NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

ERO Reliability Risk Priorities Report

Supplemental Technical Summary

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RELIABILITY | ACCOUNTABILITY




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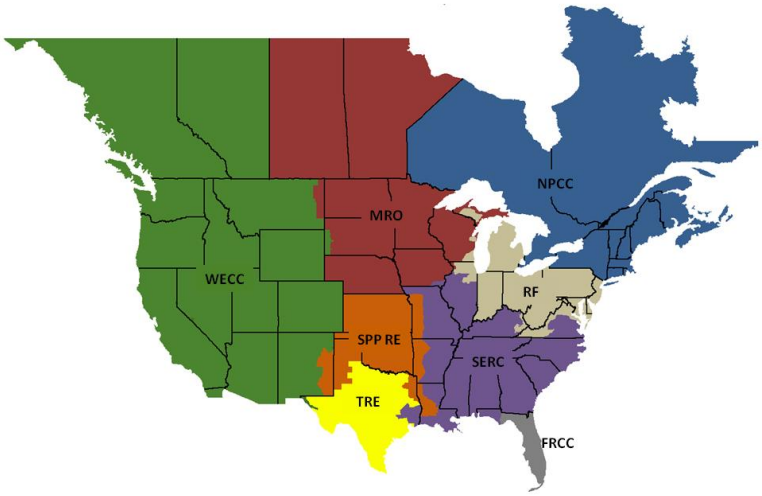
Preface

The North American Electric Reliability Corporation (NERC) is a not-for-profit international regulatory authority whose mission is to ensure the reliability of the bulk power system (BPS) in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. NERC is the Electric Reliability Organization (ERO) for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

The North American BPS is divided into the eight Regional Entity (RE) boundaries, as shown in the map and corresponding table below.



FRCC	Florida Reliability Coordinating Council
MRO	Midwest Reliability Organization
NPCC	Northeast Power Coordinating Council
RF	ReliabilityFirst
SERC	SERC Reliability Corporation
SPP-RE	Southwest Power Pool Regional Entity
TRE	Texas Reliability Entity
WECC	Western Electricity Coordinating Council

The Reliability Issues Steering Committee (RISC) is an advisory committee to the NERC Board of Trustees (Board). RISC provides key insights, priorities, and high-level leadership for issues of strategic importance to BPS reliability. The RISC advises the Board, NERC standing committees, NERC staff, regulators, Regional Entities, and industry stakeholders in an effort to establish a common understanding of the scope, priority, and goals for the development of solutions to address reliability issues. The RISC provides a framework for steering, developing, formalizing, and organizing recommendations to provide guidance to the ERO Enterprise and the industry to effectively focus resources on the critical issues to best improve the reliability of the BPS.

This 2015 report presents the results of the RISC's continued work to define and prioritize risks to the reliable operation of the BPS and thereby provide recommendations to the Board regarding the strategic approach that NERC should take to enhance reliability and manage those risks.

Risk Priorities Report – Supplemental Technical Summary

This report is intended to serve as a detailed technical supplement to the ERO Risk Priorities Report, and therein provide documentation of the RISC's continued work to provide insights and guidance about reliability risks potentially impacting the BPS. These materials are structured to provide additional reference supporting materials regarding the risk profiles, their respective priorities and groupings, the status of risk management effectiveness, and linkage with both action plans within the technical standing committees and other efforts directed by NERC staff. Further the report provides a discussion about linkages between these supporting work efforts with those designed to formulate ERO strategic plans, Business Plan and Budget development, and management of risk control measures.

These provide a summary of the range of efforts underway addressing these risks. Accordingly, it supports management oversight of the effectiveness of these efforts, their timeliness, and indications of progress in either reducing underlying reliability risk or enhancing reliability in a risk area.

Risk Profiles

The risk profiles are presented in the subsequent materials in a series of groupings of comparable reliability risks. The RISC recognizes that many of the risks identified in the 2014 ERO Risk Priorities Report represented a compilation of the range of key risks facing the ERO and industry. In this report, the RISC has attempted to group those risks and better recognize the interdependencies among the specific risks as well as the potential overlap arising from different perspectives.

Risk profiles contain a more complete description of the nature of the underlying risk to reliability as well as an updated description of the problem the risk represents for reliability of the BPS. The profiles further provide a description of the current risk management activities, as well as indication of those completed, and a series of recommendations and measures of success linked to overall approaches designed to lessen the risk or enhance relevant aspects of reliability. These materials have been reviewed within the NERC staff and the RISC representatives of the technical standing committees, and have been presented and reviewed overall by the RISC members.

The risk profiles have been grouped into three primary categories: 1) emerging risks, 2) recognized risks, and 3) effectively mitigated risks. Risks that represent the highest potential risk, encompass the composite of likelihood of occurrence and potential impact consequences, or have the greatest evolving character of risk and have been categorized as “emerging risks.” These areas warrant the greatest level of attention and action.

The second category of potential likelihood and consequence of reliability risk to the BPS is made up of risks, probabilities, and potential impacts that are widely recognized and a range of measures are in place designed to address these “recognized risks.” A number of these measures, in many cases, involve a multiyear program.

The third category of reliability risks represent risks that are well understood, the likelihood or consequences are limited, and the range of measures widely in place across the ERO and adopted within the industry are considered to have “effectively mitigated” the risks. These are risks that are recognized by the RISC, and no additional efforts to manage or lessen the risks are warranted.

By grouping the risks profiles in this manner, greater insight and guidance is gained on the alignment of resources and level of effort required, based on the priority areas. More relevant focus on risk areas with the greatest emerging threats can be identified and corresponding measures put in place while risks in the third category enable a measured scaling back of focus and resource commitment.

Action Plan Templates

The risk profiles provide various elements of tactical risk management efforts. While the RISC has focused primarily on identifying the emerging and high-priority risks, additional attention and focus was provided for gauging the range of resources, efforts, and level of effort widely across the ERO and industry. The objective was to ascertain whether these aspects were generally consistent with the consensus priorities and whether the efforts were effective in addressing the risk by lessening the risk in the respective area.

The RISC focused broadly on whether the range of efforts generally were consistent with the consensus priorities at a strategic level, and they intentionally did not focus on reviewing the details of the various elements. However, members of the RISC include officers of the respective standing technical committees, which undertook a more detailed review of these elements as components of their respective strategic and work plans along with NERC staff. In part, the effort was designed to provide clarity and accountability for actions and efforts listed in the risk profiles as appropriate for their respective committee or other group. In order to accomplish this, the leadership of the respective standing technical committees conducted a detailed review to clarify responsibilities for pursuing various explicit actions, determine accountabilities, and reach consensus alignment of these actions, compared with their respective multiyear work plans. These are maintained by the respective technical committees as part of their strategic and work plan development.

In instances when either NERC staff or the relevant technical forum or research entity became the accountable and responsible entity, the linkage has been clarified, accountability overseen by NERC staff, and ongoing actions or efforts adjusted accordingly.

An important aspect of the respective risk control measures is gauging the effectiveness of the efforts to reduce the reliability risk or enhance the reliability. Accordingly, ongoing efforts among the RISC, the NERC staff, and the technical committees are considered an important ingredient in the overall plans to address the relative priorities and focus of resources. This iteration of the report has improved the integration and accountability for executing actions and recommendations across the ERO groups and aligned efforts consistent with the RISC priorities.

Strategic Plan, Business Plan and Budget, and ERO Metrics Linkage

These risk profiles and respective priorities support the recommendations presented to the Board for consideration. The reliability risk priorities, reflecting the broad groupings, are intended to focus resources and efforts on risks with the greatest likelihood, emergence, and potential impact.

Developing the risks, determining the appropriate priorities, and ascertaining the range of actions warranted to lessen the risks or enhance reliability serve to support strategic considerations about overall ERO priorities. While the ERO priorities can be influenced and affected by a range of other factors and ERO responsibilities, it is recognized that a significant component of those priorities centers on BPS reliability and managing or reducing related reliability risks. Accordingly, two key aspects have been integrated into these reports during this RISC annual cycle: 1) focusing the reliability risks on emerging or high-priority risks in which focused attention may be warranted, and 2) adjusting the timing into the third quarter of the deliverable work in order to support development of the Strategic Plan.

The overall objective is to enhance the linkage of these risks and priorities into the formulation of the ERO Strategic Plan, which in turn represents a key element of the formulation of the planned Business Plan and Budget development. The over-arching strategic description emerging from the Reliability Leadership Summit and work of the RISC is provided in the Risk Priorities Report, and is intended to shape the depiction of the key findings, conclusions, and recommendations for each of the following risk profiles. In part, this has resulted in alignment and identification of key efforts in support of the risk priorities and in particular where enhanced resource allocations may be required to support recommended actions. These resource allocations reflected within the Business Plan and Budget are identified at the business functional group level to provide enhanced transparency and identified linkage. A subset of key efforts supporting risk priority efforts emerges as key ERO metrics are formulated to ensure alignment, specific focus on efforts, and oversight of reliability benefits result in the subsequent year. The Strategic Plan, Business Plan and Budget, and ERO metrics efforts all are formulated during the October–December time frame, and the corresponding adjustments in the time table for the RISC deliverables were implemented with this year's efforts.

