Outline

• Introduction
• Structure of the Risk Computation
• Ten Specific M&S Characteristics
• Overall M&S Risk Determination
Introduction

Risk = Impact \times Likelihood

- Identify specific M&S characteristics to be evaluated against rating criteria
- Use the ratings and a simple formula to generate a numerical input to the Likelihood of Error
- Improve the Likelihood of Error rating by executing actions identified to improve a characteristic’s rating

<table>
<thead>
<tr>
<th>Overall Likelihood of Error</th>
<th>5</th>
<th>G</th>
<th>Y</th>
<th>R</th>
<th>R</th>
<th>R</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

Level of Consequence of M&S Error
Structure of the Risk Computation
Eight Steps of the Risk Determination Computation

1) Perform the assessment of the ten M&S characteristics for the M&S

2) Using the counts of Red, Yellow, and Green instances found in Step 1, compute the Specific Likelihood of Error (SLE)

3) Determine the General Likelihood of Error (GLE) for the M&S
Eight Steps of the Risk Determination Computation

4) Use the results of Steps 2 & 3 to determine the Overall Likelihood of Error (OLE)

5) Determine the level of reliance on the M&S

6) Determine the importance level for the M&S

7) Use the results of Steps 5 & 6 to determine the Level of Consequence of M&S Error

8) Use the results of Steps 4 & 7 to determine the Overall Risk
Structure of the Risk Determination Computation

1. Specific Likelihood of Error
2. General Likelihood of Error
3. Level of Reliance on the M&S
4. Overall Likelihood of Error
5. Level of Consequence of M&S Error
6. Level of Importance of the M&S
7. Overall Risk
Ten Specific M&S Characteristics
Pillars of Credibility and Their Characteristics

**Capability**
- Intended Use and Acceptability Criteria
- Conceptual Model Validation
- Model Fidelity

**Accuracy**
- Design Validation
- Input and Embedded Data
- System Verification
- Output Validation
- Configuration Management

**Usability**
- Documentation
- User Community
The M&S and its components are supported by a sound written configuration management (CM) plan.

- A formally documented CM process is followed for ALL M&S changes and is supported with a written CM Plan.
- Some CM processes exist for major M&S upgrades/code changes; CM processes are informally documented.
- No documented CM process exists.
Rating Justifications

Provide the justification for the rating assigned
• Specific details about why a particular rating was assigned

Recommend any actions for the M&S developer
• What actions can the M&S developer take to improve a yellow or red rating

Recommend any mitigation (VV&A) steps
• What additional VV&A activities can be performed to improve a yellow or red rating
Some M&S tools composing the federation follow a CM process while others have no evidence that CM is being followed. Provide the justification for the rating assigned.

- Provide or develop a written CM plan. Recommend any actions for the M&S developer.

- Review CM documentation and artifacts for compliance with program requirements. Recommend any mitigation (VV&A) steps.
Conceptual Model Validation

The conceptual model (framework, algorithms, data sources, and assumptions) is documented and correctly and adequately describes the needs and requirements of the intended uses.

- The conceptual model is well documented and has been reviewed and judged adequate to the requirements of the intended uses by qualified subject matter experts.
- There is no formal conceptual model documentation, although informal sources are available. The conceptual model has been reviewed but may require improvement to support the intended use.
- No conceptual model documentation is available or the conceptual model does not meet the requirements of the intended use.
There is no formal conceptual model documentation. However, the M&S is based on an existing framework which has been used successfully in the past.

- Develop conceptual model documentation for the M&S

- Conduct and document a review of the conceptual model documentation
## Step 1: Complete M&S Characteristic Assessment

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capability</strong></td>
<td></td>
</tr>
<tr>
<td>Intended Use and Acceptability Criteria</td>
<td>Green</td>
</tr>
<tr>
<td>Conceptual Model Validation</td>
<td>Yellow</td>
</tr>
<tr>
<td>Model Fidelity</td>
<td>Red</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td></td>
</tr>
<tr>
<td>Design Validation</td>
<td>Yellow</td>
</tr>
<tr>
<td>Input and Embedded Data</td>
<td>Yellow</td>
</tr>
<tr>
<td>System Verification</td>
<td>Red</td>
</tr>
<tr>
<td>Output Validation</td>
<td>Red</td>
</tr>
<tr>
<td>Configuration Management</td>
<td>Red</td>
</tr>
<tr>
<td><strong>Usability</strong></td>
<td></td>
</tr>
<tr>
<td>Documentation</td>
<td>Yellow</td>
</tr>
<tr>
<td>User Community</td>
<td>Yellow</td>
</tr>
</tbody>
</table>
Overall M&S Risk Determination
Step 2: Compute the SLE

