVVC shall execute in closed loop mode automatically in real-time at regular intervals (typically every 15 minutes) definable by the operator or on-demand in open loop mode. IVVC shall execute automatically on a selected set of substation or feeders; the set of substations and feeders shall be selectable by the authorized operator.

6. The operator shall be able to prevent IVVC from considering control of individual capacitors, transformers, or line recloser/regulator devices.

7. In the case of equal-sized parallel capacitor banks in substations, VVC shall give preference to operating the bank with the lowest operation count to keep the number of operations of each bank reasonably balanced.

8. Summary of Achieved Benefits report – Shows Daily, Monthly, and Annual shall include the following data:

   8.1. Injected kWh
   8.2. Injected kVArh
   8.3. Power Factor
   8.4. Consumption kWh
   8.5. Losses kWh
   8.6. Consumption kVArh
   8.7. Losses kVArh

9. Dashboard for IVVC that indicates any problems detected by IVVC – such as low voltage violations, power factor violations (outside of .96 lag and .96 lead), shows AMI events,
shows graphically how IVVC is affecting the feeders, shows (for example, in a bar graph) IVVC calculated voltage settings versus current setpoints, etc.

10. The maximum number of operations per day per device type shall be Purchaser configurable.

11. IVVC should utilize Bellwether meters as follows:

   11.1. Periodically provide voltage sag and swell messages. IVVC shall immediately adjust behavior based on these messages.
   11.2. Periodically provide voltage from a sampling of up to 10,000 meters that provide voltage measurements every minute. IVVC shall immediately adjust behavior based on these messages.

12. The user shall be able to selectively enable or disable IVVC based on:

   12.1. Individual device (capacitor bank or voltage control).
   12.2. Feeder.
   12.3. Substation power bank (group of feeders sharing a source transformer).
   12.4. Substation.
   12.5. System wide basis.

13. IVVC shall utilize unsolicited meter voltages, sag messages, and swell messages obtained from the AMI to control how the Load Tap Changer (LTC) is set.

14. Voltage limits will be set by user in the service location (parent child relationships).

15. After executing controls, IVVC shall automatically poll meters for voltage verification that expected results were achieved.

16. State estimation calculated data quality shall be used to determine if closed loop IVVC can be run. If state estimator calculates a bad quality for any measured value, IVVC shall not be executed for that feeder.

**19.6.16 Rule-based IVVC**

1. The user shall be able to perform IVVC utilizing only AMI measurements without utilizing model-based estimates.
19.6.17 Closed Loop Readiness

1. Model readiness functionality to evaluate the state of every feeder to grade each feeder and indicate whether each feeder is modeled well enough to be used for closed loop operations of advanced applications listed below:

   1.1. IVVC
   1.2. FLISR

2. The user shall have the ability to rank the criteria that are used to score the feeders closed loop controllability on a scale from 1 to 10, 10 being the best score.

19.6.18 Protection Coordination

1. The Protection Coordination application shall use the system characteristics in the ADMS-SCADA model to analyze and assure proper coordination between the protective devices (relays, reclosers, fuses, etc.) on the entire feeder (e.g. the application shall identify all devices that do not coordinate with each other within a given feeder.). Information such as the curves associated with the devices and available short circuit current shall be the basis for the coordination; the software will analyze this information, identify areas of potential problems and guide the user in recommended changes for proper coordination.

2. Display a Summary Relay Protection Report, including all types of equipment, per Purchaser requirements. This must be exportable.

3. Display mis-coordination of fuses on a report that is also exportable.

19.6.19 Under-Load Switching

1. The ADMS shall include an Under-Load Switching function that simulates the process of under - load network reconfiguration load transfer and recommends possible solutions for this operation. The goal of reconfiguration is to transfer load of one feeder (or its part) to another through a normally open tie switch, without interrupting supply of any consumer on both feeders.

2. The ULS application shall be used in situations when changing configuration of the network without interrupting supply of the customers is required. These situations involve making a network loop (parallel) between different feeders, supply transformers or sources. Such
operation shall be allowed only temporarily, since the network is designed to run in radial operation. In some cases, loop currents can exceed rated values of equipment and cause overload protection to trip. In addition, they can exceed breaking capacity of switchgear within the loop. In these cases, it is not sufficient to know voltage differences across tie points, but the capability to simulate closing of that switch and calculating the corresponding currents of interconnected feeders shall be provided. These currents depend on both the equivalent impedances of the feeders and transmission network seen from the considered tie switch.

3. In some situations, 2 supply substations may be mutually meshed via transmission network. In this case, it is possible that ‘loop current’ is of large value, which can cause unnecessary tripping of overcurrent relays causing a larger scale outage. The loop current occurs due to difference in transformer ratios within the mesh (loop) or due to difference in modules and/or angles on HV bus bars (if they are parts of the loop, the loop is closed through transmission network).

4. The application shall be used for simulation of under-load switching process in advance, to check the possibility to perform the switching in the field.

5. The capability shall be provided to simply apply it to any other state selected from saved cases.

6. Results of the calculation shall include critical current for the most critical element in loop, feasibility, current and voltage feasibility, critical voltage for the most critical element in loop, positions for tap changers, elements (element with critical current or voltage in network), relay protection (indicates whether the current exceeds bounds of relay limits) and number of tap changes.

19.6.20 Energy Losses (EL)

1. The ADMS shall include an Energy Losses (EL) application that computes the power/energy losses in the entire distribution (MV) radial or weakly meshed, balanced or unbalanced network, or its parts, for specified network state and configuration, for a pre-configured time period based on Distribution Power Flow values.
2. EL shall provide an assessment of system as well as particular technical power/energy losses for substations, feeders, as well as on all network elements, and their participation in total losses.

3. The application shall identify and highlight the most critical parts of the network regarding energy losses.

### 19.6.21 Large Area Restoration (LAR)

1. Large Area Restoration provides higher efficiency of restoration procedure after an unplanned fault occurrence and, in this way, decreases the interruption time. The re–supply is performed taking into account the priority of customers and enables two important goals: 1) re–supplying of high priority customers first; and 2) reducing costs of non–delivered power/energy.

2. Depending on the size and importance of distribution network which is affected by a contingency, the restoration process itself has to be adjusted. Large Area Restoration determines the switching plan for restoration supply of large parts of the distribution network, which remained de–energized after a fault occurrence on a supply transformer (HV/MV transformer) or MV busbar in a supply station (HV/MV station) or after isolation of an element for maintenance purposes in a supply station. The application provides the list of necessary switching actions for re–supplying de–energized parts of network.

3. The application enables an operator to take an active role in the preparation of a restoration plan.

4. In the case of a permanent substation fault, LAR shall recommend isolating the feeders from the substation and shall propose the most appropriate actions to restore power to all affected MV feeders by switching to alternative sources of power, as may be available by closing the substation’s bus-tie breaker or the feeder tie-switches that can be used to connect the feeders to other incoming lines, feeders, or substations. In this way, the effect of the outage shall be limited only to the time it takes to complete the required reconfiguration.

### 19.6.22 Operational Losses (OL)

1. The ADMS shall include an Operational Losses (OL) application that computes the power/energy losses in the entire distribution (MV) radial or weakly meshed, balanced or
unbalanced network, or its parts, for specified network state and configuration, for a user specified time period based on historical measured values.

2. OL shall provide an assessment of system as well as particular technical power/energy losses for substations, feeders, as well as on all network elements, and their participation in total losses.

3. The application shall identify and highlight the most critical parts of the network regarding operational losses.

19.6.23 Distributed Energy Resource Management

1. The solution shall deliver Distributed Energy Resource Management functions that shall monitor and dispatch Distributed Energy Resources (DERs) in the distribution network. Solution shall also be able to dispatch fleets of DER installations, e.g. through third party aggregators, to achieve various criteria such as peak shifting, PV smoothing, and others. DER management shall provide visibility into all distributed energy capacity and shall be able to request basic dispatching of all energy resources. The system shall monitor, in real-time, the data provided by distributed energy resources, forecast their output in near future (look ahead mode), detect hidden load and provide basic control. The capability shall be provided to easily locate DER in any view from a report. In addition, the capability to open/close the breaker between the DER and network or to adjust the DER’s set point shall be provided. The DER modeling in ADMS shall be based on synchronous, asynchronous machine models, double fed induction generators and static generator models connected directly to the network or via power electronic couplers. ADMS shall calculate renewable forecast and data regarding flexible load leverage network state calculation. Additionally, DER monitoring shall include monitoring of other energy resources like energy storage and electrical vehicle.

2. Hosting Capacity - the ability to run a study on the level of distributed energy resources on a per feeder basis, to see how much more distributed energy resources could be added before violations (overvoltage, overcurrent, etc.) started to occur. The result of the analysis would be a heat map shown geographically of the different amounts in active power that could be added at different locations along a feeder before those sections experienced violations. This application can be run on the whole system at once, or on a per feeder basis. In addition, the
application shall also have an option to add multiple specific size distributed energy resources and different points along the feeder and see if the results cause any violations (ex. Adding a two 500KW generators in the middle of the feeder and adding a 1MW generator at the tail end of the feeder and seeing if this causes any violations). The user shall also be able to easily compare to different heat maps previously generated.

3. The system shall be able to make recommendations of how to optimally control DER based on user-specified objectives.

4. The following functions shall be supported by the DER functions:

   4.1. Automated Large Area Restoration
   4.2. Automatic Load Relief
   4.3. Closed Loop Network Reconfiguration
   4.4. Control Logic Simulation
   4.5. Hosting Capacity
   4.6. Load Relief
   4.7. Long-term Planning
   4.8. Medium Term Planning
   4.9. Simulation Large Area Restoration
   4.10. Smart Meter Management Service
   4.11. Telemetered Auto Reclosing
   4.12. DER modeling, hidden load
   4.13. DER monitoring and control, forecast of renewables
   4.14. Simulation of load and generation scaling

19.6.24 Phase Balancing

1. The Phase Balancing application provides a recommendation of phase swaps that need to occur in order to balance the load by user-defined target imbalance percentages.

2. User can select to do this by amps, kVA, or kW.

3. User can select that the recommendations be based on current loading or historical loading.

4. User shall be able to balance at various points on the feeder (feeder head, feeder halves, feeder thirds, and feeder quarters).

5. The ADMS shall not give recommendations that violate equipment ratings.
19.6.25 **DMS User Interface**

19.6.25.1 **GENERAL FUNCTIONALITY**

The DMS functions require a highly interactive user interface that shall provide extensive user support. For the functions to be useful, the user interface shall be logical, convenient, and simple to use.

1. The user interface shall include configurable dashboards that enhance the situational awareness for the operators visually showing conditions of the distribution network.
   
   1.1. The dashboards shall take advantage of visualization techniques to show the power system conditions and status.

2. The user interface for all real-time and study DMS functions shall conform to the user interface requirements in Section 19.4 ADMS User Interface. Within this context, the general requirements of the user interface are summarized as follows:

   2.1. The Contractor shall provide a full set of displays to support all of the specified DMS Network Analysis functions.

   2.2. The capability shall be provided to display real-time SCADA and DMS Network Analysis results data simultaneously on the same display; however, they shall be distinguished from each other through color or appended symbols.

   2.3. Displays shall clearly differentiate between DMS Network Analysis real-time and study modes through color, display heading, and dynamic field indicators. For study mode, the indicators shall clearly identify the individual study case that is being displayed.

   2.4. The Purchaser shall have review rights with respect to the DMS Network Analysis user interface, including all displays, logs, printed outputs, messages, and alarms.

   2.5. The ability for the system to send an email(s) when a point goes into stale telemetry

   2.6. The ability to configure how long a point needs to meet a condition before an email is sent out

   2.7. The ability to configure messages to be sent out for multiple points based on type of point and naming convention rather than having to manually create messages criteria for each and every point.
2.8. The ability for the messaging application to configure the body of messages be generated based on attributes of the devices, timestamps, etc. rather than having to create a message body for each and every point.

2.9. Displays shall be available to support all functional capabilities in a convenient manner.

2.10. The user interface shall allow results to be printed in PDF as well as exported in Excel format to the CEU Environment.

2.11. There shall be a high degree of consistency among the DMS Network Analysis user interface displays with respect to naming convention, layout, appearance, look and feel, presentation, and user dialogue. Simple execution control procedures shall be provided.

2.12. All displays, error messages, alarms, logs, and reports shall be designed for use by users and, in this respect, shall be clear and concise.

2.13. The ability to turn off DMS generated alarms from only the low voltage network

2.14. The capability to present DMS Network Analysis input and output details on one-line diagrams shall be provided.

2.15. All input and output shall be in engineering units.

2.16. Displays shall be provided allowing users to easily modify any data, whether telemetered, non-telemetered, calculated, or obtained from a savecase, prior to the execution of any of the DMS Network Analysis functions.

2.17. Setup and execution of all DMS Network Analysis functions shall be made as simple as possible through the utilization of interactive, menu-driven execution control displays. The capability to execute individual study DMS Network Analysis functions in an interactive mode with a minimum amount of user input required. The capability to execute a series of study DMS Network Analysis functions with a single command shall be provided.

2.18. The system shall provide the capability to execute study functions without switching the console to a dedicated study mode. The console shall have the ability to operate in both the real-time and study modes simultaneously. Only one mode will be active at any given time. Switching between the two modes through windowing is acceptable.
2.19. All execution control and output displays of the real-time DMS Network Analysis functions sequence shall show when the real-time data was collected.

2.20. All functions shall provide indications of execution progress and completion.

2.21. Each function shall provide messages of error conditions, inconsistent data, or significant events that may occur during execution. For messages related to real-time mode, the messages shall be sent to those consoles with the appropriate assigned area of responsibility. For messages generated from functions running in study mode, the messages shall be sent to the console from which execution of the function was requested. The messages shall be understandable by the user and shall be “actionable”, meaning that they shall indicate clearly what action needs to be taken given the circumstance encountered. The user shall not be exposed to messages that are meant for programmers or support personnel.

2.22. Data entry capability shall be provided via tabular displays, circuit diagrams, and one-line diagrams. Users shall be able to enter typical power flow inputs, such as individual loads, generation values, device status values, transformer tap positions, and desired voltages on one-line diagrams for use by the DMS Network Analysis functions. The user shall also have the capability to change power system operating limits in study mode. All modified data shall be saved with the savecase.

2.23. All displays shall clearly differentiate between metered data and data calculated by the DMS Network Analysis functions or any other function.

2.24. Where identical one-line and circuit diagrams and tabular displays are used for different functions (e.g., DPF, DSE, etc.), it shall only be necessary to build these displays and specify linkage names once.

2.25. User-oriented messages related to equipment shall refer to the equipment by substation and equipment name.

2.26. Maintenance displays shall be available to provide control of convergence tolerances, step sizes, and all other parameters affecting execution of the DMS Network Analysis functions.

2.27. All solution results must be limit checked and violations highlighted by providing separate tabular displays for each type of violation using standard conventions described in Section 19.4 ADMS User Interface.
Control and monitoring of the DMS Network Analysis functions shall occur at consoles with appropriate authorization as determined by their operational responsibility assignments.

A convergence summary display shall be provided for all iterative functions. For each iteration, this display shall identify the buses with the largest MW and Mvar mismatches and/or voltage angle and magnitude changes. In case of a divergent solution, the display shall also provide information regarding the network area (or buses) where the calculation process is encountering divergence (or difficulty in solving) in order to help the user correct the problem.

Detailed debug information on an iteration basis shall show, for example, matrix values, bus voltages, and generation outputs. This information shall be available to the user in a readable format for the purpose of investigating divergent cases and other solution problems. Debug information shall only be generated when specifically requested by the user.

The displays associated with the DMS Network Analysis functions, whether tabular displays or one-line diagrams, shall provide context-sensitive help.

On the geographic display, there shall be visualization/symbology for AMI meters showing under and over voltage (as calculated by IVVC)

**DMS Study Mode**

**STUDY ANALYSIS EXECUTION MODE**

1. In the study mode, programs shall be executed on user demand to analyze current, past, and future power system conditions.
2. The following study network analysis functions shall be provided:
3. Study Case Initialization
   3.1. Distribution Unbalanced Power Flow Study (DPF)
   3.2. Study Distribution State Estimation (DSE)
   3.3. Fault Location Isolation and Service Restoration (FLISR)
   3.4. Integrated Volt/VAR Control (IVVC)
4. Operators shall have the capability to easily initiate or cancel studies at any time.
5. Given the AOR authority, the study sequences can be terminated.

6. A study sequence execution control display shall be provided, which shall allow the operator to control study setup (including easily selecting groups of adaptive parameters for initialization), sequencing, and execution, and which shall show study completion as well as the occurrence of error conditions.

7. If a study is canceled, the execution shall stop as soon as possible and no database areas shall be corrupted with inconsistent data.

8. A canceled study shall be re-executable with no adverse effect on the results.

9. The control of each study function shall be totally independent of the real-time version, and each study function shall have execution and tuning parameters that can be adjusted independently of the real-time functions.

10. Study network analysis functions, except where noted for a specific study function, shall not generate any real-time alarms due to detected violations or solution failures; these types of conditions shall be available on solution results and diagnostic displays.

11. The capability shall be provided to initialize a study base case using information available from:

   11.1. The most recent complete state estimator solution:

      11.1.1. A study work area can be initialized to either the latest DSE solution of real-time or to the equipment default values on a global basis

   11.2. Distribution Unbalanced Power Flow study savecases

   11.3. Distribution State estimator savecases

   11.4. Real-time SCADA data (Applicable to study Distribution State Estimator only).

   11.5. Normal state for all devices. Devices without a normal state shall be defined as open

12. By specifying a date and time, the base case for the given date and time shall automatically be constructed using data from the parameter adaptation function.

**19.6.26.2 STUDY WORKING AREAS**

1. Multiple users with multiple independent working areas shall be supported.
2. Each user shall have an individual working area, which shall be used as a temporary location to gather information needed to run a study, modify the data as needed to represent the desired study conditions, and temporarily hold the study results.

3. Modifications made by a user in the user's working area shall not affect the source of data or any other user's working area.

4. When a saved case is moved to an individual’s study working area a new working case will be created to minimize interference with use of the cases saved in the savecase library.

5. Upon retrieving a savecase, the user can manually change the study case title in order to make the test case unique before storing it into another savecase. Interaction between users shall only be through permanent savecases. It shall be possible for multiple users to simultaneously prepare input cases, execute programs, and examine the output.

19.6.26.3 SAVECASES

1. Savecases can be created from within real-time, simulation, or study mode and be reusable by all study and distribution planning applications.

2. The savecases generated and used by different applications may be significantly different in structure and content.

3. However, the following characteristics shall be present in all savecases:

   3.1. The saved information shall include all input and output data, as well as all information needed to identically reproduce the output by rerunning the application.

      3.1.1. Where necessary to meet this requirement, it must be possible to revert to previous models if the model has been changed subsequent to the original execution of the application.

      3.1.2. The original savecase can be retrieved again to revert to the previous study case.

   3.2. Savecases shall be stored in a library.

      3.2.1. The library shall be sorted by application (or separate libraries may be supported for each application) and by date and time.

      3.2.2. Filtering will be supported via general HMI capabilities
3.3. Each savecase shall include the following information: the name of the application, the time and date the savecase was produced, a 50-character user-entered title, and a user-entered comment field of at least 512 characters.

3.4. Savecases may be copied and moved to archive media and restored from archive media to the savecase library.

3.5. A locking mechanism shall preclude deletion from the library.

3.5.1. The lock shall be set and removed by any user.

3.6. Capability to merge new model updates into the existing savecases to the extent possible to allow each savecase to reflect the new on-line production system model.

4. Savecases shall contain all information needed to describe the distribution system at the time it was saved.

5. This includes not only data normally considered as dynamic, such as system load, switching device statuses, and generating unit limits, but also a full definition of the network model (node level connectivity and electrical characteristics).

6. Savecase information shall be sufficient to execute a study for a previous network model and generation schedule, even after a database change of any of this data.

7. Savecases shall be accessible by all users.

8. A user-selectable locking mechanism shall be provided to prevent users from inadvertently purging, overwriting, or modifying specific savecases.

9. Savecases shall not be lost on a database update. It shall be possible to copy savecases to permanent storage medium and to reload savecases from permanent storage medium.

19.7 Switching Management System (SMS)

19.7.1 Switching Order Management

A switching order is a list of actions which reflect a utility’s procedures when performing switching on the power system.

