



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

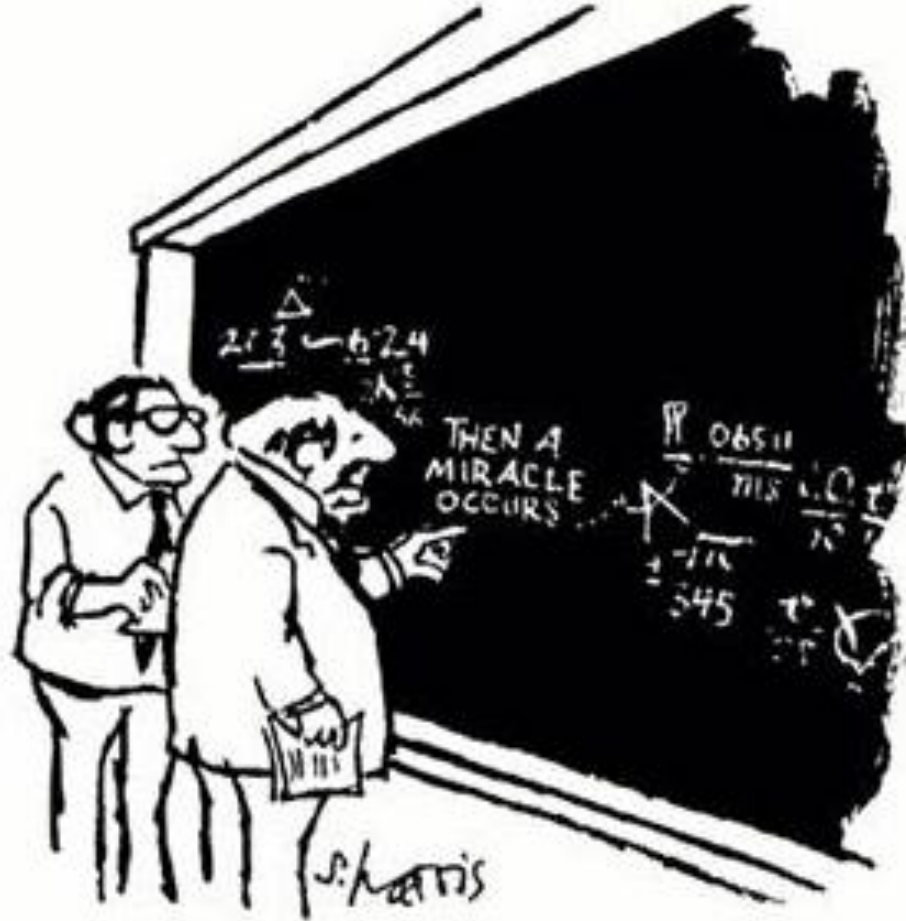
M. Walton<sup>1</sup>, L. Boley<sup>1</sup>, A. Keenan<sup>1</sup>, E. Kerstman<sup>2</sup>, R. Shah<sup>2</sup>, M. Young<sup>1</sup>, L. Saile<sup>1</sup>, Y. Garcia<sup>1</sup>, J. Myers<sup>3</sup>, D. Reyes<sup>2</sup>

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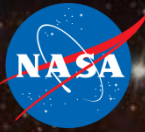


- **Background**
- **History**
- **IMM v3**
- **IMM 4.0**
- **External review**
- **Conclusions**

