NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

ERO Top Priority Reliability Risks 2014-2017

January 16, 2014

Executive Summary

NERC staff has collected input from the Reliability Issues Steering Committee (RISC), the leadership of the Standing Committees, and other stakeholders and NERC staff to develop a set of ten top priority reliability risks for consideration in the development of the 2014-2017 ERO Enterprise Strategic Plan. These risks warrant additional focus. In rank order, the top priority reliability risks are: Changing Resource Mix, Resource Planning, Protection System Reliability, Uncoordinated Protection Systems, Extreme Physical Events, Availability of Real-Time Tools and Monitoring, Protection System Misoperations, Cold Weather Preparedness, Right-of-Way Clearances and 345-kV Breaker Failures. Recommendations for action and measures of success are included.

Summary of Top Priority Reliability Risks

NERC reviewed and assembled information from various committee reports and stakeholder inputs to develop a set of ten top priority reliability risks for use in the development of the 2014-2017 ERO Enterprise Strategic Plan. Starting with the RISC's gap analyses[1] presented to the Board of Trustees in August, 2013, staff undertook further review and analysis to identify any additional reliability risk areas of strategic importance for the ERO. Next, qualitative estimates of probability, consequence, and current level of risk management were prepared for each of the identified reliability risks within the chosen areas. These were used to identify ten top priority reliability risks requiring increased attention or additional activity. Following this analysis, recommendations were developed based on previous committee discussions; industry dialogue at the Reliability Leadership Summit; and past committee work products, such as the Long Term Reliability Assessment, the State of Reliability Report, and various special reports and assessments. These recommendations include a number of different approaches based on the various tools NERC has available to influence reliability (such as Guidelines, Information Requests, Training, Standards, and others).

Listed below are the ten high priority reliability risks intended to focus ERO enterprise program areas, including training and education, standards setting, and compliance. Some of these priorities represent conclusions based on experience from reviewing actual system events (topics 3, 4, 6, 7, 8, 9 and 10) while others are more forward looking based on analysis, assessments, and forecasts (topics 1, 2, and 5). These priority risks will be considered in the development of the 2014-2017 ERO Enterprise Strategic Plan, which will in turn lead into the development of the business plan and budget, ultimately aligning resources across the ERO enterprise and program areas to help ensure the most efficient and effective approaches are undertaken to improve or maintain reliability.

[1] See http://www.nerc.com/comm/RISC/Related%20Files%20DL/RISC_Priority_Recommendations-Jul_26_2013.pdf for the complete report.

The list is in rank order. Detailed profiles for each reliability risk are provided after the list.

1. **Changing Resource Mix.** As the generation and load on the power system changes (e.g. integrated variable resources, increased dependence on natural gas, increased demand-side management, new technologies deployed), the system is being brought into states that are significantly different than those considered when the system was designed and planned, exposing new vulnerabilities not previously considered. Fundamental operating characteristics and behaviors are no longer a certainty. Absent focused action to respond, this risk will increase.
2. **Resource Planning.** Plant retirements (largely due to implemented environmental regulations; increased uncertainty in future resources due to other potential environmental regulations; and lower natural gas prices, which significantly affect power plant economics) are leading to cases where resources may be inadequate to ensure firm demand is served at all times. As the system continues to change, some regional assessments identify concerns with insufficient reserve margins as early as 2014 and 2015 in the ERCOT and Midcontinent ISOs.
3. **Protection System Reliability.** A fault accompanied by a failure of any Protection System component could in some cases result in instability, violation of applicable thermal or voltage ratings, unplanned or uncontrolled loss of demand or curtailment of firm transfers, or cascading outages. Such cases should be identified and addressed.
4. **Uncoordinated Protection Systems.** A lack of protection system coordination has the potential to increase the size and magnitude of events due to unnecessary trips. Uncoordinated protection systems were identified as contributing to the September 8, 2011 and August 14, 2003 events. Ensuring protection system coordination should be a priority for the ERO.
5. **Extreme Physical Events.** While the probability of physical events (such as physical attack, geomagnetic disturbance, or severe weather) that lead to extensive damage is low, the potential consequences are high enough that risk avoidance (reducing the probability) is insufficient as a sole risk management strategy. Risk mitigation efforts (reducing the potential consequence) are also underway, but additional focus is needed to address this risk and minimize both the magnitude and duration of the consequences of an extreme physical event.
6. **Availability of Real-Time Tools and Monitoring.** Not having the right tools and monitoring available to manage reliability in real time is a latent problem waiting for the right combination of events. Such events occurred August 14, 2003, and September 8, 2011, resulting in significant blackouts. Reducing the probability of entities not having key capabilities is essential.
7. **Protection System Misoperations.** NERC's 2012 and 2013 State of Reliability Reports identified protection system misoperations as a significant threat to BPS reliability. Additional activities are needed to ensure this risk is managed adequately.
8. **Cold Weather Preparedness.** Lack of generator preparedness for cold weather extremes may result in forced outages, de-ratings, and failures to start. Insufficient availability of intra-regional generation and limits on import transfer capability may result in insufficient generation to serve forecasted load, resulting in load shedding.
9. **Right-of-Way Clearances.** Transmission Owners and applicable Generation Owners may have established incorrect ratings based on design documents, rather than on the actual facilities built.

