National Aeronautics and Space Administration

Mapping Current Medical Systems to the IMPACT Medical Database Environment

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DISCLAIMER:

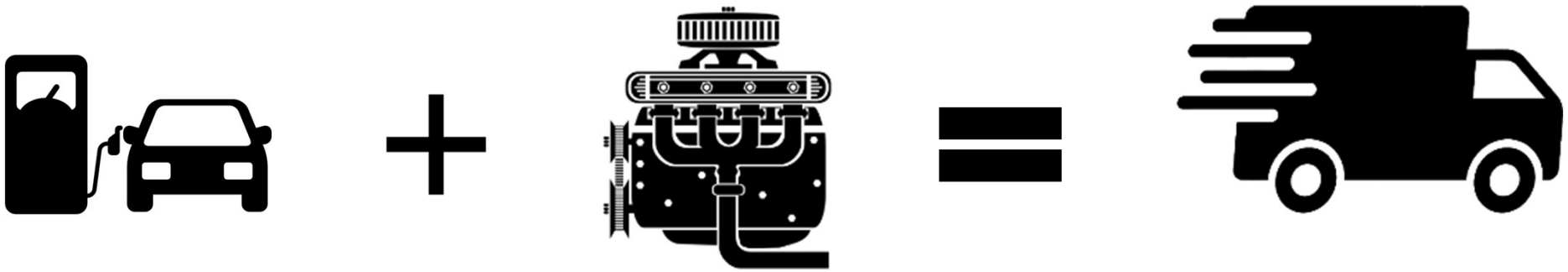
"The IMPACT Probabilistic Risk Assessment (PRA) tool is under active development. All results are preliminary, subject to change, and must not be used for mission planning, operational decisions, or formal analysis. These results are provided solely for feedback and discussion purposes to support tool improvement."

Agenda

- **Introduction**
  - IMPACT Basics
- **Goals of This Effort**
  - Defining New Baselines
  - Future Use Cases
- **ISS Medical System**
  - Key Findings
- **Notional Early Artemis System**
  - Applying Lessons Learned
  - System Performance
- **Future Work**

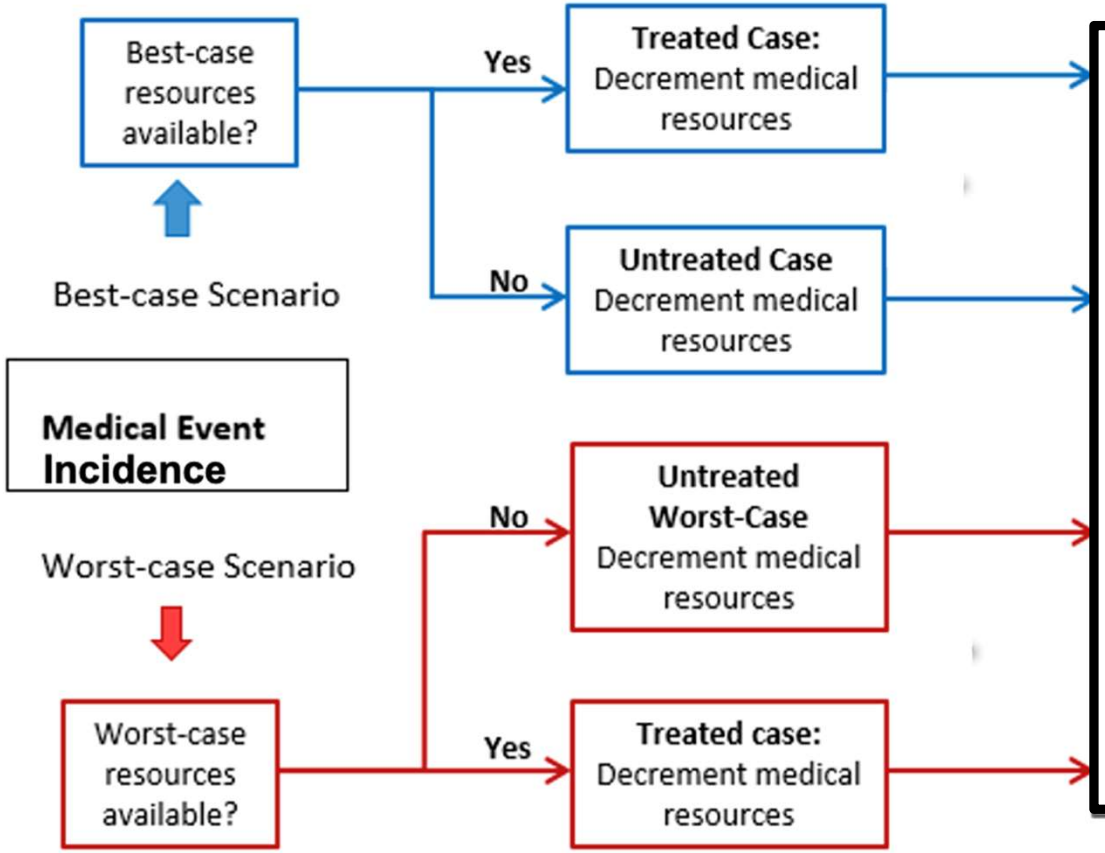
Informing Mission Planning via Analysis of Complex Tradespaces

Evidence Base + Computational Engine (PRA) = IMPACT



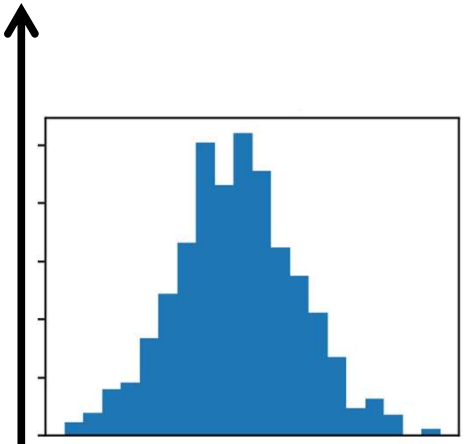
- Evolution of Integrated Medical Model (IMM)
- Uses the Medical Extensible Dynamic Probabilistic Risk Assessment Tool (MEDPRAT) as the Computational Engine
- Exploration-focused

IMPACT (MEDPRAT) – The Basics



Calculate End States:

- Loss of Crew Life (LOCL)
- Removal to Definitive Care (RTDC)
- Task Time Lost (TTL)
- Resource Utilization



Outputs can adjust with changes in mass/volume constraints

IMPACT Resource Handling – IMPACT (MD)

TREATMENT CLUSTERS

Name	Best Case								Worst Case
	Contribution	Necessity	Equivalence	Rank	Efficacy	Frequency	Quantity	Duration	Contribution
CP1 - Contain Sharps Absolute									1
CP1 - History - Collect History of Present Illness Absolute	1	0	0	0	100	N/A			1
CP1 - Imaging - Ultrasound Alternate									6
CP1 - Interpretation - Laboratory Results Absolute									1
CP1 - Interpretation - Physical Exam Absolute	1	0	0	0	100	N/A			1
CP1 - Interpretation - Ultrasound - Abdominal Absolute									1
CP1 - Interpretation - Ultrasound - Abdominal									1
CP1 - Laboratory - Venous Blood Gas With Lactate Absolute									3
CP1 - Physical Exam - Vital Signs - Periodic Absolute									7
CP1 - Physical Exam - Abdominal Absolute	1	0	0	0	100	N/A			1
CP1 - Physical Exam - Primary Assessment (ABCs) Absolute	1	0	0	0	100	N/A			1
CP1 - Software - Clinical Records and Decision Support Absolute	6	0	0	0	100	N/A			6
CP2 - Acute - Intravenous Fluid Delivery Absolute									2
CP2 - Acute - Management Decisions - Abdominal Wall Hernia Absolute	1	0	0	0	100	N/A			1
CP2 - Acute - Pharmacy - PO Antiemetics Alternate	1	0	0	0	100	N/A			1

- Treatment Capabilities mapped to conditions
  - Capability Resource Tables (CRTs)
  - Clinical Phases (CP):
    - CP1 - Diagnosis, CP2 - Treatment
- Resources are bundled within capabilities
  - Absolute vs Alternate bundles
- Scope of Partial weighting more restricted to follow treatment logic
- Alternative resources considered for all resource types

