

Executive Summary

The objective of this IMM support request is to provide an update the risk curves for the HSRB. The additional runs are requested to update the results from S-20200210-422. The additional runs reflect the Point of Departure (PoD) (860 days) the Alternate Short Stay (1030 days) and Basis of Comparison (BoC) (1224 days) Mars DRMs. The summary of the main simulation metrics are as follows:

- **Average number of Total of Medical Events (TME):**
 - Point of Departure – 860 days MedCap: 255.55 events
 - Alternate Short Stay – 1030 days MedCap: 300.28 events
 - Basis of Comparison – 1224 days MedCap: 413.44 events
 - Point of Departure – 860 days Fully Treated: 258 events
 - Alternate Short Stay – 1030 days Fully Treated: 304.60 events
 - Basis of Comparison – 1224 days Fully Treated: 430.24 events
 - Point of Departure – 860 days Fully Untreated: 200.59 events
 - Alternate Short Stay – 1030 days Fully Untreated: 225.95 events
 - Basis of Comparison – 1224 days Fully Untreated: 271.15 events
- **Average Crew Health Index (CHI):**
 - Point of Departure – 860 days MedCap: 81.19
 - Alternate Short Stay – 1030 days MedCap: 76.46
 - Basis of Comparison – 1224 days MedCap: 68.21
 - Point of Departure – 860 days Fully Treated: 88.42
 - Alternate Short Stay – 1030 days Fully Treated: 86.95
 - Basis of Comparison – 1224 days Fully Treated: 83.90
 - Point of Departure – 860 days Fully Untreated: 23.86
 - Alternate Short Stay – 1030 days Fully Untreated: 20.19
 - Basis of Comparison – 1224 days Fully Untreated: 17.04

- **Probability of consideration for Evacuation (EVAC):**
 - Point of Departure – 860 days MedCap: 0.2162
 - Alternate Short Stay – 1030 days MedCap: 0.2864
 - Basis of Comparison – 1224 days MedCap: 0.4941
 - Point of Departure – 860 days Fully Treated: 0.0879
 - Alternate Short Stay – 1030 days Fully Treated: 0.1030
 - Basis of Comparison – 1224 days Fully Treated: 0.1229
 - Point of Departure – 860 days Fully Untreated: 0.8921
 - Alternate Short Stay – 1030 days Fully Untreated: 0.9283
 - Basis of Comparison – 1224 days Fully Untreated: 0.9859

- **Probability of Loss of Crew Life (LOCL):**
 - Point of Departure – 860 days MedCap: 0.0117
 - Alternate Short Stay – 1030 days MedCap: 0.0136
 - Basis of Comparison – 1224 days MedCap: 0.0170
 - Point of Departure – 860 days Fully Treated: 0.0112
 - Alternate Short Stay – 1030 days Fully Treated: 0.0129
 - Basis of Comparison – 1224 days Fully Treated: 0.0159
 - Point of Departure – 860 days Fully Untreated: 0.0450
 - Alternate Short Stay – 1030 days Fully Untreated: 0.0502
 - Basis of Comparison – 1224 days Fully Untreated: 0.0581

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 average number of total medical events (TME), 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 DRMs were 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. Two crewmembers are scheduled to perform 15 EVAs in the PoD and AS DRM and all four crewmembers are scheduled to perform 94 EVAs in the BoC DRM.

Table 1: DRM crew profile

	Sex	Crowns	EVA	CAC	Contacts	Prior Abdominal Surgery
Crew 1	Male	Yes	BoC	No	No	No
Crew 2	Male	No	PoD, BoC, AS	Yes	No	No
Crew 3	Female	No	BoC	No	Yes	No
Crew 4	Female	No	PoD, BoC, AS	No	No	Yes

Medical Conditions and Resources

The one hundred medical conditions currently included in the IMM are shown in Appendix B. However, to better approximate long duration missions with EVAs and partial gravity environments, the set of conditions was modified for this request as described in Appendix C. The incidence of IMM medical events occurring during simulated missions are based on historical mission and cohort data contained within the Integrated Medical Evidence Database (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.

Model outcomes can be given for the all-treated (continuous resupply, e.g. ISS in low earth orbit), all-untreated (no Medkit) and baseline MedCap (one ISS Medkit without resupply). For exploration 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 as resources are depleted.

For this service request, the “MedCap” results for the DRMs correspond to one set of resources baselined to ISS according to current iMED data.

Main Outcomes

The IMM primary medical outcomes include the number of 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].

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

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 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, the simulation usually assigns each crew member only 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. Catastrophic vehicle failures such as the Challenger and Columbia accidents, and MMOD (micrometeorite and orbital debris) are not considered as possible causes of EVAC and LOCL.

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 (no resupply) scenario. The assumption in the MedCap scenario is that as the resources are utilized for the treatment of conditions during the simulation, the quantities of consumable decreases and cannot be replenished. Therefore, consumable resources may become depleted. 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 none of the resources are available to treat the event, the event is considered "untreated." The initial quantities for medical resources are baselined to one 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

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 IMM4ConvergenceReport.

IMM outcomes were determined for the DRMs using the ISS MedCap scenario where all conditions are treated, partially treated or untreated based on the available resources of the ISS MedCap without 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 are presented. Features, assumptions and limitations pertinent to this report are described in a separate section below.

The IMM is baselined to ISS and does not simulate EVAs in partial-gravity environments. For this service request, in accordance with the assumption that crewmembers would perform EVAs in partial gravity environments, the set of conditions listed in Appendix C were invalidated outside the requested EVA windows (i.e. could only occur during the EVAs). These EVA windows were 4.8 hours for the PoD (860 days) and AS (1030 days) DRMs and 4.84 hours for the BoC (1224 days) DRM to reflect the total number of EVA hours. These conditions are unlikely to occur during flight within the space vehicle due to normal ambient pressure and limited vehicle size consisting of a single module with limited movement of crew. However, these conditions could occur during EVAs in a partial-gravity environment with decreased ambient pressure. In this case, invalid means that an event cannot and did not occur. During the course of the simulation, an event might normally be considered invalid under items 2 and 3 listed below in “Features, Assumptions and Limitations of IMM Version 4.1.” That is, all events are considered valid when the occurrence is generated, but might become invalid as the simulation processed each event. To meet the assumption that the list of conditions in Appendix C could not occur outside the specified EVA windows, script that deems all the necessary events invalid immediately after event occurrence generation was written into the IMM MATLAB code. Once the necessary events were invalidated, the simulation continued as normal. To be clear, the script is not currently a feature of the IMM and was written specifically for this request. No other assumptions about deconditioned crew, etc are made in this modeling. All condition incidences and outcomes are consistent with iMED lockdown 68.

For the Point of Departure (860 days) DRM, the DRM will follow the schedule in the table below. Note, the total number of days is 860.

Point of Departure	Days
Initial Launch	90
Outbound	305
Mars loiter (Surface EVA)	50 (30)
Return	375
Staging after return	40
Total	860

During the Mars loiter segment, 2 crewmembers will perform 15 EVAs (1 each day) in a 30 day span starting on day 405 (10 days into the Mars loiter segment) and ending on day 429. The designated crewmembers are Crew 2 and Crew 4. The EVAs will be performed based on the schedule in the request form, and the total EVA hours will not exceed 144 hours.

For the Alternate Shorty Stay (1030 days) DRM, the DRM will follow the schedule in the table below.

