MURM Background
Leverage existing concepts to evolve a methodology to:

- Weigh VV&A investments against the risk of making a bad decision due to unreliable M&S results
- Tailor the V&V and Accreditation Efforts based on risk
- Perform Methods/Technique/Resource Trade-offs
Why MURM?

Previous risk-based M&S assessments have deficiencies:

- Lack cogent mathematical foundation
- Sometimes included unintended bias
- Can’t explicitly relate V&V endeavors to risk

Fundamental Driver for MURM: the need to combine M&S risk assessment and VV&A planning in a coherent fashion.

M&S Use Risk Methodology (MURM) provides:

- Coherent math foundation for M&S Use Risk
- Minimizes or avoids unintended bias
- Explicit relation of V&V to M&S Use Risk
- Facilitates automation of M&S Use Risk assessment
The MURM Builds upon Existing Concepts

- Communication to decision makers
- Uncertainty quantification
- Credibility assessment
- Sensitivity analysis
- Risk assessment
- Severity categories
- Probability levels
- Risk assessment values
- Risk acceptance levels
- Risk-based V&V tailoring
- Software integrity level
- Risk matrices
- Risk assessment
- Confidence ratios
- Sensitivity analysis
- Uncertainty quantification
- Communication to decision makers
- V&V Composite Model
- Validation Process Maturity
- Risk-driven software development
- Spiral development model
Risk & Risk-related Analysis Is Complex

- DAU review of standards found half-dozen definitions each with negative, neutral, and broad connotations for risk, which indicates the complexity of the subject.

- Many simplify risk and treat the approach as if it fully addresses risk. Common definition is:

  \[ \text{Risk} = (\text{likelihood of Error}) \times (\text{Consequence of Error}) \]

- This definition mixes a probability with a non-probability, resulting in an expected value whose dimensions change from one assessment to another.

- MURM takes a different approach.
MURM Definition
M&S Use Risk – Key Definition

- MURM is not just a collection of tables and figures. MURM applies an underlying mathematical formula based on the definition for M&S Use Risk:

  The probability that inappropriate application of M&S Results for the intended use will produce unacceptable consequences to the decision-maker.

- For unambiguous understanding of this definition of M&S Use Risk, two important conditions are noted:
  1. both the inappropriate application and the unacceptable consequences occur
  2. the unacceptable consequences are implied by the inappropriate application.

- M&S Use Risk is a probability & whole probability space is addressed

- Math Logic foundation enables:
  - explicit relationship of M&S Use Risk to V&V endeavors
  - facilitates automation of UR assessment
M&S Use Risk Mathematical Form

To put the definition into a mathematical form that can be used in a numerical calculation of M&S Use Risk, the definition is parsed into the following statement:

The probability that [(inappropriate application of M&S Results for the intended use will produce unacceptable consequences to the decision-maker) AND (that inappropriate application of M&S Results for the intended use occur) AND (unacceptable consequences to the decision-maker occur)].

In symbols:

Causes = C \equiv \text{inappropriate application of M&S Results for the intended use}
Effects = E \equiv \text{unacceptable consequences to the decision-maker}

Which results in the equation:

M&S Use Risk = p[(C \land E) \land (C \Rightarrow E)]
M&S Use Risk Mathematical Form (cont.)

Where

\[ p(\text{Causes}) = p(C_1 \cup C_2 \cup C_3) \]

With

\( C_1 \equiv \text{Lack of clarity of intended use leading to misuse (i.e., Clarity),} \)
\( C_2 \equiv \text{Adverse impact on decision if capability is not achieved (i.e., Importance), and} \)
\( C_3 \equiv \text{Incorrect recommendation to employ or not to employ M&S Results relative to that capability (i.e., Confidence).} \)

and where

\[ p(\text{Effects}) \text{ is the probability of the effects of unacceptable consequences to the decision-maker.} \]
\[ p(\text{Effects}) \text{ is based on M&S Impact and M&S Reliance.} \]
M&S USE RISK DEFINITION Evolution

**IN WORDS:**

M&S Use Risk: “The probability that inappropriate application of Simulation results for the intended use will produce unacceptable consequences to the decision-maker.”