^Capability Resource Table for Abdominal Wall Hernia

Name	Best Case								Worst Case			
	Contribution	Necessity	Equivalence	Rank	Efficacy	Frequency	Quantity	Duration	Contribution	Necessity	Equivalence	Rank
CP1 - Imaging - Ultrasound Alternate									6	0	0	0
Bundle - Ultrasound - Butterfly Absolute									0	0	1	1
Device - Tablet Computer									1	100	0	0
Device - Tablet Computer Power Supply									1	100	0	0
Hygiene - Instrument Disinfectant									1	100	0	0
Ultrasound - Acoustic Transmission Gel									1	100	0	0
Ultrasound - Butterfly Probe Power Supply									1	100	0	0
Ultrasound - Ultrasound Probe - Butterfly									1	100	0	0
Bundle - Ultrasound - GE Absolute									0	0	1	2
Hygiene - Instrument Disinfectant									1	100	0	0
Ultrasound - Acoustic Transmission Gel									1	100	0	0
Ultrasound - Ultrasound Machine - GE									1	100	0	0
Ultrasound - Ultrasound Power Supply									1	100	0	0
Ultrasound - Ultrasound Probe - Curved Array 4C-RS									1	100	0	0
Ultrasound - Ultrasound Probe - Endocavitary Probe									1	100	0	0
Ultrasound - Ultrasound Probe - Linear Array 12L-RS									1	100	0	0
Ultrasound - Ultrasound Probe - Phased Array M4S-RS									1	100	0	0
CP1 - Interpretation - Laboratory Results Absolute									1	0	0	0
CP1 - Interpretation - Physical Exam Absolute	1	0	0	0	100	N/A			1	0	0	0
CP1 - Interpretation - Ultrasound - Abdominal Absolute									1	0	0	0

Purpose/Goals

Purpose

DRM = Design Reference Mission

- **There is currently no baseline medical system for any program or DRM type in IMPACT**
  - Currently, when a requestor asks, “I would like to know how [insert DRM] will perform”, a system of IMPACT MD resources must be provided by the requestor or optimized by the model specifically for the request
    - *This service is currently available within IMM only for select DRMs*
- **Prepare baseline medical systems suitable for typical DRMs in anticipation of DRM focused requests in the IMPACT Medical Database (MD) environment**
- **The initial prototypes focus on ISS and Artemis-like (Orion) DRMs**
  - These medical systems can be a starting data point for additional tailoring

Goals

Benefits to DRM Focused Requests

- Expedite answering of questions which focus on DRM (rather than medical system) with standard reference point
  - Offer alternative to optimized medical systems
- Simplify comparisons between similar but distinct DRMs
  - Remove variability of medical system

Manifestation of External Systems

- Establish process to model external medical systems in IMPACT
  - Define translation process
  - Determine necessary considerations for systems and resources not native to MD
- Develop understanding of nature of IMPACT MD
  - Quantify differences between iMED (IMM) and MD (IMPACT)

ISS Medical System

DRM Specifications:

6 Month mission

6 Crew (3M, 3F)

3 Microgravity EVAs, performed by 2 crew (1M, 1F)

ISS Translation – First and Second Iterations

First Iteration:

Direct translation of IMM baseline

Detriments to Performance

- IMPACT expanded MD
  - 21 conditions not considered by IMM
  - 5 no longer modeled in IMPACT
- Several resources unique to IMPACT
  - Absent from IMM system
- Restrictive partial treatment (bundling)
  - Conditions and treatment procedures reviewed/reconsidered
  - Left many incomplete CRT bundles

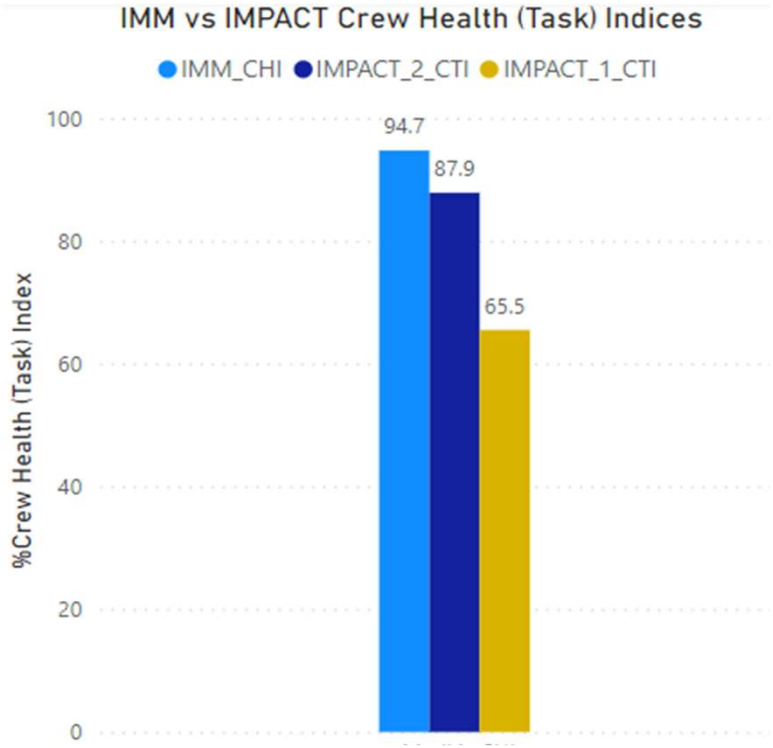
Second Iteration:

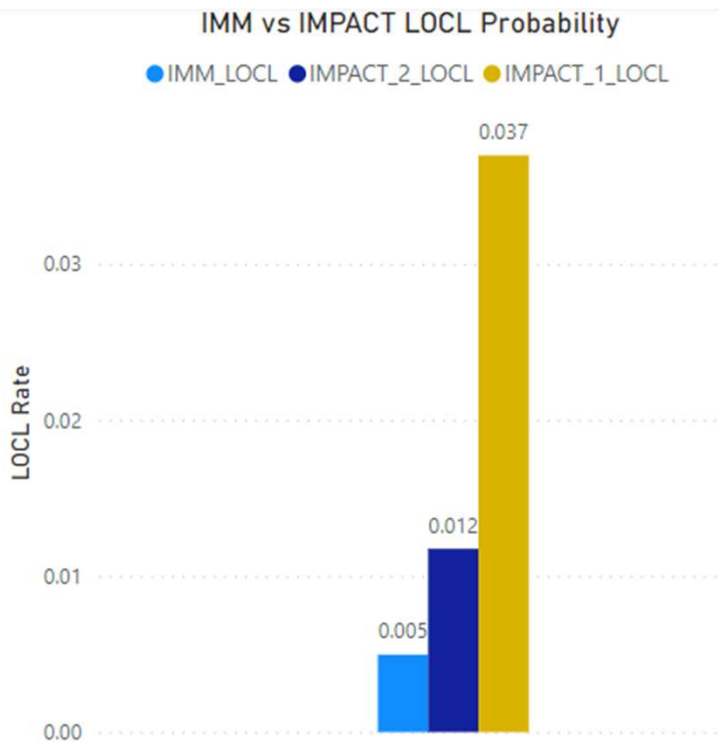
Representation of IMM baseline

Adapted to MD environment

- Additional consideration given to:
  - Massless resources
  - Unique + essential item CRTs (substituting for iMED resources; e.g. LifePak)
  - Resource quantity relative to dosage size (parcel quantity)

ISS System Results





Takeaways from ISS Translation

Findings:

IMPACT MD is NOT directly compatible with IMM iMED:

