The following document contains data and analyses developed by the NASA Human Research Program Integrated Medical Model (IMM) v3.0, which has undergone rigorous testing and review within the NASA medical community per NASA Procedural Requirement 7150.2 and NASA Standard 7009, but still requires review by the external space flight medical community. Outstanding elements for review include: assessing the applicability of the IMM v3.0 outcomes, the relevance of stated assumptions, and clearly defining limitations. Given this, it is strongly recommended that care be taken when using the results of the simulation and the output should be weighted appropriately for its level of credibility with respect to informing any decision making. If you have questions regarding remaining review activities, please contact the IMM team. The scheduled release of IMM V4.0 in FY2015 follows completion of a full internal review against NASA standards as well as the successful external review from the appropriate medical and modeling communities.

Executive Summary

The Integrated Medical Model (IMM) is a probabilistic risk assessment tool used to aid in the evaluation of in-flight crew health requirements as well as mission impacts due to medical events. The objective of this data package is to:

> Quantify the medical risk during an Extra Vehicular Activity (EVA) on an ISS mission. This quantification includes EVA-related conditions and conditions that might occur during a 6.5 hour window which starts at the beginning of the EVA.

The crew profile for this request consisted of one male and one female performing 3 EVAs apiece during a 6 month DRM. The EVAs were scheduled as early as possible in the mission (at 7, 10, and 13 days) in order to provide ample opportunity for EVAs to occur during the simulation. This resulted in 600,000 total possible EVAs. During the simulation, 59 EVAs could not be performed because the crewmember had already gone to medical evacuation (EVAC) or loss of crew life (LOCL). The events during a 6.5 hour EVA window were captured. During the simulation, 57 of the 4567 DCS events were worst case events, 2 of which resulted in EVAC. There were 4 medical events other than DCS which resulted in EVAC during the 6.5 hour EVA window. There were NO medical events which resulted in LOCL.

Background

The IMM is a stochastic model that uses Monte Carlo methodology to simulate medical outcomes during spaceflight missions. The IMM consists of a three-step process. First, mission and crew member characteristics are specified to define a particular mission profile, or design reference mission (DRM). Next, medical events and outcomes during the space flight mission are randomly generated based on pre-defined incidence values and probability distributions. Finally, total crew health and mission impact outcomes are summarized. For this report, the primary outcomes of interest are crew health index (CHI), need for evacuation (EVAC) and loss of crew life (LOCL).

The IMM is most useful for comparing risks across multiple mission profiles based on probable events and resource availability. Biased results may be incurred due to limitations of the model, but the bias will be consistent across mission profiles within the same service request.

Methods

Crew and Mission Parameters

The 6 month DRM was configured using the crew profile shown in Table 1. The outcomes of certain IMM medical conditions are influenced by pre-existing medical history including: coronary artery calcium score (CAC), dental crowns, contact lenses, and history of prior abdominal surgery. Pre-existing conditions, as defined here, are consistent with historical U.S. crew data.

Given the abilities of the IMM during a simulation, it is possible to have the EVAs performed on specific days of the mission. During an IMM simulation, it is possible for a crewmember to be designated with an EVAC or LOCL end state before the end of the mission, and before performing a scheduled EVA. In an attempt to better quantify risk during an EVA, ample opportunity was provided for EVAs to occur during the mission. That is, EVAs were scheduled consecutively earlier in the mission. Two crewmembers, one male and one female, were scheduled to perform 3 EVAs apiece at 7, 10 and 13 days into the mission thereby, improving the chance that more EVAs would be performed, and thus supplying more data points to help quantify the risk.

