

# Reliability Guideline

## Situational Awareness for the System Operator

### Preamble

It is in the public interest for the North American Electric Reliability Corporation (NERC) to develop guidelines that are useful for maintaining or enhancing the reliability of the Bulk Electric System (BES). The Technical Committees of NERC; the Operating Committee (OC), the Planning Committee (PC) and the Critical Infrastructure Protection Committee (CIPC) per their charters are authorized by the NERC Board of Trustees (Board) to develop Reliability and Security Guidelines. Guidelines establish voluntary codes of practice for consideration and use by BES users, owners, and operators. They are developed by technical committees and include the collective experience, expertise and judgment of the industry. Reliability guidelines are not to be used to provide binding norms or create parameters by which compliance to standards is monitored or enforced. While the incorporation and use of guideline practices is strictly voluntary, the review, revision, and development of a program using these practices is highly encouraged to promote and achieve the highest levels of reliability for the BES.

### Purpose

The objective of this reliability guideline is to provide information on Situational Awareness (SA) and its applicability to real-time operation of the BES. System operators must be on the same page when operating the BES. The following questions may be asked:

- What is the current status of the system?
- What has been done so far?
- What are they doing now?
- How will that affect my tasks?
- How does what I'm doing affect them?
- What will they do next?

Organizations that have a process in place for assessing and increasing the effectiveness of the situation awareness of their operators (whatever their function) will likely provide their operators the best information and therefore improve their ability to make better informed decisions

This Reliability Guideline provides a global recognition of the importance for the system operator to maintain situational awareness while operating the BES. It is meant to assist Transmission Operators (TOP), Balancing Authorities (BA), Reliability Coordinators (RC), Generator Operators (GOP) and other operating entities to use as they deem appropriate with the primary goal of supporting BES reliability.

## Situational Awareness

The BES operates in a dynamic environment and its physical properties are constantly changing. SA is necessary to maintain reliability, anticipate events and respond appropriately when or before they occur. The guideline approaches situational awareness in three levels: perception, comprehension and projection.

Endsley M.R. (1995) *Toward a Theory of Situational Awareness in Dynamics Systems. Human Factors* 37 (1), 36-64.

### Theory

#### Perception

##### Level 1 – Perception

“The first step in achieving SA is to perceive the status, attributes, and dynamics of relevant elements in the environment.”

Endsley M.R. (1995) *Toward a Theory of Situational Awareness in Dynamics Systems. Human Factors* 37 (1), p.36

The system operator needs to accurately perceive relevant information about the BES (e.g. procedures, resources, clearances, alarms, and tool status) as well as weather, emergency information, and other pertinent elements.

#### Comprehension

##### Level 2 – Comprehension

Comprehension of the situation is based on a synthesis of perceived information. Comprehension goes beyond simply being aware of (or perceiving) information that is presented to include an understanding of the significance of those elements.

Endsley M.R. (1995) *Toward a Theory of Situational Awareness in Dynamics Systems. Human Factors* 37 (1), p.37

#### Projection

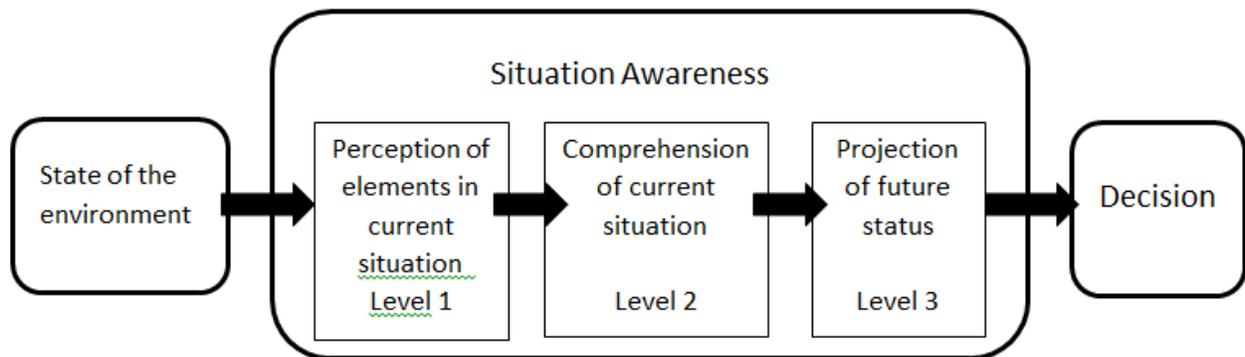
##### Level 3 – Projection

Projection is the ability to anticipate future conditions, based on the perception and comprehension of information at least in the near term in order to make informed decisions.