Managing to stay within SOL and IROL limits that are based on incorrect ratings may be inadequate to prevent equipment damage and/or cascading, instability, or separation.

10. **345-kV Breaker Failures.** NERC has identified a potential trend of 345 kV SF6 puffer type breakers failing. Circuit breaker failures, in conjunction with another fault, may lead to more BES Facilities removed from service than required to clear the original fault. This poses a risk to the reliability of the BES.

Alignment with RISC Priority Recommendations

The matrix below illustrates the alignment of these ten priority reliability risks with the broader risk areas recommended by the RISC. As reported by the RISC at the November 2013 Board Meeting, many of the risk areas they identified are in the process of being addressed and are on track for being well managed (see FOOTNOTE 1 and FOOTNOTE 2). However, a key priority area identified in the RISC report, emphasized at the 2013 Reliability Leadership Summit, and reported verbally at the November Board of Trustees meeting was the need to adapt and plan for change. Accordingly, this is reflected in the top two priority risks (nos. 1 and 2) identified in this document. While protection systems continue to be a focus area for the ERO (and several aspects have been addressed), NERC can use additional tools to improve performance in this area. As such, three of the ten top priority projects (nos. 3, 4, and 7) address protection system performance. One top priority (no. 6) deals with availability of real-time tools and monitoring, which was highlighted at the Leadership Summit as well. While activities are ongoing in this area, NERC can do more to address this risk. The four remaining top priority risks (nos. 5, 8, 9, and 10) are ones that NERC has concluded deserve additional attention, as explained in NOTE 3, NOTE 4, NOTE 5, and NOTE 6.

Alignment between ERO Top Priority Reliability Risks and RISC Priority Reliability Risk Areas

	Blue shading indicates alignment between an ERO Top Priority and a RISC High Priority Area	High Priority Areas from the July 26, 2013 RISC Report "ERO Priorities: RISC Updates and Recommendations"						
						Adaptation and Planning for Change		
		Cyber Attack SEE NOTE 1	Workforce Capability and Human Error SEE NOTE 2	Protection Systems	Monitoring and Situational Awareness	Long Term Planning and System Analysis	Resource and Transmission Adequacy	Integration of New Technologies and Operations
ERO Top Priority Reliability Risks 2014-2017	Changing Resource Mix					■	■	■
	Resource Planning						■	
	Protection System Reliability			■				
	Uncoordinated Protection Systems			■				
	Extreme Physical Events SEE NOTE 3							
	Availability of Real-Time Tools and Monitoring				■			
	Protection System Misoperations			■				
	Cold Weather Preparedness SEE NOTE 4							
	Right of Way Clearances SEE NOTE 5							
	345-kV Breaker Failures SEE NOTE 6							

NOTE 1 – Current activities related to Cyber Attack are appropriately scoped and moving forward, and do not require additional ERO focus at this time.
NOTE 2 – Current activities related to Workforce Capability and Human Error are appropriately scoped and moving forward, and do not require additional ERO focus at this time.
NOTE 3 - The RISC recommended that Coordinated Attack on Multiple Facilities be treated as a medium priority, and that other risks involving physical damage (Geomagnetic Disturbance, Extreme Weather/Acts of Nature, Localized Physical Attack, and Electromagnetic Pulse) be treated as low priority. Their priority decisions were based in part on the "all-hazards planning" approach used by utilities when planning systems. However, this issue was discussed at some length at the 2013 Reliability Leadership Summit, and NERC management has concluded it deserves additional attention.
NOTE 4 - The RISC recommended that Generator Availability and Equipment Maintenance and Management be treated as medium priority. NERC management has concluded that Cold Weather Preparedness is still a risk that needs further attention before it can be considered adequately managed, especially given the recent challenges experienced in January 2014.
NOTE 5 - The RISC recommended that and Equipment Maintenance and Management be treated as medium priority, and that Transmission Right-of-Way be treated as a low priority. Until such time as the Facility Ratings Alert tasks are completed and the data indicates the risk has been adequate managed, NERC management has concluded this risk should continue to be a top priority.
NOTE 6 - The RISC recommended that and Equipment Maintenance and Management be treated as medium priority. However, because of the potentially wide-ranging consequences of this issue and the relative ease of correcting the problem, NERC management has concluded this risk should continue to be a top priority.

