Joint Utilities Uniform & Probabilistic Risk Assessment Methodology

Presented at the California Public Utilities Commission
February 15, 2017

DRAFT
Agenda

February 15th

- Welcome and Expectations for Workshop
- Overview of CPUC Objectives and Directives
- Overview of the Joint Utilities’ Approach (JUA) – Uniform and Probabilistic
- Safety Focus: Application of the JUA to the Safety Attribute
- Comparison to CPUC Objectives and Directives
- Roadmap and Timeline
Why are we here?

“Our efforts must improve protection for the public, for utility workers and CPUC employees, ...”

“I think we’re safer,” Michael Picker, the new president of the California Public Utilities Commission, told KQED News in an interview. “I don’t think we’re safe enough to satisfy me.”
## Decision 16-08-018 Order

<table>
<thead>
<tr>
<th>Orders for The Utilities</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> Vet the Joint Intervenor Multi-Attribute Approach foundational requirements and</td>
<td>Vetting will be done once test-drive is complete</td>
</tr>
<tr>
<td>how it operates in real-world scenarios.</td>
<td></td>
</tr>
<tr>
<td><strong>2</strong> Test drive the Joint Intervenor Multi-Attribute Approach.</td>
<td>In progress</td>
</tr>
<tr>
<td><strong>3</strong> Review utility pilots.</td>
<td>On-going</td>
</tr>
<tr>
<td><strong>4</strong> Provide a showing of pilots demonstrating the use of probabilistic models. (e.g.</td>
<td>Will be presented today Update progress in future workshops</td>
</tr>
<tr>
<td>probabilistic risk analysis, calibrated subject matter expertise, and risk reduction</td>
<td></td>
</tr>
<tr>
<td>benefit per dollar)</td>
<td></td>
</tr>
<tr>
<td><strong>5</strong> Show how utilities strategies align with and/or differ from JIA using the same or</td>
<td>To be completed once the JIA and JUA complete test-drives and assess</td>
</tr>
<tr>
<td>similar problems.</td>
<td>pros and cons of both methodologies</td>
</tr>
</tbody>
</table>
Utilities’ Risk Management Uniformity Principles

- The Utilities focus on a number of uniform principles including:
  - ISO 31000
  - COSO
  - ISO 55000 tenets
  - API Recommended Practice 1173 Public Safety tenets
  - Cycla model
  - Risk lexicon
  - Impact categories
  - Likelihood category criteria
  - Safety category criteria

The JUA builds on these principles.
Expectations for the Workshop

- Introduce the Joint Utilities’ Approach – Bow Tie Analysis, Probabilistic Quantification, Safety Focus, and Roadmap
- Demonstrate the application to the Safety Attribute of the JUA using utility risk examples
- Provide a roadmap for next steps
CPUC Requirements

- Probabilistic
- Safety–focused
- Simple / clear / transparent (understandable by non-experts)
- Uniform
- Comparable across risks and utilities
- Cost-effective modeling

Acceptance Criteria

CPUC Docs
- Safety Policy Statement (July 10, 2014)
- Safety and Enforcement Division Risk Assessment Section Staff Report on SoCalGas and DOGE’s 2010-2013 ERC (March 27, 2015)
- Safety and Enforcement Division Risk Assessment Section Staff Report on PG&E’s 2017-2019 GRC (March 7, 2016)
Probabilistic

- CPUC Interim Decision* includes:
  - “… requires utilities to provide a ‘showing’ of ‘pilots’ demonstrating the use of probabilistic models (e.g., probabilistic risk analysis, calibrated subject matter expertise, and risk reduction benefit per dollar) …”
  - “… calibrated subject matter expertise is an essential component of developing the distributions used in risk analysis.”

- The JUA incorporates probabilistic risk analysis, uses calibrated subject matter expertise and results in comparable risk spend efficiency for risks and mitigations.

Demonstrated use of probabilistic models in first S-MAP filings (FiRM, TIMP, Electric T&D)
Started new pilots which will be illustrated today

*Decision 16-08-018 August 18, 2016 pg 191-192 and pg 73
Probabilistic Modeling and Risk Modeling Tiers

Different risks warrant different levels of modeling sophistication based on various factors such as the significance of the risk, the cost effectiveness of modeling, data availability and feasibility.