Endsley M.R. (1995) *Toward a Theory of Situational Awareness in Dynamics Systems. Human Factors* 37 (1), p.37

Together the three levels of SA help operators understand the current state of their environment and adapt their behavior as necessary to make effective and efficient decisions (see graphic). In the best of situations the following occurs:

1. The condition is quickly identified
2. The impact to operations is understood
3. Relevant data to address the issue is easily available and thoroughly reviewed
4. Corrective action recommendations take into account possible negative impacts to the BES
5. Corrective action can be implemented quickly with available resources
6. Information is captured and used to mitigate potential future problems



Note: Adapted from: *Designing for Situational Awareness: An Approach to User-Centered Design* (p. 114), by Endsley M.R.; D.G. Jones (2012), Boca Raton, FL., CRC Press.

## BES System Operator Roles:

To maintain reliability of the BES the following support functions are some examples of key roles impacting SA of personnel performing real-time operations functions: Training, IT/EMS, Real-time Operations Engineering, SCADA, Operations Management, and Transmission Planning. This guideline only addresses the SA of the personnel performing real time functions and assumes that the support functions above are available.

The high level SA descriptions below, outlined by functional entity, provide industry examples, but are not all-inclusive of real time applications of SA.

### Reliability Coordinator

To maintain adequate SA a RC operator at the console should be able to:

- Monitor the current frequency within the RC's Area
- Monitor the current status and capabilities (online, offline, output and dispatch availability) of the generators within the RC's Area

- Monitor the availability of generating operating reserves in real time
- Monitor resources (generator and loads) and develop plans to take action to ensure balance in real time up to and including directing the shedding of load to maintain balance of generation to load within the RC's Area
- Monitor the status of applicable EMS applications such as Real Time Contingency Analysis (RTCA) and/or alarm management to ensure wide area view
- Coordinate a generation dispatch plan for the RC's Area to meet forecasted load for the next 24 hours including any generating operating reserve requirements
- Re-assess generation dispatch plans within the RC's Area based on the loss of generating resources in real-time)
- Monitor the current status (open or closed) and real and reactive power flows on the BES tie-lines and facilities within the RC's Area
- Monitor the current voltage profile across the RC's Area
- Monitor and adjust interchange in accordance with the applicable congestion management processes
- Monitor and direct actions as necessary so that instability, uncontrolled separation, or cascading outages will not occur as a result of the most severe single contingency or specifically identified multiple outages within the RC's Area
- Coordinate with the neighboring RC(s) so that instability, uncontrolled separation, or cascading outages will not occur as a result of the most severe single contingency or specifically identified multiple outages
- Identify any actual or potential BES facility overloads within the RC's Area
- Develop, coordinate, monitor and maintain a transmission facility outage plan and coordinated generation dispatch plan that supports reliable operation of the TOPs and BAs within the RC's Area for the next 24 hours
- Adjust planned transmission facility outages across the RC Area plan based on current transmission system conditions and any unplanned element losses (generation or transmission) that could affect the reliability of the current plan
- Assess and be prepared to implement as required, the RCs mitigation strategies for unplanned events ranging from voltage coordination to full transmission system restoration
- Monitor weather forecasts, Geomagnetic Disturbance (GMD) and identify potential impacts to RC Area reliability for the next 24 hours
- Maintain effective and routine communications with its BAs, TOPs and neighboring RC(s). Distribute Interconnection wide information as necessary to preserve BES reliability (ie. GMD, cyber and physical attacks)

- Monitor current and forecasted generation levels compared to loads and declare Energy Emergencies Alerts if load cannot be served

## Balancing Authority

To maintain adequate SA a BA operator at the console should be able to:

