



INTEGRATED MEDICAL MODEL (IMM) 4.0 VERIFICATION AND VALIDATION (V&V) TESTING

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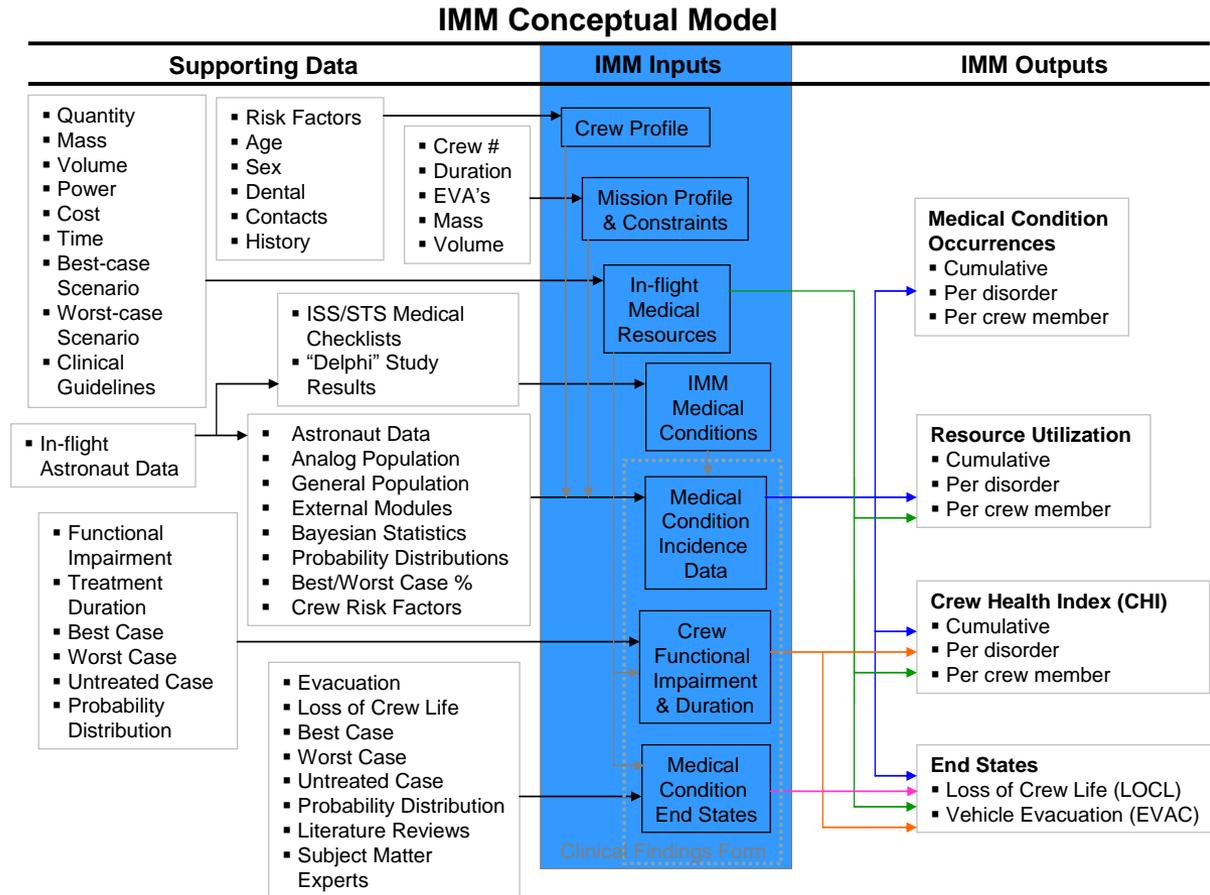


- **IMM v3 versus IMM 4.0**
- **V&V Scope**
- **V&V Objectives**
- **Methods**
- **Results**
- **Summary**

IMM v3 versus IMM 4.0



- **Timeline** – In addition to generating if conditions occur, IMM v4.0 generates when conditions occur.
- **Partial Treatment** – IMM v4.0 gives partial credit for partial treatment in generating the outcomes of a condition
- **Alternative Drug** – If a primary drug required for treatment is not available, IMM v4.0 searches for medically appropriate substitutes.