- **Risk**
- **Method for Quantitative Risk Assessment**
  - Stochastic
  - Fault/Event Tree
  - Calibrated Subject Matter Expertise

- **Risk Profile**
- **Risk Spend Efficiencies**
- **Risk Plan**

**RSE**
Uniform

- **CPUC Interim Decision*** includes:
  - “... take steps toward a more uniform risk management framework.”
  - “The utilities should take steps toward a more uniform approach towards calculation of risk reduction in a second phase of this proceeding”

The JUA proposes a uniform approach to safety risk assessment and risk spend efficiency determination.

Utilities have taken steps towards more uniformity in their process and frameworks (e.g. Cycla’s model, bowties, etc.)

JUA is a next step towards evaluation of risks and mitigations

*Decision 16-08-018 August 18, 2016 pg 1 and pg 190*
CPUC Interim Decision* includes:

- “Develop comparable risk scores across utilities”
- “The utilities need improvement in order to calculate risk reduction in a way that is comparable across utilities.”

The JUA proposes a uniform approach that allows for comparisons across safety risks, controls, mitigations and utilities.

*Decision 16-08-018 August 18, 2016 pg 179 and pg 181
Simple/Transparent

- CPUC Interim Decision* includes:
  - “Criteria to determine any priorities should be fulfillment of Commission goals, ability to impact short-term change, transparency, reasonableness, accuracy of results and ease of preparation and implementation, among other things.” (emphasis added)

The JUA provides a transparent, simple to use and easy to understand approach to comparing risks and mitigations within and across utilities.

*Decision 16-08-018 August 18, 2016 pg 173
Safety Risks

- The CPUC Guiding Principles* include:
  - “Ultimately we are striving to achieve a goal of zero accidents and injuries across all the utilities and businesses we regulate within our own workplace.”
  - “Continually assess and reduce the safety risk posed by the companies we regulate.”
  - “Hold companies (and their extended contractors) accountable for safety of their facilities and practices”

The JUA begins by focusing on the safety attribute of Safety Risks

The JUA approach is flexible and can accommodate additional attributes beyond safety

* Safety Policy Statement of the California Public Utilities Commission July 10, 2014 pg. 1
Cost Effective

- CPUC Interim Decision* includes:
  - “Adopting a common framework will ultimately streamline proceedings and minimize the mount of resources and time devoted to understanding the literacies of various models and provide useful comparisons.”

The JUA is a common framework that allows for comparability of probabilistic safety risk assessment models

JUA acknowledges and provides for a varying degree of modeling maturity (tiers)

*Decision 16-08-018 August 18, 2016 pg 180 and pg 190
The Joint Utilities’ Approach
Model Overview
Developing the JUA

- Created a compendium of CPUC objectives and requirements.
- Built on each utility’s ongoing risk management initiatives.
- Incorporated external experts’ knowledge.
- Incorporated knowledge from initial JIA workshops.
Acceptance Criteria

- Per the CPUC’s requirements, the model should be:
  - Safety-focused
  - Simple / transparent / understandable by non-experts
  - Uniform
  - Probabilistic
  - Comparable across risks and utilities
  - Cost-effective

Success = Meets the CPUC Requirements
Understand the risks in a common way, differentiating between risk events and drivers to the events

Understand what potential exposure would entail

Perform a Bow Tie analysis to identify the drivers of the risk

Determine event frequencies associated with each driver

Align, as appropriate, on consequence categories and common currencies for each category with CPUC guidance

Assess whether there are effective mitigations impacting critical risk drivers

Understand spending needs over rate case period

Calculate safety RSE as an input into decision-making

Determine the data needed to clarify and inform the risk event at each stage

The analytical framework that has been developed can be used to test the risk spend efficiency and effectiveness of mitigations
JUA Methodology: Model Overview

Bow Tie provides transparent view of exposure, data-driven frequencies of risk drivers, and a consistent approach to developing consequence attributes.

Drivers
- Exposure
  - Miles of pipeline
  - Hours worked
  - Number of employees
- Frequency
  - Driver #1 Frequency: [events / mile / year]
  - Driver #2 Frequency: [events / hour / year]
  - Driver #3 Frequency: [events / person / year]

Risk event(s)

Consequences
- Safety
- Reliability
- Environmental
- Financial
- Other

Quantitative Risk Assessment

Attribute methods and processes informed by JIA and the CPUC’s input

- Uniform methods and approaches
- Quantitative, multi-attribute scales and values will be utility-specific
- Transparent New weightings developed will help ensure Safety focus
JUA Methodology: Model Components

**Exposure**

...what is the asset or non-asset measure that fundamentally affects the risk?

- **People**
  - Example:
    - 25,050 employees
    - 8,700 contractors
    - 33,750 total workforce

**Frequency**

...what is the frequency of event drivers per exposure?

