

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

This service request determined the CHI, probability of EVAC and probability of LOCL for a 16 month design reference mission (DRM) using a medical capability (MedCap) that is baselined to ISS. The CHI was determined to be 68.25% with a 95% CI of (37.54, 90.85). EVAC was determined to have a probability of 0.49 with a 95% CI of (0.48, 0.49). LOCL was determined to have a probability of 0.013 with a 95% CI of (0.012, 0.013). The top 10 influential conditions for EVAC and LOCL are reported in Tables 3 and 4 respectively. The probability of occurrence and frequency of occurrence are also included in Tables 5-7.

BACKGROUND

The Integrated Medical Model (IMM) simulates medical events during space flight missions and estimates the impact of these events on crew health. The IMM is a stochastic model that uses Monte Carlo methodology to simulate missions. The IMM consists of a three-step process:

1. Design Reference Mission (DRM) and crew member characteristics are specified
2. Medical events, treatment and outcomes for the DRM are randomly generated based on pre-defined probability distributions
3. The crew health index, evacuation and loss of crew life outcomes, and resource utilization outcomes are summarized in a post-processing procedure.

METHODS

Crew and Mission Parameters

The DRM, including mission length, crew compliment, and number of EVA events, was established by the requestor. Table 1 below shows the predefined crew profile information for this service request. A DRM duration of 16 months was specified, with 2 female and 2 male crewmembers.

The outcomes of certain IMM medical conditions are sex-specific and influenced by crew medical history. Pre-existing conditions that influence IMM outcomes include: coronary artery calcium score (CAC), dental crowns, contact lenses, and history of any prior abdominal

surgery. Pre-existing conditions, as defined here, are consistent with historical U.S. crew data. The number of extravehicular activity (EVA) excursions influences the probability of EVA-dependent medical conditions.

Table 1: Crew profile information for the 16 month DRM.

	Sex	CAC	Crowns	Contacts	Prior Abdominal Surgery	EVA
Crew 1	male	yes	yes	no	no	no
Crew 2	male	no	no	yes	yes	no
Crew 3	female	no	yes	no	no	no
Crew 4	female	no	no	yes	no	no

Medical Conditions and Resources

The incidence of IMM medical events occurring during simulated missions are based on historical mission and cohort data from the Integrated Medical Evidence Database (iMED). For each condition, the percentage of “best case” and “worst case” scenarios are also specified, as well as a defined set of medical resources that is required to treat the medical condition. All medical condition data inputs to the model are pulled from the iMED by an SQL query written in MATLAB scripts. 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)).

In the current version of IMM, medical conditions are not treated unless all essential medical resources are available. Resources are classified as essential or non-essential, and as consumable, or non-consumable. Consumable resources are decremented as required to treat medical events; if an item is essential, but has been depleted, then the given medical condition will go untreated.

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 [3].

$$\text{CHI} = (1 - (\text{QAMTL} \div \text{Mission Length})) \times 100$$

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 is 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 the current version of the IMM, it is possible for crew members to be assigned more than one endstate of EVAC and/or LOCL. These assumptions should result in slightly high (conservative) IMM forecasts for the occurrence of EVAC and LOCL. Determining LOCL is the main objective of this service request.

Required resources for treatment are tracked for each DRM. The number of each resource that is needed from the given available resource quantities to treat all medical events is recorded. If more of any particular resource is used than is available, then that is recorded as a “depleted” resource. The initial quantities for the available resources are baselined to the ISS environment with 6 month resupply.

Modeling Approach

A simulation for a Mars Transit DRM was run using IMM version three (v3). One hundred thousand (100,000) trials were run for the DRM, where each trial can be considered an individual “mission”. This ensures that the distribution of outcomes meets 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 two - 1,000 mission increments. This last step is performed manually by the modelers using the IMMv3ConvergenceReport.

IMM outcomes were determined for the DRM under the ISS MedCap scenario where all conditions are treated until the essential resources of the ISS MedCap are depleted. Total medical events (TME) and CHI are calculated as means, with 95% confidence intervals (CIs) for the associated distributions. EVAC and LOCL are probabilities, with 95% confidence intervals (CI) for EVAC and LOCL obtained using bootstrap resampling of the simulation output [3].

To provide the probabilities of occurrence, which are listed in Table 3, a MATLAB script which utilizes the incidence information in iMED and statistical theory was written.

RELEVANT IMM ASSUMPTIONS AND LIMITATIONS

1. The IMM is baselined to the ISS environment including medical capabilities.
2. All medical conditions are correctly diagnosed and all treatments are effective.
3. Conditions are treated in order of decreasing incidence and increasing crew member count (*i.e.* crew member one is treated before crew member two for any given condition) with Space Adaptation conditions treated first.
4. When there are insufficient *essential* medical resources to treat a condition, all available resources are consumed and the medical condition is considered untreated.
5. The IMM does not include a mission timeline. All conditions occur at launch on day one.
6. Medical conditions are independent of each other; i) a mission could end in more than one evacuation or loss of crew life being considered for the same crew member, and ii) additional medical conditions can occur in a crew member assigned an end state of EVAC or LOCL.
7. IMM source data in the iMED database undergo regular updates to ensure best alignment to the real world system; this may affect the inclusion or exclusion of certain resources from the optimized MedCap, which would also effect resulting mass and volume.
8. Mass and volume for MedCap does not consider packaging materials.

RESULTS AND Discussion

The specified DRM was assessed using the IMM as described above in the Methods section above. One hundred thousand trials were simulated for the DRM with ISS MedCap to forecast IMM primary outcomes and resources required to treat each condition. The ISS MedCap is baselined to the ISS environment with 6 month resupply. Results are reported in Table 2 with the numbers for fully treated as reference. The top 10 influential conditions for EVAC and LOCL are provided in Tables 3 and 4 respectively. The probabilities by case for each of the conditions is listed in Table 5. The frequency of occurrence for each condition is listed in Table 6 and by best and worst case scenarios in Table 7. Note the absence of Fingernail Delamination Secondary EVA, Decompression Sickness Secondary EVA, Paresthesias Secondary EVA not included because no EVAs performed.

Although it did not contribute to the top 10 influential conditions, during a review of the simulation results, it was observed that Otitis Media was contributing to LOCL when it went to the untreated worst case scenario. The untreated worst case LOCL is the result of this condition progressing into two other conditions. Otitis Media should have 0% LOCL. A change request (C2-20170309-384) has been entered to make the changes in iMED.

Table 2. Mars Transit IVA Outcomes.

	Percent or Probability* (mean)	95% CI	Odds (mean)
TME	166.23	(141, 192)	-----
MedCap CHI	68.25%	(37.54, 90.85)	-----
Treated CHI	89.05%	(71.12, 97.45)	-----
MedCap EVAC	0.49	(0.48, 0.49)	1 in 2
Treated EVAC	0.067	(0.065, 0.067)	1 in 14
MedCap LOCL	0.013	(0.012, 0.013)	1 in 77
Treated LOCL	0.0087	(0.0081, 0.0093)	1 in 115

* Probability of one or more events.

