Report on the

FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans

Further Joint Study Report:

Planning Restoration Absent SCADA or EMS (PRASE)

Prepared by the Staffs of the

Federal Energy Regulatory Commission

and the

North American Electric Reliability

Corporation and its Regional Entities

June 2017

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

This report was prepared by the staff of the Federal Energy Regulatory Commission in consultation with staff from the North American Electric Reliability Corporation and its Regional Entities.
This report does not necessarily reflect the views of the Commission.

Table of Contents

I. Executive Summary

In September 2014, the Federal Energy Regulatory Commission (Commission) initiated a joint staff review, in partnership with the North American Electric Reliability Corporation (NERC) and its eight Regional Entities,[1] to assess entities' plans for restoration and recovery of the bulk-power system following a widespread outage or blackout, which culminated in the issuance of a joint Report on Restoration and Recovery Plans in January 2016.[2] While the Restoration and Recovery Report provided a comprehensive understanding of the electric utility industry's bulk-power system recovery and restoration planning, it also identified certain issues that went beyond the scope of the review, and recommended further study of those issues. One of the areas identified for further study was the potential impact of the loss of Supervisory Control and Data Acquisition (SCADA) systems on system restoration.[3]

Based on the recommendation in the Restoration and Recovery Plan Report, FERC, NERC and the Regional Entities initiated a joint study in the fall of 2016, focusing on the potential impact of the loss of SCADA, Energy Management System (EMS), or Inter-Control Center Communications Protocol (ICCP) functionality on system restoration, and the manner in which such impact could be mitigated.[4] The objective of the study was to assess applicable entities' system restoration plan steps that may be difficult in the absence of SCADA, ICCP data, and/or EMS, and identify viable resources, methods or practices that would expedite system restoration despite the loss of such systems, including identifying where such methods and practices could be incorporated into system restoration training.

---

[1] Pursuant to section 215(e)(4) of the Federal Power Act, NERC has delegated certain compliance and enforcement authority to eight Regional Entities.

[2] *Report on the FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans*, January 2016, at http://www.ferc.gov/media/news-releases/2016/2016-1/01-29-16.asp (Restoration and Recovery Report).

[3] Events such as the recent cyber-attack against the Ukraine power grid have highlighted the need for this follow-up study by demonstrating the need to have alternate methods to monitor and control the electric grid when SCADA and other control and data systems are unavailable.

[4] Appendix 3 includes a glossary of terms and acronyms used in this report.

In conducting this review, the joint study team gathered information from a representative sample of eight volunteer registered entities (the participants). The joint study team considered several factors when identifying potential participants for the study, seeking entities with significant bulk-power system responsibilities, entities that are located in different regions, entities that have gained experience in restoration from extreme conditions or events, e.g., involvement in prior blackout events, hurricanes, severe winter weather, or tornadic conditions, and entities that regularly use SCADA, EMS, ICCP or other data sources in their bulk-power system operations.

Notably, this study is based on an initial assumption that a blackout event has occurred coincident with the loss of SCADA and/or EMS functionality. This study is not intended to assess the degree to which the participants' SCADA or EMS systems are able to withstand or quickly recover from a widespread event to complete restoration back to normal operations (e.g., automatic generation control, regional market operations). However, as further discussed below in Section IV.A., the joint study team found that all participants have made significant investments in their SCADA and EMS infrastructures, including leveraging redundancies to increase availability and functionality.

While some participants have prepared more than others for the possibility that SCADA systems or EMS may be partially or totally unavailable at times during a system restoration event, the joint study team found that all participants would remain capable of executing their restoration plan without SCADA/EMS availability. This is attributed to some participants' planning to address loss of SCADA or EMS during system restoration, as well as other participants' emergency preparedness for conditions such as these without specifically planning for system restoration absent SCADA or EMS. The participants acknowledged, however, that completion of all restoration steps would be more time consuming and more involved under such conditions, especially those steps requiring a larger degree of coordination and those steps performed during later stages of the restoration process.

This report provides details of the joint study team's assessment, and makes recommendations for industry-wide consideration regarding practices, procedures and methodologies aimed to expedite system restoration during a loss of SCADA or EMS functionality based on the various practices and approaches studied. These recommendations include approaches to system monitoring without SCADA or EMS tools, planning to support system restoration under such conditions, and incorporating these measures and approaches into system restoration training.

The joint study team considers the recommendations in this report appropriate for all entities responsible for system restoration. Additionally, the joint study team observed numerous beneficial practices employed by individual participants that may not be universally appropriate or possible. The joint study team recommends that entities consider incorporating those practices, or variations thereof, as appropriate.

Recommendations

1. **Planning for backup communications measures.** The joint study team recommends that entities review and refine as necessary their backup communications measures and capabilities to ensure that they can be depended on to provide effective means of communications in the event of the loss of normal communications means during system restoration absent SCADA or EMS. This should include a review of their backup or alternative interpersonal (voice) communications systems to ensure that they are capable, available, and reliable for the increased use expected during system restoration without SCADA functionality. The joint study team also recommends incorporating loss of normal communications scenarios and use of backup communications systems in entities' system restoration training to practice their use in executing restoration plan steps and in monitoring of system restoration conditions absent SCADA. **[Section IV.B.]**

2. **Planning for personnel support during system restoration absent SCADA.** The joint study team recommends that entities review and refine their human resource operations support measures as needed to support the field and control room personnel necessary for system restoration absent SCADA. This includes personnel needed to acquire field and generation plant data, to maintain system operator situational awareness during blackout conditions for extended periods of time, and to provide logistical support for their assignments (e.g., food, shelter, transportation pre-arrangements). In refining such measures, entities should consider incorporating methods and tools that could aid personnel in gathering and managing the field data to provide useful information to the system operators. The joint study team also recommends incorporating these measures and tools into entities' system restoration training, including the involvement of both field and control center support personnel who would gather and manage the field data. **[Section IV.C.]**

3. **Planning backup power supplies for an extended period of time.** Due to the expected increase in time to accomplish system restoration absent SCADA/EMS functionality, the joint study team recommends that entities review and refine as necessary their existing provisions for backup power resources at restoration path substations and other locations identified as priority or critical in system restoration plans, to ensure they are available for an extended period of time beyond the normal expectation from battery backups. **[Section IV.D.]**

4. **Analysis tools for system restoration.** Recognizing that the absence of SCADA/EMS functionality results in loss of State Estimator and Real-Time

Contingency Analysis, the joint study team recommends that applicable entities review and refine as necessary other analysis tools for use (e.g., use of offline power system analysis tools, phasor measurement unit data) especially during the later stages of restoration. The joint study team also recommends incorporating these analysis tools into entities' system restoration training, if not being done already, to practice their setup and use by support staff during system restoration. **[Section IV.E]**

5. **Incorporating loss of SCADA or EMS scenarios in system restoration training.** The joint study team recommends that applicable entities, as part of their system restoration training, practice implementation of restoration plan steps absent SCADA/EMS functionality or other data sources, including incorporating the insights found. **[Section IV.F]**

<u>Observed Practices for Consideration</u>

Throughout its review, the joint study team found that the participants have many practices and protocols that serve to enhance their restoration and recovery planning and readiness in the event of loss of SCADA, EMS or ICCP systems. The joint study team recognizes that these practices may not be appropriate for all entities in all situations, but is confident that the sharing of this knowledge, thereby obtaining a wider understanding and incorporation of these practices, may add significant value to certain entities and to the industry as a whole. Examples of these beneficial practices include the following:

- Some participants have taken into account on-site fuel shelf life for their installed backup generators, using long shelf life fuels, and/or are routinely maintaining the quality of the on-site stored fuel to ensure that extended backup power supplies are available when needed.

- Participants transitioning to balancing area control absent EMS functionality have instituted backup area control error (ACE) applications. These backup applications receive tie-line data from backup data communications sources, which, along with other inputs, can enable the transition back to balancing authority control.

Such practices, which were voluntarily implemented, or are under development by the review participants, serve to enhance the industry's preparation for a major event, and provide training to recover more quickly and efficiently when an event occurs. The beneficial practices observed by the joint study team are discussed further in the relevant sections of this report.

II. Introduction

In September 2014, the Commission initiated a joint staff review, in partnership with the NERC and its eight Regional Entities to assess entities' plans for restoration and recovery of the bulk-power system following a widespread outage or blackout, and culminated in the issuance of a joint Report on Restoration and Recovery Plans in January 2016.[5] The Restoration and Recovery Report provided a comprehensive understanding of the electric utility industry's bulk-power system recovery and restoration planning, but identified certain issues that went beyond the scope of the review, and recommended further study of those issues. One of the identified areas for further study was the impact of the loss of SCADA systems on system restoration, since system operators rely heavily on such systems in performing and managing the restoration process. Events such as the December, 2015 cyber-attack against the Ukraine power grid have demonstrated the need to have alternate methods to monitor and control the electric grid when SCADA/EMS and other control and data systems are unavailable, and highlight the need for this study.