1. Specific Likelihood of Error
2. General Likelihood of Error
3. Level of Reliance on the M&S
4. Overall Likelihood of Error
5. Level of Importance of the M&S
6. Level of Consequence of M&S Error
7. Overall Risk

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Partial Likelihood of Error (PLOE)

1) Count the number of Red, Yellow, and Green ratings assigned in Step 1

2) Use the following equation:

\[
PLOE = \frac{Red \times 3 + Yellow \times 2 + Green - 5}{5}
\]
Partial Likelihood of Error (PLOE)

\[ PLOE = \frac{4 \times 3 + 5 \times 2 + 1 - 5}{5} \]

\[ PLOE = 3.6 \]
Specific Likelihood of Error (SLE)

Convert the PLOE to the SLE by rounding to the nearest integer.

For this example: PLOE of 3.6 → SLE = 4
### Step 3: Determine the General Likelihood of Error (GLE)

<table>
<thead>
<tr>
<th>(1) Specific Likelihood of Error</th>
<th>(2) SLE = 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3) General Likelihood of Error</td>
<td></td>
</tr>
<tr>
<td>(5) Level of Reliance on the M&amp;S</td>
<td></td>
</tr>
<tr>
<td>(6) Level of Importance of the M&amp;S</td>
<td></td>
</tr>
</tbody>
</table>

**Overall Risk**

**Level of Consequence of M&S Error**

**Overall Likelihood of Error**

**Specific Likelihood of Error**

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# General Likelihood of Error

<table>
<thead>
<tr>
<th>GLE Ranking</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Low)</td>
<td>Very High Confidence based on: Extensive body of documented verification &amp; validation, and/or prior accreditation relative to the intended use; extensive, disciplined M&amp;S development history with technical and managerial review over time including comprehensive software testing (plans, reports, known errors, bug tracking), added to the characteristics of “High Confidence” M&amp;S described below.</td>
</tr>
<tr>
<td>2</td>
<td>High Confidence based on: SME face validation relevant to current intended use, documented V&amp;V results, and evidence of effective configuration management, added to the characteristics of “Moderate Confidence” M&amp;S described below.</td>
</tr>
<tr>
<td>3</td>
<td>Moderate Confidence based on: Documented prior usage relevant to the intended use or known (documented) V&amp;V history, and at least informal configuration management, added to the characteristics of “Low Confidence” M&amp;S described below.</td>
</tr>
<tr>
<td>4</td>
<td>Low Confidence based on: SME Review of Capabilities, Limitations and known Errors of M&amp;S relative to the intended use, and some V&amp;V history, added to the characteristics of “Very Low Confidence” M&amp;S described below.</td>
</tr>
<tr>
<td>5 (High)</td>
<td>Very Low Confidence based on: comparison with M&amp;S requirements derived from the intended use; V&amp;V plans may have been written (but with no documented evidence of their execution); or the M&amp;S credibility is unknown (no documented VV&amp;A status).</td>
</tr>
</tbody>
</table>
Step 4: Compute the Overall Likelihood of Error (OLE)

Specific Likelihood of Error

General Likelihood of Error

Level of Reliance on the M&S

Level of Importance of the M&S

SLE = 4

GLE = 3

Overall Likelihood of Error

Level of Consequence of M&S Error

Overall Risk

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Compute OLE

Use the following association matrix to determine the OLE:

<table>
<thead>
<tr>
<th>GLE Ranking</th>
<th>Overall M&amp;S Likelihood of Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
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<tr>
<td>4</td>
<td>3</td>
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<td>3</td>
<td>2</td>
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<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

**Specific Likelihood of Error**  
(Computed from PLOE)
Step 5: Level of Reliance

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>SLE</th>
<th>GLE</th>
<th>OLE</th>
<th>Overall Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific Likelihood of Error</td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>General Likelihood of Error</td>
<td></td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Level of Reliance on the M&amp;S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Level of Consequence of M&amp;S Error</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Level of Importance of the M&amp;S</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6</td>
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<tr>
<td>7</td>
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<td>8</td>
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</tr>
</tbody>
</table>
## Level of Reliance on M&S Decisions