Table 3. Top 10 Influential Conditions for EVAC for the MedCap Scenario

Scenario	Treated	MedicalCondition	Total EVAC	Percent_Contribution	Cumulative_Percent
BEST CASE	UNTREATED	EYE CHEMICAL BURN	36055	49.25	49.25
WORST CASE	UNTREATED	EYE CHEMICAL BURN	6649	9.08	58.33
WORST CASE	UNTREATED	SKIN INFECTION	4614	6.30	64.64
BEST CASE	UNTREATED	FINGER DISLOCATION	2758	3.77	68.40
WORST CASE	UNTREATED	SKIN LACERATION	1912	2.61	71.02
WORST CASE	UNTREATED	LOWER EXTREMITY (LE) STRESS FRACTURE	1664	2.27	73.29
WORST CASE	UNTREATED	URINARY TRACT INFECTION	1436	1.96	75.25
WORST CASE	UNTREATED	HERPES ZOSTER REACTIVATION (SHINGLES)	1130	1.54	76.79
BEST CASE	UNTREATED	NEPHROLITHIASIS	1034	1.41	78.21
WORST CASE	UNTREATED	EYE INFECTION	1032	1.41	79.62

**EVAC numbers are for all 100,000 trials*

Table 4. Top 10 Influential Conditions for LOCL for the MedCap Scenario

Scenario	Treated	MedicalCondition	Total_LOCL	Percent_Contributio n	Cumulative_Percen t
WORST CASE	UNTREATED	SEPSIS	178	13.84	13.84
WORST CASE	TREATED	TRAUMATIC HYPOVOLEMIC SHOCK	120	9.33	23.17
WORST CASE	TREATED	SEPSIS	111	8.63	31.80
BEST CASE	UNTREATED	SEPSIS	106	8.24	40.05
WORST CASE	TREATED	MEDICATION OVERDOSE/ADVERSE REACTION	91	7.08	47.12
WORST CASE	TREATED	SMOKE INHALATION	71	5.52	52.64
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	69	5.37	58.01
BEST CASE	UNTREATED	APPENDICITIS	59	4.59	62.60
WORST CASE	TREATED	HEAD INJURY	59	4.59	67.19
WORST CASE	UNTREATED	ACUTE DIVERTICULITIS	50	3.89	71.07

**LOCL numbers are for all 100,000 trials*

Table 5. Probability of Events = 0 and Probability of Events ≥ 1 for a 16 month DRM.

Medical_Condition	Probability Zero	Probability ≥ 1	Probability ≥ 1 Best Case	Probability ≥ 1 Worst Case
ABDOMINAL INJURY	9.99E-01	8.76E-04	6.57E-04	2.19E-04
ABDOMINAL WALL HERNIA	9.98E-01	2.40E-03	2.11E-03	2.88E-04
ABNORMAL UTERINE BLEEDING	8.71E-01	1.29E-01	1.27E-01	2.59E-03
ACUTE ANGLE-CLOSURE GLAUCOMA	1.00E+00	2.23E-04	1.79E-04	4.47E-05
ACUTE ARTHRITIS	9.86E-01	1.40E-02	1.37E-02	3.50E-04
ACUTE CHOLECYSTITIS/BILIARY COLIC	9.95E-01	5.42E-03	4.88E-03	5.42E-04
ACUTE COMPARTMENT SYNDROME	1.00E+00	2.13E-04	8.11E-05	1.32E-04
ACUTE DIVERTICULITIS	9.92E-01	7.54E-03	5.62E-03	1.92E-03
ACUTE PANCREATITIS	9.98E-01	1.64E-03	1.35E-03	2.87E-04
ACUTE PROSTATITIS	9.87E-01	1.30E-02	1.21E-02	8.44E-04
ACUTE RADIATION SYNDROME	9.86E-01	1.39E-02	1.38E-02	6.95E-05
ACUTE SINUSITIS	3.10E-01	6.90E-01	6.34E-01	5.52E-02
ALLERGIC REACTION (MILD TO MODERATE)	1.17E-01	8.83E-01	8.48E-01	3.53E-02
ALTITUDE SICKNESS	1.00E+00	2.90E-04	2.85E-04	4.34E-06

ANAPHYLAXIS	9.97E-01	2.62E-03	2.60E-03	1.31E-05
ANGINA/MYOCARDIAL INFARCTION	9.97E-01	2.93E-03	2.49E-03	4.39E-04
ANKLE SPRAIN/STRAIN	1.09E-01	8.91E-01	8.73E-01	1.78E-02
ANXIETY	9.76E-01	2.37E-02	2.26E-02	1.07E-03
APPENDICITIS	9.95E-01	4.97E-03	4.10E-03	8.70E-04
ATRIAL FIBRILLATION/ ATRIAL FLUTTER	9.97E-01	2.52E-03	2.03E-03	4.91E-04
BACK PAIN (SPACE ADAPTATION)	5.10E-02	9.49E-01	9.35E-01	1.42E-02
BACK SPRAIN/STRAIN	1.93E-03	9.98E-01	9.78E-01	2.00E-02
BAROTRAUMA (EAR/SINUS BLOCK)	2.37E-03	9.98E-01	9.83E-01	1.50E-02
BEHAVIORAL EMERGENCY	1.00E+00	7.63E-05	6.83E-05	8.01E-06
BURNS SECONDARY TO FIRE	9.73E-01	2.65E-02	2.64E-02	1.33E-04
CARDIOGENIC SHOCK SECONDARY TO MYOCARDIAL INFARCTION	1.00E+00	3.41E-05	4.43E-06	2.96E-05
CHEST INJURY	9.99E-01	1.37E-03	4.78E-04	8.88E-04
CHOKING/OBSTRUCTED AIRWAY	5.57E-01	4.43E-01	4.41E-01	2.21E-03
CONSTIPATION (SPACE ADAPTATION)	4.74E-01	5.26E-01	5.23E-01	2.63E-03
DENTAL ABSCESS	9.57E-01	4.26E-02	3.36E-02	8.94E-03
DENTAL AVULSION (TOOTH LOSS)	9.85E-01	1.55E-02	1.19E-02	3.55E-03
DENTAL CARIES	9.51E-01	4.89E-02	3.08E-02	1.81E-02
DENTAL CROWN LOSS	9.86E-01	1.37E-02	1.15E-02	2.19E-03
DENTAL EXPOSED PULP	8.98E-01	1.02E-01	8.03E-02	2.13E-02
DENTAL FILLING LOSS	9.73E-01	2.69E-02	2.45E-02	2.42E-03
DEPRESSION	9.83E-01	1.72E-02	1.58E-02	1.37E-03
DIARRHEA	1.61E-03	9.98E-01	9.83E-01	1.50E-02
ELBOW DISLOCATION	1.00E+00	2.78E-04	2.42E-04	3.61E-05
ELBOW SPRAIN/STRAIN	8.90E-02	9.11E-01	8.93E-01	1.82E-02
EYE CHEMICAL BURN	3.10E-01	6.90E-01	6.38E-01	5.17E-02
EYE CORNEAL ULCER	9.96E-01	3.76E-03	3.73E-03	3.76E-05
EYE INFECTION	3.77E-01	6.23E-01	5.73E-01	4.98E-02
EYE IRRITATION/ABRASION	1.19E-06	1.00E+00	9.95E-01	5.00E-03
EYE PENETRATION (FOREIGN BODY)	1.00E+00	4.98E-05	2.49E-05	2.49E-05
FINGER DISLOCATION	8.23E-01	1.77E-01	1.76E-01	8.86E-04
GASTROENTERITIS	4.59E-01	5.41E-01	4.98E-01	4.33E-02
HEAD INJURY	9.98E-01	2.25E-03	1.01E-03	1.24E-03
HEADACHE (CO2 INDUCED)	2.03E-02	9.80E-01	9.55E-01	2.45E-02
HEADACHE (LATE)	7.11E-05	1.00E+00	9.90E-01	1.00E-02

