NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Balancing Authority/Transmission Operator Reliability Readiness Evaluation Report

Tennessee Valley Authority
Chattanooga, Tennessee

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Introduction and Evaluation Process

The North American Electric Reliability Corporation (NERC) Reliability Readiness Evaluation and Improvement Program is one of the commitments of NERC and the industry to strengthen the reliability of the North American bulk power system. The program conducts independent evaluations of balancing authorities, transmission operators, reliability coordinators, and other key entities that support the reliable operation of the bulk power system to assess their preparedness to meet their assigned reliability responsibilities. The evaluations identify strengths and areas for improvement in an effort to promote excellence in operations among these organizations.

Since its inception in 2004, NERC and the industry have been working together to enhance the program. The current process is based on fundamental aspects of reliability: culture, operations, maintenance, planning, and training. The document *NERC Readiness Evaluation Procedure* describes and defines the process used for reliability readiness evaluations. This document and other documents related to the program are available at http://www.nerc.com/~rap/.

The reliability readiness evaluation teams, each led by a NERC staff member and a regional co-leader, include industry volunteers with considerable expertise selected to provide representation from other interconnections, other regions, and neighboring operating entities. The teams also typically include representatives from the Federal Energy Regulatory Commission (FERC) staff.

The public version of the reliability readiness evaluation report contains the majority of the evaluation team's findings. Any discussion of findings pertaining to critical infrastructure will be contained in Appendix 1, a confidential appendix to the report that is sent privately to the organization evaluated and is not included in the public version of the report.

An evaluation team met on-site with Tennessee Valley Authority (TVA) representatives on March 12–15, 2007. This report reflects the views and recommendations of the evaluation team regarding the readiness of the TVA to meet its responsibilities as a balancing authority and transmission operator.

Evaluation Team

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Organization Profile

TVA was formed through congressional action in May 1933 as part of the "New Deal." Today, TVA is a federally owned corporation with a primary mission to serve the Tennessee Valley area through energy, environment, and economic development. TVA is a not-for-profit agency and does not receive federal funding. TVA service area spans 80,000 square miles, encompassing parts of seven states, and includes 8.4 million people.

The company's corporate structure consists of a nine-member board of directors appointed by the president of the United States. The TVA Transmission and Reliability Organization reports to a vice president, who in turn reports to the executive vice president, power system operations. The TVA Transmission and Reliability Organization has a Resource Market Operations department where the balancing authority function resides and a Transmission Operations department housing the real-time transmission operator function.

TVA service area spans 80,000 square miles, encompassing parts of seven states, and includes 8.4 million people. The all-time winter system peak of 30,320 MW was reached on January 31, 2007, and the all-time summer system peak of 32,008 MW occurred on July 18, 2006. The TVA power supply consists of 34,096 MW, which includes hydro (30 plants with 113 units), coal (11 plants with 59 units), nuclear (3 plants with 5 units), combustion turbines (8 plants and 83 units), and other sources, such as Army Corps diesels, green power, and firm purchases.

The TVA transmission system consists of approximately 17,000 circuit miles of transmission lines; 535 substations, switchyards, and switching stations; and 1,032 interchange and connection points. TVA is connected to 12 neighboring utilities, and interchange is delivered to neighboring systems at 56 points. To support the transmission system, TVA developed and maintains a 2,700-mile fiber network. For fiscal years 2000 through 2006, the TVA system, has had a 99.999 percent reliability factor.

TVA is a member of the SERC Reliability Corporation (SERC) region and serves as a reliability coordinator within the SERC region. The TVA reliability coordinator is a separate department from the balancing authority and transmission operator.

Executive Summary

The evaluation team found no significant operational problems and concluded that TVA balancing authority and transmission operator have excellent facilities, processes, plans, procedures, tools, and trained personnel to perform the balancing authority and transmission operator functions necessary to maintain the reliable operation of the bulk power system.

From the executive vice president, power system operations to the shift system operator, TVA's culture focuses on operational excellence using three main principles: values, performance, and reward. Values focus on how TVA coworkers treat each other. Performance is based on a "line-of-sight" concept of translating business strategy into organizational goals and individual performance goals. The reward principle relates to compensation; employees are rewarded for exemplifying the TVA values and achieving goals. As demonstrated by its 99.999 percentage rate of serving customer load, TVA is committed to operational excellence and reliability, and employees support the successful TVA culture on a day-to-day basis.

The evaluation team found seven potential examples of excellence that can be grouped into two categories: culture and operational tools and support. Regarding culture, the evaluation team found three potential examples of excellence — the Employee Council, the operations culture, and management's "Problem Evaluation Report" process. In the operational tools and support area, potential examples of excellence were discovered in software tools, the transmission operator candidate pool program, and backup facilities. The diversity of the potential examples of excellence indicates a company with a strong culture and commitment to operational excellence and reliability.

The evaluation team found 10 positive observations that show the benefits of the corporate goal for operational excellence and reliability. The positive observations ranged from the presence of a staff meteorologist to help determine potential weather impacts to system load to employee communication programs to rotational management assignments for improving knowledge sharing and broadening experience.

The evaluation team identified five recommendations, of which two were jointly designated with TVA as "key" recommendations. Key recommendations included adding a sign-off process to the document management procedure and evaluating a process to automate relay fault programs to provide more timely information to operators.

Overall, the evaluation team identified seven potential examples of excellence and 10 positive observations. The team also offers five recommendations that, if implemented, will enhance TVA's readiness to operate reliably and maintain the reliability of the bulk power system.

Potential Examples of Excellence

The evaluation team identified the following potential examples of excellence in its reliability readiness evaluation:

1. The Employee Council provides the employees with a voice in creating their own work environment (Section 1.2.5).
2. TVA's operations environment fosters respect for each individual and a true sense of worth among employees, which are cornerstones in building the foundation of an excellent company culture (Section 1.1).
3. TVA utilizes two state estimators with the same underlying model, and each effectively serves the backup to the other (Section 2.3).
4. TVA has proactively addressed succession planning through the transmission operator candidate pool program (Section 1.2.4).
5. A Problem Evaluation Report process ensures problems such as misoperations, near-miss situations, and deviations from planned operations are evaluated for corrective actions (Section 2.2.2).
6. The Transmission and Reliability Organization has developed a software application that performs daily comparisons between all systems and reports on any discrepancies (Section 4).
7. *See discussion in Appendix 1.*

Positive Observations

The evaluation team noted the following positive observations during the reliability readiness evaluation process:

1. TVA has made a commitment to implementing previous report recommendations (Section 1.1).
2. TVA created a monthly performance indicators report to share goals status with all employees (Section 1.2).
3. TVA rotates management personnel so they gain knowledge in other power supply areas (Section 1.2.2).
4. TVA's mentoring program has increased the staff knowledge of system operations and built a strong bridge between operators and support personnel (Section 1.2.2).
5. TVA uses a variety of methods to maintain interactive communication with all employees (Section 1.2.5).
6. The hiring of a staff meteorologist to forecast weather across the TVA footprint has reduced load forecast error (Section 2.3).
7. TVA created a nuclear status Web site to improve internal communications with the nuclear plants (Section 2.4).
8. The "Temporary Alteration Permit" allows for tracking field equipment changes (Section 3.2.2).
9. *See discussion in Appendix 1.*
10. *See discussion in Appendix 1.*

Recommendations

The recommendation findings are listed in order of importance. The evaluation team recommends that TVA take the following actions to address issues discovered during the evaluation process:

1. Add a sign-off requirement to the documentation process to identify the date and name of reviewed documents (Section 2.2.3).
2. Evaluate automating relay fault programs to display the information to the operator sooner (Section 2.4).
3. Implement a practice of formalizing training expectations outside of formal training periods (Section 5.1).
4. Revise satellite phone testing procedures to include operators (Section 5.1).
5. Develop a process where all operators demonstrate the use of the communication systems, including the satellite phone, at least annually (Section 5.1).

Discussion

The reliability readiness evaluation team examined the following key areas during the evaluation. The detailed discussion that follows provides the foundation for the recommendations, considerations, positive observations, and potential examples of excellence that the team identified. The report uses the generic term "system operator" to refer to all on-shift operating personnel responsible for executing the functions necessary to operate reliably and maintain the reliable operation of the bulk power system. This term will be used for the discussions unless additional specificity is required, such as the *balancing* system operator, or *transmission* system operator.

1. Culture

1.1 General

The corporate organization provides the necessary leadership and management for system operations to sustain high levels of safe, reliable operation.

TVA recognizes that of the key factors that contribute to sustained high performance and the ability to compete, none is more important than a strong company culture. Seven core values have been cultivated as the foundation of TVA's culture and the standard for expected workplace behavior: teamwork, integrity, and respect for the individual, honest communication, accountability, flexibility, and continuous improvement. TVA's values and associated behaviors define how coworkers treat each other, how they approach their work, and how they hold themselves and each other accountable for results. This forms the framework for all that is done on individual and group levels, ranging from initial and refresher training to annual assessments of performance regarding line-of-sight goals, which support the achievement of TVA's business strategy.

TVA's excellence in performance also requires basic principles for success. Respect for each individual and a true sense of worth are cornerstones in building the foundation of great company culture. TVA's culture fosters support for its employees' individual and collective talents and appreciation for the work they do. This approach translates into company success. The evaluation team acknowledges the TVA operations culture as a potential example of excellence.

The evaluation team was impressed how seriously TVA treated recommendations from the 2004 readiness report. TVA evaluated the benefits to the company and reliability, and implemented many of the recommendations, such as implementing dedicated training weeks for the system operators, enhancing the training simulators, and modifying the center environment to improve the operator's ability to manage the system under both normal and emergency conditions. The evaluation team acknowledges these actions as a positive observation.

1.2 Organizational Effectiveness

1.2.1 Foundation for System Reliability

The organization's values and behaviors—modeled by its leaders and practiced by its members—serve to make system reliability a top priority.

TVA's model to measure organizational effectiveness consists of four components: alignment, capability, engagement, and results. Alignment defines the mission, strategic direction, values, and goals. Capability includes employee skills, tools, leadership development, succession planning, and workforce assessments. The engagement portion brings in trust, motivation, recognition, and compensation. The results are measured in various manners including, but not limited to, scorecard metrics, performance, cultural health, business process improvement, and individual performance management. TVA has developed an exceptional program model.

To measure the effectiveness of its culture, TVA has developed a Cultural Health Index (CHI). This CHI approach, which is routinely reviewed and updated, translates business strategy into organizational goals (scorecards) that are directly linked to individual performance objectives. Monthly performance indicators are shared with all employees so they understand where the corporation stands with regards to the organizational goals. The evaluation team recognizes this approach as a positive observation.

TVA's values are clearly identified, published for all to see, and practiced daily. Initiatives such as an active Employee Council, an organization-wide mentoring program, communication measures, training, ongoing recognition and appreciation activities, continuous improvement, and cultivation of a clearly focused shared vision of excellence have resulted in a unique culture of excellence. High employee morale and workforce satisfaction in being part of something special highlight TVA operations culture of excellence and directly contribute to reliability.

1.2.2 Leadership and Management

Managers, by leadership, commitment, and example, establish and reinforce high standards of performance and align the organization to achieve safe, reliable system operation.

TVA's management leads by example and demonstrates a high commitment to performance and safe, reliable system operation. TVA leadership has delegated authority, both verbally and in writing, to system operators to take whatever action the operators deem appropriate to return the system to a reliable state.

TVA has instituted two programs that permit employees, both management and non-management, to be challenged in their positions and grow into new areas. The first program focuses on the practice of rotating managers to areas they do not normally work. This program permits managers to gain experience that will be directly beneficial to their job and the company's ability to plan for succession. The second program is an active mentoring program where the individual can learn about other opportunities within the company, actually work in those areas, and gain increased experience that will be useful in his/her career. This program

builds a strong bridge between system operators and support personnel. The evaluation team recognizes the rotational assignment and mentoring programs as positive observations.

To facilitate reliable system operations, the Transmission and Reliability Organization leadership team ensures procedures, processes, and training are available to transmission and system operators. TVA operates to a minimum of n-1 contingency. For operational planning decisions, such as taking transmission elements out-of-service for maintenance, outage coordination procedures have been developed. The procedures are used to ensure the transmission system configuration and the generation system dispatch, including reserves, will be adequate to ensure continued reliable operations following the most severe contingency.

TVA participates in many industry, NERC, and SERC committees, subcommittees, working groups, and task forces that support bulk power system reliability.

1.2.3 Corporate Oversight and Monitoring

Line management is used to strengthen reliability and improve performance. System reliability is kept under constant scrutiny through techniques such as self-assessments, performance indicators, and periodic management meetings.