Table 1: Crew 1 for DRM 1

	Sex	CAC	Crowns	Contacts	Prior Abdominal Surgery	EVA
Crew 1	Male	Yes	No	No	No	Yes (3)
Crew 2	Male	No	No	Yes	No	No
Crew 3	Male	Yes	No	No	No	No
Crew 4	Male	No	No	No	Yes	No
Crew 5	Male	No	No	No	No	No
Crew 6	Female	No	Yes	No	Yes	Yes (3)

Medical Conditions and Resources

The one hundred medical conditions currently included in the IMM are shown in Appendix A. The incidence of IMM medical events occurring during simulated missions are based on historical mission and cohort data contained within the iMED. For each condition the percentage of "best case" and "worst case" scenarios are specified, as well as a defined set of medical resources that are used to treat the condition. The iMED entry for each condition details the specific medical resources and quantity necessary for treatment in both the best and worst-case scenarios. In-flight medical treatment is assumed to follow a specified protocol [5] or clinical practice guidelines for each medical condition and is constrained by resource availability on the ISS (i.e. the ISS medical capabilities (MedCap)). Model outcomes can be given for the all-treated or fully-treated (continuous resupply, e.g. ISS in low earth orbit), all-untreated (no Medkit) and baseline MedCap (ISS Medkit without resupply). For longer duration missions, the MedCap state should most closely resemble a real world deep space mission where resupply is not possible but where utilization of partial and alternative treatment can occur. For this simulation, the fully treated state was used in order to more closely mirror a true ISS mission.

For this request, decompression sickness (DCS) secondary to EVA is of particular interest. When DCS occurs during a simulation, it is defined as best case or worst case. A **best case** DCS is defined as Type I DCS with mild to moderate joint pain that resolves spontaneously or with treatment. A **best case**, or Type I DCS would not lead to EVAC or LOCL and would probably not terminate an EVA. A

worst case DCS is defined as Type II DCS with severe joint pain and/or symptoms including central neurological, e.g. spotted vision, slurred speech, coordination difficulty, loss of sensation, headache, seizures, unconsciousness, and cardiopulmonary (chest pain, cough, shortness of breath). A **worst case,** or Type II DCS, could lead to EVAC or LOCL and could terminate an EVA.

The IMM does not model EVAs in isolation. They are modeled in the context of a mission. For this request, after the simulation finished, there was a variable called "Events" with all the events that occurred in each trial. For each trial, an IMM modeler filtered the "Events" variable to only include events that occurred during the 6.5 hour window. Once those items were all that remained in "Events," the MATLAB scripts that are used in the normal post-processing step were used to get counts for EVACs and LOCLs. To get the best case and worst case counts, "Events" was used along with MATLAB commands to get a count.

Main Outcomes

The IMM primary medical outcomes include: total medical events (TME), crew health index (CHI), probability of Evacuation (EVAC), probability of Loss of Crew Life (LOCL), and required resources.

CHI is a calculated percentage using the quality-adjusted mission time lost (QAMTL) due to in-flight medical events and resources available to treat those conditions [2].

CHI = (1- (QAMTL ÷ Mission Length)) x 100

For a given condition, QAMTL is determined by summing the product of functional impairment and duration for all three clinical phases of that condition: i) diagnosis and initial treatment, ii) ongoing treatment, and iii) end-state. CHI percent values range from 0-100, where zero represents complete crew impairment and one hundred represents a completely functional crew.

EVAC in the context of IMM means that medical evacuation from the ISS would be considered for definitive treatment of the afflicted crew member(s). EVAC is considered an end state result if any of the following criteria are met: 1) potential LOCL; 2) potential significant permanent impairment; or 3) potential intractable pain. When EVAC is calculated by the IMM, no consideration has been given to the availability of a return vehicle or the likelihood of a successful clinical outcome should a return vehicle be available.

LOCL in the context of IMM should be interpreted to mean that the clinical scenario resulted in death of

the affected crew member(s). In version 4.1 of the IMM, crew members are usually only assigned one end state of EVAC or LOCL. In rare instances a crewmember can get a condition that will go to EVAC or LOCL, and then develop another condition that will also go to EVAC or LOCL in the time between the onset of first condition and the EVAC or LOCL time. Both events are recorded as EVAC or LOCL outcomes. These assumptions should result in more accurate IMM forecasts for the occurrence of EVAC and LOCL as compared to the prior versions of the model.

