



INTEGRATED MEDICAL MODEL (IMM) PROJECT VERIFICATION, VALIDATION, AND CREDIBILITY (VV&C)

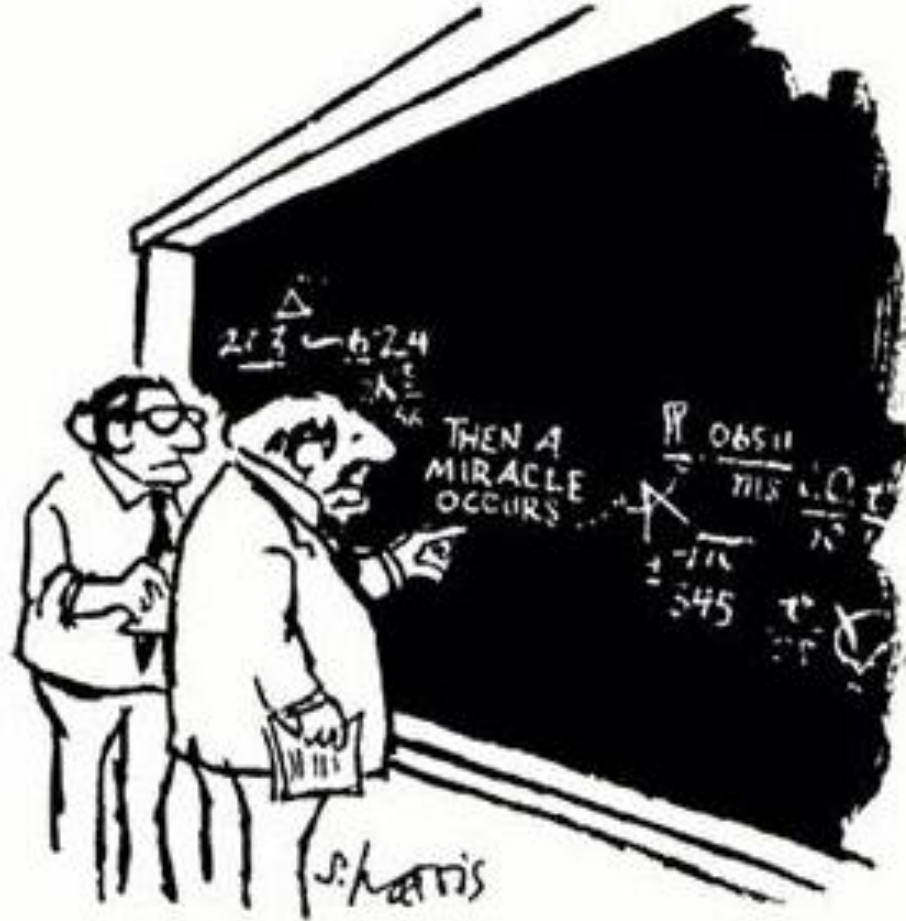
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1. Wyle Science, Technology & Engineering Group
2. University of Texas Medical Branch, Galveston, TX
3. NASA Glenn Research Center



- **Background**
- **History**
- **IMM v3**
- **IMM 4.0**
- **External review**
- **Conclusions**

VV&C - Importance of Communication



"I THINK YOU SHOULD BE MORE EXPLICIT
HERE IN STEP TWO."

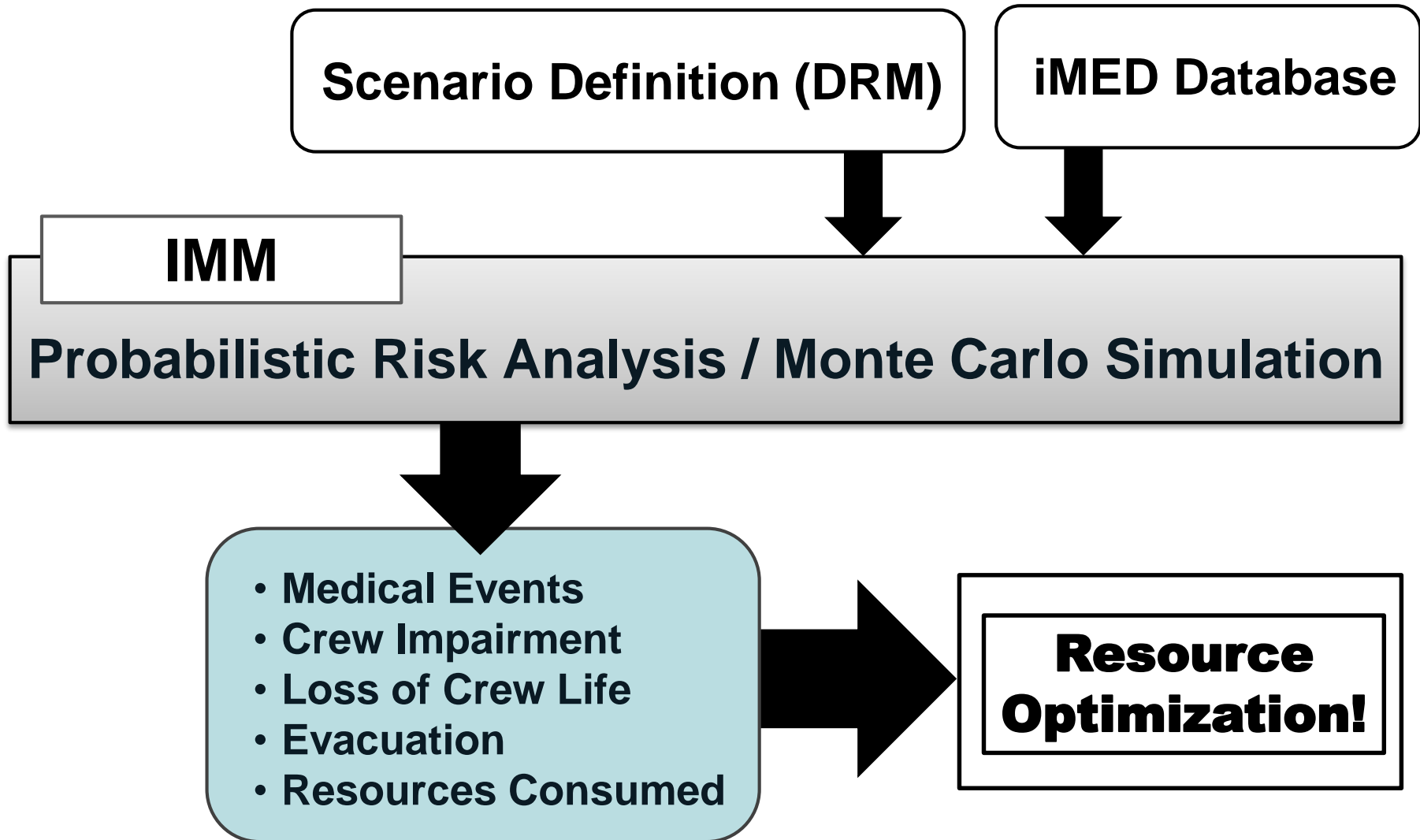
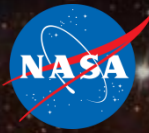