Alternate Short Stay	Days
Initial Launch	90
Outbound	200
Mars loiter (Surface EVA)	500 (30)
Return	200
Staging after return	40
Total	1030

During the Mars loiter segment, 2 crewmembers will perform 15 EVAs (1 each day) in a 30 day span starting on day 303 (10 days into the Mars loiter segment) and ending on day 327. The designated crewmembers are Crew 2 and Crew 4. The EVAs will be performed based on the schedule in the request form, and the total EVA hours will not exceed 144 hours.

For the Basis of Comparison (1224 days) DRM, the DRM will follow the schedule in the table below.

Basis of Comparison	Days
Initial Launch	90
Outbound	429
Mars loiter (Surface EVA)	365 (300)
Return	300
Staging after return	40
Total	1224

During the Mars loiter segment, all 4 crewmembers will perform 94 EVAs in a 300 day span starting on day 549 and ending on day 846. The EVAs (one each day) will be evenly distributed throughout the 300

days, and the total EVA hours will not exceed 1821 hours.

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

1. All non-space adaption (SA) and non-extravehicular activity (EVA) related conditions have a uniform likelihood of occurring throughout the mission duration. With the exception of VIIP, 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 (triggered by Solar Particle Events) and EVA-linked conditions (triggered by EVA events), 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).

Additional Caveats

- The set of conditions listed in Appendix were only allowed to occur during a roughly 5-hour EVA window during the Surface EVA portion of the Mars Loiter mission segment, as opposed to the entire Mars surface stay. Due to limited vehicle size and limited movement of crew during flight, the following conditions are judged highly unlikely to occur. However, the risk of these conditions during an EVA, which is labor intensive, may increase. This 5-hour window was used to make sure the total EVA hours followed the requestor schedule and EVA total hour guidelines. Given this tradeoff between the underlying assumptions of the model and the DRMs, the results may underestimate the contribution of these conditions. The IMM does not have evidence for these conditions in a partial gravity environment such as the Lunar or Mars surface.
- The Point of Departure and Alternate Short Stay DRMs are prescribed by HEO as split crew, however IMM does not include mission segmentation model capability. These DRMs are modeled as end-to-end missions.

Results

The IMM MedCap results for TME, CHI, EVAC, and LOCL for the simulated DRMs are presented in the tables below. Table 2 and Figure 1 show the average number of total medical events (TME) during the mission across all the DRMs. Table 3 and Figure 2 show the average CHI across all the DRMs. Table 4 along with Figure 3 and Figure 4 show the probability of EVAC and LOCL across all of the DRMs. Additional statistics for TME, QTL, EVAC, and LOCL located in Appendix D.

Table 2: Average Number of TME for the DRMs

		Average TME	95% CI	
Point of Departure – 860 days	MedCap	255.55	206	292
Alternate Short Stay – 1030 days	MedCap	300.28	239	342
Basis of Comparison – 1224 days	MedCap	413.44	319	474
Point of Departure – 860 days	Fully Treated	258.00	212	293
Alternate Short Stay – 1030 days	Fully Treated	304.60	247	344
Basis of Comparison – 1224 days	Fully Treated	430.24	342	480
Point of Departure – 860 days	Fully Untreated	200.59	109	274
Alternate Short Stay – 1030 days	Fully Untreated	225.95	117	319
Basis of Comparison – 1224 days	Fully Untreated	271.15	123	415

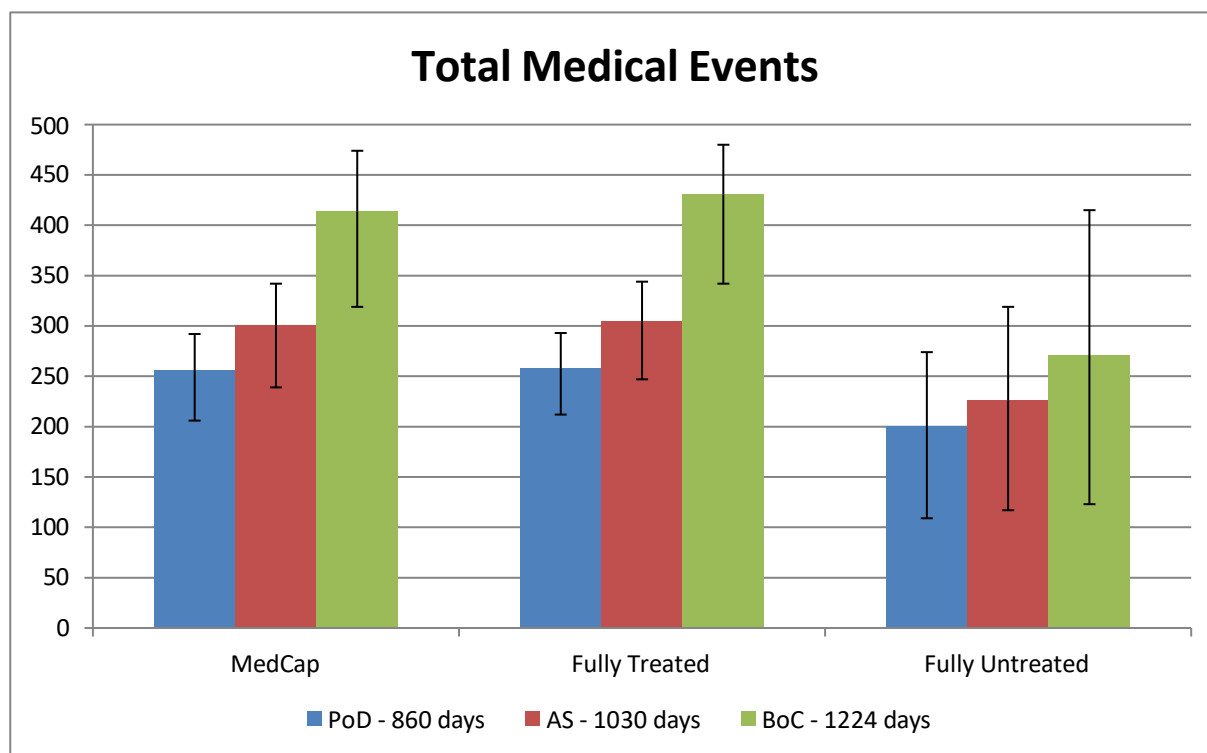


Figure 1: Average Number of TME for the DRMs

Table 3: Average CHI for the DRMs

		Average CHI	95% CI	
Point of Departure – 860 days	MedCap	81.19	63.97	91.19
Alternate Short Stay – 1030 days	MedCap	76.46	59.35	87.40
Basis of Comparison – 1224 days	MedCap	68.21	51.90	80.66
Point of Departure – 860 days	Fully Treated	88.42	71.10	96.47
Alternate Short Stay – 1030 days	Fully Treated	86.95	69.06	95.67
Basis of Comparison – 1224 days	Fully Treated	83.90	65.97	93.40
Point of Departure – 860 days	Fully Untreated	23.86	14.39	35.00
Alternate Short Stay – 1030 days	Fully Untreated	20.19	12.04	32.60
Basis of Comparison – 1224 days	Fully Untreated	17.04	10.07	31.20

