Assessing Open Phase Condition (OPC) Implementation Using Risk Insights

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Outline

- OPC Voluntary Industry Initiative (VII)
- Potential risk contribution associated with OPC
- OPC VII Implementation Risk Impact
- Application of Risk Informed Decision Making (RIDM) concepts to OPC
- OPC Modification Implementation Options Using Risk Insights
- Next Steps

OPC Voluntary Industry Initiative

- Senior industry leadership has been engaged in addressing this condition since the event at Byron in 2012 revealed the potential impact of an OPC
- Improved recognition of the condition, pre-planned trained operator response actions, and modifications have been employed to mitigate the effects of an OPC
- NRC Commission direction that response to OPC be implemented through the VII process
  - Continued progress in implementing the VII has led to reduction in OPC risk across the US fleet

Potential Risk Contribution Associated with OPC

- The event at Byron, as evaluated under the Accident Sequence Precursor (ASP) Program, was characterized as a precursor, but not a significant precursor
- Design or configuration of the power distribution system at a specific site can significantly influence the potential OPC risk impact
- Improved recognition and operator training/response to OPC events immediately after the 2012 event(s) reduced the risk from such events across the industry

Potential Risk Contribution Associated with OPC

- Monitoring and detection of OPC represents the key element in reducing the risk associated with OPC
- Independent of the Open Phase Isolation System (OPIS) modifications, plant changes or upgrades to mitigate loss of power events (e.g. post-Fukushima mitigating strategies, low leakage RCP seals) also reduce the risk associated with OPC
  - Increases response time and options to mitigate an OPC
- This risk evaluation is being developed to support the option of not engaging the auto trip function of the OPIS

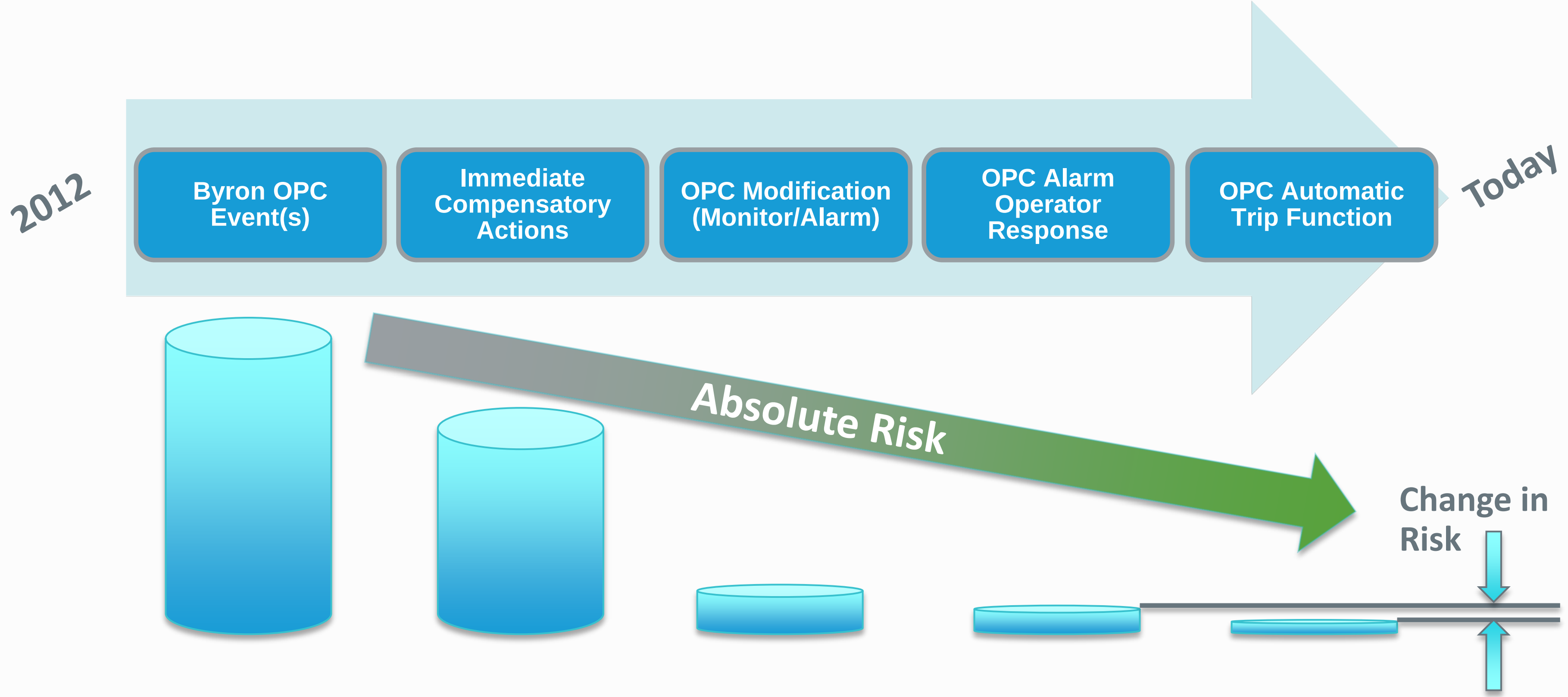
Risk Informed Decision Making (RIDM)