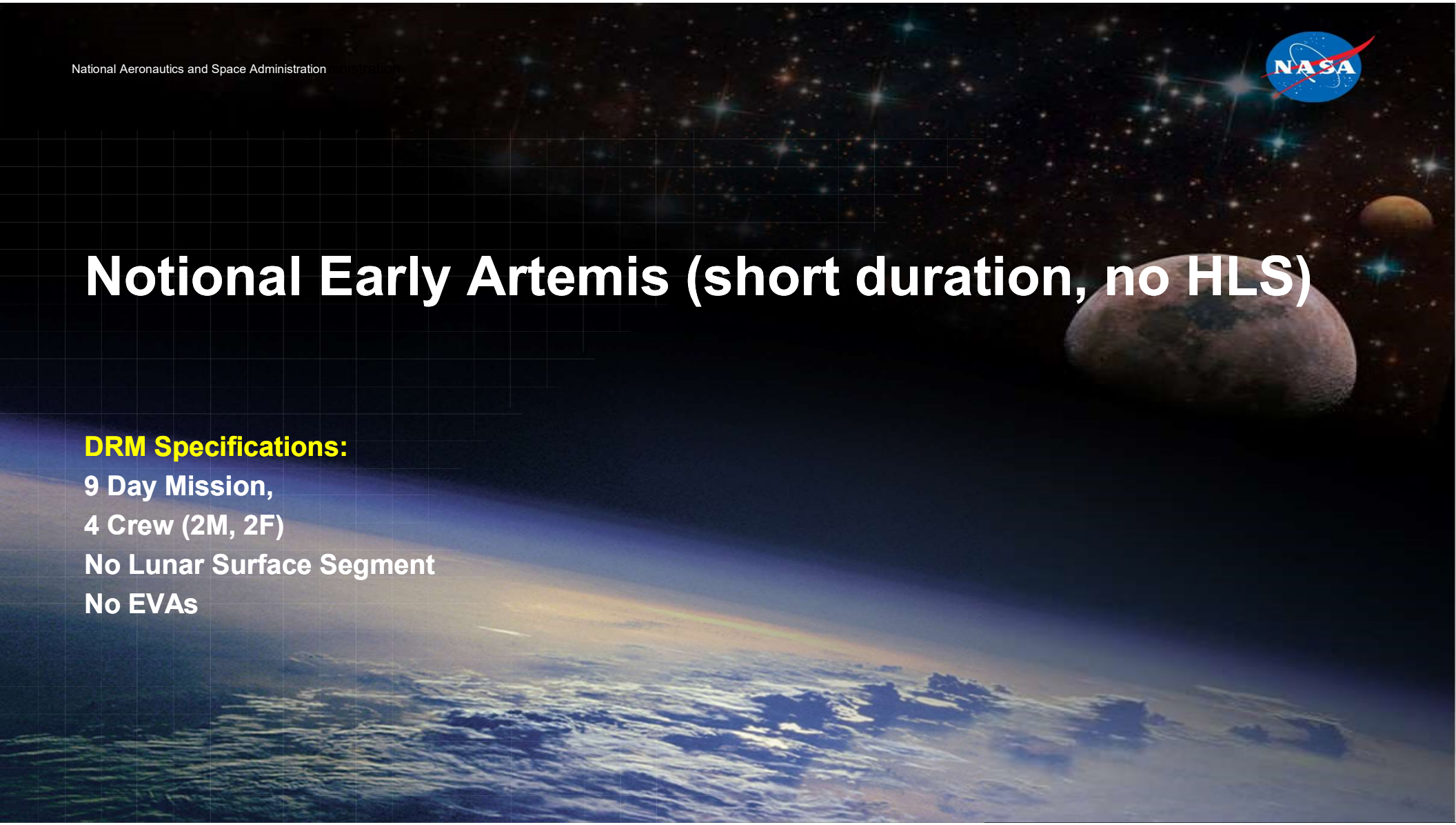
- Direct translation 1-to-1 leads to incomplete CRT bundles, inability to use linked resources
- Conditions, Resources unique to IMPACT should be considered separately

Future Baseline Systems:

- Should begin from list of desired capabilities, most prevalent conditions in untreated run
  - Revisiting Artemis-like baseline prototype

Future Translations:

- Should compare given resource to associated capability in IMPACT
- Resources should be matched based on conditions/capabilities provided



Notional Early Artemis (short duration, no HLS)

DRM Specifications:

9 Day Mission,

4 Crew (2M, 2F)

No Lunar Surface Segment

No EVAs

Capability Level Fixes – Modifying Resources

Identified 29 resources - *unused due to MD discrepancies*

- **Removed 3 resources, replaced 3 resources (-0.04kg)**
- **Added 10 resources (+1.25kg mass)**
- **Corrected 5 resource quantities**

Initial System: 2 Nasopharyngeal Airway, 0 Oropharyngeal Airway
Final System: 2 Nasopharyngeal Airway, 2 Oropharyngeal Airway

Most Influential Conditions

Took list of all conditions, sorted by each risk metric
Compared results of manifested system to Fully Treated

Top driving conditions - Space Adaptation occurrences

TTL Conditions	Diff from FT	RTDC Conditions	Diff from FT	LOCL Conditions	Diff from FT
Space Adaptation - Back Pain	0.118702	Eye Foreign Body	0.025396	Respiratory Tract Infection - Upper	0.000062
Space Adaptation – Space Motion Sickness	0.080447	Space Adaptation – Urinary Retention	0.009192		
Sleep Disturbance	0.046907				
Difference per listed conditions	**0.246056**	Difference per listed conditions	**0.034588**	Difference per listed conditions	**0.000062**
Remaining difference across all conditions	0.154804	Remaining difference across all conditions	0.00371	Remaining difference across all conditions	0.000076
Total TTL difference from FT	**0.40086**	Total RTDC difference from FT	**0.038298**	Total LOCL difference from FT	**0.000138**

Condition Level Fixes – Addressing Influential Conditions

Reviewed CRTs for identified influential conditions

- Considered which capabilities were intended to be provided
- Added certain small items as needed based on clinician recommendations

Added 5 items total, addressing *three conditions*

(Space Adaptation – Back Pain; Sleep Disturbance; Respiratory Tract Infection – Upper)

CONDITION	Capability	Bundle	Resource	Initial_Qu
TTL Conditions				
ICL91_Space Adaptation - Back Pain	Neuro Exam - MSK	Abs	Medical Instrument - Reflex Hammer	1
	Rehab- Phys. Thera	Abs	Device - Physical Therapy - TheraBand	0
			General Supplies - Clean Towel	NaN
	First Line Oral musc. Spasm	Alt	Pharmaceutical - Oral - Cyclobenzaprine 10mg	0
			Pharmaceutical - Oral - Methocarbamol 750mg	0
			Pharmaceutical - Oral - Carisoprodol 250mg	0
	Topical Pain Management	Abs	Medical Instrument - Hot And Cold Pad	1
			Pharmaceutical - Topical - Diclofenac Sodium 1% 0.5 In	8
			Pharmaceutical - Transdermal Patch - Lidocaine 5% Pat	1

Most Influential Conditions - TTL

Condition Name	Data Identifier	TTL - Mission (Person Day)
ICL97_Space Adaptation - Space Motion Sickness	Fully Treated	0.416952
	Updated_Sys	0.467021
	Initial_Sys	0.464356
ICL91_Space Adaptation - Back Pain	Fully Treated	0.267803
	Updated_Sys	0.316631
	Initial_Sys	0.385397
ICL18_Bhp - Sleep Disturbance	Fully Treated	0.140334
	Updated_Sys	0.210988
	Initial_Sys	0.220515

Most Influential Conditions - LOCL

Total Mission Graphical View (Dec)

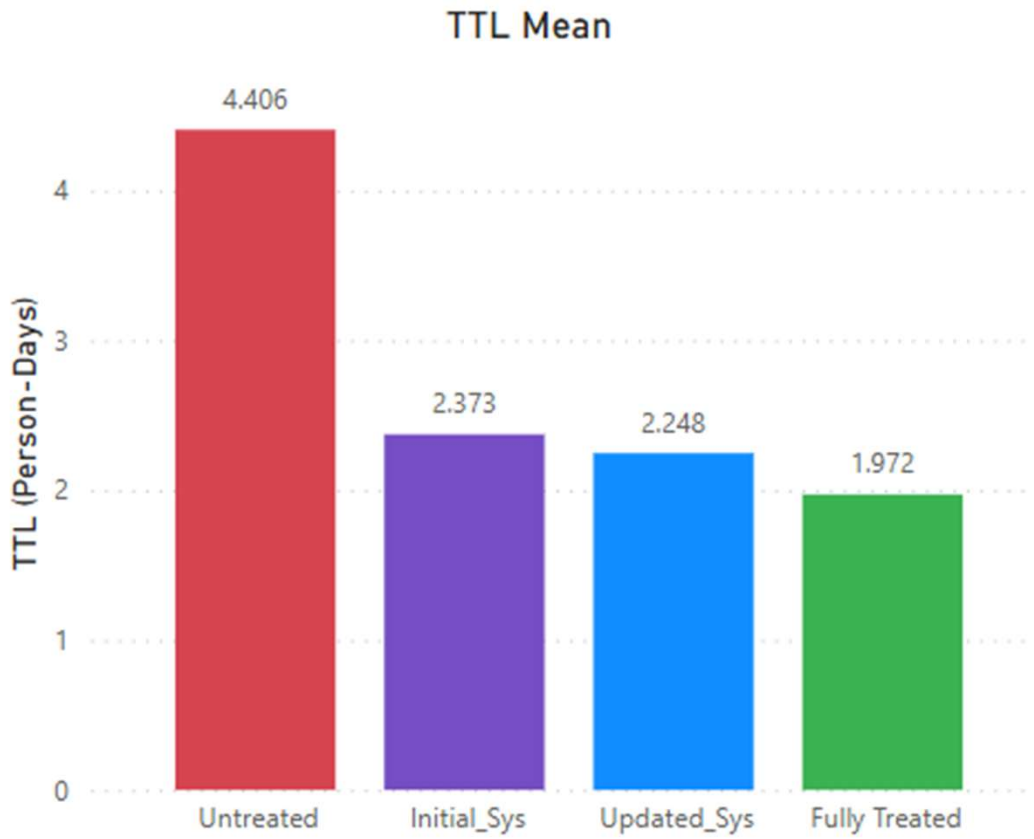
Condition Name	Data Identifier	LOCL - Mission Events
ICL82_Respiratory Tract Infection - Upper	Fully Treated	0.000000
	Updated_Sys	0.000048
	Initial_Sys	0.000062
ICL18_Bhp - Sleep Disturbance	Fully Treated	0.000000
	Updated_Sys	0.000000
	Initial_Sys	0.000000