Power System Operations has an Operations Review Committee to review unknown system disturbances or events resulting from operating errors and/or procedural deficiencies. To ensure organizational commitment and success, the committee is sponsored by the vice presidents of the Transmission and Reliability Organization, Electric System Projects department, and Transmission Operation and Maintenance department. In addition, the committee is comprised of key senior managers from those groups. The committee meets monthly to investigate unanticipated anomalies and system events using root cause analysis techniques. Once issues are investigated, the committee develops, recommends, and approves solutions to resolve the problem. Power System Operations participates in a Corrective Action Program to systematically identify, investigate, resolve, and prevent recurrence of anything that does not meet expectations, including system operations. The process uses an externally developed computer application to capture the problem description, immediate corrective actions taken, the detailed corrective action plan, and specific actions that will be tracked to completion.

TVA's senior management in Transmission and Reliability Organization supports many programs and activities to ensure employees focus on overall system reliability. Each senior manager has reliability-focused performance goals that are established annually and reviewed at least quarterly. Each senior manager's performance and compensation considerations are based on his or her individual performance against those goals. During quarterly reviews, goals may be modified or introduced to ensure they are appropriate to achieve the highest levels of reliability. Goals for senior managers are cascaded within the organization to other managers and employees. These goals are well communicated, reviewed, and revised (as appropriate) by senior managers on at least a quarterly basis.

Transmission and Reliability Organization has identified key indicators that drive the reliability of its operations. Senior management meets each month to review these indicators, which

communicate actual performance against goals. Indicators include NERC-required training, control performance standard (CPS) data, disturbance control standard (DCS) performance, control systems availability, state estimator unavailability, system operating limit (SOL)/interconnection reliability operating limit (IROL) violations, bulk system interruptions, customer interruptions, and others dealing with efficiency of operations.

In addition to monthly indicator meetings, reliability issues are addressed during monthly staff meetings among Transmission and Reliability Organization senior managers. A corrective action program is used to ensure that all identified performance issues that might impact reliability are tracked to completion: identification of cause, development of corrective actions, and implementation of corrective actions. Senior management communicates information from indicator and staff meetings and findings from corrective action processes to all employees.

The Transmission and Reliability Organization has many electronic displays throughout the system operations center and adjacent office spaces to provide management and employees with continuous status of parameters that assess reliability of operations. Critical messages regarding availability or unavailability of critical systems are broadcast to all employees and managers. All senior managers are equipped with cell phones and other devices to facilitate instant communications. On a daily basis, Transmission and Reliability Organization distributes reports on the previous day's operation for transmission and balancing functions. These reports list significant events, impacts, and actions taken. Follow-up phone calls are placed as needed.

One key factor that contributes to the TVA culture and operational excellence is simply the availability of management to the operators. First-line management works on the floor daily talking with the operators, inquiring about system reliability, and requesting feedback. Likewise, the executive vice president, regardless of travel obligations, calls the line management to understand the system conditions and expectations for the day. In addition, the executive vice president takes every opportunity to talk with the system operators, be it on the control center floor or in training. Management's commitment to communication and understanding with the system operators is a key to TVA's pursuit of higher performance and increased reliability.

1.2.4 Human Resources

Personnel resource needs are anticipated and individuals are systematically recruited, developed, and assigned positions in the system operations organization.

TVA's Human Resources group has a formal process in which management reviews and updates, if necessary, succession plans annually. An unexpected vacancy will trigger a review of the succession plan. Based on the plan, candidates are identified to fill developmental positions. These positions receive training necessary to become NERC-certified operators.

With the succession planning showing a large number of possible transmission operator retirements in the next few years, TVA had to reevaluate its hiring processes. TVA uses job announcements to compile a list of potential transmission operator candidates and then conducts interviews to evaluate each candidate's qualifications.

Following the interviews and evaluation by the management team, individuals are identified as candidates for future transmission operator positions. Individual training needs are determined, and a custom training program is used to provide necessary skills. Candidates enter a structured six-week transmission operator training class while still holding their current jobs. Weekly evaluations are made during this training process. After completing the class, candidates return full-time to their current positions. If the candidates are unable to complete the required training successfully, they return to their current jobs with an understanding of areas of needed improvement for the next time the opportunity might become available. The training during these six weeks allows each candidate to have a better understanding of the transmission operator position and the position's overall qualifications.

When a job announcement for a transmission operator is issued, all personnel that have completed the transmission operator training are eligible to apply. Once candidates apply for a position, they are subject to further interviews by the management team. The interviews include a reevaluation to ensure candidates retained the necessary knowledge needed to prepare them for the on-the-job training portion of the transmission operator training process. Based on this assessment, candidate selections are made by the management team.

TVA has found that this process identifies those candidates that are better qualified and have insight to the requirements of the position. By carefully selecting the candidate pool, TVA has been able to reduce the overall training period to become a transmission operator. The evaluation team recognizes this program as a potential example of excellence.

1.2.5 Corporate Communications

System operations communications inform and engage both corporate and system operations employees so they can contribute to the strategic priorities of the organization.

Communication is one of the keys to TVA's success, and the company has been successful in communicating with system operators. TVA sponsors many employee initiatives ranging from employee forums, mentoring program to sponsored employee training activities, and employee newsletters. During the seven-week training cycle, executives spend one to two hours per week with the operators. The evaluation team acknowledges these activities as a positive observation.

On September 20, 2000, the Transmission and Reliability Organization Employee Council met for the first time. After almost seven years, the council is still going strong and providing an example of leadership and accountability to others. The council meets once a week to address issues, suggestions, and concerns from the workforce, and council activities do not remain in a vacuum. Council business is a standing item on agendas in staff meetings throughout the organization. In these staff meetings, representatives can disperse information and collect issues for the next meeting to increase two-way communication. Minutes from the Employee Council meetings are sent out to all employees including any items that should be addressed in the top-level management staff meetings.

The Employee Council regularly fulfills its mission of *"Promoting a positive work life through open and honest communication, Celebrate"* by ensuring that all employees have a voice in

creating their own work environment. Over the years, more than three quarters of TVA's employees have had the opportunity to participate on the council. The council is managed by employees who fulfill the roles of facilitator, task manager, recorder, and editor. Each workgroup within the Transmission and Reliability Organization has representation on the council. The evaluation team recognizes the Employee Council as a potential example of excellence.

2. Fundamentals of Operations

2.1 General

Operations personnel monitor and control the system in a manner that ensures safe, reliable operation.