- **Verification:** “...computational model accurately represents the underlying mathematical model...”
- **Validation:** “...determining the degree to which a model ... is an accurate representation of the real world...”
- **Credibility:** “the quality to elicit belief or trust”

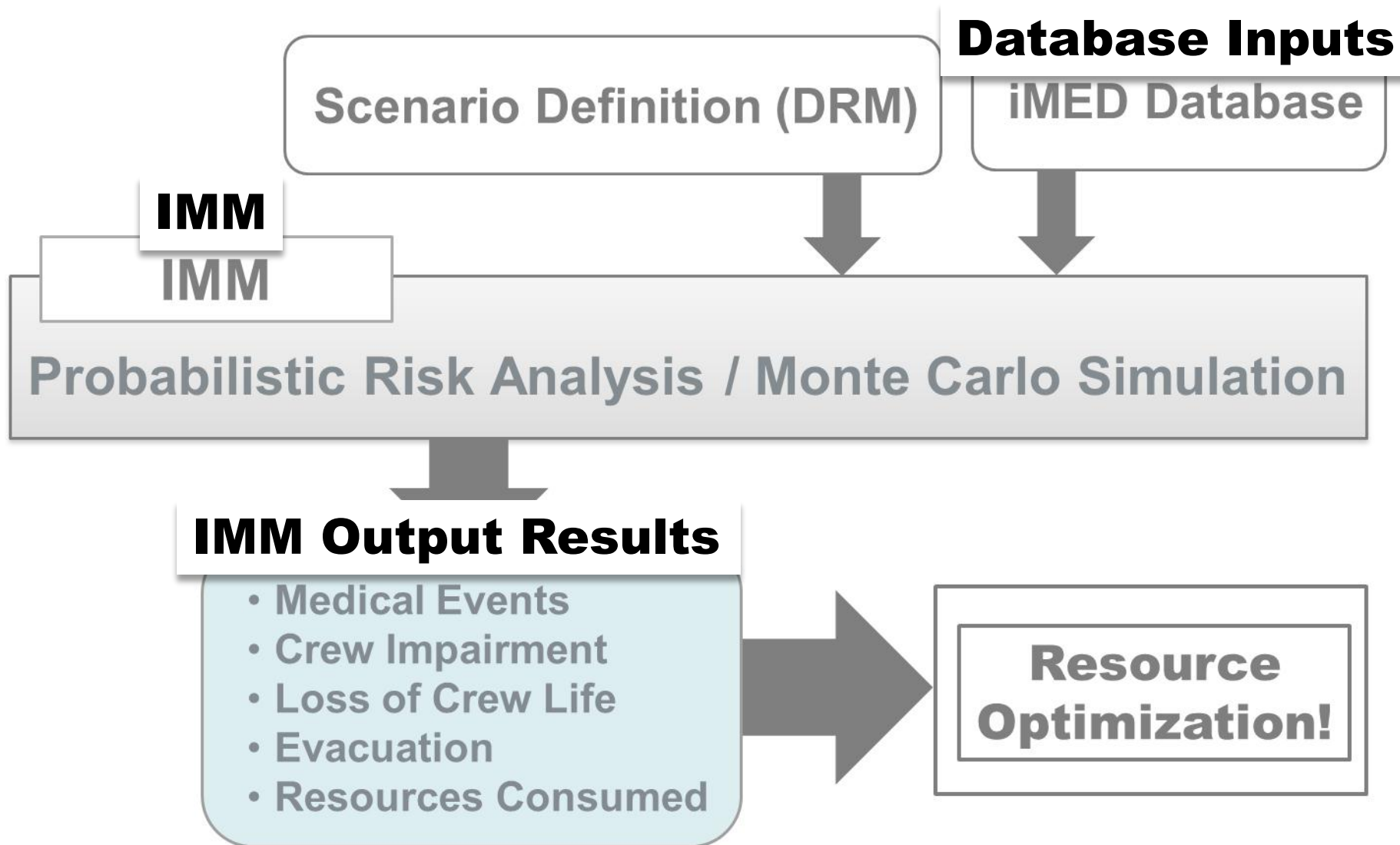
- **Credibility begins before development**
- **Includes the end users**
- **Is an ongoing assessment**



IMM Project VV&C History (April 2008)



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Scenario Defi

Database Inputs
List of medical conditions
V&V process
Database content
Internal and external review

IMM

Probabilistic Risk Analysis / Monte Carlo Simulation

- Medical Events
- Crew Impairment
- Loss of Crew Life
- Evacuation
- Resources Consumed

**Resource
Optimization!**

IMM Project VV&C History (April 2008)