Most Influential Conditions - RTDC

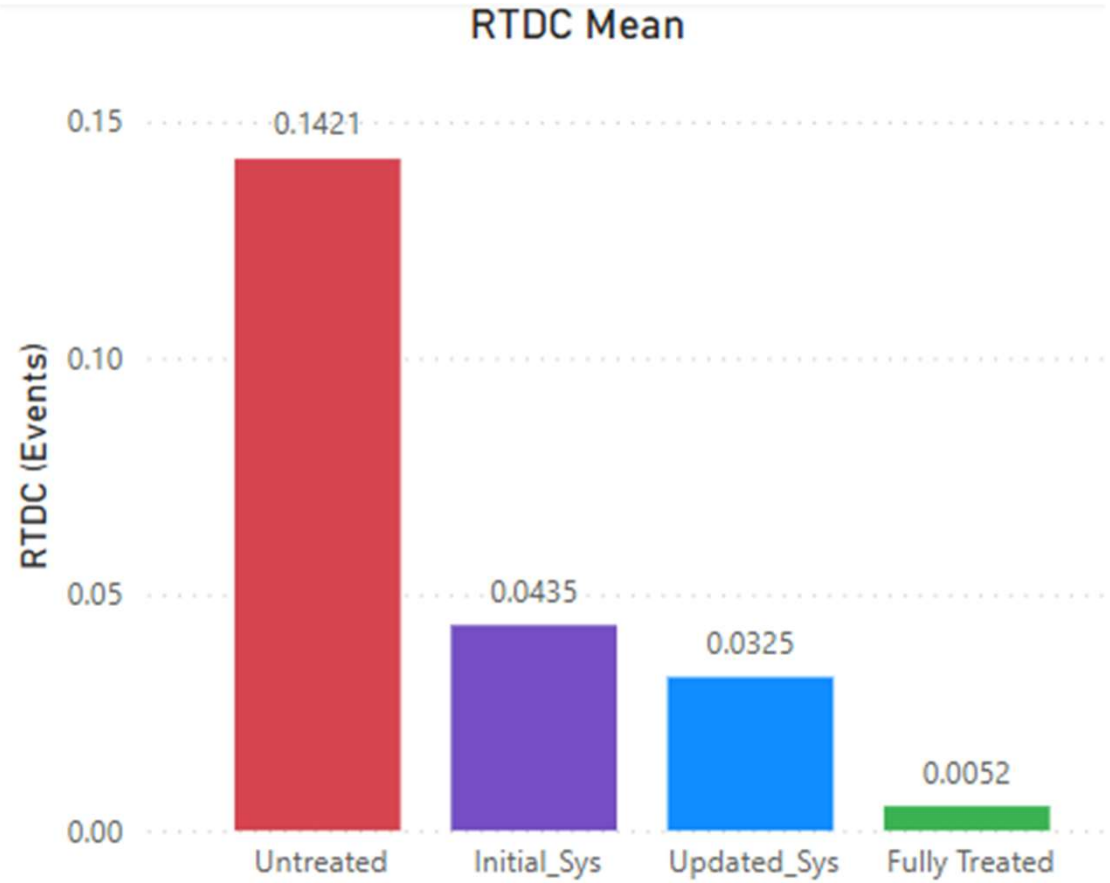
Total Mission Graphical View (Dec)

Condition Name	Data Identifier	RTDC - Mission Events
ICL48_Eye Foreign Body	Fully Treated	0.001992
	Updated_Sys	0.018172
	Initial_Sys	0.027490
ICL98_Space Adaptation - Urinary Retention	Fully Treated	0.000000
	Updated_Sys	0.009146
	Initial_Sys	0.009192
ICL82_Respiratory Tract Infection - Upper	Fully Treated	0.000000
	Updated_Sys	0.000002
	Initial_Sys	0.000002

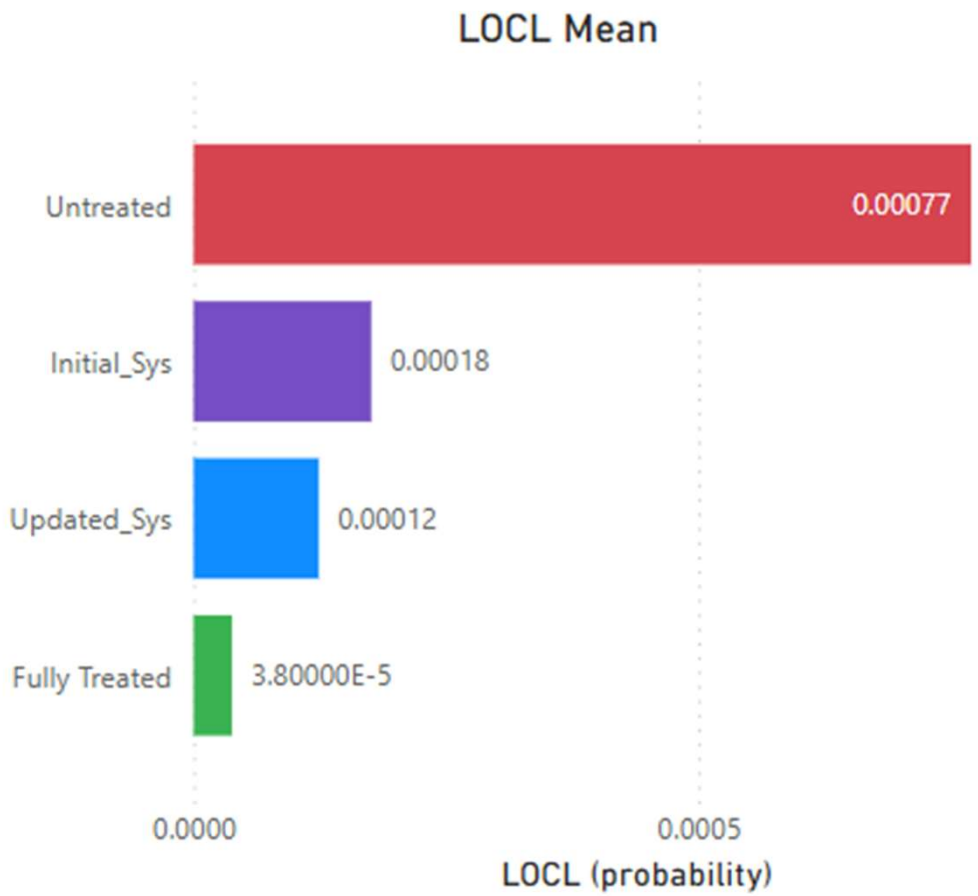
Final Medical System Performance - TTL



Final Medical System Performance - RTDC



Final Medical System Performance - LOCL



Future Work

Future Work

Validate Generated Baseline Systems:

- Test performance of Baseline system against optimized system
  - Determine that translation produces reasonable and realistic modeled health outcomes
- Notional Artemis III-like Baseline (includes HLS segment with EVAs)
  - Test across multiple Artemis-like DRMs to demonstrate generalizability

Unique/Experimental Resources:

- Potentially substituted for most similar resource native to IMPACT MD
  - New Lockdown, adjusting mass/volume, treatment expectations
- Potentially introduced into IMPACT MD
  - New Lockdown, likely as alternate in associated capabilities