<table>
<thead>
<tr>
<th>Role Level</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>M&amp;S will be the <em>only method</em> employed to make a decision</td>
</tr>
<tr>
<td>3</td>
<td>M&amp;S will be the <em>primary method</em>, employed with other non-M&amp;S methods</td>
</tr>
<tr>
<td>2</td>
<td>M&amp;S will be a <em>secondary method</em>, employed with other non-M&amp;S methods, and will <em>provide significant data unavailable through other means</em>.</td>
</tr>
<tr>
<td>1</td>
<td>M&amp;S will be a <em>supplemental method</em>, employed with other non-M&amp;S methods, and will <em>provide supplemental data already available through other means</em>.</td>
</tr>
</tbody>
</table>
Step 6: Level of Importance

(1) Specific Likelihood of Error
(2) Specific Likelihood of Error
(3) General Likelihood of Error
(4) General Likelihood of Error
(5) Level of Reliance on the M&S
(6) Level of Importance of the M&S
(7) Level of Consequence of M&S Error
(8) Overall Risk

GLE = 3
SLE = 4
OLE = 4
Reliance = 2
Level of Consequence of M&S Error

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Importance Determination

• Use the “General Importance Level Description” table...

<table>
<thead>
<tr>
<th>Importance Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Intended use addresses multiple areas of significant program risk, key program reviews and test events, key system performance analysis, primary test objectives and test article design, system requirements definition, and/or high software criticality, used to make a technical or managerial decision.</td>
</tr>
<tr>
<td>3</td>
<td>Intended use addresses an area of significant program risk.</td>
</tr>
<tr>
<td>2</td>
<td>Intended use addresses medium or low program risk, other program reviews and test events, secondary test objectives and test article design, other system requirements and system performance analysis, and medium or low S/W criticality used to make technical or managerial decisions.</td>
</tr>
<tr>
<td>1</td>
<td>Intended use addresses program objectives or analysis that is not a significant factor in the technical or managerial decision making process.</td>
</tr>
</tbody>
</table>

...or use a combination of two tables based on MIL-STD 882C/D on System Safety
Step 7: Level of Consequence

- Specific Likelihood of Error: SLE = 4
- General Likelihood of Error: GLE = 3
- Level of Reliance on the M&S: Reliance = 2
- Level of Importance of the M&S: Importance = 1

Overall Risk:

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Compute Level of Consequence

Use the following association matrix to determine the Level of Consequence:

Consequence Matrix

<table>
<thead>
<tr>
<th>Importance</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><strong>3</strong></td>
<td><strong>4</strong></td>
<td><strong>5</strong></td>
<td><strong>5</strong></td>
</tr>
<tr>
<td>3</td>
<td><strong>2</strong></td>
<td><strong>3</strong></td>
<td><strong>4</strong></td>
<td><strong>5</strong></td>
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<tr>
<td>2</td>
<td><strong>2</strong></td>
<td><strong>2</strong></td>
<td><strong>3</strong></td>
<td><strong>4</strong></td>
</tr>
<tr>
<td>1</td>
<td><strong>1</strong></td>
<td><strong>2</strong></td>
<td><strong>2</strong></td>
<td><strong>3</strong></td>
</tr>
</tbody>
</table>

Reliance

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Step 8: Overall Risk

- Specific Likelihood of Error: SLE = 4
- General Likelihood of Error: GLE = 3
- Level of Reliance on the M&S: Reliance = 2
- Level of Importance of the M&S: Importance = 1
- Overall Risk: Consequence = 2

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Overall Risk Determination

- Use the Overall Risk association matrix to determine the overall risk for the M&S:

**Overall Risk**

<table>
<thead>
<tr>
<th>Overall Likelihood of Error</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>5</td>
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<td>4</td>
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<td>1</td>
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</tr>
</tbody>
</table>

*Red = High Risk*
*Yellow = Medium Risk*
*Green = Low Risk*

**Level of Consequence of M&S Error**

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Risk Reduction

Performing the recommended actions proposed for each characteristic that did not evaluate to Green reduces the Likelihood of Error.

![Risk Reduction Diagram]

- **Initial Assessment**
- **Final Assessment**

**Overall Risk**

- **Level of Consequence of M&S Error**
  - 1
  - 2
  - 3
  - 4
  - 5

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Conclusion

1) 10 M&S characteristics are identified
2) Criteria for evaluating each characteristic is provided
3) Actions to improve the rating of a characteristic are required (if not green)
4) Initial and final risk analyses can be performed to show a reduced likelihood of error
Capability

Intended Use and Acceptability Criteria

The General and Specific Intended Use(s) of the M&S is/are clearly stated; the Acceptability Criteria and their Metrics are clearly articulated.