- A risk informed regulatory approach that complements deterministic criteria/regulations is the optimal means to make informed decisions on safety significance in an objective manner
- SECY-98-144 defines RIDM as a philosophy whereby risk insights are considered together with other factors to establish requirements that better focus licensee and regulatory attention on design and operational issues commensurate with their importance to health and safety

Margin in the Context of Risk Informed Decision Making (RIDM)

- Application of margin for general decision-making
  - Use the appropriate level of resources to investigate an issue commensurate with safety
    - Improve timely disposition of safety significance conclusions
    - Disposition low safety significance conclusions quickly
  - Prioritize regulatory issues
  - Reassess impact and use of regulatory quantitative risk thresholds
- Application of margin in support of specific decision-making
  - Increase in margin driven by plant design and operational changes should allow flexibility in response, scope, and depth of review of regulatory initiatives

OPC VII Implementation Risk Impacts

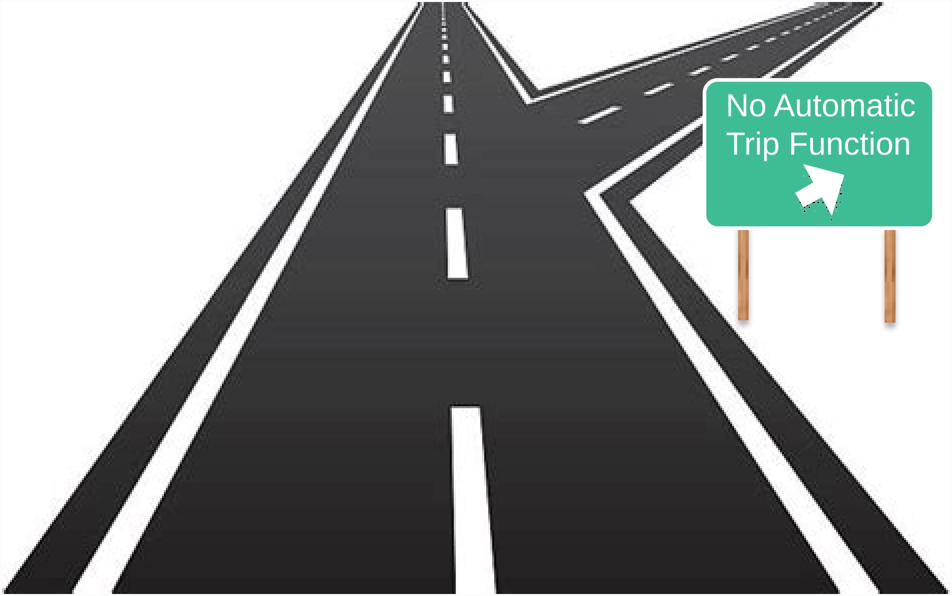


Application of RIDM Concepts to OPC

- RIDM concepts can be applied to both inform and focus implementation of the OPIS
  - A variety of plant electrical distribution designs and plant mitigation features (13 sites, 22 units) were evaluated from a risk perspective to glean OPIS implementation insights
  - General trends/insights from the risk evaluation were used to develop a decision process to assess the incremental change in risk associated with implementation of the automatic trip function of OPIS
- The RIDM concept characterized by the industry during a recent Commission Briefing is employed to illustrate application of risk insights to implementation of the VII