The primary objective of this follow-up review is to identify steps in entities' bulk-power system restoration plans that may be difficult in the absence of SCADA, ICCP data, and/or EMS, and identify viable resources, methods or practices to enable timely system restoration in the absence of SCADA/EMS functionality, which could then be incorporated into entities' system restoration training.[6]

III. Study Process and Data

The joint study team adopted a collaborative model for conducting the review. Subject matter experts from the Commission, NERC, and the Regional Entities collectively provided the necessary planning and operations expertise to conduct the study.[7]

In order to facilitate a full and open discussion of each participant's approach to restoration in the absence of SCADA/EMS functionality, the joint review team agreed not to disclose entity-specific information outside each review group. This report accordingly provides the results of the reviews without attribution to individual entities.

---

[5] Restoration and Recovery Report, *supra* note 2.

[6] *See* Appendix 2 – Request Letter for Participation.

[7] Appendix 1 lists the joint study team members.

In making its assessment, the joint study team reviewed relevant reports, as well as relevant written information and documentation as provided by each participant, and engaged in discussions with the participants to gain additional information and insights.

The process used for this study included three steps:

Step 1: Identify candidate entities;

Step 2: Assess entities' restoration plan steps that may be difficult under various SCADA, ICCP data, and/or EMS unavailability scenarios and identify viable resources, methods, or practices for timely restoration; and

Step 3: Form recommendations (viable resources, methods, beneficial practices, and training).

A. Step 1: Identify Candidate Entities

The joint study team developed participant identification criteria designed to help best achieve the overall study goals of identifying viable resources, methods or practices that would enable timely system restoration absent SCADA/EMS functionality. The following is a list of the identification criteria used:

- Entities subject to Reliability Standards EOP-005-2 and/or EOP-006-2 that have a system restoration plan or coordination steps, and/or have documented procedures for starting blackstart resources;
- Entities that use SCADA and/or EMS systems in their bulk-power system operations, including entity(ies) that use or share ICCP data;
- Entities with significant bulk-power system responsibilities, viewed as competent in the study focus areas, to help to maximize potential learning and improvement;
- Entities located in various areas or regions, where different capabilities, and/or characteristics may exist; and
- Entities that have gained experience in restoration from encountering extreme conditions or events, e.g., involvement in prior blackout events, hurricanes, severe winter weather, or tornadic conditions.

The joint study team identified eight registered entities as prospective participants in accordance with the above criteria, and contacted each to request its participation. All contacted entities agreed to participate in the study, and without exception, were exemplary in their cooperation with the joint study team, sharing the detailed technical rationale behind implementation of their system restoration plans in the absence of SCADA or EMS. The joint staff team commends the participating entities for their open and active contributions.

A study request letter was sent to each volunteer participant, which outlined the information needed for the study.[8] Specifically, participants were asked to provide, or make available for review and discussion, documentation pertaining to the following:

- Relevant steps of system restoration plans (entity-identified);
- Operating plans and procedures for backup functionality in the event that SCADA, EMS or ICCP is unavailable;
- Procedures addressing monitoring and controlling voltages, real and reactive flows, and switching transmission elements (including aspects of system restoration such as control of frequency, contingency reserves, and synchronizing) in the event of the loss of SCADA, ICCP data, and/or EMS;
- Provisions for backup facilities if the main monitoring system is unavailable,
- Procedures to mitigate the effects of analysis tool outages;
- Any results or analysis of operator drills, exercises, simulations, or tests involving a loss of situational awareness tools, e.g., SCADA, ICCP, EMS, etc.; and
- Any public or private reports or other documents that have already been produced in these areas that may be beneficial for the team to review, e.g., Severe Impact Resiliency Task Force Report.

Where possible, the joint study team reviewed these documents prior to the start of the participants' assessments, in order to aid in identifying specific areas of interest for each participating entity and for the study as a whole.

B. Step 2: Assess Entities' Restoration Plan Steps

To aid in identifying restoration plan steps that may be difficult when SCADA, EMS, and ICCP systems are not available, the joint study team examined various "unavailability scenarios." This approach afforded participants the opportunity to explain what resources, methods, or practices are used over a range of SCADA unavailability

[8] A copy of the request letter is attached hereto as Appendix 2.

scenarios, and supported a more comprehensive review. Several relevant scenarios were assessed, including:

- SCADA or EMS system is online with limited functionality due to certain transmission remote terminal units (RTUs), or RTU concentrator/communications facilities, being out-of-service;
- SCADA or EMS system is online with limited functionality, due to widespread transmission RTU outages, e.g., delay in starting system restoration results in widespread substation RTU backup power supply depletions;
- SCADA or EMS system is offline or is not functional;
- ICCP data system is offline or not functioning properly; and
- SCADA/control system of a generator used in system restoration is offline/unavailable.

These scenarios were used to gain an understanding of the participants' resources, methods, or practices to support system restoration absent SCADA/EMS functionality. The areas of focus included but were not limited to:

- Human resources for system restoration;
- Execution of system restoration steps; and
- Monitoring and control of system restoration conditions.

These areas were identified and shared with participants prior to the assessment, to enable the joint study team to perform an efficient, thorough, and consistent assessment for all participants, within the scope of review.

C. Step 3: Form Recommendations

Upon completion of the participant assessments (including site visits with all participants), the joint study team compiled its findings and recommendations in this report, developed with the intent of increasing the level of preparedness for potential problems associated with system restoration absent SCADA/EMS functionality, and sharing sound practices identified for undertaking restoration despite the loss of such functionality, including planning and training for such events.

IV. Assessment

A. Overview

During the review process, the participants provided consistent observations concerning the overall impact on system restoration of the loss of SCADA or EMS functionality, leading to some broad conclusions. The joint study team found that although all participants have made significant investments in their SCADA or EMS infrastructures in order to avoid problems associated with their loss, including instituting redundancies to ensure these systems are online and functional, they still prepare for the possibility that SCADA systems or EMS may be partially or completely unavailable, including what actions would be taken if it occurred during a system restoration event.

All participants indicated that they would be capable of executing their restoration plan independent of SCADA or EMS availability. For example, in the absence of SCADA remote control capabilities, participants will dispatch local field operators to perform the necessary monitoring and control actions. Similarly, the participants indicated that blackstart generators, and the next generating units to be started, are not dependent on SCADA/EMS availability for start-up and utilization for system restoration, and that synchronization of islands and interconnections are not dependent on SCADA/EMS availability.

Although participants indicated that system restoration will be possible absent SCADA or EMS functionality, completion of all restoration steps would overall be more time consuming and more involved without SCADA availability. The participants described several aspects of system restoration that would be more difficult and time-consuming due to the loss of these systems. For example, during the onset of a blackout, participants indicated that system restoration will demand additional use of field personnel, not only to help determine restoration strategy, but also to perform restoration plan steps that would have otherwise been completed through use of SCADA and to perform monitoring and reporting of grid conditions back to the control center system operators. In addition, the participants indicated that system restoration steps which involve additional communications and coordination with multiple personnel, such as load pick-up, will be more labor-intensive in the absence of SCADA or EMS. Overall, the participants expected that dependency on interpersonal communications would significantly increase in performing system restoration in the absence of SCADA, and that any unavailability of interpersonal communications would further hamper system restoration.

With respect to the overall restoration strategy adopted, the participants indicated that their strategies are based on the state of bulk-power system facilities impacted by a given event and their availability for restoration, not on availability of operator tools such as

SCADA or EMS. However, participants stated that they may modify their restoration strategies during later stages of restoration to preserve the reliability of the restored system, based on what may or may not be known about the loss of SCADA and the completion of associated mitigation to prevent its recurrence. For example, if a SCADA system(s) is still unavailable as system restoration progresses, the participants may adjust their restoration strategy accordingly, e.g., restore areas within the reliability coordinator footprint but remain operating as separate islands within the reliability area, holding off synchronizing to form a larger island and/or interconnecting with the rest of the interconnection, thereby reducing the risk of an outage to a larger restored area.

Similarly, if a cyber event caused the unavailability of SCADA or EMS and if it is unclear whether the underlying problem has been addressed, participants indicated that it may be more reliable to operate in an islanded configuration until associated risks are alleviated to avoid a repeat, wide-area blackout. Also, depending on the event, there may be a range of facilities impacted, and all participants agree that their strategies need to be flexible to adjust to the situation at-hand.

In addition, participants indicated that frequency control and monitoring during system restoration are not dependent on SCADA/EMS availability. Instead, participants monitor frequency via communication with generator operators who monitor and control frequency via their generating units' power plant equipment. Given this reliance on generator controls, the joint study team also explored the impact of loss of isochronous generator digital controls on the restoration process (which may occur due to a cyber event). The joint study team found that participants would rely on another generator to perform isochronous control for the island if the primary generator was compromised. In addition, if the affected generator was not available at all, participants would rely on other islands that are part of their plan for system restoration, i.e., all plans involve the development of multiple restoration paths and islands. Thus, their restoration plans incorporate diversification or backups for loss of a generator's control system.