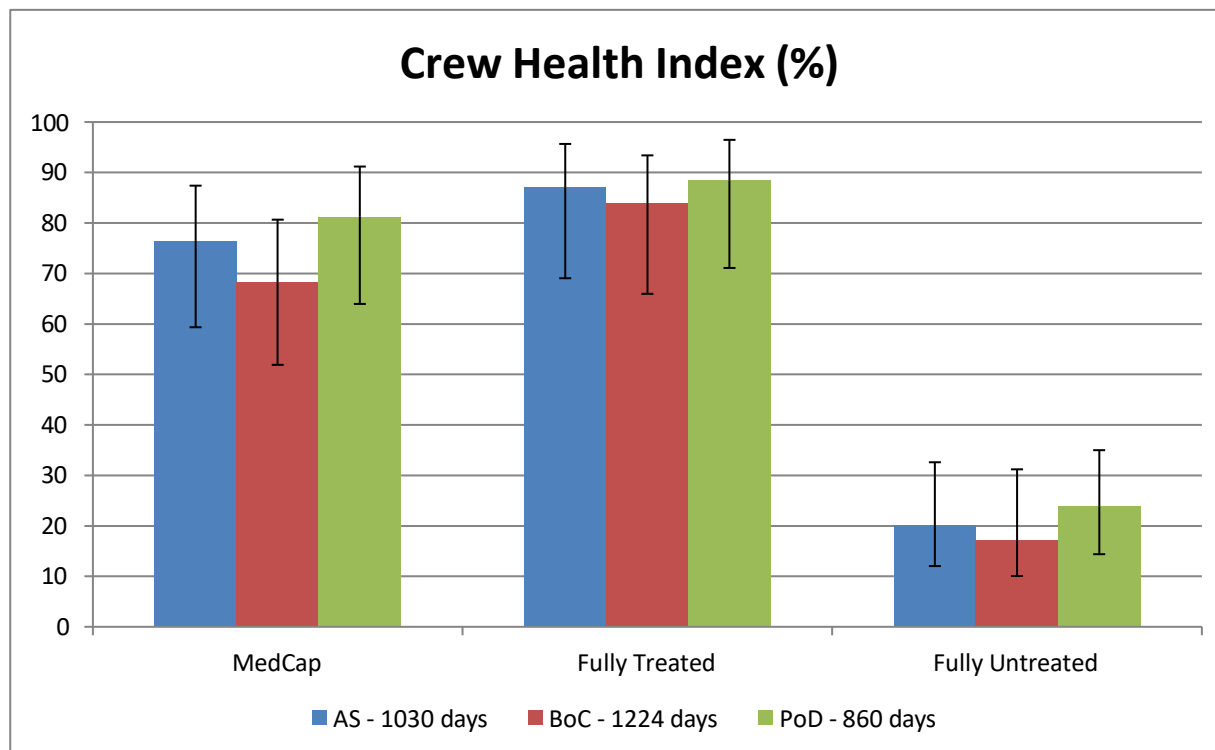


Figure 2: Average CHI for the DRMs

Table 4: Probability of EVAC and LOCL and standard deviation (SD) for the DRMs

		EVAC			LOCL		
		Probability	95% CI		Probability	95% CI	
Point of Departure – 860 days	MedCap	0.2162	0.2139	0.2186	0.0117	0.011021	0.0124
Alternate Short Stay – 1030 days	MedCap	0.2864	0.2836	0.2893	0.0136	0.0128	0.0143
Basis of Comparison – 1224 days	MedCap	0.4941	0.4907	0.4971	0.0170	0.01624	0.0179
Point of Departure – 860 days	Fully Treated	0.0879	0.0862	0.0896	0.0112	0.010548	0.0119
Alternate Short Stay – 1030 days	Fully Treated	0.1030	0.1012	0.1050	0.0129	0.0122	0.0136
Basis of Comparison – 1224 days	Fully Treated	0.1229	0.1209	0.1250	0.0159	0.0151	0.0167
Point of Departure – 860 days	Fully Untreated	0.8921	0.8901	0.8938	0.0450	0.0438	0.0463
Alternate Short Stay – 1030 days	Fully Untreated	0.9283	0.9268	0.9299	0.0502	0.0489	0.0515
Basis of Comparison – 1224 days	Fully Untreated	0.9859	0.9852	0.9866	0.0581	0.0566	0.0595