New capabilities were examined in a comparative, stepwise approach as follows:

- **comparison of the current operational IMM v3 with the enhanced functionality of timeline (IMM 4.T)**
- **comparison of IMM 4.T with the enhanced functionalities of timeline and partial treatment capability (IMM 4.TPT)**
- **comparison of IMM 4.TPT with the enhanced functionalities of timeline, partial treatment and alternative medication capability (IMM 4.0)**

Verification Objectives



Confirm that the IMM version undergoing evaluation functioned correctly and that this IMM version performed appropriately when compared to the previous IMM version:

- **Events are distributed as specified**
 - Incidence rate and proportion
 - Event timing
 - Best and worst case scenarios
 - Evacuation (EVAC) and loss of crew life (LOCL) assignments
- **Quality-adjusted mission time lost is being calculated correctly**
- **Resources are utilized and depleted correctly**

Validation Objectives



IMM primary outputs underwent quantitative evaluation and/or face validation to confirm that the IMM version undergoing evaluation functioned correctly:

- Total medical events (TME)
- Crew health index (CHI)
- EVAC
- LOCL
- Resource utilization

• Quantitative: statistical significance assessed using 95% CI to test differences between compared outcomes

• Face validation: assessment of the model and/or its behavior by SMEs to determine whether the model outputs are reasonable

- understanding directions and magnitudes of differences of the model and the RWS

Validation Objectives

(Hypothesized Qualitative Trends for Primary Outputs)



Enhanced Functionality	TME	CHI	EVAC	LOCL	Resource Utilization
Timeline (IMM 4.T)	Expected effect on IMM 4.T outputs compared to IMM V3				
	↓	↑	↓	↓	↓
Partial Treatment (IMM 4.TPT)	Expected effect on IMM 4.TPT outputs compared to IMM 4.T				
	↑	↑	↓	↓	↑
Alternate Medications (IMM 4.0)	Expected effect on IMM 4.0 outputs compared to IMM 4.TPT				
	↑	↑	↓	↓	↑

Qualitative trend directions of the primary IMM outputs were hypothesized for mission scenario comparison of each successive implementation of new IMM capability.

IMM version performed as hypothesized when compared with each successive implementation of new IMM capability