Risk Profile #1: Regulatory Uncertainty – Markets, State, and Federal/Provincial

Regulatory uncertainty reflects the risk from a combination of uncertainties surrounding federal, state, or provincial regulatory or statutory changes that could result in requirements affecting existing or planned elements of the BPS. Further, these uncertainties are amplified as market rules and either do not address reliability concerns or develop or propose rules and provisions that present market signals that can interfere with BPS reliability. These different requirements, the uncertainties in the provisions, and the timing of respective implementation and requirements can conflict from reliability view or result in infrastructure decisions that weaken reliability resilience or flexibility. Finally, these risks are magnified in an increasingly complex shift within the resource mix, the planning and operating environment. *Overall Risk Priority – High*

Detailed Reliability Risk Description

Regulatory uncertainty includes two key risk areas:

- First, future federal, state, or provincial regulations and legislation (including congressional or parliamentary action, Environmental Protection Agency (EPA) regulations, FERC, NERC, and renewable energy directives, and individual state or provincial action could impose requirements and implementation timing that conflict or interfere with ensuring reliability. While singular statutes could individually pose reliability risk associated directly with the requirements or timing obligations, additional risk arises through the complex and compounding effects of uncoordinated public policy decisions made at various levels of the government or by multiple government agencies. Specific examples include market rules, restricted bandwidth in cellular space, safety restrictions on fuel delivery, renewable portfolio standards, and continued expansion of environmental regulations—including CO_2 regulations and other regulations targeting water use or wildlife preservation by generators.
- Second, complex, competing, and diverse rules with intersecting time requirements could lead entities to take actions or infrastructure decisions based on compliance with rules, electing the most conservative requirements while secondarily considering reliability objectives. As a consequence, the planned development of a reliable BPS could be impacted, as could an operator's flexibility to reliably operate the grid.

These risks are expected to arise within the increasingly complex BPS operating environment as NERC-initiated reliability obligations begin to intersect with either state or federal layers of governmental obligations with differing compliance and enforcement consequences for the entities. These may detract from ensuring the reliability of the BPS by introducing or extending conflicting requirements or business practices.

Current Risk Management Posture

Primary Efforts – The key efforts supporting alignment among regulatory, governmental, and legislative initiatives, market rule provisions, and reliability obligations center on formulating a sound technical foundation of reliability implications and characteristics, a solid understanding of relevant risks, and extensive outreach and collaboration efforts.

Reliability Assessment Efforts – The core efforts involve conducting proactive reliability assessments regarding potential impacts associated with different sets of regulatory proposals and final rules. These assessments provide the technical foundation for understanding the potential impacts, timing aspects, infrastructure requirements, and overall changes in reliability behavior. Assessments also provide the rationale for modifications to the rules and guidance as states or entities begin to formulate implementation plans, taking reliability factors into account. This has led to the initiation of the Essential Reliability Services (ERSs) work to better quantify the reliability characteristics as the resource mix changes in response to regulatory provisions. Examples include efforts in the

development of ERS materials, reliability evaluations surrounding the implementation proposals for the EPA's Clean Power Plan rule, risk and reliability assessments addressing gas-electric interdependencies, other environmental regulation proposals, and integration of variable generation resources assessments.

Findings, Conclusions, and Recommendations

NERC Should:

- Expand development of reliability data-grounded analyses and sustain its independent, technical assessments of proposed regulatory rules or proposed statutes at state, provincial, or federal levels as well as significant market rules to determine any potential impacts to reliability.
- Expand its efforts to articulate the reliability attributes at potential risk and conduct focused outreach to governmental or market entities on reliability impacts, recognizing costs of implementation as well as overall strategic reliability value of integrated bulk power grid.
- Use industry associations and forums (e.g., North American Transmission Forum (NATF), North American Generator Forum (NAGF), Institute of Nuclear Power Operations (INPO)) to deepen the insights regarding regulatory and market proposals in order to stage and shape the relevant reliability focused assessments.
- Engage in high-level collaboration among NERC/FERC/DOE, market operators (Regional Transmission Operators (RTO)/Independent System Operators (ISOs)), and Canadian provinces and states to establish long-term strategies for aligning energy or market policy and requirements with reliability perspectives.
- Integrate considerations of cost/investment aspects in evaluations that support regulatory initiatives, prioritize actions expected to address or avoid risks exclusive of standards, formulate guidelines and assessment materials disseminated among state/federal/provincial entities and support smart asset investment decisions that effectively address multiple reliability risk dimensions.

Measures of Performance and Effectiveness

Near Term

- NERC will conduct a reliability validation assessment of EPA final rule 111(d) while considering the potential range of implementation strategies among states, including sub-regional reliability evaluations, as state plans begin to emerge. This should provide a sound data/analysis framework to validate and advise relevant entities of the reliability aspects of the proposed plans.
- NERC should collaborate with FERC and states, as well as with RTO/ISO proposals, on reliability impacts associated with state or regional proposed plans for implementation of EPA final rule 111(d) regarding resource adequacy, transmission, and related reliability impacts.

Midterm

- Development of high-level collaboration among the different government, ERO, and market authorities to establish a long-term strategy.
- Expand collaboration with RTO/ISO entities regarding the broader intersection of regulatory uncertainty and market initiatives to focus on reliability attributes and interdependencies.

Long Term

- Over the long term, expand broad alignment among industry, government, and markets with ERO reliability objectives recognized. Robust technical assessments, guidance, and risk prioritization reflect a mature and sustainable integration of reliability risk perspectives and principles such that investment decisions, market rules development, and state/federal/provincial policy efforts are formulated in alignment.

Actions Completed – Implemented

- Reliability assessments addressing the potential reliability risks associated with implementation of the EPA's MATS rules, the initial reliability assessments of the EPA's Clean Power Plan rule, the integration of variable generation assessments, and the gas-electric interdependency assessments.

Risk Profile #2A: Changing Resource Mix

Changes in the composition of generation resources and load characteristics are anticipated to continue or accelerate over the coming decade, driven by decisions made by individual consumers and companies. The resulting reliability behavior and dynamics of the BPS increasingly differs from the system's underlying design. Further, the resource mix changes are being accelerated by economic, regulatory, and policy driven requirements. These requirements are leading to retirements of synchronous generation and additions of asynchronous forms of generation, accentuating the rapid changes to the reliability characteristics. Overall Risk Priority – High

Detailed Reliability Risk Description

The present mix of resources for the BPS consists mostly of large rotating synchronous central station generators that are increasingly being replaced by variable renewable forms of asynchronous generation produced in different locations, gas-fired resources, and other new types of resources. These are increasingly complemented by load modification (e.g., demand response, energy efficiency, etc.) programs and distributed resources connected at distribution and customer facilities. The BPS composite reliability characteristics are fundamentally different with respect to some of the less obvious fundamental elements of reliable operation (e.g., inertia, frequency response, ramping, generator output maneuverability, and reactive power output). Operationally, additional risks include: uncertainty concerning the commitment of variable resources, distributed resources, and demand-side resources; altering load obligations; and the lack of visibility and controllability of such resources once committed. A further aspect of the changing resource mix centers on the increasing deployment of distributed generation resources within the distribution or behind-the-meter configurations, which increasingly impacts the BPS and alters the overall reliability behavior, compounded by the lack of transparency and controllability. At the same time, continuing improvements in smart grid technologies, energy efficiency, and other changes in load composition impact characteristics and behavior of load, reactive power needs, and how the system operates and behaves during disturbances (e.g., fault-induced delayed voltage recovery). However, modeling and tools to accurately represent the dynamic aspects of these reliability behaviors are currently inadequate to fully anticipate the entirety of reliability needs. Finally, the planning and coordination essential to adequately anticipate and implement needed infrastructure modifications to preserve reliability are insufficient, and the measures and parameters around conducting such assessments are accentuated further by seams and generator unavailability under severe weather conditions.

Current Risk Management Posture

Ongoing problem evaluation – NERC's technical committees research and analyze specific issues related to this risk, such as the work being done by the Integrating Variable Generation Task Force (IVGTF), Resources Subcommittee (RS), and the Essential Reliability Services Task Force (ERSTF).

Raising Awareness – NERC annually publishes long-term reliability assessments, seasonal assessments, and NERC special assessments (such as *Maintaining Bulk Power System Reliability While Integrating Variable Energy Resources – CAISO Approach* (2013) and *Accommodating High Levels of Variable Generation* (2009)). NERC also published a level 1 advisory alert, *Generator Governor Frequency Response*, on February 5, 2015.

Planning and Operating Guidelines and Potential Enhancements to Reliability Standards – In addition to defining various technical considerations for integrating high levels of variable generation, the IVGTF initiated development of a series of 12 reports starting in 2009, which identified a series of recommendations to investigate potential mitigating actions, practices and requirements necessary to ensure reliability. These have been summarized in a 2015 PC/OC approved report providing a series of additional recommended actions, some aspects of which are currently being considered by the Dispersed Generation Standards Drafting Team.

Essential Reliability Services Task Force – The ERSTF has a multifaceted purpose that includes developing a technical foundation of ERS; educating and informing industry, regulators, and the public about ERSs; developing

an approach for tracking and trending ERSs; formulating recommendations to ensure the complete suite of ERSs are provided and available; and providing guidance necessary for operating a reliable grid. The ERSTF actions incorporate some of the recommendations identified earlier by the IVGTF.

Long-Term Reliability Assessments – NERC's flagship report assesses and evaluates long-term challenges and emerging reliability issues. The changing resource mix has been highlighted in several recent assessments and initial analysis steps have been undertaken to better understand the reliability behavior impacts of distributed and other asynchronous resources being added to the bulk and distribution systems.

Findings, Conclusions, and Recommendations

- NERC should expand its traditional role of conducting assessments based on reliability data, reporting results, and disseminating conclusions and results to shift to greater proactive evaluations, anticipating potential resource changes and corresponding reliability consequences. The focus of subsequent outreach would be to focus more predictive efforts to identify of what is needed to avoid or prevent adverse consequences as well as effectively support overall bulk reliability framework.
- Initiate discussions with FERC regarding reliability attributes essential to support the long-term reliability of the BPS, including wide-area recognition (static VAR compensators, flexible ac transmission systems, dc lines), controls expansion for variable/renewable resources, aggregate effects of small/customer resources, distributed energy resource performance, synchronous generation retirement/shutdown effects, and other essential aspects of reliable service.
- Expand the consideration of ERSs to encompass the comprehensive range of reliability attributes under a more diverse resource and load behavior such as ramping, fast regulation, reserve services, interdependent sector performance, as examples.
- NERC should continue efforts initiated by the governor response alert and, in the context of the ERS efforts, further develop the technical foundation for provisions and metrics to ensure adequate governor response in respective time horizons to ensure BPS reliability. This should also include provisions for ensuring effective governor response within respective interconnection agreements or tariffs.
- Continue the development of accurate models for each resource type of variable generation for stability and power flow studies to increase consistency, accuracy, fidelity, and transparency across the industry.
- Assess the composite reliability risks:
  - The large generator performance aspects of transforming from historic frequent operating mode with reliable forced outage rates shifted increasingly to infrequent, peak or incidental operations with worsening forced outage rates and low capacity factors.
  - Increased reliance on natural gas and fuel dependencies
  - Increased reliance on demand response resources (i.e., what amount of demand response capacity is operationally available to support reliable operations; what amounts are actually realized);
  - Changes in load composition and characteristic behavior of load;
  - Reliability behavior of the distributed generation resources;
- NERC should develop issue/consequence discussion materials based on sound technical elements and supported by a focused special reliability assessment on the comprehensive range of reliability impacts associated with the penetration of distributed energy resources (DERs).
- NERC should continue to develop effective means to gather data and insights about the BPS reliability behavior of the composite of expanded resources added into the distributed network systems, including

distributed generation resources (i.e., customer, distribution, or otherwise), and formulate plans to achieve effective transparency and control, considering the distributed nature and intermittency.