Finally, with respect to other operator tools potentially unavailable during a widespread outage, the joint study team also considered the loss of ICCP data and of State Estimator (SE) and Real-Time Contingency Analysis (RTCA) tools. The joint study team concluded, based on discussions with and information provided by the participants, that ICCP is not critical to system restoration because transmission control center operators who are primarily responsible for system restoration use SCADA systems and do not depend on ICCP,[9] and that SE and RTCA tools are neither functional in the absence of

---

[9] Bulk-power system operating entities use ICCP applications to exchange real time operations data between entities. Although ICCP data would be used if available to

SCADA/EMS nor needed during the early stages of system restoration plan execution. Instead, in order to ensure that the restoration plans steps will be effective and allow the system to remain within tolerances, participants perform periodic offline load flow studies of the steps and loads to be energized for primary paths, and, where feasible, for alternate restoration paths.

B. Communications Resources for System Restoration absent SCADA or EMS

1. Introduction

Because the absence of communications can affect SCADA functionality and because communications availability is important to the overall system restoration process, the joint study team examined participants' primary and backup communications resources and how those resources are deployed for reliable communications during system restoration, when SCADA or EMS system functionality is compromised. [10]

All participants described scenarios where loss of field communications can result in loss of SCADA functionality, i.e., the system operators' computer displays may still be visible, but provide no SCADA functionality. For example, SCADA functionality could be affected by loss of data communications from substations when communications paths are unavailable, or by the loss of data centers that support data communications from substations. Further, with loss of SCADA functionality, all participants indicated they would rely more heavily on interpersonal communications between control center operators and field personnel performing system restoration, and that if those communications are compromised, system restoration would be further hampered.

Overall, the joint study team found that participants have made significant investments to help ensure their normal means of communications are available during blackout events to support the system restoration process, including taking steps to ensure expedited restoration of vital communications and data transfer systems, e.g., through

---

provide situational awareness to entities including reliability coordinators, transmission system operators do not use it to execute restoration plan steps.

[10] Communications elements for backup functionality and alternate communications capabilities are addressed by NERC Reliability Standards EOP-008-1 - Loss of Control Center Functionality, and COM-001-2.1 - Communications.

implementation of Telecommunications Service Priority.[11] However, similar to their approach for the potential loss of SCADA, all participants also prepare for the possibility that their normal means of communications may be partially or totally unavailable at some time during a restoration event through the provision of alternate and backup forms of communication.

2. Observations

Participants explained that for system restoration, personnel are dispatched to field locations to receive switching instructions via interpersonal communications from transmission system operators. In the absence of SCADA or EMS, additional field personnel are needed to perform restoration steps, as well as to provide operators situational awareness via remote monitoring of restoration conditions, e.g., voltage levels. Thus, the absence of SCADA functionality leads to increased reliance on and usage of interpersonal communications and additional resources.

The joint study team found that all participants have multiple forms of interpersonal communications between system operators/control centers and the following:

- Reliability coordinators (for coordinating restoration strategy, obtaining authorization to start restoration, and synchronizing during later stages of restoration);
- Blackstart generators (for initiating system restoration plan);
- Other generation plants including nuclear power plants;
- Field personnel (for executing restoration plan steps and monitoring); and
- Neighboring system operators (for synchronizing and coordination).[12]

---

[11] Telecommunications Service Priority is a Department of Homeland Security program that authorizes national security and emergency preparedness organizations to receive priority treatment for vital voice and data circuits or other telecommunications services.

[12] One participant's approach, in deciding how to deploy multiple technologies for backup interpersonal communication, is to use the "best communications available" during the event for control center-to-field communications.

The joint study team found that all participants use wireless communications systems (such as satellite systems) for alternate interpersonal communications between system operators and reliability coordinators, neighboring transmission system operators, and black start generating plants. In addition, one participant has extensive satellite communications sets available for internal deployment to field personnel to serve as an alternate means of interpersonal communication. Some participants preprogram satellite communication systems with important numbers for emergency situations such as system restoration to increase speed of use. However, these participants also conveyed concerns about satellite phone functionality during emergencies, noting that available bandwidth for satellite phone use may be limited given the expected increased use during an emergency, and that satellite communications include inherent voice delays that make conversations more difficult as compared to interpersonal communications facilities used during normal conditions.

In addition to use of satellite systems, the joint study team found that all participants with SCADA functionality have other wireless systems that provide alternate or backup communications. All applicable participants use wireless interpersonal communications for backup interpersonal communications between control center operators and field personnel when land lines are unavailable. Some participants also use wireless interpersonal communications for communicating with blackstart and next-start generation plants.

Following a sufficiency review of its wireless capability, one participant has undertaken an initiative focusing on possible expanded use of wireless for the entity's enterprise-wide backup interpersonal communications, with plans to increase its resiliency. Also, all participants noted their concern that standard cellular service capability, which can provide a backup means of interpersonal communications during normal grid conditions, may be overloaded during a large scale event and could delay restoration. Some participants use priority communications services to increase the reliability of their interpersonal communications during emergencies.

The joint study team further found that all participants have varying forms of blast messaging systems. These systems are used to send alerts to internal and external personnel and organizations, e.g., reliability coordinator blast communications to transmission system operators in their reliability area, alerting specific personnel or subgroups of emergency conditions, via cell phone, home phone recording, and PC tablets, etc. Participants conveyed that these alert systems are especially important to convey messages during the onset of a major event such as a blackout.

All participants conveyed that it was important to have control over their communications resources where possible, so that in time of need or crisis, they are not dependent on outside resources. For most of the participants, ownership of the communications resource is important. For example, all of the applicable participants' backup wireless systems for field communications are entity-owned and maintained. Other communication systems owned by participants include:

- ICCP data infrastructure (to improve its reliability and functionality); and
- A private text paging system deployed on a fixed wireless communications system within that participant's service territory.

Participants noted that external communication paths and media are unknown in some instances. For example, most participants indicated that their current blast communications system is owned and housed by external vendors. Certain participants have on-going initiatives to improve and have more control over their communications in support of system restoration during emergencies, including emergencies resulting in the loss of SCADA or EMS functionality:

- One participant is considering expanding its fiber optic grid, using new vendors (satellite phone networks, for example) to enhance its backup interpersonal communications systems, and pursuing more satellite communication options.
- Another participant is undertaking an enterprise-wide backup communications initiative, which includes identifying all the communications systems in use and what they are used for, considering how each of the systems currently in place might be used for other purposes in order to provide backups to other entity emergency operations.
- Some participants are incorporating use of backup communications devices in training events, i.e., going beyond testing them to make sure they work and having operations personnel practice using the backup systems during system restoration training.

3. Conclusions

The joint study team found that robust communications facilities are especially important to support system restoration under a loss of SCADA scenario, due to the expected increase in use of interpersonal communications. The joint study team found that entities have backup and alternate means of communications in the event of loss of normal means of communication, but that they may be able to improve their response to a wide-scale event involving the loss of SCADA systems by conducting more thorough reviews of backup and alternate communications systems, to ensure they are capable, available, and reliable for the increased use required during such an event, assuming limited or no cell phone or land line service.

a) Recommendation

Planning for backup communications measures. The joint study team recommends that entities review and refine as necessary their backup communications measures and capabilities to ensure that they can be depended on to provide effective means of communications in the event of the loss of normal communications means during system restoration absent SCADA or EMS. This should include a review of their backup and alternate interpersonal communications (voice) systems, to ensure that they are capable, available and reliable for the increased use expected during system restoration without SCADA functionality. The joint study team also recommends incorporating loss of normal communications scenarios and use of backup communications systems in entities' system restoration training to practice their use in executing restoration plan steps and in monitoring of system restoration conditions absent SCADA.

b) Observed Practices for Consideration

- Identify a preferred order of use for backup interpersonal communications in the event of loss of normal communications, e.g., order of communications: landline phones -> wireless -> satellite phones.

- Have additional, i.e., extra, satellite phones for use by field personnel as a means of providing additional backup for interpersonal communications to the transmission system operator.

- In the event the normally used telecommunications network is down, have a portable network with independent backup communications capability(s) (e.g., satellite, cellular).

- Allow key system RTU points to fail over to a cellular communication medium to provide data back to the control room to enhance SCADA functionality even if normally-used communication and data transfer systems are unavailable.[13]

---

[13] All participants have communications elements that provide for backup functionality in the event its primary control center functionality is lost, which may involve use of several communications means, e.g., redundant fiber optic, land line facilities, microwave, etc.

C. Personnel for System Restoration absent SCADA or EMS

1. Introduction

The joint study team asked participants to provide information as to how they deploy personnel to perform system restoration during an outage event or other emergency, and what, if anything, would be different under a loss of SCADA/EMS functionality scenario. Areas explored included the use of field personnel, control center personnel, and other human resource support services to support system restoration without reliance on SCADA or other remote data acquisition tools.