Required resources for treatment are tracked for each simulated mission trial. The number of each resource that is used to treat a given condition is decremented from available resources. If more of any particular resource is used than is available, then that resource is considered “depleted” in the MedCap scenario. Events that require a “depleted” resource are considered “partially treated” if only a portion of the required resources are available. If there are sufficient available alternate resources in the MedCap, the event is considered "fully treated." If there are not enough resources available to treat the event, the event is considered "untreated." The initial quantities for medical resources are baselined to a fully stocked ISS medical kit (MedCap). Note that when an event is partially treated, its outcomes are based on a weighted average of the treated and untreated values. For example, if a condition has a 0% chance of going to EVAC in the best case treated scenario and a 0-100% chance of going to EVAC in the best case untreated scenario, then under best case partial treatment, it is possible the condition will go to EVAC.

Modeling Approach

Simulations were run for a 6 month mission. One hundred thousand (100,000) trials were run for each DRM where each trial can be considered an individual “mission”. This ensures that the distribution of outcomes meet convergence criteria. Convergence criteria are met when there is less than or equal to a 5% change in the average standard deviation of the CHI, EVAC, and LOCL primary model outcomes in the last 2 - 1,000 mission increments. This last step is performed manually by the modelers using the IMMV4ConvergenceReport.

IMM outcomes were determined for the DRMs using the fully treated scenario where all conditions are treated based on the available resources of the ISS MedCap with unlimited resupply. CHI is calculated as a percentage, with 95% confidence intervals (CIs) for the associated distributions. EVAC and LOCL are probabilities, with 95% CI for EVAC and LOCL obtained using bootstrap resampling of the simulation output [3]. In this report, TME, CHI, EVAC and LOCL results, as well as pertinent influential conditions, are described. IMM version 4.1 has certain features, assumptions and limitations that impact modeled outcomes. Features, assumptions and limitations pertinent to this report are described below.

Features, Assumptions and Limitations of IMM Version 4.1 [3]

1. All non-SA and non-extravehicular activity (EVA) related conditions have a uniform likelihood of occurring throughout the mission duration. Space Adaptation Syndrome conditions occur in the first 5 days of the mission, with a peak occurrence at 48 hours.
2. Individuals cannot get the same condition for which they are currently being treated (i.e. during Clinical Phase (CP) I and II).
3. EVAC and LOCL are generated for each medical event, and then the timing of the EVAC or LOCL is generated according to a specified distribution.
4. Individuals are no longer at risk for further conditions once their status changes to either EVAC or LOCL. From the start time of the EVAC or LOCL, the functional impairment of the crew member is assumed to be 100%.
5. When the status of a crew member changes to EVAC, only one crew member is evacuated.
6. The IMM assumes that, per crew member, the first condition requiring a specific therapy utilizes all resources required for treating that condition before a second condition has access to those resources.
7. Most medical conditions, with exceptions including acute radiation syndrome and EVA-linked conditions, occur independently of the occurrence of mission events and other medical conditions. Currently there is no correlation or association within or between crew members for most medical conditions.
8. The model assumes another crew member is available to act as caregiver but does not track the time impact of providing this care.
9. Medical procedures are accurately followed and successful; no mistakes occur in executing medical procedures.
10. Crew medical skill level and preflight/inflight training is not modeled.
11. All diagnoses are 100% accurate.
12. All pharmaceuticals maintain maximum efficacy.
13. All medical events receive the appropriate treatment.
14. All medical events respond to the treatment as expected terrestrially.
15. All medical equipment is 100% reliable.
16. For each of the medical conditions specified in iMED, all crew members with the same characteristics (sex, presence of CAC, crowns, contacts, history of abdominal surgery) have the same likelihood distribution of experiencing the condition.
17. All crew members are assumed to have all intrinsic body parts intact (i.e. appendix, gall bladder, and uterus or prostate, etc.).
18. IMM assumes ISS power, potable water and oxygen resources are always available in unlimited supply.