Design Reference Mission Characteristics

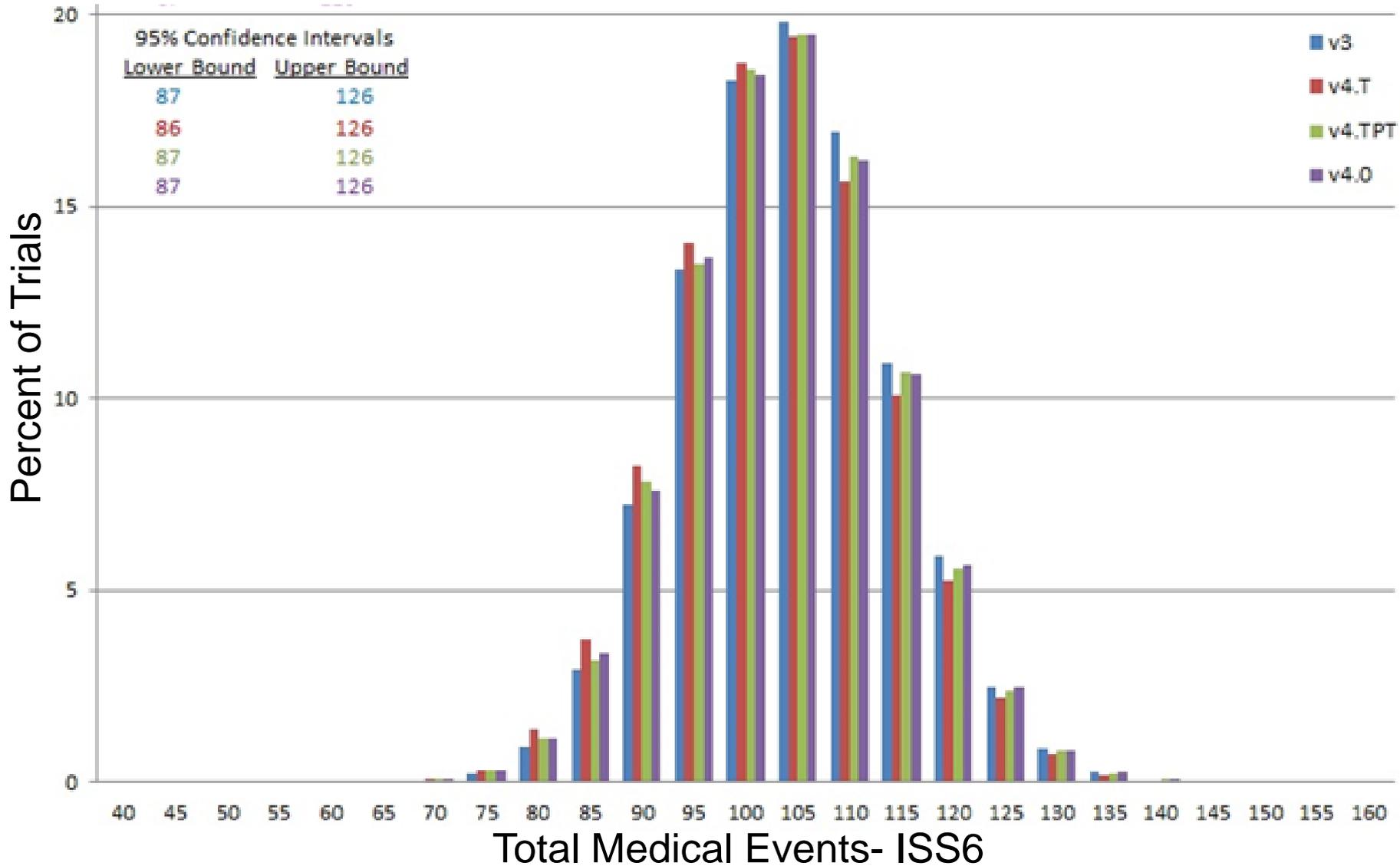
Mission	Duration	Number of 2-person EVAs*	Total EVAs	EVA Schedule
Lunar Sortie	14 (days)	8	16	every day from day 3 to day 10
ISS6	180 (days)	6	12	day 25, 50, 75, 100, 125, 150
Mars	2.5 (years)	231	462	every second day starting from day 180