Cyber Attack, Workforce Capability and Human Error, and Other Considerations

Both Cyber Attack and Workforce Capability and Human Error were identified by the Reliability Issues Steering Committee as high-priority areas of reliability risk. However, they have not been highlighted in this report as priorities, as the current activities related to each area are appropriately scoped and moving forward.

Cyber Attack is a threat that is constantly evolving. As such, the ERO has made it a priority to build a framework that can be responsive to various attacks. This includes the establishment of the ES-ISAC, ongoing efforts to improve information sharing and analytic capabilities, and the use of various approaches to aid entities in preparation for Cyber Attack (such as the development of the CIP standards, creation and sharing of the Cyber-security Capability Maturity Model, and the biennial Grid Exercise). While work in this area remains important and will continue, it represents and ongoing need for focus, rather than an exception.

Similarly, Workforce Capability and Human Error is important, but represents a continuing need for attention. NERC has enhanced its voluntary event analysis process, and both NERC and the industry are learning a great deal through this collaborative process. However, this is an area where focus is constantly changing, and what is needed is an ongoing operational capability, rather than a specific effort. Work in this area remains important and will continue as part of the ERO's regular activities.

Additional areas for work was have been identified as well. AC Substation Equipment Failure was noted in the 2013 State of Reliability report as an area of concern; however, sufficient information has not been gathered to support its inclusion in this document. As more is learned and actionable plans are developed, this area will be considered for inclusion as a top priority for the ERO. Other areas that have been identified but require additional analysis include outage coordination and the broad topic of infrastructure maintenance.

The Reliability Risk Management Process (RRMP)

The process used to develop this list is an interim approach as NERC transitions to a broader planning effort titled the Reliability Risk Management Process (RRMP). NERC staff worked with the RISC to develop this process to ensure the consideration of reliability risk and the development of associated reliability risk management projects are reflected in ERO business planning activities. Under the RRMP, the RISC will collect information to identify and prioritize broad areas of reliability risk. These areas then undergo a deeper analysis to identify specific reliability risks, how they can be measured, and what are the most critical risks within those broad areas that should be considered for further risk management activity. Following this analysis, strategies for managing these reliability risks are developed. Such strategies may include the use of Guidelines, Information Requests, Training, NERC Alerts, Technical Conferences, Research, Standards, and other tools. Strategies will be weighed for overall effectiveness and efficiency, and a plan will be developed that addresses each identified reliability risk with a set of approaches commensurate in scope to the level of risk being managed. Ultimately, these projects will be reflected in key ERO activities and the overall ERO planning process. The transition to the RRMP will be implemented and continuously improved over the next several years.

Risk Profile #1: Changing Resource Mix

Associated Reliability Risk Areas: Long Term Planning and System Analysis, Resource and Transmission Adequacy, Integration of New Technologies and Operations

As the generation and load on the power system changes (e.g. from integrated variable resources, increased dependence on natural gas, increased demand-side management, new technologies deployed), the system is being brought into states that are significantly different than those considered when the system was designed and planned, exposing new vulnerabilities not previously considered. Fundamental operating characteristics and behaviors are no longer a certainty. Absent focused action to respond, this risk will increase.

Detailed Problem Description

The energy currently produced by large rotating machines is being replaced with energy produced by variable resources, demand response programs, and other new types of resources, which exhibit different characteristics with respect to some of the less obvious fundamental components of reliable operation (*e.g.,* inertia, frequency response, maneuverability). At the same time, continuing improvements in 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). Finally, the ongoing shift in fuel from coal to natural gas brings its own sets of challenges, such as critical dependence on the just-in-time fuel supply chain of the natural gas infrastructure. All of these changes move the system toward different behaviors, operating characteristics, and levels of reliability risk.

Current Risk Management Activities

- **Ongoing problem evaluation.** Research and analysis by NERC's technical committees to address specific issues related to this risk, such as the work being done by the Integrating Variable Generation Task Force and their reports and recommendations.
- **Raising awareness.** Annually publishing Long-Term Reliability and Seasonal Assessments, and NERC special assessments (such as Maintaining Bulk Power System Reliability While Integrating Variable Energy Resources – CAISO Approach (2013); Accommodating an Increased Dependence on Natural Gas for Electric Power (2013), A Primer of the Natural Gas and Electric Power Interdependency in the United States (2011), Accommodating High Levels of Variable Generation (2009)).