HEADACHE (SPACE ADAPTATION)	1.78E-01	8.22E-01	7.73E-01	4.93E-02
HEARING LOSS	3.50E-01	6.50E-01	4.06E-01	2.44E-01
HEMORRHOIDS	6.77E-01	3.23E-01	3.21E-01	1.61E-03
HERPES ZOSTER REACTIVATION (SHINGLES)	8.23E-01	1.77E-01	1.52E-01	2.48E-02
HIP SPRAIN/STRAIN	4.46E-01	5.54E-01	5.43E-01	1.11E-02
HIP/PROXIMAL FEMUR FRACTURE	9.99E-01	1.41E-03	9.19E-05	1.32E-03
HYPERTENSION	9.66E-01	3.39E-02	3.00E-02	3.89E-03
INDIGESTION	3.10E-01	6.90E-01	6.41E-01	4.83E-02
INFLUENZA	8.23E-01	1.77E-01	1.33E-01	4.43E-02
INSOMNIA (SPACE ADAPTATION)	9.13E-02	9.09E-01	9.04E-01	4.54E-03
KNEE SPRAIN/STRAIN	2.44E-01	7.56E-01	7.41E-01	1.51E-02
LOWER EXTREMITY (LE) STRESS FRACTURE	7.48E-01	2.52E-01	2.23E-01	2.90E-02
LUMBAR SPINE FRACTURE	9.99E-01	9.96E-04	8.32E-04	1.64E-04
MEDICATION OVERDOSE/ADVERSE REACTION	6.77E-01	3.23E-01	3.21E-01	1.61E-03
MOUTH ULCER	1.73E-01	8.27E-01	7.86E-01	4.13E-02
NASAL CONGESTION (SPACE ADAPTATION)	2.94E-02	9.71E-01	9.66E-01	4.85E-03
NECK SPRAIN/STRAIN	1.63E-01	8.37E-01	8.20E-01	1.67E-02
NEPHROLITHIASIS	9.79E-01	2.09E-02	1.26E-02	8.25E-03
NEUROGENIC SHOCK	1.00E+00	2.78E-05	1.39E-05	1.39E-05
NOSE BLEED (SPACE ADAPTATION)	9.64E-01	3.57E-02	3.44E-02	1.25E-03
OTITIS EXTERNA	5.57E-01	4.43E-01	4.36E-01	6.64E-03
OTITIS MEDIA	5.57E-01	4.43E-01	3.99E-01	4.43E-02
PHARYNGITIS	1.17E-01	8.83E-01	8.43E-01	3.97E-02
RESPIRATORY INFECTION	1.61E-03	9.98E-01	9.83E-01	1.50E-02
RETINAL DETACHMENT	1.00E+00	4.92E-04	2.07E-04	2.85E-04
SEIZURES	9.99E-01	1.44E-03	1.24E-03	2.01E-04
SEPSIS	9.87E-01	1.27E-02	8.45E-03	4.27E-03
SHOULDER DISLOCATION	1.00E+00	1.99E-04	6.95E-06	1.92E-04
SHOULDER SPRAIN/STRAIN	1.18E-02	9.88E-01	9.68E-01	1.98E-02
SKIN ABRASION	1.10E-08	1.00E+00	9.45E-01	5.50E-02
SKIN INFECTION	7.93E-02	9.21E-01	8.88E-01	3.22E-02
SKIN LACERATION	8.23E-01	1.77E-01	4.43E-02	1.33E-01
SKIN RASH	1.10E-08	1.00E+00	9.95E-01	5.00E-03
SLEEP DISORDER	5.50E-12	1.00E+00	9.95E-01	5.00E-03
SMALL BOWEL OBSTRUCTION	9.94E-01	6.38E-03	5.58E-03	7.97E-04
SMOKE INHALATION	9.08E-01	9.19E-02	7.91E-02	1.29E-02

SPACE MOTION SICKNESS (SPACE ADAPTATION)	5.29E-03	9.95E-01	8.46E-01	1.49E-01
STROKE (CEREBROVASCULAR ACCIDENT)	9.96E-01	4.42E-03	2.89E-03	1.52E-03
SUDDEN CARDIAC ARREST	1.00E+00	1.93E-04	3.58E-05	1.58E-04
TOXIC EXPOSURE (AMMONIA)	9.99E-01	8.74E-04	0.00E+00	8.74E-04
TRAUMATIC HYPOVOLEMIC SHOCK	9.97E-01	3.41E-03	2.03E-03	1.38E-03
URINARY INCONTINENCE (SPACE ADAPTATION)	8.92E-01	1.08E-01	9.88E-02	9.18E-03
URINARY RETENTION (SPACE ADAPTATION)	8.80E-01	1.20E-01	1.02E-01	1.81E-02
URINARY TRACT INFECTION	1.75E-02	9.82E-01	9.33E-01	4.91E-02
VAGINAL YEAST INFECTION	3.57E-01	6.43E-01	5.47E-01	9.64E-02
VISUAL IMPAIRMENT AND/OR INCREASED INTRACRANIAL PRESSURE (VIIP)(SPACE ADAPTATION)	1.89E-01	8.11E-01	7.55E-01	5.68E-02
WRIST FRACTURE	9.87E-01	1.25E-02	9.94E-03	2.56E-03
WRIST SPRAIN/STRAIN	3.65E-01	6.35E-01	6.26E-01	9.53E-03

Table 6. Frequency of Occurrence for each condition for a 16 month DRM.