# VV&C - Importance of Communication



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

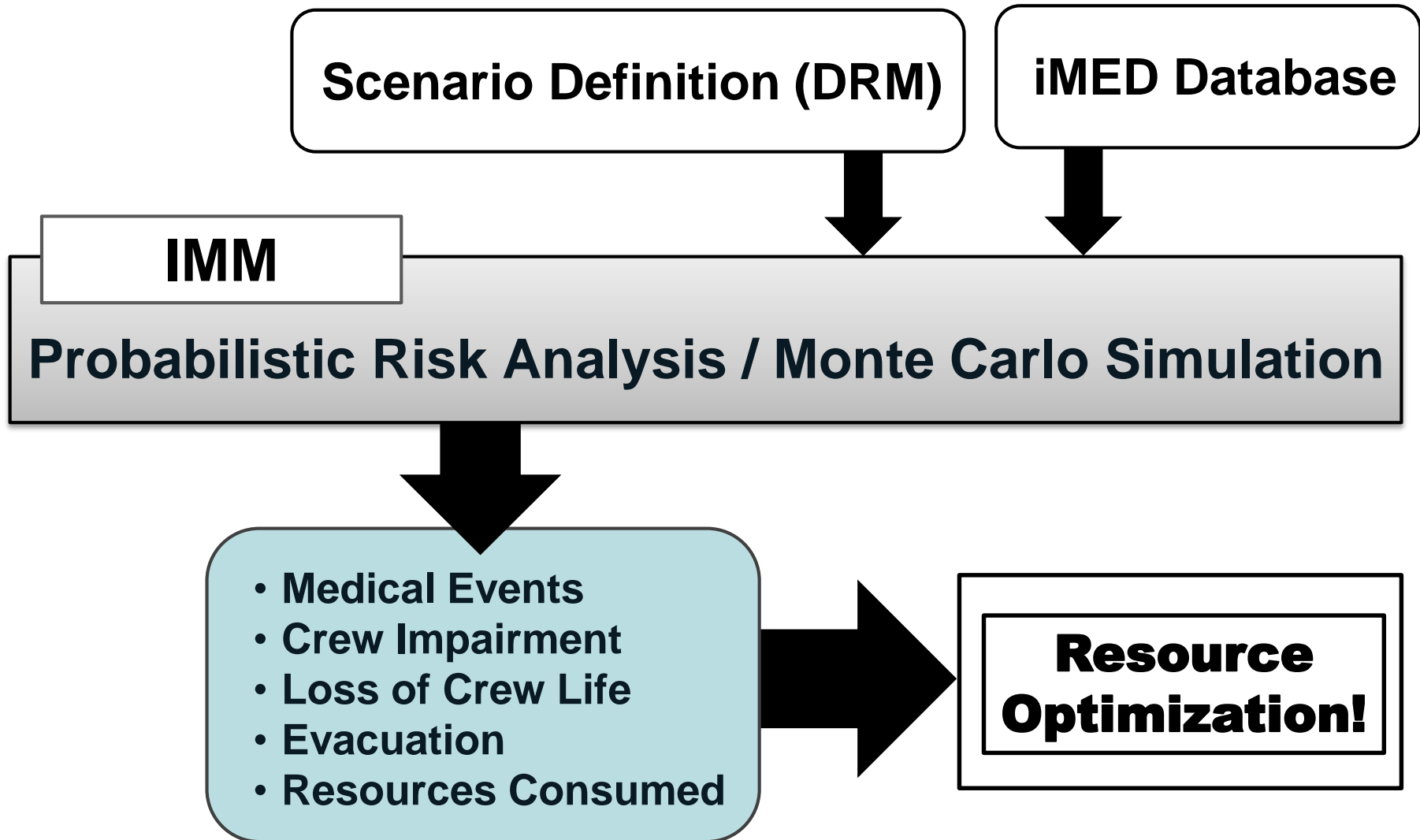


- **Verification:** “...computational model accurately represents the underlying mathematical model...”
- **Validation:** “...determining the degree to which a model ... is an accurate representation of the real world...”
- **Credibility:** “the quality to elicit belief or trust”

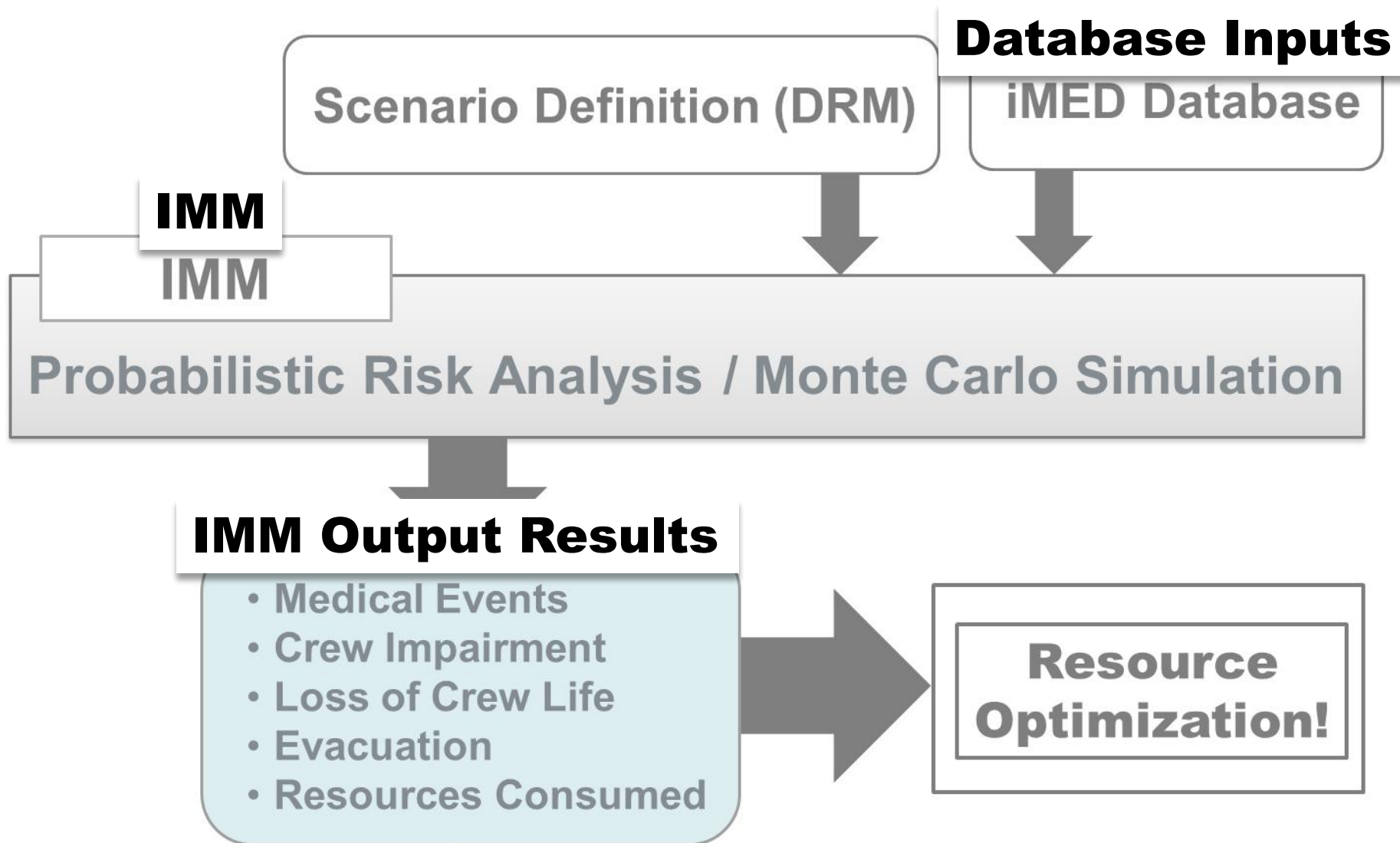
- **Credibility begins before development**
- **Includes the end users**
- **Is an ongoing assessment**