Scenario Definition (DRM)

iMED Database

IMM

IMM overall approach

Software and code

Database process

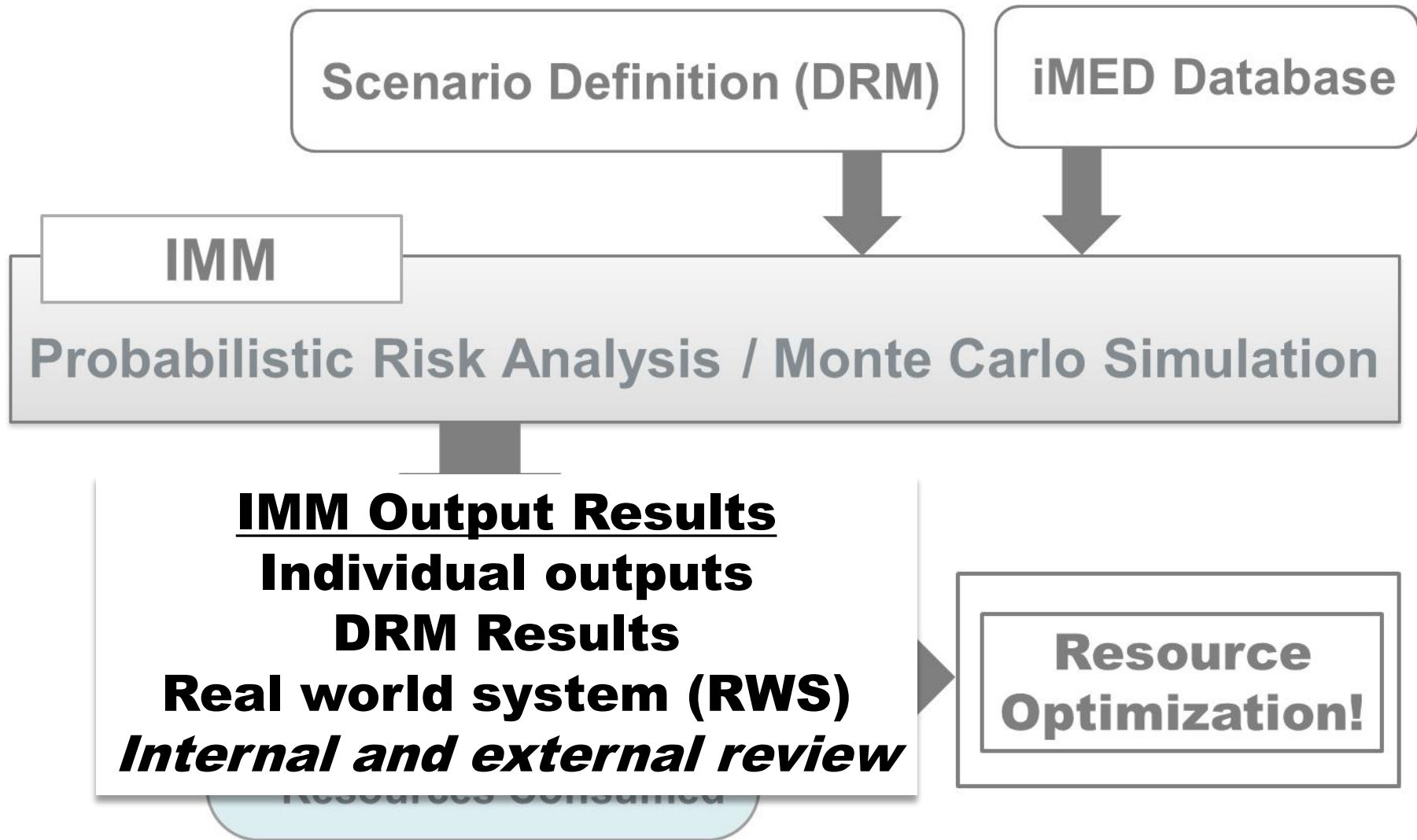
Internal and external review

Monte Carlo Simulation

- Medical Events
- Crew Impairment
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- Evacuation
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**Resource
Optimization!**

IMM Project VV&C History (April 2008)



NASA-Standard-7009 (July 2008)



Programmatics (7/49)

Models (13/49)

**Simulations and
analyses (10/49)**

**V&V and uncertainty
quantification (9/49)**

**Recommended practices:
identification and use
(1/49)**

Training (3/49)

**Credibility assessment of
model and simulation
(M&S) results (3/49)**

**Reporting results to
decision makers (3/49)**



49 Requirements

Compliant	Compliance Incomplete	Not Applicable
42	5	2



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Programmatics (6/6)

Models (11/12)

Simulations & analyses (10/10)

V&V and uncertainty (8/9)

Recommended practices (0/1)

Training (1/3)

Credibility assessment (3/3)

Reporting results (3/3)



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Credibility assessment (3/3)

Reporting results (3/3)