TVA utilizes a set of purchased and internally developed tools. The supervisory control and data acquisition (SCADA) system provides the operator with high priority alarms, which must be acknowledged and acted on for overloads on all critical lines within the TVA transmission system. The transmission operator also monitors for n-1 contingencies using SCADA and a state estimator.

TVA's footprint has multiple frequency-monitoring points that can be viewed on the energy management system (EMS). The EMS has a map of the frequency-monitoring points to determine the status of the TVA footprint and identify possible islanding conditions. TVA uses the two Symmetricon, formerly branded as TrueTime, frequency sources for frequency indication to the balancing authority and transmission operator as well as the input to the frequency bias calculation for the area control error (ACE) equation. The primary frequency source is located at the system operations center and the backup at the reliability operations center. In addition, the balancing authority can select any of four other frequency sources as a backup in the event both the primary and secondary source are not available. Both the primary and secondary frequency source drive a local independent source at the system operations center. Should the EMS fail, system operators have an independent frequency display available at the system operations center. The backup operations center at the reliability operations center and alternate backup operations center at a third location have similar setups, which would allow the balancing authority to continue monitoring system frequency following an EMS failure.

TVA's EMS has a bus voltage display that lists the voltage control devices. The display provides the rated values of these devices, bus voltage of the station where the device is located, and the ability to control these devices. Voltage levels of 500, 230, 161, 69, 46, and 13 kV are monitored in SCADA and have alarming capabilities. Strategic 500 and 161 kV voltages are included on the mapboard. Regional average voltages can be monitored using the SCADA reactive reserve display, which will alarm if the voltages are too low. TVA has no areas where it has problems meeting voltage schedules. TVA does have automatic undervoltage load shedding capability in a small area of Mississippi and Knoxville. All these areas have operating guides to address recovery efforts if an undervoltage load shed event occurs.

TVA has line reactors, reactors on the tertiary of 500 kV banks (manually operated); 500/161 kV and 230/115 kV transformer load tap changers (manual or auto); 500, 230, 161, 69, 46, 26, and 13 kV capacitor banks (manual or auto); and a static condenser unit (manual or auto). TVA also provides all generator units with a voltage schedule, which is maintained unless otherwise directed by the transmission operator.

SCADA also displays a reactive reserve page with the system divided into regions. It provides two alarms: one for low reactive reserves and one for low average voltage in the region. Each region shows used and available reactive reserves and available reactive reserve into and out of the region. Most of TVA's generating units provide an indication by SCADA for unit reactive output. Hydro units that are not shown on SCADA can be determined by the hydro dispatch control center, which is located in the same control center as the transmission operators.

The TVA balancing authority and transmission operator systems are tightly integrated with the TVA reliability coordinator from both data and application perspectives. The TVA reliability coordinator has direct access to the same systems and screens within these systems as the balancing authority and transmission operator. In addition, TVA balancing authority and transmission operator data are transferred to the TVA reliability coordinator and other reliability coordinators via intercontrol center communications protocol (ICCP) for use in advanced power and network analysis, e.g., the reliability coordinator state estimator.

2.2 Operational Focus

2.2.1 Operational Safety

System operation activities are conducted in a manner that maintains high levels of safety and reliability for all system conditions.

A specific procedure defines the operational desk responsibilities and communication for the system operator. The *Electrical System Operating Manual* also provides a guide that can be used as a reference to address operating emergencies. The Transmission and Reliability Organization *Operator Authority Letter* provides the operator with the assurance from management that the balancing authority and transmission operator have the authority to take action to ensure the integrity of the bulk power system, up to and including the shedding of firm load. This letter is posted in the main control center and at the backup facility.

Operational decisions are made by operators based on documented process and procedures. These procedures are communicated to the operators by formal and on-the-job training. Training simulators are used to ensure these process and procedures have been transferred to actionable skills and to enhance the operator's ability to assess and manage risk. Real-time state estimators are used to inform operators when a postulated n-1 condition will place the reliability of the system at risk.

TVA does not have any special protection systems or remedial action schemes.

2.2.2 Operational Decision-Making

Operational decisions are reached using a systematic and thorough approach that supports safe, reliable, and efficient system operations.

A Transmission and Reliability Organization management review committee meets weekly to determine the level of severity, scope of investigation into root cause, and adequacy of corrective action plan for each issue. A monthly meeting is held to review and track progress of balancing authority and transmission operator indicators to provide a more reliable transmission system.

When deficiencies are found, a Problem Evaluation Report can be initiated by an individual or collectively by a team. Once written, the report is reviewed by the appropriate organization, which will provide process improvement suggestions. The report is then reviewed by the Management Review Committee, which approves, denies, or adds to the recommendations. The report is then returned to the responsible organization to implement the improvement processes. The process will not allow the problem to be archived until root cause has been identified, and all corrective actions have been identified and implemented. The Problem Evaluation Report process has provisions to share lessons learned with others in TVA. The evaluation team recognizes this activity as a potential example of excellence.

2.2.3 Operational Alignment

Organizational structure supports safe and reliable system operation.

TVA's document *Administration of Electric System Operations Procedures* describes the process for preparing and updating Transmission and Reliability Organization operating policies and procedures. Once a need is identified and the subject matter expert is chosen, the policy or procedure is named, entered into the status tracking system, circulated among affected parties, and approved at the appropriate level. Once approved, the policy or procedure is circulated to the operators via a required-reading assignment, through training, or by hand delivering it to the on-shift personnel. Review cycles for procedures are determined and are available on the Transmission and Reliability Organization Web site. The evaluation team noted that some documents did have an area to indicate they had been reviewed. The evaluation team recommends that TVA add a sign-off process to identify the date and name of reviewed documents. The evaluation team offers as a consideration that TVA investigate options to expand the electronic methods utilized to notify system operators of procedural changes.

The Transmission and Reliability Organization's engineering department is responsible for developing studies on planned outages and evaluating their effects on TVA. The outage scheduling procedure is covered in the *Transmission Outage and Coordination Process.* The Dispatcher Appointment Book provides the transmission operator with a daily list of approved scheduled jobs, any special requirements, and a direct link to the *Request for Clearance* form. It also includes a message board to provide the senior transmission operator a means to convey any necessary information to the transmission operators.

The outage scheduling process includes a study by the reliability engineer that identifies all generation re-dispatch and n-1 contingency needs, which may include a pre- or post-operational

contingency plan. The specialist, reliability analysis and operations will perform a next-day study of scheduled outages to ensure that all n-1 contingencies are addressed.