# IMM Project VV&C History (April 2008)



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# IMM Project VV&C History (April 2008)



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**

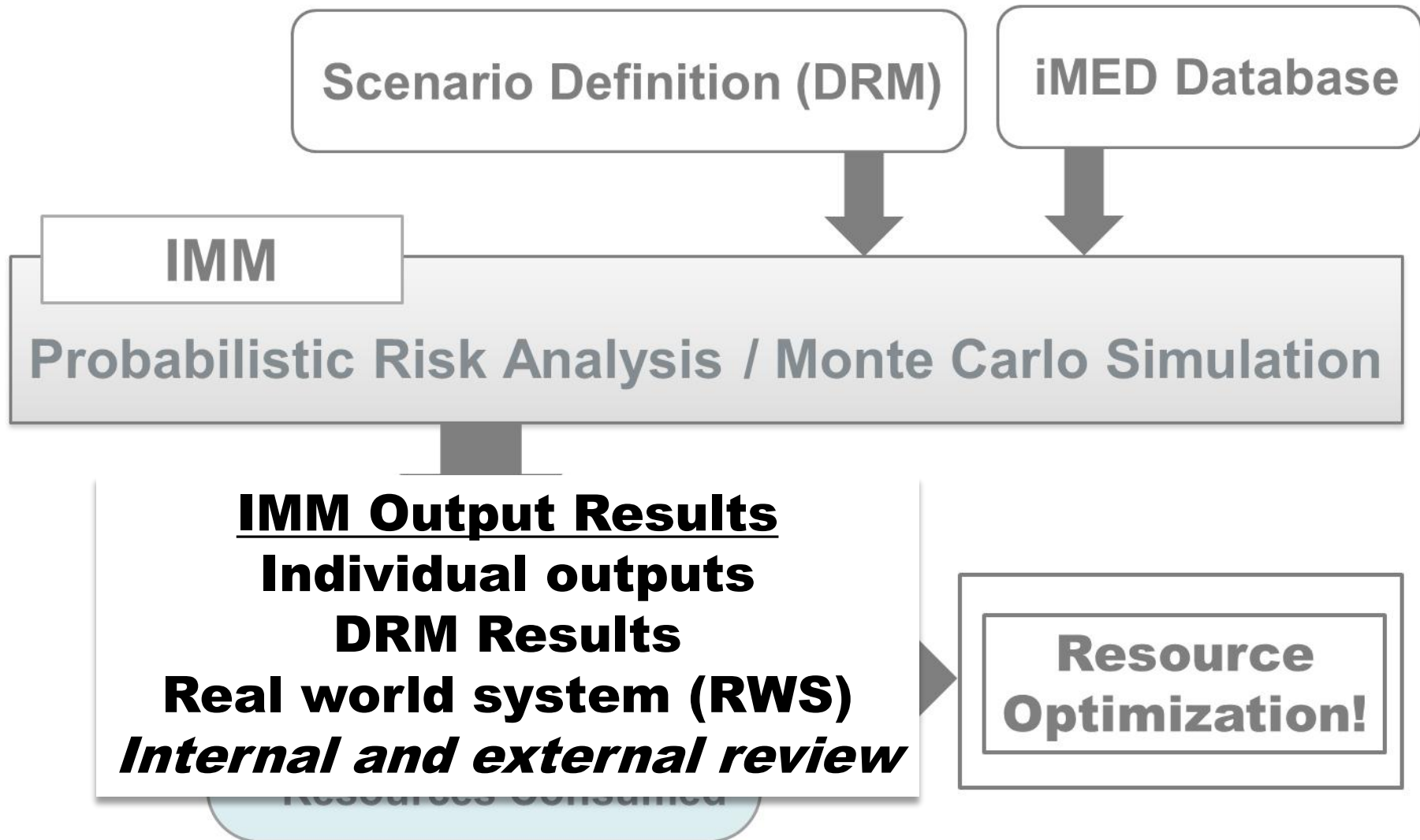
***Internal and external review***

Monte Carlo Simulation

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

**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

<b>Compliant</b>	<b>Compliance Incomplete</b>	<b>Not Applicable</b>
<b>42</b>	<b>5</b>	<b>2</b>