iMED

Internal
Verification

Internal
Validation

External
Review

Review
Disposition

IMM 4.0

Internal
Verification

Internal
Validation

External
Review

Review
Disposition

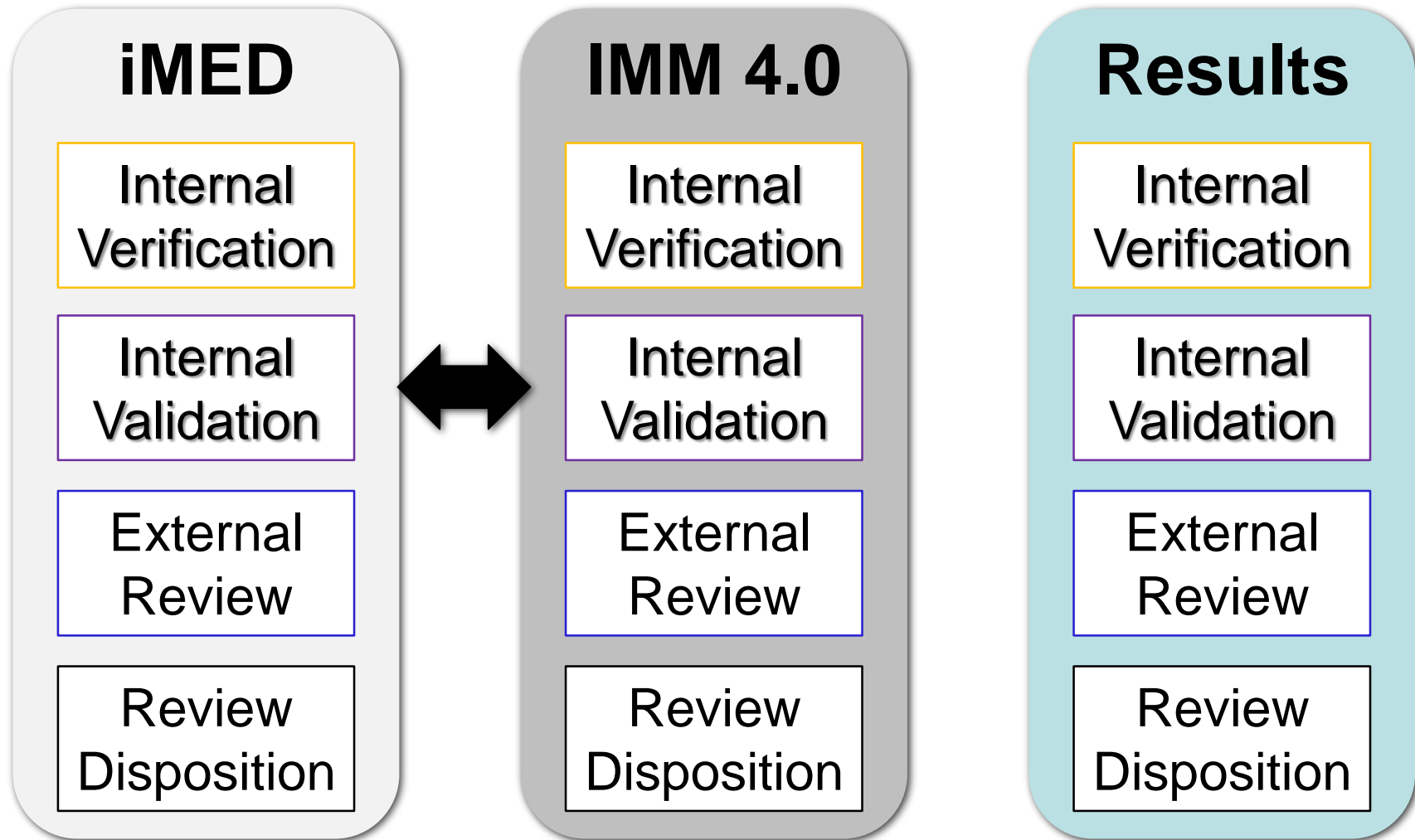
Results

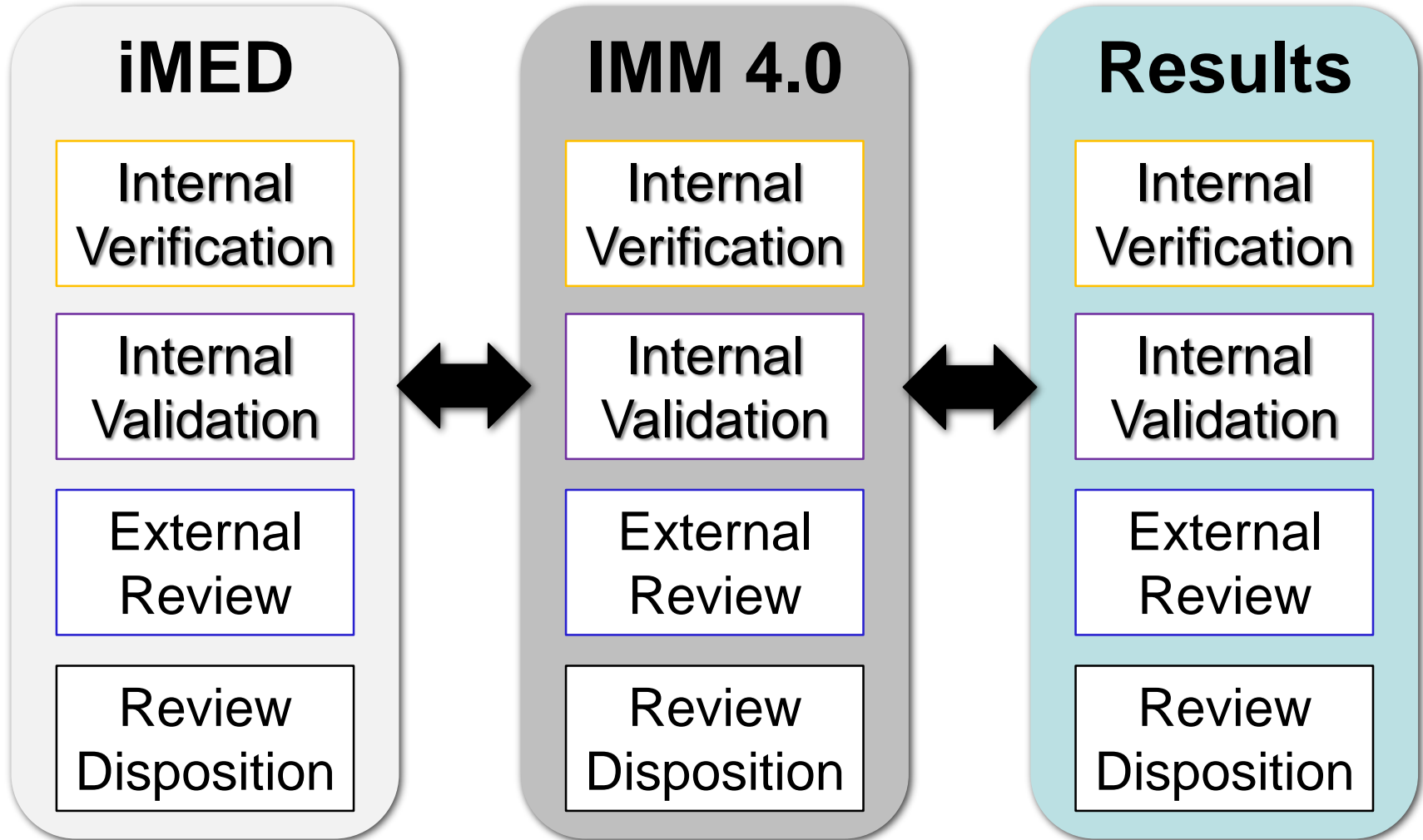
Internal
Verification

