NERC

NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

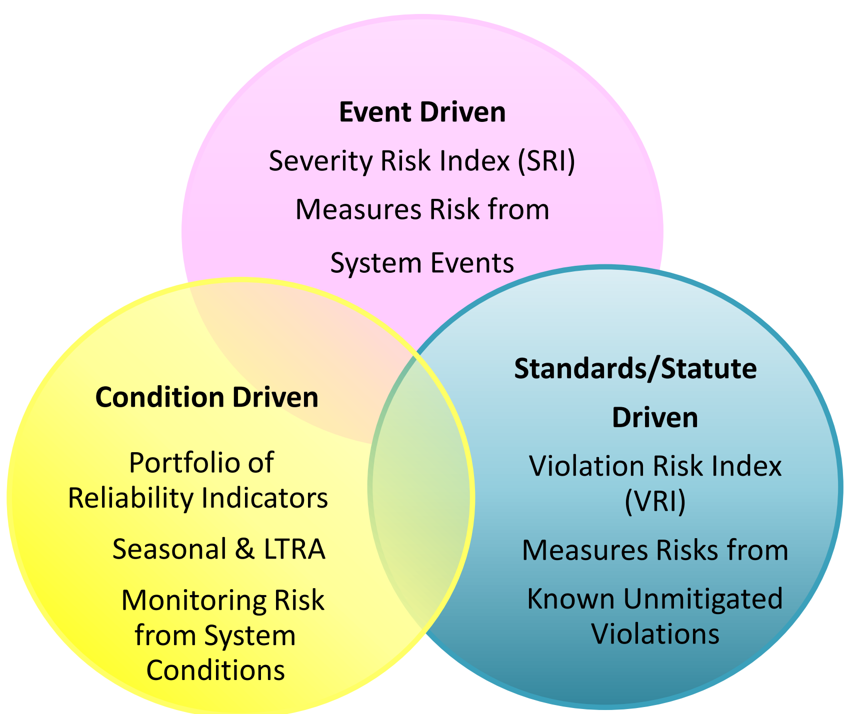
Attachment 3

Integrated Reliability Index Concepts

The development of an integrated reliability index aims to inform, increase transparency, and quantify the effectiveness of risk reduction and/or mitigation actions. The goal is to provide the industry meaningful trends of the bulk system performance and guidance on how they can improve reliability and support risk-informed decision making.

NERC has continued to develop a portfolio of reliability metrics and risk information to quantify bulk power system reliability, including condition-driven reliability indicators,[1] standards/statute-driven violation risk measures,[2] and event-driven risk indices,[3] illustrated in Figure 1. This model attempts to capture the "universe of risk" to the bulk power system reliability.

Figure1 – Conceptual Risk Model for Bulk Power System



[1] http://www.nerc.com/docs/pc/rmwg/RMWG_Metric_Report-09-08-09.pdf.
[2] http://www.nerc.com/filez/pmtf.html.
[3] Details on NERC's TADS, GADS and Event Analysis Databases are available at http://www.nerc.com.

Event-Driven Indicators – The Event-Driven approach provides a basis for prioritization of events based on bulk power system integrity, equipment performance, and/or engineering judgment. The event-driven severity-risk indicators can serve as a high value risk assessment tool to be used by stakeholders to investigate and evaluate disturbance history that can be useful in measuring the severity of these events. The relative ranking of events requires industry expertise, agreed-upon goals and engineering judgment. The final numerical ranking/scoring considers the NERC approved ALR[4] and existing NERC Standards.

Standards/Statute-Driven Indicators – The violation risk index measures improvement in compliance with Reliability Standards.[5] Each violation is associated with a predefined Violation Risk Factor (VRF) and an assessed Violation Severity Level (VSL). Based on these factors, known unmitigated violations of elevated risk factor requirements are weighted higher than lower risk factors. The index decreases if the compliance improvement is achieved over a trending period.

Condition-Driven Indicators – Condition-driven indicators focus on a set of measurable system conditions to assess bulk power system reliability. These reliability indicators identify factors that positively or negatively impact reliability and are early predictors of the risk to reliability from events or unmitigated violations. A collection of these indicators measures how far reliability performance is from desired outcome, and if the performance is headed in the preferred direction.

The integrated model of event-driven, condition-driven and standards/statute-driven risk information can be constructed to show all possible logical relations between the three risk sets (disturbance events, at-risk conditions, and unreliable violations). Each risk set may, but does not need to overlap with the other two sets. The overlapping area or intersection represents common elements among all three sets. For example, if an Interconnection Reliability Operating Limit (IROL)[6] were exceeded for greater than the associated time (T_v), the event would be considered to be simultaneously a standards/statute-driven event, a condition-driven event and a risk event. Risk-informed decisions can be made from each of these perspectives to lower overall system risk, provide input to risk-informed standards development process, and communicate the effectiveness of reliability programs.

[4] Detailed definitions of ALR are available at http://www.nerc.com/docs/pc/Definition-of-ALR-approved-at-Dec-07-OC-PC-mtgs.pdf.
[5] Detailed standards/statute-driven indicators can be viewed at http://www.nerc.com/filez/pmtf.html.
[6] Details on operating within IROLs are available at http://www.nerc.com/files/IRO-009-1.pdf.