## 49 Requirements

Compliant	Compliance Incomplete	Not Applicable
42	5	2

**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)**



## 49 Requirements

Compliant	Compliance Incomplete	Not Applicable
42	5	2

**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)**

## iMED

Internal  
Verification

Internal  
Validation

External  
Review

Review  
Disposition

## IMM 4.0

Internal  
Verification

Internal  
Validation

External  
Review

Review  
Disposition

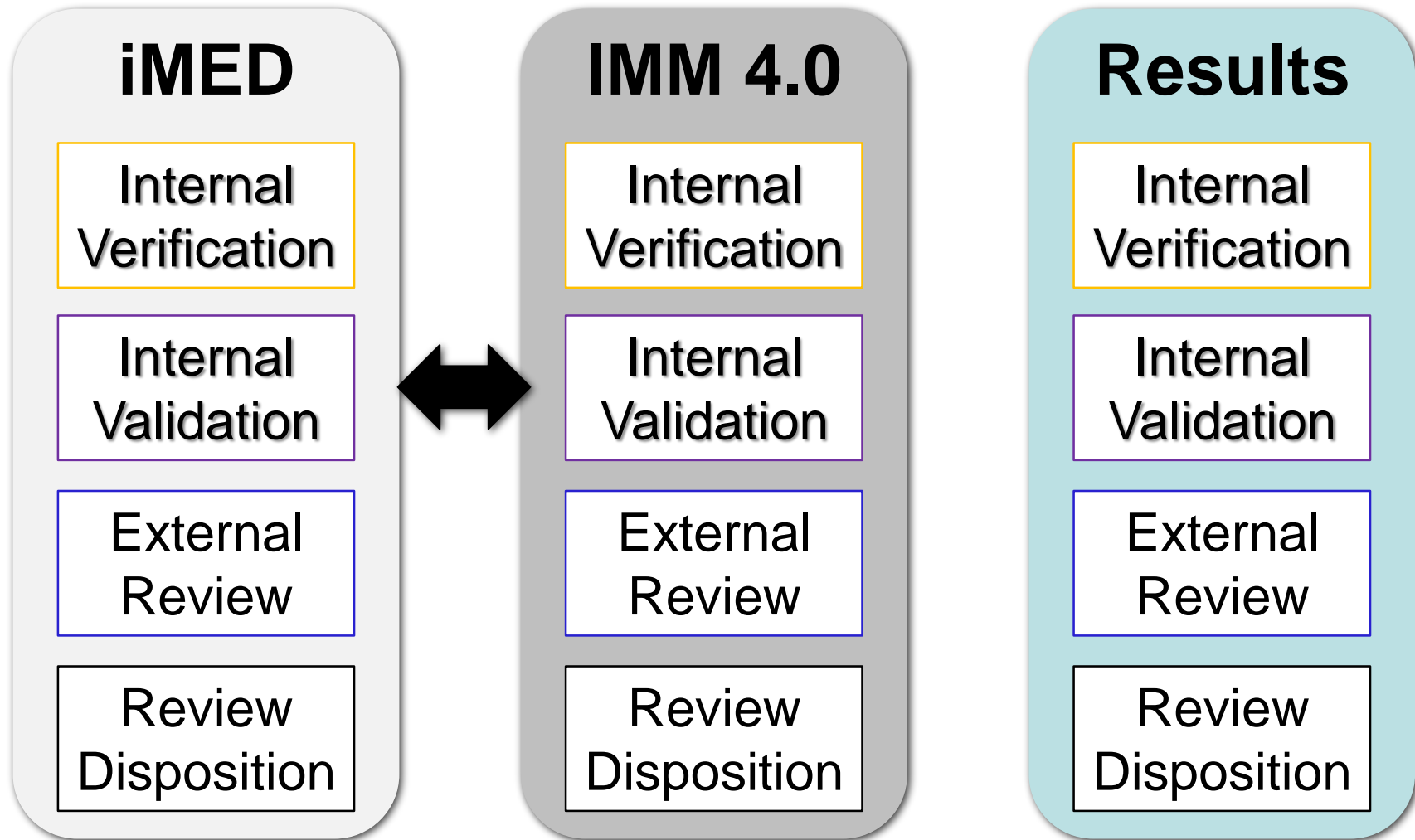
## Results

Internal  
Verification

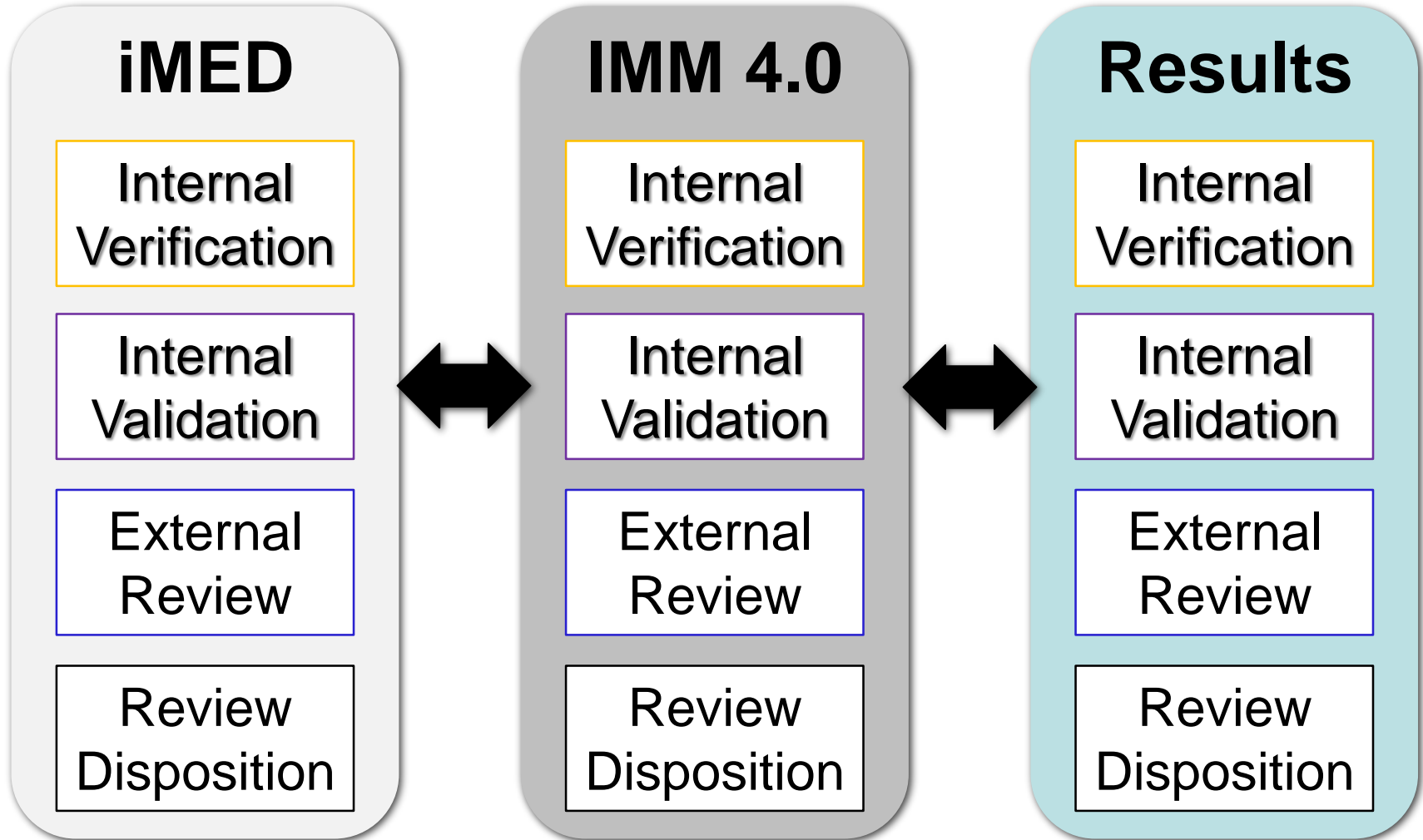
Internal  
Validation