2. Observations

All participants conveyed that, although their underlying system restoration plans remain the same assuming the loss of SCADA, EMS or other associated tool functionalities, implementation of their plans would become more human resource intensive.[14] All participants employ an emergency response organization, or incident command system (ICS) for large-scale events such as a system-wide blackout.[15] This structure allows the participants to, among other things, manage and coordinate the support resources necessary for system restoration, including in those cases where increased human resource needs are expected due to the loss of SCADA. The participants indicated that ICS provides for an "all-hazards" approach, which is flexible and scalable depending on the severity of the system conditions.[16]

---

[14] Participants indicated that several important and immediate actions to determine restoration strategy would not change regardless of SCADA, EMS or ICCP availability, such as establishing communications with the reliability coordinator, neighboring transmission operators, and generation plants to gain understanding of local and surrounding system conditions.

[15] ICS is a management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure. *See* Federal Emergency Management Administration (FEMA) "*National Incident Management System*" for more information regarding ICS, at https://www.fema.gov/national-incident-management-system.

[16] An all-hazards approach involves implementing one measure to mitigate the effects of multiple event scenarios or threats. For example, additional backup power supplies mitigate severe weather-caused local outages, as well as system-wide blackouts.

a) Expected Personnel Needs and Sufficiency

While all participants indicated that increased human resources will be needed for system restoration during the loss of SCADA or EMS systems, they also indicated that they have sufficient human resources in place for executing their system restoration plans under such conditions. Participants explained that system restoration, even under a loss of SCADA condition, may not involve dispatching field personnel to every substation on their system, and may not require field personnel initially dispatched to certain substations to remain there for the entire restoration plan implementation. All participants stated that they have qualified field personnel who would be dispatched to restoration paths, e.g., cranking paths, as designated in their system restoration plans. All participants would draw from field personnel across their company to provide additional monitoring resources at substations already restored and to provide situational awareness of system conditions to control center system operators.

b) Initial Staffing and Deployment of Personnel

With respect to the initial assessment of system conditions and initial deployment of field personnel, the participants have a variety of processes in place to facilitate restoration in the event of loss of SCADA or EMS functionality. To facilitate prompt assessment of system conditions at the onset of a blackout absent SCADA availability, some participants have identified specific substations to which field personnel will be dispatched. These substations include intra and inter-area tie-line synchronizing substations, substations connected to large generation stations, and substations connecting several extra-high voltage transmission lines.

One participant described a structured approach for loss of SCADA or EMS functionality, which could be scaled to apply to normal power grid conditions or to emergencies such as a blackout, to obtain information on initial system conditions, to conserve backup power supplies for later restoration,[17] and to subsequently maintain situational awareness in an efficient manner. This approach involves the pre-planned identification of base substations (locations where qualified and skilled substation field personnel would be mobilized 24/7), route substations (which would be inspected on pre-determined routes originating from each base substation), and non-route substations (which would be only inspected when conditions warrant, e.g., inspecting storm damage at a smaller transmission substation).

Some participants have call-out lists which pre-identify where field personnel are needed and their roles in the event of a blackout. These call-out lists typically identify specific

---

[17] *See* Section IV.D - Backup Power Resources for System Restoration absent SCADA or EMS.

personnel and their capabilities, the potential areas in need of staffing, e.g., specific substations to be manned, and the roles and duties expected to be performed by assigned personnel on location. These participants explained that in the event of the loss of SCADA, where additional field resources are needed for monitoring, they will not only deploy personnel who traditionally work at the substations, but will also deploy additional personnel trained for substation monitoring, who are normally tasked with maintaining transmission lines or are involved in new project construction but do not traditionally perform substation monitoring. One participant indicated, based on feedback from recent training on system restoration absent SCADA/EMS, that it is incorporating periodic refresher training for these non-traditional field monitoring tasks.[18]

One participant mentioned that a possible improvement in its approach to initial deployment would be to create a call-out list with field personnel pre-assigned to specific sites. Other participants indicated that call-out arrangements also demand some flexibility, and found that coordination and efficient deployment of personnel may be more difficult given that pre-assigned personnel may be unavailable due to vacation or illness, among other things. For example, some transmission control center operators have substation personnel call-out lists for each sub-region or by company district, but do not specify who and where personnel need to report. These participants found that attempting to keep a list up-to-date reflecting vacations or other absences was more difficult than having multiple qualified and trained personnel capable of executing the restoration switching instructions at the various substations.

c) Field Personnel Needed for Completion of Restoration Plan Steps

At the onset of a blackout, and independent of SCADA availability, all participants implement their system restoration plans in a similar manner. First, with approval from the reliability coordinator on restoration strategy, transmission system operators commence restoration by establishing communications with blackstart generators to initiate start-up for each restoration path defined in the system restoration plans. One participant noted that in the event of a system-wide blackout condition and with a delay in communications to initiate start-up from the transmission control center, blackstart generator personnel will autonomously initiate blackstart generator start-up procedures to be ready for use in system restoration. Using generating plant blackstart procedures, plant personnel bring generating units for providing cranking path power up to speed, but make no connections to the grid until directed by the transmission operator.

Concurrently, transmission system operators dispatch qualified personnel to specific restoration path substations to retrieve and communicate vital operations information, and

---

[18] *See* Section IV.F - Training for System Restoration absent SCADA or EMS.

to stand by for subsequent direction to perform specific restoration steps.

Because restoration will be more human resource-intensive absent SCADA or EMS, particularly with respect to additional field personnel, all participants indicated that assigned field personnel live near and work at their designated substations. In addition, to aid readiness for prompt system restoration given a loss of SCADA scenario, one participant indicated that its field personnel carry restoration procedures in their company vehicles at all times. Other participants maintain up-to-date hardcopy operating instructions and diagrams at restoration path substations for use in system restoration.

In the absence of SCADA, once switching activities are complete at a given substation, some participants re-staff the substation with monitoring personnel so that the "switching skill set" personnel can be deployed elsewhere. In addition, all participants use specifically-trained staff, such as system protection personnel, to perform synchronizing steps at pre-identified substations to connect two islands or to establish an interconnection with a neighboring entity.[19] Performance of these synchronizing steps does not depend on SCADA being available.

Load pick-up steps during system restoration involve coordination between several entities (transmission operators, substation field personnel, and generation plant control room personnel), regardless of SCADA availability. Participants indicated that these steps will be more labor-intensive and more involved absent SCADA or EMS functionality to ensure the island remains stable, since transmission operator monitoring of the changing system conditions during load pick-up will take place manually, via interpersonal communications with field personnel.[20]

d) Field Personnel Needed for System Monitoring

All participants use additional field personnel (personnel beyond those substation personnel who are executing restoration steps) for monitoring and reporting facility conditions during the restoration process absent SCADA or EMS functionality. Field personnel's monitoring responsibilities include monitoring voltage levels and assessing

[19] Training of field personnel who perform unique tasks associated with applicable entities' restoration plans is covered by NERC Reliability Standard EOP-005-2 - System Restoration from Blackstart Resources.

[20] Irrespective of SCADA availability, under the direction of transmission operators, distribution entities help to identify loads which can be energized to meet cold load pick-up constraints, and provide field resources to sectionalize distribution feeders for load energization as part of the restoration process.

the station backup power supply battery life.[21] Field monitoring personnel communicate substation conditions, voltages, equipment damage, relay targets, etc. back to the control center system operators. Some participants have also made arrangements for field monitoring personnel to use a pre-developed substation checklist or form to fill out and report back to the control center, both in hardcopy and electronic (PC-based) spreadsheet format.

Some participants use relay technicians at substations to access microprocessor based relays to obtain highly detailed voltage related information. These relay technicians also monitor relay panels for voltage readings and voltage limit exceedances, which are communicated back to control center operators. One participant reported that a computerized spreadsheet is used by operators to track voltage readings received from field personnel in order to ensure voltages are within limits. For some participants, limit exceedances at substations are alerted via annunciator panels, with lighted and audible alerts provided to the substation personnel, who communicate this information back to the control center operators.

To monitor frequency, transmission control center personnel communicate with generator operators who provide updates on frequency levels. All participants reported that their generating plant operators monitor and control island frequency. Initially, the blackstart unit will control frequency while in isochronous governor control mode.

To monitor spinning and contingency reserves in individual islands during the restoration process absent SCADA or EMS, all participants' transmission system operators track the output and capability of each online generating plant, and their associated operating reserves. Some participants have developed manual spreadsheet applications to input data to calculate and monitor island reserves, which includes generation governor response calculations to predict frequency change based on quantity of load pickup.

e) Logistical Support for Emergency Staffing Needs

In the event of a system-wide blackout, most participants stated that their field personnel would have difficulties in reaching their designated substation locations, due to possible excessive traffic conditions. To alleviate this, participants have various transportation arrangements in place, and they stressed the importance of having these services pre-arranged. For example, one participant has pre-arrangements with a transportation company for transporting field personnel using helicopters if roads become inaccessible. All participants conveyed to the joint study team that once continual (24/7) manning for

[21] All participants indicated they will conserve substation service load where necessary to preserve emergency backup generator fuel supply and backup battery life.

identified substations is needed, their operations support team, e.g., ICS, coordinates providing substation personnel on shift rotation at those locations. Most indicated that field personnel operate on 12-hour shifts, with maximum shift timeframes of 16 hours if needed for emergency conditions.