**IN MATHEMATICAL LOGIC:**

\[ M&S \text{ Use Risk} = p[ (\text{Causes} \land \text{Effects}) \land (\text{Causes} \rightarrow \text{Effects}) ] \]

**ALGEBRAIC FORM for PROBABILITY CALCULATIONS:**

\[ M&S \text{ Use Risk} = p(\text{Causes}) \times p(\text{Effects}) \times [ 1 - p(\text{Causes}) + p(\text{Causes}) \times p(\text{Effects}) ] \]
Steps in the RBA Methodology

- Obtain requirements from users & their representatives
- Identify needed representational capabilities
- Organize needed capabilities into related groupings

- Determine if the user can specify the M&S role
- Determine M&S importance to each capability
- Determine needed validation maturity level from assigned importance

- Choose V&V activities & tasks to be performed
- Choose V&V techniques to meet needed validation maturity
- Estimate schedule, costs & resource requirements

- Characterize M&S capabilities
- Characterize M&S limitations
- Communicate V&V evidence to the M&S users
PART IV: MURM’S BASIC STEPS

1. Establish intended use(s)
2. Enumerate requirements
3. Prioritize requirements
4. Establish/select “Causes” state tables
   \((C_1, C_2, C_3)\)
5. Establish initial V&V plan
6. Evaluate, requirement-by-
   requirement state levels for \(C_1, C_2, C_3\)
7. Compute \(p(Causes)\)
8. Establish/select “Effect” state table
9. Evaluate, requirement-by-
   requirement state levels for Effects;
   compute \(p(Effects)\)
10. Compute M&S User Risk for each
    requirement \((f(p(Causes), p(Effects)))\)
11. Evaluate acceptability of each
    requirement’s M&S User Risk
12. Accept or modify V&V plan (return to step (5))
MURM Implementation
DECOMPOSITION OF $P(\text{Causes})$

\[ p(\text{Causes}) = p(C_1 \cup C_2 \cup C_3) \]

$C_1 \equiv \text{Lack of clarity of intended use leading to misuse (Clarity)},$

$C_2 \equiv \text{Adverse impact on decision if capability is not achieved (Importance), and}$

$C_3 \equiv \text{Incorrect recommendation to employ or not to employ M&S Results relative to that capability (Confidence).}$
CLARITY OF INTENDED USE (MURM FACTOR C₁)

- Intended Use Statement
- M&S Requirements Specification
- Acceptability Criteria / MOEs / MOPs
- Referent
**Example: State Table Probabilities For Causes**

### Table F-2: State Table for Factor C₁ (Clarity), Assignment of p(C₁)

<table>
<thead>
<tr>
<th>Factor Level</th>
<th>Clarity of Intended Use</th>
<th>Level Weighting</th>
<th>p(C₁)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Lucid</td>
<td>1</td>
<td>0.167</td>
</tr>
<tr>
<td>B</td>
<td>Partial clarity</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>C</td>
<td>Unclear</td>
<td>5</td>
<td>0.833</td>
</tr>
</tbody>
</table>

### Table F-3: State Table for Factor C₂ (Importance), Assignment of p(C₂)

<table>
<thead>
<tr>
<th>Factor Level</th>
<th>Consequence / Mitigation</th>
<th>Level Weighting</th>
<th>p(C₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Negligible consequence / Mitigation not required</td>
<td>1</td>
<td>0.038</td>
</tr>
<tr>
<td>B</td>
<td>Negligible consequence / Mitigation complete</td>
<td>3</td>
<td>0.115</td>
</tr>
<tr>
<td>C</td>
<td>Negligible consequence / Mitigation partial or Minor consequence / Mitigation complete</td>
<td>6</td>
<td>0.231</td>
</tr>
<tr>
<td>D</td>
<td>Negligible consequence / Mitigation impossible or Minor consequence / Mitigation partial or Serious consequence / Mitigation complete</td>
<td>11</td>
<td>0.425</td>
</tr>
<tr>
<td>E</td>
<td>Minor consequence / Mitigation impossible or Serious consequence / Mitigation partial or Grave consequence / Mitigation complete</td>
<td>17</td>
<td>0.654</td>
</tr>
<tr>
<td>F</td>
<td>Serious consequence / Mitigation impossible or Grave consequence / Mitigation partial</td>
<td>22</td>
<td>0.846</td>
</tr>
<tr>
<td>G</td>
<td>Grave consequence / Mitigation impossible</td>
<td>25</td>
<td>0.962</td>
</tr>
</tbody>
</table>