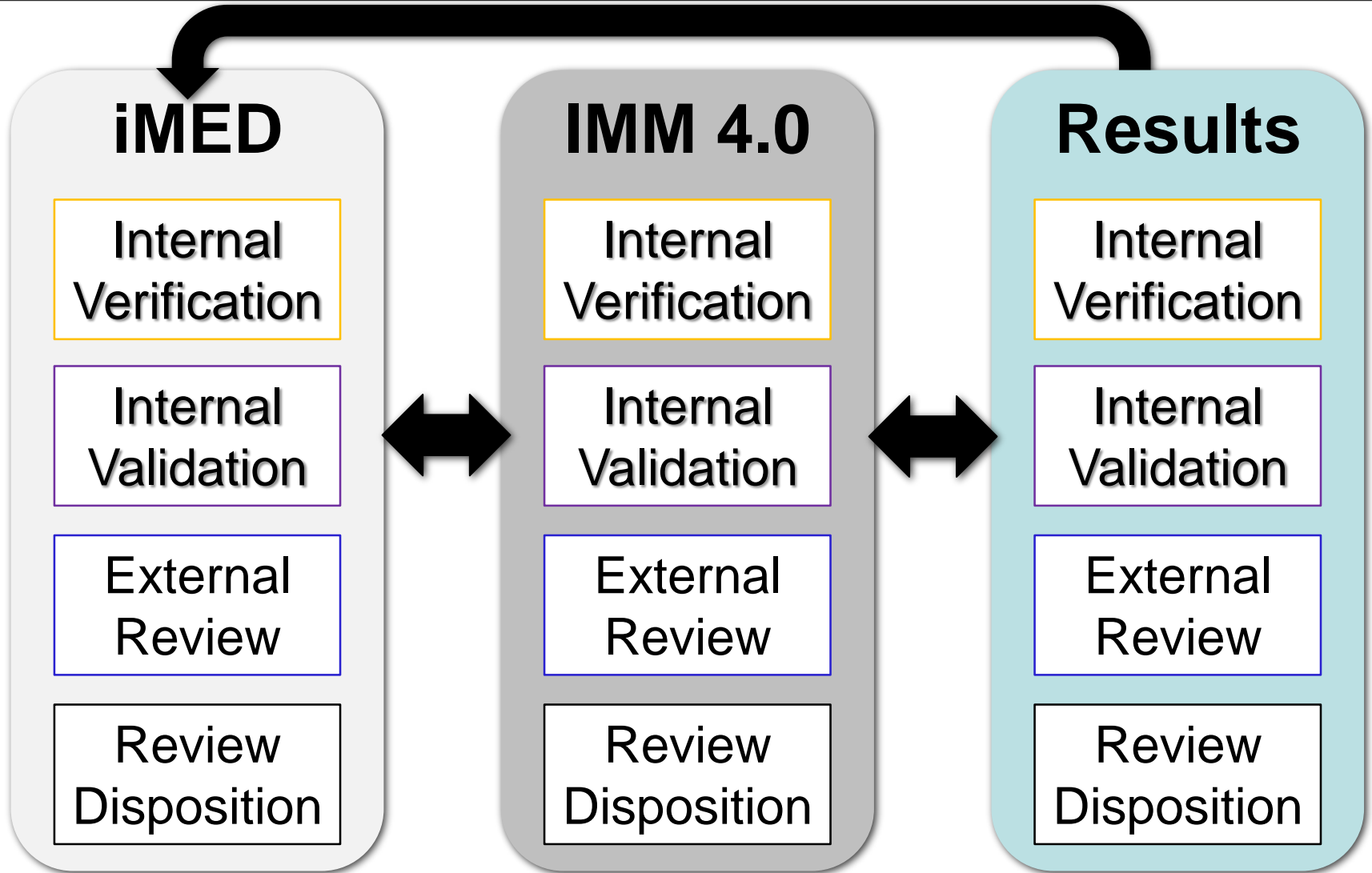
External  
Review

Review  
Disposition

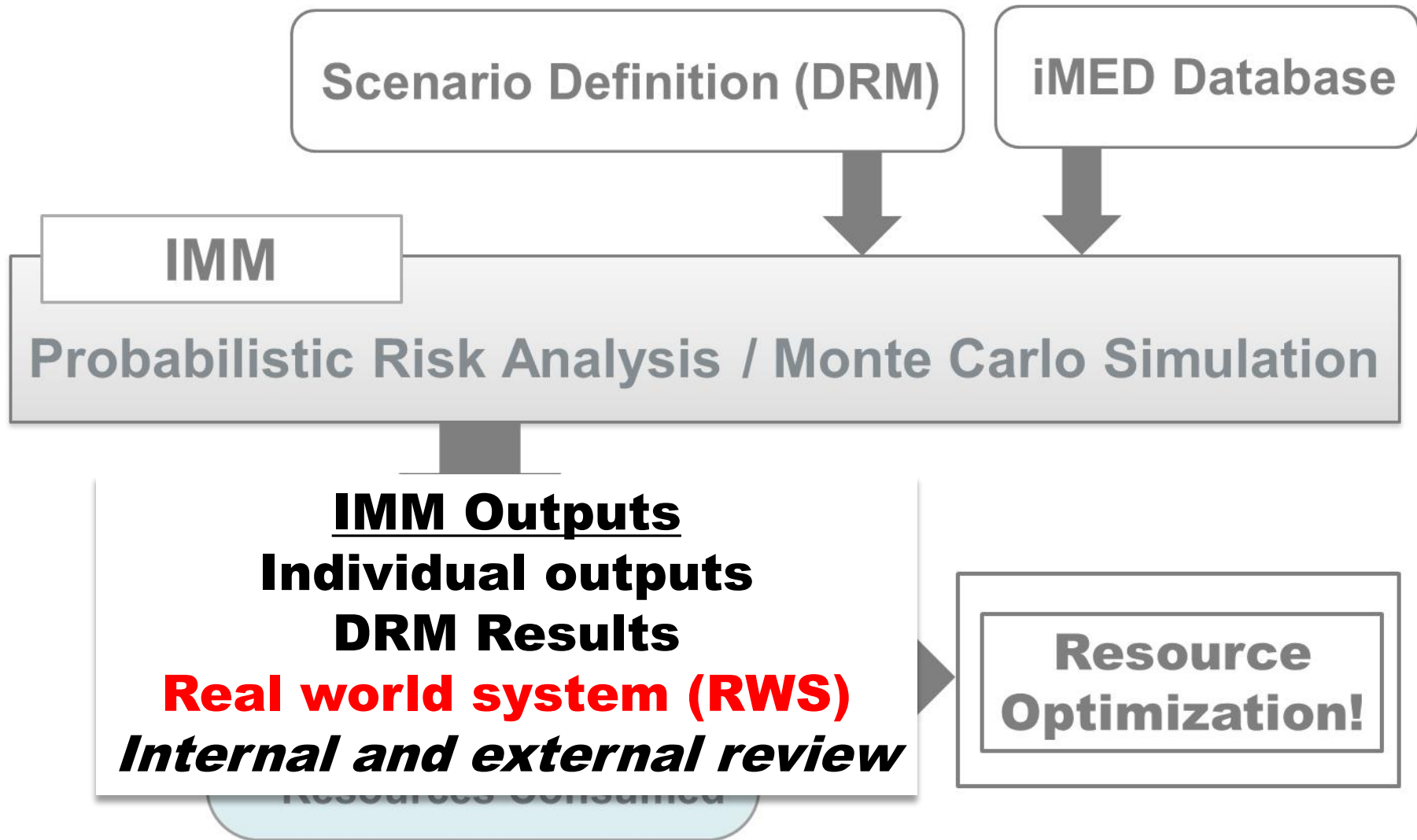








# IMM 4.0 Comparison to RWS



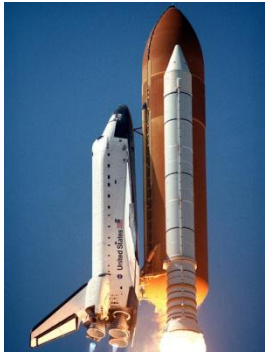
# IMM 4.0 Comparison to RWS



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

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