1. The Switching Management System (SMS) shall support the manual creation, automatic creation, validation, modification, execution, archival and printing of switching orders for both the Transmission Network and the Distribution Network.
2. It is not uncommon for a Switching Order to be used to commission, decommission or alter the physical connectivity of equipment in the field. In such cases, both the network model (network connectivity, operational designations and attributes of equipment) and the operating diagrams may change as the Switching Order is executed.

3. The SMS shall function correctly if equipment is added or deleted, or if connections or operational designations change. The capability shall be provided to prepare a Switching Order and to create one or many “patches”; a patch is a sequence of steps that may reference sites, devices and connectivity that are yet-to-be-commissioned (future network) and/or modified and/or decommissioned.

4. A Switching Order shall be prepared using either the current, normal or scheduled (at a future point in time) state and configuration of the network model. The scheduled state of the network shall be able to include the effect of other planned Switching Orders and, where necessary, ‘future’ network equipment which may be commissioned because of the implementation of the Switching Order.

5. Once the switching order has been defined, the operator shall be able to execute it in real-time mode and in study mode. Execution in study mode shall allow the user to verify the Switching Order's potential impact on the power system prior to actual execution and shall allow ‘patches’ to be applied in study mode, using designations and connections to equipment that, at the time, are still only proposed or will be changed as part of the Switching Order with correct “before” and “after” network analysis.

6. After a switching order has been created, the user shall be able save it and export it in PDF and MS-Excel in a compressed or fully expanded format – depending on how the user is viewing the switching order when requesting it to be saved. The compressed format shall minimize the number of pages by including only populated fields, while the expanded format includes all fields (whether populated or not).

7. The solution shall provide the user with the ability to edit a switching operation(s), insert operation on a desired position, link multiple switching plans, and add PDF and Multimedia attachments. Additionally, the user shall be provided with switching plan macros (templates).

19.7.2 Switching Order Life Cycle

1. The SMS shall support a switching order life cycle.
2. The switching order life cycle shall be configurable by Purchaser using graphical flowchart-style drag-and-drop functionality and shall consist of a sequence of switching order states or stages such as (and not limited to) Submitted (Proposed), Scheduled, Prepared, Checked, Rework, Authorized, Rejected, Postponed, Active, On-hold, Terminated, Completed, and Archived.

3. The capability to associate different user privileges with different state transitions, in order to control who can change a switching order from one state to the next, shall be supported.

4. Similarly, the capability to associate privileges with the different states of a switching order, as a means of controlling activities such as switching order preparation, shall be supported.

5. The capability to configure two different switching order life cycles, one for Transmission switching orders and one for Distribution switching orders shall be provided.

6. The capability to configure different switching order life cycles for planned vs unplanned switching orders shall be provided.

7. As a switching order makes its way through its life-cycle, all changes to the life-cycle state shall be tracked in terms of whom and when for audit purposes. The log of these events shall be accessible to users and shall be searchable and filterable by at least the following: time stamp, user name, AE ID, and message (description of what changed).

8. There shall be a historical summary of Switching Orders. When viewing the historical summary, the capability shall be provided to search, sort, and filter by at least the following: “AE ID”, “feeder/equipment”, date, substation, “approved by”, “created by”, description, “field crew”, and “assigned to”.

19.7.3 Content of a Switching Order

1. Each switching order shall comprise a cover sheet, header and a body.

2. The cover sheet is used to track the internal steps and approvals required to create a Switching Order.

   2.1. Cover Sheet fields shall be accessible from the Switching Plan

   2.2. In addition, the capability shall be provided to configure the cover sheet (add, modify, delete cover sheet questions and answers within sections).

   2.3. For every action taken (i.e. when the users answers questions on the cover sheet with “Yes”, “No”, or “Not Applicable”) the questions/answers shall be logged so that a
user can review historical changes to the cover sheet. It shall be required that all questions be answered. It shall be searchable by the AEID field.

2.4. A snapshot of the current version of the cover sheet is included in the three screen captures below (included for illustrative purposes only).

2.5. Purchaser is open to an implementation that incorporates the cover sheet information into the header, as long as it is configurable and collapsible:

**Exhibit 19-2: Switching Plan Cover Sheet Contents**

<table>
<thead>
<tr>
<th>Switching Order Cover Sheet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Switching To:</strong></td>
</tr>
<tr>
<td><strong>Switching Order Number:</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>REVISIONS</strong></td>
</tr>
<tr>
<td>Checked Clearance Request Form</td>
</tr>
<tr>
<td>Checked Clearance Log</td>
</tr>
<tr>
<td>Wrote Switching Order</td>
</tr>
<tr>
<td>Checked for Special Switching Instructions None</td>
</tr>
<tr>
<td>Switching Order checked by other crew member</td>
</tr>
<tr>
<td><strong>CLEARING SWITCHING</strong></td>
</tr>
<tr>
<td>Checked Clearance Log before clearing</td>
</tr>
<tr>
<td>Switching Order checked by other crew member</td>
</tr>
<tr>
<td>Checked for Special Switching Instructions None</td>
</tr>
<tr>
<td>Switching Order checked and performed by</td>
</tr>
<tr>
<td>Updated ERCOT scheduler</td>
</tr>
<tr>
<td>Updated the mapboard/overlap</td>
</tr>
<tr>
<td>Updated PowerOn</td>
</tr>
<tr>
<td>Updated DMS</td>
</tr>
<tr>
<td>Added clearance to Clearance Log</td>
</tr>
<tr>
<td>S. O. &amp; Cover Sheet for clearing complete per Sup/Lead</td>
</tr>
<tr>
<td><strong>PUTTING BACK SWITCHING</strong></td>
</tr>
<tr>
<td>Checked Clearance Log before putting back</td>
</tr>
<tr>
<td>Switching Order checked by other crew member</td>
</tr>
<tr>
<td>Checked for Special Switching Instructions None</td>
</tr>
<tr>
<td>Switching Order checked and performed by</td>
</tr>
<tr>
<td>Updated ERCOT scheduler</td>
</tr>
<tr>
<td>Updated the mapboard/overlap</td>
</tr>
<tr>
<td>Updated PowerOn</td>
</tr>
<tr>
<td>Updated DMS</td>
</tr>
<tr>
<td>Signed off Clearance Log</td>
</tr>
<tr>
<td>S. O. &amp; Cover Sheet for putting back complete per Sup/Lead</td>
</tr>
<tr>
<td><strong>Comments:</strong></td>
</tr>
</tbody>
</table>

3. The header of the switching order shall appear on the top of each page in the printed version of the Switching Order. A template (that can be modified by Purchaser) for entering header information shall be provided with the following fields:
3.1. Status (switch order state/stage – automatically updated as users indicate a given state/stage in the defined life cycle has completed successfully)

3.2. AE ID (Switching Order number assigned by Purchaser) - -- text field - AE ID is required on the switching order header and switching order browser. This AE ID field shall be shown in the Clearance Number field of the tag properties when viewing a tag.

3.3. Substation name(s) affected by a switching order

3.4. Current Circuit name(s) - Feeder and substation shall be shown in the Circuits field for Feeder Head (FH) breakers affected by the switching order

3.5. Requested By name (including contact number and email – automatically populated if switching order is created from a Work Request)

3.6. Created By name and when (If created automatically, “Created by System” shall be indicated).

3.7. Start and End Date/Time

3.8. Prepared By name and Date/Time

3.9. Reviewed By name and Date/Time

3.10. Approved By name and Date/Time

3.11. Issued By name and Date/Time (populated with the user and the timestamp of the last issued instruction)

3.12. Performed By name and Date/Time

3.13. Completed By name and Date/Time (once the switching order gets transferred to Completed status)

3.14. Equipment to be Cleared

3.15. Nature of Work (free text field)

3.16. Field Crew (when click on the field a list of the crews defined through Crew Management is presented – multiple crews can be selected from the list)

3.17. Held By Crew (Dropdown List of crews selected in the Field Crew field)

3.18. Held By Department (automatically populated based on Held By crew based on information populated in Crew Management)

3.19. AOR(s) - by default this/these shall be the AOR(s) of the system

3.20. Description Type (Nature of work, Location of Work, etc.)
4. The capability to designate certain information as mandatory or to attach conditions to changes in the state of a switching order shall be provided. For example, it shall not be possible to “Submit” a switching order until it has an AE ID number; it shall not be possible to authorize a switching order if the AE ID field is not filled.

5. The execution state (Draft, Assigned, Arrived, Issued, Stopped, Marked as Executed, Executed, and Failed) of each step in the body of the switching order shall be color-coded by an Purchaser configured color scheme. Issued indicates the Switching Order has been sent to the field client. All of the steps shall be capable of being updated by the control center operator and the following shall be updatable by the field client: Arrived, Stopped, Marked as Executed, Executed, and Failed.

6. The body of the switching order shall consist of multiple entries (with each step being assignable to a different crew) defining the actions to be taken. Each entry shall have an entry number assigned automatically. The list of actions that shall be available for inclusion in a switching order shall include but not be limited to:

   6.1. Open and closing switches, either as SCADA control or via manual entry (reflecting switching actions performed by field crews).
   6.2. Placing and removing tags
   6.3. Disabling reclosers
   6.4. Placing cuts or jumpers
   6.5. Comment or text step
   6.6. Safety procedures, cautions, etc.
   6.7. Earthing/grounding circuits or devices
   6.8. Releasing earthed/grounded circuits or devices
   6.9. Operating physical interlocks
   6.10. Performing a visual inspection
   6.11. Issuing and recording caution statements
   6.12. Others as required by Purchaser’s safety manual and procedures

7. A user shall have the ability to expand an instruction by clicking next to the number of the instruction
8. Crew Status, GIS Information, Circuit Tie and Clearance Number fields shall be included in the instruction in the switching steps window.

9. “Arrive” and “Issue” check boxes shall be included in the instruction window. When a user clicks the Issue button, the instruction is issued and the crew status is updated to “Arrived” at the same time (and crew is visualized on the view). If an instruction is not issued and user checks the Arrive box, the instruction remains not issued but the crew is “Arrived” and is visualized on the view. If the user unchecks the Arrive box, the crew is reverted to Assigned, and the status of instruction is not changed (if issued then remains issued), and crew symbol is removed from view.

10. User shall have a one click option to STOP where all instructions get stopped, not cancelled.

11. Partially Completed switching orders should be enabled for further execution.

12. If a user tries to complete a switching order when all instructions have not been executed or the cover sheet is incomplete they shall receive a validation error message.

13. The capability to define time delays and breakpoints as steps in a switching order shall be provided. A note field shall be associated with time delay and breakpoint steps.

14. All of the incorporated switching rules shall be compliant with Purchaser’s rules. The SMS shall allow the user to easily create and/or modify such rules.

15. Purchaser will work with the Contractor to determine the exact form and content of the different types of Switching Orders (including printout formats) during project implementation.

19.7.4 **Manual Preparation of Switching Orders**

1. The user shall be able to enter information for the cover sheet, header and the body of the switching order using pre-defined forms. Preparation of the switching order, in the form of a list of actions to be performed, shall require no more than 3 clicks to add a switching step. User shall be able to configure which fields are required to proceed. This shall include the ability to start from an existing order and the ability to create or complete an order using, for example, power system device drag-and-drop selections from one-line schematic and/or geographical displays. In creating or completing an order, easy-to-use features such as the ability to enter tags and any other switching related action shall be provided.
2. The user shall be able to enter steps directly, or employ a macro capability in which the macro has already been defined as a complete or partial switching order. In order to import a macro, the user shall select from a list of macros, and shall be able to view the contents of the macro file, and select the macro. When the user selects a switching order macro, the macro shall be automatically expanded to the full text. The user shall be able to edit the text of the macro expansion. In some cases, the user may have to fill in the blanks in the macro expansion to complete the entry.

3. The user shall be able to start from a blank switching order or from a template with certain fields pre-filled. The user shall also be able to make a copy of an existing switching order (which may be completed or not). The user shall also have access to archived switching orders for this purpose. When starting from an existing switching order, the user shall be able to find and replace the names of devices to operate/tag.

4. The user shall be able to “record” switching and tagging steps in study mode via schematic or geographic displays. When the “record” capability is activated, the actions the user performs on the schematic or geographic display will be replicated in the switching order body.

19.7.5 Automatic Preparation of Switching Orders – Distribution

1. The user shall be able to initiate the automatic creation of a switching order.

2. As described in Sections 19.6.8 Optimal Feeder Reconfiguration (OFR) and 19.6.12Fault Location, Isolation and Service Restoration (FLISR), both of those applications shall be able to propose a list of switching actions that can be translated into a formal unplanned switching order.

3. As described in Section 19.10.11 Transmission Outage Application (TOA) the application shall be able to automatically generate a switching order initializing 5-10 fields of the switching order header and setting an execution status to “Draft”.

4. The equivalent capability shall be available for generating planned switching order steps, in which case the Switching Management application shall be able to propose a set of switching actions to isolate a portion of the network on user request. The basis for the algorithm shall be the same as that used by OFR and FLISR in that it will reconfigure buses or feeders according to rules supplied by Purchaser.

5. Typical rules used by Purchaser shall include, but shall not be limited to:
5.1. Consideration of tags
5.2. Not drop customer load
5.3. Limiting overloads
5.4. Secondary transfers to non-adjacent feeders when there is insufficient capacity
5.5. Minimizing switching actions
5.6. Taking into consideration priority when determining which loads can be de-energized
5.7. Consideration of future loading of the network as well as current loading when analyzing the impact of switching operations.

6. To initiate automatic creation of a planned switching order, the user shall be able to identify (e.g., by a point-and-click operation) the bus, feeder section(s), or cable section(s) to be reconfigured (i.e., isolated) and then request the system to automatically propose the appropriate switching operations and generate the corresponding switching order - the process for linking a planned switching order with the corresponding work order shall be straightforward.

7. Alternatively, the user shall be able to request the generation of the proposed switching actions from within the context of the Planned Switching Order itself, based on the device-to-be-isolated identified in the switching order.

8. The user shall be able to specify whether the proposed switching actions should be limited to SCADA-operable devices or a combination of SCADA-operable and manually operated devices; the capability shall be provided to configure a system-wide default, and override that default on a substation basis.

9. The user shall be able to review the automatically generated steps and make any necessary changes. The switching order shall then be subject to the switching order lifecycle as if its switching steps had been generated manually.

**19.7.6 Planned Customer Outages – Distribution**

1. The user shall be able to generate a list of affected customers for each planned outage.
2. The system shall store the list of customers affected by the switching plan and track the status for each until the final restoration is completed and archive this data.
3. The system shall track any changes to the planned outage status (delayed, cancelled, change in schedule) by each impacted customer and send this information to customer notification systems.

4. The system shall have the ability to auto group outage “calls” into the planned switching-related outage to provide appropriate customer messaging and handling as part of a planned outage.

5. The system shall retain the list of affected customers and track the status of each call until the final restoration is completed. This information shall be accessible from a web application and shall be archived.

6. The user shall be notified when the planned restoration time is within a configurable number of minutes if power has not yet been restored.

7. The system shall track the performance of the planned outage start and finish times to the actual outage start and finish times.

19.7.7 Automatic Generation of Back-out Switching Steps

Most planned switching orders are created to perform temporary work. When the work is completed, there is often a requirement to restore or back out the circuit to normal conditions. This is frequently the opposite procedure from the one used initially.

1. The system shall provide a mechanism to automatically generate back-out switching steps, either as part of the original order, or as part of a separate order.

2. Starting from the set of initial switching order steps, the user shall be able to request the generation of back-out steps corresponding to a subset (or all) of the original steps: the back-out steps shall be the reverse steps (“open” shall be reversed to “close”, “apply tag XX” shall be reversed to “remove tag XX”) and the steps shall be in reverse order when the user requests "Generate Back-out Order", the ADMS shall reverse the order of selected entries in the body of the initial switching order and shall change each of the "reversible" entries to its opposite. For example, an entry “close breaker” shall be reversed to “open breaker”, and an entry “place tag” shall be reversed to “remove tag”. The ultimate list of "reversible" entries and their associated "opposites" shall be developed in coordination with Purchaser during the course of the project.

3. The user shall be able to edit the resulting switching order steps.
19.7.8  **Management of Switching Orders**

1. After a switching order has been created, the user shall be able to save it. In the case where macros have been used to define the switching steps, the actual expanded content of the macros shall be saved (not the name of the originating macro).

2. The system shall maintain a directory of switching orders, organized by areas of operational responsibility. The user shall be able to use the directory to review, copy, rename, export, print, and delete switching orders, and to call them up for review and modification.

3. The system shall also maintain a catalog of switching order macros and templates. Authorized users shall be able to add, delete, and modify the macros in this catalog.

4. The system shall provide a means of archiving switching orders for a configurable period of time and of retrieving archived switching orders.

19.7.9  **Switching Order Validation**

1. Once defined, the Dispatcher shall be able to validate any planned or unplanned switching order by executing it in study mode (without requiring any export/import/scratchpad actions to bring the switching order into study mode or return it to real-time mode).

2. The operator shall be able to execute the switching order in study manually step-by-step or automatically.

3. The switching order should not have to be built a second time to execute in study mode and in real time.

4. All built-in time delays and breakpoints shall be recognized during automatic execution.

5. The ADMS shall automatically execute DPF each time topology changes in study mode, enabling the user to determine the potential impact.

19.7.10  **Automated Validation of Switching Orders**

1. The capability shall be provided to validate the set of Switching Orders planned for a specific future date, taking into consideration the load forecast on that future date, in order to determine if the switching orders whose execution is planned to include that date will result in negative consequences for the network and the ensure that the planned switching orders will not interfere with each other.
2. The capability shall be provided to trigger the automated validation of switching orders periodically, so that, for example, every morning at 6AM CT, the set of switching orders planned for the current day and the next day are automatically validated.

19.7.11 *Switching Order Execution*

1. Only the user who is assigned (or whose console is assigned) the AORs associated with the Switching Order shall be able to trigger its execution.

2. Execution of an individual step within a switching order shall result in the execution of the corresponding action in the ADMS and logging of the corresponding time-stamp, for example:

   2.1. In the case of a switching instruction to a remotely controllable device, the system shall send the SCADA control to the device; the user that executed the step, the time-stamps shall log the time when the control was sent, and the time when the change of state was confirmed complete. If the device fails to operate (e.g. RTU issue, device issue or DNO tag), the automatic execution shall stop and the Switching Management application (and/or the client application, e.g. FLISR) shall generate an alarm.

   2.2. In the case of a switching instruction to a device that is not remotely controllable, the time-stamps shall log the user that executed the step and the time when the step was executed, the instruction was given to the crew, and the time when the crew confirmed that the operation was completed, at which time a manual entry of the new switch state shall be performed in the SCADA.

3. The capability shall be provided to have a separate time-stamp for the time when the crew reported the action completed, vs. the time when the action was actually completed which may have been earlier. The actual completed time shall be propagated to the historical records (e.g. the time-stamp associated with the manual entry of the device shall be the same as the “completed” time-stamp that appears in the switching order execution log, vs. the “reported” time-stamp).

4. In the case of tagging of a non-controllable device, the sequence shall be essentially the same.
5. Study mode execution shall allow the user to verify the switching orders’ potential impact on the power system prior to execution in real-time.

6. The user shall be able to invoke Pre-Switching Validation (described in Section 19.6.7 Pre-Switching Validation (PSV)) when executing switching steps during manual execution of a switching order, whether in real-time mode or in study mode.

7. The authorized user shall be able to adjust the steps within a switching order after execution has started; this shall not result in re-numbering of steps.

8. The capability to print or export a switching order or to send electronically to a mobile device to crews in the field shall be provided. (Refer to Section 19.7.1 Switching Order Management)

### 19.7.12 SMS User Interface

1. The user shall be able to navigate from a display showing the switching order or a tabular listing the switching order to its extents on a graphical view (i.e. the extent of the switching devices operated by the switching order).

2. This information shall be accessible, with permissions based editing, from a web application and will be displayed exactly as in the operator view.

### 19.8 Outage Management System (OMS)

#### 19.8.1 General

1. The Outage Management System (OMS) shall support the following types of Distribution network incidents:

   1.1. Work Locations (Non-Outage)
   1.2. Work Location Outages (Outage)
   1.3. Load Shedding Outages (Outage)
   1.4. Hazards (Non-Outage)
   1.5. Unplanned Outages (Outage)

2. The OMS shall collect all available information about unplanned outages on the network and support the coordination of restoration activities.
3. Work Locations and Work Location Outages are used by Purchaser distribution crews that are performing work not planned by the Operations group. It enables Operations to view where crews are located, increasing their situational awareness of crew locations. When a crew arrives at a location they notify Operations of their location and Operations creates a Work Location or Work Location Outage incident. The OMS shall allow Operations to create the Work Location or Work Location Outage incident.