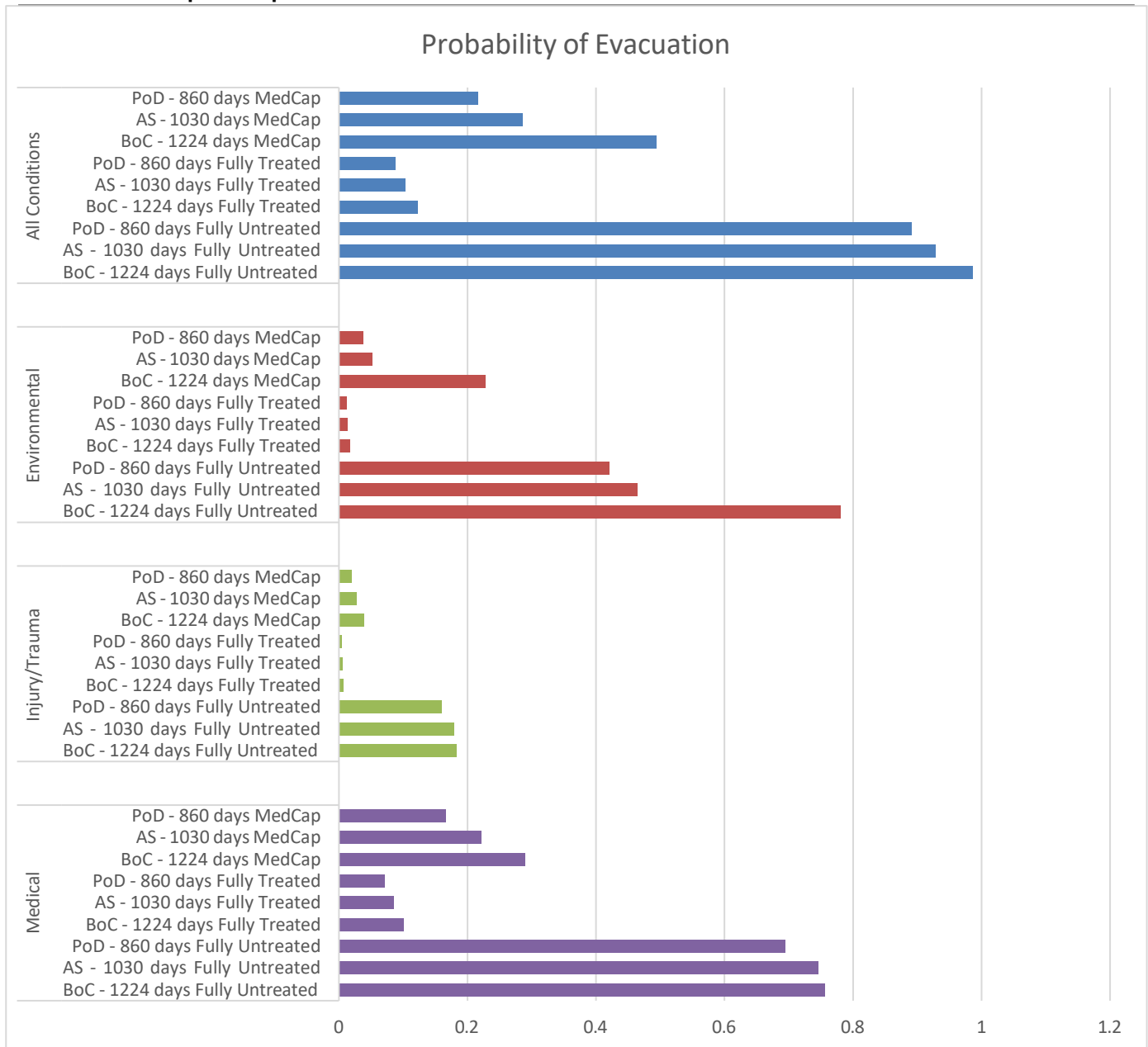


Figure 3: Probability of EVAC for the DRMs

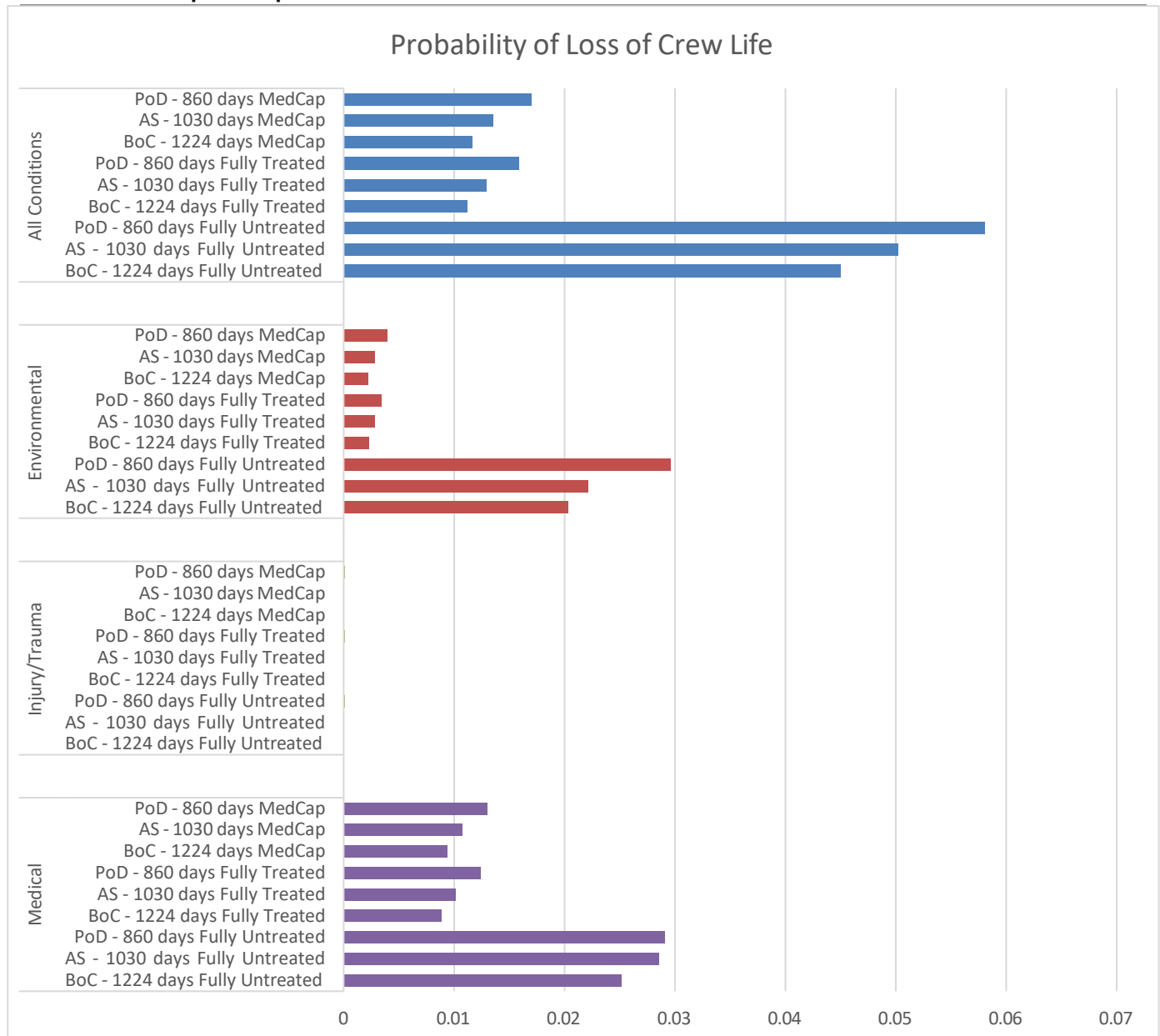


Figure 4: Probability of LOCL for the DRMs

The top ten influential conditions for the DRMs are organized according to the following list. Note, that for the BoC MedCap influential conditions list, Decompression Sickness (DCS) Secondary to EVA, #1 on the list, the number of EVACs contributed is an order of magnitude higher than the next condition on the list. Recall that for BoC, the number of EVAs is 94 beginning approximately 550 days into the mission compared to 15 EVAs approximately 400 days and 300 days into the mission for PoC and AS respectively.

- Point of Departure – 860 days
 - MedCap
 - EVAC – Table 5
 - LOCL – Table 8
 - Fully Treated
 - EVAC – Table 11
 - LOCL – Table 14
 - Fully Untreated
 - EVAC – Table 17
 - LOCL – Table 20
- Alternate Short Stay – 1030 days
 - MedCap
 - EVAC – Table 6
 - LOCL – Table 9
 - Fully Treated
 - EVAC – Table 12
 - LOCL – Table 15
 - Fully Untreated
 - EVAC – Table 18
 - LOCL – Table 21
- Basis of Comparison – 1224 days
 - MedCap
 - EVAC – Table 7
 - LOCL – Table 10
 - Fully Treated
 - EVAC – Table 13
 - LOCL – Table 16
 - Fully Untreated
 - EVAC – Table 19
 - LOCL – Table 22

Table 5: Point of Departure – 860 days MedCap; Top Ten Influential Conditions for EVAC

Scenario	Treated	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
WORST CASE	PARTIAL	HERPES ZOSTER REACTIVATION (SHINGLES)	MEDICAL	3362	14.19	14.19
WORST CASE	PARTIAL	URINARY TRACT INFECTION	MEDICAL	2413	10.18	24.37
BEST CASE	PARTIAL	EYE CHEMICAL BURN	ENVIRONMENTAL	1751	7.39	31.76
WORST CASE	PARTIAL	RESPIRATORY INFECTION	MEDICAL	1495	6.31	38.06
WORST CASE	PARTIAL	EYE INFECTION	MEDICAL	1338	5.65	43.71
WORST CASE	PARTIAL	NEPHROLITHIASIS	MEDICAL	869	3.67	47.38
BEST CASE	PARTIAL	EYE CORNEAL ULCER	MEDICAL	768	3.24	50.62
WORST CASE	PARTIAL	EYE CHEMICAL BURN	ENVIRONMENTAL	764	3.22	53.84
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	673	2.84	56.68
WORST CASE	TREATED	NEPHROLITHIASIS	MEDICAL	569	2.40	59.08

Table 6: Alternate Short Stay – 1030 days MedCap; Top Ten Influential Conditions for EVAC