**IMM 4.0 vs. RWS**

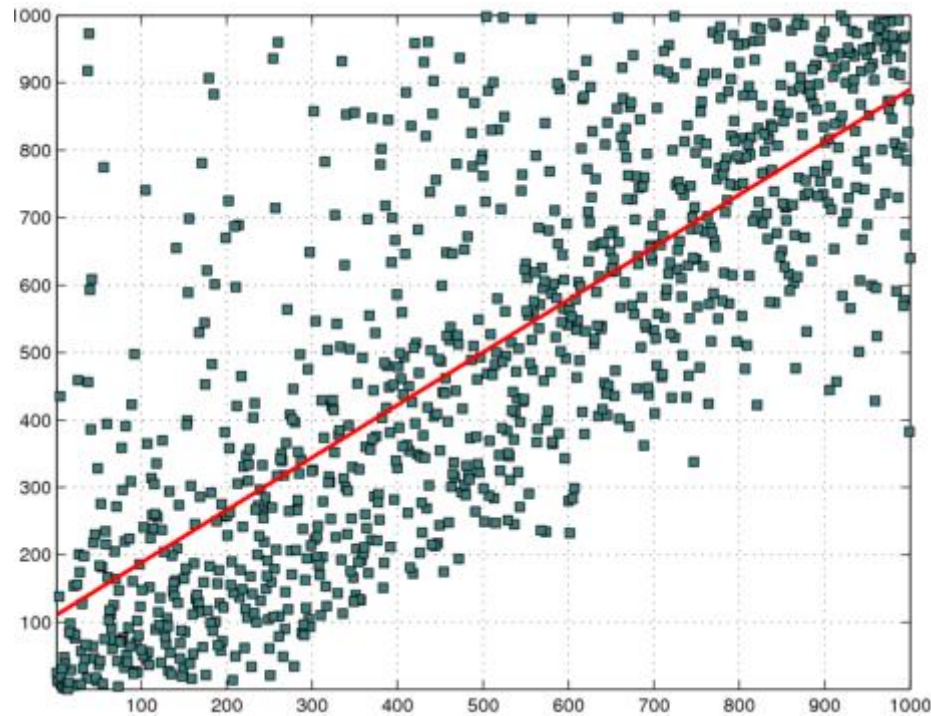


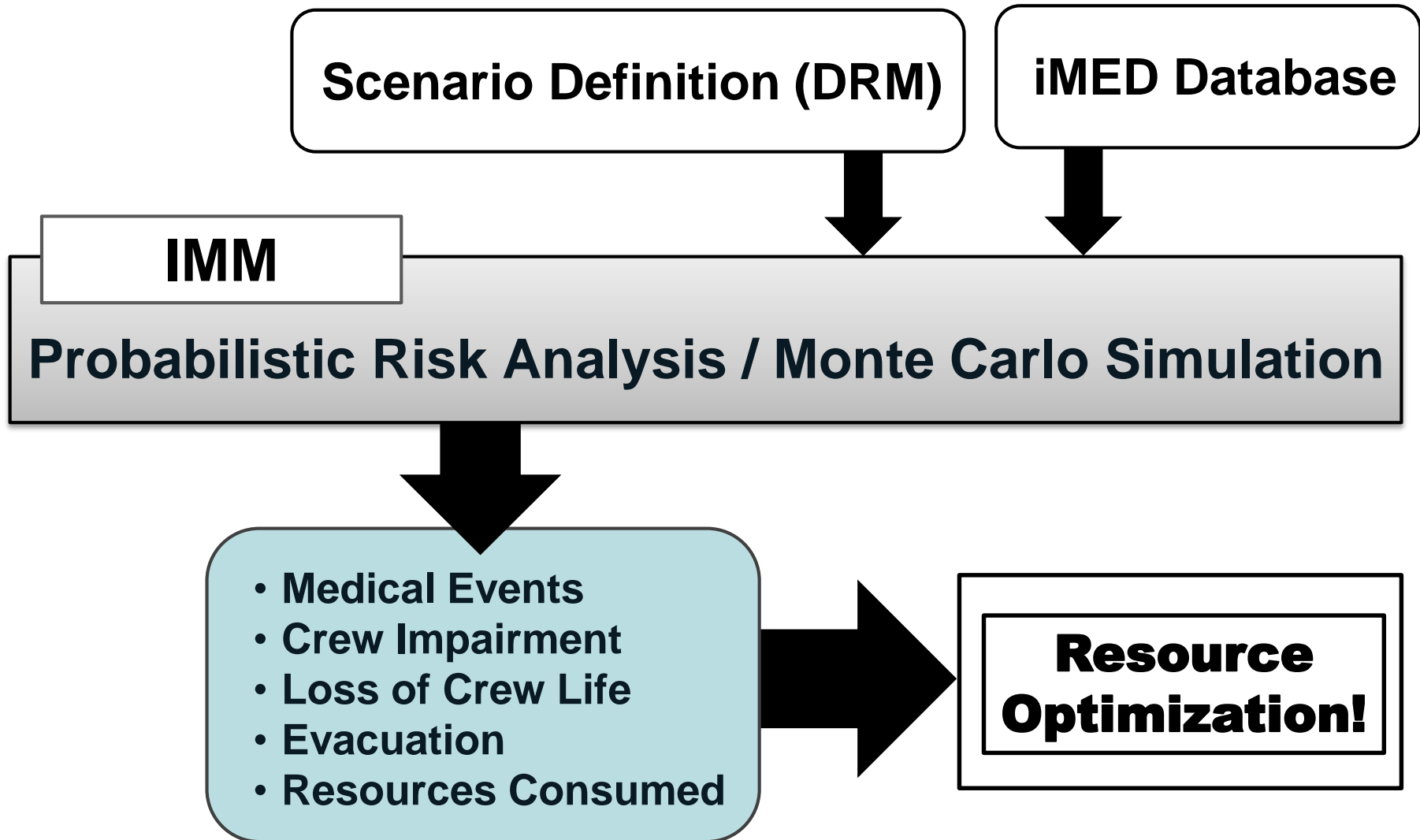
**IMM of sufficient fidelity?**

# Example RWS Results (Quantitative)



- Trends and distributions
- R and R<sup>2</sup>





# External Review: Software and Code

Scenario Definition (DRM)