Well documented and linked to M&S program requirements and goals

At least informally documented but not linked to M&S requirements and specific program goals

Not well documented and/or not linked to M&S program requirements and goals
Capability

Conceptual Model Validation

The conceptual model (framework, algorithms, data sources, and assumptions) is documented and correctly and adequately describes the needs and requirements of the intended uses.

- The conceptual model is well documented and has been reviewed and judged adequate to the requirements of the intended uses by qualified subject matter experts.
- There is no formal conceptual model documentation, although informal sources are available. The conceptual model has been reviewed but may require improvement to support the intended use.
- No conceptual model documentation is available or the conceptual model does not meet the requirements of the intended use.
The model’s functions, entities, and data (framework, algorithms, data values, and assumptions) representation levels are documented and appropriate for the intended use.

- **Level of detail:** Level of detail has been reviewed by qualified SMEs, is determined to be appropriate and well documented for the M&S intended use.
- **Functional/entity decomposition:** Functional/entity decomposition is documented; level of detail requires verification and may need improvements to produce credible results for the intended application.
- **Functional/Entity decomposition:** Functional/Entity decomposition is inappropriate; Level of detail is unknown or inappropriate; fidelity may or may not produce credible results for the intended use.
Accuracy

Design Validation

The algorithms and/or mathematical formulations are correct and valid. The premises for the application of the algorithms and/or mathematical formulations are correct with no assumptions violated.

- Algorithms and/or mathematical formulations have been reviewed and verified and they satisfy all M&S requirements and acceptability criteria for the intended uses.
- Algorithms and/or mathematical formulations have not been reviewed and verified or they may need improvement to satisfy the M&S requirements and acceptability criteria.
- Algorithms and/or mathematical formulations are undocumented, and may be invalid. Major revisions are necessary to satisfy the intended use requirements. No software implementation accuracy tests have been conducted and documented.
Input and Embedded Data

The simulation input and embedded data are credible and subject to review and revision.

- All data have been reviewed, and judged to be valid and/or certified; input and embedded data are current, and were provided by authoritative sources.
- Most data traceable to certified sources; most (but not all) data reviewed; any identified issues can be resolved within program constraints.
- Key data and data drivers are arbitrary or best guess estimates.
Accuracy

System Verification

The M&S has been formally tested or reviewed and has been demonstrated to accurately represent the specific intended uses and requirements.

- The model has been formally tested and accurately represents the intended use and requirements; satisfactory SME review of sensitivity analysis has been conducted in cases where formal verification has not been accomplished. Software implementation accuracy tests have been conducted, and documented; identified errors and faults (if any) have been documented and corrected or mitigated.

- The model has been tested informally and appears to satisfy the intended use requirements and/or some satisfactory SME review of sensitivity analysis has been conducted. Minimal formal software tests have been conducted and documented; identified errors and faults (if any) have not been corrected or mitigated.

- The model has not been tested and has not been demonstrated to satisfy the intended use requirements; may not cover the domain of applicability for the current Intended Use.
Output Validation

The M&S responses have been compared with known or expected behavior from the subject it represents and has been demonstrated to be sufficiently accurate for the specific intended uses.

- The model’s results have been rigorously compared to realistic conditions and are sufficiently accurate for the intended use. Examples include empirical data (e.g., operational, T&E), another widely used and accepted or accredited simulation, and/or formal SME review.

- The model’s results have been demonstrated to be sufficiently accurate in some cases but not others, or results validation efforts only cover part of the models’ domain important to the intended uses; satisfactory SME review of sensitivity analyses have been conducted in areas where results validation data are not available. Model has been widely used but no formal V&V has been done.

- The model’s results have not been examined and/or have been demonstrated not to be sufficiently accurate for the intended use. The M&S has never been subjected to a formal validation.
The M&S and its components are supported by a sound written configuration management (CM) plan.

- A formally documented CM process is followed for ALL M&S changes and is supported with a written CM Plan.
- Some CM processes exist for major M&S upgrades/code changes; CM processes are informally documented.
- No documented CM process exists.
Usability

Documentation

The M&S is well documented as to capabilities, limitations, and assumptions; documentation is readily available, up-to-date, and complete.