Given that system restoration is expected to take longer absent SCADA functionality, participants indicated that planning for extended deployment of field and other personnel becomes even more critical. Participants noted that substations generally have control building HVAC, often with one or two sleeping cots, but in general do not have food, water, or restroom provisions sufficient for extended occupancy.[22] Most participants have measures in place to address these problems and to provide for extended occupancy at field locations, which were developed from their storm response plans and are implemented through their ICS. With some food provisions covered by field personnel who are typically on call and keep some food in their vehicles for unplanned events, ICS, provides additional logistical support by making arrangements for food and hotel rooms for field personnel as needed.

f) Control Center Personnel

For human resources needed to support transmission system operators absent SCADA/EMS, all participants coordinate the provision of both control center and field support personnel and associated resource management, through implementation of an ICS as described above. Participants indicated that they use all available shift supervisors and dispatcher/operators, including extra teams of operators called in, to support the control room during restoration absent SCADA or EMS. In addition, participants use additional control center technical support personnel to help organize and manage field-reported system conditions. One participant has a “communicator” personnel position during system restoration, whose duties include assisting in organizing manually-collected data from field personnel at substations, for provision to transmission system operators. Finally, additional operators are positioned at auxiliary or “storm” workstations in the control room, to aid in system restoration.[23]

To assist the transmission operator in system restoration absent SCADA, some participants use control room support staff to assist in surveying generators to determine their availability and fuel levels, and to coordinate with field personnel regarding system

---

[22] Some urban substations may have water and restroom facilities, but more suburban and rural substation are less likely to have such provisions.

[23] *See* Section IV.E - Analytical Support for System Restoration Absent SCADA or EMS.

restoration activities. These activities include manually collecting data on voltage levels, station backup power supply battery life, substation conditions, equipment damage, relay targets, VAr output, frequency, etc.

Participants also use transmission control room personnel during restoration absent SCADA or EMS functionality, as follows:

- Support personnel are used to log information on restoration progress (assigning scribes to key positions in the control room to help system operators document events related to system restoration).

- Support personnel, e.g. additional shift supervisors, act as liaisons with the reliability coordinators/Independent System Operators to communicate restoration progress, so that transmission operators can continue their focus on restoring the system.

- Some participants designate certain additional operations personnel as "pinners," who, in the absence of SCADA, help maintain situational awareness by marking-up or using colored pins on hardcopy transmission diagrams to indicate status of transmission facilities (breaker status, transmission lines energized, etc.).[24]

- Additional operators are used to assist the transmission system operators in managing the developing islands' generator loadings, island spinning reserves, online capacity necessary for cold-load pick-up, etc.

- Support engineers are called in to aid the transmission system operators in the analyses needed for system restoration. For example, additional operations engineering support and power system modeling staff work together using offline (not dependent on SCADA or EMS functionality) power flow tools to simulate restoration steps, to assist operators in their decision-making process.[25]

- Some participants use reliability coordinator staff to assist in or perform engineering analyses and other support needed for system restoration.

---

[24] For further information regarding use of hardcopy information for situational awareness, *see* Section IV.E.2.a. - Analysis and Support Tools during Early Stages of System Restoration.

[25] *See also* Section IV.E.2.a. - Analysis and Support Tools during Early Stages of System Restoration.

3. Conclusions

The team concluded that performing system restoration without the use of SCADA or other similar tools will demand much greater use of field and other personnel to complete restoration plan steps that would otherwise be completed through use of SCADA, and to monitor and report on equipment status. Among other things, the joint study team concluded that entities should plan for a lengthy system restoration period with a loss of SCADA functionality, including by setting up support systems for the provision of food, shelter, fuel, security and other services at critical field locations, while recognizing that facilities that may normally be relied upon for this support, e.g., area hotels, may also be without power.

Recognizing the challenge of how to compile all of the field information retrieved (in the absence of SCADA) so that it is useful information for the control center operator, the joint study team found that entities should consider providing field personnel with pre-determined data teams, collection methods, record-keeping, and modeling methods. To expedite restoration, these tasks should be pre-identified as well as vetted to include not only those tasks normally undertaken during a blackout, but those additional tasks that would be performed due to the loss of SCADA/EMS. Lastly, the joint study team concluded that periodic refresher training would benefit personnel in non-traditional field roles during system restoration (such as taking substation readings), and that training for field personnel in general becomes more significant assuming a loss of SCADA and EMS functionality.

a) Recommendation

Planning for personnel support during system restoration absent SCADA. The joint study team recommends that entities review and refine their human resource operations support measures as needed to support the field and control room personnel necessary for system restoration absent SCADA. This includes personnel needed to acquire field and generation plant data, to maintain system operator situational awareness during blackout conditions for extended periods of time, and to provide logistical support for their assignments (e.g., food, shelter, transportation pre-arrangements). In refining such measures, entities should consider incorporating methods and tools that could aid personnel in gathering and managing the field data to provide useful information to the system operators. The joint study team also recommends incorporating these measures and tools into entities' system restoration training, including the involvement of both field and control center support personnel who would gather and manage the field data.

b) Observed Practices for Consideration

- In addition to the dispatch of field personnel to determine system conditions, use distribution entity "outage management" applications/systems if available, to aid in initially assessing system conditions in order to determine restoration strategies.

- Use electronic logging to allow control center support personnel to provide assistance in supporting, tracking, and communicating restoration progress without interrupting transmission operators in accessing operator log information.

- During a system restoration emergency, have system protection personnel access certain substation digital devices to remotely monitor voltages and other system conditions for limit exceedances, which can then be communicated back to transmission system operators for situational awareness.

D. Backup Power Resources for System Restoration absent SCADA or EMS

1. Introduction

Recognizing that system restoration absent SCADA/EMS may result in a prolonged restoration period, the joint study team examined what provisions participants have for backup power supplies for critical locations, such as key substations and control centers essential for system restoration, to provide an emergency source of power in the event of a system-wide blackout. The joint study team also reviewed provisions made for a longer-term supply of backup power, given the magnitude and severity of events being considered.[26]

---

[26] Several current Reliability Standards include requirements that relate to the backup power needed to provide for bulk-power system transmission operation and reliability coordination, as follows:

- Requirements for the independent functionality of primary and backup control centers are found in EOP-008-1 - Loss of Control Center Functionality Reliability Standard;

- Requirements for meeting transmission system performance through operation, maintenance, and testing of protection system and other automatic controls are found in TPL-001-4 – Transmission System Planning Performance Requirements, and PRC-005-1.1b - Transmission and Generation Protection System Maintenance and Testing; and

2. Observations

a) Backup Power Supply for Control Centers, SCADA Data and Communications Sites, and Priority Loads

Similar to findings made in the Restoration and Recovery Report,[27] the joint study team found that all participants provide for backup power for an extended period of time for transmission control centers, data centers, and SCADA/EMS and interpersonal communications facilities. In general, participants installed permanent backup generators to provide power to these critical sites. In addition, those participants who have priority loads such as pipe-type transmission cable facilities have installed backup generators at these locations.

b) Backup Power Supply for Substations

All participants' substations have battery backup power supplies that are typically designed to provide backup power for at least eight hours. Participants also indicated that field personnel dispatched to a substation for a large-scale event such as a blackout will reduce substation service load where necessary to preserve backup power supply life until the substation has been restored, thereby extending the availability of the backup supply for as long as possible.

Some participants also provide for backup power for a more extended period of time, *i.e.*, beyond the period expected for battery backup, for substations that are critical to system restoration. For example, some participants have installed permanent backup generators with on-site fuel supplies sufficient to last for an extended period at all restoration path substations, and at substations used for synchronizing islands and interconnecting with

- Requirements for operator monitoring of facilities and performing real-time assessments to ensure prompt action to prevent or mitigate bulk-power system instability, uncontrolled separation, or cascading outages are found in TOP-001-3 – Transmission Operations, IRO-002-4 Reliability Coordination – Monitoring and Analysis, IRO-008-2 – Reliability Coordinator Operational Analysis and Real-time Assessments, and IRO-009-2 – Reliability Coordinator Actions to Operate Within IROLs Reliability Standards.