4. Work Locations are used for crew management to show placement of crews on the distribution system in real-time so that, in the case of an event such as a distribution circuit operation, the crew can be verified to be in-the-clear before re-energizing the circuit. It is also used to verify there is not a field crew present before dispatching an unplanned outage. These incidents shall be displayed in the incident view like any other incident.

5. If the Work Location requires a customer outage, this incident shall be able to be changed to a Work Location Outage via switching on the distribution model (which automatically transitions the incident type to Work Location Outage). Work Location Outages are for planned crew work which shall be tracked through the OMS system. A Work Location shall be able to be electrically connected to the Purchaser distribution model and visible from the map and incident view.

6. The OMS shall be integrated with Switching Order Management.

7. The OMS shall also be integrated with the Load Shedding functions (5.9 Load Shedding and Restoration) so that it tracks outages that are the result of load shedding but does not initiate crew assignment. All outages that are the result of a Load Shedding action shall be merged into one incident.

8. Hazard – A non-outage incident that identifies, at a minimum (editable by Purchaser), the following problems Wire Down, Tree on Wire, Arcing Wire, Low Wire, Pole Down, Other, Explosion, Foreign Object, or Dig In shall be provided.

9. For Unplanned Outages, the OMS shall analyze service interruption notifications to the Purchaser in order to determine the most likely component(s) where Purchaser’s supply has been interrupted. From initial notification of an electric service interruption through topology analysis / prediction, crew assignment, fault isolation and return-to-normal switching, the Dispatcher shall be able to manage each outage while remaining aware of other network activities. The OMS shall be integrated with the DMS Network Topology Processor and
Fault Location Isolation and Service Restoration (FLISR) applications including the Unplanned Switching Orders produced via the ADMS Switching Management function. The capability shall be provided to access and track of the various FLISR sub-functions and their results from within an Incident Detail page.

10. The OMS shall also handle Forced Outages, e.g. outages that are the result of a deliberate action which is intended to de-energize a portion of the network (e.g. in response to a request from the Fire Department in the case of a gas leak) as an Unplanned Outage.

11. The OMS shall be able to handle major storm situations and divide or combine areas of responsibility and consequently balance Dispatchers’ workload.

12. Records of all outages shall be maintained, providing a convenient central repository of distribution outage information that could be used to support historical analysis, the calculation of outage reliability indices, and current real-time operations, such as responding to trouble calls and interacting with field crews. This information shall provide the basis for the statistics that can be used for planning the repair work and detecting poor functionality of the Distribution Network elements.

13. OMS shall provide standard functionality required for resolution of outages, including integration to other DMS functions such as Fault Location Isolation and Service Restoration, and interfaces to other IT systems.

14. The OMS functions shall operate based on the same network model as the Distribution Management System functions. The users of the OMS shall operate from the same Distribution network schematics as other users of the ADMS. i.e. there shall not be separate one-line diagrams from showing SCADA, DMS application results and OMS information. The OMS shall be integrated with the other applications within the system, including the Switching Order Management IS&R, the SCADA functions and the DMS functions. All switching steps associated with an incident shall be tracked in the incident detail and must be able to be copied to the Switching Order Management.

19.8.2 Incident Creation

1. A user must be able to link any incident to equipment (including section of line), not just to a customer.
2. New incidents shall be created by the following means, and the means used to create the incident shall be recorded in the incident detail page:

   2.1. Topology change – caused either by SCADA telemetry or by manual entry by an operator, if it causes any customers to be de-energized
   2.2. Customers call the call center to notify the utility their power is off.
   2.3. Customers send SMS texts to notify the utility their power is off.
   2.4. Customers notify the utility their power is off via the Interactive Voice Response (IVR).
   2.5. Customers notify the utility their power is off via on-line (internet) or mobile applications.
   2.6. OMS operator shall be able to enter a call from the geographic view.
   2.7. An incident can be created by OMS operator from the geographic view. In either case, an incident with the following fields is created. Some of the fields are automatically populated by Outage Management while others are manually entered by an operator.

3. Note that throughout the rest of this specification, the term “call” is used to refer to a notification by a customer regardless of the technology (telephone, internet, SMS, etc.)

19.8.3 Incident Life-Cycle

1. The incident life cycle shall be configurable by Purchaser using graphical flowchart-style drag-and-drop functionality. The incident lifecycle shall be configurable to meet Purchaser needs. Examples of possible states include:

   1.1. New – A new incident
   1.2. Dispatched - crew is en-route
   1.3. Follow up required – Work is required by a group outside of Operations. In order to get to this state, all customers must be “Restored.”
   1.4. Field Completed – Field work has been completed. Currently entered by user once crew notifies user, but may be updated by Field Client in future.
   1.5. Closed – Incident has been closed by a user
   1.6. Cancelled – Incident has been cancelled by a user or by AMI
1.7. Archived – Automatically archived after a Purchaser configurable amount of time (after incident is closed), or can be done on-demand by a user

2. New incidents shall be created, refer to Section 19.8.2 Incident Creation.

3. The OMS Outage Notification Management function shall be integrated with the Purchaser’s facilities and systems to support these various interactions.

4. The OMS shall display the number of calls and high priority trouble calls based on configurable rules.

5. The OMS shall automatically remind the operator that they have not received an acknowledgement back from the crew for a dispatched event, after a configurable amount of time. This reminder shall be saved by the OMS in an event logger.

6. The user shall be able to view the list of outage events associated with the user’s Area of Responsibility (AOR), and filter or sort it by any combination of the displayed sets of fields per the standard Tabular and List display capabilities described in Section 6 User Interface Requirements and Section 19.4.3.2 Tabular Displays.

7. The user shall be able to select any incident event and see:

   7.1. The detailed customer-provided comments entered by the customer service representative or customer associated with the predicted or confirmed event, including any photographs submitted.

   7.2. The details of any incident event, including level, priority, cause, ETRs, status, etc.

8. The user shall be able to search incident events by customer name, address, telephone number, account number or customer email.

9. The OMS shall assign an outage start time automatically to the first customer call or meter event message.

10. The user shall be able to manually enter in the start time for an incident event. The OMS shall track incident events that had their start times manually overridden.

11. The user shall be able to create an event anywhere along a circuit segment or at a device for a hazardous/emergency call.

12. The OMS shall generate and assign an estimated time of arrival (ETA) for each job assigned.

13. The capability shall be provided to associate a priority with an incident job:
13.1. The OMS shall move emergency police/fire calls to the top of the job list as a priority. The incident shall have an indication that it is an emergency call (set from Hazard field of AECall).

13.2. The OMS shall identify life support customers and customer critical facilities and have the ability to move these to the top of the job list; these events shall be configurable by code.

13.3. The OMS shall track the number of life support customers out and identify those that are still out and provide this information as a displayable report.

14. The user shall be able to assign multiple jobs to a single crew for the crew to work on in the future. The user shall be able to dispatch a job to one or more crews (and see all crews assigned to the event).

15. Incidents shall have the ability to be nested, each with a separate ETR.

16. There is a power restore field and the possible states are:

   16.1. Partially Restored – crew restored power to some but not all of the affected customers
   16.2. Not Restored
   16.3. Restored - crew restored power

17. The OMS shall automatically indicate that an event has been dispatched once the OMS indicates the crew has accepted the event.

18. The OMS shall accept damage assessment reports received from the field and input manually or electronically from a mobile device. The user shall be able to select an incident job and view the damage assessment report(s) associated with it.

19. The user shall be able to enter all incident event details required to complete the incident.

20. The user shall be able to enter enough information to generate a follow-up (referral) for the incident event.

21. The user shall be able to edit incidents in a closed or archived state. Edits shall be automatically replicated system-wide so that a user doesn’t have to manually replicate.

22. The system shall automatically close incidents determined to be momentary.

23. The OMS shall provide a record and audit trail of data corrections and updates made to incidents reviewed after they were closed or archived.
24. The OMS shall be able to create a work order request based on the previously entered information and send to a Work Management System (WMS) and email to a Purchaser defined list to notify them of its creation.

24.1. The OMS shall track all work order requests that were created for an incident event. The user shall be able to generate a tabular list of work orders that were created for an incident event and see their status information or completion dates.

25. The user shall be able to enter completion details for partial restoration events. The OMS shall keep track of all partial restoration events that were part of restoring customers. Each partial step shall have its own ending time stamp for the set of customers it restored.

26. The OMS shall be able to generate a list of customer account executives and managers to be used to page, email or phone with the related outage details when a set of critical customers are affected by an incident. Needs to be highly configurable, enabling AE to decide which customers to send the e-mails to and which to exclude, and also have the ability to determine which incident types should trigger emails.

27. The OMS shall support an automated restoration verification process.

27.1. Contractor shall describe system’s use of AMI to support an automated restoration/verification process.

28. The OMS shall support the configuration of outage completion details including defining list of outage cause codes.

19.8.4 **OMS Key Components**

The OMS shall comprise a set of tools that allow the operator to monitor and restore the MV and LV networks.

1. Incident management – shall support management of flexible workflows matching the utilities' business processes and procedures for planned and unplanned work, including safety management/hazards

2. Notification management – shall support various mechanisms for notification of outages and interaction with the various notification sources, as well as tracking of those notifications
3. Outage grouping and analysis – shall support various mechanisms for associating notifications with an outage, and grouping outages
4. Calculation of Estimated Time to Restore (ETR) – shall support various mechanisms for calculating, adjusting and tracking ETRs
5. Crew management – shall track the mobile crews and support workflow management around dispatching, integrating with incident management, GPS navigation systems and possibly a 3rd party mobile workforce application.

19.8.4.1 INCIDENT MANAGEMENT

1. An Incident Overview shall present a summary of data regarding incidents across the entire network, for use by supervisors and shift managers in the control room.
2. An Incident Overview dashboard, configurable by Purchaser that presents the current state of the distribution system shall also be available to managers accessing from the corporate environment.
3. The Incident Browser display shall support viewing current or historical incidents and the same fields shall be viewable whether looking at current or historical incidents. The performance of viewing current incidents is more critical than viewing historical incidents, so the performance of the user interface when viewing current incidents shall not be impacted if not viewing historical incidents.

3.1. The user shall be able to assign a resolution code (Cause, Subcause) to selected incidents. The user shall have the ability to make edits to the user defined resolution codes of archived incidents. The user shall be able to create new causes and Subcauses at will without the need for Contractor support.

3.2. The following, at a minimum, shall be enterable to define an incident and shall be viewable through the incident browser for all current and/or historical incidents:

3.2.1. Incident ID – (Unique number – auto-generated by Outage Management)
3.2.2. Current feed – (Feeder ID, two letters to indicate substation and two letters to indicate feeder)
3.2.3. Normal feed – (Feeder ID, two letters to indicate substation and two letters to indicate feeder)
3.2.4. Crews – (Crew Number of crew(s) associated with the incident, 32 alphanumeric characters – typically four digit numbers, but may be followed by a letter or be composed entirely of letters)

3.2.5. Type of Incident – (Auto-populated, but can be overridden with a Dropdown List of the following: Work Location, Work Location Outage, Load Shedding Outage, Hazards, Unplanned Outage)

3.2.6. Confirmed – (Yes/No)

3.2.7. Crew Status – (Buttons on the incident detail with the following choices: Assigned, En Route, Arrived)

3.2.8. Address – (Text field – 64 characters) – Populated by Outage Management with the following priority: 1) as street address of customer – only if incident is associated with a single customer, 2) device address if more than a single customer (but if a device address is not available use closest customer associated with that device). In either case, the Outage Management populated value shall be editable by the user.

3.2.9. Pole Number – (Numeric field – Six digits) – optional field

3.2.10. Substation – (Alphabetic – Substation Name, 32 characters) – Auto-populated by Outage Management

3.2.11. Device – (Alphanumeric - Device ID, 32 characters) – Auto-populated by Outage Management

3.2.12. Problem – (Wire Down, Tree on Wire, Arcing Wire, Low Wire, Pole Down, Other, Explosion, Foreign Object, or Dig In) – Auto-populated by Outage Management, but editable by user via Dropdown List

3.2.13. Instruction – (Free text – 100 characters)

3.2.14. Calls – (Number - count of all customer calls associated with the incident, 6 digits)

3.2.15. Affected Customers – (Number - count of all customers associated with the incident, 6 digits)

3.2.16. Unrestored Customers – (Number - count of de-energized customers associated with the incident, 6 digits)
3.2.17. Customer Priority – (Auto-populated by Outage Management based on topology and the highest priority of all Affected Customers – None, Regular, Life Support, Key Account, Critical Load 1 (CL1), Critical Load 2 (CL2), Critical Load 3 (CL3))

3.2.18. Emergency Call (specifically police or fire) – A column with a symbol (e.g. flames or a police car) indicating the incident is associated with an emergency call.

3.2.19. Affected critical customers (Number - count of CL1+CL2+CL3 customers associated with the incident), 6 digits – types of customers to be included in count shall be editable by Purchaser

3.2.20. Assigned user – (user name, 32 characters)

3.2.21. Priority – (Number, 1 digit) – configurable by Purchaser

3.2.22. Status – (Selected by operator through buttons: New, Dispatched, Cancelled, Field Completed, Closed, Archived, Follow up required). Font colors of the incident shall be based on the status as follows (Purchaser configurable):

   3.2.22.1. New – Red
   3.2.22.2. Dispatched – Green
   3.2.22.3. Cancelled – Blue
   3.2.22.4. Field Completed – Brown
   3.2.22.5. Closed – Black
   3.2.22.6. Archived – Orange
   3.2.22.7. Follow up required – Gray

3.2.23. Estimated Restoration Time (ERT) – (Date Time – e.g. 03/17/2018 13:30, auto-populated by Outage Management based on Estimate To Repair (ETR) tables (configurable by Purchaser), but can be modified by selecting date from a calendar and/or setting time with arrow buttons). If the ERT is about to expire, the ERT field shall be visually differentiated (e.g. within x minutes of expiration ERT field highlights in yellow, then within y minutes of expiration ERT field highlights in red). The time to expiration (x and y values) shall be user configurable globally.
3.2.24. Actual Restoration Time (ART) – (Date Time – e.g. 03/17/2018 13:30, auto-populated by Outage Management when outage has been restored (when all affected customers have been re-energized based on topology), but can be modified by selecting date from a calendar and/or setting time with arrow buttons)

3.2.25. Outage Time – (Date Time – e.g. 03/17/2018 13:30, auto-populated by Outage Management when an outage is first reported by a call/telemetry/etc., but can be modified by selecting date from a calendar and/or setting time with arrow buttons)

3.2.26. Creation Time – (Date Time – e.g. 03/17/2018 13:30, auto-populated by Outage Management when an incident is created)

3.2.27. Affected Phase(s) – (Alphabetical field, 3 characters – automatically set by Outage Management based on the phase of the outaged equipment and associated calls)

3.2.28. Nested – (Yes/No) – Has a nested incident

3.2.29. Is Nested – (Yes/No) – Is a nested incident

3.2.30. Indication if an update due to a new call or smart meter event since the incident has been opened – (!)

3.2.31. Upstream Device – (Alphanumeric, 32 characters - Device ID of the next upstream protection device)

3.2.32. Subtype – (Sustained, Momentary)

3.2.33. Smart meter events – (Number, 6 digits - count of all smart meter events associated with the incident)

3.2.34. Created By – (Call, Field Event, Smart Meter Event, operator)

3.2.35. Cancel Reason – (Text, 20 characters - Dropdown List - Purchaser definable dropdown list)

3.2.36. Cause – (Text, 20 characters - Dropdown List - Purchaser definable dropdown list)

3.2.37. Sub-cause – (Text, 20 characters - Dropdown List - Purchaser definable dropdown list)
3.2.38. ERT – ART – (delta time HH:MM) – Auto-populated by Outage Management when outage has been restored (when all affected customers have been re-energized based on topology)

3.2.39. Customer Hours of Interruption – (Floating Point - Number of Hours, 6 digits before decimal, two digits after) – Auto-populated by Outage Management when outage has been restored (when all affected customers have been re-energized based on topology)

3.2.40. Close Time – (Date Time – e.g. 03/17/2018 13:30) – Auto-populated by Outage Management when incident is Closed

3.2.41. Energy Non-Supplied Index (ENSI) – (Floating Point, 7 digits before decimal, 4 after) - kWh/Interval – Auto-populated by Outage Management when outage has been restored (when all affected customers have been re-energized based on topology)

3.2.42. Failed Component Type – (Text, 20 characters - Dropdown List - Purchaser definable dropdown list)

3.2.43. Incident Duration – (Number – in minutes, 6 digits) – Auto-populated by Outage Management when incident is Closed

3.2.44. Material – (Text, 20 characters - Dropdown List - Purchaser definable dropdown list)

3.2.45. Postal Code – (Five-digit numerical field)

3.2.46. Refer To – (Text, 20 characters - Dropdown List - Purchaser definable dropdown list)

3.2.47. Data Problem – (Text, 20 characters - Dropdown List - Purchaser definable dropdown list)

3.2.48. Construction Type – (Text, 20 characters - Dropdown List - Purchaser definable dropdown list)

3.2.49. Unsecured – Yes/No

3.2.50. Comments – (Text – 128 characters)

3.3. The user shall be able to merge multiple incidents from the incident browser or the geographic view.
3.3.1. Merging two incidents shall require a maximum of 4 clicks. Acceptable implementations would be drag and drop based or Ctrl-Select multiple incidents, then user right click to merge from both the incident browser and the geographic view.

3.3.2. The parent shall automatically be selected as the furthest upstream incident, retaining its header, unless the incidents are on two separate feeders.

3.3.3. The incident historical browser shall note when an incident has been merged or merged to and shall archive the header of the child merged incidents.

3.4. The user shall be able to manage (arrive, assign, en-route, complete, etc.) a crew from the incident browser or geographic view either by right clicking and selecting add crew or by selecting the incident and using an “add crew” icon that opens crew management.

3.5. The user shall have the ability to manage an incident (delete, confirm, cancel, field complete, close, archived, follow-up required, etc.) from the incident browser or geographic view using icons.

4. Incident Detail
   Any of the columns listed shall be user configurable.

4.1. Incident header

4.1.1. Incident header shall be AE user configurable.

4.1.2. The incident header shall provide the user with the ability to add a Multimedia attachment.

4.1.3. Incident header fields shall include, but not limited to:

   4.1.3.1. Incident ID
   4.1.3.2. Current Feeder
   4.1.3.3. Normal Feeder
   4.1.3.4. Type (incident type)
   4.1.3.5. Sub-type (sustained, momentary)
   4.1.3.6. Priority (number 1-5)
   4.1.3.7. Outage Time (date and time)
4.1.3.8. ETR (date and time)
4.1.3.9. Instruction (free text)
4.1.3.10. Calls (number of calls)
4.1.3.11. Smart Meter events (number of events)
4.1.3.12. Created At (date and time)
4.1.3.13. Create By (user name)
4.1.3.14. Problems (hazards indicated in the calls)
4.1.3.15. Confirmed (yes, no)
4.1.3.16. Status (incident status)
4.1.3.17. Power Status (power restore field)
4.1.3.18. ATR (date and time)
4.1.3.19. Is Nested (yes, no)
4.1.3.20. Has Nested/Coupled (yes, no)
4.1.3.21. Affected (number of customers affected)
4.1.3.22. Unrestored customers (number of unrestored customers)
4.1.3.23. Restoration verified customers (number of customers with power up AMI messages)

4.2. Devices

4.2.1. The incident device section shall identify where the incident is electrically connected to the system.

4.2.2. The user shall be able to locate this element in the geographic view from the incident list.

4.2.3. If the device listed is a switchable device, the user shall be able to toggle the state of this device from the incident list.