- Formal M&S documentation (e.g., Concept, Design, Requirements, Software, Users, VV&A Plans and Reports) is complete and up-to-date with the current M&S version. Specific M&S results applicability/limitations have been identified and documented.
- The M&S documentation is informal, incomplete or out of date with respect to the current version of the M&S.
- The M&S is undocumented and/or documentation is only in very informal sources not generally available to the user.
User Community

The M&S is designed and developed for the level of competency of the intended users. The users have access to documents such as a user’s manual, training manuals, and/or reference guides. User support is available from the M&S developer or proponent.

- **User community has the ability and tools to fully utilize the model (e.g., documentation, websites, help-desk, POCs are readily available).**
- **User community has some of the tools and knowledge required to properly use the model, but gaps exist.**
- **User community lacks adequate tools and knowledge to properly use the model.**
## Level of Importance (Alternate)

<table>
<thead>
<tr>
<th>Importance Level</th>
<th>Description</th>
<th>Description Based On 5.4H and MIL-STD 882C/D on System Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Intended use addresses <strong>multiple areas</strong> of significant program risk, key program reviews and test events, key system performance analysis, primary test objectives and test article design, system requirements definition, and/or high software criticality, used to make a technical or managerial decision.</td>
<td>Level 3 plus simulation supports a technical decision on multiple ORD thresholds or an ORD Key Performance Parameter (KPP) or Critical Technical Parameter (CTP), or the simulation supports a technical decision involving a catastrophic or critical impact level.</td>
</tr>
<tr>
<td>3</td>
<td>Intended use addresses <strong>an area of significant program risk</strong>.</td>
<td>Level 2 plus simulation supports a technical decision on the verification of an ORD threshold, key program technical/acquisition reviews and test events, primary test objectives and test article design, and/or high software criticality, or the simulation supports a technical decision involving a marginal impact level.</td>
</tr>
<tr>
<td>2</td>
<td>Intended use addresses <strong>medium or low program risk</strong>, other program reviews and test events, secondary test objectives and test article design, other system requirements and system performance analysis, and medium or low S/W criticality used to make technical or managerial decisions.</td>
<td>Level 1 plus simulation supports a technical decision on non-required system attributes, minor program reviews and test events, secondary test objectives and test article design, and/or medium or low software criticality, or the simulation supports a technical decision involving a negligible impact level.</td>
</tr>
<tr>
<td>1</td>
<td>Intended use addresses <strong>program objectives or analysis that is not a significant factor</strong> in the technical or managerial decision making process.</td>
<td>Simulation supports a decision on non-required system attributes, non-mandated program reviews and simple test events and test objectives for non-critical test article design, and/or low criticality software, or the simulation supports a technical decision involving a fractional part of a negligible impact level.</td>
</tr>
</tbody>
</table>
## Impact Levels (Alternate)

<table>
<thead>
<tr>
<th>Impact Categories</th>
<th>Catastrophic</th>
<th>Critical</th>
<th>Marginal</th>
<th>Negligible</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Personnel Safety</strong></td>
<td>Death</td>
<td>Severe injury</td>
<td>Minor injury</td>
<td>&lt; Minor injury</td>
</tr>
<tr>
<td><strong>Equipment Safety</strong></td>
<td>Major equipment loss, broad scale major damage</td>
<td>Small scale major damage</td>
<td>Broad scale minor damage</td>
<td>Small scale minor damage</td>
</tr>
<tr>
<td><strong>Environmental Damage</strong></td>
<td>Severe (Chernobyl)</td>
<td>Major (Love Canal)</td>
<td>Minor</td>
<td>Some trivial</td>
</tr>
<tr>
<td><strong>Occupational Illness</strong></td>
<td>Severe and broad</td>
<td>Severe or broad</td>
<td>Minor and small scale</td>
<td>Minor or small scale</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>Loss of program funds; 100% cost growth</td>
<td>Reduction of program funds; 50-99% cost growth</td>
<td>20-49% cost growth</td>
<td>&lt; 20% cost growth</td>
</tr>
<tr>
<td><strong>Schedule</strong></td>
<td>Slip reduces Department of Defense (DoD) capabilities</td>
<td>Slip causes cost impact</td>
<td>Slip causes internal turmoil</td>
<td>Republish schedules</td>
</tr>
<tr>
<td><strong>Political</strong></td>
<td>National or international (Watergate)</td>
<td>Significant (Tailhook)</td>
<td>Embarrassment ($200 hammer)</td>
<td>Local</td>
</tr>
<tr>
<td><strong>Operational</strong></td>
<td>Widespread additional combat deaths</td>
<td>Limited additional combat deaths</td>
<td>Moderate additional casualties</td>
<td>Minimal additional casualties</td>
</tr>
</tbody>
</table>