[27] *See* Restoration and Recovery Report at 25-26 (finding that the participants in that study had installed local generation at control centers and other key facilities as backup power sources, and that they test those generators regularly to ensure operability).

neighboring entities. In addition, several of the participants have additional portable backup generators and battery charging equipment that can be transported to substations if needed to restore backup power to facilitate system restoration. Whatever the particular arrangement for backup power supply, some participants stressed the importance of reviewing these backup supply provisions to ensure that backup power is ready at any time.

c) Backup Generator Fuel Considerations

Those participants that have installed backup generation at key locations for extended system restoration timeframes indicated that they also consider and try to address any concerns with on-site fuel shelf life, using long shelf life fuels and/or routinely maintaining the quality of the on-site stored fuel. Some participants also indicated that they have fuel supply contracts with local fuel suppliers near key field locations, and that these contracts are designed to provide firm, top priority fuel service in an emergency such as a blackout.

One participant indicated, however, that even with priority fuel service contracts or with an entity's own fuel supplies/tanks for refills, it is important to verify that, in the event of a system-wide blackout, the delivery truck refill pumps will have backup power on-site in order to fill the delivery trucks in the event more fuel is needed at key locations. This includes verifying that fuel delivery terminals have backup power to access delivery trucks that may be parked within garages that need power to open the garage doors.

d) Backup Power Provisions versus Length of Time for System Restoration

All participants estimate it may take more than one day to fully restore their system from a widespread blackout, depending on the extent of the event, and that the time for restoration will likely be further extended without SCADA/EMS availability. Most participants indicated that the timing for full restoration is also likely to be influenced by potential obstacles faced in mobilizing field personnel to substations in the event of a blackout condition,[28] regardless of whether SCADA is available, particularly with the kinds of severe events being considered as part of the study. Some participants have reviewed their restoration plans assuming a lengthy restoration process, and are more prepared with backup power provisions than others, especially for substations on cranking or restoration paths, to expedite restoration of service to priority loads (such as

[28] *See* Section IV.C.2.e. - Logistical Support for Emergency Staffing Needs).

off-site power to nuclear power plants and natural gas compressor pumping stations).

3. Conclusions

Given the possible delays in system restoration, whether due to loss of SCADA or EMS or other factors, most participants have taken an all-hazards approach in providing additional backup power supplies beyond battery backup at substations and other sites. All participants have provided for backup generation at transmission control centers, data centers, and SCADA/EMS and interpersonal communications facilities. Some participants also provide for additional backup power at other critical locations, including substations on cranking or restoration paths, to help ensure system restoration is not delayed and power is provided to priority loads. Finally, many participants have special procedures in place to help ensure the availability of fuel for backup power supply during a system emergency, through use of long shelf life fuels, checking and replacement of fuels as needed, or special fuel delivery contracts.

a) Recommendation

Planning backup power supplies for an extended period of time. Due to the expected increase in time to accomplish system restoration absent SCADA/EMS functionality, the joint study team recommends that entities review and refine as necessary their existing provisions for backup power resources at restoration path substations and other locations identified as priority or critical in system restoration plans, to ensure they are available for an extended period of time beyond the normal expectation from battery backups.

b) Observed Practices for Consideration

- Install backup generators at many substations, including all cranking path substations on primary and alternate paths and several tie-line substations, as well as at pipe-type transmission cable installations.

- Take into account on-site fuel shelf life for installed backup generators, using long shelf life fuels and/or routinely maintaining the quality of the on-site stored fuel to ensure that extended backup power supplies are available when needed.

- Have a priority contract with a fuel delivery service for supply to backup generators at critical locations, obtained via state-level Department of Homeland Security, with top priority to secure fuel in the event of an emergency.

- Have both backup battery power supplies and backup on-site generators at interpersonal communications sites, including on-site fuel to support backup generation availability for an extended period of time.

E. Analytical Support for System Restoration absent SCADA or EMS

1. Introduction

Recognizing that system restoration absent SCADA/EMS may necessitate significant "manual" data gathering (via field personnel) and organizing at the transmission control center, the joint study team examined the offline or backup support tools and analysis methods used by participants to monitor and analyze conditions during system restoration. Also, recognizing that entities periodically test or simulate their restoration plans, the joint study team explored how participants use these simulations and tests to assist with system restoration in the absence of SCADA or EMS.

2. Observations

a) Analysis and Support Tools during Early Stages of System Restoration

Participants indicated that SE and RTCA computer tools, which are commonly used by system operators to provide situational awareness of the bulk-power system, will not be functional in the absence of SCADA or EMS functionality, as these tools depend on receiving input data from SCADA systems to function.[29]

When such tools are not functional, several participants use information from prior simulations both to monitor restoration conditions (by comparing simulation data with actual data received from field personnel), and to predict expected conditions with each restoration step. These simulations and studies include the results from load flow studies of the restoration plan steps, including testing of loads to be energized, to ensure that the baseline restoration plan steps and switching will work and that the system will be within tolerance. Participants noted that they use these past studies during system restoration regardless of SCADA availability.

In addition, some participants use offline power flow models and cases to support analysis during system restoration. To develop these models, participants use restoration plan power flow simulations (saved cases) from prior verification of the plans. In the absence of SCADA or EMS, the operations support engineers set up the power flow case

---

[29] Even if SCADA were available, SE and RTCA tools would have no value during the early stages of restoration for the blacked-out area, because these tools are designed for use in analyzing energized transmission network data.

by incorporating manually-gathered field data and conditions. They then run the power flow case to study the next steps of restoration. Participants indicated that these manually-updated offline power flow models provide a means for island development analysis, and are especially useful if deviation from the baseline restoration plan steps is needed. In those situations, participants indicated that the training and tools provided to support engineers enables prompt analysis of the manually-collected field data, and effective communication of the alternate restoration steps to field personnel.

For situational awareness, including tracking of system restoration progress absent SCADA or EMS, all participants' standard practice is for control center operations and support staff to use and mark up hard-copy one-line diagrams of the system. One participant has its control center operators document or mark each step of restoration as it is performed, recording it directly in pre-identified locations of the restoration plan documentation along with the associated field readings, e.g., voltage readings, MW readings, etc..[30]

Some participants also use dry-erase transmission system map boards for tracking restoration progress. These can be used to track which transmission and generation facilities are in or out of service. One participant has a paper map board of its entire transmission system in its control room, which can be updated to indicate system restoration conditions with colored magnetic indicators (lines and generators in-service, islands being formed, etc.).[31] All participants' operator workstations, including spare or "storm" workstations used during system restoration, have large work areas for control center dispatchers to spread out hardcopy diagrams and maps, using different-colored markers to keep track of the current status of breakers and of energized sections of transmission. These workstations have PCs, and, regardless of SCADA or EMS availability, are equipped with their normal and alternate interpersonal communications capabilities. The PCs are used, for example, to access emergency messaging

---

[30] That participant's restoration plan includes a space to record applicable values alongside the steps of the plan. Also, in monitoring limits at substations while generation and load is being restored, participants' operators use reference tables to convert Amperes to Volt-Amperes and vice-versa at the various voltage levels. Substation metering is generally shown in Amperes, while control centers use megawatts, necessitating conversions.

[31] One participant mentioned that a possible area for improvement is to tie all maps together for better visualization, which it indicated would be particularly useful during later stages of restoration absent SCADA or EMS.

applications[32] or to access operations data, such as system protection information, for use as needed during system restoration.[33]

For situations in which the SCADA system is still online but field data or field data communications are lost, some participants are considering use of the SCADA system with manually overridden data (received from field personal located at substations). This would allow control room system operators to visualize their system via normally-used wall or workstation displays.

In addition, in order to manage generation and load for each island being developed absent SCADA or EMS, most participants use a pre-formatted spreadsheet tool to track load picked up and generation reserves for each island. Generator loading and capability information received from the field personnel are input into the spreadsheet. The spreadsheet then calculates reserves available for the next increments of load pick-up and for contingency loss of online generation. This monitoring ensures that generator reserves are allocated appropriately, including the reserve capacity needed for the isochronous unit to be able to effectively respond to frequency changes. The transmission system operator uses this tool to make sure each island has sufficient reserves.

Most participants conveyed that they receive phasor measurement unit (PMU) data from major substations across their system, via a separate system from SCADA or EMS. The data is primarily used for post-event analysis of power system disturbances, and not to assess system status in real-time. However, in the absence of SCADA, one participant uses separately-received PMU data to assess precipitating event conditions. The participant's reliability coordinator receives PMU data across its wide area view, and can assess it to determine, for example, if there are small islands remaining at the onset of a blackout across the reliability coordinator's footprint, and communicate the conditions to the participant.[34]

---

[32] *See* Section IV.B - Communications Resources for System Restoration Absent SCADA or EMS.

[33] In addition to use of hardcopy maps, one participant's transmission operators use their workstation PCs to access searchable electronic maps to use in system restoration.

[34] *See also* Restoration and Recovery Report at 31.

b) Analysis and Support Tools during Later Stages of System Restoration

Participants conveyed that as restoration progresses, and as larger islands are synchronized and interconnections with external transmission operators are being established, the need for real-time on-line analysis tools increases. They indicated it becomes increasingly important to have SCADA, EMS as well as ICCP monitoring systems in-service, in order to enable the functionality of other analytical tools such as SE and RTCA.