OPC Modification Implementation Options Using Risk Insights

- Purpose:
  - Identify the incremental risk reduction associated with the automatic trip function
- Applicability:
  - Plant Electrical Design
  - Emergency Bus Configuration
  - Installed Mitigation Features
  - OPIS Modification and Operator Response



OPC Automatic Trip Function Graded Evaluation Paths

- The graded approach uses the offsite power alignments to the ESF buses summarized in the NRC Bulletin 2012-01 Summary Report as the framework. Examples:
  - Configuration (3) - Redundant ESF trains supplied from different transformers
  - Configuration (1) - A single connection to offsite power source feeding all ESF buses
- The insights and quantitative results from the industry risk evaluation associated with the different offsite power alignments are applied to facilitate the evaluation process

OPC Automatic Trip Function Graded Evaluation Paths

Evaluation Path	Conditions	2012-01 Config.
Qualitative	• Redundant ESF trains supplied from different transformers • Unlikely to have simultaneous conditions on the redundant ESF buses	Config. (3)
Qualitative/ Semi-quantitative	• ESF buses do not automatically transfer to redundant offsite circuits • Normal feeds to ESF buses split between UATs and SATs	Config. (2,4,5)
Quantitative	• A single connection to offsite power source feeding all ESF buses	Config. (1)

NEI OPC Risk Methodology

- Uses the NRC preliminary risk estimate methodology issued May 2017 as an initial framework
- Employs existing utility PRA models to estimate the change in risk between automatic and manual response to an OPC
- The process is not focused on a detailed risk analysis of the OPIS design, but rather on the key functions, OPIS attributes, and plant-specific design features used to mitigate the impact of an OPC
- The methodology is, in aggregate, conservatively biased