4.2.4. The user shall be able to roll up or roll down to the next switching device.

4.2.5. User shall be able to split an incident into separate incidents when the outage is incorrectly predicted.

4.2.6. User shall be able to confirm an outage from the device section.

4.2.7. The user shall be able to edit the device by dragging and dropping a new device into the device section.
4.2.8. The following columns shall include, but not limited to

4.2.8.1. Device address
4.2.8.2. Name (device name)
4.2.8.3. Status (if switchable, the state of that device)
4.2.8.4. Affected phase
4.2.8.5. Phases
4.2.8.6. Upstream (the next switchable device upstream)
4.2.8.7. Current feeder
4.2.8.8. Normal feeder
4.2.8.9. Telemetered (yes, no)
4.2.8.10. Quality (SCADA quality)
4.2.8.11. Based on (populated from the Created By field)

4.3. Crews

4.3.1. The user shall be able to assign a crew from the crew section of the incident detail. When the user assigns a crew, the list presented shall be ranked optimally based on proximity and crew type.

4.3.2. The user shall be able to indicate the following crew statuses:

4.3.2.1. Assigned
4.3.2.2. En Route
4.3.2.3. On Site
4.3.2.4. Completed

4.3.3. If the crew is completed on that incident, it will no longer show up on the incident browser.

4.3.4. The user shall be able to edit or delete the selected the crew from the crew section.

4.3.5. The user shall be able to locate the crew and the crew vehicle from the crew section.

4.3.6. The user shall be able to open the crew properties from the crew section.

4.3.7. The following columns shall include, but not limited to:
4.3.7.1. Crew ID
4.3.7.2. Name
4.3.7.3. Type
4.3.7.4. Status (crew status)
4.3.7.5. Availability (on duty, off duty, on break), user can update availability from the crew section
4.3.7.6. Company
4.3.7.7. Field Client (yes, no)

4.4. Problems

4.4.1. The problem shall initially be populated from hazards from customer calls.
4.4.2. The user shall be able to add or enter a problem to an incident from the problem section of the incident detail by selecting the equipment on the geographic map and dragging and dropping into the problem section of an incident. The user shall be able to select the type of problem from a Dropdown List (in the problem section).
4.4.3. The user shall be able to edit or delete the selected problem from the problem section.
4.4.4. The user shall be able to locate the problem on the geographic map from the problem section.
4.4.5. The problem view shall include the following, but not limited to:

4.4.5.1. ID
4.4.5.2. Equipment
4.4.5.3. Network location
4.4.5.4. Fault
4.4.5.5. Type
4.4.5.6. Priority
4.4.5.7. Status
4.4.5.8. Is Hazard
4.4.5.9. Creation time
4.4.5.10. Creation user
4.4.5.11. Comments (any comments associated with the problem)

4.5. Call Details

4.5.1. The user shall be able to locate calls from the call section.
4.5.2. The user shall be able to cut and paste calls from the call section.
4.5.3. The user shall be able to open call properties from the call section.
4.5.4. The following columns shall include, but not limited to

<table>
<thead>
<tr>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>! (new call)</td>
</tr>
<tr>
<td>Location</td>
</tr>
<tr>
<td>Comment</td>
</tr>
<tr>
<td>Meter ID</td>
</tr>
<tr>
<td>Reason</td>
</tr>
<tr>
<td>Hazard</td>
</tr>
<tr>
<td>Source</td>
</tr>
<tr>
<td>Caller Name</td>
</tr>
<tr>
<td>Caller Last Name</td>
</tr>
<tr>
<td>Account</td>
</tr>
<tr>
<td>Priority</td>
</tr>
<tr>
<td>Event time</td>
</tr>
</tbody>
</table>

4.6. Resolution

4.6.1. The following fields shall be Purchaser configurable and include, but not limited to:

<table>
<thead>
<tr>
<th>Field</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause</td>
</tr>
<tr>
<td>Sub cause</td>
</tr>
<tr>
<td>Data problem</td>
</tr>
<tr>
<td>Refer to</td>
</tr>
<tr>
<td>Construction type</td>
</tr>
<tr>
<td>Failed component</td>
</tr>
<tr>
<td>Material</td>
</tr>
</tbody>
</table>
4.6.1.8. Notes

4.6.1.8.1. The user shall be able to select the role type (operator, field crew) entering notes

4.6.1.8.2. Notes shall include the following columns:

4.6.1.8.3. Time noted

4.6.1.8.4. User noted

4.6.1.8.5. Type

4.6.1.8.6. Comment

4.7. Incident Location

4.7.1. The user shall be able to link any incident to any landbase attribute, including but not limited to:

4.7.1.1. Pole ID

4.7.1.2. Switch gear ID or alias

4.7.1.3. Intersections (street 1 and street 2)

4.7.1.4. Address

4.7.1.5. Primary meter customer name

4.8. Switching Operations

4.8.1. Any switching operations that occur within the affected incident shall be cataloged in the switching operation section.

4.8.2. The user shall be able to copy and paste switching steps into the switching operations section.

4.8.3. All functionality associated with switching management shall be available in switching operation section, e.g. adding text instructions or temporary elements, and validating switching steps.

4.9. Nested/Coupled incidents

4.9.1. The user shall be able to add, delete or edit a nested incident from the incident detail.
4.9.2. The user shall be able to open selected nested incidents from the incident detail.

4.9.3. The user shall be able to locate nested incidents from the incident detail.

4.9.4. The user shall be able to promote to a nested incidents from the incident detail.

4.9.5. The following columns shall be available in the nested incident section, but not limited to:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.9.5.1.</td>
<td>ID</td>
</tr>
<tr>
<td>4.9.5.2.</td>
<td>Nested/Coupled</td>
</tr>
<tr>
<td>4.9.5.3.</td>
<td>Device</td>
</tr>
<tr>
<td>4.9.5.4.</td>
<td>Device status</td>
</tr>
<tr>
<td>4.9.5.5.</td>
<td>Affected</td>
</tr>
<tr>
<td>4.9.5.6.</td>
<td>Phases</td>
</tr>
<tr>
<td>4.9.5.7.</td>
<td>Type</td>
</tr>
<tr>
<td>4.9.5.8.</td>
<td>Confirmed</td>
</tr>
<tr>
<td>4.9.5.9.</td>
<td>Unrestored</td>
</tr>
<tr>
<td>4.9.5.10.</td>
<td>Outage time</td>
</tr>
<tr>
<td>4.9.5.11.</td>
<td>Sub type</td>
</tr>
</tbody>
</table>

4.10. Customers

4.10.1. The user shall be able to ping and poll selected or all customer meters associated with an incident from the incident detail.

4.10.2. The user shall be able to filter the customer list in the customer section.

4.10.3. The user shall be able to export the customer list from the customer section.

4.10.4. The user shall be able to create callbacks from the customer section.

4.10.5. The customer section shall display the following statistics:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.10.5.1.</td>
<td>Customers</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.10.5.1.1.</td>
<td>Unrestored Critical</td>
</tr>
<tr>
<td>4.10.5.1.2.</td>
<td>Unrestored</td>
</tr>
<tr>
<td>4.10.5.1.3.</td>
<td>Affected Critical</td>
</tr>
</tbody>
</table>
4.10.5.4. Affected
4.10.5.5. Restoration Verified
4.10.5.6. CMI (Customer Minutes of Interruption)

4.10.5.2. Power

4.10.5.2.1. Unrestored Critical (kW)
4.10.5.2.2. Unrestored (kW)
4.10.5.2.3. Affected Critical (kW)
4.10.5.2.4. Affected (kW)

4.10.5.3. Meter Ping Statistics

4.10.5.3.1. Ping to Customer
4.10.5.3.2. Power down responses
4.10.5.3.3. Power up responses
4.10.5.3.4. Pending pings
4.10.5.3.5. Failed pings

4.10.6. The customer section shall include the following columns, but not limited to:

4.10.6.1. Address
4.10.6.2. Meter ID
4.10.6.3. Name
4.10.6.4. Last Name
4.10.6.5. Account
4.10.6.6. Priority
4.10.6.7. Phase
4.10.6.8. Ping supported
4.10.6.9. SDP Custom ID
4.10.6.10. Voltage C phase
4.10.6.11. Voltage B phase
4.10.6.12. Voltage A phase
| 4.10.6.13. | Last polled status  |
| 4.10.6.14. | Last polled user  |
| 4.10.6.15. | Feedback result  |
| 4.10.6.16. | Restoration time  |
| 4.10.6.17. | Restoration Verified time  |
| 4.10.6.18. | Interruption minutes  |
| 4.10.6.19. | Last power up time  |
| 4.10.6.20. | Last power down time  |
| 4.10.6.21. | Last ping time  |
| 4.10.6.22. | Last ping user  |
| 4.10.6.23. | Last ping status  |
| 4.10.6.24. | Power down supported  |
| 4.10.6.25. | Power up supported  |
| 4.10.6.26. | Last polled time  |

4.11. Smart Meter Events

4.11.1. User shall be able to locate a smart meter event from an affected customer in the incident detail.

4.11.2. The following columns shall be shown in the smart meter events section, including but not limited to:

| 4.11.2.1. | ID (unique system ID)  |
| 4.11.2.2. | Reason (power down, power restored, etc.)  |
| 4.11.2.3. | Location  |
| 4.11.2.4. | Account  |
| 4.11.2.5. | Priority  |
| 4.11.2.6. | Name  |
| 4.11.2.7. | Last Name  |
| 4.11.2.8. | Source  |
| 4.11.2.9. | Event time  |
| 4.11.2.10. | Meter ID  |
4.12. FLISR

4.12.1. The user shall be able to execute manually or view the results of automatic FLISR from the incident detail. This shall include viewing reports, editing options, and enabling geographic representation for each of the FLISR sub-functions. The system shall indicate the state of each FLISR sub-function for example: not started, completed with warning, etc.

4.12.2. When FLISR is run and the incident is archived, reports associated with each FLISR sub-function shall be historized as well, so the user has a history of FLISR reports.

19.8.4.2 OUTAGE NOTIFICATION MANAGEMENT

1. The Outage Notification Management function shall include the following features and capabilities:

1.1. The OMS shall provide an efficient means of recording customer notifications related to service interruptions, including the cause and location of events. Customer identification shall provide search fields to enable the capture and identification of the client based on customer information.

1.2. The OMS shall support incoming notifications that report multiple incident types on a single call (e.g. that indicate that there is an outage, there is an emergency situation (outage and wire down), there is a need for maintenance and/or there is a request for service).

1.3. A list of all active customer outage notifications in the OMS containing information that is important for identifying the problem shall be available and recorded in OMS database.

1.4. The OMS shall be capable of displaying different incident types geographically with configurable symbology (example, wires down, police/fire calls, etc.)

1.5. The OMS shall have the ability to purge calls in the OMS based on a pre-defined set of rules (date, time, etc.) during storm conditions.
1.6. The user shall be able to retrieve and display customer technical and commercial information such as circuit and associated transformer, commercial status (active, suspended, etc.).

1.7. The user shall be able to retrieve and display customer operational information such as whether the customer is currently involved in an event, if customer has scheduled events, the current state of repair, active previous calls, etc.

1.8. The OMS shall support the concept of a call priority, the meaning of which shall be configurable (e.g. Priority 1 for Police Department/Fire Department standing by)

1.9. The operator shall be able to associate non-outage calls to an existing incident or outage ticket or create a new incident or outage ticket. All data contained in the associated non-outage call shall be clearly viewable within the incident or outage ticket detail.

1.10. The OMS shall display a history of customer(s) who called, and the number of times they called, as part of an outage.

1.11. The OMS shall provide the capability to search historical information using different query patterns, historical information associated with the calling customer: previous calls, events in which he was involved, etc. It can search by any of the basic customer data, by date, by call status, etc.

1.12. The OMS shall have the ability to archive and save calls based on pre-defined rules (date, time, etc.).

1.13. The OMS shall maintain a history of the customer’s outages (sustained and momentary) and non-outage service notifications including any company related projects (i.e. circuit improvements). The history shall be viewable by operators and Purchaser’s Customer Support personnel via the notifications screens. The log shall include the contact method used (IVR, phone, internet, smart phone, text), inbound and outbound messages, automated or manual contacts, type of message (outage reporting, ETR, restoration notification, customer feedback, etc.).

1.14. The user shall have the ability to receive and display an image from the field or from a customer and associate it to an outage event.

1.15. Device Address must included

2. Displays showing outage notification information shall be updated in real time.
3. Callbacks are generated by the OMS to notify the various Call Center / IVRs of callbacks that have been generated for an outage incident and shall be stored in a historical database and viewable through a Historical Callback Summary display.

4. The callbacks information shall include, but not limited to:

   4.1. ID (unique system ID)
   4.2. Order Time
   4.3. Incident ID
   4.4. Callback assigned
   4.5. Feedback result
   4.6. Feedback reason (restored, assigned crew, change of ETR)
   4.7. Location (Feeder)
   4.8. Name
   4.9. Last Name
   4.10. Contact Phone Number
   4.11. Emergency
   4.12. Preferred Contact info
   4.13. Type of contact (landline, cell)
   4.15. City
   4.16. Street
   4.17. Postal Code
   4.18. Connection Status
   4.19. Priority
   4.20. Initial Call Comments
   4.21. Callback Comments
   4.22. ADMS Operator Comments
   4.23. Assigned to
   4.24. Incident status
   4.25. Estimated time of restoration
   4.26. Service Delivery Point (SDP) ID
   4.27. Customer Email
5. The callback status notification is triggered by the "Call Center / IVR" on the corporate side, to notify the resolution status of callbacks to the OMS.

6. When the Call center or IVR performs a callback, the callback may be satisfactory, or not satisfactory for different reasons, for example the customer does not answer, or the customer notifies that the problem still exists. This customer feedback must be used by the OMS.

19.8.4.3 OUTAGE GROUPING AND ANALYSIS

1. The OMS shall be integrated with DMS (e.g. FLISR) and SCADA functions that would allow grouping of outage notifications using the topology and real-time state of the distribution network, determining the probable site of failure, information on the status of the associated event, estimated repair time and other relevant information to inform the customer of the status of their outage notification.

2. The Outage Grouping and Analysis function shall include the following features and capabilities:

   2.1. The OMS shall have the ability to auto-group notifications for prediction analysis, e.g. grouping them to a common upstream device on the feeder on the same outage.

   2.2. Prediction percentage per device types

   2.3. Stable prediction based on timestamps

   2.4. The OMS shall also allow manual grouping of outage calls that overrides the auto-grouping capability; manual grouping shall be supported via graphical displays (e.g. via a polygon tool).

   2.5. The user shall be able to move notifications from one outage to another.

   2.6. The user shall be able to push any predicted outage event upstream to the next device.

   2.7. The user shall be able to push a predicted outage event downstream. The OMS shall generate a new predicted outage for each of the devices (typically lateral fuses) that are immediately downstream from the currently predicted outage device.

   2.8. The OMS shall allow multiple outage notifications to be grouped under one job and resource.

   2.9. The user shall be able to add unassociated calls to an existing event.
2.10. The capability to remove any trouble calls to create independent jobs at any time while the job is active.

2.11. The capability to remove a call from a job and return it to the call list as an unassociated call.

2.12. The user shall be able to confirm a predicted event is a real outage.

2.13. The OMS shall have the ability to re-analyze a predicted outage event.

2.14. The user shall have the ability to suspend the auto-grouping feature (for example, during the initial stages of a major storm when there is a heavy volume of incoming notifications (customer outage calls or meter last-gasp messages).

2.15. In the event of a suspension, the OMS shall save and archive the calls that were received prior to suspension, and after a period of time, resume the auto-grouping process, analyzing the notifications that were received prior to the suspension in order to identify any nested outages.

2.16. The user shall be able to designate a pre-defined area or areas within the territory as being in Storm mode.

2.17. The OMS shall assist the operator to identify and manage nested outages and single service outages during storm events when there are still a large number of outage events outstanding, using predefined timing rules to associate further incoming calls with the correct events.

2.18. The OMS shall capture unassociated call information as possible data errors that need to be corrected in the GIS.

2.19. The OMS shall provide a configuration mechanism for non-programmers to change the prediction and grouping behavior of the OMS.

2.20. The OMS shall provide auto-grouping of customers impacted during automatic sectionalizing functions of distribution automation circuits.

2.21. The OMS shall use the distribution SCADA to keep predicted outages from rolling up to the set of SCADA monitored devices based on trouble calls ingested.

2.22. The OMS shall support momentary outages and provide for automatically grouping of call types such as lights flickering to a momentary outage event.

2.23. The OMS shall have the ability to analyze a single-phase outage as part of a three-phased circuit (i.e., only one phase is out).
19.8.4.4 ESTIMATED TIME OF RESTORATION (ETR)

1. ETRs shall be automatically generated by the OMS and applied to all entered outage incidents. The OMS shall generate ETRs that are realistic based on definable rules as a function of, for example, resources available, device type, feeder type, number of active crews, location of active crews, status of work orders assigned to active crews, number of outage calls, number of active outage events and restoration time intervals, damage assessment reports both globally and/or by pre-defined areas.

2. Contractor shall describe the algorithm for calculating ETRs and the degree of configurability.

3. The user shall be able to manually modify an ETR and have it carry as part of the status of the outage event. Modification of the auto-generated ETR by the user shall require a justification for the change.

4. The user shall have the ability to adjust ETRs for each restoration step performed.

5. The OMS shall accept job status sent by field personnel manually or, optionally, electronically using a mobile device; the OMS shall be able to revise the ETR based on this status. The user shall have the ability to override manually any field status that impacts ETR adjustments; also, field conditions from a mobile device sent from a repair crew may also override previous status and ETR adjustments.

6. The OMS shall alert the operator when there are a configurable number of minutes remaining on the ETR through configurable color/symbology on the Incident Summary. The OMS shall record the customers who have received an ETR. The OMS shall track and identify customers who have missed their ETR. The user shall be able to track the number of ETR updates by customer and the ETR given to customers with time stamp.

7. The OMS shall track and record the number of times customers have received multiple ETRs by customer due to changes in the estimate. The user shall have the ability to vary the levels of field resources and have the OMS adjust the ETR.

8. The OMS shall have the capability to compare ETRs generated versus the actual time to restore for analysis purposes.

9. As an option, Purchaser is interested in Intelligent ETR functionality, where the ETRs for device types are adjusted based on “learning” from historical restoration times for conditions similar to current conditions.
19.8.5 **Planned Outages**

1. The OMS shall compare estimated outage durations for planned outage to the actual outage duration; the OMS shall alert the operator when there are a configurable number of minutes remaining on the estimated outage duration.

2. Similarly, the system shall detect and notify the operator if, in the context of a planned outage, he is about to de-energize the network ahead of the announced outage start time.

19.8.6 **Customer Information**

1. Complete information about all customers shall be obtained from the Purchaser’s Customer Information System. Updates to customer information shall be available to the OMS at least daily.

2. Access to customer data shall be restricted to the users with special permissions to access it (normally permissions are managed by authorized utility personnel).

3. The customer information needed by the OMS shall be defined by the Contractor and may include, but shall not be limited to:

   3.1. Account ID,
   3.2. First name
   3.3. Last name (Company names go here)
   3.4. Priority (Key Account, Critical Load 1, Critical Load 2, Critical Load 3, Life Support)
   3.5. Address
   3.6. City
   3.7. Zip Code
   3.8. District ID
   3.9. Phone Number 1
   3.10. Phone Number 1 Type
   3.11. Phone Number 2
   3.12. Phone Number 2 Type
   3.13. Phone Number 3
   3.14. Phone Number 3 Type
3.15. Service Delivery Point ID
3.16. Meter ID
3.17. Meter type (Simple, Net, PV, EV, etc.)
3.18. Normal Feeder
3.19. Phase (populated by network model)
3.20. Normal Substation
3.21. Current Feeder
3.22. Current Substation
3.23. Power Down Supported
3.24. Power Up Supported
3.25. Ping Supported
3.26. Account type (RES, COM, etc.)
3.27. Rate Schedule Code (E-RES, E-SEC1, E-SEC2, E-COM1, etc.)