MedicalCondition	Events	Mean trial	Minimum	Maximum	Standard Deviation
ABDOMINAL INJURY	93	0.00093	0	1	0.0305
ABDOMINAL WALL HERNIA	239	0.00239	0	1	0.0488
ABNORMAL UTERINE BLEEDING	13589	0.13589	0	4	0.3693
ACUTE ANGLE-CLOSURE GLAUCOMA	23	0.00023	0	1	0.0152
ACUTE ARTHRITIS	1433	0.01433	0	2	0.1196
ACUTE CHOLECYSTITIS/BILIARY COLIC	545	0.00545	0	2	0.0739
ACUTE COMPARTMENT SYNDROME	15	0.00015	0	1	0.0122
ACUTE DIVERTICULITIS	762	0.00762	0	2	0.0871
ACUTE PANCREATITIS	176	0.00176	0	1	0.0419
ACUTE PROSTATITIS	1297	0.01297	0	2	0.1137
ACUTE RADIATION SYNDROME	1516	0.01516	0	3	0.1325
ACUTE SINUSITIS	116898	1.16898	0	12	1.1100

ALLERGIC REACTION (MILD TO MODERATE)	214730	2.1473	0	11	1.5006
ALTITUDE SICKNESS	26	0.00026	0	1	0.0161
ANAPHYLAXIS	291	0.00291	0	1	0.0539
ANGINA/MYOCARDIAL INFARCTION	295	0.00295	0	2	0.0546
ANKLE SPRAIN/STRAIN	221971	2.21971	0	11	1.5303
ANXIETY	2476	0.02476	0	2	0.1572
APPENDICITIS	516	0.00516	0	2	0.0718
ATRIAL FIBRILLATION/ ATRIAL FLUTTER	218	0.00218	0	1	0.0466
BACK PAIN (SPACE ADAPTATION)	210167	2.10167	0	4	0.9978
BACK SPRAIN/STRAIN	623807	6.23807	0	20	2.5606
BAROTRAUMA (EAR/SINUS BLOCK)	603941	6.03941	0	20	2.5214
BEHAVIORAL EMERGENCY	5	0.00005	0	1	0.0071
BURNS SECONDARY TO FIRE	2657	0.02657	0	2	0.1627
CARDIOGENIC SHOCK SECONDARY TO MYOCARDIAL INFARCTION	2	0.00002	0	1	0.0045
CHEST INJURY	161	0.00161	0	1	0.0401
CHOKING/OBSTRUCTED AIRWAY	58459	0.58459	0	6	0.7805
CONSTIPATION (SPACE ADAPTATION)	68492	0.68492	0	4	0.7547
DENTAL ABSCESS	4324	0.04324	0	3	0.2084
DENTAL AVULSION (TOOTH LOSS)	1553	0.01553	0	2	0.1246
DENTAL CARIES	4947	0.04947	0	3	0.2229
DENTAL CROWN LOSS	1420	0.0142	0	2	0.1189
DENTAL EXPOSED PULP	10953	0.10953	0	4	0.3317
DENTAL FILLING LOSS	2719	0.02719	0	2	0.1655
DEPRESSION	1748	0.01748	0	2	0.1321
DIARRHEA	642624	6.42624	0	22	2.5929
ELBOW DISLOCATION	20	0.0002	0	1	0.0141
ELBOW SPRAIN/STRAIN	242345	2.42345	0	12	1.5950
EYE CHEMICAL BURN	117286	1.17286	0	9	1.1125
EYE CORNEAL ULCER	383	0.00383	0	2	0.0621
EYE INFECTION	97337	0.97337	0	8	1.0102
EYE IRRITATION/ABRASION	1366013	13.66013	1	32	3.7931
EYE PENETRATION (FOREIGN BODY)	10	0.0001	0	1	0.0100

FINGER DISLOCATION	19281	0.19281	0	5	0.4508
GASTROENTERITIS	78184	0.78184	0	7	0.9043
HEAD INJURY	237	0.00237	0	1	0.0486
HEADACHE (CO2 INDUCED)	390401	3.90401	0	16	2.0291
HEADACHE (LATE)	954490	9.5449	0	26	3.1581
HEADACHE (SPACE ADAPTATION)	140717	1.40717	0	4	0.9531
HEARING LOSS	105016	1.05016	0	8	1.0689
HEMORRHOIDS	38923	0.38923	0	6	0.6418
HERPES ZOSTER REACTIVATION (SHINGLES)	19279	0.19279	0	5	0.4518
HIP SPRAIN/STRAIN	80871	0.80871	0	9	0.9249
HIP/PROXIMAL FEMUR FRACTURE	146	0.00146	0	1	0.0382
HYPERTENSION	3387	0.03387	0	2	0.1842
INDIGESTION	116659	1.16659	0	10	1.1012
INFLUENZA	19422	0.19422	0	4	0.4509
INSOMNIA (SPACE ADAPTATION)	180659	1.80659	0	4	0.9948
KNEE SPRAIN/STRAIN	140861	1.40861	0	10	1.2169
LOWER EXTREMITY (LE) STRESS FRACTURE	28996	0.28996	0	5	0.5384
LUMBAR SPINE FRACTURE	110	0.0011	0	1	0.0331
MEDICATION OVERDOSE/ADVERSE REACTION	38822	0.38822	0	5	0.6374
MOUTH ULCER	175114	1.75114	0	10	1.3540
NASAL CONGESTION (SPACE ADAPTATION)	234032	2.34032	0	4	0.9814
NECK SPRAIN/STRAIN	182024	1.82024	0	11	1.3755
NEPHROLITHIASIS	2049	0.02049	0	2	0.1427
NEUROGENIC SHOCK	3	0.00003	0	1	0.0055
NOSE BLEED (SPACE ADAPTATION)	4330	0.0433	0	3	0.2079
OTITIS EXTERNA	58547	0.58547	0	7	0.7814
OTITIS MEDIA	58947	0.58947	0	6	0.7878
PHARYNGITIS	214820	2.1482	0	11	1.4994
RESPIRATORY INFECTION	644880	6.4488	0	20	2.5927
RETINAL DETACHMENT	50	0.0005	0	1	0.0224
SEIZURES	118	0.00118	0	1	0.0343
SEPSIS	1259	0.01259	0	2	0.1122

SHOULDER DISLOCATION	20	0.0002	0	1	0.0141
SHOULDER SPRAIN/STRAIN	443980	4.4398	0	16	2.1536
SKIN ABRASION	1830522	18.30522	3	43	4.3903
SKIN INFECTION	252994	2.52994	0	12	1.6314
SKIN LACERATION	19541	0.19541	0	5	0.4527
SKIN RASH	1833733	18.33733	3	38	4.3820
SLEEP DISORDER	2592548	25.92548	7	52	5.2200
SMALL BOWEL OBSTRUCTION	675	0.00675	0	2	0.0821
SMOKE INHALATION	9478	0.09478	0	3	0.3074
SPACE MOTION SICKNESS (SPACE ADAPTATION)	291194	2.91194	0	4	0.8923
STROKE (CEREBROVASCULAR ACCIDENT)	450	0.0045	0	1	0.0669
SUDDEN CARDIAC ARREST	16	0.00016	0	1	0.0126
TOXIC EXPOSURE (AMMONIA)	68	0.00068	0	1	0.0261
TRAUMATIC HYPOVOLEMIC SHOCK	367	0.00367	0	2	0.0606
URINARY INCONTINENCE (SPACE ADAPTATION)	12870	0.1287	0	2	0.3472
URINARY RETENTION (SPACE ADAPTATION)	14810	0.1481	0	3	0.3732
URINARY TRACT INFECTION	404848	4.04848	0	19	2.3070
VAGINAL YEAST INFECTION	103055	1.03055	0	7	1.0137
VISUAL IMPAIRMENT AND/OR INCREASED INTRACRANIAL PRESSURE (VIIP)(SPACE ADAPTATION)	139320	1.3932	0	4	0.9519
WRIST FRACTURE	1196	0.01196	0	3	0.1136
WRIST SPRAIN/STRAIN	100618	1.00618	0	9	1.0298

Table 7. Frequency of Occurrence for each condition by Case for a 16 month DRM.