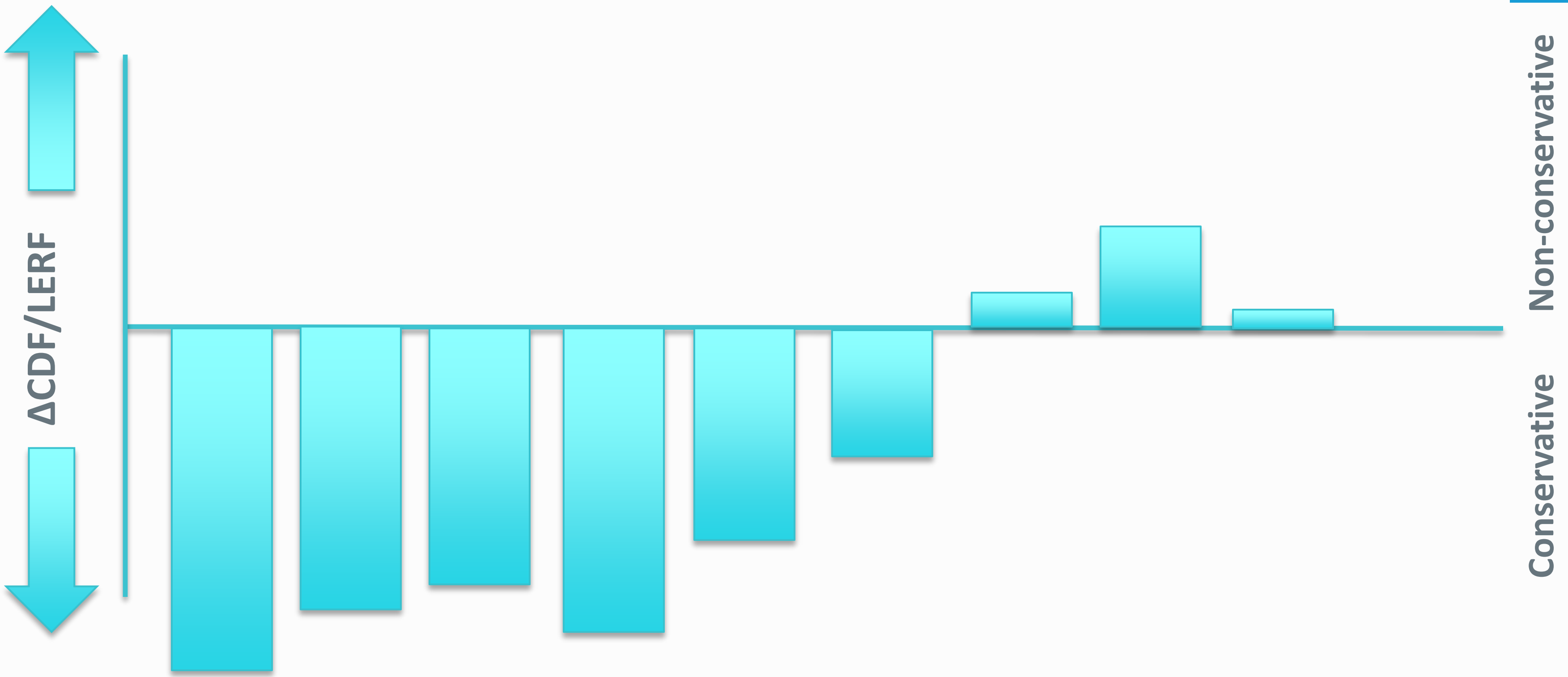
NEI OPC Risk Methodology

- Conservative Bias
  - All OPC events are assumed applicable to all units
  - A reactor trip is assumed to occur for all OPC events
  - No credit is taken for existing overcurrent or undervoltage relaying to detect the condition and isolate the open phase condition
  - In manual alarm response mode the OPC induced phase imbalance is assumed to result in trip of protective relaying for each load powered by the bus affected by the OPC
  - Offsite power recovery is modeled using grid recovery data as a surrogate for repairing the components that failed and caused the OPC
  - FLEX strategies are not quantitatively included in the evaluation

NEI OPC Risk Methodology

- Non-Conservative Bias
  - All plants are assumed to be in normal electrical configuration (average PRA model)
  - In manual alarm response mode, all electrical loads are assumed to be recoverable given actuation of protective relaying
  - In manual alarm response mode, if RCP motors are affected by the same phase imbalance that propagates to the emergency buses, the protective relaying is assumed to trip the RCPs on time-overcurrent exceedance

Methodology Assumption Impacts



Risk Evaluation Criteria (Delta Risk)

1E-05 ΔCDF
Ceiling

Quantitative
Configuration (1)

Semi-quantitative
Configurations (2,4,5)