19.8.7 Customer Browser

1. User shall be able to query customer information, current or historical, through a Customer Browser.
2. In addition to being able to search, filter, and sort (multiple levels) on any of the fields viewable through the browser, the user shall be able to select a time range and view the associated historical incidents that affected a customer during that time frame.
3. The user shall also be able to ping and poll the customer meter from this browser. Historical AMI information (power down, power up, sag, swell, etc.) shall also be viewable this browser.
4. In addition to all of the customer fields identified in 19.8.6 above, some additional incident-related fields shall be viewable through the browser. The additional fields are:

   4.1. Number of planned outages
   4.2. Number of unplanned outages
   4.3. Number of planned interruptions
   4.4. Number of unplanned interruptions
   4.5. Interruption minutes
   4.6. Energy not supplied index (kWh/interval)
4.7. Number of calls
4.8. Number of power down events
4.9. Number of power up events
4.10. Number of ping requests
4.11. Number of power down responses
4.12. Number of power up responses
4.13. Number of failed responses to ping

19.8.8 Reports

1. The system shall provide an on-demand reporting environment that allows users to develop their own reports against the system’s IS&R.
2. The user shall be able to name and save their reports in a catalog of reports.
3. The user shall be able to view any report definition and copy it to re-use its logic as a starting point for a new report.
4. The user shall be able to print the results of any basic report that is executed.
5. The user shall be able to designate Microsoft Excel or Word, or CSV, as the output format and the system shall start up Excel or Word and load the results of the report into Excel or Word or output in CSV format.
6. The system shall provide data to generate post-storm reports (average time to dispatch, arrival times, work durations, completions, etc.).
7. The system shall provide error correction capability with full audit trail for report data corrections.
8. The system shall provide the capability to assist with regulatory audit reporting using configurable audit trails.
9. The system shall provide tools to archive data from the production operational database to the IS&R.
10. The system shall have the ability to produce damage assessment reports.
11. The system shall provide data to generate summary and detailed reports on customer contact data (customer messages and notifications).
12. The system shall provide job closeout data for reporting.
13. The OMS shall have the capability to extend to and integrate with a reporting system that is part of the Contractor’s solution, and the Contractor is able to provide both as a packaged solution.

14. Alternately, the OMS shall have the capability to extend to and integrate with a reporting system solution that is not part of the Contractor’s product line offering and that is selected by the Purchaser.

19.8.9 **Performance Indices**

1. The OMS shall provide the ability to calculate quality of service indices that can be used to track and report on the performance characteristics of Purchaser's Distribution System over various time periods (custom dates, monthly, quarterly, seasonally, annually or multi-year) as specified by the user.

2. This shall include quality of service indices pre-defined in the database or created by the user on-line. At least, the following quality of service indices shall be implemented: SAIDI, SAIFI, CAIDI, CEMI, and MAIFI.

3. The OMS shall record all input data related to the calculations of quality of service indices down to the customer level. The user shall be able to view the quality of service indices and the variables used to calculate them via interactive displays that allow the user to:

   3.1. Create, verify, and edit quality-of-service formulas
   3.2. Verify and edit individual values of the calculation variables
   3.3. Enable and disable one or more index calculations
   3.4. Enter schedules for index calculations.
   3.5. Set the minimum and maximum duration to be included in a calculation
   3.6. Variables for calculation should include but not be limited to feeder breaker, map grid, zip code, cause, date, time of day, type of customer (commercial, residential, etc.), and type of equipment operating, including, but not limited to, outages originating in the distribution, substation, transmission, and generation systems.

4. The calculation variables shall include any values available, including real-time and historical data.
5. Tools shall be provided to compare sets of indices created at different times and over
   different time periods. These tools shall allow statistical information to be generated for user-
   selected indices. In addition, the user shall be able to generate, review, and schedule reports
   based on the quality of service indices.
6. The OMS shall compute and track performance reliability statistics in accordance with the
   guidelines established in IEEE Standard 1366:
   6.1. CAIDI
   6.2. CEMI
   6.3. SAIDI
   6.4. SAIFI
   6.5. MAIFI
7. The OMS shall allow the user to designate Major Event Days (MEDs).
8. The OMS shall provide a set of outage index performance reports.
9. The user shall be able to drill down into detailed information used to calculate the indexes.
   The capability to show the statistics for different time periods shall be provided. The UI shall
   include dashboards that show the data in user friendly views.
10. The OMS shall support the configuration of the parameters used in the outage performance
    reporting indices such as duration used to delineate between momentary and sustained
    outages.
11. The OMS shall include Customer Restoration and Incident Completion dashboards.
12. The Contractor shall provide widgets related to reliability indices so that the user can create
    custom dashboards (visible on the Web UI that execute and display reliability indices).
13. Contractor shall provide user customizable graphical analytics and widgets to help organize
    work response priorities related to reliability. For example, display on a geographic map the
    customers with greater than x number of outages highlighted.

19.8.10  Crew Management

1. The Crew Management function shall provide functionality that is required to manage and
   monitor crew performance, workload and location.
19.8.10.1 CREW DEFINITION

1. The user shall be able to:

   1.1. Define preconfigured crews. Each crew shall comprise crew members, trucks and special equipment.
   1.2. Create crews from a master list and set-up crews by shift.
   1.3. Create crews “on the fly”
   1.4. Create new crews containing mutual aid or contractors and make them active so they can have events dispatched or assigned to them.
   1.5. Split or merge crews based on crew restrictions or outage event conditions.
   1.6. Define individuals, their qualifications / skill set
   1.7. The solution will provide an “On Site” column in Crew Assignment Window and Crew browser. The values for this column are YES and NO and is dynamically populated based on Purchaser defined conditions.
   1.8. The solution will provide an “Availability” (On Duty, Off Duty, On Break) column in Crew Assignment window
   1.9. The solution will include crew scheduled start and end times. The crew status (on-duty or off-duty) shall be automatically updated based the scheduled start and end times. The user shall have the ability to define the crew times and the crew schedule can be updated by the user on the fly, from the desktop and Web versions.
   1.10. The solution will provide an “Arrive” button in Crew Assignment window: By clicking the Arrived button, all selected crews obtain the appropriate assignments and the crew statuses of these assignments are immediately set to “On Site”.

2. For each individual crew member, the OMS shall contain this contact information:

   2.1. Cell number
   2.2. Radio number
   2.3. Truck id
   2.4. Emergency contact number
   2.5. Other definable information
3. The capability to import a list of available and scheduled crew definitions in a pre-defined format into the OMS for crew assignments shall be provided. The capability for a user to update the crews on demand from a Web version shall be provided.

19.8.10.2 **OPERATION OF CREWS**

1. The user shall be able to update the status of incidents as work progresses. In particular, these personnel shall be able to record job completion and associated details, such as the diagnosed cause of the outage. The authorized user shall be able to declare an outage complete (i.e., restoration work complete) without having completed all administrative data entry, but the OMS shall ensure that all details are completed before archiving the outage.

2. The assignment of crews to outages and the monitoring of their current location and status shall be performed directly on the Outage Management Displays. Crew Management function of OMS shall include:

   2.1. Ability to view the list of available crews and the types of crews.
   2.2. Ability to assign and manage crews and resources for resolution of Outage or Non-Outage incidents.
   2.3. Monitor crew performance, workload, and location
   2.4. Determine the preferred crew or crews for handling the work
   2.5. Ability to reassign incidents between crews.
   2.6. Ability to assign multiple crews to different incident phases and track the status of these multiple tasks as part of a larger event.
   2.7. Ability to view multiple crews assigned to a single incident (example, an incident assigned to a primary/secondary crew but is pending the arrival of a tree crew).
   2.8. Ability to mark a crew as active or inactive.
   2.9. The OMS shall display a symbol to represent each vehicle at the appropriate location on distribution geographical map (the Purchaser has GPS coordinates/AVL for crews). The symbol may reflect crew status in addition to location. User shall be able to drag and drop a vehicle symbol based on GPS/AVL coordinates to an incident from either the geographic or incident browser and have that crew automatically assigned.
   2.10. Ability to view current repair status.
2.11. The OMS shall generate and display for each crew the estimated time they have left on the trouble events that have been dispatched or assigned to them.

2.12. The user shall be able to view a summary of current staffing levels assigned to storm assessment and restoration (by resource type) to incidents.

2.13. The OMS shall be able to generate the number of additional crews required based on the current set of known and predicted incidents and the number of active crews, their remaining availability and the user entered desired incident completion time.

2.14. The OMS shall be able to provide counts of crews working within a pre-defined geographic area (e.g. zip code or another user defined district).

3. The Crew Management function shall provide convenient access to all information necessary to track, contact, and assign work schedules to Purchaser's field crews. As a minimum, this information shall include:

3.1. Crew name or ID
3.2. Planned and unplanned work assignments
3.3. Crew composition details (e.g., size and individual names)
3.4. Crew and truck locations
3.5. Available equipment (e.g., hot-line equipment)
3.6. Work assignments completed
3.7. Work assignments uncompleted
3.8. Assignment start and end times (actual and estimated)
3.9. Work assignment forms
3.10. Availability information

4. The user shall be able to display information about all current incidents, including but not limited to:

4.1. Area of Responsibility
4.2. Creation time or range
4.3. Feeder or device
4.4. Priority level or priority level range
4.5. User category
4.6. Type
4.7. Facility code
4.8. Key accounts (strategic accounts)
4.9. Crew assignment (dispatched incidents)

5. The Crew Management function shall recommend the preferred crew or crews for handling an incident based on crew member skills, vehicles available to the crew, crew proximity, current workload, activity priorities, remaining time before the crew’s scheduled off time and other such considerations. The method used by the Crew Management function in dealing with such considerations shall be configurable.

6. The Crew Management function shall determine what work should be assigned to a crew that is available for a new assignment and shall prioritize incidents when the number of incidents exceeds the number of crews. The system will assign no more than two incidents per crew at any given time. The operator shall be able to override the priority set by the OMS. Once the incident is assigned, the operator shall be allowed to dispatch, re-assign, edit or cancel the incident. The operators shall be able to use drag and drop functionality to assign or re-assign an incident between crews.

7. A Job Tracking view shall display the following incident resolution information gathered by the field crews (all of them shall be custom configurable by the Purchaser):

7.1. “Construction Type” code – shall include codes for at least 100 construction types (e.g., ring main unit, streetlight, traffic signal, etc.).
7.2. “Problem” code – shall include codes for at least 30 problem types.
7.3. “Cause” code – shall include codes for at least 100 Cause types.
7.4. “Action Taken” code – shall include codes for at least 10 possible field crew actions.
7.5. “Failed Component” code – shall include codes for at least 150 possible power system components.
7.6. “Material” code – shall include codes for at least 100 material codes.
7.7. “Refer To” code – this field shall identify the organizations within Employer to which the trouble ticket should be referred for follow up actions. At least 30 possible codes shall be custom configurable by Employer.
7.8. “Observations” field – this field shall include space for at least 100 characters of free form input for comments.

19.8.10.3 **HOURS TRACKING**

1. The OMS shall track hours on the incident for each individual crew member.
2. The OMS shall generate an alarm that color codes the crew on both the graphical and tabular displays they are displayed on when any member of the crew has reached a user definable threshold of hours on the incident.
3. This system shall alarm the operator when a crew member is overdue for a meal or rest period.
4. The user shall be able to generate a list of crew members that have reached a threshold number of hours on the incident.
5. The user shall be able to list for each crew, its members and the hours (and partial hours to the tenth of an hour) currently on the incident for each crew member and all events that have either been dispatched or assigned to the crew.

19.8.10.4 **CREW STATISTICS**

1. The Crew Management function shall maintain various Purchaser-defined statistics on crew performance over an historical period of at least one year.
2. These statistics shall be capable of being displayed and edited on console monitors and shared in the form of reports.
3. The crew management information shall also be capable of being archived and retrieved for review and analysis on demand.

19.8.11 **OMS User Interface Requirements**

1. The set of displays, dashboards and data entry forms associated with the OMS User Interface shall be configurable.
2. The basic ability to locate described in 19.4 ADMS User Interface shall include the ability for the user to locate an outage from a tabular list to a geographic or schematic display. Similarly, the user shall be able to navigate from a tabular or other display (e.g. a switching order) where a crew is listed and locate the crew at its current location on a geographic tabular (assumes that the crew has GPS coordinates/AVL).
3. From a graphical display showing the presence of a crew, the user shall be able to view the corresponding crew information. The capability to view static or dynamic information or both shall be provided.

4. The ability to locate any device or landbase element from on geographic displays of the Distribution Network shall be supported by entering the ID (with “assumed” wildcards) in a single field (i.e. regardless of the type of the object, the same field shall be used to initiate the search). Examples, but not a complete list, of searchable items are:

   4.1. Equipment ID (switch number, breaker number, feeder id)
   4.2. Pole number
   4.3. Customer info – name, phone, address
   4.4. Street address or intersection (street 1, street 2)

19.8.11.1 **INFORMATION RELATED TO A DEVICE**

1. From a graphical or tabular or list display, the user shall be able to call up customer information related to a device:

   1.1. The count of customers served by the selected facility by phase.
   1.2. The list of critical customers or critical customer facilities served by the selected facility by phase.
   1.3. The list of all customers served by the selected facility by phase.

2. The user shall be able to view all current and historical incidents that reference the selected device.

19.8.11.2 **INFORMATION RELATED TO A CUSTOMER**

1. The user shall be able to view all current and historical incidents that affect a selected customer from a single display. For current work in progress, the OMS shall display the status of the incidents.

2. The OMS shall highlight via blinking and use of other visual cues, all outage events that are in their unacknowledged state. The OMS shall contain routing codes and trouble clues to support this function.
19.8.12 **Field Client**

1. The Field Client shall be a mobile solution for field crews to manage switching and incidents, enabling them to view the geographic view and the portions of a switching order (optionally, the entire switching order or only the steps assigned to them) for switching orders with at least one step assigned to them or the incident detail for those incidents assigned to them.

2. The field crew shall be able to update the Crew Status and ETR fields, as well as create a Work Location and assign themselves to it.

3. The solution must provide alignment of all Switching Management features, configurations, customizations in Field Client as well as the ability to configure user options and workspaces consistent with the user interface. This provides flexibility for different types of troubleshooters as well as different crew departments which use field client.

4. The field client must demonstrate acceptable performance under load; the User must be provided with quick access to the main Incident/Switching plan information in single click, quick response/refresh when a new document is assigned, as well as ability to record video/photo via field client. Dispatching is still focused on control room jobs i.e. Incidents and Switching plans.

5. User shall be able to search for active incidents (incidents which have not been completed) by the following search criteria

   5.1. Zip Code
   5.2. District

6. The search results incidents are displayed in the same way as the tickets are displayed in Incident Browser. Refer to the Incident Browser described in Section 19.8.4.1 Incident management. All the incident result information shall be shown in read-only mode.

7. Workspace management (window position, tab position, toolbar access etc.) shall be implemented on web platform in order to support multiple different user roles, since number of roles once the workforce management comes in place is significantly increased comparing to the traditional ADMS implementation. Workspace can be saved per user.

8. Allow the field personnel to access most frequently used features from shortcut screens and improve general usability of the application. Enable broader use of geolocation data within the application for usability improvements.
9. User configuration (presets) shall be implemented on a web platform to support multiple different user roles in the Field Client, since the number of roles (if workforce management integration is present) is significantly increased compared to a traditional ADMS implementation.

10. Workspace can be saved globally, per role and per user.

11. Mobile Dispatching

   11.1. The solution must provide the user the ability to update device from map and perform Switching validation.

12. Incident details

   12.1. Field crews may be authorized to see all existing incidents in the Field Client, not just incidents assigned to them. With that authorization, the field crew will be able to toggle between viewing all existing incidents or only those assigned to them.

   12.2. System shall allow the user to input the status of work progress for a selected incident. System shall provide entry points for the field crew to update time stamps for En Route Time, Estimated Time of Arrival (ETA), Estimated Time of Restoration (ETR), Time of Arrival, Time of Restoration & Complete time. System shall display the clearance number linked to the incident and allow the field crew to enter incident comments.

   12.3. System shall display a Time Builder pop-up window to update the time stamps for ETA & ETR, when the user chooses the respective options for the same. The system shall display a pop-up window with values designed to record the time efficiently.

13. Incident Historical browser

   13.1. The same Incident Browser used for viewing active incidents shall be used for viewing history of incidents (see Section 19.8.4.1 Incident management bullet 3).

14. Customer History

   14.1. In the Field Client, the user shall have the same capabilities as described in the Customer Browser Section (19.8.7 Customer Browser).
15. Site Notes

15.1. System shall allow the user to navigate to the site notes of the customer if the call (from the calls list) or customer (from the Customer List) is selected.

15.2. System shall display all “unsafe condition” type of notes for selected customer and site in addition to the last 5 (configurable) notes associated with given site in the notes list.

15.3. A Site Notes screen shall display the residential and community Gate Codes information for the selected site from the CIS system.

15.4. System shall display driving instructions for selected site from CIS system.

15.5. On selection of a note in the notes list, system shall display the detailed note text in a text area below the notes list. All notes information shall be displayed in read-only mode.

15.6. The Site Notes button shall show some obvious visible display (change color or use icon) if there is information available in Gate Codes, Driving Instructions, or Meter Trail fields.

15.7. The Site Notes button shall show some additional obvious visible display (change color or Highlight or use icon) if there are unsafe conditions and/or other CIS notes.

15.8. System shall allow the user to view customer history and site notes for the selected call (from the Call list) or customer (from the Customer List). If no call (from the Call list) or customer (from the Customer List) is selected, system shall disable these options.

15.9. System shall provide visual cues on the Site Notes button (color codes or use of icons) that indicate if: a) additional information such as gate codes, driving instructions, or CIS notes is available on the Site Notes screen (turn button yellow or use an indicative icon), or b) hazard information is available on the Site Notes screen (turn button red or use an indicative icon).

15.10. Field crews should be able to add a new Site Note (using Field Client)

16. Advanced Tracing in Field Client

16.1. Field Client shall provide capability to Trace Up/Down to specified type of the device.
16.2. Supporting of advanced tracing and Customer list functionality in Field client application which will enable to field crew to perform any type of electrical navigation (up, down, all to specified type of element with stop/pass option). The typical use cases for field crews are to trace to nearest capacitors, to the first upstream regulator, to downstream fuse etc.

17. Configuration

17.1. System shall display the incidents in a scrollable list. System shall allow the user to move the header columns for the list. This column order preference shall be saved on the user’s system. System shall allow the user to sort the incidents by choosing any header column in the list.

19.8.13 **Automatic Vehicle Location**

1. Purchaser uses Global Positioning System (GPS) receivers in field crew vehicles used by Purchaser to operate the distribution power system. The geographical location (latitude and longitude, or map coordinates) of each of the vehicles will be transmitted to a GPS master station. Purchaser will provide an interface to allow the GPS master station to be integrated to the system.

2. The CM function shall have an interface to the GPS master station to receive the location of each crew vehicle, along with associated miscellaneous status information (e.g. vehicle parked, bucket in use, etc.). The CM function shall display a symbol to represent each vehicle at the appropriate location on an Outage and Crew Management graphic map.

3. The capability to define different symbols to represent different types of vehicles or their associated crews (e.g. overhead versus underground, multiple vehicle types, assigned “mission” such as capacitor bank truck, etc.) shall be provided. When the operator clicks on the symbol for a vehicle, the associated Crew Information View shall be brought up.

4. In order to prevent stranded truck symbols on maps, e.g. in the event of a GPS malfunction, the system shall monitor truck location and delete a truck symbol from displays if the truck hasn’t moved within 24 hours.

5. When assigning a crew to an incident, the distance of each crew (in miles) from the incident should be displayed on the display for picking which crew to assign.
6. The CM function shall update the crew location symbol on the geographic display within 5 seconds of receipt of coordinates from AVL.

19.9 Distribution Operator Training Simulator (DOTS)

1. The DOTS shall mimic the actions of Purchaser’s distribution system and this Advanced Distribution Management System. All functionality that is available in the production system will be available in the DOTS.

2. Previous ADMS models shall be available to recreate past events. The DOTS shall have the ability to download scenarios from past events, from the ADMS and from the PI Historian.

3. DOTS shall have the ability to interface with the ADMS and PI. The DOTS shall have the ability to interface with the EMS OTS or at the very least shall be able to mimic relevant Transmission and Generation System conditions.