Recommendations

Current activities provide information, but do not actively drive change. To directly respond to this risk, NERC should focus on these additional activities:

- **Execute previously proposed plans.** Implement the recommendations that have been made in the assessments and reports described above, such as:
  - Develop a standardized model of variable generation for stability and power-flow studies.
  - Develop guidelines for performing load composition modeling analysis; operations and emergency coordination with gas suppliers and transporters; planning considerations for variable energy resources, performance and monitoring requirements for variable energy resources.
  - Incorporate fuel risk and capacity impacts into long-term reliably assessments and planning activities.
  - Consider standards modifications to ensure appropriate applicability and alignment with reliability goals.
- **Define essential reliability services by the end of 2014**. Identify the fundamental components of reliable operation, and determine how to best ensure the need for those components is well understood and met (currently underway at the Planning Committee).

Measures of Success

- Stable and reliable levels for essential reliability services.
- Accurate forecasts of system performance that account for characteristics of the changes to the resource mix.

Risk Profile #2: Resource Planning

Associated Reliability Risk Areas: Resource and Transmission Adequacy

Plant retirements (largely due to implemented environmental regulations; increased uncertainty in future resources due to other potential environmental regulations; and lower natural gas prices, which significantly affect power plant economics) are leading to cases where resources may be inadequate to ensure firm demand is served at all times. As the system continues to change, some regional assessments identify concerns with insufficient reserve margins as early as 2014 and 2015 in the ERCOT and Midcontinent ISOs.

Detailed Problem Description

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. 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 employ environmental retrofits also may have impacts. This all contributes to a lack of certainty regarding resource adequacy in North America over the next several years. Forecasts show potential deficiencies in reserve margins as early as 2014 and 2015 in the ERCOT and Midcontinent ISOs.

Current Risk Management Activities

- **Ongoing problem evaluation.** Research and analysis by NERC's technical committees to address specific issues related to this risk, such as the work being done by the Reliability Assessments Subcommittee.
- **Raising awareness.** Publishing Long-Term Reliability Assessments and NERC special assessments: Potential Impacts of Future Environmental Regulations (2011); Resource Adequacy Impacts of Potential U.S. Environmental Regulations (2010).

Recommendations

While entities are aware of this issue and taking action, the amount of time required to implement solutions may be too long to provide relief in the near term, making a reactive approach inadequate. In order to be more proactive and provide assurance that issues are being addressed, NERC should undertake the following additional activities. Dependent on the results of these activities, NERC may need to consider whether its current body of Reliability Standards is sufficient to ensure this risk is appropriately managed.

- **Request information.** Ask entities experiencing problems with resource planning to provide explanations of the activities taken to manage this issue, as well as present regular progress updates.
- **Raise awareness.** Continue emphasis on sharing information through assessments. Meet with regulators to discuss the issue and explain the potential consequences. Issue press releases. Host technical conferences.
- **Promote Best Practices and Guidelines.** Collaborate with entities that have experienced challenges in maintaining sufficient reserve margins to develop best practices and guidelines to help other entities that may experience these challenges in the future manage the issue proactively.

Measures of Success

- Resource adequacy in all North American regions should reverse declining trends and approach target reserve margin levels by the end of the 2014-2017 period. Reserve margins forecasts should not fall below targets within the future three-year horizon.

Risk Profile #3: Protection System Reliability

Associated Reliability Risk Areas: Protection Systems

A fault accompanied by a failure of any Protection System component could in some cases result in instability, violations of applicable thermal or voltage ratings, unplanned or uncontrolled loss of demand or curtailment of firm transfers, or cascading outages. Such cases should be identified and addressed.

Detailed Problem Description

Protection Systems serve a vital role in defense against system disturbance events. However, there are cases where design of a protection system design may be insufficient - where a fault accompanied by a failure of any single Protection System component could result in outage significant event on the BES. One example is the June 24, 2004 Westwing outage event, which resulted in the loss of approximately 5,000 MW of generation and the potential for collapse of the Western Interconnection. NERC identified five events between 2004 and 2010 where a single point of failure on a protection system caused, in whole or in part, an event on the Bulk-Power System.

Current Risk Management Activities

- **Ongoing problem evaluation.** Research and analysis by NERC's technical committees to address specific issues related to this risk, such as the work being done by System Protection and Control Subcommittee.
- **Promote Best Practices and Guidelines.** System Protection and Control Subcommittee (SPCS) publication of a document explaining the need for and design of redundancy in protection systems.
- **Section 1600 Data Request.** NERC's ongoing data request and analysis to determine the risks to the Bulk Power System ("BPS") posed by potential single point of failure events.