Scenario	Treated	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
WORST CASE	PARTIAL	URINARY TRACT INFECTION	MEDICAL	4351	13.45	13.45
WORST CASE	PARTIAL	HERPES ZOSTER REACTIVATION (SHINGLES)	MEDICAL	4334	13.40	26.85
BEST CASE	PARTIAL	EYE CHEMICAL BURN	ENVIRONMENTAL	2701	8.35	35.20
WORST CASE	PARTIAL	EYE INFECTION	MEDICAL	1919	5.93	41.14
WORST CASE	PARTIAL	RESPIRATORY INFECTION	MEDICAL	1858	5.74	46.88
BEST CASE	PARTIAL	EYE CORNEAL ULCER	MEDICAL	1193	3.69	50.57
WORST CASE	PARTIAL	NEPHROLITHIASIS	MEDICAL	1154	3.57	54.14
WORST CASE	PARTIAL	EYE CHEMICAL BURN	ENVIRONMENTAL	1094	3.38	57.52
WORST CASE	PARTIAL	SKIN LACERATION	INJURY/TRAUMA	838	2.59	60.11
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	739	2.28	62.40

Table 7: Basis of Comparison – 1224 days MedCap; Top Ten Influential Conditions for EVAC

Scenario	Treated	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
BEST CASE	PARTIAL	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	17873	28.77	28.77
WORST CASE	PARTIAL	URINARY TRACT INFECTION	MEDICAL	6912	11.13	39.90
WORST CASE	PARTIAL	HERPES ZOSTER REACTIVATION (SHINGLES)	MEDICAL	5556	8.94	48.84
BEST CASE	PARTIAL	EYE CHEMICAL BURN	ENVIRONMENTAL	3779	6.08	54.93
WORST CASE	PARTIAL	EYE INFECTION	MEDICAL	2654	4.27	59.20
WORST CASE	PARTIAL	RESPIRATORY INFECTION	MEDICAL	2220	3.57	62.78
BEST CASE	PARTIAL	EYE CORNEAL ULCER	MEDICAL	1903	3.06	65.84
WORST CASE	PARTIAL	EYE CHEMICAL BURN	ENVIRONMENTAL	1455	2.34	68.18
WORST CASE	PARTIAL	NEPHROLITHIASIS	MEDICAL	1409	2.27	70.45
WORST CASE	PARTIAL	SKIN LACERATION	INJURY/TRAUMA	1252	2.02	72.46

Table 8: Point of Departure – 860 days MedCap; Top Ten Influential Conditions for LOCL

Scenario	Treated	Medical Condition	Category	Total LOCL	Percent Contribution	Cumulative Percent
WORST CASE	PARTIAL	SEPSIS	MEDICAL	262	22.37	22.37
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	245	20.92	43.30
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	132	11.27	54.57
WORST CASE	TREATED	SEPSIS	MEDICAL	128	10.93	65.50
WORST CASE	TREATED	MEDICATION OVERDOSE/ADVERSE REACTION	MEDICAL	111	9.48	74.98
WORST CASE	TREATED	APPENDICITIS	MEDICAL	60	5.12	80.10
WORST CASE	TREATED	TOXIC EXPOSURE (AMMONIA)	ENVIRONMENTAL	57	4.87	84.97
WORST CASE	TREATED	SUDDEN CARDIAC ARREST	MEDICAL	26	2.22	87.19
BEST CASE	PARTIAL	APPENDICITIS	MEDICAL	25	2.13	89.33
BEST CASE	PARTIAL	SEPSIS	MEDICAL	22	1.88	91.20

Table 9: Alternate Short Stay – 1030 days MedCap; Top Ten Influential Conditions for LOCL

Scenario	Treated	Medical Condition	Category	Total LOCL	Percent Contribution	Cumulative Percent
WORST CASE	PARTIAL	SEPSIS	MEDICAL	293	21.53	21.53
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	275	20.21	41.73
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	158	11.61	53.34
WORST CASE	TREATED	SEPSIS	MEDICAL	143	10.51	63.85
WORST CASE	TREATED	MEDICATION OVERDOSE/ADVERSE REACTION	MEDICAL	119	8.74	72.59
WORST CASE	TREATED	TOXIC EXPOSURE (AMMONIA)	ENVIRONMENTAL	76	5.58	78.18
WORST CASE	TREATED	APPENDICITIS	MEDICAL	54	3.97	82.15
BEST CASE	PARTIAL	APPENDICITIS	MEDICAL	41	3.01	85.16
BEST CASE	PARTIAL	SEPSIS	MEDICAL	38	2.79	87.95
WORST CASE	TREATED	SUDDEN CARDIAC ARREST	MEDICAL	32	2.35	90.30

Table 10: Basis of Comparison – 1224 days MedCap; Top Ten Influential Conditions for LOCL

Scenario	Treated	Medical Condition	Category	Total LOCL	Percent Contribution	Cumulative Percent
WORST CASE	PARTIAL	SEPSIS	MEDICAL	349	20.39	20.39
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	341	19.92	40.30
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	184	10.75	51.05
WORST CASE	TREATED	SEPSIS	MEDICAL	149	8.70	59.75
WORST CASE	TREATED	MEDICATION OVERDOSE/ADVERSE REACTION	MEDICAL	135	7.89	67.64
WORST CASE	TREATED	APPENDICITIS	MEDICAL	90	5.26	72.90
WORST CASE	PARTIAL	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	73	4.26	77.16
WORST CASE	TREATED	TOXIC EXPOSURE (AMMONIA)	ENVIRONMENTAL	71	4.15	81.31
WORST CASE	TREATED	SUDDEN CARDIAC ARREST	MEDICAL	42	2.45	83.76
BEST CASE	PARTIAL	APPENDICITIS	MEDICAL	41	2.39	86.16

Table 11: Point of Departure – 860 days Fully Treated; Top Ten Influential Conditions for EVAC

Scenario	Treated	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
WORST CASE	TREATED	NEPHROLITHIASIS	MEDICAL	1460	16.07	16.07
WORST CASE	TREATED	SEPSIS	MEDICAL	799	8.79	24.86
WORST CASE	TREATED	DENTAL ABSCESS	MEDICAL	761	8.38	33.24
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	698	7.68	40.92
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	486	5.35	46.27
WORST CASE	TREATED	HERPES ZOSTER REACTIVATION (SHINGLES)	MEDICAL	477	5.25	51.52
BEST CASE	TREATED	SMALL BOWEL OBSTRUCTION	MEDICAL	469	5.16	56.68
WORST CASE	TREATED	WRIST FRACTURE	INJURY/TRAUMA	433	4.77	61.45
WORST CASE	TREATED	HEADACHE (CO2 INDUCED)	ENVIRONMENTAL	263	2.89	64.34
WORST CASE	TREATED	URINARY TRACT INFECTION	MEDICAL	253	2.78	67.13

Table 12: Alternate Short Stay – 1030 days Fully Treated; Top Ten Influential Conditions for EVAC

Scenario	Treated	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
WORST CASE	TREATED	NEPHROLITHIASIS	MEDICAL	1699	15.87	15.87
WORST CASE	TREATED	DENTAL ABSCESS	MEDICAL	969	9.05	24.92
WORST CASE	TREATED	SEPSIS	MEDICAL	886	8.28	33.20
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	769	7.18	40.38
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	608	5.68	46.06
BEST CASE	TREATED	SMALL BOWEL OBSTRUCTION	MEDICAL	601	5.61	51.68
WORST CASE	TREATED	HERPES ZOSTER REACTIVATION (SHINGLES)	MEDICAL	560	5.23	56.91
WORST CASE	TREATED	WRIST FRACTURE	INJURY/TRAUMA	517	4.83	61.74
WORST CASE	TREATED	URINARY TRACT INFECTION	MEDICAL	298	2.78	64.52
WORST CASE	TREATED	HEADACHE (CO2 INDUCED)	ENVIRONMENTAL	291	2.72	67.24