- Example:
  - 204 events/1 year/all employees

**Consequences**

...if an event happens, what are the consequences?

- **Safety**
  - Example:
    - 22 injuries / event
    - 14 fatalities / event

- **Other attributes**

**Mitigations**

...which programs alter the frequency or consequences of risk events? By how much?

- Security programs, workforce training, etc.
  - Example:
    - Location access control among facilities and key personnel
Simulation and modeling allows for creation of different reports.

**Report 1: Consequence Results over Time (Unmitigated vs. Mitigated)**

**Report 2: Mitigation Effectiveness per consequence**

**Report 3: Absolute Mitigation Effectiveness over time**

**Report 4: Risk Spend Efficiency Reduction in consequence per dollar spent**
Near-Term Application: The Safety Attribute of the JUA Model
Safety Attribute: A Good First Step

- JUA:
  - Focuses on safety
  - Allows for uniform, probabilistic comparison across risks, mitigations, utilities
  - Enables the use of various levels of modeling sophistication
  - Translates various types of modeling outputs into a common model that the utilities can use to prioritize and mitigate safety risks
  - Evaluates the effectiveness of mitigations in the context of the risks in the utilities’ risk registers such as:
    - Safety risk reduction from wildfire risk
    - Safety risk reduction from pipeline failure risk
  - Flexible to be used in numerous ways
    - Risk Tolerances, Risk Spend Efficiency
Internal Utility Analysis
- Developed internally
- Proportionate model detail
- Appropriate Data
- May include company-specific concerns

Outputs from various modeling approaches are translated into a

Uniform Safety Risk Matrix

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs*)</th>
<th>High (0.5 – 2.5 SIFs)</th>
<th>Moderate (0.1 – 0.5 SIFs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood**</td>
<td>0.05</td>
<td>0.10</td>
<td>0.33</td>
</tr>
</tbody>
</table>

* SIF = Serious Injury and/or Fatality.
** Values in table are annual likelihoods of occurrence, accumulated by any trigger in the risk category.

Note: This is a preliminary concept that helps translate various modeling approaches into common safety assessments. The safety metric and its associated impact categories are still under development and will incorporate lessons learned from JIA.
### JUA Potential Applications

Potential application to be determined in collaboration with commission and interested parties

<table>
<thead>
<tr>
<th>Safety Reporting</th>
<th><strong>Value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value</strong></td>
<td></td>
</tr>
<tr>
<td>Transparently communicate safety exposure for each risk in a common language</td>
<td></td>
</tr>
<tr>
<td>Enables commission and parties to understand and compare utilities’ safety risk exposure</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety Risk Scoring</th>
<th><strong>Value</strong></th>
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<tbody>
<tr>
<td><strong>Value</strong></td>
<td></td>
</tr>
<tr>
<td>Develop common safety risk scores using natural units</td>
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</tr>
<tr>
<td>Enables commission and parties to understand and compare utilities’ safety risk profiles</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Safety Risk Spend Efficiency</th>
<th><strong>Value</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Value</strong></td>
<td></td>
</tr>
<tr>
<td>Calculate common safety risk spend efficiencies for mitigations</td>
<td></td>
</tr>
<tr>
<td>Enables commission and parties to understand and compare utilities’ efficiency of safety mitigations</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
- RSE is useful because it cultivates the utilities’ safety culture and provides valuable inputs that inform investment decisions in a transparent safety-focused way
- Other attributes, factors and constraints are important to consider when making final decisions
Safety risk score calculation

Use midpoints of each impact level to do math:

\[
Risk\ Score = \sum Impact \times Likelihood
\]

Safety Risk Score: \( (7.5 \times 0.05) + (1.5 \times 0.10) + (0.3 \times .33) = 0.624 \)

Interpretation in Natural Units: On average, \(~0.6\) SIFs are expected to occur each year.
If desirable, mitigations can be ranked based on safety risk reduction per dollar

<table>
<thead>
<tr>
<th>Mitigation 1</th>
<th>Safety Risk Score Before (SIFs/yr)</th>
<th>Safety Risk Score After (SIFs/yr)</th>
<th>Cost ($)</th>
<th>RSE Safety Risk Score Reduction/$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitigation 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Mitigation n</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Illustrative
JUA Potential Outputs

- Safety-based risk ranking for each company using a common framework

- Individual risk assessment summaries including:
  - Risk description
  - Utility-specific modeling approach (inputs, model, outputs)
  - Evaluation of current safety risk level
  - Alternatives analysis and mitigation ranking using a safety-based RSE
JUA Demo