---

**Examples of factor state tables**

**Built using mathematical logic & maximum information entropy principle**
CONFIDENCE (MURM FACTOR C₃)
V&V ACTIVITIES FROM THE COMPOSITE MODEL

Major Activities:
1. Plan the V&V effort
2. Analyze historical information
3. Verify and validate the conceptual model
4. Perform supplemental verification
5. Use the verification products
6. Verify and validate the data and knowledge
7. Validate the M&S Results
8. Integrate the V&V evidence

It is Assumed:
- All V&V efforts would begin with planning
- All V&V efforts end with integrating the evidence
- Some form of data V&V would be required unless no data are available
- The two verification activities, (4 and 5) can be collapsed into a single activity (Development Product (DP) verification)
V&V State Table Values

This process leaves the following four tailoring choices:

1. Historical Record Analysis
2. Conceptual Model (CM)
3. DP Verification
4. Results Validation

Where:

\[ w = \text{Conceptual Model Verification & Validation (CM V&V)} \]
\[ x = \text{Development Product Verification (DP verification)} \]
\[ y = \text{Historical Record Analysis} \]
\[ z = \text{Results Validation} \]
V&V ACTIVITY COMBINATIONS

Activity Combinations:

A. CM V&V
B. DP verification
C. historical record analysis or CM V&V + DP verification
D. historical record analysis + CM V&V
E. historical record analysis + DP verification
F. historical record analysis + CM V&V + DP verification
G. results validation
H. CM V&V + results validation
I. historical record analysis + results validation or DP verification + results validation
J. historical record analysis + CM V&V + results validation
K. historical record analysis + DP verification + results validation
L. CM V&V + DP verification + results validation
M. historical record analysis + CM V&V + DP verification + results validation
<table>
<thead>
<tr>
<th>Activity Set</th>
<th>Logical Sentence #1</th>
<th>Logical Sentence #2</th>
<th>Weighting</th>
<th>Adjusted Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>w<del>x</del>y~z</td>
<td>-</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>B</td>
<td><del>w</del>x<del>y</del>z</td>
<td>-</td>
<td>3</td>
<td>300</td>
</tr>
<tr>
<td>C</td>
<td><del>w</del>x<del>y</del>z</td>
<td>w<del>x</del>y~z</td>
<td>6</td>
<td>600</td>
</tr>
<tr>
<td>D</td>
<td>w<del>x</del>y~z</td>
<td>-</td>
<td>9</td>
<td>900</td>
</tr>
<tr>
<td>E</td>
<td><del>w</del>x<del>y</del>z</td>
<td>-</td>
<td>11</td>
<td>1100</td>
</tr>
<tr>
<td>F</td>
<td>w<del>x</del>y~z</td>
<td>-</td>
<td>13</td>
<td>1300</td>
</tr>
<tr>
<td>G</td>
<td><del>w</del>x<del>y</del>z</td>
<td>-</td>
<td>15</td>
<td>1500</td>
</tr>
<tr>
<td>H</td>
<td>w<del>x</del>y~z</td>
<td>-</td>
<td>17</td>
<td>1700</td>
</tr>
<tr>
<td>I</td>
<td><del>w</del>x<del>y</del>z</td>
<td><del>w</del>x<del>y</del>z</td>
<td>20</td>
<td>2000</td>
</tr>
<tr>
<td>J</td>
<td>w<del>x</del>y~z</td>
<td>-</td>
<td>23</td>
<td>2300</td>
</tr>
<tr>
<td>K</td>
<td><del>w</del>x<del>y</del>z</td>
<td>-</td>
<td>25</td>
<td>2500</td>
</tr>
<tr>
<td>L</td>
<td>w<del>x</del>y~z</td>
<td>-</td>
<td>27</td>
<td>2700</td>
</tr>
<tr>
<td>M</td>
<td>w<del>x</del>y~z</td>
<td>-</td>
<td>29</td>
<td>2900</td>
</tr>
</tbody>
</table>
## V&V Techniques Selection State Table