*Only two crew members are EVA eligible, 1 male, 1female

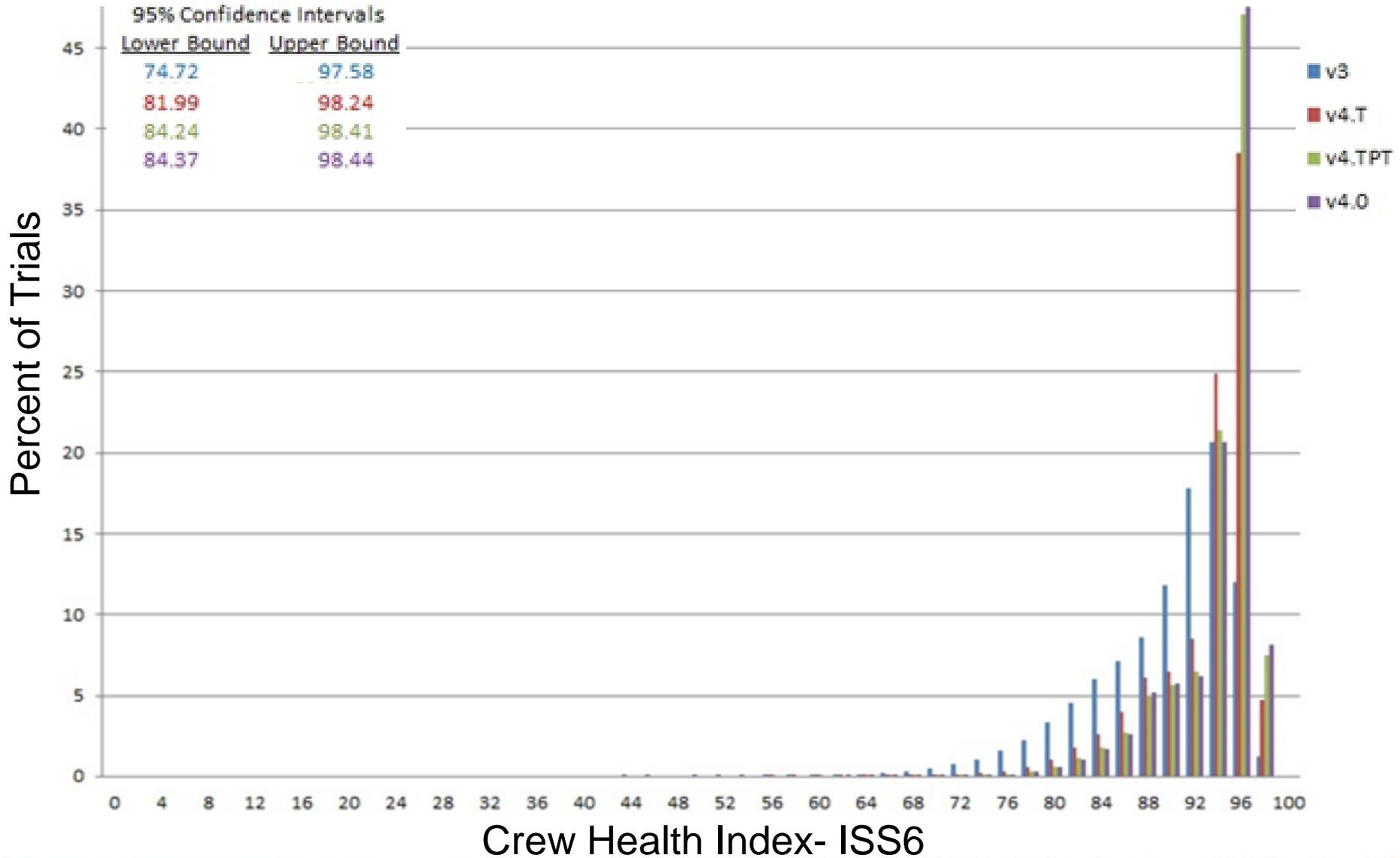
•Crew characteristics

- Six- 4 males, 2 females
- Diverse physiological traits representative of astronaut corps

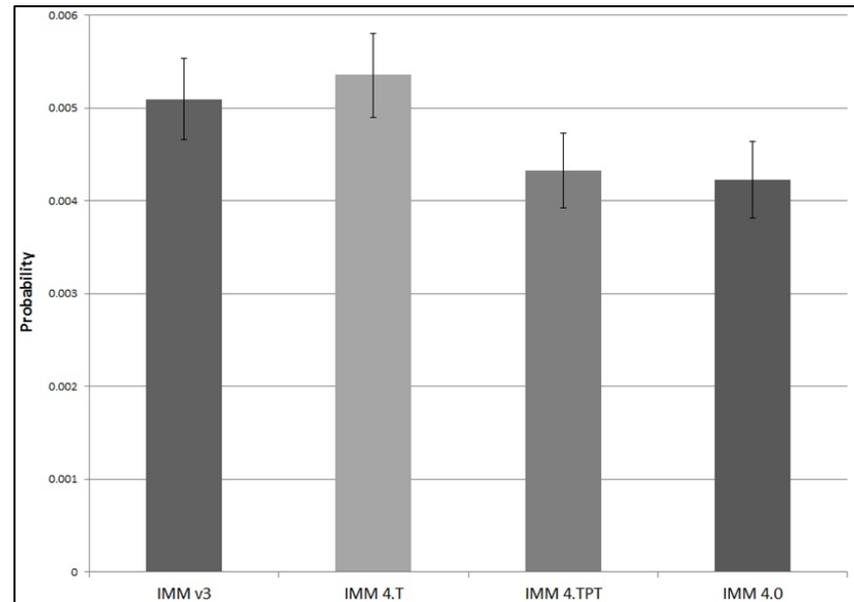
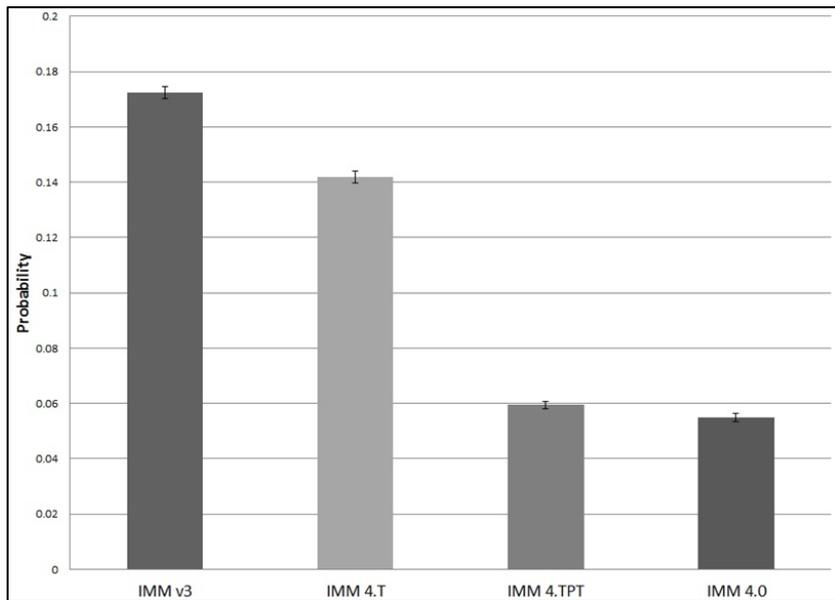
Results: TME (ISS6 DRM -MedCap Scenario)