Illustrative Examples
SDG&E Examples

Illustrative Examples
Aviation – Stochastic
Fail to Black Start – Event Tree
Stochastic Example: SDG&E Aviation

Probabilistic Model

- Equipment Failure
- Inadequate Visual Markings
- Environment

Aviation Incident

- Loss of Life
- Serious Bodily Injury
- Damage to Facilities
**Risk:** Aviation risk from helicopters incurring safety events during operations

- **Likelihood of Event:**
  - Gamma distribution
  - Parameters: (14.658, 0.80717)

- **Consequence of Event:**
  - Geometric distribution
  - Fatality: (0.77834)
  - Serious Injury: (0.82717)
  - Minor Injury: (0.72194)

<table>
<thead>
<tr>
<th>Run</th>
<th>Fatality</th>
<th>Serious Injury</th>
<th>Minor Injury</th>
<th>SIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>C</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0.21</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2.1</td>
</tr>
</tbody>
</table>
Stochastic Example: SDG&E Aviation

Aviation Risk - SDG&E
(10,000 simulations)

<table>
<thead>
<tr>
<th>SIFS</th>
<th>Moderate</th>
<th>High</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5-12.5</td>
<td>0.5-2.5</td>
<td>0.1-0.5</td>
<td>0-0.1</td>
</tr>
<tr>
<td>Occurrences</td>
<td>12</td>
<td>212</td>
<td>56</td>
</tr>
<tr>
<td>Likelihood</td>
<td>.0012</td>
<td>.0212</td>
<td>.0056</td>
</tr>
</tbody>
</table>

Illustrative
Stochastic Example: SDG&E Aviation

<table>
<thead>
<tr>
<th>Impact</th>
<th>Extreme</th>
<th>High</th>
<th>Moderate</th>
<th>Not Shown</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIFs</td>
<td>2.5-12.5</td>
<td>0.5-2.5</td>
<td>0.1-0.5</td>
<td>0-0.1</td>
</tr>
<tr>
<td>Occurrences</td>
<td>12</td>
<td>212</td>
<td>56</td>
<td>9720</td>
</tr>
<tr>
<td>Likelihood</td>
<td>0.0012</td>
<td>0.0212</td>
<td>0.0056</td>
<td>0.972</td>
</tr>
</tbody>
</table>

Uniform Safety Risk Matrix

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
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<th>Moderate (0.1 – 0.5 SIFs)</th>
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</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.0012</td>
<td>0.0212</td>
<td>0.0056</td>
</tr>
</tbody>
</table>
## Stochastic Example: SDG&E Aviation

### Aviation Risk – Pre-Mitigation (Operating single-engine helicopters)

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
<th>High (0.5 – 2.5 SIFs)</th>
<th>Moderate (0.1 – 0.5 SIFs)</th>
<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.0012</td>
<td>0.0212</td>
<td>0.0056</td>
<td>0.0424</td>
</tr>
</tbody>
</table>

### Aviation Risk – Post-Mitigation (Operating twin-engine helicopters)

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
<th>High (0.5 – 2.5 SIFs)</th>
<th>Moderate (0.1 – 0.5 SIFs)</th>
<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.0003</td>
<td>0.0104</td>
<td>0.0006</td>
<td>0.0180</td>
</tr>
</tbody>
</table>

### Risk Spend Efficiency

<table>
<thead>
<tr>
<th>Mitigation</th>
<th>Safety Risk Score Before</th>
<th>Safety Risk Score After</th>
<th>Cost</th>
<th>Safety Risk Score Reduced/$1M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replacing single engine with twin-engine</td>
<td>0.0424</td>
<td>0.0180</td>
<td>$3M</td>
<td>0.00815</td>
</tr>
</tbody>
</table>
Fault/Event Tree Example: SDG&E Fail To Black Start

Event Tree Model

Assumes a blackout has occurred

Facility Availability
Inadequately Maintained Black Start Equipment
Lack of training / preparation

Fail to Black Start

Health / Safety
Grid Impact
Compliance Violations
Impact from prolonged outage
Pre-Mitigation

**Current State**

<table>
<thead>
<tr>
<th>Current likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8%</td>
</tr>
</tbody>
</table>

Blackout less than 8 hours: 0.3%
20.5% of the time

- 91.2% At least one neighbor on interconnect is not blacked out
- 83.3% Blackstart facility is not undergoing maintenance
- 8.8% All 4 critical neighboring interconnect utilities affected
- 16.7% Blackstart facility is unavailable (2 months/year)