19. No Russian medical capabilities aboard the ISS are available to US crew members in this model.
20. Medical capabilities do not include the use of personal crew carry-on items contained in the Individual Medical Accessories Kit, (IMAK).
21. If a crew member is undergoing treatment for concurrent medical conditions requiring the same consumable resource, the crew member will only utilize resources at the level required by the condition that requires the most resources.
22. If the primary resource required for treating a medical condition is unavailable, one or more alternative resources are considered, if appropriate. One example might be using acetaminophen in place of ibuprofen.
23. Total quantities of a consumable medical resource requiring a daily dose will be adjusted if a dosage schedule runs past the end of the mission.
24. If a solar particle event causes acute radiation sickness in one or more crew members, IMM assumes the condition begins identically in all affected crew members at the beginning of the solar particle event.
25. The IMM does not decrement non-consumable items and allows all non-consumable items to be used simultaneously by multiple astronauts (e.g. blood pressure cuff).

Results

The results presented below, specifically retrieved for analysis, only pertain to events for the two crewmembers performing the EVAs and only within a 6.5 hour window starting at the beginning of each of the three scheduled EVAs. A condition summary list for the influential conditions from the fully treated timeline is presented in Table 2. The condition summary shows a breakdown by case for the total number of events for the conditions listed in the influential conditions. The influential conditions for EVAC are listed in Table 3. Note, there were NO conditions that resulted in LOCL during the simulation. The full condition summary list of conditions that occurred during the EVAs is presented in Table 4.

When the simulation events are analyzed to obtain event frequency, only valid events are included in the analysis. During a simulation, the event occurrence time is generated for all events, best case or worst case is determined, then the events are processed to determine treatment and outcomes as well as invalid events. One way events become invalid is if they would have occurred after a crewmember goes to EVAC or LOCL. Another way events are invalidated is if the same condition is scheduled to occur during the first 2 clinical phases (diagnosis and treatment) of the event. Note that overlapping EVA conditions (with the exception of DCS) are not invalidated. Because of this invalidation step, there were a small number of EVAs that could not be performed during the simulation because the crewmembers went to EVAC or LOCL before one or more EVAs could be performed. During the 100,000 trials, two crewmembers were scheduled to perform 3 EVAs each for a total of 600,000 total EVAs. Of these 600,000 EVAs, 59 EVAs were invalidated because the crewmember had been scheduled for EVAC or LOCL. During these 59 EVAs, 26 DCS events, all best case, were scheduled to occur.

There were a total of 57 episodes of worst case DCS during the EVAs. It was assumed that all worst case DCS events (Type 2 DCS) would require EVA termination and that no best case DCS events (Type

1 DCS) would require EVA termination.

There were 5 medical events other than DCS which resulted EVAC during the 6.5 hour EVA window. Two of these medical events were worst case Smoke Inhalation. The other 3 medical events were one each of worst case Urinary Tract Infection, worst case Eye Chemical Burn, and best case Angina/Myocardial Infarction. It was assumed that all medical events occurring during EVA that resulted in EVAC (with the exception of Smoke Inhalation) would require EVA termination. Note that worst case UTI leading to EVAC is considered equivalent to a severe UTI terrestrially that would require inpatient hospitalization. While unlikely, it is possible that due to underreporting/possible erroneous self-diagnosis crew could begin an EVA with a UTI that progressively worsens over the hours during pre-breathe and EVA. Also note that all incidences of inflight Eye Chemical Burn recorded in the iMED were historically a result of exposure to a certain EVA mask surfactant (anti-fog agent) that is no longer used. Smoke Inhalation, as defined for the IMM, only occurs secondary to fire on the ISS vehicle and not in the EMU suit. Smoke Inhalation could, therefore, be excluded from the conditions under consideration for termination of an EVA.

Table 2: Fully Treated EVAC Influential Conditions for crewmembers performing EVAs

Scenario	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
WORST CASE	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	2	28.57	28.57
WORST CASE	SMOKE INHALATION	ENVIRONMENTAL	2	28.57	57.14
WORST CASE	URINARY TRACT INFECTION	MEDICAL	1	14.29	71.43
WORST CASE	EYE CHEMICAL BURN	ENVIRONMENTAL	1	14.29	85.71
BEST CASE	ANGINA/MYOCARDIAL INFARCTION	MEDICAL	1	14.29	100.00

Table 3: Condition summary breakdown (number of events that occurred) by case for EVAC influential conditions