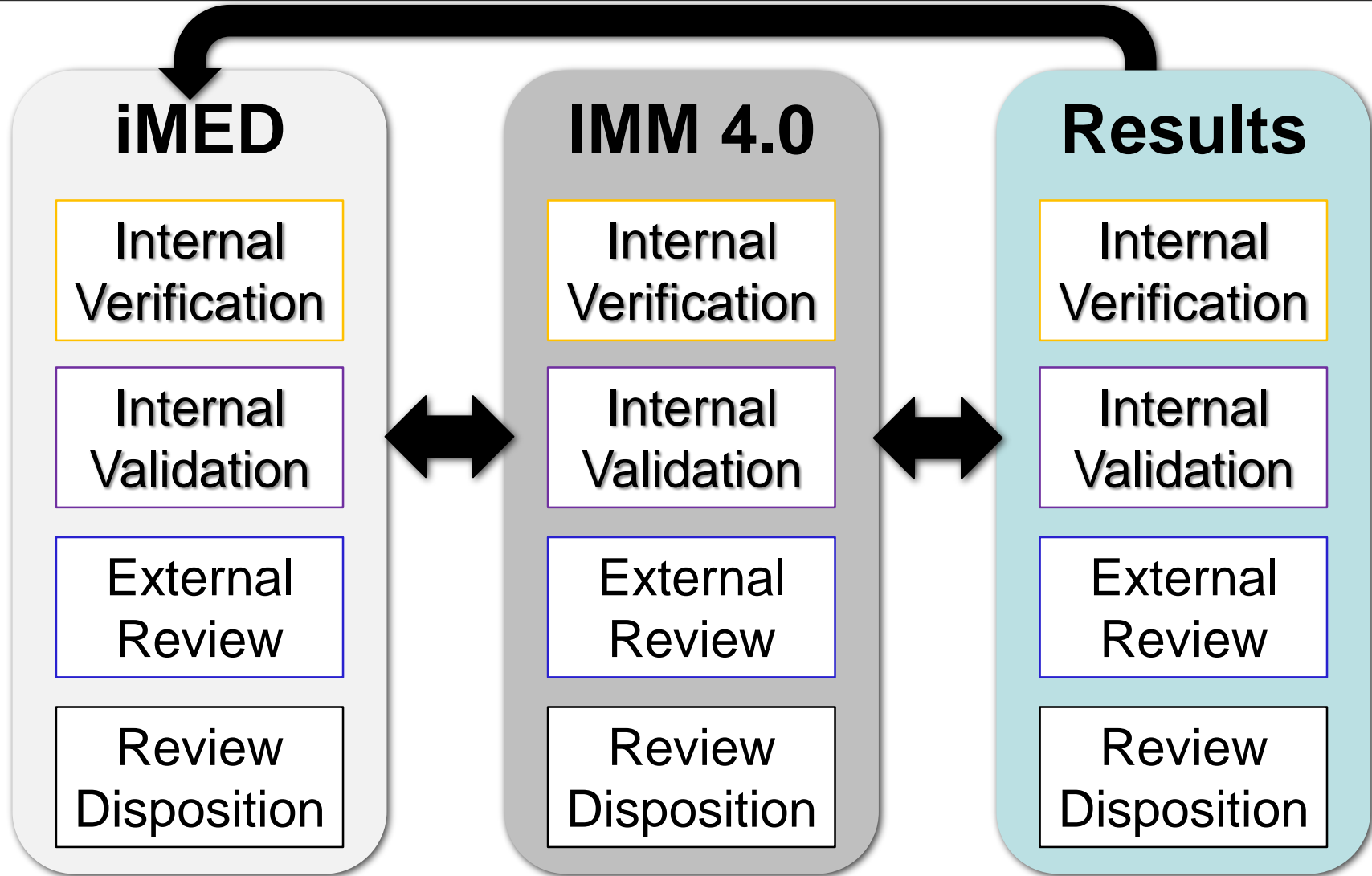
Internal
Validation

External
Review

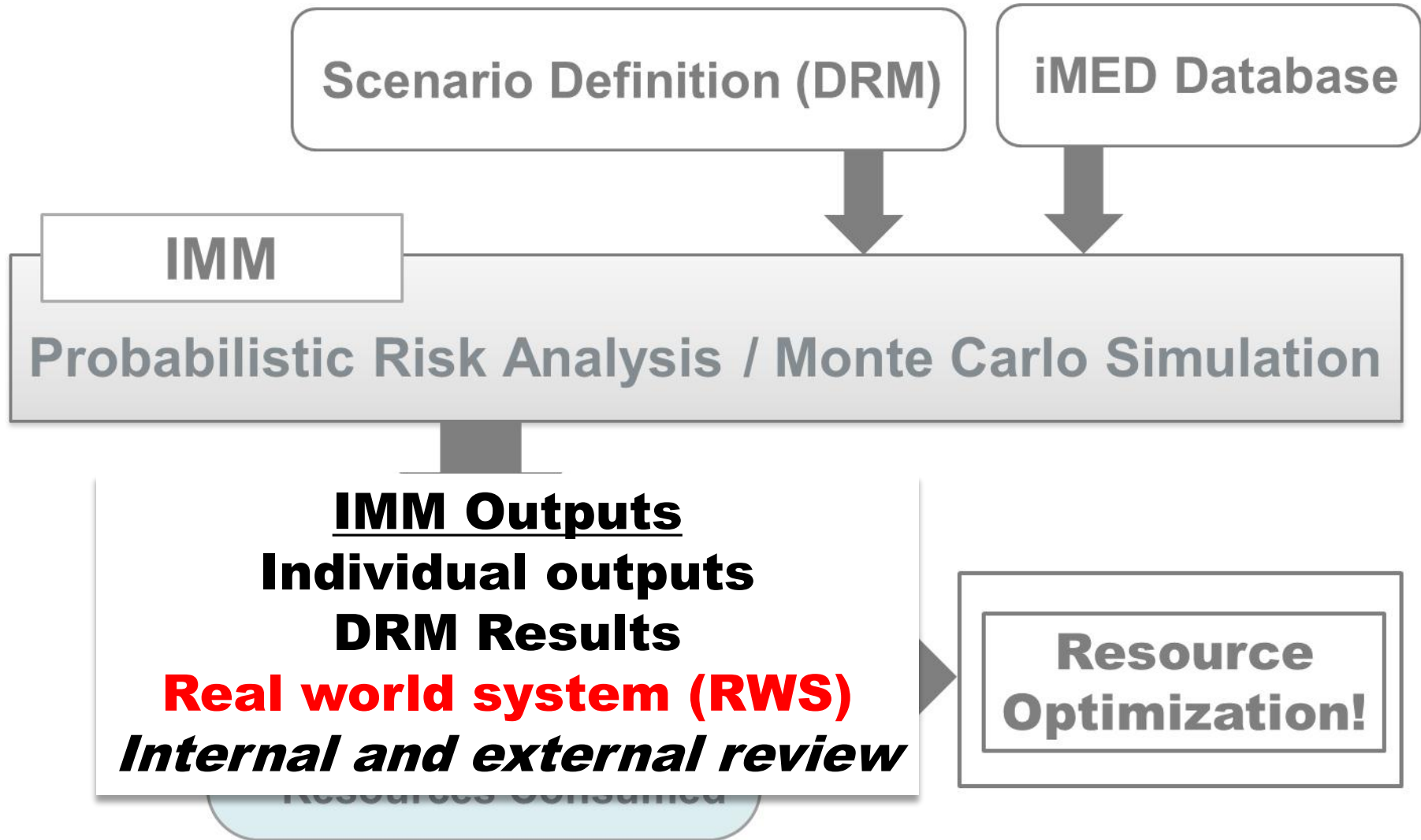
Review
Disposition







IMM 4.0 Comparison to RWS



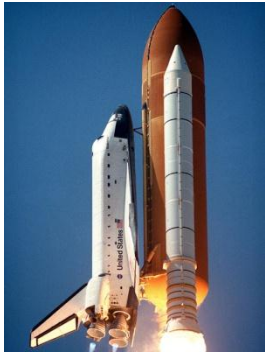
IMM 4.0 Comparison to RWS



iMED (current)
STS thru STS-114
ISS thru Exp13

Validation data