**Successful Blackstart**

99.999986% At least 1 cranking path available
99.999986% Blackstart facility is not undergoing maintenance

**Failure to Blackstart**

0.000014% Both cranking paths unavailable
This is basically 0

Blackout greater than 8 hours: 1.5%
79.5% of the time

- 91.2% At least one neighbor on interconnect is not blacked out
- 83.3% Blackstart facility is available
- 8.8% All 4 critical neighboring interconnect utilities affected
- 16.7% Blackstart facility is unavailable (batteries expired after 8 hours)

**Successful Blackstart**

93.8% Batteries work for both cranking paths

**Failure to Blackstart**

6.3% Batteries fail for both cranking paths

This is basically 0

---

Fault/Event Tree Example: SDG&E Fail To Black Start

**Illustrative**
Example Methodology: SDG&E Fail to Black Start

Post-Mitigation

**Proposed Redundant Path (P1)**

- New P1 Likelihood: 0.62%
- Blackout less than 8 hours: 0.05%

### Blackout less than 8 hours: 20.5% of the time

- **91.2% At least one neighbor on interconnect is not blacked out**
  - **83.3% Blackstart facility is not undergoing maintenance**
    - **Successful Blackstart**
  - **16.7% Blackstart facility is unavailable (2 months/year)**
    - **Proposed Redundant Path is available**
      - **Successful Blackstart**
    - **16.7% Proposed Redundant Path is unavailable**
      - **failure to blackstart**

### Blackout greater than 8 hours: 79.5% of the time

- **91.2% At least one neighbor on interconnect is not blacked out**
  - **93.8%** Batteries work for either (or both) Blackstart facility
  - **75.0%** Batteries work for Proposed Redundant Path’s 1 cranking path
- **8.8% All 4 critical neighboring interconnect utilities affected**
  - **83.3% Blackstart facility is available**
    - **Successful Blackstart**
  - **6.3% Batteries fail for both Blackstart facility cranking path**
    - **16.7% Proposed Redundant Path is unavailable**
      - **failure to blackstart**
  - **25.0% Batteries fail for Proposed Redundant Path’s 1 cranking path**
    - **16.7% Blackstart facility is unavailable**
      - **16.7% Proposed Redundant Path is unavailable**
        - **failure to blackstart**
Fault/Event Tree Example: SDG&E Fail To Black Start

SDG&E Black Start Risk - Pre-Mitigation
(0 SIF likelihood not shown)

- Impact
  - Extreme
  - High
  - Moderate
  - <Moderate

- SIFs
  - 2.5-12.5

- Likelihood
  - 0.006
  - 0.018
  - 0.058
  - 0.918

- Multiplier
  - 7.5
  - 1.5
  - 0.3
  - 0
## Fault/Event Tree Example: SDG&E Fail To Black Start

### Fail to Black Start Risk – Pre-Mitigation

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
<th>High (0.5 – 2.5 SIFs)</th>
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<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.006</td>
<td>0.018</td>
<td>0.058</td>
<td>0.0894</td>
</tr>
</tbody>
</table>

### Fail to Black Start Risk – Post-Mitigation (South Grid Black Start Project: adds additional redundant cranking path. Likelihood reduced by 65.9%)

<table>
<thead>
<tr>
<th>Safety Impact</th>
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<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.002</td>
<td>0.006</td>
<td>0.018</td>
<td>0.0294</td>
</tr>
</tbody>
</table>

### Risk Spend Efficiency

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<th>Cost</th>
<th>Safety Risk Score Reduced/$1M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black Start Redundancy</td>
<td>0.0894</td>
<td>0.0294</td>
<td>$1.2M</td>
<td>0.05</td>
</tr>
</tbody>
</table>
SCG Example

Illustrative Example

Third Party Dig-Ins
The risk of a dig-in, caused by third party activities, which results in catastrophic consequences.

- Third party contractors or homeowners/renters do not call one-call center prior to excavation
- Company employees do not mark underground gas infrastructure correctly
- Excavator fails to comply with excavation laws or best practices
- Company does not respond to one-call center request in required timeframe
- Company does not perform “standby” duties

Catastrophic Damage Involving Third Party Dig-Ins

- Fatalities or severe injuries and property loss
- Major outage
- Adverse litigation
- Erosion of public confidence
Event Tree Example – SCG – Dig-ins

- Started with dig-in data collected by “damage cause” according to event tree
- Identified causes and triggers affected by each mitigation
- Calibrated likelihood and mitigation improvements with engineering

Triggers

- Excavator failure to notify
- Excavator digging error
- Inaccurate locates
- Failure to locate