Recommendations

Current activities provide information, but do not actively drive toward change. Because of the number of events in which this risk has been implicated, NERC must take a more active role in addressing the problem by focusing on these additional activities:

- **Continued data collection and analysis.** NERC's should continue its ongoing data request and associated analysis to determine the risks to the Bulk Power System ("BPS") posed by potential single point of failure events.
- **Mandatory Standards.** Upon the completion of the data request described above and dependent on the associated findings from that analysis, develop a standard that requires entities identify and address on an ongoing basis those cases in which a fault accompanied by a failure of any single Protection System component could result in instability, violations of applicable thermal or voltage ratings, unplanned or uncontrolled loss of demand or curtailment of firm transfers, or cascading outages.

Measures of Success

- Zero instances in which a single point of failure on a protection system causes or contributes to an event on the Bulk Power System.

Risk Profile #4: Uncoordinated Protection Systems

Associated Reliability Risk Areas: Protection Systems

A lack of protection system coordination has the potential to increase the size and magnitude of events due to unnecessary trips. Uncoordinated protection systems were identified as contributing to the September 8, 2011 and August 14, 2003 events. Ensuring protection system coordination occurs should be a priority for the ERO.

Detailed Problem Description

Protection systems that trip unnecessarily can contribute significantly to the size of an event. When protection systems 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. This can also occur with special protection systems, remedial action schemes, and under-frequency and under-voltage load shedding schemes. Such coordination errors occurred in the September 8, 2011 event (see Recommendation 19) and the August 14, 2003 event (see recommendation 21).

Current Risk Management Activities

- **Promote Best Practices and Guidelines.** SCPS publication of a document explaining the need for power plant and transmission system protection coordination, as well as associated training materials and webinars.
- **Mandatory Standards.** Development of requirements for sharing information and protection system coordination studies for interconnecting elements between functional model entities when certain system conditions change (Standards Project 2007-06 System Protection Coordination).

Recommendations

NERC already has requirements (and associated enforcement capability) to address this area of concern, and additional improvements are being developed. However, an increased focus on prevention in addition to accountability, education and coaching techniques will help produce positive results, especially given the complex nature of the subject. To this end, NERC should undertake the following additional activity.

- **Mandatory Standards.** Complete the standards project described above.
- **Develop Strategies for Coordination of Protection Systems and Other Devices.** Develop a best practices document on coordinating the design and operation of transmission system protection, generator protection and control, special protection systems, and UFLS and UVLS programs; include modeling considerations necessary for assessing coordination through planning and operating assessments of system performance. The issue of coordinating protection systems and controls that respond to different quantities such as voltage, frequency, apparent impedance, and excitation, is not traditional relay-to-relay coordination. Coordination must be addressed in assessments of system performance to compare the response of protection and controls responding to different quantities, and to account for time-based and location-based variations in these quantities.
- **Promote Best Practices and Guidelines.** Continue to promote best practices and guidelines to aid in protection system design and coordination, such as developed by the SCPS as described above. Collaborate with industry, as well as other entities, to develop additional training programs and educational opportunities for protection engineers to share knowledge and learn about best practices and guideline associated with protection system coordination. Consider working with other bodies (e.g., Energy Providers Coalition for Education) to provide continuing education credits and improve certifications related to protection system education programs.

Measures of Success

- Downward trend in the frequency of unnecessary protection system trips caused by lack of coordination.

Risk Profile #5: Extreme Physical Events

Associated Reliability Risk Areas: Coordinated Attack on Multiple Facilities, Geomagnetic Disturbance, Extreme Weather/Acts of Nature, Localized Physical Attack, Electromagnetic Pulse

While the probability of physical events (such as physical attack, geomagnetic disturbance, or severe weather) that lead to extensive damage is low, the potential consequences are high enough that risk avoidance is insufficient as a sole risk management strategy. Risk mitigation is also underway, but additional focus is needed to address this risk and minimize both the magnitude and duration of the consequences of an extreme physical event.

Detailed Problem Description

Coordinated sabotage attacks, severe weather events, and geomagnetic disturbances are physical events that, at the extreme, can cause extensive equipment damage. Because of the long time involved in manufacturing and replacing some BES assets, an extreme physical event that causes extensive damage to equipment would result in degraded reliability for an extended period of time. While these events of this magnitude have a low probability of occurrence, the potential consequences of such an event are high enough that additional focus is needed to properly address this risk and minimize the consequences of an extreme physical event to acceptable levels.