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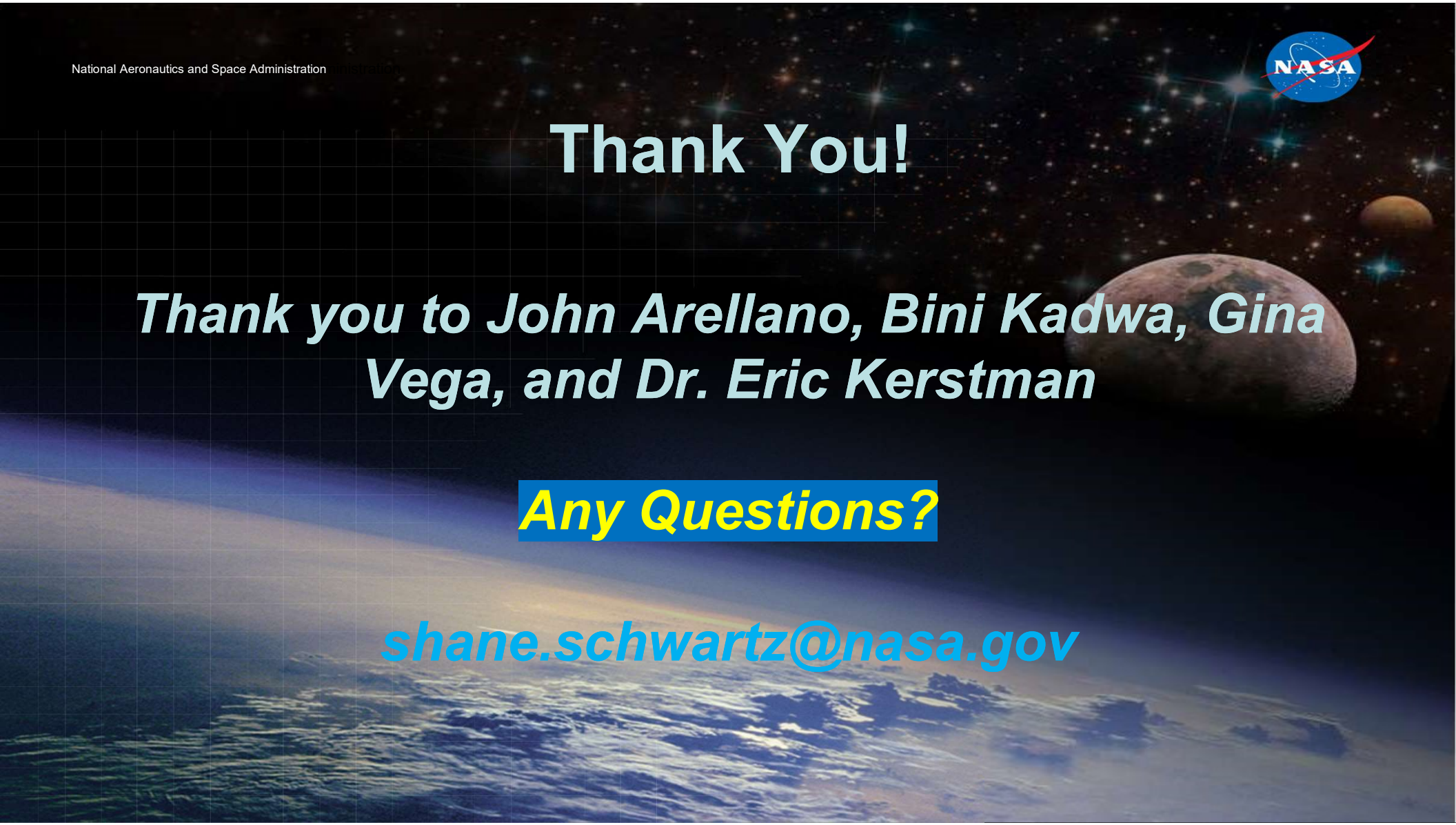

Thank You!

Thank you to John Arellano, Bini Kadwa, Gina Vega, and Dr. Eric Kerstman

Any Questions?

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BACKUP:

Risk Metrics – IMPACT vs IMM

IMM Risk Metrics	IMPACT Risk Metrics	Functional Definition	Methodology Differences
Quality Time Lost **(QTL)**	Task Time Lost **(TTL)**	Time detriment due to health impairment	Source Data Set
EVAC	**RTDC**	Need for higher level of care	EVAC = *end of mission* (affected indiv.) RTDC = *flag* (affected indiv. stays in mission)
Crew Health Index **(CHI)**	Crew Task Index **(CTI)**	% of time crew is healthy enough to complete tasks	CHI calculated from QTL; CTI calculated from TTL
Loss of Crew Life **(LOCL)**	Loss of Crew Life **(LOCL)**	Probability of crew death	No significant difference

Comparisons will focus on CHI/CTI and LOCL as methodology most consistent between models

IMM versus IMPACT – A New Way to Predict

IMM *(iMED + IMM)*

- Integrated Medical Evidence Database (iMED): Baselined to ISS missions and resources
- 280 unique resources
  - 250 available to Baseline Branch
- 100 distinct medical conditions

IMPACT *(MD + MEDPRAT)*

- Medical Database (MD): Baselined to Exploration missions and resources
  - Includes Evidence Library (EvLib) and Medical Item Database (MedID)
- 900 unique resources
  - 842 available to Baseline Branch
- 119 distinct medical conditions

IMM versus IMPACT Resource Handling – IMM (IMed)

- Capabilities are not mapped to conditions
  - Relevant Knowledge, Skills, Abilities (KSA) always assumed
- Resources tracked at individual resource level, not bundled
- Partial weighting for all available essential resources, regardless of related items
- Alternative resources only considered for pharmaceuticals

The Resource Table (RT)

Resource	Units Required Best Case	Units Required Worst Case	Units Available At Start Of Mission	Consumable	Essential	Rationale
BZK wipes	0	2	60	Yes	No	Cleanse skin for IV insertion.
CMRS	0	1	1	No	No	For crew safety during procedures.
Dilaudid (Hydromorphone) 2mg/mL, 1mL syringe	0	4	18	Yes	Yes	Pain relief.
Ertapenem 1gm	0	1	6	Yes	Yes	Antibiotic
Hot and Cold Pad	0	1	1	No	No	Pain relief.
IV administration set	0	1	3	Yes	Yes	Administration IV fluids
IV Cap	0	1	5	Yes	No	IV administration
IV Catheter (18G, 20G, or 22G)	0	1	14	Yes	Yes	IV fluid administration
IV Fluid 1L (1000mL)	0	2	5	Yes	Yes	IV fluid.

^Resource Table for Abdominal Wall Hernia

Modeling Conditions & Treatments in IMM & IMPACT

Risk Metrics – IMPACT vs IMM

Crew Task Index and Crew Health Index are similar in that they both are based on time loss from impairment divided by total mission duration, giving a percentage that represents how functional the crew is.

- Crew Task Impairment (CTI) is an IMPACT metric that measures the percentage of the availble crew time when the crew is healthy enough to perform tasks. Task Time Lost (TTL) represents the amount of time that the crew is functionally impaired and cannot perform tasks.

$$\text{CTI (\%)} = \left(1 - \frac{TTL}{mission\ duration\ x\ number\ of\ crew}\right) * 100$$

- Crew Health Index (CHI) is an IMM metric that measures the percent quality adjusted time and is calculated by using mission length *L* and total Quality Time Lost (QTL) by crew members.

$$\text{mCHI (\%)} = \left(1 - \frac{mQTL}{L}\right) * 100$$

TTL and QTL are more aptly described as task time affected, as crew members are not completely incapacitated

IMM versus IMPACT Resource Handling

IMM

- Capabilities are not mapped to conditions
- Resources tracked at individual resource level, not bundled
- Partial weighting for all essential resources, regardless of related items
- Alternative resources only considered for pharmaceuticals

IMPACT

- Treatment Capabilities mapped to conditions
  - Capability Resource Tables (CRTs)
  - CP1 - Diagnosis, CP2 - Treatment
- Resources are bundled within capabilities
  - Absolute vs Alternate bundles
- Scope of Partial weighting more restricted to follow treatment logic
- Alternative resources considered for all resource types

Medical System Translation Process

Iterative Approach

1) Generate spreadsheet w/ columns for:
   a. Requested resource name,
   b. Equivalent resource(s) in IMPACT,
   c. IMPACT Mass and Volume,
   d. Requested resource quantity,
   e. Adjusted quantity in IMPACT,
   f. Total resource Mass and Volume
2) Search current IMPACT MD for equivalent resources
3) For resources without direct equivalents, label with issue code to indicate reason for missing equivalence
4) Confer with Clinicians/SMEs to resolve/update issue codes, support corresponding equivalence or defend exclusion of resource from new system
   a. Identify substitute based on purpose, resource type, target area/delivery vehicle
5) Repeat 2-4 until all resource equivalents confirmed