Table 13: Basis of Comparison – 1224 days Fully Treated; Top Ten Influential Conditions for EVAC

Scenario	Treated	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
WORST CASE	TREATED	NEPHROLITHIASIS	MEDICAL	2111	16.39	16.39
WORST CASE	TREATED	DENTAL ABSCESS	MEDICAL	1156	8.98	25.37
WORST CASE	TREATED	SEPSIS	MEDICAL	1013	7.87	33.23
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	937	7.28	40.51
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	744	5.78	46.29
BEST CASE	TREATED	SMALL BOWEL OBSTRUCTION	MEDICAL	696	5.40	51.69
WORST CASE	TREATED	HERPES ZOSTER REACTIVATION (SHINGLES)	MEDICAL	642	4.99	56.68
WORST CASE	TREATED	WRIST FRACTURE	INJURY/TRAUMA	615	4.78	61.45
WORST CASE	TREATED	URINARY TRACT INFECTION	MEDICAL	372	2.89	64.34
WORST CASE	TREATED	HEADACHE (CO2 INDUCED)	ENVIRONMENTAL	356	2.76	67.11

Table 14: Point of Departure – 860 days Fully Treated; Top Ten Influential Conditions for LOCL

Scenario	Treated	Medical Condition	Category	Total LOCL	Percent Contribution	Cumulative Percent
WORST CASE	TREATED	SEPSIS	MEDICAL	385	34.38	34.38
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	257	22.95	57.32
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	135	12.05	69.38
WORST CASE	TREATED	MEDICATION OVERDOSE/ADVERSE REACTION	MEDICAL	115	10.27	79.64
WORST CASE	TREATED	APPENDICITIS	MEDICAL	76	6.79	86.43
WORST CASE	TREATED	TOXIC EXPOSURE (AMMONIA)	ENVIRONMENTAL	73	6.52	92.95
WORST CASE	TREATED	SUDDEN CARDIAC ARREST	MEDICAL	26	2.32	95.27
WORST CASE	TREATED	BURNS SECONDARY TO FIRE	ENVIRONMENTAL	12	1.07	96.34
WORST CASE	TREATED	SMALL BOWEL OBSTRUCTION	MEDICAL	9	0.80	97.14
WORST CASE	TREATED	ACUTE DIVERTICULITIS	MEDICAL	8	0.71	97.86

Table 15: Alternate Short Stay – 1030 days Fully Treated; Top Ten Influential Conditions for LOCL

Scenario	Treated	Medical Condition	Category	Total LOCL	Percent Contribution	Cumulative Percent
WORST CASE	TREATED	SEPSIS	MEDICAL	460	35.44	35.44
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	289	22.27	57.70
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	166	12.79	70.49
WORST CASE	TREATED	MEDICATION OVERDOSE/ADVERSE REACTION	MEDICAL	125	9.63	80.12
WORST CASE	TREATED	TOXIC EXPOSURE (AMMONIA)	ENVIRONMENTAL	95	7.32	87.44
WORST CASE	TREATED	APPENDICITIS	MEDICAL	76	5.86	93.30
WORST CASE	TREATED	SUDDEN CARDIAC ARREST	MEDICAL	33	2.54	95.84
WORST CASE	TREATED	BURNS SECONDARY TO FIRE	ENVIRONMENTAL	11	0.85	96.69
WORST CASE	TREATED	CHOKING/OBSTRUCTED AIRWAY	MEDICAL	9	0.69	97.38
WORST CASE	TREATED	CARDIOGENIC SHOCK SECONDARY TO MYOCARDIAL INFARCTION	MEDICAL	7	0.54	97.92

Table 16: Basis of Comparison – 1224 days Fully Treated; Top Ten Influential Conditions for LOCL

Scenario	Treated	Medical Condition	Category	Total LOCL	Percent Contribution	Cumulative Percent
WORST CASE	TREATED	SEPSIS	MEDICAL	506	31.70	31.70
WORST CASE	TREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	387	24.25	55.95
WORST CASE	TREATED	SMOKE INHALATION	ENVIRONMENTAL	195	12.22	68.17
WORST CASE	TREATED	MEDICATION OVERDOSE/ADVERSE REACTION	MEDICAL	145	9.09	77.26
WORST CASE	TREATED	APPENDICITIS	MEDICAL	112	7.02	84.27
WORST CASE	TREATED	TOXIC EXPOSURE (AMMONIA)	ENVIRONMENTAL	102	6.39	90.66
WORST CASE	TREATED	SUDDEN CARDIAC ARREST	MEDICAL	45	2.82	93.48
WORST CASE	TREATED	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	22	1.38	94.86
WORST CASE	TREATED	BURNS SECONDARY TO FIRE	ENVIRONMENTAL	15	0.94	95.80
WORST CASE	TREATED	CARDIOGENIC SHOCK SECONDARY TO MYOCARDIAL INFARCTION	MEDICAL	12	0.75	96.55

Table 17: Point of Departure – 860 days Fully Untreated; Top Ten Influential Conditions for EVAC

Scenario	Treated	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
BEST CASE	UNTREATED	EYE CHEMICAL BURN	ENVIRONMENTAL	27766	16.30	16.30
WORST CASE	UNTREATED	URINARY TRACT INFECTION	MEDICAL	19423	11.40	27.70
WORST CASE	UNTREATED	HERPES ZOSTER REACTIVATION (SHINGLES)	MEDICAL	17785	10.44	38.14
WORST CASE	UNTREATED	EYE INFECTION	MEDICAL	11040	6.48	44.62
WORST CASE	UNTREATED	SKIN LACERATION	INJURY/TRAUMA	10304	6.05	50.66
BEST CASE	UNTREATED	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	8653	5.08	55.74
BEST CASE	UNTREATED	EYE CORNEAL ULCER	MEDICAL	7185	4.22	59.96
WORST CASE	UNTREATED	EYE CHEMICAL BURN	ENVIRONMENTAL	6199	3.64	63.60
BEST CASE	UNTREATED	URINARY RETENTION (SPACE ADAPTATION)	MEDICAL	5899	3.46	67.06
WORST CASE	UNTREATED	EYE IRRITATION/ABRASION	INJURY/TRAUMA	3861	2.27	69.33

Table 18: Alternate Short Stay – 1030 days Fully Untreated; Top Ten Influential Conditions for EVAC

Scenario	Treated	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
BEST CASE	UNTREATED	EYE CHEMICAL BURN	ENVIRONMENTAL	31723	16.52	16.52
WORST CASE	UNTREATED	URINARY TRACT INFECTION	MEDICAL	22454	11.69	28.22
WORST CASE	UNTREATED	HERPES ZOSTER REACTIVATION (SHINGLES)	MEDICAL	19892	10.36	38.58
WORST CASE	UNTREATED	EYE INFECTION	MEDICAL	12366	6.44	45.02
WORST CASE	UNTREATED	SKIN LACERATION	INJURY/TRAUMA	11334	5.90	50.92
BEST CASE	UNTREATED	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	9263	4.82	55.75
BEST CASE	UNTREATED	EYE CORNEAL ULCER	MEDICAL	8205	4.27	60.02
WORST CASE	UNTREATED	EYE CHEMICAL BURN	ENVIRONMENTAL	6846	3.57	63.59
BEST CASE	UNTREATED	URINARY RETENTION (SPACE ADAPTATION)	MEDICAL	5950	3.10	66.68
WORST CASE	UNTREATED	EYE IRRITATION/ABRASION	INJURY/TRAUMA	4433	2.31	68.99