Mitigations

- B1 Locate & Mark Training
- B2 Locate & Mark Operator Qualification
- B3 Staff Support
- B4 Locate & Mark
- B5 Damage Prevention Public Awareness
- B6 Pipeline Observation (standby)
- P1 Standardize & Upgrade Equipment
- P2 Issue Smart Phones
- P3 Upgrade reporting systems
- P4 Incremental support staff
- P5 Incremental locate & mark resources
- P7 Public awareness

Admin-side analysis
In-field dig-in prevention and improvements
Public awareness

Third Party Dig-In
Event Tree Example – SCG – Dig-ins

- Used event tree to apply each mitigation improvement to post-mitigation likelihood data

Next, calibrate with industry research and industry data

Source: SoCalGas RAMP Chapter SCG-1. SoCalGas - I16-10-016 - RISK ASSESSMENT AND MITIGATION PHASE REPORT OF SAN DIEGO GAS & ELECTRIC COMPANY AND SOUTHERN CALIFORNIA GAS COMPANY
### Third Party Dig-Ins Risk – Pre-Mitigation

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
<th>High (0.5 – 2.5 SIFs)</th>
<th>Moderate (0.1 – 0.5 SIFs)</th>
<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.0183</td>
<td>0.33</td>
<td>0.4</td>
<td>0.76</td>
</tr>
</tbody>
</table>

### Third Party Dig-Ins Risk – Post-Mitigation (Increase public awareness)

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
<th>High (0.5 – 2.5 SIFs)</th>
<th>Moderate (0.1 – 0.5 SIFs)</th>
<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.018</td>
<td>0.3283</td>
<td>0.394</td>
<td>0.75</td>
</tr>
</tbody>
</table>

### Risk Spend Efficiency

<table>
<thead>
<tr>
<th>Mitigation</th>
<th>Safety Risk Score Before</th>
<th>Safety Risk Score After</th>
<th>Cost</th>
<th>Safety Risk Score Reduced/$1M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Public Awareness</td>
<td>0.76</td>
<td>0.75</td>
<td>$200K</td>
<td>0.05</td>
</tr>
</tbody>
</table>
PG&E Example

Illustrative Example

Insider Threat
“A current or former employee or contractor uses their company issued PG&E access and company knowledge to harm the company through theft, fraud, sabotage, or workplace violence. Such activities may cause loss of assets or information, financial liability, damage to facilities or systems, or harm to individuals, company assets, or reputation.”
Insider Threat Bow Tie Diagram - Left Side

Exposure

- Number in Workforce by Location

Risk top-level drivers

- Fraud
  - 19%
- Theft
  - 7%
- Vandalism
  - ~0.4%
- Sabotage
- Workplace Violence (Non-active shooter)
  - 43%
- Workplace Violence (Active shooter)
  - < 0.1%
- Fitness For Duty (Drugs/Alcohol)
  - 6%
- Misuse of Company Assets
  - 20%
- Erroneous Completion of Company Docs
  - 4%

Indicators

- MALICIOUS Insider Threat Risks
- NON-MALICIOUS Employee Behaviors Observed

Risk event(s)

- Insider Threat Event with Adverse Impact to PG&E
The relationship between mitigations and drivers / consequences governs the structure of the risk model.

**Mitigation matrices**

**Frequency**
- Theft
- Fraud
- Vandalism/Sabotage
- Workplace Violence
- Fitness For Duty/(Drugs Alcohol)
- Misuse of Company Assets
- Falsification of Company Documents

**Consequence**
- Safety
- Reliability
- Trust
- Environmental
- Compliance
- Financial

**Costs/Year of Expense**
- Capital
- O&M
- Start Year
- End Year

<table>
<thead>
<tr>
<th>Mitigation</th>
<th>Theft</th>
<th>Fraud</th>
<th>Vandalism/Sabotage</th>
<th>Workplace Violence</th>
<th>Fitness For Duty/(Drugs Alcohol)</th>
<th>Misuse of Company Assets</th>
<th>Falsification of Company Documents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitigation 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mitigation 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Costs/Year of Expense</th>
<th>Start Year</th>
<th>End Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theft</td>
<td></td>
<td>2018</td>
<td></td>
</tr>
<tr>
<td>Fraud</td>
<td></td>
<td>2018</td>
<td></td>
</tr>
<tr>
<td>Vandalism/Sabotage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workplace Violence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fitness For Duty/(Drugs Alcohol)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misuse of Company Assets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Falsification of Company Documents</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safety</td>
<td>$3 M</td>
<td>2018</td>
<td>2018</td>
</tr>
<tr>
<td>Reliability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compliance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Financial</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Illustrative
Results - SIF Distribution