This whitepaper focuses on an integrated model and development of a quantitative measure for determining achievement of the qualitative reliability goals. Using this integrated measure enables NERC to continuously monitor industry reliability performance to identify adverse trends, take prompt actions and communicate effectiveness of reliability programs.

Conceptual Integrated Reliability Index (IRI)

An Integrated Reliability Index (IRI) can be constructed based on the risk model illustrated in Figure 1. The IRI includes the following three components:

- **Key Reliability Indicators (MI) -** A subset of metrics covering major factors to reliability
- **Event Risk Index (RI) -** The risk value associated with significant events, , and uses the SRI calculation as a basis
- **Compliance Violation Index (CI) -** A subset of standards that have highest impact to reliability

The value of the IRI can be calculated based on risk impact of the above three components and their relative weightings, as shown below:

$$IRI = w_M*(MI) + w_S*(RI) + w_C*(CI) \qquad (1)$$

Where:

IRI	=	integrated reliability index for a specific period,
w_M	=	weighting of metric component,
MI	=	normalized metric impact level in percent,
w_S	=	weighting of event severity component,
RI	=	normalized severity risk level in percent,
W_C	=	weighting of compliance violation component,
CI	=	normalized compliance level in percent

The value of IRI will range from 0 to 100, and can be aggregated at NERC, Interconnection and Region levels. The three weights can be adjusted as we learn more and gain experience after one to two years of trending.

Criteria for IRI components include that risk factors should not double count across each component, they should be measurable for specific time periods of interest, such as quarterly or annually, and they should have independence from each other. Conceptually, also the components might be considered as “success rates” for events experienced (as measured by RI), compliance history (as measured by CI) and condition performance (as measured by MI).

The IRI would be used as a historical measure, not a real-time performance score. The index is calculated using deterministic and actual field data.[7]

MI Component

The Reliability Metrics Working Group (RMWG) applied the following selection criteria to identify which subset of metrics should be to be included in MI:

- Cover majority of risks
- Show a consistent link to reliability
- Never overlap with RI and VI
- Consider randomness and independence

The RMWG recommends the following five reliability indicators be included in MI component.

1. ALR1-5 – System Voltage Performance (metric focused by OC)
2. ALR1-12 – Interconnection Frequency Response (metric focused by OC)
3. ALR2-5 – DCS greater than MSSC
4. ALR3-5 – IROL/SOL Exceedance (less than 30 minutes, metric focused by OC)
5. ALR4-1 – Protection System Misoperation

Three of reliability indicators are recommended by OC to be closely monitored and tracked; and other two indicators are also direct measures and early predictors of the risk to reliability.

To integrate individual metrics with differing units of measure, key common factors were identified which impact the value of each metric. With engineering judgment and technical experience, relative importance can be selected and weightings computed. The metric contribution will be equal to:

$$\text{Metric contribution (MI)} = \sum (\text{Weighting}*\text{Specific Factor Level}) \qquad (2)$$

The value of the metric contribution will range from 0 and 100. This calculation aggregates the MI as a weighted average by relative importance. For example, SMART ratings[8] of the above five metrics can be served as their importance values in the MI equation shown below:

$$\text{MI} = \sum ((100\text{-metric contribution})*\text{metric SMART rating})/\sum(\text{SMART score}) \qquad (3)$$

[7] From forward-looking point of view, one can also create another index with forecast variables and probabilistic approach. This projection index is held for future consideration.

[8] http://www.nerc.com/docs/pc/rmwg/RMWG_Metric_Report-09-08-09.pdf

RI Component

RI component is obtained from RMWG's Severity Risk Index (SRI) values.[9] The SRI is the value of the risk severity based on the impact of significant events. It includes generator outages, transmission outages, as well as load loss and its durations. The RI can be computed as follows:

$$RI = (\text{Duration in Days} - \sum SRI)/(\text{Duration in Days}) \quad (4)$$

The value of RI will range from 0 and 100. The SRI is a daily Severity Risk Index and the duration is a specific time period of interest, such as quarterly or annually.

CI Component

A selection criterion was required to identify which subset of standard requirements should be included in CI, which the RMWG determined to be standard requirements with the following attributes:

- Their violations could have severe impact to reliability
- Violation Risk Factor and Severity Level are high or severe

"Failure to maintain vegetation clearance could cause or exacerbate a cascading outage" is an example of severe impact; "lack of regular maintenance and testing could result in misoperations" is an example of moderate impact; "the entity is conducting training, but its training program did not include a plan for the initial operator training" is an example of minimal impact.

By applying the similar aggregation as RI, the CI can be calculated as

$$CI = 100 - \sum (w_V * NV/TR) \quad (5)$$

Where:

CI	=	integrated compliance index for a specific period,
w_V	=	weighting of a particular requirement violation,
NV	=	number of violations for the selected requirement,
TR	=	number of registered entities who are required to comply with the selected requirement

[9] http://www.nerc.com/docs/pc/rmwg/Integrated_Bulk_Power_System_Risk_Assessment_Concepts_Final.pdf