<table>
<thead>
<tr>
<th>Factor Level</th>
<th>Technique</th>
<th>Weighting</th>
<th>(w) Adjusted Weighting</th>
<th>(x) Adjusted Weighting</th>
<th>(y) Adjusted Weighting</th>
<th>(z) Adjusted Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Use a LEVEL “1” technique</td>
<td>1</td>
<td>199</td>
<td>597</td>
<td>1194</td>
<td>2985</td>
</tr>
<tr>
<td>B</td>
<td>Use a LEVEL “2” technique</td>
<td>3</td>
<td>597</td>
<td>1791</td>
<td>3582</td>
<td>8955</td>
</tr>
<tr>
<td>C</td>
<td>Use a LEVEL “3” technique</td>
<td>5</td>
<td>995</td>
<td>2985</td>
<td>5970</td>
<td>14925</td>
</tr>
<tr>
<td>D</td>
<td>Use a LEVEL “4” technique</td>
<td>7</td>
<td>1393</td>
<td>4179</td>
<td>8358</td>
<td>20895</td>
</tr>
<tr>
<td>E</td>
<td>Use a LEVEL “5” technique</td>
<td>9</td>
<td>1791</td>
<td>5373</td>
<td>10746</td>
<td>26865</td>
</tr>
</tbody>
</table>
## Examples

**Calculations of p(Causes)**

<table>
<thead>
<tr>
<th>Requirement No.</th>
<th>CLARITY $C_1$ Level [$p(C_1)$]</th>
<th>IMPORTANCE $C_2$ Level [$p(C_2)$]</th>
<th>CONFIDENCE $C_3$ Level [$p(C_3)$]</th>
<th>$p($Causes$)$ [$p(C_1 \cup C_2 \cup C_3)$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lucid; A [0.167]</td>
<td>Grave/Partial; F [0.846]</td>
<td>Very high; A [0.05]</td>
<td>0.878</td>
</tr>
<tr>
<td>2</td>
<td>Lucid; A [0.167]</td>
<td>Grave/Partial; F [0.846]</td>
<td>Very low E [0.45]</td>
<td>0.930</td>
</tr>
<tr>
<td>3</td>
<td>Unclear; A [0.833]</td>
<td>Grave/Partial; F [0.846]</td>
<td>Very high; A [0.05]</td>
<td>0.976</td>
</tr>
<tr>
<td>4</td>
<td>Lucid; A [0.167]</td>
<td>Serious/Complete; D [0.423]</td>
<td>Very low E [0.45]</td>
<td>0.735</td>
</tr>
<tr>
<td>5</td>
<td>Unclear; A [0.833]</td>
<td>Serious/Complete; D [0.423]</td>
<td>Very low E [0.45]</td>
<td>0.947</td>
</tr>
<tr>
<td>6</td>
<td>Partial; B [0.5]</td>
<td>Serious/Complete; D [0.423]</td>
<td>Medium; C [0.25]</td>
<td>0.784</td>
</tr>
<tr>
<td>7</td>
<td>Lucid; A [0.167]</td>
<td>Serious/Complete; D [0.423]</td>
<td>Medium; C [0.25]</td>
<td>0.639</td>
</tr>
<tr>
<td>8</td>
<td>Lucid; A [0.167]</td>
<td>Serious/Complete; D [0.423]</td>
<td>Very high; A [0.05]</td>
<td>0.543</td>
</tr>
</tbody>
</table>

\[
p($\text{Causes}$) = p(C_1 \cup C_2 \cup C_3) = p(C_1) + p(C_2) + p(C_3) - p(C_1)p(C_2) - p(C_1)p(C_3) - p(C_2)p(C_3) + p(C_1)p(C_2)p(C_3)
\]
p(Effects) is the probability of the effects resulting from unacceptable consequences to the decision-maker and is derived from key components: M&S Impact and M&S Reliance

- M&S Impact is an indication of how much information the M&S is providing relative to the decision space.