- NERC should expand the collaboration framework with the RTO/ISO Council, Balancing Authorities (BAs) in nonmarket areas, and FERC on ERS recommendations for effective implementation as key recommendations emerge. The collaboration framework should include market structure and tariff considerations, the tools to be used, and incentive and performance provisions that serve to support for reliability of the BPS.

The NERC Standing Technical and Standards Committees Should Perform these Activities:

- In collaboration with the Standards Committee, assess technical foundations to support potential standards modifications that are required to ensure appropriate applicability and alignment with reliability goals as defined in the long-term reliability assessments [Technical – Planning Committee (PC)/Operating Committee (OC), Standards – SC].
- Provide reliability technical subject matter support for determining ERSs, reflecting focus on the impacts of variable energy resources (VERs), demand response, distributed resources, changing asynchronous resources, and demand-side resources. Implement appropriate recommendations emerging from the ERSTF recommendations for operational integration of these resources [OC] and planning recognition of these composite resources [PC].
- Establish a guideline to consistently account for demand response and demand-side resources in operational planning [OC].
- Develop appropriate guidelines for transparency, accounting, and controllability for managing the operations [OC] and for resource/capacity planning for [PC] behind-the-meter and distributed types of resources. Consider whether, based on technical recommendations, modifications or additions are needed within standards to ensure reliability [SC].
- Monitor changes and expansion market provisions that could represent barriers to effective reliability of the BPS.
- Enhance reliability assessments to reflect changing resource mix behavior with probabilistic approaches, including distributed energy resources and ERSs, considering the variable and energy-limited nature of the resource shifts.

Measures of Performance and Effectiveness

Near Term

- A NERC established timeline for defining ERS, and presenting recommendations for implementation.
- NERC should pursue development of reliability assessments focused on the final EPA CPP rule and designed to provide guidance and recommendations for states, FERC, the EPA, and industry.

Midterm

- Based on the approved established definition of ERSs, develop appropriate guidelines and potential standards modifications or additions [OC and PC] while recognizing the impacts of VERs, demand response, distributed generation, energy dominated regions, and demand-side resources. NERC expansion of data and insights emerging from performance of demand response resources (i.e., what amount of demand response capacity is operationally available to support reliable operations) and consider development of measurement and verification requirements building on North American Energy Standards Board (NAESB) efforts.

Long Term

- NERC and the industry should focus on using increased stability and BPS reliability, as the resource mix changes as key measures. Also, there should be an enhanced integration of renewables, reflecting the overall reliability behavior impacts of the BPS, through accurate models and probabilistic analyses.
- For standard improvements, or any standard modifications, the SC will review the OC/PC recommendations emerging from the IVGTF and ERS activities through the Enhanced Periodic Review process and the existing Dispersed Generation Standard Drafting Team. The SC and OC/PC will make suggestions on the way forward for each of these recommendations to ensure applicability and alignment with reliability goals.
- NERC and the industry should integrate standardized models for variable generation, energy-only resources, asynchronous resources, distributed generation resources, and composite load behavior models for stability and power-flow studies. Develop an effective NERC oversight approach to validate the reliability characteristics and event performance reflecting these models.
- The OC/PC should expand the guidelines for both short-term and long-term horizons to simulate fuel and other related upstream risk in reliability assessments and capacity impacts due to extreme cold weather, interstate pipeline failure, most severe single contingency, capacity shortfalls, and other assumptions.
- The OC/PC should establish a guideline for demand response and demand-side resources in operational and planning analyses.
- The OC/PC should establish guidelines and recommendations for addressing visibility and controllability concerns about behind-the-meter and distributed generation resources and their relevant reliability characteristics.

Actions Completed – Implemented

- NERC is tracking specific unit retirements (due to the Mercury and Air Toxics Standards (MATS) Rule, Environmental Protection Agency (EPA) Section 111(d), etc.) and include those retirements in a separate table in the long-term reliability assessments (LTRA).
- NERC performed an assessment of the EPA's proposed rule 111(d) on resource adequacy and reliability.
- NERC tracked construction of variable resources with expected in-service dates.
- Consider the requirements to use in planning for VERs as well as performance and monitoring requirements for all generation types for transparency across the industry.
- NERC included information on specific unit retirement information included in the LTRA.

Risk Profile #2B: Inadequate Planning Coordination

The planning and coordination for variable and intermittent resources heightens the need to develop adequate probabilistic tools, methods, and the corresponding coordination functions. This is increasingly the case as different types of resources, retirements of synchronous resources, new technologies, and distributed resources contribute to more complex reliability behavior and more comprehensive coordination. The ability of markets and nonmarket areas to provide signals for needed additional generation introduces another layer of planning and coordination. Further, as markets and nonmarket areas employ different mechanisms to identify and incorporate new resources, additional planning tools and coordination are essential at the seam intersections, particularly as the boundaries of balancing areas, RTOs, and markets continue to evolve. Inadequate coordination of planning at the seams can lead to instances where generation or transmission resources, or information coordination concerning those resources, may be inadequate to ensure firm demand is served. *Overall Risk Priority – High*

Detailed Reliability Risk Description

The increased rate of plant retirements, especially conventional synchronous generation resources, coupled with the increasing integration of renewable, distributed, and asynchronous resources, amplifies the complexity of reliability coordination. In addition, uncertainty regarding the on-peak variability, intermittency performance of new technologies, and dynamic system reliability behavior of the operating characteristics contribute to a lack of certainty regarding resource behavior and coordination. Adequate planning assessment and analysis tools are essential to evaluate potential reliability concerns, reflecting much different reliability characteristics of the composite resource mix. Forward assessment projections point to potential deficiencies in reserve margins as early as 2015 in certain regions of North America. In other regions, extended periods have been necessary to adequately adapt and resolve reliability concerns and planning assessment dynamics as these significant resource shifts have taken place. Additionally, uncertainty in resource adequacy is attributed to differences in long-term planning assessment methods, the use of different models, a lack of information sharing, limited coordination of planning across seams, limited reliability behavior insights, and variability/intermittency of certain resources. As major regulatory or legislative initiatives emerge, there is increasing uncertainty about the composite effects of such requirements, increasing the resource adequacy analysis and decreasing the reliability certainty. In the short term, as major groups of conventional generation retirements or retrofits are required under short time frames, the planning necessary to manage long-duration outages in wide groups of generation can adversely affect overall reliability while different resource types in new locations raise transmission and power flow reliability aspects needing effective coordination.

Current Risk Management Activities to Date

Ongoing Planning Assessments – NERC's technical committees have continued to expand the analysis of specific issues related to this risk, including the Reliability Assessment Subcommittee (RAS), the IVGTF, the Smart Grid Task Force (SGTF), the Geomagnetic Disturbance Task Force (GMDTF), the System Analysis and Modeling Subcommittee (SAMS), the Modeling Working Group (MWG), the ERSTF, and the Gas Electric Interdependency Task Force.

Raising Awareness – NERC continues proactive anticipation of resource planning and coordination issues through publishing long-term reliability assessments and special assessments: *Potential Impacts of Future Environmental Regulations* (2011), *Resource Adequacy Impacts of Potential U.S. Environmental Regulations* (2010), Reliability assessment of the potential impacts of the EPA's Clean Power Plan (2013 and 2014).

Reliability Standards – Industry implementation of new Transmission Operator (TOP) and Transmission Planning (TP) standards and modifications to the modeling, data, and analysis (MOD) Standards.

Modeling and Dynamics – Improving the development of comprehensive modeling and assessment tools to validate the accuracy and fidelity of steady state and dynamics reliability behavior is under accelerated

development. These complement the consideration of phasor measurement unit (PMU) outputs to substantiate these results and the introduction of node-breaker models that align operating environments with planning assessments, expanding probabilistic assessment tools and practices to address the variability and intermittency aspects of bulk reliability.

Findings, Conclusions, and Recommendations

NERC Should Perform these Additional Activities:

- Continue to develop expanded assessment, modeling, reporting, and outreach efforts to build a long-term platform for more predictive guidance and expectations to ensure reliability. This includes continued sharing of insights and trends emerging from assessments, building platforms for effective planning and operating models and tools that reflect reliability behavior. Host technical conferences and encourage meetings with regulators to discuss the issue and explain the potential consequences.
- Enhance coordination efforts for long-term planning by (1) developing enhanced accuracy/fidelity models of reliability performance, reflecting market and dispatch operations, and (2) assisting in performing regional studies to quantify reliability impacts due to market operations across operational seams. Develop enhanced scenarios and stress testing methods for planning studies.
- Highlight resource adequacy and coordination issues associated with various state and market regimes to ensure sufficient resources with different variability behavior are available to satisfy increasingly diverse resource and load behavior.

The NERC PC Should Perform these Additional Activities:

- Based on the finalized ERS development report, evaluate the sufficiency of the current body of Reliability Standards to address the sufficiency of ERSs and wide area coordination.
- Continue to expand development of interconnection-wide models more commensurate with expected dispatches, both market and nonmarket, and reflecting dynamic reliability behavior to help conduct long-term planning assessments.