Results: CHI (ISS6 DRM -MedCap Scenario)



Results: EVAC and LOCL (ISS6 DRM -MedCap Scenario)



Results Summary



Enhanced Functionality	TME	CHI	EVAC	LOCL	Resource Utilization
Timeline (IMM 4.T)	IMM 4.T outputs compared to IMM V3				
	↓	↑	↓	↓	↓
V3	106.41	90.36	0.1724	0.0051	739.29
4.T	105.49	93.96	0.1418	0.0054	720.89
Partial Treatment (IMM 4.TPT)	IMM 4.TPT outputs compared to IMM 4.T				
	↑	↑	↓	↓	↑
4.T	105.49	93.96	0.1418	0.0054	720.89
4.TPT	105.97	94.87	0.0594	0.0043	724.09
Alternate Medications (IMM 4.0)	IMM 4.0 outputs compared to IMM 4.TPT				
	↑	↑	↓	↓	↑
4.TPT	105.97	94.87	0.0594	0.0043	724.09
4.0	106.02	94.92	0.0550	0.0042	723.41

Summary



- IMM 4.0 functionalities of timeline, partial treatment, and alternative treatments were added to IMM v3 to provide a closer approximation of the baselined real world system (*i.e.* the International Space Station).
- V&V of these enhanced functionalities indicates that the IMM 4.0 version is functioning correctly and performs as hypothesized based on meeting the proposed verification and validation objectives
- Analysis confirmed:
 - medical events are distributed as specified by the IMM
 - quality-adjusted mission time lost is being calculated correctly
 - resources are utilized and depleted correctly
 - total medical events, crew health index, probability of evacuation, and probability of loss of crew life were as hypothesized
- Although original resource utilization hypotheses were not tested; subject matter expertise was used to evaluate the resources required- with this consideration, no unacceptable findings were identified.



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Thank you!