a	b	c / c	d	e	f / f	
Orion_Resource_Name	IMPACT_EQUIVALENT	Mass	Volume	Orion_Initial_	Updated_Qua	Total Ma	Total Volun
Acetaminophen (Tylenol)	Pharmaceutical - Oral - Acetaminophen 500mg	0.00063	0.70573	50	50	0.0315	35.2865
Amoxicillin (Amoxil)	Pharmaceutical - Oral - Antibiotics - Amoxicillin 500mg	0.00062	0.97193	20	20	0.0124	19.4386
Aspirin	Pharmaceutical - Oral - Aspirin 81mg	0.00018	0.14691	30	30	0.0054	4.4073
Bisacodyl (Dulcolax)	Pharmaceutical - Oral - Bisacodyl 5mg	0.00014	0.09856	16	16	0.00224	1.57696
Bismuth Subsalicylate (Pepto Bismol)	Pharmaceutical - Oral - Bismuth Subsalicylate 262mg Tablet	0.00187	2.25561	12	12	0.02244	27.06732
Caffeine (Vivarin)	*Pharmaceutical - Oral - Caffeine 300mg*	0.00049	0.53727	24	16	0.00784	8.5963216
Cefdinir (Omnicef)	*Pharmaceutical - Oral - Antibiotics - Cefdinir 600mg*	0.0006	0.927752	20	10	0.006	9.277516
Cephalexin (Keflex)	*Pharmaceutical - Oral - Antibiotics - Cephalexin 500mg*	0.0006	0.92775	36	18	0.0108	16.6995
Clindamycin (Cleocin)	Pharmaceutical - Oral - Antibiotics - Clindamycin 300mg	0.00062	0.97193	21	21	0.01302	20.41053
Diazepam (Valium)	Pharmaceutical - Oral - Diazepam 5mg	0.00023	0.21112	7	7	0.00161	1.47784
Diltiazem (Cardizem)	XX -- IMPACT LD150 only includes Intravenous Diltiazem			4	4	0	0
Diltiazem LA (Cardizem LA)	XX -- IMPACT LD150 only includes Intravenous Diltiazem			30	30	0	0
Diphenhydramine (Benadryl)	Pharmaceutical - Oral - Diphenhydramine 25mg	0.00037	0.356374	28	28	0.01036	9.9784832
Doxycycline (Vibramycin)	Pharmaceutical - Oral - Antibiotics - Doxycycline 100mg	0.0006	0.92775	20	20	0.012	18.555
Famotidine (Pepcid)	Pharmaceutical - Oral - Famotidine 20mg	0.00023	0.21112	10	10	0.0023	2.1112
Fexofenadine (Allegra)	YY -- Not included in LD150 Resource list			20	20	0	0
Flecainide (Tambocor)	YY -- Not included in LD150 Resource list			40	40	0	0
Fluconazole (Diflucan)	Pharmaceutical - Oral - Antibiotics - Fluconazole 150mg	0.00035	0.36367	3	3	0.00105	1.09101
Hydrocodone and Acetaminophen (Vicodin)	WW -- Orion group specified 5mg/300mg tablet			36	36	0	0
Ibuprofen (Motrin)	Pharmaceutical - Oral - Ibuprofen 400mg	0.00079	0.91287	80	80	0.0632	73.0296
Loperamide (Imodium)	Pharmaceutical - Oral - Loperamide 2mg	0.00039	0.39584	16	16	0.00624	6.33344
Lorazepam (Ativan)	Pharmaceutical - Oral - Lorazepam 1mg	0.00018	0.14691	15	15	0.0027	2.20365
Meclizine (Antivert)	Pharmaceutical - Oral - Meclizine 25mg	0.00034	0.34939	10	10	0.0034	3.4939
Metronidazole (Flagyl)	Pharmaceutical - Oral - Antibiotics - Metronidazole 500mg	0.00049	0.53043	20	20	0.0098	10.6086
Modafinil (Provigil)	*Pharmaceutical - Oral - Modafinil 100mg*	0.00023	0.21112	10	20	0.0046	4.2224

Issue Codes

Code	Definition	Priority	Solution(s)
QQ	Multiple close equivalents (binary)	3	Identify options, consult clinicians/SMEs to confirm best equiv.
WW	Incompatible dosage/quantity	4	A – same med. diff. conc. – adjust quantity to match total concentration of original resource
			B – diff. medication – adjust quantity to match number of doses of original resource
XX	Multiple indirect equivalents	2	Identify best suited replacement based on purpose/use case, consult EvLib for intended capability; match delivery method if possible
YY	No equivalent in IMPACT MD	1	Refer to intended use/coverage from purpose, confer with clinicians/SMEs to identify options or support exclusion from new kit
ZZ	Requested resource unclear	1	*See Solution for YY*
E	Extraneous	3	Resources either unique to sampled mission, or without use should be excluded from new kit
D	Repeated resource/equivalent	5	Combine duplicate instances into single entry

Final Product – One Excel Workbook, Three Spreadsheets

Kit_Equivalents

Original medical system, organized similar to customer version

Includes Columns:

1) Original resource
2) Original dosage/concentration
3) Equivalent in IMPACT
4) Equivalent Mass, Volume
5) Original system quantity
6) IMPACT system Quantity
7) Total Mass, Volume for each resource

IMPACT_Equivalents

Equivalent medical system, alphabetical (repeat resources grouped together)

Includes Columns:

1) Original resource
2) Equivalent in IMPACT
3) Equivalent Mass, Volume
4) IMPACT system Quantity
5) Total Mass, Volume for each resource

IMPACT_Resources

Similar to Available_Resource file passed into IMPACT to run model

Includes Columns:

1) Resource in IMPACT (single instance)
2) Consumable vs Non-Consumable
3) Single Item Mass, Volume
4) IMPACT system Quantity
5) Total Mass, Volume for each resource

All instances of a resource are totaled into one entry per item

Each sheet also shows total quantity of items included, total mass, volume of equivalent system

National Aeronautics and Space Administration

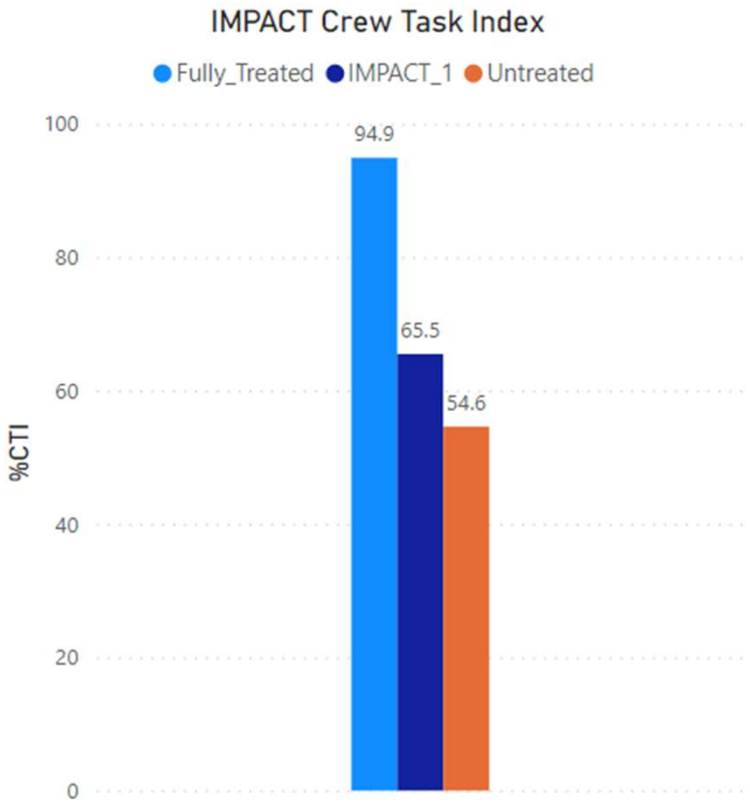
ISS Medical System

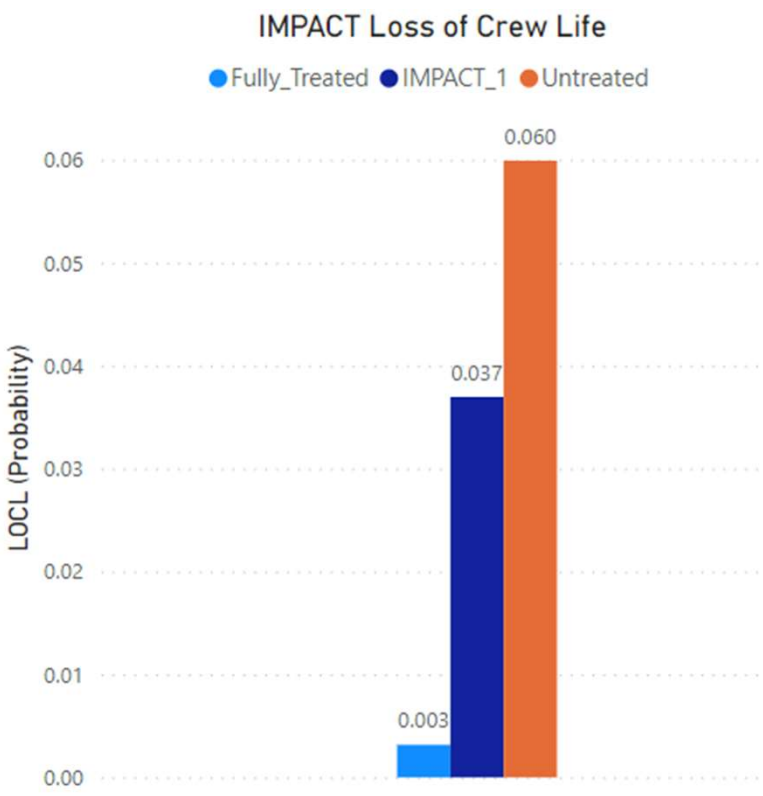
ISS Medical System Timeline

- **3/12 – Received initial version of ISS System**
  - Taken from iMED (IMM), Lockdown 68 ISS Baseline
- **Meetings:**
  - Weekly with clinicians to resolve challenges, specific resource questions
  - Less individual work, more collaboration/meeting time
- **6/18 – Final version delivered**
- **Time Invested:**
  - 20 days over 3 calendar months (deprioritized for 6 weeks, inconsistent access to MD/EvLib)
  - About 70 hours total investment

