

# The Future of Integrated Performance Modeling in the Crew Health and Performance Probabilistic Risk Assessment Project

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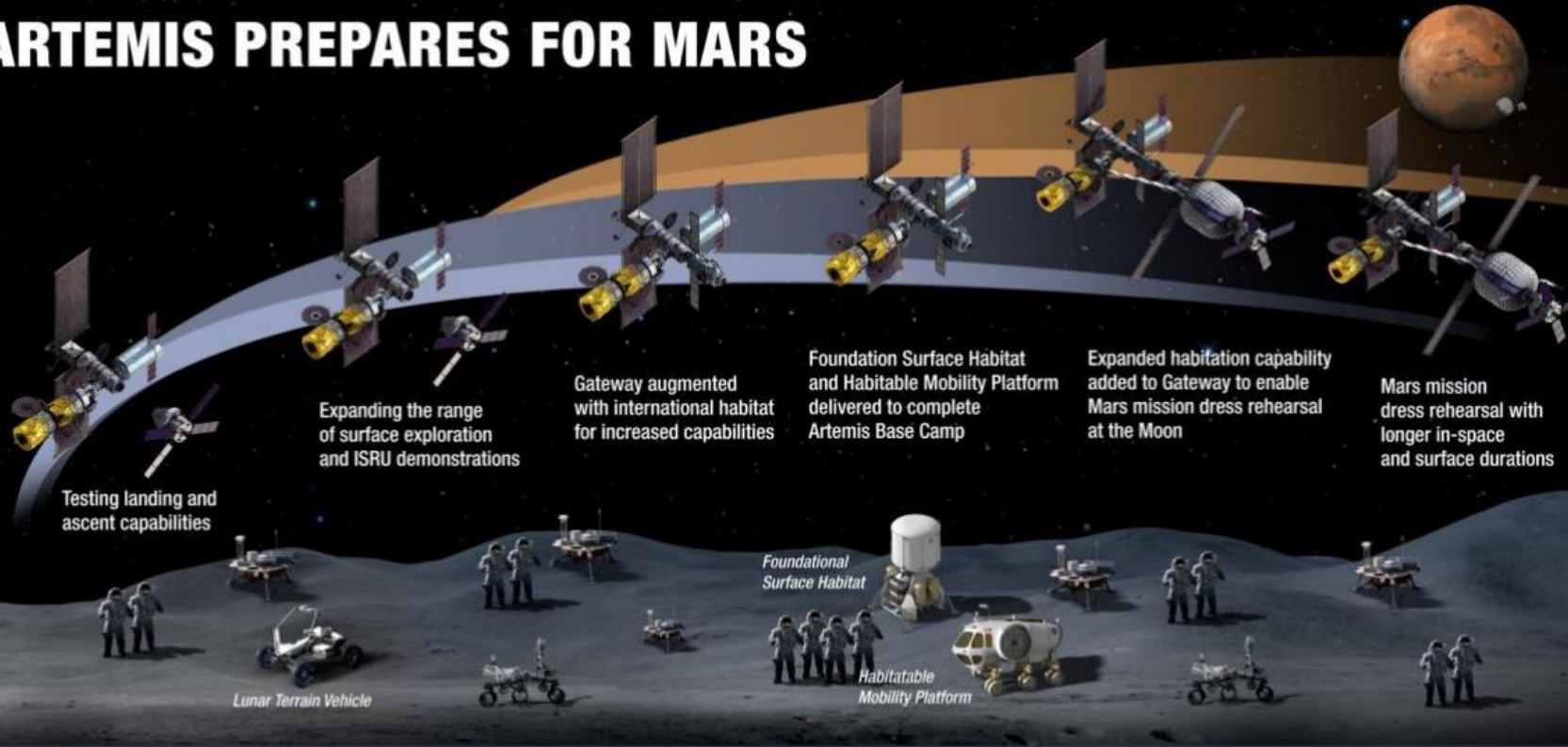
NASA Glenn Research Center, Cleveland, OH