- Monitor the current status of the BES tie lines of the BA's Area (open or closed) as well as real and reactive power flows, including interchange power transfers with other BAs
- Monitor the current frequency within the BA's Area
- Monitor the current status and capabilities (online, offline, output and dispatch availability) of the generators within the BA's Area
- Monitor the availability of generating operating reserves in real time
- Monitor the status of applicable EMS applications such as RTCA and/or alarm management
- Monitoring resources (generators and loads-) and developing plans to take action to ensure balance in real time up to and including the shedding of load to maintain balance of generation to load within the BA Area
- Maintain a generation dispatch plan to serve forecasted load for current-day and next-day including regulating reserves and any generating operating reserve requirements
- Maintain a dispatch plan that includes the capability to mitigate the loss of the BAs largest generating resource
- Understand generation limitations/transmission constraints due to transmission system configurations, maintenance outages or unplanned line outages
- Monitor weather forecasts to identify potential impacts to generation dispatch plan for current-day and next-day
- Monitor generation dispatch levels based on current system conditions and maintain awareness of reserves to replace loss of generating resources in real time
- Monitor current and forecasted generation levels and when reserve levels are below required minimums compared to loads, initiate appropriate Energy Emergencies Alerts

## Transmission Operator

To maintain adequate SA a TOP system operator, at the console, should be able to:

- Monitor the current status (open or closed) and real and reactive power flows on the BES tie-lines and transmission facilities within the TOP's Area
- Monitor and adjust the current BES voltage profile across the TOP's Area using available reactive resources
- Monitor and take appropriate actions in accordance with the applicable congestion management processes

- Monitor the status of applicable EMS applications such as RTCA and/or alarm management
- Monitor and adjust the TOP's transfer flows so that instability, uncontrolled separation, or cascading outages will not occur as a result of the most severe single contingency or specifically identified multiple outages
- Monitor the TOP's area along with the appropriate sections of neighboring TOP areas to identify system conditions that could lead to instability, uncontrolled separation, or cascading outages
- Be aware of any actual or potential BES facility overloads within the TOP's Area (Level 1 and 2) Monitor and maintain BES facility line flows and voltages within IROLs, SOLs and facility ratings using available generation dispatch, re-dispatch or load shedding as necessary
- Be aware of and maintain a transmission facility outage plan of the TOP's Area that maintains reliable operation of the BES for the current-day and next-day
- Be aware of the generation dispatch plan and coordinate and monitor as appropriate with BAs and GOPs connected to the TOP transmission system, over the current-day and next-day
- Be aware of planned facility outages (generation or transmission) and any unplanned facility outages that could affect the reliability of the BES
- Assess and be prepared to implement as required, the TOP's mitigation strategies for unplanned events ranging from voltage coordination to full transmission system restoration
- Monitor weather forecasts and identify potential impacts to transmission facility outage plan for current-day and next-day. This includes the pre-positioning of personnel and equipment to deal with identified threats to the TOP Area reliability

## Generator Operator

To maintain adequate SA as it pertains to BES reliability, a GOP system operator at the console should be able to:

- Monitor facility output and adjust in accordance to agree upon schedules.
- Be aware of any unit or availability limitations on real and reactive power outputs or other system imposed requirements and provide feedback to host BA and TOP accordingly (e.g. AVR, System stabilizers, RASs, Blackstart resources)
- Monitor the status of applicable systems, such as alarm management tools
- Monitor generator voltage to maintain published voltage schedules (ensuring a common point of measurement with the host TOP)
- Monitor the current status of the generating unit(s) online and adjust real and reactive power outputs based on the needs/direction of the host BA and/or TOP
- Maintain a generation dispatch plan for the current-day and next-day including identification of any generator limitations

- Monitor and maintain effective and routine communications with host BA and TOP. Be prepared to coordinate actions after a system events as required (e.g. Unit tripping offline, expected load shedding, transmission system failure and restoration, blackstart initiation)
- Monitor availability of required fuel for the current-day and next-day dispatch plan
- Monitor weather forecasts and identify potential impacts to generator(s) dispatch plan or generator preparation for the next 24 hours

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## Summary of the Various Definitions of Situation Awareness

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**USCG (1998).** *Team Coordination Training Student Guide, Chapter 5 Situational Awareness*, Retrieved May 20, 2015 from <http://www.uscg.mil/auxiliary/training/tct/chap5.pdf>