Medical Condition	Scenario	Total Events	Minimum	Maximum
ANGINA/MYOCARDIAL INFARCTION	Best Case	1	0	1
ANGINA/MYOCARDIAL INFARCTION	Worst Case	0	0	0
DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	Best Case	4510	0	2
DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	Worst Case	57	0	1

EYE CHEMICAL BURN	Best Case	86	0	1
EYE CHEMICAL BURN	Worst Case	10	0	1
SMOKE INHALATION	Best Case	8	0	1
SMOKE INHALATION	Worst Case	5	0	1
URINARY TRACT INFECTION	Best Case	316	0	1
URINARY TRACT INFECTION	Worst Case	15	0	1

Table 2: Full condition summary list of all conditions that occurred during the EVAs

Medical Condition	Scenario	Events	Minimum	Maximum
ABNORMAL UTERINE BLEEDING	Best Case	6	0	1
ABNORMAL UTERINE BLEEDING	Worst Case	0	0	0
ACUTE ANGLE-CLOSURE GLAUCOMA	Best Case	1	0	1
ACUTE ANGLE-CLOSURE GLAUCOMA	Worst Case	0	0	0
ACUTE ARTHRITIS	Best Case	3	0	1
ACUTE ARTHRITIS	Worst Case	0	0	0
ACUTE DIVERTICULITIS	Best Case	1	0	1
ACUTE DIVERTICULITIS	Worst Case	0	0	0
ACUTE PANCREATITIS	Best Case	1	0	1
ACUTE PANCREATITIS	Worst Case	0	0	0
ACUTE RADIATION SYNDROME	Best Case	1	0	1
ACUTE RADIATION SYNDROME	Worst Case	0	0	0
ACUTE SINUSITIS	Best Case	94	0	1
ACUTE SINUSITIS	Worst Case	11	0	1
ALLERGIC REACTION (MILD TO MODERATE)	Best Case	180	0	2
ALLERGIC REACTION (MILD TO MODERATE)	Worst Case	6	0	1
ANGINA/MYOCARDIAL INFARCTION	Best Case	1	0	1
ANGINA/MYOCARDIAL INFARCTION	Worst Case	0	0	0
ANKLE SPRAIN/STRAIN	Best Case	167	0	1
ANKLE SPRAIN/STRAIN	Worst Case	3	0	1
BACK SPRAIN/STRAIN	Best Case	493	0	2
BACK SPRAIN/STRAIN	Worst Case	12	0	1
BAROTRAUMA (EAR/SINUS BLOCK)	Best Case	483	0	2
BAROTRAUMA (EAR/SINUS BLOCK)	Worst Case	3	0	1
BURNS SECONDARY TO FIRE	Best Case	3	0	1
BURNS SECONDARY TO FIRE	Worst Case	0	0	0
CHOKING/OBSTRUCTED AIRWAY	Best Case	40	0	1
CHOKING/OBSTRUCTED AIRWAY	Worst Case	1	0	1
CONSTIPATION (SPACE ADAPTATION)	Best Case	2	0	1
CONSTIPATION (SPACE ADAPTATION)	Worst Case	0	0	0
DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	Best Case	4510	0	2
DECOMPRESSION SICKNESS SECONDARY TO	Worst Case	57	0	1