NERC Should Conduct Reliability Assessments Addressing:

- Reliability aspects associated with integrating new transmission capacity and power transfers, resulting within interconnections, and at the boundaries between market and nonmarket areas.
- The reliability behavior of the composite resource mix and the resource adequacy methods, both for markets and nonmarket areas.

Measures of Performance and Effectiveness

Near Term

- Continue development of reliability assessments focused on key resource adequacy aspects, reliability behavior of the composite resource mix, and expanding tools needed to evaluate overall composite reliability.

Midterm

- NERC should continue to conduct periodic long-term reliability and special topic assessments of the BPS focused on following:
  - Challenges associated with adding transmission capacity associated with changing resource mix and locational dispersion

- Integrating new resource adequacy evaluation approaches, recognizing markets, variability, and composite resource and load behavior
- Transmission integration and power transfers aspects, to accommodate the changes in the dispersion and retirements of resources and load behavior
- Interdependency of BPS infrastructure development with associated interstate gas line expansions

Long Term

- Increased consistency in the application of respective energy emergency alert (EEA) levels
- Long-term dispatch models that generate credible scenarios for planning studies
- Transmission Load Relief (TLR) and the need for implementation of path relief practices continue to trend downward

Actions Implemented – Completed

Reliability Standards MOD-032-1 and MOD-033-1 have been approved and with an implementation plan.

Risk Profile #2C: Ineffective Resource Planning

Plant retirements and the changing resource mix are leading to cases where resource margins are declining and may be inadequate to ensure firm demand is served at all times. Traditional measures to assess the adequacy of the BPS, centered on reserve margins at peak times, are increasingly ineffective to provide sound reliability perspectives on the overall resource adequacy for the BPS. Overall Risk Priority – High

Detailed Reliability Risk Description

This all contributes to a lack of certainty regarding resource adequacy in North America over the next several years, and increasing reliability risk associated in areas anticipated to fall below reserve margin targets. Forecasts show potential deficiencies in reserve margins as early as 2014 and 2015 in the Electric Reliability Council of Texas (ERCOT) and Midwest Independent Transmission System Operator, Inc. (MISO) areas respectively. Environmental regulations, increased uncertainty in future resources due to other potential environmental regulations, low natural gas prices, load forecasting uncertainty, and economic factors all contribute to an increased rate of plant retirements and a lack of construction of new plants, adversely affecting resource adequacy. While demand response and energy efficiency may offset some of these losses, performance of those technologies can be uncertain and each brings unique challenges. Long-term outages of multiple units to apply environmental retrofits also may have impacts. The reliability risk arises at the juncture where reliability planning and assessments indicate declining or below-target resource margins against the limitations of direct action that NERC and FERC, under section 215 of the Federal Power Act, can do to remedy these conditions. While entities are aware of this issue and are taking action, the amount of time required to implement solutions may be too long to provide relief in the near term, and taking a reactive approach would result in compromises to resource adequacy, increasing reliability risk to the BPS.

Current Risk Management Posture

Ongoing Problem Evaluation – NERC's technical committees research and analyze specific issues related to this risk, such as the work being done by the RAS and the respective reliability assessments conducted by NERC.

Raising Awareness – NERC continues an ongoing practice of publishing LTRAs and special assessments: *Potential Impacts of Future Environmental Regulations* (2011); *Resource Adequacy Impacts of Potential U.S. Environmental Regulations* (2010). These assessments are translated into outreach efforts conducted with federal and state governmental entities to raise awareness of the long-term resource adequacy needs and the actions necessary to support and sustain overall reliability.

Reliability Planning Assessments – The respective efforts to conduct forward-looking reliability assessments, considering the impact of changes occurring within the resource composition affecting the reserve margin adequacy, are an important foundation to understand effective responses and actions. This includes evaluating the appropriateness of probability measures in assessing reserve margin targets to the extent that additional reserve margin adequacy measures become needed, both from the resource planning and the composite load (including distributed energy resources) perspectives.

Findings, Conclusions, and Recommendations

NERC Should Perform these Additional Activities:

- Continue to develop expanded assessment, modeling, reporting, and outreach efforts to build a long-term platform for more predictive and anticipatory guidance and expectations to ensure reliability. This includes continued sharing of insights and trends emerging from assessments and building platforms for effective planning and operating models and using that reflect reliability behavior. Host technical conferences and encourage meeting with regulators to discuss the issue and explain the potential consequences.

- Define the essential adequate level of reliability to encompass, for example, reactive power, reactive reserves, controllable assets, diverse resource, dynamic loads, and frequency necessary to establish technology-neutral balancing area criteria and associated guidelines and expectations.
- Collaborate with entities to develop industry practices and guidelines for effective management of reserve margins that reflect the changing reliability behavior of resources and loads. Consideration of enhanced approaches to assess resource adequacy under scenarios other than seasonal peak capacity is also important.
- Introduce probabilistic approaches to develop second-generation resource adequacy measures that reflect variability and overall reliability characteristics of the resources and composite loads.
- Expand collaboration with state regulators, ISO/RTOs, and industry to formulate technically sound reliability approaches through, for example, markets, service agreements, and interconnection provisions that ensure overall resource adequacy for scenarios of load behavior.
- Promote better unit retirement forecast models to generate scenarios for planning studies.

The NERC PC Should Perform these Additional Activities:

- Consider whether the current body of Reliability Standards is sufficient to support current and expanded resource adequacy and target reserve margin approaches to appropriately manage this risk.
- Develop interconnection-wide models more commensurate with expected dispatches to help perform long-term planning for resource adequacy.

Measures of Performance and Effectiveness

Near Term

- A NERC/technical committee strategic plan to engage entities, disseminate information, and provide a framework for technical conferences as needed.
- Expanded development of resource adequacy and target reserve margin approaches to assess the effectiveness of the overall resource to satisfy composite load behavior under seasonal as well as peak conditions.

Long Term

- Resource adequacy and transmission capacity in all North American Regions should reverse declining trends and approach target reserve margin levels by the end of the 2016–2020 period. Reserve margin forecasts should not fall below targets within the future three-year horizon.
- Reserve margin forecasts should not fall below targets within the future three-year horizon.
- Re-establish appropriate reserve margin and adequacy strategies that incorporate probabilities, variabilities, and ERSs.
- No significant uptick in energy emergency alerts (EEA) associated with capacity deficiencies.
- Long-term dispatch models that generate credible scenarios for planning studies.
- TLR trends resulting from resource capacity dispatches significantly align with resource and planning models.

Risk Profile #2D: Generator Unavailability

Extreme weather conditions over extended periods can lead to very high demands for electricity and contribute to the simultaneous loss of large amounts of generation. This combination of generation unavailability and high electricity demand can lead to the need for emergency operation actions (including shedding load or triggering emergency resources) needed to maintain reliability and avoid cascading/uncontrolled separation of the overall BPS. Overall Risk Priority – Moderate

Detailed Reliability Risk Description

Extreme weather conditions, such as severe cold, heat, and drought, create significant stress on generator's resources, which strains BPS reliability. This presents unique challenges for electric system planners and operators. These conditions can significantly increase residential and commercial electricity demand and consumption while also imposing adverse regional generation availability, adversely affecting facility ratings, and causing fuel availability issues. The combination of increased consumption of large amounts of electricity can significantly increase the use of fuels commonly used by many power plants to produce electricity. Further, the extreme weather can stress key power plant components needed to generate electricity and can result in decreased fuel deliveries due to limited transport capability (e.g., on key gas pipelines, compressor stations, or rail service used for coal deliveries). Extreme weather conditions can also vary the amount of wind and clouds, which impact the expected amount of available renewable generation in some areas.

When combined, the heightened electricity demand, increased potential for failure, availability/deratings of power plant components, limitations on fuel supply availability, and competing use of certain fuels can lead to increased risks of adverse reliability impacts, including simultaneous forced outages, deratings, and failures to start of multiple generating units. When these severe conditions are present over large geographic areas, the combined impacts on the fuel supply, power plant operations, generation unavailability, and heightened electricity demand can lead to severe reliability impacts.

Although these conditions are anticipated to occur rarely, planners and operators responsible for managing a reliable BPS can be extremely challenged by these combined impacts. These extreme conditions occur beyond the extent of planned stress conditions, anticipated severe operation conditions, or fuel supply availability expectations. Further, the conditions can lead to imprecise forecasts of residential and commercial electricity demand, which is the baseline for planning the BPS and determining the amount of electric generation needed during critical periods. When the combination of some, or all, of these conditions occur during these extreme incidents, the end result can be operations under severe unanticipated scenarios or a shortage of generation, prompting operators to implement curtailments or shed load in local areas to maintain reliability in the overall grid.

Current Risk Management Posture

Promote Best Practices and Guidelines – The NERC OC has developed a guideline for generator unit winter weather readiness. NERC will continue sharing lessons learned and best practices for managing equipment during extreme weather.

Raise Awareness – NERC issues annual notifications reminding entities to prepare for extreme events. *Accommodating an Increased Dependence on Natural Gas for Electric Power* (2013) and *A Primer of the Natural Gas and Electric Power Interdependency in the United States* (2011).

Enhanced Short-Term Reliability Assessments – In 2015, NERC began developing the Operational Risk Analysis, which assesses resource adequacy from an operation perspective, reflecting anticipated conditions for the upcoming seasons. This analysis takes into account historical generator performance under seasonal stress

conditions, and evaluates various normal and severe conditions that then integrated within NERC's seasonal assessments.

Findings, Conclusions, and Recommendations

NERC Should Perform these Additional Activities:

- Continue to develop expanded assessment, modeling, reporting, and outreach efforts to build a long-term platform for more predictive guidance and expectations to ensure reliability under extreme generator availability conditions. This includes continued sharing of insights and trends emerging from assessments, building platforms for effective planning and operating models and tools that reflect reliability behavior. Host technical conferences and encourage meeting with regulators to discuss the issue and explain the potential consequences.
- Monitor the effectiveness of the governor alert results across industry and develop recommendations for any further actions warranted.
- Coordinate with the American National Gas Association to develop natural gas availability and pipeline capacity approaches under severe conditions to ensure BPS reliability under a range of scenarios impacting across sectors. Specifically, develop a pipeline performance metric for operations and emergency conditions and expand coordination effort practices between electric and natural gas sectors.
- Coordinate with the current EIPC Gas-Electric Interface Study.