Pre-mitigated vs Post Mitigated Histogram
(10,000 Trials)

- Pre-Mitigated
- Post Mitigated

Probability

SIFs/Year

High
Extreme

Illustrative

0.9959
### Stochastic Example: PG&E Insider Threat

**Insider Threat Risk – Pre-Mitigation**

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
<th>High (0.5 – 2.5 SIFs)</th>
<th>Moderate (0.1 – 0.5 SIFs)</th>
<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.0020</td>
<td>0.0021</td>
<td>0.0005</td>
<td>0.0183</td>
</tr>
</tbody>
</table>

**Insider Threat Risk – Post-Mitigation**

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
<th>High (0.5 – 2.5 SIFs)</th>
<th>Moderate (0.1 – 0.5 SIFs)</th>
<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.0017</td>
<td>0.0024</td>
<td>0.0004</td>
<td>0.0165</td>
</tr>
</tbody>
</table>

**Risk Spend Efficiency**

<table>
<thead>
<tr>
<th>Mitigation</th>
<th>Safety Risk Score Before</th>
<th>Safety Risk Score After</th>
<th>Cost</th>
<th>Safety Risk Score Reduced/$1M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insider Threat Mitigation</td>
<td>0.0183</td>
<td>0.0165</td>
<td>$3M</td>
<td>0.0006</td>
</tr>
</tbody>
</table>
SCE Example

Illustrative Example

Wire Down
The example shown focuses entirely on the safety consequence of the injury outcome.

A complete evaluation would score each consequence of every outcome.

**Probabilistic Model**

- Weather
- Mylar Balloons
- Vegetation

- Wire Down
- Injury
- Wildfire
- Property Damage
- Outage
- Freeway/Road Closure

- Safety
- Financial
- Environmental
- Safety
- Financial
- Safety
- Financial
- Reliability
- Financial
Step 1
• Assume wire downs are a Poisson process with a mean calculated from historical data.

Step 2
• Simulate 10,000 trials by sampling TEF values from the distribution.

Step 3
• For each simulation, draw the number of outcomes from a binomial distribution with a number of trials equal to the simulated TEF and a probability of success based on recorded safety incidents.

Step 4
• For each positive outcome, randomly choose the number of SIFs from the distribution of historical SIFs caused by wire down events.

Step 5
• Sum the SIFs for each scenarios.

The modeling approach, assumptions, and results are illustrative.
Results - TEF Distribution

- **Pre-Mitigated Scenario**
  - **Assumptions**
    - Wire downs are a Poisson process
    - Historical TEF used as mean for Poisson distribution

- **Post-Mitigated Scenario**
  - **Assumptions**
    - Reconductor mitigation applied to all distribution circuits
    - Reconductor effectively reduces TEF by 47%

Wire Down Histogram

Impact of Mitigation
Results - SIF Distribution

Pre-Mitigated vs Post-Mitigated SIFs
Histogram

<table>
<thead>
<tr>
<th>SIFs</th>
<th>Pre-Mitigated</th>
<th>Post-Mitigated</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td>1</td>
<td>0.17</td>
<td>0.17</td>
</tr>
<tr>
<td>2</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>3</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>4</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>5</td>
<td>0.07</td>
<td>0.07</td>
</tr>
<tr>
<td>6</td>
<td>0.04</td>
<td>0.04</td>
</tr>
<tr>
<td>&gt; 6</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Impact

<table>
<thead>
<tr>
<th>SIFS Occurrences</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5-12.5</td>
<td>Extreme: 0.185, High: 0.279, Moderate: 0.000, Not Shown: 0.536</td>
</tr>
<tr>
<td>1848</td>
<td>Extreme: 0.000, High: 0.000, Moderate: 0.000, Not Shown: 0.000</td>
</tr>
<tr>
<td>2791</td>
<td>Extreme: 0.000, High: 0.000, Moderate: 0.000, Not Shown: 0.000</td>
</tr>
<tr>
<td>5361</td>
<td>Extreme: 0.000, High: 0.000, Moderate: 0.000, Not Shown: 0.000</td>
</tr>
</tbody>
</table>
## Wire Down Risk – Pre-Mitigation

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
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<th>Moderate (0.1 – 0.5 SIFs)</th>
<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.18</td>
<td>0.28</td>
<td>0.00</td>
<td>1.80</td>
</tr>
</tbody>
</table>