**WWW.ARMY.MIL (2013).** *Situational Awareness Training Develops Critical Thinking Skills for Soldiers*, Retrieved May 20, 2015 from [http://www.army.mil/article/109161/Situational\\_awareness\\_training\\_develops\\_critical\\_thinking\\_skills\\_for\\_soldiers/](http://www.army.mil/article/109161/Situational_awareness_training_develops_critical_thinking_skills_for_soldiers/)

## Attachment: A

### Reliability Coordinator

To maintain adequate situational awareness (SA) a Reliability Coordinator (RC) operator at the console should be able to:

- Monitor the current frequency within the RC's Area (Level 1 and 2)
- Monitor the current status and capabilities (online, offline, output and dispatch availability) of the generators within the RC's Area (Level 1 and 2)
- Monitor the availability of generating operating reserves in real time (Level 1 and 2)
- Monitor resources (generator and loads) and develop plans to take action to ensure balance in real time up to and including directing the shedding of load to maintain balance of generation to load within the RC Area (Level 1, 2 and 3)
- Monitor the status of applicable EMS applications such as Real Time Contingency Analysis (RTCA) and/or alarm management to ensure wide area view (Level 1)
- Coordinate a generation dispatch plan for the RC Area to meet forecasted load for the next 24 hours including any generating operating reserve requirements (Level 2)
- Re-assess generation dispatch plans within the RC Area based on the loss of generating resources in real-time (Level 1, 2 and 3)
- Monitor the current status (open or closed) and real and reactive power flows on the BES tie-lines and facilities within the RC's Area (Level 1 and 2)
- Monitor the current voltage profile across the RC's Area (Level 1 and 2)
- Monitor and adjust interchange in accordance with the applicable congestion management processes (Level 1, 2 and 3)
- Monitor and direct actions as necessary so that instability, uncontrolled separation, or cascading outages will not occur as a result of the most severe single contingency or specifically identified multiple outages within the RC's Area (Level 1, 2 and 3)
- Coordinate with the neighboring RC(s) so that instability, uncontrolled separation, or cascading outages will not occur as a result of the most severe single contingency or specifically identified multiple outages (Level 1, 2 and 3)
- Identify any actual or potential BES facility overloads within the RC's Area (Level 1)
- Develop, coordinate, monitor and maintain a transmission facility outage plan and coordinated generation dispatch plan that supports reliable operation of the TOPs and BAs within the RC's Area for the next 24 hours (Level 1, 2 and 3)
- Adjust planned transmission facility outages across the RC Area plan based on current transmission system conditions and any unplanned element losses (generation or transmission) that could affect the reliability of the current plan (Level 1, 2 and 3)

- Assess and be prepared to implement as required, the RCs mitigation strategies for unplanned events ranging from voltage coordination to full transmission system restoration (Level 1, 2 and 3)
- Monitor weather forecasts, Geomagnetic Disturbance (GMD) and identify potential impacts to RC Area reliability for the next 24 hours (Level 1, 2 and 3)
- Maintain effective and routine communications with its BAs, TOPs and neighboring RC(s). Distribute Interconnection wide information as necessary to preserve BES reliability (ie. GMD, cyber and physical attacks) (Level 1, 2 and 3)
- Monitor current and forecasted generation levels compared to loads and declare Energy Emergencies Alerts if load cannot be served (Level 1, 2 and 3)

## Balancing Authority

To maintain adequate situational awareness (SA) a Balancing Authority (BA) operator at the console should be able to:

- Monitor the current status of the BES tie lines of the BA's Area (open or closed) as well as real and reactive power flows, including interchange power transfers with other BAs (Level 1)
- Monitor the current frequency within the BA's Area (Level 1)
- Monitor the current status and capabilities (online, offline, output and dispatch availability) of the generators within the BA's Area (Level 1)
- Monitor the availability of generating operating reserves in real time (Level 1)
- Monitor the status of applicable EMS applications such as RTCA and/or alarm management
- Monitoring resources (generators and loads-) and developing plans to take action to ensure balance in real time up to and including the shedding of load to maintain balance of generation to load within the BA Area (Level 1, 2 and 3)
- Maintain a generation dispatch plan to serve forecasted load for current-day and next-day including regulating reserves and any generating operating reserve requirements (Level 2)
- Maintain a dispatch plan that includes the capability to mitigate the loss of the BAs largest generating resource (Level 1, 2 and 3)
- Understand generation limitations/transmission constraints due to transmission system configurations, maintenance outages or unplanned line outages (Level 1, 2 and 3)
- Monitor weather forecasts to identify potential impacts to generation dispatch plan for current-day and next-day (Level 1 and 2)
- Monitor generation dispatch levels based on current system conditions and maintain awareness of reserves to replace loss of generating resources in real time (Level 1, 2 and 3)
- Monitor current and forecasted generation levels and when reserve levels are below required minimums compared to loads, initiate appropriate Energy Emergencies Alerts (Level 1, 2 and 3)