The Service Interruption Report is used by transmission operators and transmission owner personnel to review transmission system events. In addition to the date and time of each event, the report displays information on the station, switchgear, and protection at each end of the transmission element (or line) interrupted. Data are entered into the report by the transmission operators though a TVA-developed Microsoft Access application.

Transmission operator and balancing authority personnel use shift-turnover procedures and checklists to communicate all pertinent operational information, and a shift turnover process procedure is available for reference. The operators have a notebook that contains anything going on that may affect reliability. Coordinator notes contain a list of planned derates, times that they are expected to go out, etc. If it is a standard process and procedure, and an e-mail is sent, there is a verbal contact, and it is included in the training assignment list. The transmission operator desk uses e-mail with return receipt. The senior system operator provides training to the other system operators. There is no special time built into the schedule for shift turnover.

2.3 Managing System Configuration

Power system configuration is carefully designed, analyzed, maintained, and controlled throughout the life of the infrastructure, ensuring that system and equipment margins are understood, considered in decision-making, and managed consistent with design and system requirements.

Over the past five years, TVA has made considerable efforts to improve operator tools and systems. These efforts continue as projects are being pursued over the coming months. Projects include a number of research and development projects, such as Southeast Regional Wide-Area PowerWorld, AREVA wide-area display tools, the Eastern Interconnect Phasor Project, and participation on the RTO/ISO Council's Information Technology Committee.

Automatic voltage regulators (AVRs) are installed on all generators and are required to be in automatic mode. If there is a need to place AVRs on manual, the generator operator requests approval from the transmission operator. In the case of emergencies, the generator operator informs the transmission operator the AVR has been "forced out of service." SCADA contains an AVR status page updated by the transmission operator to show the position of all AVRs. A comment section allows operators to state the reason why an AVR is on manual.

Digital power system stabilizers (PSSs) are installed on all four units at TVA's Raccoon Mountain pumped storage facility. PSS settings are based on studies performed by TVA's transmission planning department. Transmission planning is responsible for performing studies on a periodic basis to ensure the settings are appropriate. If any of the PSSs are not available, the unit operator notifies the transmission operator and reliability coordinator.

Disturbance monitoring equipment is required by TVA's regional reliability organization, SERC. Approximately 80 percent of TVA's disturbance fault recorders (DFRs) are time synchronized

using the Global Positioning System (GPS). TVA's plan is to have 90 percent of its DFRs GPS time synchronized by the end of this fiscal year, September 30, 2007 and the long-term goal is to have all DFRs GPS time synchronized by the end of fiscal year 2010. The evaluation team believes that this project should be completed as planned.

The balancing authority operator utilizes an electronic *Summary Spreadsheet* as a scratch pad from which to operate the system from hour-to-hour. This spreadsheet is created daily based on the *TVA Day-Ahead Resource Plan* and can be refreshed on demand as balance-of-day plans are produced. The Transmission and Reliability Organization generates a daily report that details the next day's plan for power system operation. It includes a power supply narrative, reliability analysis, listing of upcoming issues, a 10-day power supply update, peak and hourly reliability plans, pick-up plan, turn-down plan, commitment report, hourly schedules, asset availability, energy, ancillary services, asset views, and load.

The TVA balancing authority sends dispatch instructions to all TVA fossil units through the Unit Operators Dashboard. Plant operators are required to acknowledge they received this instruction through the Unit Operators Dashboard. TVA uses its Asset Availability system for recording planned generation outage and derates as well as to log unreported derates and/or forced outages in near real time.

TVA retains 25 percent of its contingency reserves as spinning, and 100 percent of the spinning reserves are under governor control at all times. TVA only considers reserves that are under governor control to count toward spinning reserve requirements. The operators believe reserves are distributed through the system. All hydro is automated and is controlled out of the system operations center. Operators have a dashboard listing fossil plants, although the fossils aren't used to respond to DCS events.

The Generation of Record system is used by TVA generation plant personnel to perform daily validation and monthly confirmation of official generation to the grid as collected by TVA's SCADA/EMS. The system also allows plants to nominate changes to SCADA/EMS data based on local plant metering. The balancing authority reviews any modifications made by the plant and approves or denies these changes. The Operations Data Store is the balancing authority's tool for viewing hourly operational data and can be used to edit and correct data errors due to bad telemetry.

TVA has several weather services that provide images to the balancing authority and transmission operator. Data are received from National Weather Service sites across the country and input through the National Oceanic & Atmospheric Administration port. Software then combines the different radar sites for an area to create a mosaic for that region. In addition, TVA has a meteorologist on staff to interpret the information and adjust load forecasts. The evaluation team acknowledges this action as a positive observation.

TVA utilizes a digital system to log calls and provides digital voice recording for designated phones and turrets. The system produces removable tapes, which are retained by TVA for six months.

Interruptible load programs that provide the operator with a real-time estimate of loads that can be interrupted, order of reduction displays, and emergency load curtailment processes are other tools the leadership team has provided the operators to help manage risk decisions.

TVA has significantly lessened the chance of being in an "unanalyzed condition" through use of two state estimators. Each state estimator uses the same underlying model; however, one model handles 3,100 buses while the other model handles 6,500 buses, and each model's support infrastructure is totally independent of the other. Each state estimator effectively serves as the backup to the other and provides operators a second source for verification of alarms and results. The evaluation team acknowledges the use of two state estimators as a potential example of excellence.

In real time, TVA maintains and uses state estimation to continuously monitor any threats to reliability and provide feedback to operators. Operating procedures to return the system to an n-1 posture have been developed and communicated to operators. TVA uses a simulator as part of its required training to enhance the risk management skills of its operators.

TVA has developed a business process and a software application that allows TVA to make model changes, build equivalent external models dynamically, and push the model to both platforms. The Transmission Planning department performs seasonal studies to determine system equipment ratings and sends any changes to the Fault Analysis Working Group system, which updates a Web-based program that identifies all equipment ratings. Operators are made aware of these changes. If there are concerns regarding limitations due to the new ratings, operating guides are developed. Those operating guides are available in the electronic format at the operator desk. TVA maintains a common network model for both state estimator and real-time contingency analysis platforms. This common model is currently housed in a Microsoft Access system. This system allows a portion of its explicit model to be extracted, e.g., the TVA model, and then an equivalent model is built dynamically. Transmission and Reliability Organization configuration management processes allow network models to be updated as frequently as once a week for both systems. The TVA reliability coordinator model is more dynamic than the TVA balancing area model and is typically updated every week.