Without these tools, participants have taken, or are developing, a number of other approaches to support the latter stages of system restoration. One participant is planning to develop an offline power system model, using manually-collected data from field personnel. The participant's goal is to have a model that can be updated every several hours and is approximately reflective of current system conditions, in order to then perform studies such as contingency analyses.[35]

One participant is currently using PMU data during normal operations to develop a means of state estimation, including providing associated one-line displays to system operators, to provide situational awareness in the absence of SCADA or EMS. Another participant stated that it will be able to use "near real-time" data obtained from the substations possessing the PMUs for system monitoring during later stages of restoration when these locations have been subsequently energized.

3. Conclusions

The joint team found that during earlier stages of restoration, participants possess various tools and offline applications that can be used to assist in the analysis necessary to support system restoration steps. However, during latter stages of restoration, such as when interconnections with other transmission operators are established, the need for online tools such as SE and RTCA become more important, and manual setup and use of offline system analysis tools may become less feasible.

---

[35] The joint study team also found that those participants who have plans for using offline power flow analysis tools during earlier and/or later stages of restoration also have developed processes for organizing larger amounts of the manually-obtained data from field personnel to expedite its use (*See* Section C.2.e. - Logistical Support for Emergency Staffing Needs).

Notably, all participants indicated that they have IT response and recovery teams that will work to promptly restore SCADA and EMS functionality while system restoration is underway.

a) Recommendation

Analysis tools for system restoration. Recognizing that the absence of SCADA/EMS functionality results in loss of SE and RTCA, the joint study team recommends that applicable entities review and refine as necessary other analysis tools for use (e.g., use of offline power system analysis tools, PMU data) especially during the later stages of restoration. The joint study team also recommends incorporating these analysis tools into entities' system restoration training, if not being done already, to practice their setup and use by support staff during system restoration.

b) Observed Practices for Consideration

- Develop an offline power system model, using manually-collected data from field personnel that can be updated every several hours and is approximately reflective of current system conditions, to perform studies such as contingency analyses.

- Develop a small "tertiary" EMS application for capturing substation data, which will allow use of a limited amount of telemetry to aid in situational awareness of the transmission system.

- Develop a system restoration database tool to assist in the event of loss of SCADA during system restoration, which contains generation and load data for all of the islands identified in restoration plans. Operations support staff can use the tool to track online island generation capacity, contingency reserves, and load restored, and can calculate cold-load pick-up limitations for the next increment of load to add for each island being developed. Another option is to use a spreadsheet-based system to track all of the following:
  - Identification of 1st and 2nd largest generation contingencies:
  - Calculation of contingency reserves needed; and
  - Recording and accounting for generators providing reserves.

  The spreadsheet can be kept in laminated hard copy, to ensure access even if computers are not available, and can include multiple methods of contacting designated entities for manual dispatch.

- Use PMU data to develop a means of state estimation for use during later stages of restoration, including providing associated one-line displays to system operators, to provide situational awareness in the absence of SCADA or EMS.

- Institute backup ACE applications to receive tie-line data from backup data communications sources, which, along with other inputs, can enable the transition back to balancing authority control absent EMS/SCADA.

F. Training for System Restoration absent SCADA or EMS

1. Introduction

Based on the joint study team's assessment of participants' resources and support measures for system restoration as discussed in Sections IV.A-E above, and recognizing the importance of incorporating several of those measures in training, the joint study team also examined the participants' current system restoration drills and training exercises, to gain an understanding of their preparedness to perform system restoration under conditions where SCADA or EMS tools are unavailable.

As found in the Restoration and Recovery Report most participant entities use dispatcher training simulators (DTS), which afford operators use of the same tools, e.g., SCADA/EMS simulation tools, used in normal operations, for the many steps executed during system restoration.[36] For this analysis, however, the joint study team was interested in how participants may have considered or incorporated absence of SCADA functionality scenarios into their system restoration training. In doing so, the joint study team did not propose to downplay the importance of DTS in system restoration training, or to suggest that participants or other entities should consider practicing system restoration without it or otherwise consider relying solely on a tabletop exercise. Instead, the joint study team focused on learning of any methods participants currently use or are considering to practice restoration absent SCADA functionality. For example, entities could conduct restoration simulations without use of the remote control and monitoring functions in DTS. In that case, the simulation aspects of each manually-executed switching step could still be entered in the DTS via training support staff to verify the effectiveness of the operators' manual restoration actions.

2. Observations

A few participants have developed, and implemented as of 2016, loss-of-SCADA/EMS

[36] Restoration and Recovery Report at 53 (finding that most participants use operator or dispatcher training simulators (DTS) in their system restoration drills).

training and exercises, with emphasis on blackstart of the system without SCADA functionality and reflective of the complexities of manual switching. These participants identified a number of strengths and benefits from running these training simulations, including the following:

- Incorporation of an ICS, which provided flexibility and scalability depending on the severity of the simulation/scenario;
- Staff experience and knowledge from past widespread events, to better-structure response efforts and organize additional field personnel needed;
- Ability to identify field and control center support resource priorities to help expedite restoration; and
- Teamwork, which during the training scenarios, was found to be critical in coordination of additional human resources to support system restoration without SCADA.

These participants also identified the following areas for further development following these simulation exercises:

- Further refinement of resources for blackstart without SCADA, e.g., human resource support measures;
- Addition of field personnel security escorts to dispatched locations;
- Incorporate mutual aid and periodic training for non-traditional roles, e.g., use of remote training tools such as pre-recorded videos to augment classroom training regarding substation configuration, and obtaining associated readings for communication to the transmission operator, etc.; and
- Enhance training by incorporating substation checklists and practicing use of forms/templates to document meter readings; participants found that this practice helped to improve the templates.

One participant is developing an event management framework, which includes evaluating many equipment outage scenarios, including loss of SCADA and communications systems and the associated impact on operations. That participant is using this framework to develop operator training drills, to commence in 2017. These drills will include scenario-based training drills involving both control center operations and field personnel.

One participant who does not use SCADA to perform system restoration plan steps, regularly incorporates alternate and backup interpersonal communications facilities in its system restoration training.

Another participant (an investor-owned utility with both transmission and distribution personnel under one umbrella organization) has placed significant focus on training distribution support staff on their role in system restoration from a blackout condition, recognizing that restoration of the system absent SCADA will result in increased use of field personnel for system monitoring, as well as use of distribution field personnel for load pick-up. That participant noted that, unlike more typical emergency storm distribution outage response, where the control of field personnel is more commonly with the distribution control centers, control over distribution support for blackstart system restoration will be with the transmission operators. That participant's field personnel training drills emphasize this difference. In addition, that participant has been conducting training on its blackstart restoration plan over the past several years with field personnel, distribution personnel, and generation personnel.

3. Conclusions

The joint study team found that a few participants are already actively pursuing system restoration training and exercises that incorporate loss of SCADA or EMS functionality. These participants provided notable insights on how to approach these scenarios, including:

- Developing loss of SCADA functionality training scenarios and associated measures to incorporate approaches modular and flexible enough to respond to any event, i.e., an all-hazards approach;
- Incorporating specific training on restoration with different levels of loss of SCADA or SCADA communications during the restoration process;
- Using alternative methods of interpersonal communications beyond normal system communication modes to familiarize staff with those methods; and
- Using additional personnel in system restoration training absent SCADA or EMS, including distribution entity staff, blackstart unit operators, and adjacent transmission operators, as well as field personnel used to perform non-traditional, e.g., monitoring, tasks. Such training may require coordination with separate entities involved in system restoration under the assumed conditions (e.g., distribution providers within a transmission operator's footprint).

Even though participants have trained their operators on loss of SCADA scenarios in their normal operations training, the joint study team found that most participants have not incorporated loss of SCADA scenarios in their system restoration training exercises.

a) Recommendation

Incorporating loss of SCADA or EMS scenarios in system restoration training. The joint study team recommends that applicable entities, as part of their system restoration training, practice implementation of restoration plan steps absent SCADA/EMS functionality or other data sources, including incorporating the above insights.

b) Observed Practices for Consideration

- Incorporate into restoration training programs practice with physical aids at the locations where they will be undertaking the restoration activity, e.g., training with substation checklists.

- Incorporate video training of specific substations, to remotely train personnel tasked with performing monitoring duties at those substations during system restoration, but who are otherwise not normally assigned to that substation. The participant has developed a video training library, which provides personnel with job/task aids for tasks that are not performed on a daily basis.