STS-115 - STS-135
Post ISS Exp13

IMM 4.0 vs. RWS

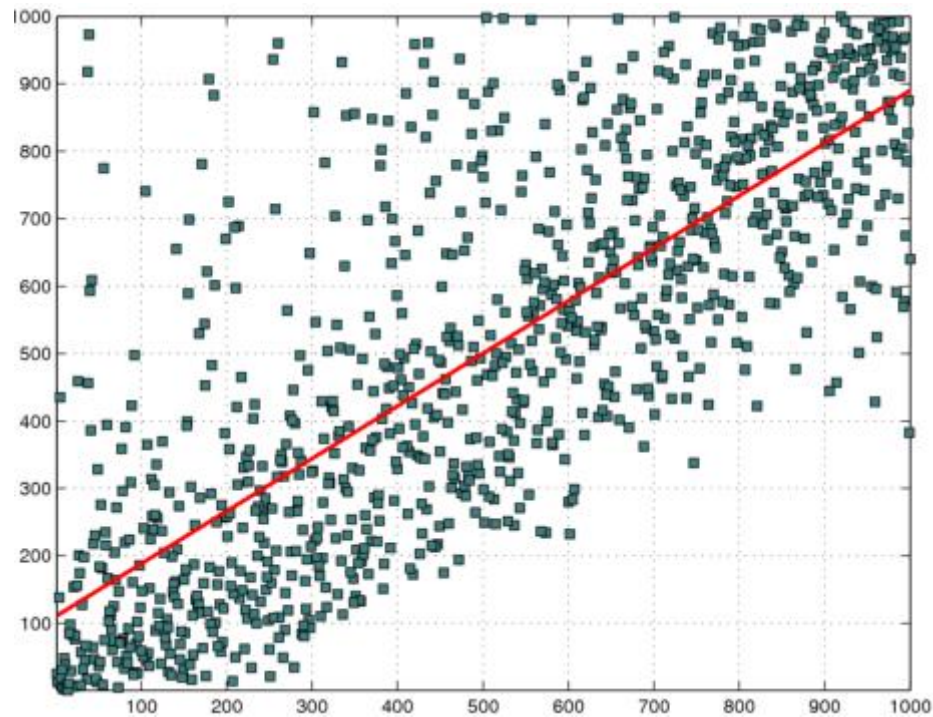


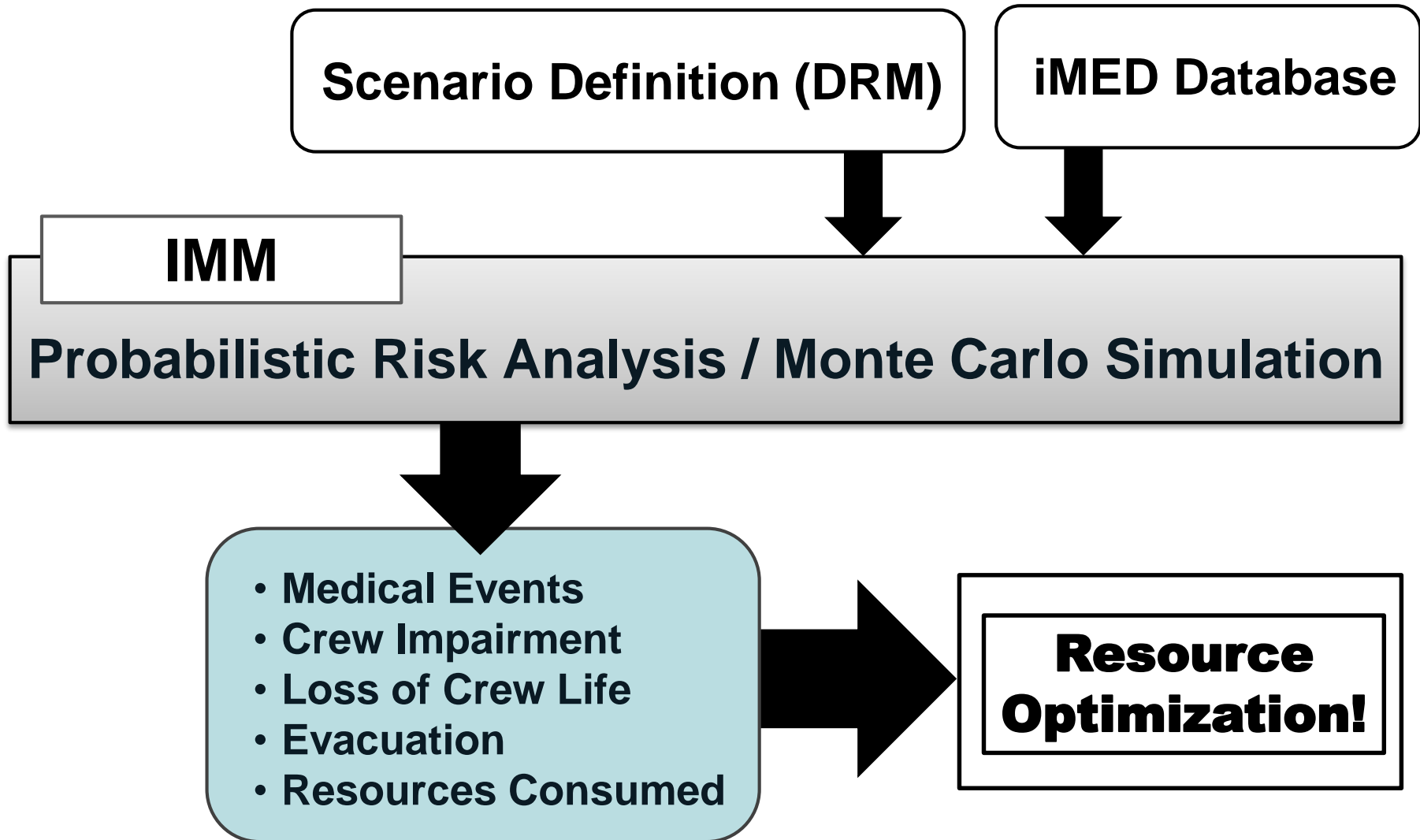
IMM of sufficient fidelity?

Example RWS Results (Quantitative)



- Trends and distributions
- R and R^2







External Review: Software and Code

Scenario Definition (DRM)