Current Risk Management Activities

- **Ongoing problem evaluation.** Research and analysis by NERC's technical committees to address specific issues related to this risk, such as the work being done by the Geomagnetic Disturbance Task Force, Severe Impact Resiliency Task Force and the Critical Infrastructure Protection Committee.
- **Simulation and training.** The biennial Grid Exercise, which identifies strengths and weaknesses by providing entities the opportunity to respond to simulated malicious attacks against the electricity subsector.
- **Raising awareness.** Publishing NERC special assessments and reports: High-Impact, Low-Frequency Event Risk to the North American Bulk Power System (2009), Geo-Magnetic Disturbances (GMD):Monitoring, Mitigation, and Next Steps (2011), Effects of Geomagnetic Disturbances on the Bulk Power System (2012)
- **Mandatory standards.** Requirements related to GMD (Standards Project 2013-03 GMD Mitigation).
- **Develop coordination programs.** Establishment of NERC's Spare Equipment Database, which facilitates sharing of equipment in times of need. This is complementary to EEI's Spare Transformer Equipment Program.

Recommendations

While risk avoidance strategies can help prevent manifestation of this risk, a number of events are outside of human control, and avoidance strategies are ineffective. Mitigation efforts to reduce the magnitude of the consequence will address both malicious physical attack and those events which we have little or no ability to prevent.

- **Mandatory Standards.** Complete the standards projects described above.
- **Promote and support coordination programs.** Emphasize the need for industry to participate in coordination support programs, such as the Spare Equipment Database and the Spare Transformer Equipment Program.
- **Encourage resiliency.** Promote the sharing of resiliency best practices within NERC, as well as through collaborative activities with the North American Transmission Forum, the North American Generation Forum, and the North American Energy Standards Board. By leveraging best practices, the magnitude and duration of any significant event would be reduced. Additionally, support entities in pursuing and recovering the costs of implementing resilience strategies, such as the Recovery Transformer Program consortium's efforts to design and test a universal mobile spare transformer that could be deployed to respond to emergency needs quickly.

Measures of Success

- Increased participation in the Spare Equipment Database and Spare Transformer Equipment Program.
- Strategic deployment of recovery transformers across North America.
- Reduced durations of customer outages caused by extreme physical BPS events.
- Positive trending in other measures of system resilience and restoration performance.

Risk Profile #6: Availability of Real-Time Tools and Monitoring

Associated Reliability Risk Areas: Monitoring and Situational Awareness

Not having the right tools and monitoring available to manage reliability in real time is a latent problem waiting for the right combination of events. Such events occurred August 14, 2003, and September 8, 2011, resulting in significant blackouts. Reducing the probability of entities not having key capabilities is essential.

Detailed Problem Description

Less than adequate situational awareness has the potential for significant negative reliability consequences, and is often a precursor event or contributing cause to events. Experience has shown that not having the right tools and data available can play a critical role in reduced situational awareness, contributing to events such as those seen September 8, 2011 (see Recommendation 12) and August 14, 2003 (see Recommendation 22). NERC has analyzed data and identified that outages of tools and monitoring systems are fairly common occurrences, with approximately an 89% chance of a tool or monitoring system outage occurring within a given month. Each time one of these outages occurs, it creates a potential lack of situational awareness, resulting in a latent risk that could combine with other risks to produce a large event. In addition to outages, simply not having the correct tools or data provided to operators is also a key concern.

Current Risk Management Activities

- **Ongoing problem evaluation.** Research and analysis by NERC's technical committees to address specific issues related to this risk, such as the work being done by the Real-time Tools Best Practices Task Force.
- **Raising awareness.** Issuing Alerts, publishing Lessons Learned, presenting data and case studies to appropriate technical committees, and NERC's Monitoring and Situational Awareness Technical Conference, which provided a forum for vendors and users to share information and exchange knowledge about increasing EMS availability.

Recommendations

Current activities provide information, but do not actively drive toward change. Additional emphasis on education and coaching techniques will help produce positive results, especially given the complex nature of the subject. Because of the number of events in which this risk has been a factor, NERC must take an active role in addressing the problem. To more directly respond to this risk, NERC should focus on the following additional activities:

- **Raise awareness.** Continue emphasis on analyzing and addressing unplanned full and partial EMS outages, including activities such as issuing Alerts, publishing Lessons Learned, presenting data and case studies to appropriate technical committees, and hosting additional vendor/stakeholder conferences to discuss issues and strategies for minimizing unplanned full and partial EMS outages.
- **Develop Best Practices and Guidelines.** Collaborate with industry and vendors to develop best practices for system design and maintenance that minimize the probability of downtime, and a guideline to describe approaches for continued reliable operation following the loss of critical tools, such as reliable Real Time Contingency Analysis (RTCA) and Automatic Generation Control (AGC).
- **Mandatory Standards.** Develop a reliability standard to mandate minimum real-time monitoring and analysis capabilities (Standards Project 2009-02 Real Time Reliability Monitoring and Analysis Capabilities).