## Wire Down Risk – Post-Mitigation

<table>
<thead>
<tr>
<th>Safety Impact</th>
<th>Extreme (2.5 – 12.5 SIFs)</th>
<th>High (0.5 – 2.5 SIFs)</th>
<th>Moderate (0.1 – 0.5 SIFs)</th>
<th>Safety Risk Score (Expected SIFs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood</td>
<td>0.10</td>
<td>0.19</td>
<td>0.00</td>
<td>1.01</td>
</tr>
</tbody>
</table>

## Risk Spend Efficiency

<table>
<thead>
<tr>
<th>Mitigation</th>
<th>Safety Risk Score Before</th>
<th>Safety Risk Score After</th>
<th>Cost</th>
<th>Safety Risk Score Reduced/$1M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire Down mitigation</td>
<td>1.80</td>
<td>1.01</td>
<td>$5.6B</td>
<td>0.00014</td>
</tr>
</tbody>
</table>
Comparability
Utilities maintain their appropriately unique modeling approaches with the ability to translate results into a common safety risk language that allows for comparability across the utilities.

<table>
<thead>
<tr>
<th>Risk</th>
<th>PG&amp;E</th>
<th>SDG&amp;E</th>
<th>SCE</th>
<th>SCG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insider threat</td>
<td>Aviation incident</td>
<td>Fail to black start</td>
<td>Wire down incident</td>
<td>Third-party dig-ins</td>
</tr>
<tr>
<td>Modeling Approach</td>
<td>Stochastic</td>
<td>Stochastic</td>
<td>Fault/Event Tree Analysis</td>
<td>Stochastic</td>
</tr>
<tr>
<td>Pre-Mitigation Safety Risk Score (Expected SIFs/yr)</td>
<td>0.0183</td>
<td>0.0424</td>
<td>0.0894</td>
<td>1.8450</td>
</tr>
<tr>
<td>Post-Mitigation Safety Risk Score (Expected SIFs/yr)</td>
<td>0.0165</td>
<td>0.0180</td>
<td>0.0294</td>
<td>0.9600</td>
</tr>
<tr>
<td>Cost ($)</td>
<td>$3.0M</td>
<td>$3.0M</td>
<td>$1.2M</td>
<td>$5.6B</td>
</tr>
<tr>
<td>RSE (Safety Risk Score Reduced/$1M)</td>
<td>0.00060</td>
<td>0.00815</td>
<td>0.05000</td>
<td>0.00014</td>
</tr>
</tbody>
</table>
Next Steps

- Develop roadmap for Safety attribute evolution, which includes:
  1. For all IOUs: Decide on the numerical safety scales (e.g. SIF, injuries, etc)
  2. For each IOU separately: Produce a risk distribution for the Safety attribute using the numerical scales from #1
  3. For all IOUs: Decide how many categories to use (i.e. Extreme, High, Moderate, etc)
  4. For all IOUs: Decide on the numerical safety scales for the categories from #3
  5. For all IOUs: Decide on the safety multipliers for all categories from #3
  6. For each IOU separately: Calculate the new risk score

- Future potential expansion to other attributes:
  - Incorporate other attributes in the future
  - Development of risk tolerances / ALARP
  - Heat map
## Success Criteria Evaluation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety-Focused</td>
<td>Safety-based risk ranking and mitigation</td>
</tr>
<tr>
<td>Simple</td>
<td>Easy to communicate and understand</td>
</tr>
<tr>
<td>Uniform</td>
<td>Can be uniformly applied by all utilities</td>
</tr>
<tr>
<td>Probabilistic</td>
<td>Enables probabilistic modeling</td>
</tr>
<tr>
<td>Comparable</td>
<td>Enables comparison of safety risks across utilities</td>
</tr>
<tr>
<td>Cost-Effective</td>
<td>Is not costly to implement</td>
</tr>
</tbody>
</table>
### Roadmap

#### 2017 Actions
- Continue to participate in JIA test drives.
- Meet and confer with parties.
- Determine how to conduct test drives for JUA.
- Begin test drives for JUA platform.
- Continue the use of the tiered modeling approach.
- Finalize JIA test drive.

#### 2018 Actions
- Finalize JUA test drive.
- Consider other attributes for JUA.
- Begin SME calibration and common risk profiles among the IOUs.
- Utilities file second S-MAP applications.
- Begin discussion on incorporation of risk tolerance.
- Develop a common risk taxonomy.

#### 2019 Actions
- Continued evolution risk methodologies.
- Workshops associated with the second S-MAP.
- Incorporate CPUC decisions into RAMP filings.
Questions?