Table 19: Basis of Comparison – 1224 days Fully Untreated; Top Ten Influential Conditions for EVAC

Scenario	Treated	Medical Condition	Category	Total EVAC	Percent Contribution	Cumulative Percent
BEST CASE	UNTREATED	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	75416	28.52	28.52
BEST CASE	UNTREATED	EYE CHEMICAL BURN	ENVIRONMENTAL	32431	12.26	40.78
WORST CASE	UNTREATED	URINARY TRACT INFECTION	MEDICAL	23031	8.71	49.49
WORST CASE	UNTREATED	HERPES ZOSTER REACTIVATION (SHINGLES)	MEDICAL	20575	7.78	57.27
WORST CASE	UNTREATED	EYE INFECTION	MEDICAL	12792	4.84	62.11
WORST CASE	UNTREATED	SKIN LACERATION	INJURY/TRAUMA	11697	4.42	66.53
BEST CASE	UNTREATED	EYE CORNEAL ULCER	MEDICAL	8298	3.14	69.67
WORST CASE	UNTREATED	EYE CHEMICAL BURN	ENVIRONMENTAL	7216	2.73	72.40
BEST CASE	UNTREATED	URINARY RETENTION (SPACE ADAPTATION)	MEDICAL	5866	2.22	74.62
WORST CASE	UNTREATED	EYE IRRITATION/ABRASION	INJURY/TRAUMA	4586	1.73	76.35

Table 20: Point of Departure – 860 days Fully Untreated; Top Ten Influential Conditions for LOCL

Scenario	Treated	Medical Condition	Category	Total LOCL	Percent Contribution	Cumulative Percent
WORST CASE	UNTREATED	SMOKE INHALATION	ENVIRONMENTAL	1812	39.55	39.55
WORST CASE	UNTREATED	SEPSIS	MEDICAL	609	13.29	52.84
BEST CASE	UNTREATED	SEPSIS	MEDICAL	533	11.63	64.47
WORST CASE	UNTREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	379	8.27	72.74
BEST CASE	UNTREATED	APPENDICITIS	MEDICAL	269	5.87	78.61
BEST CASE	UNTREATED	ANAPHYLAXIS	MEDICAL	184	4.02	82.63
WORST CASE	UNTREATED	ACUTE DIVERTICULITIS	MEDICAL	143	3.12	85.75
WORST CASE	UNTREATED	CHOKING/OBSTRUCTED AIRWAY	MEDICAL	132	2.88	88.63
WORST CASE	UNTREATED	TOXIC EXPOSURE (AMMONIA)	ENVIRONMENTAL	124	2.71	91.34
WORST CASE	UNTREATED	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	90	1.96	93.30

Table 21: Alternate Short Stay – 1030 days Fully Untreated; Top Ten Influential Conditions for LOCL

Scenario	Treated	Medical Condition	Category	Total LOCL	Percent Contribution	Cumulative Percent
WORST CASE	UNTREATED	SMOKE INHALATION	ENVIRONMENTAL	1982	38.71	38.71
WORST CASE	UNTREATED	SEPSIS	MEDICAL	649	12.68	51.39
BEST CASE	UNTREATED	SEPSIS	MEDICAL	620	12.11	63.50
WORST CASE	UNTREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	454	8.87	72.36
BEST CASE	UNTREATED	APPENDICITIS	MEDICAL	337	6.58	78.95
BEST CASE	UNTREATED	ANAPHYLAXIS	MEDICAL	224	4.38	83.32
WORST CASE	UNTREATED	CHOKING/OBSTRUCTED AIRWAY	MEDICAL	146	2.85	86.17
WORST CASE	UNTREATED	ACUTE DIVERTICULITIS	MEDICAL	142	2.77	88.95
WORST CASE	UNTREATED	TOXIC EXPOSURE (AMMONIA)	ENVIRONMENTAL	139	2.71	91.66
WORST CASE	UNTREATED	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	95	1.86	93.52

Table 22: Basis of Comparison – 1224 days Fully Untreated; Top Ten Influential Conditions for LOCL

Scenario	Treated	Medical Condition	Category	Total LOCL	Percent Contribution	Cumulative Percent
WORST CASE	UNTREATED	SMOKE INHALATION	ENVIRONMENTAL	2119	35.64	35.64
WORST CASE	UNTREATED	DECOMPRESSION SICKNESS SECONDARY TO EXTRAVEHICULAR ACTIVITY	ENVIRONMENTAL	738	12.41	48.05
BEST CASE	UNTREATED	SEPSIS	MEDICAL	688	11.57	59.62
WORST CASE	UNTREATED	SEPSIS	MEDICAL	636	10.70	70.32
WORST CASE	UNTREATED	STROKE (CEREBROVASCULAR ACCIDENT)	MEDICAL	473	7.95	78.27
BEST CASE	UNTREATED	APPENDICITIS	MEDICAL	289	4.86	83.13
BEST CASE	UNTREATED	ANAPHYLAXIS	MEDICAL	228	3.83	86.97
WORST CASE	UNTREATED	ACUTE DIVERTICULITIS	MEDICAL	159	2.67	89.64
WORST CASE	UNTREATED	CHOKING/OBSTRUCTED AIRWAY	MEDICAL	132	2.22	91.86
WORST CASE	UNTREATED	TOXIC EXPOSURE (AMMONIA)	ENVIRONMENTAL	122	2.05	93.91

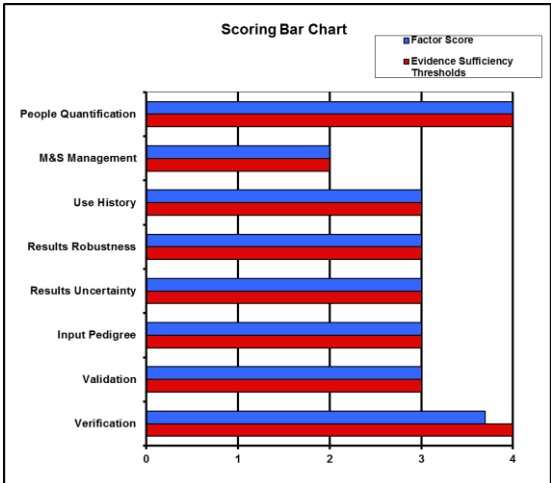
Discussion

The average total number of medical events (TME) is greater for the longer DRM with more EVAs (BoC) than the shorter DRMs with less EVAs (PoD and AS) for both the MedCap and fully treated scenarios. This result is as expected. The average CHI is lower for the BoC DRM than the PoD and ASDRM for both the MedCap and fully treated scenarios. This result is as expected. The probability of EVAC is higher for the BoCDRM than the PoD and AS DRMs for both the MedCap and fully treated scenarios. This result is as expected. The probability of LOCL is higher for the BoC DRM than the PoD and AS DRM for both the MedCap and fully treated scenarios. This result is as expected. Decompression Sickness secondary to EVA is the most influential condition for EVAC in the MedCap scenario for the BoC DRM. This is due to the large number of EVAs in this DRM and depletion of resources in the MedCap scenario which includes the equivalent of 1 ISS medkit with no resupply.