V. Appendix 1 - Joint Study Team

Federal Energy Regulatory Commission:
Justin Cunningham
John Denis
Julie Greenisen
David Huff
Justin Kelly
Raymond Orocco-John
David Taylor
Michelle Veloso

Florida Reliability Coordination Council, Inc.:
Hassan Hamdar

Midwest Reliability Organization:
William Kunkel
Daniel Schoenecker

North American Electric Reliability Corporation:
Robert Kenyon
Scott Mix
Katherine Street
Jim Stuart

Northeast Power Coordinating Council, Inc.:
Andrey Oks
Ralph Rufrano

ReliabilityFirst Corporation:
John Idzior

SERC Reliability Corporation:
David Greene

Texas Reliability Entity, Inc.:
Jagan Mandavilli

Western Electricity Coordinating Council:
Evan Paull

VI. Appendix 2 – Request Letter for Participation

On January 29, 2016, the Commission posted to its web site the Report on the FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans.[1] The report describes how the joint staff review team examined restoration, response, and recovery plans of a representative sample of nine registered entities and, from that review, identified beneficial practices that could be more widely deployed, recommendations for changes, and five areas for further study. One of the areas for further study is how to address the potential loss of SCADA or other data systems as part of a major system disturbance, as this could significantly delay system restoration.

Commission staff, in collaboration with NERC and Regional Entity staff, is initiating a study of bulk-power system restoration plan steps that may be difficult in the absence of SCADA, ICCP data, and/or EMS.[372] As an entity with bulk-power system significance and representative operating characteristics that may be beneficial to this analysis, we are requesting [entity's] participation in this review. Additionally, other registered entities with other representative characteristics are also being asked to participate in order to achieve a more comprehensive review of restoration capabilities in the absence of SCADA or loss of other data sources.

The joint staff review will:

- Gather information via outreach with a select sample of bulk-power system entities i.e., NERC-registered entities;
- Analyze the bulk-power system restoration plan steps that may be difficult in the absence of SCADA, ICCP data, and/or EMS;
- Identify viable resources, methods or practices that would enable timely system restoration to occur absent SCADA/EMS functionality, which could then be incorporated into entities' system restoration training; and
- Identify beneficial practices that may be shared across the industry.

---

[1] *See* "Report on the FERC-NERC-Regional Entity Joint Review of Restoration and Recovery Plans" (January 2016), at http://www.ferc.gov/legal/staff-reports/2016/01-29-16-FERC-NERC-Report.pdf (Joint Report).

[2] *See* Joint Report at pp. iv, 17-20.

Specifically, documents and information[3] to be requested during the entity outreach, depending on applicable functions, pertain to:

- Steps of system restoration plans (entity-identified) that may be difficult in the absence of SCADA, ICCP data, and/or EMS;
- Operating plans and procedures for backup functionality in the event that SCADA, EMS or ICCP data is unavailable*;*
- Procedures addressing monitoring and controlling voltages, real and reactive flows, and switching transmission elements (including aspects of system restoration such as control of frequency, contingency reserves, and synchronizing) in the event of the loss of SCADA, ICCP data, and/or EMS;
- Provisions for backup facilities if the main monitoring system is unavailable;
- Procedures to mitigate the effects of analysis tool outages;
- Any results or analysis of operator drills, exercises, simulations, or tests involving a loss of situational awareness tools scenarios, e.g., SCADA, ICCP, EMS, etc.; and
- Any public or private reports or other documents that have already been produced in these areas that may be beneficial for the team to review, e.g., Severe Impact Resiliency Task Force Report. Pre-review of these documents at the start of the study can aid in identifying to the entities, specific areas of interest within scope for the review.

In addition to the information specified above, entities are encouraged to provide any further information or documents that may be helpful in explaining their viable resources, methods or practices that would enable timely system restoration to occur in the event of the loss of SCADA, ICCP data, and/or EMS.

This collaborative assessment by the Commission, NERC and the Regional Entities is an important step in protecting reliability by gauging the electric utility industry's level of preparation for a major event and the ability to restore the bulk-power system quickly and efficiently. In anticipation of [entity's] participation, we thank you and will work closely with you to ensure this project is conducted as a partnership with minimal disruption to your organization. My staff will contact you at your earliest convenience regarding any questions or concerns that you may have about this joint staff review.

---

[3] As noted in the restoration and recovery report, there are system restoration resources and situational awareness tools that are covered by other Reliability Standards.

VII. Appendix 3 – Glossary of Terms and Acronyms Used in Report

Area Control Error (ACE): The instantaneous difference between a Balancing Authority's net actual and scheduled interchange, taking into account the effects of frequency bias, correction of meter error, automatic time error correction (ATEC), if operating in the ATEC mode. ATEC is only applicable to balancing authorities in the Western Interconnection.

Automatic Generation Control (AGC): Equipment that automatically adjusts generation in a balancing authority area from a central location to maintain the balancing authority's interchange schedule plus frequency bias. AGC may also accommodate automatic inadvertent payback and time error correction.

Balancing Authority: The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time.

Blackstart Resource: Generating unit(s) and associated equipment which has the ability to be started without support from the system or is designed to remain energized without connection to the remainder of the system, with the ability to energize a bus, meeting the transmission operator's restoration plan needs for real and reactive power capability, frequency and voltage control, and that have been included in the transmission operator's restoration plan.

Cranking Path: A portion of the electric system that can be isolated and then energized to deliver electric power from a generation source to enable the startup of one or more other generating units.

Dispatcher Training Simulator (DTS): An application which allows operators in-training to use the same tools and computer applications used in normal operations for the many steps executed during system restoration. The DTS also tracks the status of generation and dynamically updates and displays the latest simulated system conditions.

Energy Management System (EMS): A system of computer-aided tools used by bulk-power system operators to monitor, control and optimize system performance.

Generator Operator: The entity that operates generating facility(ies) and performs the functions of supplying energy and Interconnected Operations Services. The generator operator is responsible to have procedures for starting each blackstart resource, in accordance with Reliability Standard EOP-005-2.

Incident Command Structure (ICS): A management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure.

Inter-Control Center Communications Protocol (ICCP): A communications protocol that allows the exchange of real-time and historical power system information between entities, including status and control data, measured values, scheduling data, energy accounting data and operator messages.
Island: An electrically isolated portion of an interconnection. The frequency in an electrical island must be maintained by balancing generation and load in order to sustain operation. Islands are frequently formed after major disturbances wherein multiple transmission lines trip, or during restoration following a major disturbance.
Isochronous Generator Governor Control: An isochronous (or zero droop) governor maintains the same speed regardless of the load, and ensures that the frequency of the electricity generated is constant or flat. Isochronous control mode is used to control frequency in an island during system restoration.
Phasor Measurement Unit (PMU): Device that measures the electrical waves on an electricity grid, using a common time source for synchronization.
Reactive Power, Volt-Amperes reactive (VAr): The portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive power must be supplied to most types of magnetic equipment, such as motors and transformers. It also must supply the reactive losses on transmission facilities. Reactive power is provided by generators, synchronous condensers, or electrostatic equipment such as capacitors and directly influences electric system voltage. It is usually expressed in kilovars (KVAr) or megavars (MVAr).
Real-Time Contingency Analysis (RTCA): A computer application which evaluates system conditions using real-time data to assess potential (post-contingency) operating conditions.
Regional Entity: An independent, regional entity with delegated authority from NERC to propose and enforce Reliability Standards and to otherwise promote the effective and efficient administration of bulk-power system reliability.
Registered Entity: An entity that is a user, owner, or operator of the bulk-power system that is generally required to register with NERC.
Reliability Coordinator: The entity that is the highest level of authority who is responsible for the reliable operation of the Bulk Electric System (BES), has the Wide Area view of the BES, and has the operating tools, processes and procedures, including the authority to prevent or mitigate emergency operating situations in both next-day analysis and real-time operations. The reliability coordinator has the purview that is broad enough to enable the calculation of Interconnection Reliability Operating Limits, which may be based on the operating parameters of transmission systems beyond any Transmission Operator's vision.
Restoration: The process of returning generators and transmission system elements and restoring load following an outage on the electric system.
State Estimator (SE): A computer application which evaluates system conditions using real-time data to assess existing operating conditions.

Supervisory Control and Data Acquisition (SCADA): A system of remote control and telemetry used to monitor and control the transmission system.

Synchronize: The process of bringing two electrical systems together by closing a circuit breaker at an interface point when the voltages and frequencies are properly aligned. Also, when generators are brought on-line, they are said to be synchronized to the system.

System Operator: An individual at a control center of a balancing authority, transmission operator, or reliability coordinator, who operates or directs the operation of the Bulk Electric System in real-time.

System Restoration Plan: Plan required to allow for restoring the Transmission Operator's System following a Disturbance in which one or more areas of the Bulk Electric System shuts down and the use of Blackstart Resources is required to restore the shut down area to a state whereby the choice of the next Load to be restored is not driven by the need to control frequency or voltage regardless of whether the Blackstart Resource is located within the Transmission Operator's System.

Telecommunications Service Priority: A Department of Homeland Security program that authorizes national security and emergency preparedness organizations to receive priority treatment for vital voice and data circuits or other telecommunications services.

Transmission Operator: The entity responsible for the reliability of its "local" transmission system, and that operates or directs the operations of the transmission facilities. The transmission operator is required to have a restoration plan, in accordance with EOP-005-2.