An AREVA state estimator, which cycles every two minutes, is the primary tool for TVA's reliability coordinator functions. The network model supporting the estimator includes transmission within the service areas of the companies for which TVA provides reliability services. This model currently contains about 7,000 buses and addresses 1,100 contingencies. This AREVA system is scalable to 50,000 buses.

A second state estimator to support TVA transmission operator and balancing authority functions executes on the SCADA/EMS platform, which is provided by Siemens/Telegyr. This state estimator is primarily used by the transmission operator to study the impact of switching options and scenarios. The network model contains about 3,100 buses and analyzes 600 contingencies. It cycles every 15 minutes.

2.4 Emergency Preparedness

The organization is prepared to manage and mitigate the impact of system emergencies in order to preserve the reliability of the system and to protect the interests of the public.

Authority is embedded in the system operator job descriptions and further reflected by TVA document 1.0 *VP System Operator Authority 2006*.

Following transmission forced outages, the system operator has an option to have support staff run a relay fault location program. This process can closely estimate the location of the fault and can provide the transmission operator with characteristics of the fault. The evaluation team recommends that TVA evaluate automating the relay fault programs to display the information to the operator sooner.

TVA has emergency procedures and processes posted on the Power System Operations/ Transmission and Reliability Organization emergency Web site and in the system operator "Red Books" that detail responses to a spectrum of emergency conditions. TVA's *Transmission Emergency Plan* and *Continuity of Operations Plan* are two primary procedures that describe how TVA would respond to emergencies on a macro scale. A Transmission and Reliability Organization operations center protocol describes the makeup and actions of TVA's emergency response team when the transmission emergency operations center is activated.

TVA's emergency response is governed by its *Agency Emergency Response Plan* of which TVA's *Transmission Emergency Plan* is a subordinate procedure. The transmission emergency operations center acts as a satellite of the agency coordination center when TVA must respond to a national or regional emergency. Both plans are compliant with the *National Incident Management System*, which governs how TVA must interact with other agencies and outside entities for emergency response.

TVA has a procedure for energy emergency assistance for control area (balancing authority) operations. All available load curtailment measures up to firm load interruption must be enacted, "Energy Deficient Entity" status must be declared, and an alert is issued in order to request energy emergency assistance from neighboring utilities. TVA's emergency load curtailment program and order of load curtailment have provisions with set criteria to help TVA avoid needing emergency assistance. The Transmission and Reliability Organization has a *Power Supply Alert/Energy Emergency Alert* process flowchart to guide the system operators.

The *Order of Reduction* and its associated Web site are available to guide the balancing authority through all load curtailment processes. Currently, only the Cumberland Unit 1 and Cumberland Unit 2 have underfrequency and overfrequency trip in service. TVA's Sequoyah Nuclear Units 1&2 and Watts Bar Nuclear Unit 1 have underfrequency protection for their reactor coolant pumps designed to protect the reactor. All these generators' underfrequency trips are well below the last trip point for underfrequency load shedding (UFLS).

The TVA balancing authority has an automated customer telephone notification system called ACTS to notify interruptible customers of the suspension of availability of interruptible products,

restoration of availability, tests, and market-day pricing information. ACTS is capable of 144 simultaneous telephone notifications. In addition, the balancing authority uses the direct load control activation program to automatically control (via radio signal) residential water heaters during times of peak demand. Total load under control is approximately 40 MW.

The transmission operator is responsible, in coordination with the TVA reliability coordinator, for coordinating blackstart and system restoration. TVA has a blackstart procedure and individual plant blackstart manuals that place priority on returning off-site power to nuclear plants. TVA has 11 hydro blackstart units and 2 combustion turbine blackstart units. Each thermal generating plant, including nuclear, has a blackstart plan that provides the necessary procedure for a normal and alternate path to restore station service. SCADA has a display page showing the normal and alternate paths for all generating units. The system restoration plan addresses the need for synchronizing small islands and concerns for cold load pickup. The transmission operator also has a geographic view of area voltages and frequencies, which can be used to identify islands and assess the system condition during an emergency. The transmission operator will coordinate with the TVA reliability coordinator, which has the overall responsibility for coordinating the restoration effort including synchronizing cross-jurisdictional islands.

The regional requirement states that load shed should occur in "approximately equal increments in a minimum of three steps." Currently, TVA's UFLS program uses five steps and will shed 36.6 percent of its load at peak, which is above the regional requirement of 30 percent of peak load. The amount of load shed per step is in "approximately equal" increments. TVA is revising relay settings for its UFLS program to redistribute the load shed per increment so it will be more equal.

Working closely with the TVA nuclear section, the Transmission and Reliability Organization has developed a nuclear status Web site to improve internal communications between the two groups. Transmission equipment and lines that are critical to the nuclear plants are listed and color-coded to reflect any changes to the transmission system status. The evaluation team recognizes this activity as a positive observation.

3. Fundamentals of Maintenance

3.1 General

Maintenance is conducted by skilled personnel to achieve safe, reliable control center equipment and system performance.

The TVA network operations center is staffed 24 hours a day, 7 days a week to monitor all vital telecommunication paths and systems related to the power system. Statuses come from the Telegyr 8.0 EMS and the Megasys Telenium Monitoring System. Data integrity and voice communications are monitored constantly. Prioritized alarming is reported to the center by these systems and acted on by the Transmission & Operations Maintenance Transcomm group. The network operations center has the authority to call out those necessary to remedy adverse conditions. Maintenance personnel are on call 24 hours a day, 7 days a week.

Metering errors are detected in real time by the EMS. If a metering error occurs on a primary tie-line meter within established limits and criteria, the EMS defaults the tie line to the backup meter. A flashing visual alarm will identify the meter and time of failure. If an additional failure occurs on the backup tie-line meter, the EMS will automatically suspend the automatic generation control (AGC) and give the system operator a visual flashing indication of the problem. At this point, with the primary and backup meters failed, the system operator will normally place the backup meter in manual and obtain readings by calling the adjacent balancing authority involved. The AGC can now be returned to normal operation. Periodic updates will be made to the meter until at least one of the meters becomes operable.

3.2 Equipment Reliability

3.2.1 Equipment Performance

The organization achieves high levels of equipment reliability. Equipment problems that impact reliability are resolved in a thorough and timely manner.