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*
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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
6. ISS PRA Model v.3.2.0. ISS PRA Fire and Ammonia Model Contributions to the Integrated Medical Model. 2015. Houston, Texas, NASA Johnson Space Center. *Ref Type: Report*

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. Scoring Bar Chart <table><thead><tr><th>IMM Element</th><th>Evidence Sufficiency Thresholds</th><th>Factor Score</th></tr></thead><tbody><tr><td>People Quantification</td><td>4</td><td>4</td></tr><tr><td>M&S Management</td><td>2</td><td>2</td></tr><tr><td>Use History</td><td>3</td><td>3</td></tr><tr><td>Results Robustness</td><td>3</td><td>3</td></tr><tr><td>Results Uncertainty</td><td>3</td><td>3</td></tr><tr><td>Input Pedigree</td><td>3</td><td>3</td></tr><tr><td>Validation</td><td>3</td><td>3</td></tr><tr><td>Verification</td><td>4</td><td>3.7</td></tr></tbody></table>	IMM Element	Evidence Sufficiency Thresholds	Factor Score	People Quantification	4	4	M&S Management	2	2	Use History	3	3	Results Robustness	3	3	Results Uncertainty	3	3	Input Pedigree	3	3	Validation	3	3	Verification	4	3.7																										
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Verification	4	3.7																																																				
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><thead><tr><th>Compliant</th><th>Compliance Incomplete</th><th>Not applicable</th></tr></thead><tbody><tr><td>36</td><td>5</td><td>5</td></tr></tbody></table>	Compliant	Compliance Incomplete	Not applicable	36	5	5																																															
Compliant	Compliance Incomplete	Not applicable																																																				
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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. <table><thead><tr><th>Factor</th><th>Sufficiency Thresholds</th><th>Factor Score</th><th>Weighted Scores</th><th>Overall Score</th></tr></thead><tbody><tr><td>Verification</td><td>4</td><td>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></tbody></table> Legend from NASA-STD-7009 <table><tbody><tr><td>CAS Score > Threshold</td><td>Exceeds credibility requirements</td></tr><tr><td>Threshold > CAS Score ≥ (Threshold-0.5)</td><td>Ready for use</td></tr><tr><td>Threshold-0.5 > CAS Score ≥ Threshold-1.0</td><td>Use with caution</td></tr><tr><td>CAS Score < Threshold - 1.0</td><td>Use not recommended or to be used with EXTREME CAUTION by subject matter experts only</td></tr></tbody></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 IDs: (68), created on (6/29/2029)																																																					
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 (CO₂ 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)

Appendix C: Medical Conditions Excluded or Modified for the PoD (860 days) AS (1030 days) and BoC (1224 days) DRMs

Due to limited vehicle size consisting of a single module and limited movement of crew during flight, the following conditions are judged highly unlikely to occur:

- Abdominal Injury
- Acute Compartment Syndrome
- Barotrauma
- Chest Injury
- Elbow Dislocation
- Head Injury
- Hip/Proximal Femur Fracture
- Lower Extremity (LE) Stress Fracture
- Lumbar Spine Fracture
- Shoulder Dislocation
- Neurogenic Shock
- Traumatic Hypovolemic Shock

However, due to the partial gravity environment during the EVA schedule for this request, these conditions were allowed to occur during, but not outside the EVA windows.

Appendix D: Additional Statistics Tables for TME, QTL, EVAC and LOCL

Table 23: Median Number of TME, standard deviation (SD), and Interquartile Range (IQR) for the DRMs

		Median TME	SD	Interquartile Range	
Point of Departure – 860 days	MedCap	257	20.99	244	269
Alternate Short Stay – 1030 days	MedCap	303	25.17	287	317
Basis of Comparison – 1224 days	MedCap	421	39.85	393	441
Point of Departure – 860 days	Fully Treated	259	19.74	247	271
Alternate Short Stay – 1030 days	Fully Treated	307	23.07	293	320
Basis of Comparison – 1224 days	Fully Treated	434	32.18	417	450
Point of Departure – 860 days	Fully Untreated	203	43.05	172	232
Alternate Short Stay – 1030 days	Fully Untreated	229	52.64	190	264
Basis of Comparison – 1224 days	Fully Untreated	272	75.11	219	324

Table 24: Median QAMTL, standard deviation (SD), and Interquartile Range (IQR) for the DRMs

		Median QAMTL (Hours)	SD (Hours)	Interquartile Range (Hours)	
Point of Departure – 860 days	MedCap	14254.16	5917.37	11255.22	18704.06
Alternate Short Stay – 1030 days	MedCap	21980.4	7256.32	18004.44	27453.33
Basis of Comparison – 1224 days	MedCap	36527.3	8750.19	31031.5	42831.65
Point of Departure – 860 days	Fully Treated	7990.408	5545.47	5727.89	11748.36
Alternate Short Stay – 1030 days	Fully Treated	11029.84	6903.53	8090.58	15880.95
Basis of Comparison – 1224 days	Fully Treated	16828.76	8452.9	12972.77	22827.72
Point of Departure – 860 days	Fully Untreated	62950.74	4225.37	60463.21	65520.06
Alternate Short Stay – 1030 days	Fully Untreated	79176.83	4749.63	76602.85	81804.73
Basis of Comparison – 1224 days	Fully Untreated	97908.27	5303.68	95391.83	100509.2

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Table 25: Mean, Median, standard deviation (SD) and Interquartile range (IQR) of the EVAC-Event and LOCL-Event ratios for the DRMs

		EVAC					LOCL				
		Mean	Median	SD	IQR		Mean	Median	SD	IQR	
Point of Departure – 860 days	MedCap	1.02E-03	0.00E+00	2.11E-03	0.00E+00	0.00E+00	5.23E-05	0.00E+00	4.87E-04	0.00E+00	0.00E+00
Alternate Short Stay – 1030 days	MedCap	1.18E-03	0.00E+00	2.07E-03	0.00E+00	3.21E-03	5.18E-05	0.00E+00	4.46E-04	0.00E+00	0.00E+00
Basis of Comparison – 1224 days	MedCap	1.65E-03	0.00E+00	2.03E-03	0.00E+00	2.58E-03	4.77E-05	0.00E+00	3.67E-04	0.00E+00	0.00E+00
Point of Departure – 860 days	Fully Treated	4.02E-04	0.00E+00	1.34E-03	0.00E+00	0.00E+00	4.95E-05	0.00E+00	4.70E-04	0.00E+00	0.00E+00
Alternate Short Stay – 1030 days	Fully Treated	4.02E-04	0.00E+00	1.24E-03	0.00E+00	0.00E+00	4.89E-05	0.00E+00	4.32E-04	0.00E+00	0.00E+00
Basis of Comparison – 1224 days	Fully Treated	3.45E-04	0.00E+00	9.71E-04	0.00E+00	0.00E+00	4.31E-05	0.00E+00	3.43E-04	0.00E+00	0.00E+00
Point of Departure – 860 days	Fully Untreated	1.00E-02	9.22E-03	8.46E-03	4.41E-03	1.29E-02	2.69E-04	0.00E+00	1.33E-03	0.00E+00	0.00E+00
Alternate Short Stay – 1030 days	Fully Untreated	1.01E-02	8.73E-03	8.22E-03	4.00E-03	1.35E-02	2.70E-04	0.00E+00	1.27E-03	0.00E+00	0.00E+00
Basis of Comparison – 1224 days	Fully Untreated	1.17E-02	1.03E-02	8.09E-03	6.35E-03	1.47E-02	2.67E-04	0.00E+00	1.19E-03	0.00E+00	0.00E+00