MedicalCondition	Scenario	Events	Mean trial	Minimum	Maximum	Standard Deviation
ABDOMINAL INJURY	BEST	69	0.00069	0	1	0.0263
ABDOMINAL INJURY	WORST	24	0.00024	0	1	0.0155

ABDOMINAL WALL HERNIA	BEST	210	0.0021	0	1	0.0458
ABDOMINAL WALL HERNIA	WORST	29	0.00029	0	1	0.0170
ABNORMAL UTERINE BLEEDING	BEST	13329	0.13329	0	4	0.3658
ABNORMAL UTERINE BLEEDING	WORST	260	0.0026	0	1	0.0509
ACUTE ANGLE-CLOSURE GLAUCOMA	BEST	17	0.00017	0	1	0.0130
ACUTE ANGLE-CLOSURE GLAUCOMA	WORST	6	0.00006	0	1	0.0077
ACUTE ARTHRITIS	BEST	1396	0.01396	0	2	0.1181
ACUTE ARTHRITIS	WORST	37	0.00037	0	1	0.0192
ACUTE CHOLECYSTITIS/BILIARY COLIC	BEST	491	0.00491	0	2	0.0700
ACUTE CHOLECYSTITIS/BILIARY COLIC	WORST	54	0.00054	0	1	0.0232
ACUTE COMPARTMENT SYNDROME	BEST	6	0.00006	0	1	0.0077
ACUTE COMPARTMENT SYNDROME	WORST	9	0.00009	0	1	0.0095
ACUTE DIVERTICULITIS	BEST	570	0.0057	0	1	0.0753
ACUTE DIVERTICULITIS	WORST	192	0.00192	0	1	0.0438
ACUTE PANCREATITIS	BEST	148	0.00148	0	1	0.0384
ACUTE PANCREATITIS	WORST	28	0.00028	0	1	0.0167
ACUTE PROSTATITIS	BEST	1213	0.01213	0	2	0.1097
ACUTE PROSTATITIS	WORST	84	0.00084	0	1	0.0290
ACUTE RADIATION SYNDROME	BEST	1508	0.01508	0	3	0.1320
ACUTE RADIATION SYNDROME	WORST	8	0.00008	0	1	0.0089
ACUTE SINUSITIS	BEST	107719	1.07719	0	10	1.0647
ACUTE SINUSITIS	WORST	9179	0.09179	0	4	0.3042
ALLERGIC REACTION (MILD TO MODERATE)	BEST	206141	2.06141	0	11	1.4688
ALLERGIC REACTION (MILD TO MODERATE)	WORST	8589	0.08589	0	3	0.2938
ALTITUDE SICKNESS	BEST	25	0.00025	0	1	0.0158
ALTITUDE SICKNESS	WORST	1	0.00001	0	1	0.0032
ANAPHYLAXIS	BEST	291	0.00291	0	1	0.0539
ANAPHYLAXIS	WORST	0	0	0	0	0.0000
ANGINA/MYOCARDIAL INFARCTION	BEST	256	0.00256	0	2	0.0509

ANGINA/MYOCARDIAL INFARCTION	WORST	39	0.00039	0	1	0.0197
ANKLE SPRAIN/STRAIN	BEST	217593	2.17593	0	11	1.5145
ANKLE SPRAIN/STRAIN	WORST	4378	0.04378	0	2	0.2083
ANXIETY	BEST	2367	0.02367	0	2	0.1538
ANXIETY	WORST	109	0.00109	0	1	0.0330
APPENDICITIS	BEST	400	0.004	0	2	0.0633
APPENDICITIS	WORST	116	0.00116	0	1	0.0340
ATRIAL FIBRILLATION/ ATRIAL FLUTTER	BEST	173	0.00173	0	1	0.0416

ATRIAL FIBRILLATION/ ATRIAL FLUTTER	WORST	45	0.00045	0	1	0.0212
BACK PAIN (SPACE ADAPTATION)	BEST	206971	2.06971	0	4	0.9981
BACK PAIN (SPACE ADAPTATION)	WORST	3196	0.03196	0	3	0.1784
BACK SPRAIN/STRAIN	BEST	611231	6.11231	0	20	2.5328
BACK SPRAIN/STRAIN	WORST	12576	0.12576	0	4	0.3547
BAROTRAUMA (EAR/SINUS BLOCK)	BEST	594881	5.94881	0	20	2.5021
BAROTRAUMA (EAR/SINUS BLOCK)	WORST	9060	0.0906	0	3	0.3026
BEHAVIORAL EMERGENCY	BEST	3	0.00003	0	1	0.0055
BEHAVIORAL EMERGENCY	WORST	2	0.00002	0	1	0.0045
BURNS SECONDARY TO FIRE	BEST	2643	0.02643	0	2	0.1622
BURNS SECONDARY TO FIRE	WORST	14	0.00014	0	1	0.0118
CARDIOGENIC SHOCK SECONDARY TO MYOCARDIAL INFARCTION	BEST	0	0	0	0	0.0000
CARDIOGENIC SHOCK SECONDARY TO MYOCARDIAL INFARCTION	WORST	2	0.00002	0	1	0.0045
CHEST INJURY	BEST	61	0.00061	0	1	0.0247
CHEST INJURY	WORST	100	0.001	0	1	0.0316
CHOKING/OBSTRUCTED AIRWAY	BEST	58164	0.58164	0	6	0.7783
CHOKING/OBSTRUCTED AIRWAY	WORST	295	0.00295	0	2	0.0544
CONSTIPATION (SPACE ADAPTATION)	BEST	68170	0.6817	0	4	0.7531
CONSTIPATION (SPACE ADAPTATION)	WORST	322	0.00322	0	2	0.0568
DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	BEST	0	0	0	0	0.0000
DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	WORST	0	0	0	0	0.0000
DENTAL ABSCESS	BEST	3394	0.03394	0	3	0.1847
DENTAL ABSCESS	WORST	930	0.0093	0	2	0.0963