EXTRAVEHICULAR ACTIVITY				
DENTAL ABSCESS	Best Case	7	0	1
DENTAL ABSCESS	Worst Case	0	0	0
DENTAL AVULSION (TOOTH LOSS)	Best Case	1	0	1
DENTAL AVULSION (TOOTH LOSS)	Worst Case	1	0	1
DENTAL CARIES	Best Case	4	0	1
DENTAL CARIES	Worst Case	4	0	1
DENTAL CROWN LOSS	Best Case	2	0	1
DENTAL CROWN LOSS	Worst Case	1	0	1
DENTAL EXPOSED PULP	Best Case	8	0	1
DENTAL EXPOSED PULP	Worst Case	2	0	1
DEPRESSION	Best Case	2	0	1
DEPRESSION	Worst Case	0	0	0
DIARRHEA	Best Case	560	0	2
DIARRHEA	Worst Case	7	0	1
ELBOW SPRAIN/STRAIN	Best Case	174	0	1
ELBOW SPRAIN/STRAIN	Worst Case	6	0	1
EYE CHEMICAL BURN	Best Case	86	0	1
EYE CHEMICAL BURN	Worst Case	10	0	1
EYE INFECTION	Best Case	75	0	1
EYE INFECTION	Worst Case	6	0	1
EYE IRRITATION/ABRASION	Best Case	1094	0	2
EYE IRRITATION/ABRASION	Worst Case	0	0	0
FINGER DISLOCATION	Best Case	13	0	1
FINGER DISLOCATION	Worst Case	0	0	0
FINGERNAIL DELAMINATION SECONDARY TO EXTRAVEHICULAR ACTIVITY	Best Case	38799	0	5
FINGERNAIL DELAMINATION SECONDARY TO EXTRAVEHICULAR ACTIVITY	Worst Case	2335	0	2
GASTROENTERITIS	Best Case	57	0	1
GASTROENTERITIS	Worst Case	5	0	1
HEADACHE (CO2 INDUCED)	Best Case	336	0	2
HEADACHE (CO2 INDUCED)	Worst Case	12	0	1
HEADACHE (LATE)	Best Case	778	0	2
HEADACHE (LATE)	Worst Case	8	0	1
HEADACHE (SPACE ADAPTATION)	Best Case	105	0	1
HEADACHE (SPACE ADAPTATION)	Worst Case	4	0	1
HEARING LOSS	Best Case	36	0	1
HEARING LOSS	Worst Case	30	0	1
HEMORRHOIDS	Best Case	37	0	1
HEMORRHOIDS	Worst Case	0	0	0
HERPES ZOSTER REACTIVATION (SHINGLES)	Best Case	13	0	1
HERPES ZOSTER REACTIVATION (SHINGLES)	Worst Case	4	0	1
HIP SPRAIN/STRAIN	Best Case	55	0	1
HIP SPRAIN/STRAIN	Worst Case	1	0	1

HYPERTENSION	Best Case	4	0	1
HYPERTENSION	Worst Case	0	0	0
INDIGESTION	Best Case	92	0	1
INDIGESTION	Worst Case	10	0	1
INFLUENZA	Best Case	13	0	1
INFLUENZA	Worst Case	3	0	1
KNEE SPRAIN/STRAIN	Best Case	109	0	2
KNEE SPRAIN/STRAIN	Worst Case	1	0	1
LOWER EXTREMITY (LE) STRESS FRACTURE	Best Case	23	0	1
LOWER EXTREMITY (LE) STRESS FRACTURE	Worst Case	2	0	1
MEDICATION OVERDOSE/ADVERSE REACTION	Best Case	34	0	1
MEDICATION OVERDOSE/ADVERSE REACTION	Worst Case	0	0	0
MOUTH ULCER	Best Case	137	0	2
MOUTH ULCER	Worst Case	7	0	1
NECK SPRAIN/STRAIN	Best Case	153	0	1
NECK SPRAIN/STRAIN	Worst Case	4	0	1
NEPHROLITHIASIS	Best Case	1	0	1
NEPHROLITHIASIS	Worst Case	0	0	0
OTITIS EXTERNA	Best Case	60	0	1
OTITIS EXTERNA	Worst Case	0	0	0
OTITIS MEDIA	Best Case	45	0	1
OTITIS MEDIA	Worst Case	9	0	1
PARESTHESIAS SECONDARY TO EXTRAVEHICULAR ACTIVITY	Best Case	62913	0	5
PARESTHESIAS SECONDARY TO EXTRAVEHICULAR ACTIVITY	Worst Case	2005	0	2
PHARYNGITIS	Best Case	156	0	1
PHARYNGITIS	Worst Case	7	0	1
RESPIRATORY INFECTION	Best Case	523	0	2
RESPIRATORY INFECTION	Worst Case	7	0	1
SHOULDER SPRAIN/STRAIN	Best Case	385	0	2
SHOULDER SPRAIN/STRAIN	Worst Case	10	0	1
SKIN ABRASION	Best Case	1421	0	2
SKIN ABRASION	Worst Case	85	0	1
SKIN INFECTION	Best Case	176	0	1
SKIN INFECTION	Worst Case	7	0	1
SKIN LACERATION	Best Case	4	0	1
SKIN LACERATION	Worst Case	21	0	1
SKIN RASH	Best Case	1542	0	2
SKIN RASH	Worst Case	8	0	1
SLEEP DISORDER	Best Case	2140	0	3
SLEEP DISORDER	Worst Case	11	0	1
SMOKE INHALATION	Best Case	8	0	1
SMOKE INHALATION	Worst Case	5	0	1
URINARY INCONTINENCE (SPACE ADAPTATION)	Best Case	4	0	1