## Transmission Operator

To maintain adequate situational awareness (SA) a Transmission Operator (TOP) system operator, at the console, should be able to:

- Monitor the current status (open or closed) and real and reactive power flows on the BES tie-lines and transmission facilities within the TOP's Area (Level 1 and 2)
- Monitor and adjust the current BES voltage profile across the TOP's Area using available reactive resources (Level 1, 2 and 3)
- Monitor and take appropriate actions in accordance with the applicable congestion management processes (Level 1, 2 and 3)
- Monitor the status of applicable EMS applications such as RTCA and/or alarm management (Level 1 and 2)
- Monitor and adjust the TOP's transfer flows so that instability, uncontrolled separation, or cascading outages will not occur as a result of the most severe single contingency or specifically identified multiple outages (Level 1, 2 and 3)
- Monitor the TOP's area along with the appropriate sections of neighboring TOP areas to identify system conditions that could lead to instability, uncontrolled separation, or cascading outages (Level 1, 2 and 3)
- Be aware of any actual or potential BES facility overloads within the TOP's Area (Level 1 and 2) Monitor and maintain BES facility line flows and voltages within IROLs, SOLs and facility ratings using available generation dispatch, re-dispatch or load shedding as necessary (Level 1, 2 and 3)
- Be aware of and maintain a transmission facility outage plan of the TOP's Area that maintains reliable operation of the BES for the current-day and next-day (Level 1 and 2)
- Be aware of the generation dispatch plan and coordinate and monitor as appropriate with BAs and GOPs connected to the TOP transmission system, over the current-day and next-day (Level 1 and 2)
- Be aware of planned facility outages (generation or transmission) and any unplanned facility outages that could affect the reliability of the BES (Level 1 and 2)
- Assess and be prepared to implement as required, the TOPs mitigation strategies for unplanned events ranging from voltage coordination to full transmission system restoration (Level 1, 2 and 3)
- Monitor weather forecasts and identify potential impacts to transmission facility outage plan for current-day and next-day. This includes the pre-positioning of personnel and equipment to deal with identified threats to the TOP Area reliability (Level 1, 2 and 3)

## Generator Operator

To maintain adequate situational awareness (SA) as it pertains to BES reliability, a Generator Operator (GOP) system operator at the console should be able to:

- Monitor facility output and adjust in accordance to agree upon schedules. (Level 1, 2 and 3)

- Be aware of any unit or availability limitations on real and reactive power outputs or other system imposed requirements and provide feedback to host BA and TOP accordingly (e.g. AVR, System stabilizers, RASs, Blackstart resources) (Level 1, 2 and 3)
- Monitor the status of applicable systems, such as alarm management tools (Level 1 and 2)
- Monitor generator voltage to maintain published voltage schedules (ensuring a common point of measurement with the host TOP) (Level 1, 2 and 3)
- Monitor the current status of the generating unit(s) online and adjust real and reactive power outputs based on the needs/direction of the host BA and/or TOP (Level 1, 2 and 3)
- Maintain a generation dispatch plan for the current-day and next-day including identification of any generator limitations (Level 1 and 2)
- Monitor and maintain effective and routine communications with host BA and TOP. Be prepared to coordinate actions after a system events as required (e.g. Unit tripping offline, expected load shedding, transmission system failure and restoration, blackstart initiation) (Level 1, 2 and 3)
- Monitor availability of required fuel for the current-day and next-day dispatch plan (Level 1 and 2)
- Monitor weather forecasts and identify potential impacts to generator(s) dispatch plan or generator preparation for the next 24 hours (Level 1 and 2)