DENTAL AVULSION (TOOTH LOSS)	BEST	1174	0.01174	0	2	0.1083
DENTAL AVULSION (TOOTH LOSS)	WORST	379	0.00379	0	2	0.0616
DENTAL CARIES	BEST	3087	0.03087	0	2	0.1760
DENTAL CARIES	WORST	1860	0.0186	0	2	0.1366
DENTAL CROWN LOSS	BEST	1207	0.01207	0	2	0.1097
DENTAL CROWN LOSS	WORST	213	0.00213	0	2	0.0463
DENTAL EXPOSED PULP	BEST	8641	0.08641	0	3	0.2944
DENTAL EXPOSED PULP	WORST	2312	0.02312	0	2	0.1523
DENTAL FILLING LOSS	BEST	2488	0.02488	0	2	0.1578
DENTAL FILLING LOSS	WORST	231	0.00231	0	1	0.0480
DEPRESSION	BEST	1611	0.01611	0	2	0.1269
DEPRESSION	WORST	137	0.00137	0	1	0.0370
DIARRHEA	BEST	633231	6.33231	0	22	2.5740
DIARRHEA	WORST	9393	0.09393	0	3	0.3081
ELBOW DISLOCATION	BEST	17	0.00017	0	1	0.0130
ELBOW DISLOCATION	WORST	3	0.00003	0	1	0.0055
ELBOW SPRAIN/STRAIN	BEST	237512	2.37512	0	12	1.5774
ELBOW SPRAIN/STRAIN	WORST	4833	0.04833	0	3	0.2205
EYE CHEMICAL BURN	BEST	108608	1.08608	0	9	1.0678
EYE CHEMICAL BURN	WORST	8678	0.08678	0	4	0.2963
EYE CORNEAL ULCER	BEST	382	0.00382	0	2	0.0620
EYE CORNEAL ULCER	WORST	1	0.00001	0	1	0.0032
EYE INFECTION	BEST	89440	0.8944	0	8	0.9691
EYE INFECTION	WORST	7897	0.07897	0	3	0.2820
EYE IRRITATION/ABRASION	BEST	1359190	13.5919	1	32	3.7837
EYE IRRITATION/ABRASION	WORST	6823	0.06823	0	3	0.2617
EYE PENETRATION (FOREIGN BODY)	BEST	5	0.00005	0	1	0.0071
EYE PENETRATION (FOREIGN BODY)	WORST	5	0.00005	0	1	0.0071
FINGER DISLOCATION	BEST	19200	0.192	0	5	0.4499
FINGER DISLOCATION	WORST	81	0.00081	0	1	0.0284
FINGERNAIL DELAMINATION SECONDARY TO EXTRAVEHICULAR ACTIVITY	BEST	0	0	0	0	0.0000
FINGERNAIL DELAMINATION SECONDARY TO EXTRAVEHICULAR ACTIVITY	WORST	0	0	0	0	0.0000

GASTROENTERITIS	BEST	71938	0.71938	0	7	0.8673
GASTROENTERITIS	WORST	6246	0.06246	0	3	0.2502
HEAD INJURY	BEST	107	0.00107	0	1	0.0327
HEAD INJURY	WORST	130	0.0013	0	1	0.0360
HEADACHE (CO2 INDUCED)	BEST	380674	3.80674	0	15	2.0019
HEADACHE (CO2 INDUCED)	WORST	9727	0.09727	0	3	0.3130
HEADACHE (LATE)	BEST	944990	9.4499	0	26	3.1413
HEADACHE (LATE)	WORST	9500	0.095	0	3	0.3103
HEADACHE (SPACE ADAPTATION)	BEST	132246	1.32246	0	4	0.9393
HEADACHE (SPACE ADAPTATION)	WORST	8471	0.08471	0	3	0.2881
HEARING LOSS	BEST	65325	0.65325	0	7	0.8301
HEARING LOSS	WORST	39691	0.39691	0	5	0.6420
HEMORRHOIDS	BEST	38751	0.38751	0	5	0.6399
HEMORRHOIDS	WORST	172	0.00172	0	2	0.0417
HERPES ZOSTER REACTIVATION (SHINGLES)	BEST	16604	0.16604	0	5	0.4182
HERPES ZOSTER REACTIVATION (SHINGLES)	WORST	2675	0.02675	0	2	0.1642
HIP SPRAIN/STRAIN	BEST	79293	0.79293	0	9	0.9156
HIP SPRAIN/STRAIN	WORST	1578	0.01578	0	2	0.1253
HIP/PROXIMAL FEMUR FRACTURE	BEST	6	0.00006	0	1	0.0077
HIP/PROXIMAL FEMUR FRACTURE	WORST	140	0.0014	0	1	0.0374
HYPERTENSION	BEST	2960	0.0296	0	2	0.1723
HYPERTENSION	WORST	427	0.00427	0	2	0.0654
INDIGESTION	BEST	108366	1.08366	0	10	1.0591
INDIGESTION	WORST	8293	0.08293	0	3	0.2893
INFLUENZA	BEST	14611	0.14611	0	4	0.3901
INFLUENZA	WORST	4811	0.04811	0	3	0.2207
INSOMNIA (SPACE ADAPTATION)	BEST	179726	1.79726	0	4	0.9941
INSOMNIA (SPACE ADAPTATION)	WORST	933	0.00933	0	2	0.0962
KNEE SPRAIN/STRAIN	BEST	138074	1.38074	0	10	1.2038
KNEE SPRAIN/STRAIN	WORST	2787	0.02787	0	2	0.1674
LOWER EXTREMITY (LE) STRESS FRACTURE	BEST	25748	0.25748	0	5	0.5076
LOWER EXTREMITY (LE) STRESS FRACTURE	WORST	3248	0.03248	0	3	0.1807