URINARY INCONTINENCE (SPACE ADAPTATION)	Worst Case	0	0	0
URINARY TRACT INFECTION	Best Case	316	0	1
URINARY TRACT INFECTION	Worst Case	15	0	1
VAGINAL YEAST INFECTION	Best Case	67	0	1
VAGINAL YEAST INFECTION	Worst Case	13	0	1
WRIST FRACTURE	Best Case	1	0	1
WRIST FRACTURE	Worst Case	0	0	0
WRIST SPRAIN/STRAIN	Best Case	82	0	1
WRIST SPRAIN/STRAIN	Worst Case	1	0	1

References

1. Integrated Medical Model Project. Integrated Medical Model Operations Plan. JSC-66114. 2011. Houston, TX, NASA, Johnson Space Center. *Ref Type: Report*

2. Integrated Medical Model Project. Integrated Medical Model Software Requirements Specification. IMM-SFTWR-008. 2017. Houston, Texas, KBRwyle Integrated Science, Technology and Engineering. *Ref Type: Report*

3. Integrated Medical Model Project. Integrated Medical Model version 4 Assumptions and Limitations. IMM-GEN-300. 2017. Houston, Texas, KBRwyle Integrated Science and Engineering Space Medicine Information Technology. *Ref Type: Report*

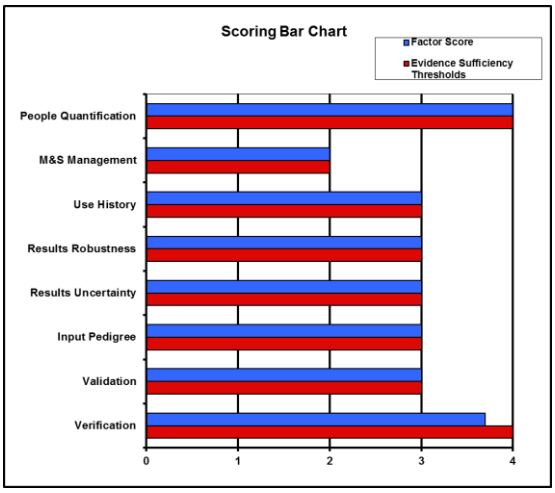
4. NASA-STD-7009: Standard for Models and Simulations (2008). NASA: Washington, DC.

5. ISS Medical Checklist (Med CL), 04 June 2014, NASA Johnson Space Center, Medical Operations Group.

Appendix A: IMM Status at Time of Service Request Report

Validation status for IMM

IMM V&V Matrix: The following bar chart shows the IMM v4.1 MATLAB status of IMM validation for each IMM element listed.



Compliance with NASA-Standard-7009 requirements

IMM Compliance Matrix: The IMM has no waivers to any of the requirements in the NASA-Standard-7009 for Models and Simulations (6); however there are certain requirements that are not applicable to the IMM and other requirements where IMM compliance has not yet been fully attained.

Compliant	Compliance Incomplete	Not applicable
36	5	5

Current NASA-Standard-7009 credibility assessment score

IMM Credibility Matrix: The following table shows the overall IMM v4.1 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.