Measures of Success

- No event where a root, initiating, or contributing cause is identified as a Reliability Coordinator, Transmission Operator, or Balancing Authority not having the real-time tools and monitoring they need to maintain reliability.
- Downward trend in frequency and duration of unplanned full and partial EMS outages.

Risk Profile #7: Protection System Misoperations

Associated Reliability Risk Areas: Protection Systems

NERC's 2012 and 2013 State of Reliability Reports identified protection system misoperations as a significant threat to BPS reliability. Additional activities are needed to ensure this risk is managed adequately.

Detailed Problem Description

Protection System Misoperations represent a double threat. Unnecessary trips can result in making a bad event worse, and even start cascading failures as each successive trip can cause another protection system to trip. However, failures to trip and slow trips can result in damaged equipment, which may result in degraded reliability for an extended period of time. Key Finding 4 from NERC's 2012 State of Reliability Report concluded protection system misoperations are a significant contributor to disturbance events and automatic transmission outage severity.

Current Risk Management Activities

- **Ongoing problem evaluation.** Research and analysis by NERC's technical committees to address specific issues related to this risk, such as the work done by the Protection System Misoperations Task Force.
- **Promote Best Practices and Guidelines.** The Protection System Misoperations Task Force development of a set of suggestions for addressing commonly seen problems and improving protection system performance through the development of guidelines. Ongoing development of training modules to further educate the industry in this area.
- **Raise awareness.** Publication of misoperations statistics in the State of Reliability Report, highlighting this risk. Quarterly updates and outreach to the Regional Protection Committees.
- **Information Requests.** Data collection and analysis regarding protection system misoperations, as well as additional activities to improve processes for collecting data and ensuring data quality and collaborating with other organizations for more focused analysis.
- **Mandatory Standards.** Development of requirements for analysis and corrective action for all protection system misoperations (Standards Project 2010-05.1 Phase 1 of Protection Systems: Misoperations), as well as a standard requiring appropriate disturbance monitoring equipment (Standards Project 2007-11 Disturbance Monitoring).

Recommendations

Increased focus on prevention through education, awareness, and coaching techniques are also expected to produce positive results, especially given the complex nature of the subject. To this end, NERC should undertake the following additional activities.

- **Mandatory Standards.** Complete the standards projects described above.
- **Promote Best Practices and Guidelines.** Develop best practices and guidelines to aid in the proper application of relay elements, minimizing setting errors, maintaining microprocessor-based relay firmware, and the application of power line carrier communication aided protection. Collaborate with industry, as well as other entities, to develop training programs and educational opportunities for protection engineers. Consider working with other bodies to provide continuing education credits and improve certifications related to protection system education programs.
- **Raise Awareness.** Develop a better understanding of regional differences in protection system misoperation rates to support actions to reduce variability, where appropriate. Actively engage the industry through different forums (conferences, regional committee meetings, etc.) to promote awareness and foster mitigation measure development.

Measures of Success

- Variability of regional and registered entity misoperation performance is reduced.
- Overall median misoperation performance rate improves.

Risk Profile #8: Cold Weather Preparedness

Associated Reliability Risk Areas: Extreme Weather/Acts of Nature, Generator Availability

Lack of generator preparedness for cold weather extremes may result in forced outages, de-ratings, and failures to start. Insufficient availability of intra-regional generation and limits on import transfer capability may result in insufficient generation to serve forecasted load, resulting in load shedding.

Detailed Problem Description

Lack of generator preparedness for cold weather extremes may result in forced outages, de-ratings, and failures to start. During wide-area extreme weather events, unexpectedly large amounts of generation may be unavailable within a region or sub-region. Failure to communicate changes in operating status of generation during next-day and real time operations time periods may result in inaccurate Balancing Authority generation/load forecasts. Insufficient availability of intra-regional generation and limits on import transfer capability may result in inadequate generation to serve forecasted load, resulting in load shedding.

Current Risk Management Activities

- **Promote Best Practices and Guidelines.** NERC Operating Committee development of a guideline for generator unit winter weather readiness. Ongoing training offerings to further educate the industry in this area.
- **Raise awareness.** Annual notifications, reminding entities to prepare for cold weather.

Recommendations

The industry experiences in January 2014 were less severe that those from the 1994 and 2011 cold weather events. Despite this, more work remains to be done. NERC should undertake the following additional activities. Dependent on the results of these activities, NERC may need to consider whether its current body of Reliability Standards is sufficient to ensure this risk is appropriately managed.