LUMBAR SPINE FRACTURE	BEST	92	0.00092	0	1	0.0303
LUMBAR SPINE FRACTURE	WORST	18	0.00018	0	1	0.0134
MEDICATION OVERDOSE/ADVERSE REACTION	BEST	38640	0.3864	0	5	0.6358
MEDICATION OVERDOSE/ADVERSE REACTION	WORST	182	0.00182	0	2	0.0429
MOUTH ULCER	BEST	166459	1.66459	0	10	1.3211
MOUTH ULCER	WORST	8655	0.08655	0	3	0.2948
NASAL CONGESTION (SPACE ADAPTATION)	BEST	232836	2.32836	0	4	0.9826
NASAL CONGESTION (SPACE ADAPTATION)	WORST	1196	0.01196	0	2	0.1090
NECK SPRAIN/STRAIN	BEST	178463	1.78463	0	11	1.3619
NECK SPRAIN/STRAIN	WORST	3561	0.03561	0	2	0.1889
NEPHROLITHIASIS	BEST	1233	0.01233	0	2	0.1106
NEPHROLITHIASIS	WORST	816	0.00816	0	2	0.0901
NEUROGENIC SHOCK	BEST	1	0.00001	0	1	0.0032
NEUROGENIC SHOCK	WORST	2	0.00002	0	1	0.0045
NOSE BLEED (SPACE ADAPTATION)	BEST	4163	0.04163	0	2	0.2038
NOSE BLEED (SPACE ADAPTATION)	WORST	167	0.00167	0	1	0.0408
OTITIS EXTERNA	BEST	57663	0.57663	0	7	0.7757
OTITIS EXTERNA	WORST	884	0.00884	0	2	0.0942
OTITIS MEDIA	BEST	53039	0.53039	0	6	0.7455
OTITIS MEDIA	WORST	5908	0.05908	0	3	0.2448
PARESTHESIAS SECONDARY TO EXTRAVEHICULAR ACTIVITY	BEST	0	0	0	0	0.0000
PARESTHESIAS SECONDARY TO EXTRAVEHICULAR ACTIVITY	WORST	0	0	0	0	0.0000
PHARYNGITIS	BEST	204994	2.04994	0	11	1.4638
PHARYNGITIS	WORST	9826	0.09826	0	3	0.3162
RESPIRATORY INFECTION	BEST	635062	6.35062	0	20	2.5733
RESPIRATORY INFECTION	WORST	9818	0.09818	0	3	0.3134
RETINAL DETACHMENT	BEST	23	0.00023	0	1	0.0152
RETINAL DETACHMENT	WORST	27	0.00027	0	1	0.0164
SEIZURES	BEST	102	0.00102	0	1	0.0319

SEIZURES	WORST	16	0.00016	0	1	0.0126
SEPSIS	BEST	853	0.00853	0	2	0.0924
SEPSIS	WORST	406	0.00406	0	2	0.0637
SHOULDER DISLOCATION	BEST	0	0	0	0	0.0000
SHOULDER DISLOCATION	WORST	20	0.0002	0	1	0.0141
SHOULDER SPRAIN/STRAIN	BEST	435082	4.35082	0	16	2.1323
SHOULDER SPRAIN/STRAIN	WORST	8898	0.08898	0	3	0.2997
SKIN ABRASION	BEST	1730017	17.30017	3	39	4.2605
SKIN ABRASION	WORST	100505	1.00505	0	8	1.0024
SKIN INFECTION	BEST	243989	2.43989	0	12	1.6001
SKIN INFECTION	WORST	9005	0.09005	0	4	0.3007
SKIN LACERATION	BEST	5018	0.05018	0	4	0.2259
SKIN LACERATION	WORST	14523	0.14523	0	4	0.3890
SKIN RASH	BEST	1824704	18.24704	3	38	4.3689
SKIN RASH	WORST	9029	0.09029	0	3	0.3011
SLEEP DISORDER	BEST	2579476	25.79476	7	52	5.2069
SLEEP DISORDER	WORST	13072	0.13072	0	4	0.3623
SMALL BOWEL OBSTRUCTION	BEST	565	0.00565	0	2	0.0752
SMALL BOWEL OBSTRUCTION	WORST	110	0.0011	0	1	0.0331
SMOKE INHALATION	BEST	8192	0.08192	0	3	0.2862
SMOKE INHALATION	WORST	1286	0.01286	0	2	0.1133
SPACE MOTION SICKNESS (SPACE ADAPTATION)	BEST	247285	2.47285	0	4	0.9742
SPACE MOTION SICKNESS (SPACE ADAPTATION)	WORST	43909	0.43909	0	4	0.6259
STROKE (CEREBROVASCULAR ACCIDENT)	BEST	291	0.00291	0	1	0.0539
STROKE (CEREBROVASCULAR ACCIDENT)	WORST	159	0.00159	0	1	0.0398
SUDDEN CARDIAC ARREST	BEST	1	0.00001	0	1	0.0032
SUDDEN CARDIAC ARREST	WORST	15	0.00015	0	1	0.0122
TOXIC EXPOSURE (AMMONIA)	BEST	0	0	0	0	0.0000
TOXIC EXPOSURE (AMMONIA)	WORST	68	0.00068	0	1	0.0261

TRAUMATIC HYPOVOLEMIC SHOCK	BEST	217	0.00217	0	2	0.0467
TRAUMATIC HYPOVOLEMIC SHOCK	WORST	150	0.0015	0	1	0.0387
URINARY INCONTINENCE (SPACE ADAPTATION)	BEST	11793	0.11793	0	2	0.3332
URINARY INCONTINENCE (SPACE ADAPTATION)	WORST	1077	0.01077	0	2	0.1035
URINARY RETENTION (SPACE ADAPTATION)	BEST	12616	0.12616	0	3	0.3462
URINARY RETENTION (SPACE ADAPTATION)	WORST	2194	0.02194	0	2	0.1472
URINARY TRACT INFECTION	BEST	384651	3.84651	0	18	2.2368
URINARY TRACT INFECTION	WORST	20197	0.20197	0	4	0.4615
VAGINAL YEAST INFECTION	BEST	87560	0.8756	0	7	0.9350
VAGINAL YEAST INFECTION	WORST	15495	0.15495	0	4	0.3951
VISUAL IMPAIRMENT AND/OR INCREASED INTRACRANIAL PRESSURE (VIIP)(SPACE ADAPTATION)	BEST	129550	1.2955	0	4	0.9350
VISUAL IMPAIRMENT AND/OR INCREASED INTRACRANIAL PRESSURE (VIIP)(SPACE ADAPTATION)	WORST	9770	0.0977	0	3	0.3086
WRIST FRACTURE	BEST	959	0.00959	0	3	0.1010
WRIST FRACTURE	WORST	237	0.00237	0	1	0.0486
WRIST SPRAIN/STRAIN	BEST	99073	0.99073	0	9	1.0210
WRIST SPRAIN/STRAIN	WORST	1545	0.01545	0	2	0.1245

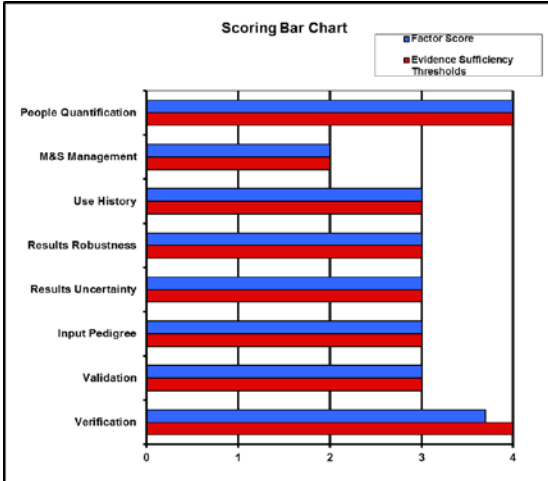
SUMMARY

This service request provides estimates of the TME, CHI, probability of EVAC and LOCL for a 16 month DRM using a MedCap that is baselined to the ISS. Medical conditions secondary to EVA were not included because EVAs were not included in the DRM. The TME is approximately 166, with a CHI of 68.25%. The probability of EVAC was determined to be 0.49 (1 in 2) and the probability of LOCL was determined to be 0.013 (1 in 77) for the 16 month DRM. The IMM is baselined to the ISS environment. Therefore, caution should be used when using the IMM to assess Mars transit medical risk.