4. The DOTS shall be used for the following purposes:

   4.1. Train Purchaser’s operating staff and other users who participate in the management and administration of the distribution system
   4.2. Test software, applications, and database changes
   4.3. Study configuration changes to distribution feeders
   4.4. Develop and test operating procedures
   4.5. Analyze past storm conditions and other distribution network disturbances
   4.6. Create scenarios for restoration training

5. All DOTS functions shall be integrated and work in concert to accurately represent the real-world environment.

6. The DOTS shall support its operation from two perspectives as defined in this section:

   6.1. Trainer – an ADMS user responsible for development of training scenarios, supervision and presentation of training exercises, and maintenance of the DOTS
   6.2. Student – an ADMS user or users normally assigned to operate the distribution network.
19.9.1 **OMS Simulator**

1. The control system simulator shall be a replica of the ADMS, SCADA functions and User Interface components of the system.
2. The OMS Simulator shall support a simulation environment as a training facility for Purchaser’s operating staff and other field supervisors that participate in the management and administration of trouble calls associated with customer outages.
3. Functions the trainee shall perform include taking ownership of an outage, dispatching crews, writing and performing switching operations, FLISR, installing and removing jumpers and closing outage orders, executing all DMS applications, etc. In addition, the OMS simulation mode shall be used as an analysis tool for replaying historical OMS events, including trouble calls, operator data entries, crew assignments and active outages, in a time-sequenced simulation.
4. The OMS Simulator will utilize historical data or automatically generate calls (based on number of calls identified by instructor) and send simulated outage calls to the ADMS. This information will be the foundation for predicting outages within the system. Sets of calls will be grouped to form scenarios. These scenarios will be used to simulate multiple concurrent outage events.
5. The simulation shall operate with an overall user performance that is consistent with real time operations.
6. The OMS Simulator will send simulated outage calls to ADMS.
7. This information will be the foundation for predicting outages within the system.
8. Sets of call calls will be grouped to form scenarios.
9. These scenarios will be used to simulate multiple concurrent outage events.
10. The system will allow an individual (typically a trainer) to in near real-time indicate which scenario should be executed and when.
11. Scenarios may be grouped to allow concurrent execution of a number of events. This will allow creation of similar outages in the variously assigned areas of responsibility.
12. The OMS Simulator will have the ability to reset the system back to normal (device state, customer calls, outages, etc.).
19.9.1.1 CALL INITIATION

1. The OMS simulator shall have the ability to generate calls that are associated with customers connected to the distribution system.
2. The ability to simulate last gasp calls with various traffic volumes and multiple origination circuits shall be provided.
3. These calls will be used in predicting outage location and the device that operated. The Customer Calls Model will include:
   3.1. Calls associated with customers to be used in the following ways:
      3.1.1. Triggered when part of an outage caused by the operation of a power system device (in real time or with the outage scenario builder)
      3.1.2. Loaded into a queue to be used by outage prediction engine to identify the outage location.
   3.2. Scenario based groups of calls that may be sent to the OMS Simulator to derive sets of outages.

19.9.1.2 CALL CREATION

1. The OMS Simulator will allow the trainer to create a new trouble call to be used in training outage scenarios.
2. Calls shall be created via a point and click approach, interacting with the customer representations on the screen.
3. A mechanism shall be included to select multiple customers and create multiple calls at a time from the screen.
4. The system shall also provide the ability to load calls from an external database, facilitating the replaying of a prior outage event.

19.9.2 Control System Simulator

1. The control system simulator shall be a replica of the system functions and User Interface components of the ADMS with the following exceptions:
1.1. The data acquisition functionality shall be simulated by the distribution system simulation.

1.1.1. Telemetered data shall appear to the student to be originating from the same data source as in the real-time Production system.

1.2. The IS&R functionality shall be supported to the extent required for scenario replay.

2. The control system simulator shall reproduce the operation of all ADMS functionality, except as described above.

3. The required functionality specifically includes the following items:

3.1. Supervisory control, including tags.

3.1.1. Where a supervisory control is linked to a switching device in the distribution system model, the distribution system simulator shall reflect the change in network topology from a control action.

3.1.2. Where the supervisory control is linked to a device not in the distribution system model, the control action shall change the state of the value.

3.2. Data entry.

3.3. Any workstation shall be able to be used for training.

3.4. When performing any of these actions, the telemetry and calculated load flow values will change in the same way as in the production system, without any delay and will run automatically. With no instructor or trainee action required, the distribution load flow shall execute every 4 seconds or less and on topology change in order to simulate field behavior.

19.9.3 Scenario Builder

1. A DOTS scenario shall represent the system activity to be simulated over the course of a training session.

2. A scenario shall include the initial state of the distribution system and control system simulators, load allocation modeling, and events that occur over the duration of the scenario.

3. DOTS shall have the ability to capture snap shots from the ADMS and from PI historian.
4. DOTS shall have the ability to import and export CIM files.
5. DOTS scenarios shall be managed in a similar manner as and work with savecases as defined in Section 19.6.26.3 SaveCases.
6. The trainer will have the ability to begin a particular scenario to initiate similar events in multiple Areas of Control for the students.
7. Scenario “building” (definition or modification) shall be possible while another scenario is being executed.
8. Scenario building shall include the following activities:
   8.1. Setup of execution parameters, including simulation time
   8.2. Setup of the initial conditions.
      8.2.1. Initial conditions may be set by copying another scenario, by importing a distribution power flow savecase, or by retrieving power system measurements for a specified time and date from the Historian.
      8.2.1.1. Data retrieved from the Historian shall be processed by the distribution power flow function to produce valid initial conditions.
   8.2.2. Initial condition data not available from power flow savecases or Historian shall be manually entered by the trainer.
   8.3. Definition of the feeder load profiles
   8.4. Definition of events.
      8.4.1. An event shall be defined by specifying the event type (see below), one or more distribution system devices or control system elements on which the event is to act, and a time (in simulation time) for the event.
      8.4.2. Where an event is to act on a power system device, the trainer shall be able to select the device from any one-line or tabular display containing the device.
      8.4.3. For Outage Management simulation, events will generate calls from affected customers.
8.4.4. Sets of call captured during an actual event may be used as basis for creating an Outage Management event.

9. Event types shall include at least the following items:

9.1. Switching device operations, both single operations (such as trip or close) and multiple operations (such as trip/close).

9.1.1. For multiple operations, each simulated operation (such as trip and close) shall be reported to the control system model to ensure that actions that are triggered by the operation of the device will occur.

9.2. Changes in the state of status points

9.3. Changes in the value of analog points not defined in the distribution system model

9.4. Changes in the value of analog points defined in the distribution system model.

9.4.1. The changed value shall override the value provided by the distribution system simulator.

9.5. Changes in the state of relay and field logic enable/disable flags. (This can be used to simulate failure of devices to operate.)

9.6. Single load changes. Load changes shall override load values set by the load allocation simulation.

9.7. Change in generator unit output for a distributed generation source connected to the modeled low-voltage or medium-voltage network.


9.9. New outage calls


9.11. Occurrence of a momentary or sustained fault (simulated by relay operation acting on circuit breakers).

9.11.1. Reclose operations where the reclose time is less than the simulation periodicity shall be simulated as occurring over consecutive cycles.

19.9.4 *DOTS Execution Management*

1. DOTS execution management features shall facilitate execution and management of scenarios and interaction between the student and the trainer, including the following actions:
   1.1. Initialize the DOTS simulation to a scenario
   1.2. Start the simulation at any time within the scenario
   1.3. Stop the simulation at any time within the scenario
   1.4. Pause the training sequence at any time within the scenario and resume the simulation
   1.5. Generate a snapshot of the simulation.
      1.5.1. The snapshot shall include sufficient information so that the simulation can be returned to that point in the scenario and simulation resumed.
   1.6. Control the speed (periodicity) of simulation, from step-on-demand, through normal simulation speed, through fast (where the simulation is executed as quickly as possible)
   1.7. Generate events (Section 19.9.3 Scenario Builder) spontaneously, without creating a scenario entry.

2. All scenario events, trainer actions, and student actions (excluding actions such as display callups, window sizing, and study application executions) shall be recorded in the scenario.

3. The capability to replay a scenario shall be provided, including the capability to pause, fast forward, and rewind the scenario, including trainer and student actions, beginning at the start of the scenario or from any point within the scenario.

19.9.5 *Distribution System Simulator*

1. The DOTS simulation shall be executed for the distribution network, including the bulk power source points.

2. The DOTS distribution system simulator will have the ability to work with the Outage Management Simulator and the Control System Simulator, allowing analyzing circuit conditions during restoration.

3. The DOTS shall have the ability to be driven in steps as well as in continuous mode.
4. The distribution system simulator shall reproduce the operation of the distribution network in a discrete time-step manner, no less frequently than every 4 seconds.

5. At each time step, the simulation shall produce a complete unbalanced, three-phase distribution network solution, with voltages and flows at each network node.

6. The distribution system simulator shall be able to solve parallel, looped, and meshed circuits as defined in the Distribution Operations model.

7. On-demand executions shall be performed for an operator-assigned area of the distribution network when triggered by an event (e.g., whenever a change in topology or pre-defined change in status or analog data occurs).

8. The voltage and flow solution shall be passed to the control system simulator as a simulation of telemetered data.

9. The power system simulation shall produce a valid result for the following conditions:
   
   9.1. Operation of the distribution system with multiple isolated feeder segments that might contain low-voltage generation facilities as well as loads.
   
   9.2. Pick-up of de-energized feeders.

10. For data included in the ADMS database model, but not included in the distribution operations model, facilities for the trainer to simulate telemetry changing the value or attributes of a point shall be provided.

11. The distribution network shall be simulated in the DOTS, with the definition of the distribution system derived from the DOTS model components.

19.9.6 The Operator Training Simulator model

1. This DOTS database component shall include all distribution network information necessary to model the dynamics of the distribution system that are not used by the real-time ADMS functions.

2. The DOTS shall have the ability to copy current ADMS configuration.

3. Except for temporary grounds, jumpers, and circuit cuts that might be added during a training session, the Distribution System Operations Model in DOTS shall be identical to the source DSOM of the real-time Production System as defined in Section 19.3.1.1 Distribution System Operations Model (DSOM).
4. The DOTS model shall include all busses, feeders, loads, and network devices defined in the source DSOM.

5. Changes to the source DSOM made for any ADMS function shall also be automatically made to the DOTS Distribution Operations model.

6. The Outage Management DOTS model shall include all active elements defined in the source DSOM.

7. This DOTS database component shall include all the information necessary to model the inputs that drive the behavior of the ADMS Outage Management functions.

8. The DOTS shall include the ability to randomly simulate load and events previously defined by the instructor in a realistic manner.

9. In addition to recording all trainee operations, the DOTS shall measure its response time and file them for purposes of evaluation and benchmarking.

19.9.6.1 CUSTOMER CALLS ASSOCIATIONS

1. The Outage Management DOTS model will contain the elements necessary to generate calls that are associated with customers connected to the distribution system.

2. These calls will be used in predicting outage location and the device that operated.

3. The Customer Calls Model will include:

   3.1. Calls associated with customers to be used in the following ways

   3.1.1. These will be triggered when affected by an outage when the ADMS-SCADA operates a device (in real time or with the outage scenario builder loaded into a queue to be used by outage prediction engine to identify the outage location

   3.1.2. Scenario based groups of calls that may be sent to the Outage Management DOTS to drive sets of outages

19.9.6.2 SCADA TELEMETRY MODEL

1. Scenario based groups of trip signals that may be sent to the Outage Management DOTS to drive outage prediction
19.9.6.3 RELAY AND FIELD LOGIC MODELING

1. The DOTS shall simulate the following types of relays and field logic:
   
   1.1. Overcurrent relays
   1.2. Overvoltage relays
   1.3. Undervoltage relays
   1.4. Overfrequency relays
   1.5. Underfrequency relays
   1.6. Synchronism check relays
   1.7. Recloser relays, with up to three reclose actions
   1.8. Transfer tripping
   1.9. Relay lockout
   1.10. Load tap changers
   1.11. Voltage regulators
   1.12. Capacitor banks and controllers (including operating constraints)

2. Each relay and field device shall be modeled with an enable/disable flag.
3. When set to disable, the relay or device shall not operate.
4. When set to enable, the relay or device shall operate as normal.
5. Selected relays devices may be implemented for supervisory control of the enable/disable flag.
6. For those devices, the DOTS shall link the supervisory control command to the enable/disable flag.
7. Selected underfrequency and lockout relays shall include a reset feature.
8. When implemented, the reset feature shall be linked to a supervisory control point in the control system simulator.
9. The relay shall inhibit operation of the switching device it controls until the student operates the reset supervisory control.
10. Except as described above, no other field logic such as special protection schemes shall be modeled in the DOTS.
19.9.6.4 LOAD ALLOCATION MODELING

1. Distribution feeder loads shall be modeled for conforming and non-conforming loads using predefined daily area load profiles.

   1.1. Sets of daily load profiles for 24 hourly periods are required based on load type (e.g., small & large commercial, residential, industrial) as a function of both day types and seasons.

   1.2. The real and reactive components of each load profile shall be specified independently as functions of time, day type, and season.

   1.3. The load profiles shall be selectable through displays.

   1.4. The trainer shall be able to modify the load by entering individual load values or by applying a scale factor to the entire load profile.

2. Each conforming feeder load shall be scaled as a function of transformer capacity or, if available, monthly KWh usage.

   2.1. Where a switching device operation results in the disconnection of load from the feeder circuit that load shall not be reallocated among the other connected loads.

   2.2. Each modeled load shall include features to simulate changes in the load due to changes in voltage.

   2.3. Individual loads on a feeder that are telemetered shall be linked to the control system simulator (Section 19.9.2 Control System Simulator).

19.9.6.5 THE OUTAGE MANAGEMENT DATABASE MODEL

1. This DOTS Outage Management Database component shall include all ADMS database objects and their attributes.

2. This includes operational devices such as breakers, reclosers, sectionalizers, fuses and transformers. It also includes all switchable devices such as switches and regulators.

3. The Outage Management database model shall be populated by the Control System Simulator described in Section 19.9.2 Control System Simulator.

4. Changes to the ADMS production database model shall be carried to the DOTS without requiring the changes to be redefined on the DOTS.

5. The OM database model can be refreshed from the production database upon request.
5.1. Calls – associated with devices on the distribution system.
5.2. Outage Scenario – Allow sets of calls and device telemetry
5.3. Scenario grouping – Allows execution of multiple scenarios

19.9.6.6 THE ADMS DATABASE MODEL.

1. This DOTS database component shall include all ADMS database objects and their attributes, whether or not these objects are linked to Distribution Operations model (e.g., field device control status, calculation results).

2. The ADMS DOTS database model shall be populated by the Control System Simulator described in Section 19.9.2 Control System Simulator.

3. Changes to the ADMS database model shall be carried to the DOTS without requiring the changes to be redefined on the DOTS.

19.9.7 DOTS Synchronization Process

1. A rollback capability shall be provided for the DOTS. It will be robust, fully automated DOTS synchronization process, which will provide following capabilities:

1.1. DOTS Synchronization – a single click of a button on a DOTS administration tool, will perform a complete synchronization of the DOTS (Student and Instructor) with the active Production system, for DMS, SCADA and Historian.

1.2. The UI show an automatic step by step execution, which happens in the background. A click on the button will execute the complete synchronization of DOTS system (no further actions on DOTS would be required).

1.3. DOTS Savecase – this will be a single click of a button which saves following items in Historical Scratchpad database, on active production system:

1.3.1. DMS active model version
1.3.2. Just created DMS savecase
1.3.3. Currently active SCADA RTDB

1.4. DOTS Load Case – a single click of a button which lists all saved DOTS Saved Cases from Historical Scratchpad database, and allows the user to pick any one of them and synchronize the DOTS with that particular DOTS Savecase, created at any
point in time with “DOTS Savecase” functionality. This is similar to standard DMS savecase functionality, but more powerful because it saves static, dynamic DMS values, and the RTDB (listed in “DOTS Savecase” description)

1.5. Load and generation patterns can be changed system wide or by element from the instructor console with minimal clicks.

19.10 ADMS Interfaces

1. The scope for the interface component of ADMS project includes implementing interfaces to the Enterprise Service Bus (ESB)/Service Oriented Architecture (SOA) to expose to ADMS.

19.10.1 Customer Care & Billing (CC&B)

Currently a weekly file based customer update is sent from CC&B to ADMS, including Critical Load and Key Account identifiers. The intention is to move to real-time customer information updates.

1. The ADMS shall interface with AE’s existing Customer Information Systems. CIS functions include new customer connections information, customer information modification.

2. Information to be exchanged with the CIS is as follows:

   2.1. On a periodic or real-time basis, CIS sends to the ADMS all appropriate customer information. Some additional fields specific to the AE implementation include: City Council District ID, rate code used for load profile, meter status (on/off), solar size, critical load and key accounts.

2. The system will allow adding and removing of fields in the file structure.

3. The data imported from the CIS shall be subjected to two levels of validation before it is incorporated in the ADMS database: automatic and manual.

4. The ADMS shall perform automatic data checking and validation when the data are first received from the CIS.

5. The automatic validation shall include the following checks:

   5.1. All required parameters are specified
5.2. All customers are connected to a valid load point

6. If there is an error in the file, all other valid fields will load.
7. The data received shall be placed in a provisional table, with all errors identified.
8. The user of the ADMS shall be provided the ability to correct errors and supply missing data.
9. Then, as a separate step, a properly authorized user (typically a supervisor) will review the data in the provisional table and may choose to accept it.
10. The performance of the interface shall be such that the expected daily incremental changes of AE data during a normal day shall be incorporated in the ADMS within one hour.
11. During the data update period, there shall not be degradation of the normal ADMS-SCADA operation as defined by the specified performance figures for response times.
12. Data received from the CIS shall not cause the loss of any real-time information, any manually-entered data or any user-entered notes.

19.10.2 Solar Size – manual import

The Solar size information is added to the GIS feeder before it is inserted into ADMS.

1. Use of the Contractor’s equipment catalog database solution, or if not available, then use of a Distribution Equipment Database (DEQDB), an Excel workbook, that is exported to CSV in order for the DEQDB to be used during CIM transformation

   1.1. Full List – DG Generators PV, and Generator Regulating Control PV
   1.2. Delta List – DG Generators PV, and Generator Regulating Control PV

19.10.3 AEcall

1. The ADMS shall interface with the AEcall, an application, developed by AE to support CSRs and to capture information necessary to create a trouble call.
2. AEcall allows a CSR to determine if a customer is involved in an outage, provide the customer with status information regarding the outage and capture new outage information.
3. AEcall is also used as the mechanism to view trouble call information captured by other input channels.
4. The Contractor shall provide APIs to allow AEcall to:
4.1. Enter Trouble Call and Unlocated Call (35-45 fields, including some lists)
4.2. Get Next Callback (45-55 fields, including some lists)
4.3. Pending Callbacks with functionality to Close Callbacks after restoration (30-40 fields, including some lists)
4.4. Unlocated Calls Report (25-35 fields, including some lists)
4.5. Customer History (35-45 fields, including some lists)
4.6. System Outage Summary (45-55 fields)
4.7. Trouble Call Summary (5-10 fields)

5. The Vendor shall provide an API to send AECall individual outage customer calls that have been resolved.

19.10.4 **21st Century High Volume Call Application (HVCA)**

21st Century High Volume Call Application (HVCA) is an IVR that is turned on during high call volume in place of local agents collecting trouble information in AECall.

1. 21st Century HVCA files must be identified as IVR calls in a separate interface.
2. ADMS must look at the timestamp on the IVR calls to group calls with existing incidents, even if the incident is already closed.
3. If a callback is requested, the callback shall be sent from the ADMS to AECall to go through the AECall callback process.

19.10.5 **Automatic Vehicle Locator (AVL) (COA managed)**

1. ADMS interface to COA CTM to get AVL coordinates, vehicle identifier and radio identifier for Crew Management and MWM.
2. Another interface to synchronize the vehicle identifier and radio identifier with ADMS. Two interfaces will be included:
   2.1. Deliver vehicle coordinates to ADMS system
   2.2. Vehicle Radio Association Synchronization

19.10.6 **Advanced Metering Infrastructure (AMI) Real Time Meter Status**

1. The system shall be able to acquire and use data from MDMS or the AE hosted L+G server.
2. The system shall provide a mechanism to obtain voltage readings, last gasp events, and restoration status from the operator workstation and display the returned status visually for the operators on the geographic and schematic displays.
   2.1. Last gasp/power restore – event based
   2.2. Ping service status – on demand
   2.3. Ping voltage – on demand
   2.4. Programmed/Unsolicited Voltage – scheduled, every 1 minute

3. A user shall be able to request average active and reactive power values from the MDMS for every meter for use in both the Distribution Power Flow and planning applications.

4. MWM integration with integration layer to check for scheduled field activities (disconnect for non-pay, meter exchange, etc.)

5. Handling of smart metering functions will be a non-critical service so if the service goes down nothing else is affected.