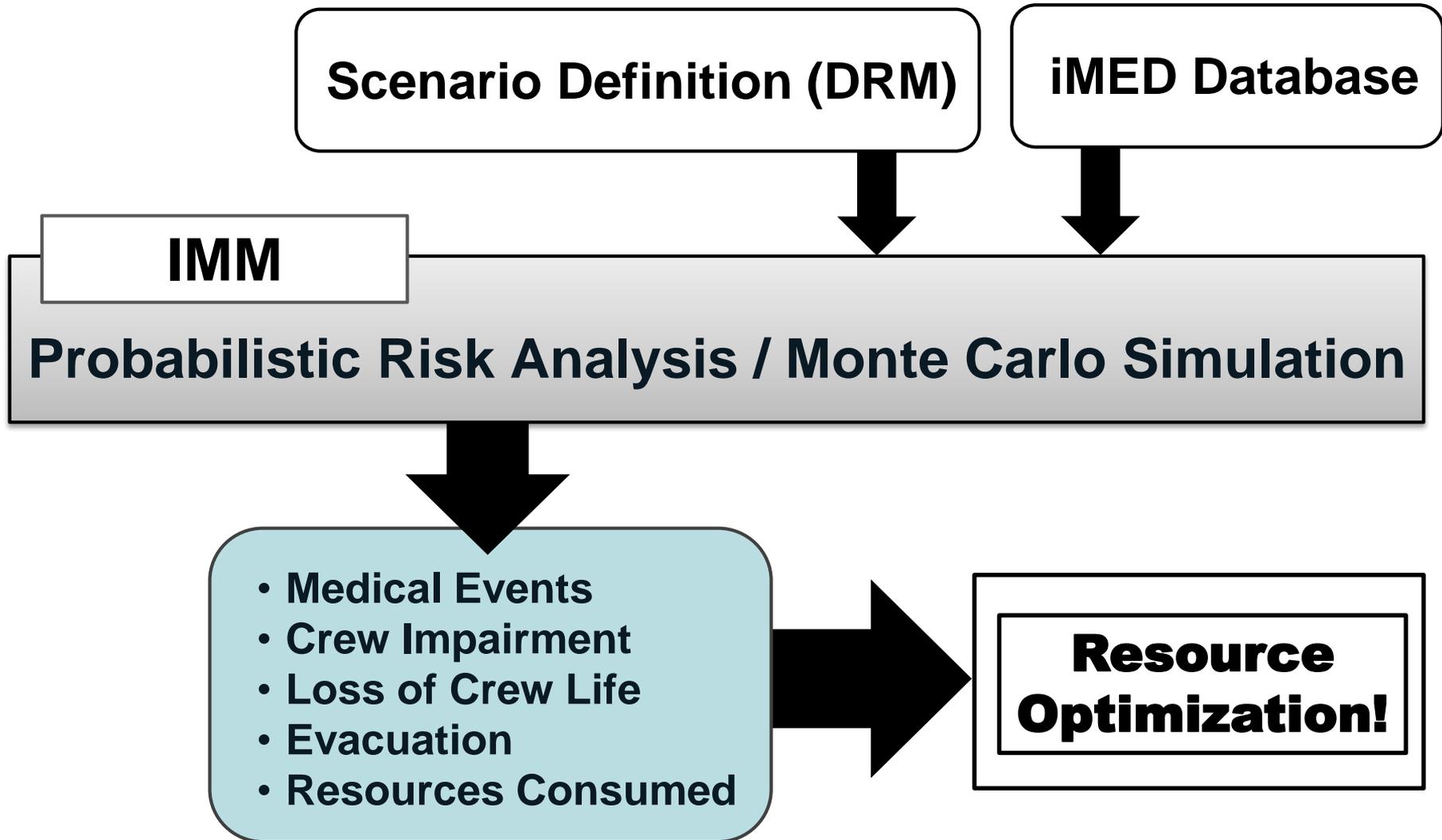
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Back up Slides



- **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...”

IMM Project VV&C History



Methods: Crew Characteristics



Table 2: Crew Characteristics

	Sex	CAC	EVA*	Crowns	Contacts	Abdominal Surgery History
Crew 1	M	Yes	No	Yes	No	No
Crew 2	M	No	Yes	No	No	No
Crew 3	M	No	No	No	Yes	No
Crew 4	M	No	No	No	Yes	Yes
Crew 5	F	No	Yes	Yes	No	No
Crew 6	F	No	No	No	Yes	No

*EVA schedule described in Table 1

M- male(s); F- female(s); CAC- coronary artery calcium

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)**



- **7009 Technical Review**

- Evidence
- Processes
- Identify limitations

Credibility assessment of M&S results

Verification

Validation

Input
Pedigree

Results
Uncertainty

Results
Robustness

Use History

M&S
Management

People
Qualifications