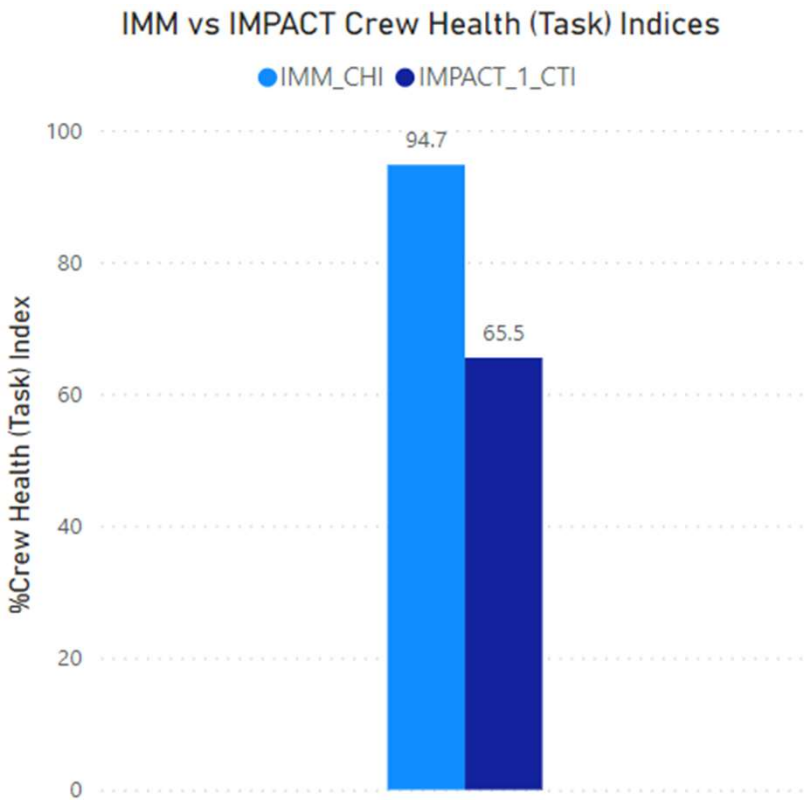
System:	ISS	IMPACT
M (kg)	121.56	88.08
V (mL)	437000	222991
I (#)	5514	5529

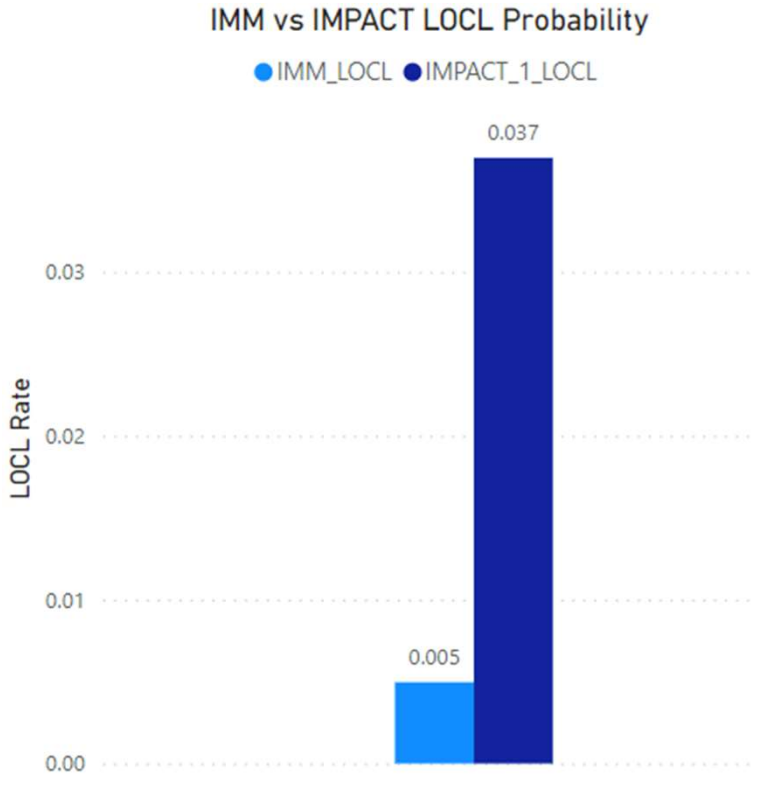
First Iteration Results – IMPACT vs IMPACT





First Iteration Results – IMM vs IMPACT





ISS Translation – Medical System Differences

- **LifePak and Other Large Devices**
  - LifePak+Power Supply (-16.7kg, -42000mL)
    - One instance used in place of: AED, Blood Oximeter, BP, ECG, EtCO2
  - Ultrasound (-5.7kg, -17020mL)
  - Ventilator (+3.5kg, +5000mL)
  - Suction Device (+5kg, +17000mL)

System:	IMM	T_1	T_2
M (kg)	121.56	86.87	90.07
V (mL)	437238	223815	227207
I (#)	5519	5530	5567

- **Modified Resource Quantities**
  - Several resources unique to each model
  - Adjusted pharmaceutical quantities relative to concentration differences
  - Removed resources which could not be translated (conditions/capabilities not modeled)

- **Updates to Medical Database**
  - Some IMM resources modeled as IMPACT capabilities
  - Changes to masses/volumes between medical databases accounts for 19.88kg, 163500mL

ISS Medical System – Second Iteration

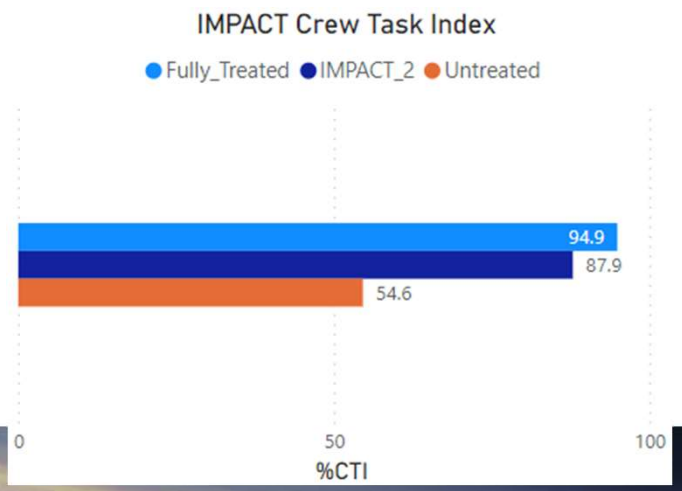
Representation of IMM medical system in IMPACT MD environment

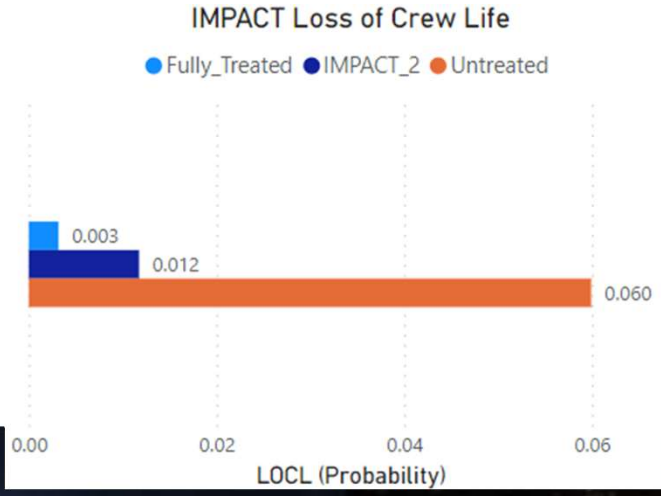
- Additional consideration given to:
  - Massless resources
  - Unique + essential item CRTs (substituting for iMED resources; e.g. LifePak)
  - Resource quantity relative to dosage size (parcel quantity)

Improved Performance

- Better adapted to complex nature of IMPACT
- Performance closer to expectations