TVA uses Symmetricon (previously TrueTime) XL-DC receivers that include the FTM-III option module. This module is a frequency and time deviation monitor that measures system frequency, system time, and frequency deviation to 1 mHz and time deviations to 1 ms accuracy. The manufacturer's "Maintenance and Troubleshooting" section of the manual for the FTM-III module states no periodic servicing or calibration is required. There are no user serviceable components.

TVA has two Symmetricon XL-DC receivers, both GPS synchronized. These are the frequency devices used to display frequency to the operators and are used to determine actual frequency for ACE and CPS calculations. One is located at the system operations center and the other at the reliability operations center, and either can backup the other.

3.2.2 Work Management

Work activities, including corrective, elective, and preventive maintenance, surveillance testing, and modifications, are managed effectively to support safe, reliable operation during both outage and routine periods.

TVA monitors the system from six vantage points:

1. The status of serial communications from remote terminal units (RTUs) and metering locations is monitored by the SCADA/EMS. The network operations center responds directly to these SCADA alarms and opens tickets for field diagnosis and resolution. Communication line status information is exported to Web systems that display the minutes of outage each hour for the current day as a secondary tool to ensure visibility and resolution of communications problems.
2. Problems in voice communications are reported to the network operations center. In case of failure or loss of telephone service, the network operations center can initiate failover of

the critical ringing circuits from one location to the backup facility utilizing the HiPath 4000 Path Manager from Siemens.

3. The status of all SCADA/EMS processes is monitored by the balancing authority desk. Both the balancing authority and network operations center can restart these processes from this display.
4. All critical information flows (about 120 of them), such as the load forecast and transmission schedules, are monitored through the System Status and Alarm Monitor.
5. Network and server status are monitored by the operations duty specialist desk through Concord eHealth and HP Open View systems.
6. Security through real-time network traffic analysis is monitored by an outside monitoring service.

Prioritized alarming is reported to the network operations center by these systems and acted on by the Transmission & Operations Maintenance Transcomm group. The network operations center has the authority to call out those necessary to remedy adverse conditions. All TVA balancing authority and transmission operator computer systems and applications are supported on a 24 hours a day, 7 days a week by the Transmission and Reliability Organization Control Systems staff.

TVA utilizes a Temporary Alteration Permit system for non-permanent changes in wiring, control circuits, and mechanical elements that affect the operation of the transmission system. The chief system transmission operator is responsible for the implementation and administration of this procedure. The changes are reviewed each quarter, and updates are requested from the transmission operations maintenance group. The evaluation team recognizes this activity as a positive observation.

4. Fundamentals of Operational Planning

Operational planning provides the technical information and support necessary for safe, reliable system operation.

Since operations planning is a continual process, TVA recognizes the particular challenges of outage scheduling in the spring and fall and higher net system loads in the summer and winter. Long-range planning (beyond one year) is handled by the TVA Bulk System Planning department, which is not under the transmission operator or balancing authority functional areas.

The base case models originate from the VASTE (VACAR, AEP, Southern, TVA, Entergy) OASIS Support Study Group. This group creates seasonal Power System Simulator for Engineering, or PSS/E, cases for the next five seasons, which are derived from the NERC Multiregional Modeling Working Group (MMWG) cases. The detail of the neighboring control areas is the same as supplied to the MMWG process (typically, all facilities above 100 kV with radials equalized). Every quarter, each company will make any known changes to topology, ratings, generation dispatch, and interchange.

The Transmission Planning department performs seasonal studies to determine system equipment ratings and sends any changes to the Fault Analysis Working Group (FAWG) system, which updates a Web-based program that identifies all equipment ratings. This program will also identify when there is a discrepancy between FAWG and SCADA limits. The senior transmission operator will address any discrepancies and will facilitate any required changes to SCADA. Operators are made aware of these changes. If there are concerns regarding limitations due to the new ratings, operating guides are developed. If a change is needed in projected limits, the values will be updated in SCADA and state estimator tools. This information is communicated in training sessions. In addition, e-mails are issued to all system operators with follow up by the senior transmission operator or asset management to ensure understanding and clarification.

In October 2005, TVA operations planning implemented an Automated Model Builder (AMB) application to create forward-looking operational load flow models. The AMB application generates over 1,300 load flow models each day to represent a variety of forward-looking time horizons. Utilizing coordinated seasonal cases, the AMB process creates 18 monthly models, 35 daily models, and 192 hourly models (with 48 hourly models generated hourly on a rolling basis to cover the next 48 hours). These models represent the peak hour for the period under study and include all relevant outage and load data provided through the NERC System Data eXchange (SDX). In addition, the process uses a variety of subsystem files that provide generation dispatch, capacitor bank outages, pumped storage profiles, load profiles, and NERC Tag Dump schedules. The AMB process also calculates available flowgate capability (AFC) on all flowgates and provides dc contingency analysis results from each model. This process allows TVA operations planning engineers to select a model to study upcoming outages with expected conditions for the study period.

Completed in 2005, the Ratings Accuracy and Comparison System gives any user the capability to go to a single display and generate a report highlighting rating differences between "system A" and "system B." This ability to see discrepancies quickly has not only been a huge timesaver but has also built a higher level of confidence within the TVA operator community that the current ratings are correct.

The evaluation team recognizes the Transmission and Reliability Organization's software application, developed through the FAWG system and AMB operations and model-building process, that performs daily comparisons between all systems and reports on any discrepancies as a potential example of excellence.

The five seasonal base cases are conditioned to be inputs for the AMB process. The AMB process utilizes the PTI AFC MUST application to create 168 hourly cases, 35 daily cases, and 18 monthly cases. Detailed block dispatches are used for the neighboring control areas. These block dispatches consist of generator groups dispatched in a priority order. TVA and the neighboring control area loads are scaled, and generation is dispatched to match the load forecast from SDX. Generation and transmission outages are modeled in the neighboring control areas from the SDX data. This process is further documented in the TVA *Load Flow Model Development* procedure.

Transmission Planning has a *Reactive Optimization Plan* designed to maintain 500 kV system voltage between 525 and 500 kV and 161 kV system between 165 and 169 kV. These voltage ranges are within TVA's contractual delivery point obligations. Generally, customers select taps on their transformers at each delivery point, based on the specified normal wholesale delivery voltage, to obtain an adequate distribution voltage on the low side of their transformers. SCADA and state estimator tools are programmed with these limits, which are used by the balancing authority and transmission operator for reliability studies and real-time monitoring. SCADA alarms for voltages above or below contingency limits are coordinated with the reliability coordinator, which has the same viewing capability as the transmission operator.