Factor	Sufficiency Thresholds	Factor Score	Weighted Scores	Overall Score
Verification	**4**	**3.7**	0.28	
Validation	**3**	**3**	0.45	
Input Pedigree	**3**	**3**	0.53	
Results Uncertainty	**3**	**3**	0.60	**3.06**
Results Robustness	**3**	**3**	0.45	
Use History	**3**	**3**	0.45	
M&S Management	**2**	**2**	0.10	
People Qualification	**4**	**4**	0.20	

Legend from NASA-STD-7009	
	CAS Score > Threshold ***Exceeds credibility requirements***
	Threshold > CAS Score ≥ (Threshold-0.5) ***Ready for use***
	Threshold-0.5 > CAS Score ≥ Threshold-1.0 ***Use with caution***
	CAS Score < Threshold - 1.0 ***Use not recommended or to be used with EXTREME CAUTION by subject matter experts only***

Additional verification and validation information applicable to this analysis

none

Integrated Medical Evidence Database (iMED) code version and date accessed

iMED Lockdown ID: (26), created on (2/21/2017)

IMM version and code version

Data analysis for this report was generated using IMM v4.1 with release 2016a of MATLAB software. MATLAB and all other MathWorks product or service names are registered trademarks or trademarks of MathWorks, Natick, MA, USA.

Modifications made to the code for analysis

None

Appendix B: Medical Conditions in iMED by Category (iMED_20170221)

ENVIRONMENTAL
Acute Radiation Syndrome
Altitude Sickness
Barotrauma (ear/sinus block)
Burns secondary to Fire
Decompression Sickness Secondary to EVA
Eye Chemical Burn
Headache (CO_2 induced)
Smoke Inhalation
Toxic Exposure: Ammonia

INJURY/TRAUMA
Abdominal Injury
Acute Compartment Syndrome
Ankle Sprain/Strain
Back Sprain/Strain
Chest Injury
Dental: Avulsion (tooth loss)
Elbow Dislocation
Elbow Sprain/Strain
Eye Irritation/Abrasion
Eye Penetration (foreign body)
Finger Dislocation
Fingernail Delamination Secondary to EVA
Head Injury
Hip Sprain/Strain
Hip/Proximal Femur Fracture
Knee Sprain/Strain
Lower Extremity Stress Fracture
Lumbar Spine Fracture
Neck Sprain/Strain
Neurogenic Shock
Paresthesias Secondary to EVA
Shoulder Dislocation
Shoulder Sprain/Strain
Skin Abrasion
Skin Laceration
Traumatic Hypovolemic Shock
Wrist Fracture
Wrist Sprain/Strain

MEDICAL ILLNESS
Abdominal Wall Hernia
Abnormal Uterine Bleeding
Acute Angle-Closure Glaucoma
Acute Arthritis
Acute Cholecystitis/Biliary Colic
Acute Diverticulitis
Acute Pancreatitis
Acute Prostatitis
Acute Sinusitis
Allergic Reaction (mild to moderate)
Anaphylaxis
Angina/Myocardial Infarction

MEDICAL ILLNESS (continued)
Anxiety
Appendicitis
Atrial Fibrillation/Atrial Flutter
Back Pain (space adaptation)
Behavioral Emergency
Cardiogenic Shock Secondary to Myocardial infarction
Choking/Obstructed Airway
Constipation (space adaptation)
Dental: Exposed Pulp
Dental Caries
Dental: Abscess
Dental: Crown Loss
Dental: Filling Loss
Depression
Diarrhea
Eye Corneal Ulcer
Eye Infection
Gastroenteritis
Headache (Late)
Headache (space adaptation)
Hearing Loss
Hemorrhoids
Herpes Zoster Reactivation (shingles)
Hypertension
Indigestion
Influenza
Insomnia (space adaptation)
Medication Overdose/Adverse Reaction
Mouth Ulcer
Nasal Congestion (space adaptation)
Nephrolithiasis
Nose bleed (space adaptation)
Otitis Externa
Otitis Media
Pharyngitis
Respiratory Infection
Retinal Detachment
Seizures
Sepsis
Skin Infection
Skin Rash
Sleep Disorder
Small Bowel Obstruction
Space Motion Sickness (space adaptation)
Stroke (Cerebrovascular Accident)
Sudden Cardiac Arrest
Urinary Incontinence (space adaption)
Urinary Retention (space adaptation)
Urinary Tract Infection
Vaginal Yeast Infection
Visual Impairment and Increased Intracranial Pressure (VIIP) (space adaptation)