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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 v3.0 MATLAB status of internal (black bars) and external (gray bars) IMM validation for each IMM element listed. Scoring Bar Chart <table border="1"><caption>Data for Scoring Bar Chart</caption><thead><tr><th>IMM Element</th><th>Factor Score</th><th>Evidence Sufficiency Threshold</th></tr></thead><tbody><tr><td>People Quantification</td><td>4.0</td><td>4.0</td></tr><tr><td>M&S Management</td><td>2.0</td><td>2.0</td></tr><tr><td>Use History</td><td>3.0</td><td>3.0</td></tr><tr><td>Results Robustness</td><td>3.0</td><td>3.0</td></tr><tr><td>Results Uncertainty</td><td>3.0</td><td>3.0</td></tr><tr><td>Input Pedigree</td><td>3.0</td><td>3.0</td></tr><tr><td>Validation</td><td>3.0</td><td>3.0</td></tr><tr><td>Verification</td><td>3.7</td><td>4.0</td></tr></tbody></table>	IMM Element	Factor Score	Evidence Sufficiency Threshold	People Quantification	4.0	4.0	M&S Management	2.0	2.0	Use History	3.0	3.0	Results Robustness	3.0	3.0	Results Uncertainty	3.0	3.0	Input Pedigree	3.0	3.0	Validation	3.0	3.0	Verification	3.7	4.0																															
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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. <table><tr><td>Compliant</td><td>Compliance Incomplete</td><td>Not applicable</td></tr><tr><td>27</td><td>20</td><td>2</td></tr></table>	Compliant	Compliance Incomplete	Not applicable	27	20	2																																																				
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Current NASA-Standard-7009 credibility assessment score	IMM Credibility Matrix: The following table shows the overall IMM v3.0 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. <table><tr><th>Factor</th><th>Sufficiency Thresholds</th><th>Factor Score</th><th>Weighted Scores</th><th>Overall Score</th></tr><tr><td>Verification</td><td>4</td><td>3.7</td><td>0.28</td><td></td></tr><tr><td>Validation</td><td>3</td><td>3</td><td>0.45</td><td></td></tr><tr><td>Input Pedigree</td><td>3</td><td>3</td><td>0.53</td><td></td></tr><tr><td>Results Uncertainty</td><td>3</td><td>3</td><td>0.60</td><td>3.06</td></tr><tr><td>Results Robustness</td><td>3</td><td>3</td><td>0.45</td><td></td></tr><tr><td>Use History</td><td>3</td><td>3</td><td>0.45</td><td></td></tr><tr><td>M&S Management</td><td>2</td><td>2</td><td>0.10</td><td></td></tr><tr><td>People Qualification</td><td>4</td><td>4</td><td>0.20</td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td></tr></table> Legend from NASA-STD-7009 <table><tr><td></td><td>CAS Score > Threshold Exceeds credibility requirements</td></tr><tr><td></td><td>Threshold ≥ CAS Score ≥ (Threshold-0.5) Ready for use</td></tr><tr><td></td><td>Threshold-0.5 > CAS Score ≥ Threshold-1.0 Use with caution</td></tr><tr><td></td><td>CAS Score < Threshold - 1.0 Use not recommended or to be used with EXTREME CAUTION by subject matter experts only</td></tr></table>	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								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
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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 v3.0 with release 2014a 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: LIST OF THE CURRENT 100 MEDICAL CONDITIONS USED IN THE IMM.

ENVIRONMENTAL	MEDICAL ILLNESS (continued)
Acute Radiation Syndrome	Anxiety
Altitude Sickness	Appendicitis
Barotrauma (ear/sinus block)	Atrial Fibrillation/Atrial Flutter
Burns secondary to Fire	Back Pain (space adaptation)
Decompression Sickness Secondary to EVA	Behavioral Emergency
Eye Chemical Burn	Cardiogenic Shock Secondary to Myocardial infarction
Headache (CO2 induced)	Choking/Obstructed Airway
Smoke Inhalation	Constipation (space adaptation)
Toxic Exposure: Ammonia	Dental: Exposed Pulp
INJURY/TRAUMA	Dental Caries
Abdominal Injury	Dental: Abscess
Acute Compartment Syndrome	Dental: Crown Loss
Ankle Sprain/Strain	Dental: Filling Loss
Back Sprain/Strain	Depression
Chest Injury	Diarrhea
Dental: Avulsion (tooth loss)	Eye Corneal Ulcer
Elbow Dislocation	Eye Infection
Elbow Sprain/Strain	Gastroenteritis
Eye Irritation/Abrasion	Headache (Late)
Eye Penetration (foreign body)	Headache (space adaptation)
Finger Dislocation	Hearing Loss
Fingernail Delamination Secondary to EVA	Hemorrhoids
Head Injury	Herpes Zoster Reactivation (shingles)
Hip Sprain/Strain	Hypertension
Hip/Proximal Femur Fracture	Indigestion
Knee Sprain/Strain	Influenza
Lower Extremity (LE) Stress Fracture	Insomnia (space adaptation)
Lumbar Spine Fracture	Medication Overdose/Adverse Reaction
Neck Sprain/Strain	Mouth Ulcer
Neurogenic Shock	Nasal Congestion (space adaptation)
Paresthesias Secondary to EVA	Nephrolithiasis
Shoulder Dislocation	Nose bleed (space adaptation)
Shoulder Sprain/Strain	Otitis Externa
Skin Abrasion	Otitis Media
Skin Laceration	Pharyngitis
Traumatic Hypovolemic Shock	Respiratory Infection
Wrist Fracture	Retinal Detachment
Wrist Sprain/Strain	Seizures
MEDICAL ILLNESS	Sepsis
Abdominal Wall Hernia	Skin Infection
Abnormal Uterine Bleeding	Skin Rash
Acute Angle-Closure Glaucoma	Sleep Disorder
Acute Arthritis	Small Bowel Obstruction
Acute Cholecystitis/Biliary Colic	Space Motion Sickness (space adaptation)
Acute Diverticulitis	Stroke (Cerebrovascular Accident)
Acute Pancreatitis	Sudden Cardiac Arrest
Acute Prostatitis	Urinary Incontinence (space adaption)
Acute Sinusitis	Urinary Retention (space adaptation)
Allergic Reaction (mild to moderate)	Urinary Tract Infection
Anaphylaxis	Vaginal Yeast Infection
Angina/Myocardial Infarction	Visual Impairment and Increased Intracranial Pressure (VIIP) (space adaptation)