- M&S Reliance is an indication of the dependence on using M&S Results in making the decision.
<table>
<thead>
<tr>
<th>M&amp;S Intended Use</th>
<th>M&amp;S Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5</strong></td>
<td>Intended Use addresses multiple areas of high impact to the decision, key experiment, study, or analysis; key program review or test event; key system performance analysis or requirements definition; primary test objective or test article design; critical operational issue; key technical or managerial decision; critical skills training; regulatory compliance, licensing, permitting, or law.</td>
</tr>
<tr>
<td><strong>4</strong></td>
<td>Intended Use addresses a single area of high impact to the decision, key experiment, study, or analysis; key program review or test event; key system performance analysis or requirements definition; primary test objective or test article design; critical operational issue; key technical or managerial decision; critical training; regulatory compliance, licensing, permitting, or law.</td>
</tr>
<tr>
<td><strong>3</strong></td>
<td>Intended Use addresses multiple areas of medium and low impact to the decision, other experiment, study, or analysis, other program review or test event; other system performance analysis or requirements definition; secondary test objective; other skills training; other technical or managerial decision.</td>
</tr>
<tr>
<td><strong>2</strong></td>
<td>Intended Use addresses a single area of medium impact to the decision, other experiment, study, or analysis, other program review or test event; other system performance analysis or requirements definition; secondary test objective; other skills training; other technical or managerial decision.</td>
</tr>
<tr>
<td><strong>1</strong></td>
<td>Intended Use addresses a single area of low impact to the decision, objective or analysis that is not a significant factor in the technical or managerial decision-making process.</td>
</tr>
</tbody>
</table>
### User Reliance on M&S in Decision Making

<table>
<thead>
<tr>
<th>M&amp;S Reliance</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td><strong>M&amp;S</strong> will be the <em>only</em> method employed to support the decision-making process.</td>
</tr>
<tr>
<td>3</td>
<td><strong>M&amp;S</strong> will be the <em>primary</em> method, employed with other non-M&amp;S methods, to support the decision-making process.</td>
</tr>
<tr>
<td>2</td>
<td><strong>M&amp;S</strong> will be a <em>secondary</em> method, employed with other non-M&amp;S methods, to support the decision-making process, and will provide significant data unavailable through other means.</td>
</tr>
<tr>
<td>1</td>
<td><strong>M&amp;S</strong> will be a <em>supplemental</em> method, employed with other non-M&amp;S methods, to support the decision-making process, and will provide supplemental data already available through other means.</td>
</tr>
</tbody>
</table>
Example: State Table Probabilities For Effects

Example of more complex Effects state table

<table>
<thead>
<tr>
<th>Factor Level</th>
<th>Probability of Unacceptable Consequences to Decision-Maker Based on Dependency/Use Area</th>
<th>Level Weighting</th>
<th>p(Effects)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Supplemental Use: Single Low Risk Area</td>
<td>1</td>
<td>0.025</td>
</tr>
<tr>
<td>B</td>
<td>(Supplemental Use: Single Medium Risk Area)</td>
<td>4</td>
<td>0.100</td>
</tr>
<tr>
<td>C</td>
<td>(Supplemental Use: Multiple Med-Low Risk Area)</td>
<td>9</td>
<td>0.225</td>
</tr>
<tr>
<td>D</td>
<td>(Supplemental Use: Single High Risk Area)</td>
<td>13</td>
<td>0.400</td>
</tr>
<tr>
<td>E</td>
<td>(Supplemental Use: Multiple High Risk Area)</td>
<td>24</td>
<td>0.600</td>
</tr>
<tr>
<td>F</td>
<td>(Primary Use: Single High Risk Area)</td>
<td>31</td>
<td>0.775</td>
</tr>
<tr>
<td>G</td>
<td>(Primary Use: Multiple High Risk Area)</td>
<td>36</td>
<td>0.900</td>
</tr>
<tr>
<td>H</td>
<td>(Only Use: Multiple High Risk Area)</td>
<td>39</td>
<td>0.975</td>
</tr>
</tbody>
</table>
MURM Output
EXAMPLES
CALCULATIONS OF M&S USE RISK

M&S Use Risk = p(Causes) p(Effects) [ 1- p(Causes) + p(Causes) p(Effects) ]

Suppose for Requirement #2, it is determined Table F4-3 Effects Level is “A”

\[ p(Effects) = 0.025 \text{ (from slide 27)} \]
\[ p(Causes) = 0.930 \text{ (from slide 23)} \]

\[ M&S \text{ Use Risk} = 0.930 \times 0.025 \times [ 1 - 0.930 + 0.930 \times 0.025 ] = 0.002 \text{ (Very Low)} \]

Suppose for Requirement #4, it is determined Table F4-3 Effects Level is “C”

\[ p(Effects) = 0.225 \text{ (from slide 27)} \]
\[ p(Causes) = 0.735 \text{ (from slide 23)} \]

\[ M&S \text{ Use Risk} = 0.735 \times 0.225 \times [ 1 - 0.735 + 0.735 \times 0.225 ] = 0.071 \text{ (Very Low)} \]