iMED Database

IMM 4.0

IMM overall approach

Software and code

Database process

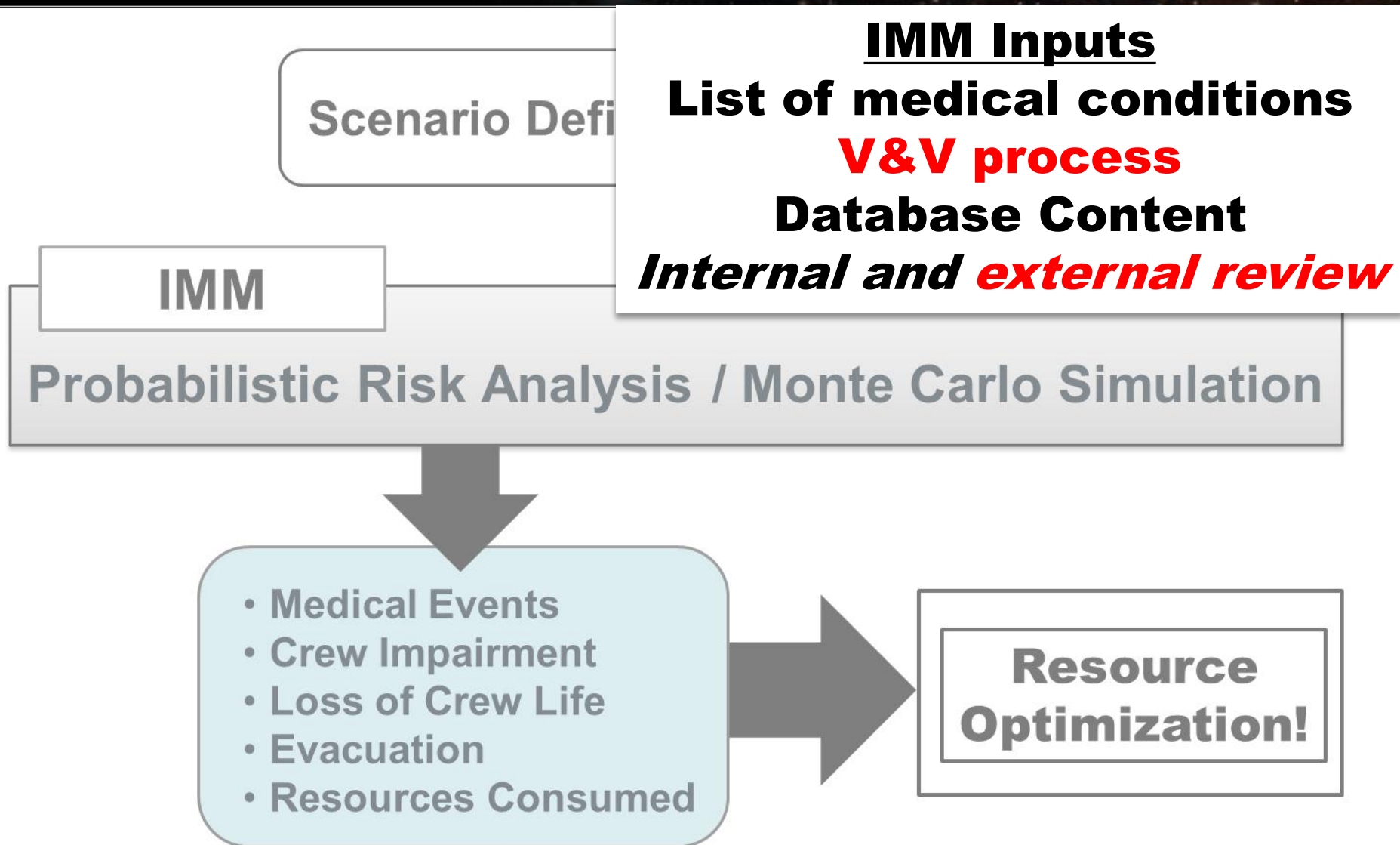
Internal and external review

Monte Carlo Simulation

- Medical Events
- Crew Impairment
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Resource Optimization!