The NATF and the NAGF Should Perform these Additional Activities:

- Develop and promote specific resiliency best practices for dissemination with regard to planning for extreme events.

The NERC OC Should Perform these Additional Activities:

- The NERC OC should define and develop a process for interregional coordination of critical resources.
- Evaluate opportunities to develop more accurate short-term load forecast models through collaboration with the BAs and REs.

The NERC PC Should Perform these Additional Activities:

- Conduct an interregional pipeline study to assess pipeline failure risks and to identify a wide-area profile of potential impacts under a range of scenarios.
- Develop a wide-area profile of potential generator/natural gas vulnerabilities and communicate the information to regional Reliability Coordinators to improve coordination of critical resources.

Measures of Performance and Effectiveness

Near Term

- NERC conduct continued reliability assessments on the following:
  - EPA final rule 111(d) on resource adequacy and reliability, reflecting implementation timelines
  - Natural gas availability and pipeline capacity impacts on reliability under severe weather conditions
  - Improved generator performance during cold weather events as indicated by decreasing values in the following:
    - Frequency of unexpected loss of generation
    - Percentage of generation de-rates

- Frequency of generator failures
- Equivalent Forced Outage Rate (EFOR)
- Frequency and magnitude of load shedding
- Trend error in short-term load forecast per Balancing Authority

Long Term

- Gas pipeline performance and availability metrics under severe weather and temporal conditions
- Development of system modelling and probabilistic analyses incorporating both electric generating and upstream MSSC natural gas deliverability capabilities
- Refined models based on actual performance of forecast wide-area stress points during extreme weather events

Actions Completed – Implemented

- NERC completed an assessment of the EPA's proposed rule 111(d) on resource adequacy and reliability.

Risk Profile #3A: Inadequate Maintenance/Asset Management

The failure to maintain and manage BPS equipment and transmission rights of way can represent a latent risk to BPS reliability. Such a risk may manifest either as a direct or indirect contributor to an unplanned event or disturbance incident that results in an abnormal system condition. Overall Risk Priority – Moderate

Detailed Reliability Risk Description

The failure to maintain equipment is a reliability risk that is exacerbated when an entity either does not have replacement components available or cannot procure needed parts in a timely fashion. Deficiencies in maintenance strategies or execution thereof create additional pressure on sparing programs and aggravate aging infrastructure. Another aspect of this reliability risk, highlighted by the 2010 Facility Ratings Alert to industry, involved the misalignment between the design and actual construction of transmission facilities. Risks are also present in the vendor supply chain, where manufacturing quality control or product failures come to light (e.g., 345 kV Breaker Failure Industry Advisory). Additionally, emerging threats may impact product delivery systems such as cargo carriers or downstream service providers.

Current Risk Management Posture

Raise Awareness – In general, the use of industry advisory alerts provides valuable information on a variety of risks, including manufacturer defects and supply chain concerns. Regarding the transmission line clearance discrepancies, two alert recommendations on October 7, 2010, and November 30, 2010 were issued.

Information Requests – Data collection and analysis regarding field conditions and alignment with design assumptions for transmission facilities is ongoing. An example of this type of data collection and analysis would be the 345 kV breaker failure. NERC requested the NATF, the NAGF, and other trade associations to work with their members to collect and report aggregate information related to this concern.

Technical Task Force – The NERC PC established the AC Substation Equipment Task Force (ACSETF) to look at substation equipment failures and make recommendations. The Spare Equipment Working Group (SEWG) reviews the industry posture and acts as a conduit on long-lead-time equipment and maintains.

Findings, Conclusions, and Recommendations

NERC Should Perform these Additional Activities:

- Evaluate and enhance the Alert program to address scoping for information requests with industry input, earlier dissemination of detailed reports, and potential follow-up activities involving maintenance and management of assets.
- Finalize findings and conclusions associated with the implementation of the Facility Ratings Alert.
- Establish effective communication interfaces between the Electricity Information Sharing and Analysis Center (E-ISAC) and the Supply Chain ISAC.
- NATF, NAGF, OC, and PC should collaborate to establish a strategic plan to identify technologies that may aid spare sharing and recovery.
- Conduct NERC webinars on equipment event lessons learned, equipment maintenance, and seasonal preparedness.
- Enhance the event analysis process to include ACSETF recommendations and evaluate new, additional information for industry trends.

Measures of Performance and Effectiveness

Near Term

- Enhance event reporting interaction with industry participants.
- Track the number of successful activities, success stories, maintenance, and reliability issues to gain insights on trends in effective asset maintenance.

Midterm

- Evaluate equipment failure trends using additional data collected by event analysis and present data collection functions within NERC to extract insights, issues, and trends for dissemination across industry participants.
- Expand industry partnership with related industry strategic spare resource efforts [e.g., – EEI STEP or STEP connect, the DOE Recovery Transformers, etc.]

Actions Implemented – Completed

- Efforts to execute and implement right-of-way maintenance for transmission lines as a result of the industry's adoption of FAC – 003, resulting in a distinct reduction in vegetation-related outages on bulk transmission lines.
- Provided a timely close-out report of the results of the Facility Ratings Alert recommendations.

Risk Profile #3B: Protection System and SPF Failures

A fault accompanied by a failure of a protection system component or a single point of failure (SPF) could result in expanding the severity of transmission/generation contingencies, leading to increased proximity to instability or other BPS reliability concerns, violations of applicable thermal or voltage ratings, unplanned or uncontrolled loss of demand or curtailment of firm transfers, or cascading outages. The presence of SPFs within the protection system can further exacerbate the severity of otherwise minor BPS outages by resulting in wider zones of disruption and operating under system conditions not completely analyzed. Inadequate protection system coordination potentially increases the severity and magnitude of events due to unnecessary trips. Protection system misoperations (PSMs) are a significant threat to BPS reliability and have been demonstrated to increase the severity of contingencies and there is limited evidence of declining rates of misoperations as well as wide ranges of misoperation performance among Regions and entities. Overall Risk Priority – Moderate

Detailed Reliability Risk Description

Protection systems serve a vital role in the defense against system disturbance events. When protection system components fail or are not coordinated properly, the order of execution can result in either incorrect elements being removed from service or more elements being removed than necessary. Failures to trip and slow trips can result in damaged equipment, which may result in degraded reliability for an extended period of time. The presence of single points of failure within protection systems can accentuate the severity of BPS outages by expanding the zone of tripping needed to clear an outage or clearing an entire bus or station. NERC's annual State of Reliability reports have consistently concluded that PSMs are a significant contributor to disturbance events and increase the severity of automatic transmission outages.

Current Risk Management Posture

Information Requests – NERC has completed its analysis of information from a data request to determine the reliability risks posed by potential single-point-of-failure events in response to FERC Order 754. These analyses and recommendations found that TPL-001-4 should be modified to address identified risks to reliability. Data collection and analysis regarding PSMs is facilitated by revised Reliability Standard PRC-004-2 – Protection System Misoperations.

Promote Best Practices and Guidelines – The NERC System Protection and Control Subcommittee (SPCS) published a document explaining the need for redundancy in protection systems. The SPCS also published a document explaining the need for power plant and transmission system protection coordination and associated training materials and webinars. The Protection System Misoperations Task Force (PSMTF) developed a report and recommendations for addressing commonly seen problems and improving protection system performance through the development of guidelines. Region-specific coordination to address variations in misoperation performance have begun.

Mandatory Standards – Project 2007-06 System Protection Coordination addresses information sharing and protection system coordination studies driven by changes in system conditions and is still in development. Project 2010-05.1 Protection Systems (Misoperations) involves analysis and corrective action plans for all PSMs and has also been approved. Project 2007-11 Disturbance Monitoring requires the use of appropriate disturbance monitoring equipment and has been approved.

NATF Protection System Misoperation Reduction Guidance –The NATF is continuing to work to develop PSM best practices and performance improvement guidance.

NERC Misoperation Performance – NERC has initiated complementary efforts among Regions and entities to address the significant performance variations for misoperations, designed to amplify and enhance the efforts under NATF.

Findings, Conclusions, and Recommendations

NERC Should Perform these Additional Activities:

- Evaluate recommendations from the report on single points of failure in protections systems to determine whether TPL-001-4 should be modified.
- Based on the results of the ongoing data request and associated analysis, implement and refine the recommendations to lessen the reliability risks posed by potential single-point-of-failure events. NERC and industry (SPCS, NATF, and NAGF) should continue to analyze PSMs.
- Misoperation performance analysis should continue to inform Regions and individual entities on methods of improving performance as well as sharing best practice performance methods more widely.
- Develop technical guidance that supports the proper application and setting of relay elements and associated firmware in order to minimize the chance of a misoperation occurring.

Measures of Performance and Effectiveness

Near Term

- Obtain insights about industry practices and develop guidance directed at specific causes to inform industry about best practices to improve protection system performance.

Midterm

- Analyze and develop benchmarks of protection system misoperations and document ion report to industry.
- More technical guidance and recommendations should be developed supporting the proper application and setting of relay elements and associated firmware to minimize the chance of a misoperation adopted by industry.
- Further reduce:
  - instances in which an SPF on a protection system causes or contributes to an event on the BPS;
  - the frequency of unnecessary protection system trips caused by incorrectly applied protection system schemes/settings; and
  - misoperation rates (i.e., the ratio of misoperations to total correct operations).

Long Term

- The overall mean (average) misoperation performance improving to reflect steady enhancement in performance.
- Integrate and implement results and recommendations related to mitigating the SPF reliability risk.
- Expand the socialization of the insights and guidance regarding effective approaches to improve relay settings and associated coordination as well as inherent logic and design performance.