Suppose for Requirement #8, it is determined Table F4-3 Effects Level is “E”

\[ p(Effects) = 0.600 \text{ (from slide 27)} \]
\[ p(Causes) = 0.543 \text{ (from slide 23)} \]

\[ M&S \text{ Use Risk} = 0.543 \times 0.600 \times [ 1 - 0.543 + 0.543 \times 0.600 ] = 0.255 \text{ (High)} \]
**EXAMPLES**

**CALCULATIONS OF M&S USE RISK**

\[
M&S \text{ Use Risk } = p(\text{Causes}) \times p(\text{Effects}) \times (1 - p(\text{Causes}) + p(\text{Causes}) \times p(\text{Effects}))
\]

Suppose for **Requirement #2**, it is determined Table F4-3 Effects Level is “A”

\[
p(\text{Effects}) = 0.025 \text{ (from Table F4-3)} \\
p(\text{Causes}) = 0.930 \text{ (from previous slide)}
\]

\[
M&S \text{ Use Risk } = 0.930 \times 0.025 \times (1 - 0.930 + 0.930 \times 0.025) = 0.002 \text{ (Very Low)}
\]

Suppose for **Requirement #4**, it is determined Table F4-3 Effects Level is “C”

\[
p(\text{Effects}) = 0.225 \text{ (from Table F4-3)} \\
p(\text{Causes}) = 0.735 \text{ (from previous slide)}
\]

\[
M&S \text{ Use Risk } = 0.735 \times 0.225 \times (1 - 0.735 + 0.735 \times 0.225) = 0.071 \text{ (Low)}
\]

Suppose for **Requirement #8**, it is determined Table F4-3 Effects Level is “E”

\[
p(\text{Effects}) = 0.600 \text{ (from Table F4-3)} \\
p(\text{Causes}) = 0.543 \text{ (from previous slide)}
\]

\[
M&S \text{ Use Risk } = 0.543 \times 0.600 \times (1 - 0.543 + 0.543 \times 0.600) = 0.255 \text{ (High)}
\]
Visualization of MURM C₃ Results
(see following chart for full MURM results)

This figure shows the results for an M&S with 15 required capabilities and a confidence threshold for the V&V evidence set at medium or higher. The priority of the capability is designated as a number 1-3, the results of the V&V efforts for a capability is designated by color, and the computed confidence of the V&V evidence is designated by the height or depth of the bar.

For example, C#4 is a high priority capability that met the acceptability criteria (as shown by the associated green bar) but with no confidence in the accuracy of that result (as shown by C4 bar falling below the tolerable risk level.)
Illustrated are results for 15 capabilities & their associated M&S User Risk.

A capability is identified by a number within its symbol.

A capability’s priority is noted by the shape of its symbol.

A capability’s disposition is noted by the color of its fill.

The position of the capability’s symbol on the risk surface indicates its M&S User Risk; the surface is divided into five equal area regions and are labeled from Very Low risk to Very High risk.

The distribution of the symbols give a sense of the User Risk status of the M&S; for example, #4, a high priority capability, met its acceptability criteria but the risk level, perhaps driven in part by the $p(C_3)$ recommendation confidence, propels it into the high user risk region.
Comments about MURM

- MURM allows full use of *ALL* available information in Use Risk assessment: objective (quantitative), limited (such as only knowing ranking of alternatives), and subjective

- Use of information entropy theory reduces or precludes inadvertent & intended bias in assessment

- MURM operates at M&S individual capability levels (vice only treating M&S results as a whole)

- MURM uses the V&V Composite Model (VCM) to identify V&V phases, activities, and tasks comprehensively

- MURM uses the V&V Process Maturity Model (VPMM) characterization of information quality & objectivity to relate information produced by V&V activities to UR
Comments about MURM (cont.)

- A V&V Techniques Catalogue characterizes the quality and objectivity of information that can be produced by the various V&V techniques.

- State tables support Use Risk computation – can be developed to the level supported by available information.

- Any sophisticated math methodology requires particular math skills. With automation, V&V personnel will be able to use MURM just as Mathematica is used effectively by those without the math skills to apply all of its techniques without use of that program.

- Examples of the kinds of information that can be produced by MURM are illustrated on following charts.
More Information Is Available

For detailed discussion of MURM and its application or to obtain the MURM report:

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