1E-06 ΔCDF
Evaluation
Goal

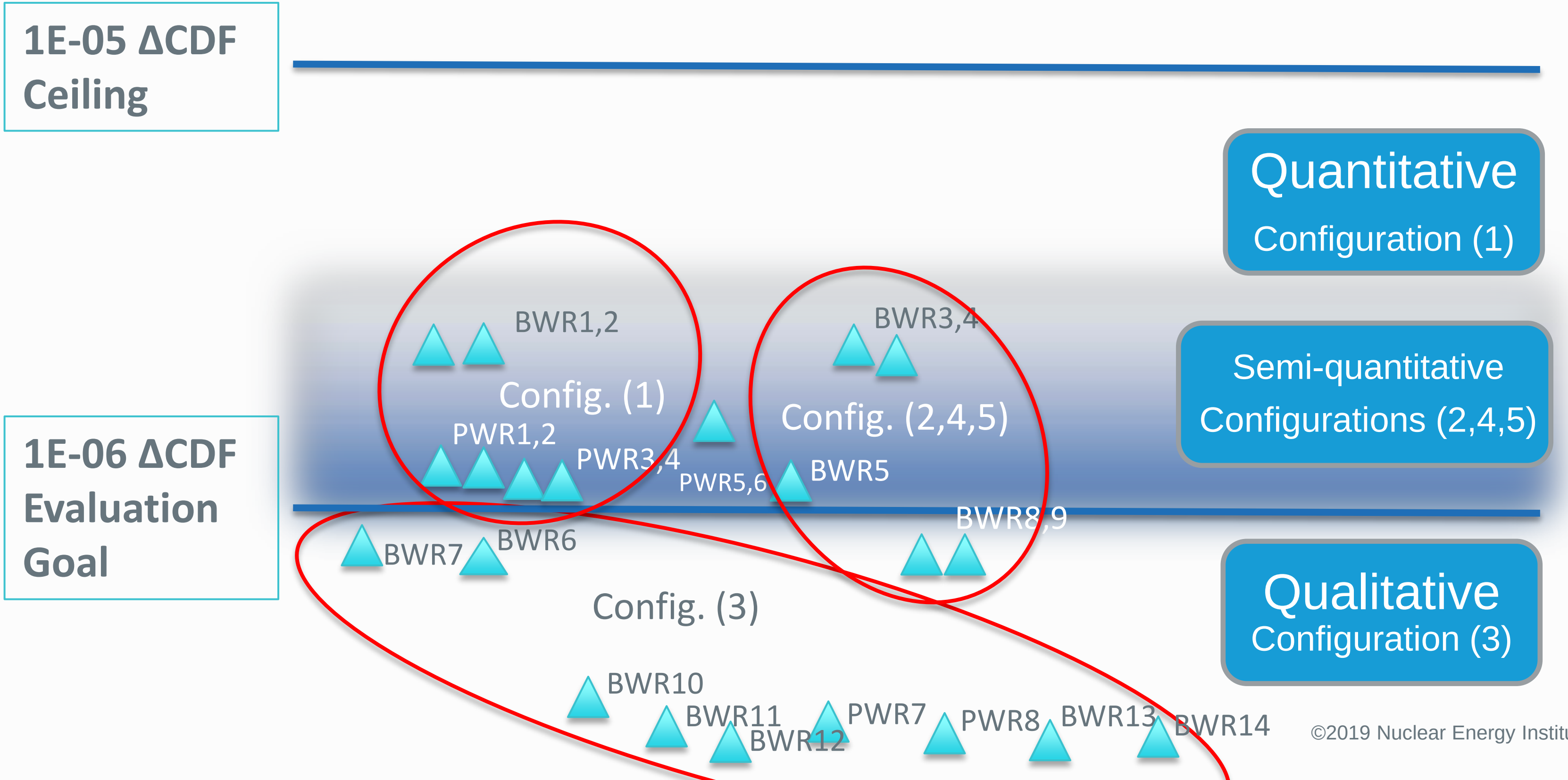
Deminimus
<1E-06 ΔCDF

Qualitative
Configuration (3)

Preliminary Risk Evaluation Benchmarks

Plant	All ESF Buses Impacted	2012-01 Config.	Baseline CDF	OPC Manual CDF	OPC Manual Δ CDF	OPC Auto CDF	OPC Auto/Man Δ CDF
BWR7	No	3	3.1E-06	4.4E-06	1.3E-06	3.7E-06	7E-07
PWR8	No	3	1.1E-05	1.1E-05	2.6E-07	1.1E-05	2E-07
PWR4	Yes	1	1.1E-05	1.3E-05	1.5E-06	1.2E-05	1E-06
BWR1	Yes	1	1.3E-06	6.8E-06	5.5E-06	2.8E-06	4E-06

Risk Evaluation Benchmark (Delta Risk)



OPC Automatic Trip Function Removal Evaluation Criteria

- Configuration (3)
  - Engineering/design confirmation that the OPC does not impact all emergency (ESF) buses
  - Alarm response actions minimize or prevent potential OPC impact on the non-impacted ESF bus
  - Simplified/qualitative risk evaluation confirming the electrical design, mitigation features, and operator response contribute to a deminimus (<1E-06) change in baseline CDF
- Approximately 40 units fall into this category per the NRC 2012-01 Summary report

OPC Automatic Trip Function Removal Evaluation Criteria

- Configuration (1)
  - Engineering/design confirmation that the OPC does impact all emergency (ESF) buses
  - Evaluate the operator alarm response actions to understand the risk insights, and incorporate if appropriate, to maximize the risk reduction potential of operator response
  - Evaluate/credit loss of power plant mitigation features
  - Quantitative risk evaluation using the developed NEI methodology to determine the change in baseline CDF with and without the automatic trip function
- Approximately 19 units fall into this category per the NRC 2012-01 Summary report

Next Steps

- The risk results using the process described provides sufficient basis to limit the need to engage the automatic trip function after the OPIS monitoring period is completed
- All evaluation approaches (qualitative through quantitative) can provide sufficient basis to prevent the need for the automatic trip function
- The industry VII will be revised to allow, as an option, the risk evaluation in support of not engaging the auto trip function