Actions Completed – Implemented

- Issue an alert on the limitations of ground relay settings, design, and coordination to enhance entity awareness.
- Develop NERC and Region misoperation performance metrics to facilitate consistent reporting of PSMs.
- Disseminate over 20 lessons learned on relaying and protection systems practices over the prior 5 years, including the System Protection Subcommittee Relaying Practices guidelines.

Risk Profile #3C: Loss of EMS Situational Awareness

The loss of situational awareness associated with the loss of Energy Management Systems (EMSs), inadequate decision-support tools, and ineffective alternate procedures can represent a latent reliability risk that compromises the operational visibility of local and neighboring entities' operations and effective management of reliability in real time that could lead to interconnection-wide reliability issues. Overall Risk Priority – Moderate

Detailed Reliability Risk Description

The overall analysis of event and incident information identified that outages of EMSs and related operator tools and monitoring systems are not uncommon occurrences. This risk impacts functional capabilities including perceiving and comprehending the information provided by decision-support tools, information sharing, coordination of models, and planning across seams. Less-than-adequate situational awareness can cause serious reliability consequences and be a precursor or contributor to BPS events. Additionally, insufficient communication and data regarding neighboring entities' operations is also a latent risk that could result in invalid assumptions and communication of adjacent system's reliability operating behavior or system state, including undetected impacts on the interconnection-wide network.

Current Risk Management Posture

Ongoing Problem Evaluation – NERC's technical committees research and analyze specific issues related to this risk, such as the work being done by the real-time Tools Best Practices Task Force and EMS Working Group (EMSWG).

Raising Awareness – NERC continues an ongoing practice of issuing Alerts, publishing Lessons Learned, presenting data and case studies to appropriate technical committees, and hosting a Monitoring and Situational Awareness Technical Conference, which provides a forum for vendors and users to share information and exchange knowledge about improving EMS availability.

Findings, Conclusions, and Recommendations

NERC Should Perform these Additional Activities:

- Complete Reliability Standards that mandate minimum real-time monitoring and analysis capabilities (Standards Project 2009-02 Real-Time Reliability Monitoring and Analysis Capabilities).
- Finalize the Transmission Operations/Interconnection Reliability Operations and Coordination (TOP/IRO) Project 2009-02 related to EMS and decision support tool aspects.

The NERC OC Should Perform these Additional Activities:

- Continue emphasis on work currently underway by the EMSWG, including analyzing and addressing unplanned full and partial EMS outages.
- Develop a guideline describing approaches for continued reliable operation following the loss of critical tools such as reliable real-time contingency analysis (RTCA) and automatic generation control (AGC).
- Develop a guideline to improve recognition of a neighboring entity's operation and planning impacts on interconnection-wide reliability and thereby enhance operational awareness and visibility.
- Collaborate with industry and vendors to develop best practices and change management processes for system design and maintenance that minimize the probability of downtime.
- Develop a guideline to improve preparedness following loss of situational awareness through effective mitigation techniques, such as manned substations, and adopting a conservative system operations posture when returning facilities to service.

The NERC PC Should Perform these Additional Activities:

- Review data protocols between BAs to ensure appropriate data modeling and information sharing needs are in place.

Industry Should Perform these Additional Activities:

- Improve preparedness following the loss of situational awareness by training personnel on effective mitigation techniques, such as manned substations, and adopting a conservative system operations posture when returning facilities to service.
- Clarify accountability for Reliability Coordinators and system operators to maintain awareness and understanding beyond their local systems.

Measures of Performance and Effectiveness

Near Term

- Develop trends for EMS availability and performance including an initial baseline measure of the frequency and duration of unplanned full and partial EMS outages.

Midterm

- A guideline emphasizing best practices and approaches for continued reliable operations following loss of critical tools
- A guideline addressing operational recognition of a neighboring entity's operation and planning impacts on interconnection-wide reliability
- A review of data protocols between planning entities to ensure that appropriate data modeling and information sharing needs are in place

Risk Profile #4A: Cyber Security

Cyber security vulnerabilities generally refer to reliability risks to the BPS that include the expanding use of both network and digital assets across BPS elements while increasing the interrelationships with distributed resources. These vulnerabilities can be exploited through the use of computer-based attacks with the intention of damaging or destroying a computer network or BPS functions. Cyber vulnerabilities represent an area of increased focus due to the potential for harm and disruption that it represents to utilities, telecommunications, and other industries. This potential risk to the BPS arises from exploits of respective vulnerabilities arising from the expanding use of network-based devices coupled with the expanding use of digital control assets from all forms of resources additions, in particular renewables and distributed generation. Overall Risk Priority – High

Detailed Reliability Risk Description

The implementation of mandatory Critical Infrastructure Protection (CIP) standards and the establishment of the E-ISAC, including the Cyber Security Risk Information Sharing Program (CRISP) program, are substantial risk mitigation measures representing the base foundation of mitigation for cyber vulnerabilities. Cyber vulnerabilities pose a threat to the BPS reliability that is constantly evolving, requiring adaptive and flexible approaches to reduce the risk of these attacks. The growing effectiveness of the partnership and information sharing among industry participants, E-ISAC within NERC, GridEx exercises and GridSecCon, and with government agencies provides near real-time information to address these threats. The continued expansion and effectiveness of these measures to resolve communication or information sharing gaps between the cyber experts and industry operators should help lessen these vulnerabilities and provide for enhanced industry posture by more rapid identification and response. The fast-paced changes in technology, the addition of increased automation, remote control technology, digital devices, control systems, and grid sensors continue to present an expanding breadth of the approaches necessary to provide the close monitoring and operations of systems. The industry will need more advanced tools to counter ever-evolving threats.

Current Risk Management Posture

Government-Industry Collaboration

- The Department of Homeland Security (DHS) revised the National Infrastructure Protection Plan (NIPP), providing a comprehensive risk management framework that includes electricity-sector-specific plans to contribute to national critical infrastructure security and resilience.
- The Department of Energy (DOE) and industry developed the Electricity Subsector Cybersecurity Capability Maturity Model (ES-C2M2), providing a reference model for gauging the maturity of an overall security program.
- NERC, the DOE, and industry developed a comprehensive information sharing and management facility called the Cyber Security Risk Information Sharing Program (CRISP) which is continuing an expanded implementation within industry.

NERC-Industry Collaboration

- Lead the development of anticipatory/predictive guidelines and expectations to enhance the mitigation, incident containment, and effective recovery/restoration of potential cyber threats across the electric sector entities, including states, federal agencies, industry, and the ERO.
- The E-ISAC has expanded its information sharing and analytic capabilities, including strengthening functional separation.
- The CIP Reliability Standards ensure the security of cyber assets that are essential to the reliable operation of the electric grid, and they were recently expanded to include provisions related to physical security protection.

- The biennial Grid Security Exercise (GridEx) events include a North American drill with national and local scenarios to exercise the detection and response capabilities to coordinated cyber and physical attacks. These are complemented by the Grid Sec Con initiatives.
- The Cyber Risk Preparedness Assessment (CRPA) provides on-site assessments that are performed by NERC staff to help owners evaluate their overall risk preparedness.
- Develop expanded interdependency collaboration with the telecommunications sector to enhance resilience, recovery, and anticipation of threats potentially impacting the BPS.
- Develop expanded interdependency collaboration, including the use of NAESB and the forums with the natural gas sector, to enhance the cyber integrity requirements while considering potential joint-standards, reviews, evaluations of coordinated standards or protocols.

NERC Technical Committee – Critical Infrastructure Protection Committee (CIPC) Initiatives

- The BES Security Metrics Working Group is continuing development of metrics to measure the state of BPS security and is providing periodic reports.
- The Electricity Sub-sector Information Sharing Task Force is developing a framework for the type of information to share that would be beneficial for both the E-ISAC and the industry.
- The Cyber Attack Tree Task Force has developed information/profiles that will be useful in identifying potential attack vectors that have been transferred to the E-ISAC for implementation.
- The Security Training Working Group is developing informational workshops and webinars on current cybersecurity-related issues.
- The CIPC is updating the business continuity guidelines and recommendations.

Electricity Sub-sector Coordinating Council (ESCC)

- The ESCC conducted a far-reaching strategic review of the effectiveness of the E-ISAC, CRISP deployment, and respective drills/exercises, resulting a series of enhancing recommendations.
- The ESCC provides strategic guidance and recommendations for actions that enhance the effectiveness of cyber security measures and protect the electricity infrastructure from physical and cyber threats.
- The ESCC developed an extreme event approach and guidance on obtaining expanded security clearances for improved information sharing between industry and government entities.

Findings, Conclusions, and Recommendations

NERC Should Continue to Perform these Additional Activities:

- Develop an E-ISAC implementation strategy plan from the ESCC Strategic Review recommendations.
- Enhance the effectiveness of near real-time communication and information sharing between E-ISAC and the industry.
- Enhance the implementation and deployment of the CRISP program/technology and integrate it within the E-ISAC work scope.
- Continue to facilitate deployment of CRISP technology and enhanced actionable communication among participants.
- Develop outreach to industry on extreme event preparation and enhanced communications scenarios.
- Develop an oversight plan to evaluate, monitor, and incorporate emerging technologies to maintain perspective on the need to expand to address reliability with evolving technologies and threats.

- Conduct effective and evolving cyber exercises and drills.

Industry Should Perform these Additional Activities:

- Participate in exercises that incorporate coordinated cyber and security events.
- Incorporate new E-ISAC and ESCC communications protocols into utility disaster preparedness processes.
- Assess the reliability impact of supply chain vulnerabilities
- Incorporate lessons learned from exercises and extreme events into disaster preparedness processes.

The NATF and the NAGF Should Perform these Additional Activities:

- Identify and promote specific resiliency best practices with regard to preparation for extreme events.