System:	IMM	IMPACT_2
M (kg)	121.56	90.07
V (mL)	437238	227207
I (#)	5514	5567

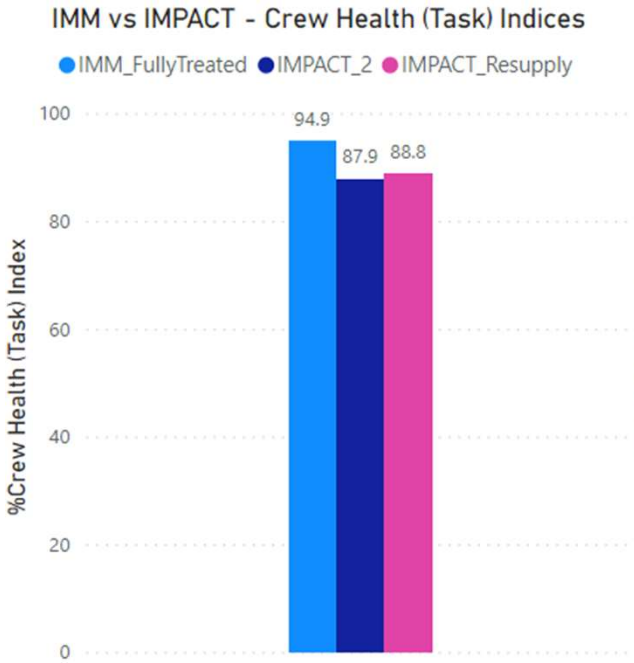


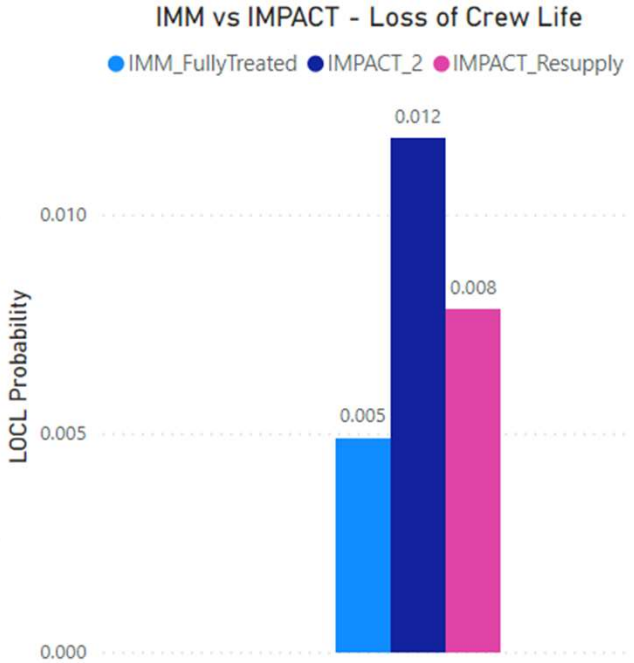


ISS Medical System – Second Iteration RESUPPLY

Test included a "resupply" run

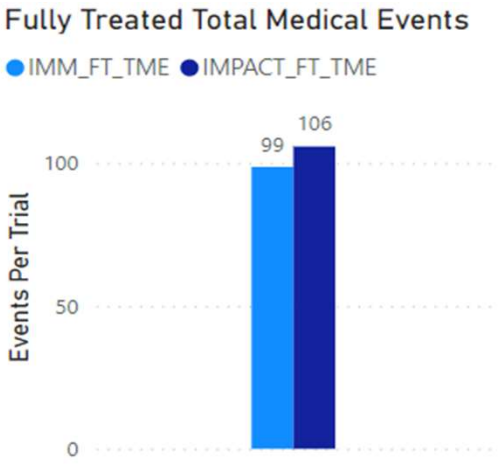
- Simulates fully treated run, restricted to ISS resources
- Performed similarly well to constrained ISS medical system
- Conditions addressed by ISS medical system handled adequately

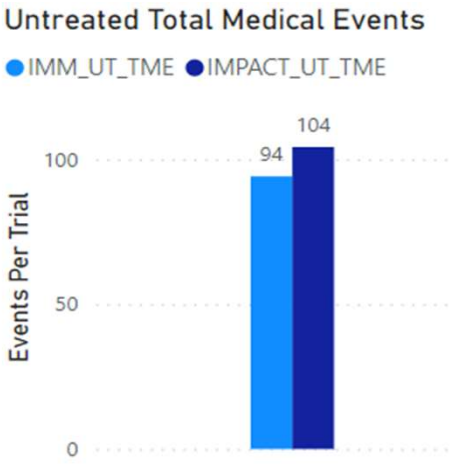


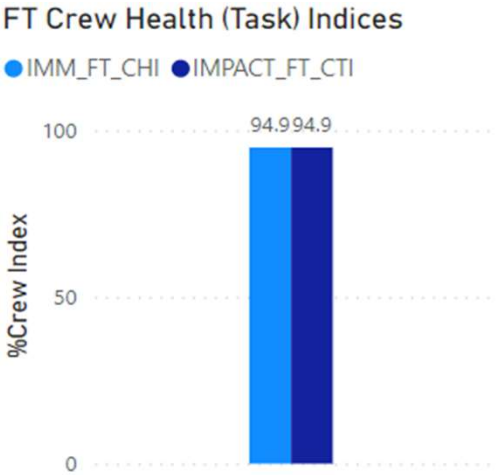


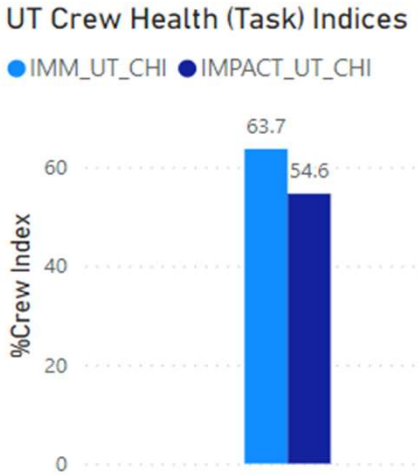
System:	IMM	IMPACT_2
M (kg)	121.56	90.07
V (mL)	437238	227207
I (#)	5514	5567

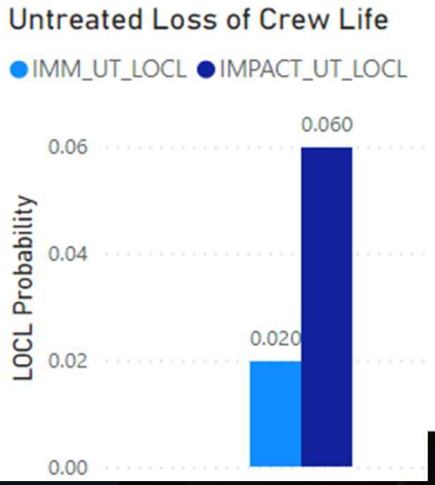
IMM vs IMPACT – Bounding – Fully Treated and Untreated Results











Artemis II Medical System

Received: 2/1
Final Deliverable: 4/18

Total Time Invested:
- 25 working days
- 100 hours invested

Artemis Medical System Timeline

- **2/1 – Received initial version of Artemis II System**
  - Received from Medkit SE Team
  - Similar to Inventory/Packing list in Excel
    - Lacked information on resource mass/volume, conditions, capabilities
- **Meetings:**
  - Weekly with clinicians to resolve challenges, specific resource questions
  - One follow up meeting with SE Team
- **4/18 – Final version delivered**
- **Time Invested:** More final versions required less individual work, more collaboration/meeting time
  - 25 days over 2.5 calendar months
  - About 100 hours total investment

System:	Art. II	IMPACT
Mass (kg)	13.6	21.66
Vol. (mL)	18288	67165
Items (#)	1220	1168

Artemis II System – Key Differences

- **LifePak and Other Large Devices**
  - LifePak + Power Supply (10.4kg, 33202 mL) for small ECG, BP monitor
  - POC UA device (0.18kg, 278 mL) for urinalysis chart
- **Changes to Modeling Treatments**
  - Two resources to model one treatment item
    - Gauze + tape for Bandaids; Betadine + swab for premade iodine swabs
- **Changes to Resource Quantities**
  - Removed resources which could not be manifested, not mapped to conditions (E – Extraneous)
  - Adjusted pharmaceutical quantities when modeling different concentrations (WW – Weighting)
  - Expanded resources listed based on CRT bundles, itemized lists for "kits"

System:	Art. II	IMPACT
M (kg)	13.6	21.66
V (mL)	18288	67165
I (#)	1220	1168

Challenge to identify exact differences w/o individual resource mass/volume for original system

TTL – Conditions Driving RTDC and LOCL

Condition Name	Data Identifier	TTL - Mission (Person Day)
ICL48_Eye Foreign Body	FullyTreated	0.042833
	Translated_Final	0.055570
	Translated_ZMPQ	0.063752
ICL82_Respiratory Tract Infection - Upper	FullyTreated	0.030250
	Translated_Final	0.037968
	Translated_ZMPQ	0.041269
ICL98_Space Adaptation - Urinary Retention	FullyTreated	0.008062
	Translated_Final	0.012502
	Translated_ZMPQ	0.012703