- **Promote Best Practices and Guidelines.** Collaborate with industry, as well as other entities, to develop a voluntary review process through which entities can verify their preparedness. Consider working with other bodies to provide continuing education credits and improve certifications related to cold weather preparation.

Measures of Success

- Decreasing values in the following areas:
  - Frequency of unexpected loss of generation during cold weather events
  - Percentage of Generation de-rates due to cold weather events
  - Frequency of generator failures during cold weather events
  - Frequency and magnitude of load shedding during cold weather events

Risk Profile #9: Right-of-Way Clearances

Associated Reliability Risk Areas: Transmission Right of Way, Equipment Maintenance and Management

Transmission Owners and applicable Generation Owners may have established incorrect ratings based on design documents, rather than on the actual facilities built. Managing to stay within SOL and IROL limits that are based on incorrect ratings may be inadequate to prevent equipment damage and/or cascading, instability, or separation.

Detailed Problem Description

Reports from various entities have indicated that in a number of cases, actual conductor-to-ground clearances seen in the field have been inconsistent with those assumed during the design of the facility. Examples of inaccurate historical information that leads to these inconsistencies includes, but is not limited to, misplaced structures or supports, inadequate tower height, and ground profile inaccuracies. While an entity may address this concern by changing the facility ratings, modifying the transmission line configuration, or changing the topography, such cases must be identified before they can be addressed. Failure to address these misalignments could lead to incorrect ratings that are be inadequate to prevent equipment damage and/or cascading, instability, or separation.

Current Risk Management Activities

- **Raise awareness.** Publication of two alert Recommendations on October 7, 2010, and November 30, 2010.
- **Information Requests.** Data collection and analysis regarding field conditions and alignment with design assumptions, and when misalignment is identified, how that will be corrected.

Recommendations

While this risk is in the process of being evaluated and managed, further activity may be needed.

- **Information Requests.** Monitoring and analysis of the data collection described above should continue. Dependent on the results of these activities, NERC may need to consider whether additional information requests are warranted, as well as whether its current body of Reliability Standards and associated compliance enforcement activities are sufficient to ensure this risk is appropriately managed.

Measures of Success

- 95% of entities either have verified facility design, installation, and field conditions are within design tolerances when the facilities are loaded at their rating or have taken remediation steps such that facility design, installation, and field conditions are within design tolerances when the facilities are loaded at their rating.

Risk Profile #10: 345-kV Breaker Failures

Associated Reliability Risk Areas: Equipment Maintenance and Management

NERC has identified a trend of 345 kV SF6 puffer type breakers failing. Circuit breaker failures, in conjunction with another fault, may lead to more BES facilities removed from service than required to clear the original fault. This poses a risk to the reliability of the BES.

Detailed Problem Description

NERC has reviewed nine 345 kV breaker failures affecting both generation and transmission facilities. Six of these failures have occurred within the past year. From these reviews, NERC has identified a trend of 345 kV sulfur hexafluoride (SF6) puffer type breakers failing. A SF6 puffer type breaker compresses a bellows when opening, directing SF6 gas across the parting contacts to extinguish the arc. The SF6 gas is directed across the contacts via a nozzle. The reports indicate a trend with respect to a separation of the nozzle from its point of attachment. In most cases, the nozzle has been found lying on the tank floor. The manufacturer, Hitachi HVB, Inc. (formerly HVB AE Power Systems, Inc.) issued a Maintenance Advisory on the affected model of breaker in 2010. The manufacturer has indicated that approximately 1,000 of these breakers were delivered to customers. Based on Transmission Availability Data System data, it is estimated that this type of breaker could comprise 10% to 16% of the 345 kV breakers in service.

Current Risk Management Activities

- **Raise awareness.** NERC published an Industry Advisory alert on August 27, 2013. This alert was accompanied by the Manufacturer's Maintenance Advisory.
- **Information Requests.** NERC requested the North American Transmission Forum, the North American Generator Forum, and other trade associations work with their members to collect and report aggregate information related to this concern (such as the number of these breakers believed to be in operation and whether maintenance has been conducted to address this risk in accordance with the manufacturer's maintenance advisory).

Recommendations

While this risk is in the process of being evaluated and managed, further activity may be needed.

- **Information Requests.** Monitoring and analysis of the data described above should continue. Depending on the results of these activities, NERC may need to consider whether additional information requests are warranted, as well as whether its current body of Reliability Standards and associated compliance enforcement activities are sufficient to ensure this risk is appropriately managed.

Measures of Success

- Reduction in the frequency of 345 KV SF6 puffer type breaker failures.