Measures of Performance and Effectiveness

Near Term

- No significant impact to reliability or business continuity due to cyber or physical security incidents
- Continue expansion of a NERC-developed E-ISAC strategic plan, including expanded deployment of the CRISP and other technology.
- Continue expansion of regional/national exercises that reflect cyber/physical security events, sharing within industry, and expanded participation in extreme event preparedness efforts.
- Continue to develop appropriate metrics for effectiveness of the E-ISAC and CRISP programs

Midterm

- Work with industry executives, the NATF, and the NAGF to identify best practices on cyber security and indicators of compromise.
- Integrate extreme event exercises and communications across industry participants.
- Establish forums and effective information sharing capabilities within the ERO and industry to exchange cyber risk assessment and mitigation strategy best practices.
- Expand the development of effective metrics to determine the trends of cyber threat actors.
- Increase CRISP deployment as well as machine based information sharing with government, industry, and ES ISAC.
- Develop an effective plan to ensure joint coordination of ISAC efforts on potential supply chain disruptions.
- Develop an effective plan to evaluate, monitor, and incorporate adoption of emerging new technologies to identify any reliability needs to address these evolving technologies and threats.
- Expand involvement of E-ISAC representatives in industry meetings to enhance operational and cyber knowledge transfer across the industry.

Long Term

- Effectively position the industry and NERC to adapt/evolve in pace with evolving technology and security attack vulnerabilities.
- Expand effectiveness and sustainable relationships with ESCC, government, industry and ERO.
- Advance a culture of cyber security preparedness across the electric sector participants.

Actions Completed – Implemented

- Established effective communication between E-ISAC and the Operating Reliability Subcommittee (ORS).
- Established effective communication between E-ISAC and the Bulk Power Situational Awareness (BPSA) group.
- E-ISAC Effectiveness Report completed by ESCC
- Goals for target numbers of CRISP participants by specific dates has been completed.
- Ensure functional and physical separation of E-ISAC staff and NERC staff with a strong code of conduct and restrictions on passing information to FERC, NERC and RE staff for compliance and enforcement purposes.
- Model various scenarios (contingency analysis) on systematic cyber-attack and consider standard design basis.

Risk Profile #4B: Extreme Physical Natural Events

The likelihood and risk to reliability from extreme physical events, such as severe weather like Hurricanes Katrina and Sandy or the Polar Vortex, that can lead to extensive damage potentially impacting large portions of a Region or interconnection is stable. At the same time, the expectations among customers, government, and others for effective and timely restoration and recovery are increasingly heightened. As a result, the potential BPS impact consequences and increasing expectations are high enough that additional risk mitigations warrant attention. Overall Risk Priority – Moderate

Detailed Reliability Risk Description

Severe weather events (e.g., hurricanes, tornadoes, protracted extreme temperatures, GMDs, etc.) are physical events that, at the extreme, can cause extensive interconnection-wide equipment damage, fuel limitations, and disruptions of telecommunications. Because of the long lead time involved in manufacturing and replacing some BPS assets, an extreme physical event that causes extensive damage to equipment could result in degraded reliability for an extended period of time. While isolated and local physical events have a high likelihood of occurrence, the possibility of extensive interconnection-wide events is low. However, the potential consequences of such an event are high enough that additional focus is needed to properly address this risk; furthermore, risk management activities for extensive regional or interconnection-wide events will likely have collateral value in improving resilience to more common localized or regional scale events. While additional facilities and infrastructure could be one aspect of enhanced mitigation, permitting, siting, and construction of additional facilities will require long lead times for implementation.

Current Risk Management Posture

Ongoing Problem Evaluation – NERC's technical committees research and analyze specific issues related to this risk, such as the work being done by the Geomagnetic Disturbance Task Force (GMDTF), Severe Impact Resiliency Task Force, and the CIPC.

Raising Awareness – NERC publishes special assessments and reports as needed, like *High-Impact, Low-Frequency Event Risk to the North American Bulk Power System* (2009), *Geo-Magnetic Disturbances (GMD): Monitoring, Mitigation, and Next Steps* (2011), and *Effects of Geomagnetic Disturbances on the Bulk Power System* (2012). Perform event analysis on cold weather events like the polar vortex, including collaboration with industry to secure detailed information on failures for subsequent analysis.

Mandatory Reliability Standards – Industry has developed requirements related to GMD in EOP-010 and TPL-007 Reliability Standards.

Develop Coordination Programs – Expand industry partnership with related industry strategic spare resource efforts [e.g., EEI STEP and STEP connect, the DOE Recovery Transformers, etc.].

Industry Initiatives – Industry has been performing the following activities:

- The ESCC has developed a national disaster approach that includes tabletop exercises and cross-sector relationships with strategic infrastructure, including telecommunications, finance, downstream natural gas, water, and transportation.
- Industry has participated in restoration and recovery drills.
- Entities have developed specific business assurance programs that include continuity planning and exercises.

Findings, Conclusions, and Recommendations

NERC Should Perform these Additional Activities:

- Complete the implementation of the GMD standards across industry.
- Expand communications among the E-ISAC, the Telecommunications ISAC, and the Natural Gas ISAC.
- Assess the risks to the BPS of the following through the long-term reliability assessments and planning activities:
  - Inadequate natural gas availability and pipeline capacity and their impacts on reliability
  - Multiple simultaneous limitations on natural gas deliveries during extreme cold weather
  - Vulnerability to GMD events
- Consider state-level requirements and factor them into any NERC reports or recommendations. Consult with states as needed.
- Analyze data from GMD events to further the understanding of geomagnetic induced current effects on BPS facilities.
- Institutionalize relationships among ESCC, Government, and industry partners.

Industry Should Perform these Additional Activities:

- Participate in exercises that incorporate extreme physical events.
- Incorporate new E-ISAC and ESCC communications protocols into utility disaster preparedness processes.
- Conduct a gap analysis of critical spare transmission equipment, including logistics transportation issues, to expand on industry participation in coordination support programs, such as EEI's Spare Transformer Equipment Program and EEI's SpareConnect program.
- Evaluate inventories of critical spare transmission equipment and increase as required.

The NATF, the NAGF, the NERC OC, and the NERC PC should perform these additional activities:

- Identify and promote specific resiliency best practices with regard to planning for extreme events.
- Develop an event guideline outlining event response protocols and recovery strategy elements for extreme physical events, building on the underlying practical necessities for EOP 5 and EOP 6.
- NERC (through the OC and PC) and industry should leverage the Severity Risk Index (SRI), potentially on a more granular regional level, as a measure of system resilience and restoration performance for loss of generation, transmission, and load. These efforts should consider enhancing existing or developing new comparative and descriptive metrics.

Measures of Performance and Effectiveness

Near Term

- Extreme physical events incorporated into NERC's GRIDEX activities.
- Encourage industry to refresh business continuity plans, reflecting extreme physical and cyber events.

Midterm

- NERC performance and reporting on joint E-ISAC and Telecommunications ISAC assessments of potential disruptions

- Determine spare equipment gaps and associated mitigation strategies.
- Develop analytic data trend insights regarding resiliency under severe weather conditions and identify preventable aspects for BPS integrity

Long Term

- Improving trend of SRI as indicative measure of system resilience and restoration performance for loss of generation, transmission, and load.

Actions Implemented – Completed

- NERC completion of the special long-term assessment that addresses the following:
  - Natural gas availability and pipeline capacity impacts on reliability
  - Multiple simultaneous limitations on natural gas deliveries during extreme cold weather
- FERC approved GMD standards, for both planning and operational aspects.
- FERC approved Physical Security Standards.
- Event guideline outlining prevention strategies and event response protocols.

Risk Profile #4C: Extreme Physical Man-made Events

While the likelihood of extreme physical events (such as a coordinated or localized physical attack) that lead to extensive interconnection-wide damage is low, the potential consequences are high enough that additional risk mitigations warrant attention. Overall Risk Priority – Moderate

Detailed Reliability Risk Description

Coordinated sabotage attacks, such as localized physical attacks of significance or portable EMP attacks, are physical events that, at the extreme, can cause extensive interconnection-wide equipment damage and disruptions of telecommunications. Because of the long lead time involved in manufacturing and replacing some BPS assets, an extreme physical event that causes extensive damage to equipment could result in degraded reliability for an extended period of time. While isolated and local physical events have a higher likelihood of occurrence, the likelihood of interconnection-wide events is low. The potential consequences of such an event are high enough that additional focus is needed to properly address this risk, despite the low likelihood of occurrence.

Current Risk Management Posture

Ongoing Problem Evaluation – NERC's technical committees research and analyze specific issues related to this risk, such as the work being done by the Severe Impact Resiliency Task Force and the CIPC.

Simulation and Training – NERC hosts the biennial GridEx, which identifies strengths and weaknesses by providing entities the opportunity to respond to simulated malicious attacks against the electricity subsector.

Raising Awareness – NERC publishes special assessments and reports as needed: *High-Impact, Low-Frequency Event Risk to the North American Bulk Power System* (2009).

Develop Coordination Programs – Expand industry partnership with related industry strategic spare resource efforts [e.g., EEI STEP and STEP connect, the DOE Recovery Transformers, etc.].

Mandatory Reliability Standards – Industry has developed Reliability Standard CIP-014-1 – Physical Security.

Partnering with Governmental Agencies – The risks related to an intentional coordinated attack and electromagnetic pulse can be mitigated in some measure as an act of national defense. In partnership with the ESCC, acting under the Critical Infrastructure Partnership Advisory Council (CIPAC) framework to protect sensitive information, industry (including NERC) leadership engages in dialogue with governmental agencies to explore potential mitigation strategies for such intentional acts. Reports with recommendations are provided to membership. See http://www.dhs.gov/critical-infrastructure-partnership-advisory-council for more information on how the ESCC works under security clearance with DHS and other agencies to better understand threats and associated recommendations. The CIPAC framework allows confidential topics to be discussed without triggering Freedom of Information Act (FOIA) requirements for disclosure.

Findings, Conclusions, and Recommendations

NERC Should Perform these Additional Activities:

- Oversee the implementation of the Physical Security Standard project (CIP-014-1).
- Enhance the effective communication between E-ISAC and the Telecommunications ISAC.
- Assess the risks of physical attack scenarios on midstream or interstate natural gas pipelines with respect to natural gas availability for generation and pipeline capacity impacts on reliability to the BPS in the long-term reliability assessments and planning activities.