**19.10.7 Load Profile**

ADMS will interface to MDMS for load profile data:

1. MDMS Custom extract – monthly
2. MDMs Custom extract – annually
3. Storm Geo weather file integration – monthly

Note: MDMS provides measurements in IEC 61968-9, Interface Standard for Meter Reading and Control.

**19.10.8 GIS interface, including landbase and other layers**

The GIS contains the information to define the distribution system, the feeder topology and all devices associated with the distribution system including their features, attributes, and connectivity.

The GIS also contains distribution transformers, secondaries and load point to which the customer relationship is maintained.
1. The ADMS shall be interfaced with Purchaser’s existing Geographic Information Systems (GIS), whose connectivity implementation is complete for the implementation of the ADMS.

2. Purchaser’s GIS is a tool able to capture, store, edit, update, analyze, consult, and display all the referenced geographic information of the distribution system. This information is useful to all corporate areas as a powerful and functional tool for the decision-making process, asset assessment, maintenance, and operational job documentation.

3. The existing Purchaser GIS is based on GE’s Smallworld (Electric Office), which shall be the source of landbase information.

4. Therefore, adequate interfaces to extract and export alphanumeric and graphical data from/to these platforms are required.

5. The data to be imported from GIS shall include both actual power system facilities as updated by Purchaser on a daily basis and planned data for modifications or additions planned for the future.

6. The operators will have the capability to validate proposed construction/work and to permit it to become a part of the actual distribution power system model (DSOM) once work is completed in the field.

   6.1. This shall include the capability to update the model to reflect the actual work performed in the field based on as-built information from the field crews performing the work.

7. Graphical differentiation of each type of data is required. Incremental updates of data shall be possible at any time.

8. The distribution system network is modeled based on device connectivity. In addition, the geographic division shall also be identifiable.

9. It shall be possible to import complete feeders at once without requiring identifying the geographic areas where the feeder is located.

10. The data imported from the GIS shall be subjected to two levels of validation before it is incorporated in the ADMS database: automatic and manual.

11. The ADMS shall perform automatic data checking and validation when the data are first received from the GIS.
11.1. The automatic validation shall include, but not be limited to, the following checks and a report of the GIS errors to be addressed shall be generated (one file will include the errors for all the feeders including circuit ID as a prefix of each line or section).

11.1.1. All required parameters are specified
11.1.2. All devices are connected to one and only one power source, loops shall be identified and highlighted
11.1.3. Phase connections are made correctly
11.1.4. Values of all numeric parameters fall within pre-specified ranges, etc.
11.1.5. All devices are connected (de-energized devices shall be identified and highlighted)
11.1.6. All unconnected devices and line segments shall also be identified and highlighted.

12. The data received shall be placed in a provisional layer, with all errors listed in a table and flagged or highlighted on a graphical display.

13. Then, as a separate step, a properly authorized user (typically a supervisor) will review the data in the provisional layer and may choose to accept it.

14. The performance of the interface shall be such that the expected daily incremental changes of Purchaser data during a normal day shall be incorporated in the ADMS within an estimated time of one hour maximum.

15. During the data update period there shall not be degradation of the normal ADMS-SCADA operation as defined by the specified performance figures for response times.

16. Only after the data has passed the complete suite of validity checks and has been accepted by an authorized user shall the ADMS incorporate the data in the database, overlaying or supplementing the existing graphical and facilities data. Data received from the GIS shall not cause the loss of any real-time information, any manually-entered data, any user-entered notes, or any temporary changes to the topology (such as temporary cuts, jumpers, or grounds).

17. The user shall be able to identify in the ADMS geographic view desired updates and send that data to the GIS.
17.1. Temporary jumpers, cuts, etc. to be made permanent
17.2. Notes about inaccuracies in the model, e.g. pole numbers, wire sizes, lateral phasing, mislinked customer to transformer
17.3. Conversion of “planned” network infrastructure to “in service”.

19.10.9 **Storm Center**

1. EnergySuite is an integration layer for a web-based application (Storm Center), SMS texting (Notifi), and Outage Reporting and Status (OR&S) developed by a third party vendor (KUBRA) that allows AE’s customers to directly view and enter outage information using the internet or SMS texting.

2. EnergySuite provides the following functionality:
   
   2.1. View general outage and hazard information on a map through Storm Center
   2.2. Enter a new outage trouble call though OR&S from a link on the Storm Center map or by texting with Notifi
   2.3. Access current status of their outage though OR&S from a link on the Storm Center map or by texting with Notifi.

3. The trouble call information entered via OR&S shall be used by ADMS for outage prediction.

4. The following are high level flows of information that need to go to/from the ADMS-SCADA and the KUBRA EnergySuite:
   
   4.1. Outage, restoration, cancellation file. The Vendor shall provide a periodic file to ADMS for overall status information that it may display on a map of the AE territory. This information will include: 20-30 fields
   
   4.1.1. The location of all outages and hazards within the AE territory requested
   4.1.2. The size of each outage within the AE territory
   4.1.3. The ADMS shall provide APIs to allow new trouble calls to be inserted into ADMS from the customer-facing KUBRA input channels.
   4.1.4. The ADMS shall allow EnergySuite to query and to determine if an individual customer is involved in an outage.
4.2. If the customer is part of an existing outage, the information to be returned shall include:

4.2.1. Number of Customers affected, Outage start time, Crew dispatched information (if available), Estimated time of restoration, Cause of the outage (if available).

5. ADMS generates and publishes a list of outage incidents and service delivery points that Storm Center picks up and applies to the Outages Map - every 10 minutes. Currently done with sftp.

6. ADMS generates and publishes a list of hazard incidents and service delivery points that Storm Center picks up and applies to the Outages Map - every 10 minutes. Currently done with SFTP.

7. Outage Reporting and Status functions are customer driven event based actions. Customers can query current outage status and can report an outage through one of the KUBRA customer-facing input channels. ADMS returns the outage details, or confirmation that AE is not aware of an outage at the customer’s location, which is provided back to the customer UI.

19.10.10 Weather Service

1. Purchaser will subscribe to a weather service to bring in data to be used by various applications such as Load Forecasting and DERMS management, and to drive the geographical display to show lightning strikes, weather locations, etc.

19.10.11 Transmission Outage Application (TOA)

1. Interface to TOA to get 5-10 fields, automatically generate a switching order initializing the switching order header with that data and setting an execution status to “Draft”.

19.10.12 Work and Asset Management System (WAMS) (requirement for future use)

1. There will be an interface between the ADMS and existing Work Management System (WMS) to create work orders for follow-up work from an outage, such as additional investigative work, clean-up, broken pole replacement, tree trimming, service and meter re-attachment.
19.10.13 **Other interfaces that are managed by control Engineering:**

1. PI Historian
2. SCADA EMS

   2.1. Common points represented in the EMS power network model and ADMS model shall be accommodated.
   2.2. Device status data (e.g., feeder breaker operation/lockout, etc.) and analog values shall be sent (one-way) from the existing EMS to the ADMS for status and analysis purposes.

3. Sys Log
4. Primate Video Wall – refer to Section 11.3 Video Wall Display Workstation Software.
List of Interfaces Between ADMS and Austin Energy IT

1. CC&B Extract
2. Customer Load
3. L+G Meter Ping: On/Off and Voltage
4. Last Gasp and Power Up
5. Customer/Meter Information and Trouble Call Information
6. Outage Updates, Callbacks
7. Data transfers to ADMS every 5 minutes
8. Vehicle ID and Coordinates
9. Dispatch Crews and Create/Update/Complete Trouble Orders
10. Status Complete and Incomplete
11. Outage, Restoration and Cancellation
12. Outage Reporting and Status

Partial List of Interfaces Outside ADMS

A. Customer Status
B. CC&B Extract to MDMS
C. L+G Ping through MDMS
19.11 ADMS Capacity and Performance

1. The ADMS shall be designed to meet the capacity and performance requirements defined in this section while meeting:

1.1. The performance requirements of Section 19.11.3 ADMS Performance through 19.11.7 Resource Monitoring.

1.2. The availability requirements of Section 2.6 System Availability.

1.3. The ability to interface with other systems such as PI Historian, SCADA EMS, Substation Based Mini SCADA.

1.4. The ability to handle real time non-operational data for condition monitoring and make them available to an enterprise DB. Handling of this data shall neither compromise the performance of the ADMS nor burden real time with alarms related to such data, which shall be directed via email or cell phone to designed technical personnel.

1.5. The ability to handle IED’s such as intelligent transformers
1.6. The ability to identify and categorize extremely high volume of automatic (last gaps) calls without unduly burden the operators,

19.11.1 **ADMS Sizing**

1. It is intended that the ADMS be sized to support the following numbers of users.

**Exhibit 19-3: Number of Users**

<table>
<thead>
<tr>
<th>Concurrent users</th>
<th>Installed clients</th>
<th>Event</th>
<th>Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECC</td>
<td>15</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>BUCC</td>
<td>5</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Control Engineering</td>
<td>20</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>System Engineering &amp; Planning</td>
<td>12</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Off-site</td>
<td>15</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Web clients</td>
<td>100</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>167</strong></td>
<td><strong>106</strong></td>
<td><strong>81</strong></td>
</tr>
</tbody>
</table>

2. The distribution system model shall be sized to represent the following:

**Exhibit 19-4: Distribution System Model Sizing**

<table>
<thead>
<tr>
<th>Facility counts</th>
<th>2017</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution Substations</td>
<td>80</td>
<td>85</td>
</tr>
<tr>
<td>Feeders</td>
<td>500</td>
<td>550</td>
</tr>
<tr>
<td>Airswitches</td>
<td>1,764</td>
<td>1,800</td>
</tr>
<tr>
<td>Remotely Controlled Airswitches</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>Disconnects</td>
<td>1,801</td>
<td>2,000</td>
</tr>
<tr>
<td>Sectionalizer</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>Capacitors</td>
<td>745</td>
<td>850</td>
</tr>
<tr>
<td>Remotely Controlled Capacitors</td>
<td>150</td>
<td>400</td>
</tr>
<tr>
<td>Recloser</td>
<td>50</td>
<td>75</td>
</tr>
<tr>
<td>Remotely Controlled Reclosers</td>
<td>24</td>
<td>200</td>
</tr>
<tr>
<td>Regulator</td>
<td>11</td>
<td>30</td>
</tr>
<tr>
<td>Switch Gear</td>
<td>309</td>
<td>400</td>
</tr>
<tr>
<td>Primary Meter</td>
<td>159</td>
<td>400</td>
</tr>
<tr>
<td>Overhead Transformer</td>
<td>42,757</td>
<td>50,000</td>
</tr>
<tr>
<td>Pad Mount Transformers</td>
<td>34,285</td>
<td>40,000</td>
</tr>
<tr>
<td>Submersible Transformers</td>
<td>654</td>
<td>700</td>
</tr>
</tbody>
</table>
## Facility counts

<table>
<thead>
<tr>
<th>Facility</th>
<th>2017</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line-monitors</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>AE Owned Poles</td>
<td>148,516</td>
<td>175,000</td>
</tr>
<tr>
<td>Telco owned poles</td>
<td>13,906</td>
<td>17,000</td>
</tr>
<tr>
<td>Line Fuses</td>
<td>5,727</td>
<td>8,000</td>
</tr>
<tr>
<td>Riser Fuses</td>
<td>7,799</td>
<td>9,000</td>
</tr>
<tr>
<td>Risers</td>
<td>14,136</td>
<td>17,000</td>
</tr>
<tr>
<td>Manholes</td>
<td>2,364</td>
<td>3,000</td>
</tr>
<tr>
<td>Pull boxes</td>
<td>33,772</td>
<td>40,000</td>
</tr>
<tr>
<td>Service boxes</td>
<td>51,487</td>
<td>60,000</td>
</tr>
<tr>
<td>OH primary conductor</td>
<td>2,370</td>
<td>2,750</td>
</tr>
<tr>
<td>OH secondary conductor</td>
<td>931</td>
<td>1,200</td>
</tr>
<tr>
<td>OH service conductor</td>
<td>1,513</td>
<td>1,750</td>
</tr>
<tr>
<td>OH streetlight conductor</td>
<td>661</td>
<td>750</td>
</tr>
<tr>
<td>UG primary conductor</td>
<td>2,898</td>
<td>3,500</td>
</tr>
<tr>
<td>UG secondary conductor</td>
<td>787</td>
<td>850</td>
</tr>
<tr>
<td>UG service conductor</td>
<td>1,509</td>
<td>1,600</td>
</tr>
<tr>
<td>UG streetlight conductor</td>
<td>650</td>
<td>700</td>
</tr>
<tr>
<td>Customer Meters</td>
<td>470,000</td>
<td>520,000</td>
</tr>
<tr>
<td>Customer Calls per hour (including AMI)</td>
<td>100</td>
<td>150</td>
</tr>
<tr>
<td>Max Customer Calls per hour</td>
<td>30,000</td>
<td>35,000</td>
</tr>
</tbody>
</table>

### 19.11.2 ADMS Capacity

1. The ADMS functions and their associated databases shall be dimensioned to support Purchaser’s 2022 requirements as defined in Exhibit 19-4: Distribution System Model Sizing.

2. ADMS functions and their associated databases shall be architected to allow expansion to support anticipated future growth also defined in Exhibit 19-4: Distribution System Model Sizing.

3. The ADMS functions and databases shall be capable of growing with Purchaser’s needs. Contractor shall state the total capacity limitations as part of their proposal.

### 19.11.3 ADMS Performance

1. Satisfaction of the performance requirements will be verified during both the factory test and the site test.
2. To this end, the ADMS shall satisfy the performance and capacity requirement of this specification with up to eight physical workstations (four monitors each) and the interface to the Primate Video Wall Software.

3. The loading on the system introduced by additional workstations will be simulated.

19.11.4 **ADMS Activity Scenarios**

1. The ADMS performance shall be tested under the following activity scenarios:
   
   1.1. The base conditions define ADMS activities and conditions upon which the steady state and high activity scenarios are layered.
   
   1.2. The steady-state scenario represents field operating conditions during a minor event over a 60-minute period.
   
   1.3. The high-activity scenario represents field operating conditions during a 240-minute period such as might be experienced during a severe event.
   
   1.4. The tests shall be designed such that each test run is repeatable as much as possible, so that the results between successive runs can be compared.

19.11.4.1 **BASE CONDITIONS**

1. The following conditions shall apply to both the steady-state and high-activity scenarios:

   1.1. The ADMS shall be configured with all hardware and functions required by this Specification operating, including hardware and functions specified as optional that have been selected by Purchaser.
   
   1.2. Purchaser will determine the interfaces that will be tested during SAT.
   
   1.3. All anti-virus and related software with all current patches installed and operational.
   
   1.4. All ADMS function execution parameters shall be as determined by mutual agreement between Contractor and Purchaser.
   
   1.5. The ADMS software and databases shall be configured in accordance with the sizing tables in Section 2.6 System Availability.
   
   1.6. The contents of the ADMS network model databases shall be an import of actual data from the Purchaser data and the display and report definitions shall be as determined by Purchaser.
1.6.1. The database contents will not be greater than the delivered capacity and the integrity of the data shall be agreed upon between Contractor and Purchaser.

1.7. Each workstation (including operations, support, and management workstations) shall present all “common information” deemed by Purchaser to be part of the normal display arrangement including, display title and window border, alarm zone, operator message area, time and date area, and top-level menu bar.

1.7.1. Common information that is part of the normal display shall be agreed upon between Contractor and Purchaser before the start of pre-FAT.

1.8. Panning and zooming of the distribution graphical views shall be performed during the duration of the test as the users execute the various functions on the system.

1.9. Normal compliment of windowing capability

1.10. The test environment will mimic calls coming in from AECall

1.11. The test system will mimic web based status queries initiated from Storm Center

1.12. The test system will be running IVVC while executing the Steady State Scenario

1.13. The test system will be running Fault Isolation and Service Restoration during the execution of both the Steady State and the High Activity Scenarios

1.14. The system will be preloaded with five years of historical data (outages, operator actions on incidents/switching, closed-loop actions performed by system for VVO, system communication messages for telemetry, alarms, device state changes, etc.)

19.11.4.2 **STEADY-STATE SCENARIO**

1. The Steady-State Scenario shall consist of the Base Conditions and the following activities over a sixty-minute period:

   1.1. The system will be preloaded with 500 trouble calls from AECall

   1.2. The system will be preloaded with 100 existing, predicted outages

   1.3. A minimum of 250 new trouble calls coming into the system from the message queue evenly spread out over the duration of the test.

      1.3.1. 15% of these not be associated with an existing outage
1.4. A minimum of 1000 new power outage reports from AMI 75% of these not be associated with an existing outage

1.5. A minimum of 90 outages coming from Storm Center

1.6. A total of 40 workstations will be logged in, capable of full ADMS functionality

   1.6.1. 10 workstations staffed by Purchaser personnel, performing the functions of a system operator, running the Full Client, each logged into an area of responsibility covering 100% of the service territory, users will be executing test procedures consisting of:

     1.6.2. Run Distribution Circuit Fault Location

         1.6.2.1. Verify an outage
         1.6.2.2. Assign a crew
         1.6.2.3. Add a tag
         1.6.2.4. Remove a tag
         1.6.2.5. Restore an outage
         1.6.2.6. Right size an outage (force upstream and downstream)
         1.6.2.7. Dispatch and arriving crews
         1.6.2.8. Enter estimated arrival times and restoration times
         1.6.2.9. Close outage and non-outage events
         1.6.2.10. Group and ungroup related events together
         1.6.2.11. Assign un-located events to the correct location
         1.6.2.12. Manually create switch orders
         1.6.2.13. Automatically create switch orders
         1.6.2.14. Run DPF
         1.6.2.15. Execute switch orders
         1.6.2.16. Place Cuts and Jumpers

   1.6.3. 30 workstations staffed by Purchaser personnel performing the functions of users other than operators, each logged into an area of responsibility covering 100% of the service territory. Users will be executing test procedures consisting of:
1.6.3.1. Running DPF
1.6.3.2. Performing Distribution Load Forecasts
1.6.3.3. Running Integrated Volt/Var Control
1.6.3.4. Administrative functions such as querying the database for historical reports
1.6.3.5. Perform queries of the device event summary
1.6.3.6. Perform queries of customer data
1.6.3.7. Perform queries of historical customer data
1.6.3.8. Perform queries of historical incident data
1.6.3.9. Perform historical snapshot and playback actions while also changing the model version
1.6.3.10. Apply extracts of ~50 change sets (feeder extracts) and go through the model promotion process

1.7. One hundred restoration estimate inquiries from the AECall
1.8. Two sets of fault isolation and service restoration switching sequences requiring up to 10 separate controls each per staffed live user workstation.
1.9. Outage and hazard data capture for Storm Center updating every 10 minutes

19.11.4.3 HIGH-ACTIVITY SCENARIO

1. The high-activity performance scenario shall consist of the base conditions and the following scenario for a 240-minute time period.