External Review: Input Process



External Review: End-to-End Review



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**Resource
Optimization!**

Credibility assessment of M&S results

Verification

Validation

Input
Pedigree

Results
Uncertainty

Results
Robustness

Use History

M&S
Management

People
Qualifications

- **7009 Technical Review**

- Evidence
- Processes
- Identify limitations

IMM 4.0 End-to-End External Review



49 Requirements

Compliant	Compliance Incomplete	Not Applicable

Programmatics

Models

Simulations & analyses

V&V and uncertainty

Recommended practices

Training

Credibility assessment

Reporting results

IMM 4.0 Transition to Ops



Scenario Definition

IMM Inputs

List of medical conditions

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Database Content

Internal and external review

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**Resource
Optimization!**



- **Current operational IMM**
 - 42/47 compliant
 - 5/47 compliance incomplete
- **IMM 4.0**
 - Functionality results → JPR 7150.2
 - RWS validation → 7009 Technical review



IMM PROJECT VERIFICATION, VALIDATION, AND CREDIBILITY

Thank you!

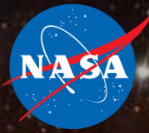
Questions?

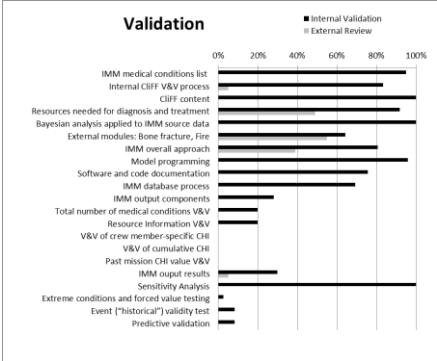


IMM PROJECT VERIFICATION, VALIDATION, AND CREDIBILITY

Back up Slides

IMM Assessment Report



<p>Validation status for IMM</p>	<p>IMM V&V Matrix: The following bar chart shows the IMM version three MATLAB status of internal (black bars) and external (gray bars) IMM validation for each IMM element listed.</p> 																																																		
<p>Compliance with NASA-Standard-7009 requirements</p>	<p>IMM Compliance Matrix: The IMM has no waivers to any of the requirements in the NASA-Standard-7009 for Models and Simulations (4); however there are certain requirements that are not applicable to the IMM and other requirements where IMM compliance has not yet been fully attained.</p> <table border="0" style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;"><u>Compliant</u></td> <td style="text-align: center;"><u>Not yet compliant</u></td> <td style="text-align: center;"><u>Not applicable</u></td> </tr> <tr> <td style="text-align: center;">42</td> <td style="text-align: center;">5</td> <td style="text-align: center;">2</td> </tr> </table>	<u>Compliant</u>	<u>Not yet compliant</u>	<u>Not applicable</u>	42	5	2																																												
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<p>Current NASA-Standard-7009 credibility assessment score</p>	<p>IMM Credibility Matrix: The following table shows the overall IMM version three MATLAB credibility assessment score (CAS), individual factor CAS, customer-specified sufficiency thresholds, and weighted scores. Legend depicts CAS score designated range and color assignments from NASA-Standard-7009. Review subfactor weights for bolded factors is 0.3.</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th colspan="2">Legend</th> </tr> </thead> <tbody> <tr> <td>CAS Score > Threshold</td> <td style="background-color: #0070C0; width: 20px; height: 10px;"></td> </tr> <tr> <td>Threshold ≥ CAS Score ≥ Threshold-0.5</td> <td style="background-color: #008000; width: 20px; height: 10px;"></td> </tr> <tr> <td>Threshold-0.5 > CAS Score ≥ Threshold-1.0</td> <td style="background-color: #FFD700; width: 20px; height: 10px;"></td> </tr> <tr> <td>CAS Score < Threshold - 1.0</td> <td style="background-color: #FF0000; width: 20px; height: 10px;"></td> </tr> <tr> <td>Overall score indicating sufficiency thresholds met</td> <td style="text-align: center;">3.075</td> </tr> </tbody> </table> <table border="1" style="margin-left: auto; margin-right: auto; width: 100%;"> <thead> <tr> <th>Factor</th> <th>Sufficiency Thresholds</th> <th>Factor Score</th> <th>Weighted Scores</th> <th>Overall Score</th> </tr> </thead> <tbody> <tr> <td>Verification</td> <td>4</td> <td style="background-color: #FFD700;">3</td> <td>0.225</td> <td rowspan="10" style="text-align: center; vertical-align: middle;">2.50</td> </tr> <tr> <td>Validation</td> <td>3</td> <td style="background-color: #FFD700;">2.3</td> <td>0.2925</td> </tr> <tr> <td>Input Pedigree</td> <td>3</td> <td style="background-color: #FF0000;">1.6</td> <td>0.28</td> </tr> <tr> <td>Results Uncertainty</td> <td>3</td> <td style="background-color: #008000;">3</td> <td>0.6</td> </tr> <tr> <td>Results Robustness</td> <td>3</td> <td style="background-color: #008000;">3</td> <td>0.3975</td> </tr> <tr> <td>Use History</td> <td>3</td> <td style="background-color: #FFD700;">2</td> <td>0.375</td> </tr> <tr> <td>M&S Management</td> <td>2</td> <td style="background-color: #008000;">2</td> <td>0.1</td> </tr> <tr> <td>People Qualification</td> <td>4</td> <td style="background-color: #008000;">4</td> <td>0.2</td> </tr> </tbody> </table>	Legend		CAS Score > Threshold		Threshold ≥ CAS Score ≥ Threshold-0.5		Threshold-0.5 > CAS Score ≥ Threshold-1.0		CAS Score < Threshold - 1.0		Overall score indicating sufficiency thresholds met	3.075	Factor	Sufficiency Thresholds	Factor Score	Weighted Scores	Overall Score	Verification	4	3	0.225	2.50	Validation	3	2.3	0.2925	Input Pedigree	3	1.6	0.28	Results Uncertainty	3	3	0.6	Results Robustness	3	3	0.3975	Use History	3	2	0.375	M&S Management	2	2	0.1	People Qualification	4	4	0.2
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