- Institutionalize relationships among ESCC, Government, and industry partners, in part to enhance a culture of recognizing and addressing extreme physical event preparedness across industry.

Industry Should Perform these Additional Activities:

- Expand participation in security exercises that reflect extreme physical events.
- Conduct a gap analysis of critical spare transmission equipment and transportation logistics issues in order to expand industry participation in coordination support programs, such as the NERC Spare Equipment Database, EEI's Spare Transformer Equipment Program, and EEI's SpareConnect program.
- Evaluate inventories of critical spare transmission equipment and increase as required.
- NERC and industry should leverage the SRI as an indicative measure of system resilience and restoration performance for loss of generation, transmission, and load under physical man-made compromises.

The NATF, the NAGF, should perform these additional activities:

- Forums effectively develop mitigation strategies and physical security assessment best practices.
- Identify and promote specific resiliency and vulnerability assessment best practices with regard to planning for extreme events, including good physical security assessment practices.
- Develop an event guideline outlining prevention strategies and event response and recovery protocols for man-made physical attack scenarios.

Measures of Performance and Effectiveness

Near Term

- Develop catalog of regional/national exercises that incorporate extreme physical events and share information with industry, supporting increased participation across industry.
- Industry refreshes updated business continuity plans reflecting consideration of physical security scenarios.

Midterm

- Develop effective performance and metrics reporting on joint E-ISAC and Telecommunications ISAC assessments of potential man-made physical attack disruptions, differentiating from vandalism or theft incidents.
- NERC should conduct a scenario special regional assessment that addresses the following:
  - Natural gas availability and pipeline capacity reliability impacts under man-made physical attack scenarios
  - Multiple simultaneous compromises on natural gas deliveries during extreme cold weather from man-made attacks
- Identify spare equipment gaps, transportation logistics issues, and effective mitigation strategies.
- Evaluate mechanisms for cost recovery of implementing specific resiliency strategies by the industry.
- Effective metrics are formulated to understand the trend of physical attacks and potential threats.

Long Term

- Leverage the SRI as a measure of system resilience and restoration performance for loss of generation, transmission, and load under physical man-made attacks scenarios.

Actions Implemented – Completed

- FERC-approved Physical Security standard (CIP-014-1).

Risk Profile #4D: Pandemic

The risk of a pandemic is unique when compared to other risk areas. This risk area may impact a large number of people who become infected with a disease that can be transmitted from human to human. When a pandemic occurs, severe loss of uniquely trained staff will be experienced across the ERO and the industry. Overall Risk Priority – Low

Detailed Reliability Risk Description

Pandemic generally refers to an event occurring over a wide geographical area and affecting an exceptionally high proportion of the population. Industry has in the past prepared plans for responding to a pandemic. While a pandemic has a low likelihood of occurring, the impact could be high (i.e., Ebola pandemic or swine flu pandemic). Consideration should be given regarding what to do to prevent the pandemic as well as how to recover and maintain reliability during one. Pandemic is currently considered a low-likelihood, albeit high-impact, event.

Current Risk Management Posture

- EEI provides the Threat Scenario Project.
- NERC and DOE developed the *High-Impact, Low-Frequency Event Risk to the North American Bulk Power System* report (2010).
- Entity-specific business continuity programs include continuity planning and exercises.
- Utilities and other appropriate entities participate in state, local and federal exercises.

Findings, Conclusions, and Recommendations

NERC should perform these additional activities:

- NERC activities should primarily be categorized as monitoring in nature.
- Pandemic plans should be monitored as needed by the ERO.
- Include pandemic response in regular business continuity table-top exercises designed to reveal any gaps between the roles and expectations of government and industry.
- Continue to monitor pandemic or infectious disease likelihood through interfaces with the Centers for Disease Control and Prevention (CDC), World Health Organization (WHO), and state and federal government entities.
- Communicate pandemic or infectious disease likelihood to industry as warranted.
- Maintain communication with the CDC, WHO, and appropriate government entities as appropriate regarding developing pandemic threats and issues. Provide periodic communications on pandemic or infectious disease likelihood to industry.
- Plan to include pandemic response in regular business continuity table-top exercises designed to reveal any gaps between the roles and expectations of government and industry. Disseminate the exercise outcomes and reports on lessons learned.

Measures of Performance and Effectiveness

- A strategic plan for establishing parameters for the pandemic model, objective, and coordination of facilitators and participants using the universal risk assessment method being widely available.

Risk Profile #5: Inadequate Human Performance

Human Performance (HP) error is indicative of conditions that depart from expected behavior and can result in an event if barriers are not in place and effective. Latent errors include deficient management controls, processes, design, and at-risk behaviors. An HP event is a consequence of an HP or human factors error, and an underlying cause or contributing factor arises in the increasingly complex BPS reliability behavior, expanding information streams, and conversion aspects from data into actionable data. Overall Risk Priority – Moderate

Detailed Reliability Risk Description

NERC's Event and wide-area system analyses have identified human performance as a key problem that spans a number of potential issues and reflects the contribution of organizational culture and management to operational error. Specifically, enhanced management controls and programs reduce operational errors, and enhance the ability to identify and address precursor conditions that enable effective mitigation and behavior management that lessen or eliminate the impact of an event. Broad industry engagement renders more organizational support to reduce operational errors and ensure such errors are not repeated. Reliability Standards continue to contribute to improved human performance (i.e., Reliability Standard COM-002-4 for three-part communication). Increasing complexity of BPS resources and associated reliability behavior coupled with the increasingly diverse and complex information streams presented to operators and planners lead to potential HP issues related to translating data into actionable information.

Current Risk Management Posture

- NERC is aggressively working to improve industry performance in this area through training and communication initiatives within the Event Analysis program, Alerts, and lessons learned.
- NATF has established the HP Practices Group, which can increase its dissemination of insights in partnership with NERC.

Findings, Conclusions, and Recommendations

NERC Should Perform these Additional Activities:

- In partnership with the NATF's HP Practices Group, expand the assistance and communication of insights throughout the industry regarding best practices for increasing HP effectiveness through event analysis, root cause analysis, and lessons learned.
- Develop and distribute lessons learned, advisories and alerts, and disseminate detailed event or incident reports in a timely and secure fashion.
- Continue to expand industry engagement with workshops and seminars, such as the HP conference and workshop.
- Expand HP education and training, and use the OC to support guidelines and relevant materials for industry dissemination.
- Review the human factors aspects of complex data streams for integration in a white paper and a related guideline of enhanced practices.

Measures of Performance and Effectiveness

Midterm

- NERC's State-of-Reliability Report documented metrics including the trends associated with HP and human factors aspects of events and incidences.

Risk Profile #6: Inadequate Event Response or Recovery

The risk associated with inadequate event response/recovery incorporates the failure to safely and efficiently restore transmission service to critical load in a timely manner. Failure is indicated when insufficient methods or resources are deployed following an event and such methods contribute to prolonged transmission outage durations, thereby increasing the duration of BPS unreliability. Overall Risk Priority – Low

Detailed Reliability Risk Description

The effect of inadequate event response and recovery is far reaching. For example, during restoration activities, owners and operators of BPS facilities are exposed to safety, operational, or equipment-related risks. The concerns could be amplified in a hastily performed restoration where procedures are rushed or discarded. From the customer's perspective, a prolonged transmission outage or frequent intermittent disruptions because of poor response or recovery could impact critical health services such as fire and rescue operations.

Inadequate event response and recovery occurs when an entity cannot effectively mobilize or use available resources to restore transmission service in the most timely, safe, and cost-effective manner. While each event is unique, an effective recovery includes some attributes that are (1) within an entity's control and (2) can be measured against realistic expectations. Attributes may include adequate material stores, specialized fleet/equipment, possessing a skilled workforce, and established safety procedures/protocols.

Current Risk Management Posture

The Following Entity-Specific Efforts Enhance Event Response and Recovery:

- Spare equipment initiatives provide focus on maintaining sufficient stores of materials in times of emergency.
- Fleet maintenance programs ensure that specialized fleet and equipment is available and ready to assist in recovery.
- A skilled workforce is better prepared through professional development, drills/exercises, and planning. Together, these efforts allow engineers and operators to understand an entity's system operating characteristics and flexibility.
- Safety procedures and protocols are reinforced through business continuity plans and incident response teams.

Various Entities Provide Leadership and Assistance:

- EEI provides the Voluntary Mutual Assistance Program, the Spare Transformer Equipment Program (STEP), the SpareConnect program, and executive support of business continuity initiatives.
- NERC's SED program and Grid Ex tabletop exercises across industry include specific attention to recovery and response aspects.
- The NATF maintains a peer review program and several practice groups focused on improving electric transmission system performance.
- The ESCC provides direction and sponsorship of high-level industry and government emergency plans and approaches, including efforts designed to enhance the effectiveness for the E-ISAC and expand the CRISP deployment among registered entities.
- NERC's Reliability Risk Management program area includes the Event Analysis and lessons learned programs, which provide integral functions for improving performance.

Findings, Conclusions, and Recommendations

NERC and the NERC OC Should Perform these Additional Activities:

- Develop metrics and drill elements to improve the overall industry posture on post-event preparedness. An entity can use these as a learning experience for preparation with future events.
- Explore opportunities to engage Regional Entities, trade associations, and industry forums (e.g., EEI and NATF) on specific and cost-effective solutions to improve response times.
- Promote the alignment of event analysis and lessons learned with system hardening and resiliency measures such that entities can better plan, budget, and implement lasting and robust solutions after major events.

Industry:

- Identify through partnership with the NATF regarding best practices on how to approach public and public officials to understand restoration prioritization needs.

Measures of Performance and effectiveness

Near Term

- An established communications plan to inform industry on best use of reliability metrics and indices

Midterm

- A strategic plan for highlighting BPS restoration best practices and indices for gauging improvement
- A preliminary assessment highlighting risk areas and collaborative solutions as recommended by Industry, NERC, ESCC, and other stakeholders

Actions Implemented – Completed

- Outreach to trade associations and industry forums was conducted to ensure consistent understanding of the risk of inadequate event response and recovery.