2. During this test, customer callback functionality shall be limited to calling back only those customers who have requested a callback:

2.1. A minimum of 1,500 calls will be in the system at the start of the test
2.2. A minimum of 200 orders will be in the system at the start of the test

2.2.1. 150 predicted to isolating devices (fuse, recloser, sectionalizer)
2.2.2. 50 predicted to transformer

2.3. A total of 50,000 geographically diverse new trouble calls shall be received over the test period. They shall be received in the following pattern sequence:
2.3.1. 30,000 during the First Hour

  2.3.1.1. 28,000 from AMI
  2.3.1.2. 2,000 from AECall

2.3.2. 15,000 during the Second Hour

  2.3.2.1. 10,000 from AMI
  2.3.2.2. 5,000 from AECall

2.3.3. 2,500 during the Third Hour

  2.3.3.1. 1,000 from AMI
  2.3.3.2. 1,500 from AECall

2.3.4. 2,500 during the Fourth Hour

  2.3.4.1. 1,000 from AMI
  2.3.4.2. 1,500 from AECall

2.4. A total of 40 workstations will be logged in, capable of full ADMS functionality

  2.4.1. 10 workstations staffed by Purchaser personnel, performing the functions of a system operator, running the Full Client, each logged into an area of responsibility covering 100% of the service territory, users will be executing test procedures consisting of:

    2.4.1.1. Verify an outage
    2.4.1.2. Assign a crew
    2.4.1.3. Add a tag
    2.4.1.4. Remove a tag
    2.4.1.5. Restore an outage
    2.4.1.6. Right size an outage (force upstream and downstream)
    2.4.1.7. Dispatch and arriving crews
    2.4.1.8. Enter estimated arrival times and restoration times
    2.4.1.9. Close outage and non-outage events
2.4.1.10. Group and ungroup related events together
2.4.1.11. Assign un-located events to the correct location
2.4.1.12. Running Distribution Circuit Fault Location
2.4.1.13. Running Fault Isolation and Service Restoration
2.4.1.14. Manually create and execute switch orders
2.4.1.15. Automatically create and execute switch orders
2.4.1.16. Place Cuts and Jumpers

2.4.2. 30 workstations staffed by Purchaser personnel performing the functions of users other than operators, each logged into an area of responsibility covering 100% of the service territory. Users will be executing test procedures consisting of:

2.4.2.1. Running DPF
2.4.2.2. Performing Distribution Load Forecasts
2.4.2.3. Running Integrated Volt/Var Control
2.4.2.4. Administrative functions
2.4.2.5. Perform queries of the device event summary
2.4.2.6. Perform queries of customer data
2.4.2.7. Perform queries of historical customer data
2.4.2.8. Perform queries of historical incident data
2.4.2.9. Perform historical snapshot and playback actions while also changing the model version

2.5. Over the duration of this scenario restoration estimate inquiries from AECall will be spread evenly over the hour.

2.5.1. First Hour 2,000 inquiries
2.5.2. Second Hour 5,000 inquiries
2.5.3. Third Hour 1,500 inquiries
2.5.4. Fourth Hour 1,500 inquiries

2.6. Five data entries shall occur at each operating workstation every minute.

2.7. Outage data capture for Storm Center updating every 30 minutes
19.11.4.4  **DEGRADED OPERATION**

1. Purchaser expects that the ADMS will infrequently experience operating conditions beyond those embodied in the high-activity scenario.
2. The ADMS shall continue to operate under such conditions and may exhibit degraded performance under such conditions.
3. However, the ADMS shall include features to minimize the degradation and the ensuing effects on power system operations.

   3.1. Question for Contractor – please describe how your ADMS handles degraded operation

4. The ADMS shall be configured to give priority to the following when operating in a degraded state:

   4.1. Usability of the key operator displays such as geographical, schematic, one-line diagram, and other such displays
   4.2. Issuing operator-initiated controls to field devices
   4.3. Detecting and annunciating exception conditions (alarms) in the power system
   4.4. Presenting data to the users through the workstations – priority shall be given to users at operating workstations
   4.5. Maintaining coherency of the database – specifically including data used as inputs to functions and the outputs produced by the functions
   4.6. Any actions taken by the ADMS to mitigate degraded operating conditions shall be alarmed to the users.

19.11.5  **Resource Utilization**

1. Refer to Section 3.2.2 Utilization Requirements for the utilization requirements for Steady State and High Activity states.

19.11.6  **User Interface Response**

1. The ADMS shall provide rapid and consistent response to power system events and user inputs.
2. Responsiveness to events and inputs shall be within the following requirements under both the steady state and high activity scenarios.

3. User Interface response times shall conform to the requirements shown in Exhibit 19-5: User Interface Response.

19.11.6.1 **DISPLAY REQUEST**

1. The display response time is defined as the elapsed time from a user’s request for a display until the requested display is presented complete with current data retrieved from the ADMS databases.

2. Display response times shall be demonstrated for the ADMS operating in the steady state and the high activity scenarios.

3. The display response time for each request shall conform to the display response time requirements shown in Exhibit 19-5: User Interface Response.

19.11.6.2 **USER REQUESTS**

1. The response to user requests shall be measured from the time the user completes all information necessary to define the request or any step of a sequence that makes a request, until the time the requested action is completed.

2. Completion of the request shall include production of all results, storage of the results in the ADMS database, and updating of all relevant displays.

3. The default response time shall be met for all other user requests not specifically included in this RFP.

19.11.7 **Resource Monitoring**

1. Resource utilization shall be measured, calculated and displayed for the ADMS processors, devices, and networks.

2. The minimum set of parameters to be presented includes:

   2.1. Time utilization (percent processor utilization) of each function per processor

   2.2. Time utilization (percent disk utilization) of each function per disk

   2.3. Disk data transfers per disk

   2.4. Utilization of memory and disk
2.5. Performance of LANs, bridges, routers, switches, firewalls and other network devices.

2.5.1. All active network elements shall respond to RMON (groups 1-5, 9 as a minimum) and SNMP level 1 data requests

3. Statistical sampling and accumulation techniques shall be used to collect these parameters over a user-selected time period.

4. Typical study periods shall be ten seconds to sixty minutes, and typical sampling frequencies shall be once per fifty milliseconds.

### Exhibit 19-5: User Interface Response

<table>
<thead>
<tr>
<th>Action</th>
<th>Maximum Response Time (For Local/WAN)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steady State</td>
<td>High Activity</td>
</tr>
<tr>
<td>Default response</td>
<td>1/2 second</td>
<td>1.5/3 seconds</td>
</tr>
<tr>
<td>Display request</td>
<td>1/2 seconds</td>
<td>2/3 seconds</td>
</tr>
<tr>
<td>Distribution Circuit schematic display call up</td>
<td>2/5 seconds</td>
<td>3/6 seconds</td>
</tr>
<tr>
<td>IS&amp;R display requests</td>
<td>2/4 seconds</td>
<td>4/6 seconds</td>
</tr>
<tr>
<td>Display data update (subsequent to the initial presentation of data)</td>
<td>1/1 seconds</td>
<td>1/1 seconds</td>
</tr>
<tr>
<td>Alarm and event annunciation</td>
<td>1/2 second</td>
<td>1.5/3 seconds</td>
</tr>
<tr>
<td>Viewport creation</td>
<td>1/1 second</td>
<td>1.5/1.5 seconds</td>
</tr>
<tr>
<td>World-map panning</td>
<td>5/5, 20-pixel steps per second</td>
<td>5/5, 20-pixel steps per second</td>
</tr>
<tr>
<td>Action</td>
<td>Maximum Response Time (For Local/WAN)</td>
<td>Notes</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>---------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Steady State</td>
<td>High Activity</td>
</tr>
<tr>
<td>World-map zooming</td>
<td>2/2, 10% steps per second</td>
<td>2/2, 10% steps per second</td>
</tr>
<tr>
<td>Pop-up menu, pull down menu, dialog box, etc.</td>
<td>1/2 second</td>
<td>1.5/3 seconds</td>
</tr>
<tr>
<td>Display hardcopy</td>
<td>10/10 seconds</td>
<td>15/15 seconds</td>
</tr>
<tr>
<td>Workstation user logon</td>
<td>10/10 seconds</td>
<td>10/10 seconds</td>
</tr>
</tbody>
</table>

Exhibit 19-6: Function Periodicity and Execution Time

<table>
<thead>
<tr>
<th>Function</th>
<th>Periodicity</th>
<th>Maximum Execution Time</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Acquisition (any data source)</td>
<td>Sizing Tables in 19.11.1</td>
<td>1 second</td>
<td>1 second</td>
</tr>
<tr>
<td>Supervisory Control</td>
<td>-</td>
<td>1 second</td>
<td>1 second</td>
</tr>
<tr>
<td>IS &amp; R:</td>
<td></td>
<td></td>
<td>Execution time is measured from the time the user executes the command until the command exchange with the data source is complete.</td>
</tr>
<tr>
<td>- Alarms &amp; Events</td>
<td></td>
<td>As occurs &lt; 1 minute</td>
<td>As occurs &lt; 2 minutes</td>
</tr>
<tr>
<td>- Load snapshot</td>
<td></td>
<td>As occurs &lt; 1 minute</td>
<td></td>
</tr>
<tr>
<td>- Historical playback</td>
<td></td>
<td>As occurs &lt; 2 minutes</td>
<td></td>
</tr>
<tr>
<td>Periodic DMS Functions</td>
<td>Weekly</td>
<td>5 seconds</td>
<td>10 seconds</td>
</tr>
<tr>
<td>Distribution Load Forecast</td>
<td>30 minutes</td>
<td>5 seconds</td>
<td>10 seconds</td>
</tr>
<tr>
<td>Load Shed</td>
<td>15 minutes</td>
<td>10 seconds</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Distribution State Estimation</td>
<td>5 minutes</td>
<td>10 seconds</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Distribution Unbalanced Power Flow</td>
<td>30 minutes</td>
<td>10 seconds</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Optimal Feeder Reconfiguration</td>
<td>15 minutes</td>
<td>10 seconds</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Model-based IVVC</td>
<td>15 minutes</td>
<td>10 seconds</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Rule-based IVVC</td>
<td>15 minutes</td>
<td>10 seconds</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Closed Loop Readiness</td>
<td>15 minutes</td>
<td>10 seconds</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Distributed Energy Resource Mgmt</td>
<td>15 minutes</td>
<td>10 seconds</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Function</td>
<td>Periodicity</td>
<td>Maximum Execution Time</td>
<td>Notes</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>-------------</td>
<td>------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Non-Periodic DMS Functions</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network Topology Processing</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 2 seconds High Activity: 10 seconds On topology change</td>
</tr>
<tr>
<td>Pre-Switching Validation</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds</td>
</tr>
<tr>
<td>Fault Analysis</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single fault</td>
</tr>
<tr>
<td>Distribution Circuit Fault Location</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single fault</td>
</tr>
<tr>
<td>Safety Tagging</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single tag</td>
</tr>
<tr>
<td>FLISR</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Two feeders</td>
</tr>
<tr>
<td>Location of Open Conductor Faults</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single area (partial feeder)</td>
</tr>
<tr>
<td>Location of Downed Conductor</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single area (partial feeder)</td>
</tr>
<tr>
<td>Protection Coordination</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td>Under-Load Switching</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single transformer area</td>
</tr>
<tr>
<td>Energy Losses</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td>Large Area Restoration</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single transformer area</td>
</tr>
<tr>
<td>Operational Losses</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td>Phase Balancing</td>
<td>1 second</td>
<td>2 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td><strong>Distribution Planning Apps</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimal Capacitor Placement</td>
<td>5 seconds</td>
<td>8 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td>Optimal Voltage Regulator Placement</td>
<td>5 seconds</td>
<td>8 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td>Optimal Switching Device Placement</td>
<td>5 seconds</td>
<td>8 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td>Reconductoring</td>
<td>5 seconds</td>
<td>8 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td>Motor Start Studies</td>
<td>5 seconds</td>
<td>8 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td>Customer Connections</td>
<td>5 seconds</td>
<td>8 seconds</td>
<td>Steady State: 10 seconds High Activity: 2 seconds Single feeder</td>
</tr>
<tr>
<td>Insert temporary elements (cuts, jumpers, ground, generator, load)</td>
<td>1 second</td>
<td>2 seconds</td>
<td>The time from the user executes the command until the time the system has installed a jumper and reconfigured the connectivity</td>
</tr>
<tr>
<td><strong>Outage related functions Predicitions Engine</strong></td>
<td>Continuous</td>
<td>10 seconds</td>
<td>20 seconds On event/call occurrence with configurable delay</td>
</tr>
<tr>
<td>Operator Actions</td>
<td>As requested</td>
<td>2 seconds</td>
<td>3 seconds Distribution service reliability statistics and daily reports</td>
</tr>
<tr>
<td>Operator Actions</td>
<td>Hourly</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Calculate Parameters for Reliability Performance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Exhibit 19-7: Software Maintenance**

<table>
<thead>
<tr>
<th>Action</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import of entire Distribution Network Model from GIS</td>
<td>4 hours</td>
</tr>
<tr>
<td>Incremental import of 20 feeders from GIS</td>
<td>2 minutes</td>
</tr>
<tr>
<td>Complete database regeneration (1)</td>
<td>2 hours</td>
</tr>
<tr>
<td>Action</td>
<td>Performance</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Incremental Database Update (Typical) (2)</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Complete system software build, including operating system, applications, and databases</td>
<td>6 hours</td>
</tr>
<tr>
<td>Software build or all applications and databases</td>
<td>3 hours</td>
</tr>
<tr>
<td>Software build of a single applications and databases</td>
<td>30 minutes</td>
</tr>
<tr>
<td>Installation of a single, new display including distribution to all workstations</td>
<td>60 seconds</td>
</tr>
<tr>
<td>Reinstallation of all displays</td>
<td>60 minutes</td>
</tr>
<tr>
<td>On-line update of a database parameter and propagation of the change to the source data</td>
<td>60 seconds</td>
</tr>
</tbody>
</table>

19.12 Information Storage and Retrieval

1. Please refer to Section 10 Information Storage and Retrieval (IS&R) for the general requirements for IS&R. In response to this ADMS section, the Contractor shall provide the same IS&R functionality as described for the SCADA/EMS.

2. A stand-alone ADMS would have its own IS&R components.

3. An integrated EMS/ADMS, the historical database(s) may be shared between EMS and ADMS and only incremental costs to include ADMS-specific data should be included in the pricing table for EMS/ADMS.

19.13 System Software

1. Please refer to Section 11 System Software Requirements for the general requirements related to software. In response to this ADMS section, the Contractor shall meet the same system software requirements as described for the SCADA/EMS.

2. A stand-alone ADMS would have its own system software components.

3. For an integrated EMS/ADMS, the requirements shall be interpreted to apply to the overall EMS/ADMS and only incremental costs to apply those requirements to ADMS components should be included in the pricing table for EMS/ADMS.

19.14 ADMS Hardware

1. Please refer to Section 12 Hardware Requirements for the general requirements for the capabilities and recommendations for the system hardware. In response to this ADMS
section, the Contractor shall identify and prepare recommended hardware lists for the hardware specific to the two ADMS architectures required as follows: 1) Stand-alone ADMS system, and 2) ADMS functionality added to the EMS system. Requirements for the ADMS architecture can be found in Section 19.1 ADMS Architecture and requirements for ADMS sizing can be found in Section 19.11 ADMS Capacity and Performance. Further, the Contractor shall submit architecture diagrams and recommended hardware List of Deliverables for both of the specified architectures.

2. The recommended hardware provided by the Contractor shall meet the architecture, performance, security, and availability requirements defined in this Specification.

3. Pricing for hardware for the ADMS shall include only the hardware unique to the ADMS. For example, pricing of hardware for an entire stand-alone ADMS and pricing of additional hardware required to expand the EMS to include all ADMS functionality (e.g. OMS servers, DMS servers, etc.).

19.15 ADMS Knowledge Transfer and Training

1. Please refer to Section 17 Training and Knowledge Transfer for the general requirements for knowledge transfer workshops and training. In response to this ADMS section, the Contractor shall identify and provide the training courses and knowledge transfer workshops specific to the ADMS only, particularly for DMS and OMS applications and configuration.

2. The pricing for knowledge transfer and training for the ADMS shall include only the formal courses and knowledge transfer workshops unique to the ADMS system (e.g. common courses such as SCADA applications, system administrations, etc. will be included in the EMS courses and pricing).

19.16 ADMS Documentation

1. Please refer to Section 13 Documentation Requirements for the general requirements for documentation. In response to this ADMS section, the Contractor shall identify and provide the documentation specific to the ADMS only.

2. Pricing for documentation for the ADMS shall include only the documents unique to the ADMS system (e.g. Outage Management user guide, Switching Orders user guide, interfaces, cutover plan, etc.).
19.17 ADMS System Security

1. Please refer to Section 4 System Security for the general requirements for system security. While a stand-alone ADMS is not required to meet NERC CIP requirements, as described in Section 4, Purchaser processes for system administration and their approach to infrastructure is the same for EMS and ADMS. Accordingly, for both the stand-alone ADMS and the integrated EMS/ADMS, the proposed architecture shall meet the same system security requirements as the stand-alone EMS.

2. Since it is Purchaser’s goal to minimize cyber assets within the ESP, the Contractor shall clearly indicate which equipment to include within the ESP for the integrated EMS/ADMS case.

3. The ADMS should have the same Role-based Access Control (RBAC) rules and functionality as referenced in Section 4.11 Account Management. For an integrated EMS/ADMS the purchaser shall be able to define the users once in a centralized domain, but configure their EMS and ADMS permissions separately.

4. Any additional pricing for system security implementation unique to the stand-alone ADMS and the integrated EMS/ADMS shall be identified in the appropriate pricing option.

19.18 Quality Assurance and System Testing

1. Please refer to Section 14 Quality Assurance and System Testing for the general requirements for quality assurance and system testing. For a stand-alone ADMS all of the requirements in Section 14 Quality Assurance and System Testing are applicable to the ADMS.

2. For an integrated EMS/ADMS, the identified EMS testing shall be expanded to include ADMS-specific functionality identified below.

3. Pricing for ADMS-specific testing shall be included in the ADMS pricing options.

4. ADMS-specific Testing shall include:

   4.1. Proof of concept that ADMS works in a Nutanix environment
   4.2. Proof of concept that ADMS works in a CISCO ACI managed LAN
   4.3. All system architecture oriented tests (e.g. resiliency, fail over, switch over, performance, etc.) shall be repeated
4.4. For the performance test, the scenarios and setup described in Section 19.11 ADMS Capacity and Performance shall be executed and the performance measured against the performance requirements of that same section

4.5. ADMS User Interface

4.6. Distribution Management System Applications/Functionality

4.7. Switching Management System Applications/Functionality

4.8. Outage Management System Applications/Functionality

4.9. The transfer and processing of the data between the ADMS and the following application Interfaces:

   4.9.1. Customer Care & Billing (CC&B)

   4.9.2. Solar Size

   4.9.3. AE Call

   4.9.4. 21st Century High Volume Call Application (HVCA)

   4.9.5. Automatic Vehicle Locator (AVL)

   4.9.6. Advanced Metering Infrastructure (AMI) / Meter Data Management System (MDMS)

   4.9.7. Load Profile

   4.9.8. GIS Interface, including landbase and other layers

   4.9.9. Storm Center

   4.9.10. PI Historian

   4.9.11. Primate Video Wall shall include status, analog and quality flags.

19.19 ADMS Project Implementation

1. Please refer to Section 15 Project Implementation for the general requirements for project implementation. Except for the activities specifically assigned to the Purchaser in Section 15 Project Implementation, and expanded in the ADMS Purchaser section below, the Contractor shall assume full responsibility for the design, assembly, development, configuration, integration, delivery, installation, and commissioning of the ADMS within the context of its meeting fully and completely all of Purchaser’s operational performance requirements.
2. In addition to the requirements in Section 15 Project Implementation, implementation responsibilities unique to the ADMS aspect of the project are included below – separated into Contractor responsibilities and Purchaser responsibilities.

3. Pricing for ADMS-specific project implementation shall be included in the ADMS pricing options.

4. Contractor:

4.1. Develop all interfaces described in Section 19.10 ADMS Interfaces

4.2. Convert Purchaser’s current ADMS database utilizing a Purchaser provided Small World XML extract for connectivity and Milsoft EDQB extract for electrical characteristics of Purchaser system

5. Purchaser:

5.1. Providing interface details for all interfaces identified in Section 19.10 ADMS Interfaces

5.2. Providing Small World XML extract for connectivity and Milsoft EDQB extract for electrical characteristics of Purchaser system to Contractor for: 1) conversion of the ADMS database and 2) installation in the ADMS’s.

5.3. Providing distribution system network model database updates up until two months prior to the pre-Factory Test and again two weeks prior to FAT.

19.20 ADMS Maintenance, Support, and Upgrade Program

1. Please refer to Section 16 Maintenance, Support, and Upgrade Program for the general requirements for various types of support/maintenance programs to be included in the Contractor’s proposal.

2. Pricing for ADMS-specific support/maintenance contracts shall be included in the ADMS pricing options. The pricing for the integrated EMS/ADMS shall clearly indicate whether the price covers both EMS and ADMS or is incremental to the EMS pricing.
19.21 ADMS PROJECT MILESTONE PAYMENT SCHEDULE

1. The Contractor shall propose a schedule and payment milestones for both a stand-alone ADMS project and an integrated EMS/ADMS project schedule using the table for the EMS in Section 18 SCADA/EMS Project Milestone Payment Schedule.

2. This table could apply for both the stand-alone ADMS and the integrated EMS/ADMS projects, but the Contractor may propose alternate milestones/dates in order to phase the EMS/ADMS most appropriately.

3. The primary date that drives the schedule for the integrated EMS/ADMS is the cutover of the EMS in the Fall of 2020 (or earlier).