The operations planning process (day-ahead through one year) ensures that planned generation patterns and transmission outages will not disqualify the off-site power source, unless coordinated with the affected nuclear power plant. Special nuclear plant requirements, such as alternate internal plant load alignments requiring a higher level of grid voltage support, are entered into the transmission outage schedule to ensure visibility and proper coordination with planned system outages and generation profiles.

Operational planning studies are conducted to identify potential constraints using a day-ahead commitment and generation dispatch plan. Contingency analysis is performed to identify potential voltage violations. Identified violations are studied to ensure that adequate reactive reserves are available—if not, operating guides are developed to ensure proper post-contingent voltage can be maintained. Mitigating actions are developed for each constraint that includes generation dispatch requirements and/or transmission reconfigurations options.

TVA uses a flow-based approach based upon AFC to evaluate requests for transmission service. For each transmission path defined by a source and a sink, TVA identifies a set of constrained facilities (flowgates) that impact that path. AFC may vary between seasons due to thermal limits.

The operational planning evaluation, including outage analysis and day-ahead analysis, requires that the transmission system remain within SOL and IROL bounds for any single contingency. Evaluation for thermal limits requires all facilities to be within normal ratings pre-contingency and emergency ratings post-contingency. Voltage limits are evaluated at a 1.0 p.u. pre-contingency and .95 p.u. post-contingency. A violation below .95 p.u. is further evaluated for voltage collapse utilizing a 10 percent margin.

Grid operating studies are performed to identify key grid parameters, such as net system load, line outages, generation profiles, and bus voltages that will ensure nuclear off-site power adequacy based on shutdown loads and voltage requirements provided by the nuclear plants operators. These parameters are monitored by the transmission operator in real time to ensure prompt identification and correction of any problems.

A security constrained day-ahead generation plan for use in operational planning studies is in the final stages of development. Feedback from these studies will be used to refine the day-ahead

plan prior to publication to the balancing authority and generator owners and operators. Feedback will also be used as input into the intra-day planning process.

5. Fundamentals of Training

5.1 General

Training in both specific job-related skills and broader technical fundamentals is used to provide highly skilled, knowledgeable personnel for safe, reliable operations, and to achieve performance improvement.

TVA has an Operator Training Committee that provides oversight and direction for the initial and continuing training programs. Additionally, the committee determines training content and analyzes training feedback. The Operator Training Committee is made up of management and senior operators from each discipline; i.e., the balancing authority, transmission operators, and reliability coordinators.

The initial training for balancing authority operators consists of on-the-job training under the direction of a certified, experienced senior balancing authority operator. Transmission operator trainees are selected from experienced substation electricians, transmission operators from other entities, or electrical engineers. The initial training consists of on-the-job training under the direction of a certified, experienced transmission operator and a six-week course covering transmission system switching. The required training topics are identified and documented on the *Technical Qualifications Training Checklist* for each position. If trainees do not have a NERC system operator certification, they are enrolled in a vendor-provided NERC certification preparation course. Upon completion of the certification preparation course, the trainee is required to pass the NERC operator certification exam.

Transmission and Reliability Organization requires training to meet statutory and regulatory requirements, such as proper methods for cyber security and compliance with standards of conduct. This training is provided annually using computer-based training modules. NERC standards and Transmission and Reliability Organization procedures for cyber security are included in operator continuing training segments. Standards of conduct are reinforced during the operator continuing training.

Two weeks of continuing classroom and simulator training are provided to each operator annually. Topics covered in classroom/simulator training are determined from technical qualifications checklists for system operators, feedback from system operators and managers, industry and system operating events, and updates/changes to operating equipment (tools) and processes used by system operators. TVA also participates in blackstart and system restoration drills with other reliability entities. Besides the two continuing training cycles, operators have additional time throughout the year that permits other continuing training. At this time, few expectations are set for these additional training periods. The evaluation team recommends that TVA implement a practice of formalizing training expectations for each training week outside of the formal continuing training periods.

During the tools demonstration, the evaluation team observed some reluctance by the operator regarding how to test and use the satellite phone. The evaluation team was informed that the satellite phone was tested by the communications support personnel on a routine basis. The evaluation team recommends that procedures be revised so operators are involved in routine satellite phone testing. Furthermore, the evaluation team recommends that a training process be implemented so all operators demonstrate their proficiency on an annual basis.

Instructors are required to complete the TVA instructor training program, which includes several days of systematic approach to training instruction. In addition, to assess the course and the instructor, course instructor feedback evaluations are conducted. These evaluations provide feedback on the effectiveness of the course, including the instructor's ability to convey knowledge, the module's relevance to job requirements, and the material's adequacy. As a final element of training evaluation, management provides feedback on operator performance after completion of training.

Training participants also provide feedback to the trainers on problem areas during training and topics that they would like to see included in training. This feedback is incorporated into the program and used for developing upcoming cycles of training. Some examples of training provided as a result of training feedback include "FERC and the ERO - Regulatory Relationship," "Telegyr State Estimator - Solving Study Cases," and "Alcoa - TVA Contractual Relationship."

All completed internal training is documented on a roster entitled *Training and Development Attendance Record* and entered into the *Automated Training Information System*. Instructors are responsible for ensuring that the rosters are correct and submitted to the assigned data entry personnel in a timely manner. External training is documented on the *Completed External Training* section of employee training transcripts. Training records, rosters, and transcripts are entered into an electronic document management system.

5.2 Organizational Effectiveness

5.2.1 Human Performance

Personnel select and apply appropriate human error prevention techniques commensurate with the importance of assigned tasks to minimize the frequency and consequences of events.

Change initiatives are reviewed by representatives of the impacted group(s) of system operators. This review provides feedback to the owner/project manager for the change initiative. This allows determination of needed training, enhancements, or changes to prevent negative impacts on system operation.

To reduce potential human error during switching of the transmission system, the counterparty who receives transmission switching instructions from the transmission operator is required to repeat those instructions to the transmission operator to verify the understanding of what was communicated. In addition, those who receive transmission switching instructions for execution are required to complete a six-step instruction that details how those instructions should be performed. This instruction focuses on human error prevention.

APPENDIX 1: Critical Infrastructure

The following discussion will be presented under private letter to the evaluated entity only and will not be included within the public version of the report.

APPENDIX 2: Evaluation Participants

The following will be presented under private letter to the evaluated entity only and will not be included within the public version of the report.

APPENDIX 3: Documents Reviewed

The following will be presented under private letter to the evaluated entity only and will not be included within the public version of the report.