iMED Database

## IMM 4.0

**IMM overall approach**

**Software and code**

**Database process**

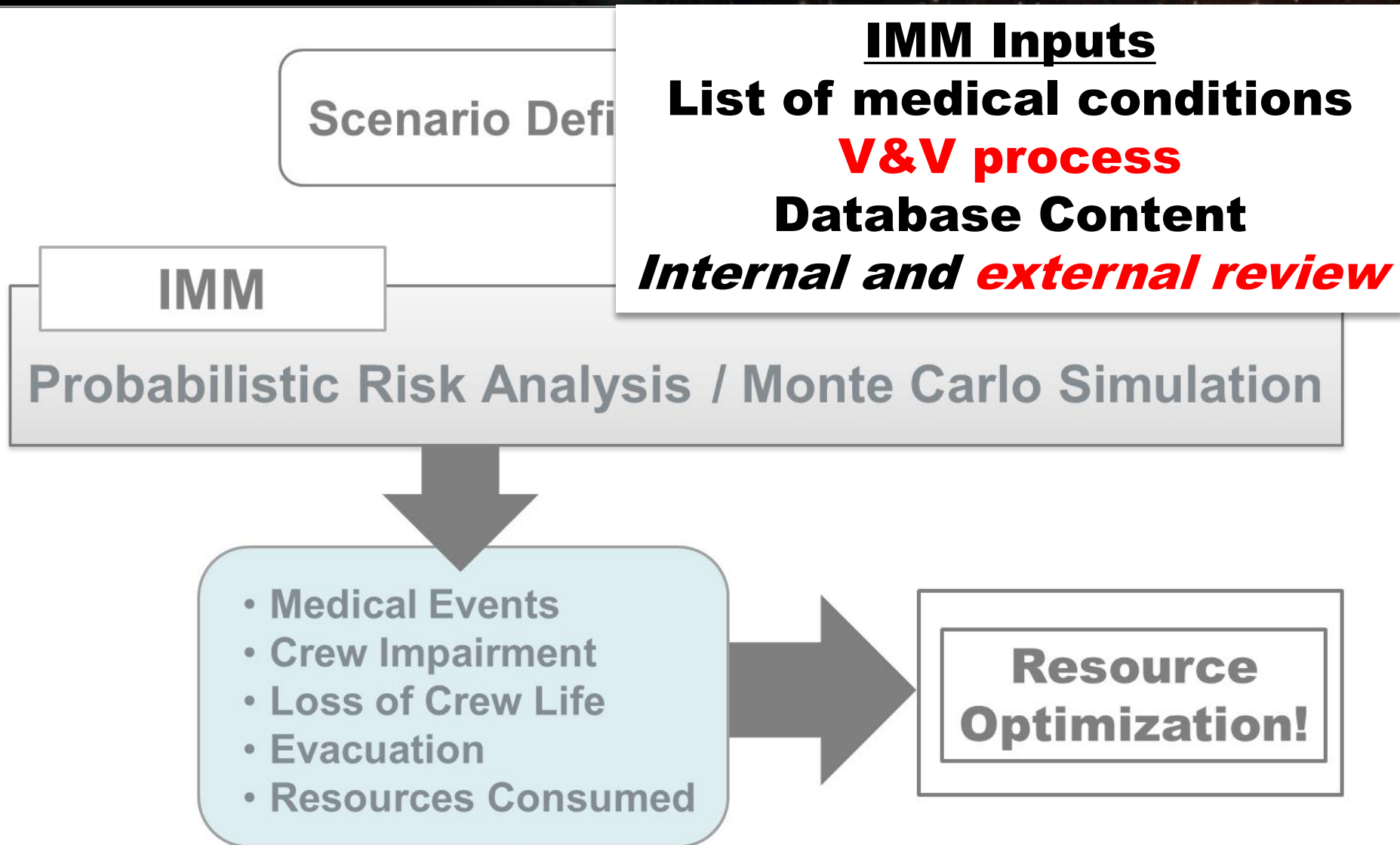
**Internal and external review**

Monte Carlo Simulation

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

**Resource Optimization!**

# External Review: Input Process





# External Review: End-to-End Review



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
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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**

**V&V process**

**Database Content**

***Internal and external review***

## IMM 4.0

**IMM overall approach**

**Software and code**

**Database process**

***Internal and external review***

Monte Carlo Simulation

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

**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?***

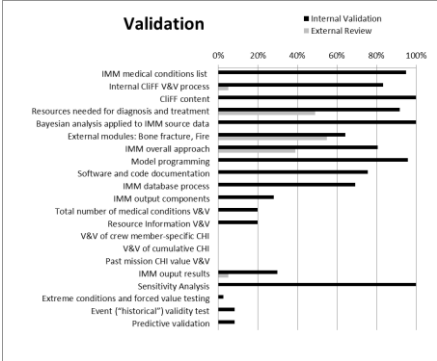


# IMM PROJECT VERIFICATION, VALIDATION, AND CREDIBILITY

*Back up Slides*

# IMM Assessment Report



<p><b>Validation status for IMM</b></p>	<p><b>IMM V&amp;V Matrix:</b> 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><b>Compliance with NASA-Standard-7009 requirements</b></p>	<p><b>IMM Compliance Matrix:</b> 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><b>Current NASA-Standard-7009 credibility assessment score</b></p>	<p><b>IMM Credibility Matrix:</b> 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 &gt; 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 &gt; CAS Score ≥ Threshold-1.0</td> <td style="background-color: #FFD700; width: 20px; height: 10px;"></td> </tr> <tr> <td>CAS Score &lt; 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><b>Verification</b></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; background-color: #FFD700;"><b>2.50</b></td> </tr> <tr> <td><b>Validation</b></td> <td>3</td> <td style="background-color: #FFD700;">2.3</td> <td>0.2925</td> </tr> <tr> <td><b>Input Pedigree</b></td> <td>3</td> <td style="background-color: #FF0000;">1.6</td> <td>0.28</td> </tr> <tr> <td><b>Results Uncertainty</b></td> <td>3</td> <td style="background-color: #008000;">3</td> <td>0.6</td> </tr> <tr> <td><b>Results Robustness</b></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&amp;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	<b>Verification</b>	4	3	0.225	<b>2.50</b>	<b>Validation</b>	3	2.3	0.2925	<b>Input Pedigree</b>	3	1.6	0.28	<b>Results Uncertainty</b>	3	3	0.6	<b>Results Robustness</b>	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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