# Crew Health and Performance Challenges for Exploration Missions

## ARTEMIS PREPARES FOR MARS



### SUSTAINABLE LUNAR ORBIT STAGING CAPABILITY AND SURFACE EXPLORATION

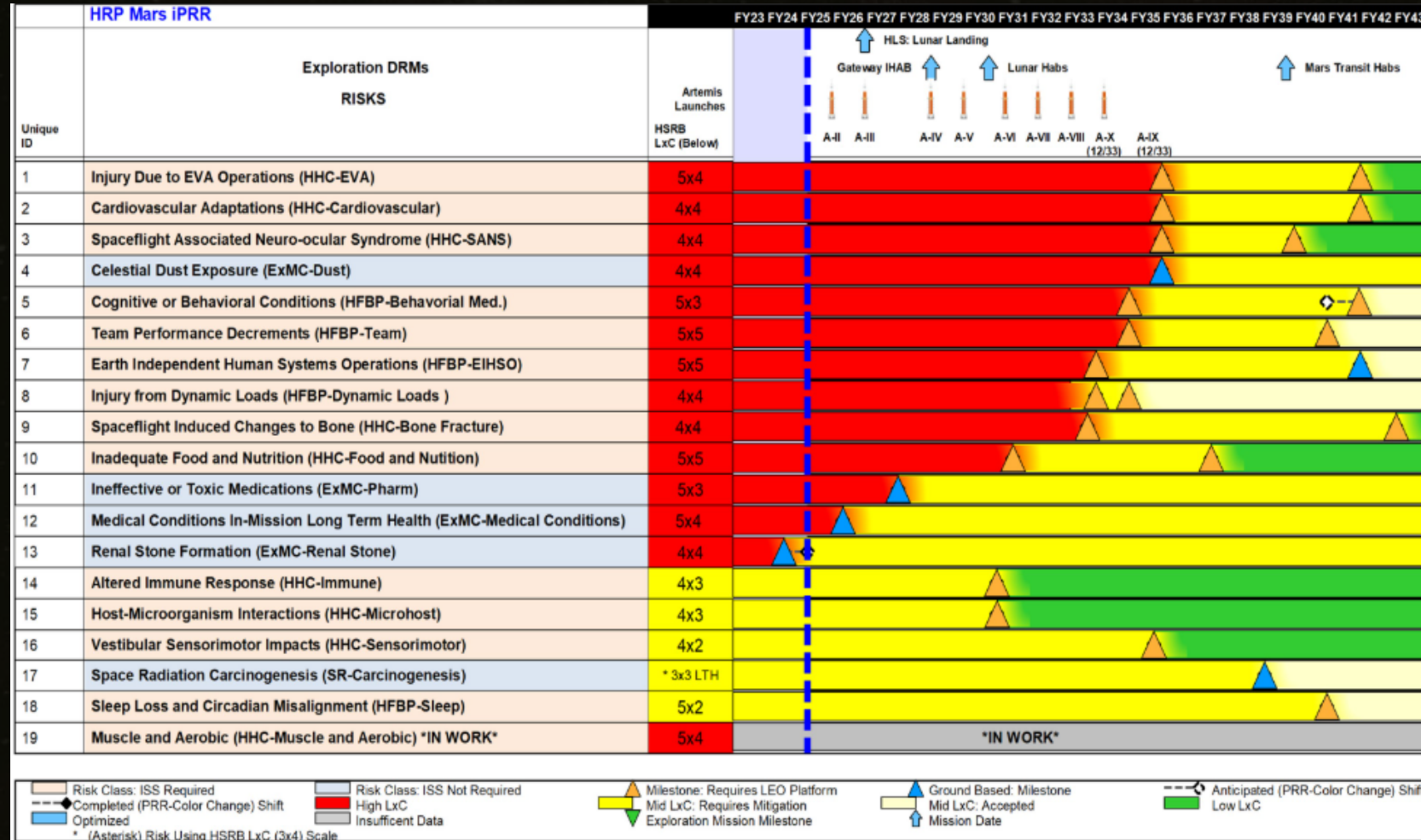
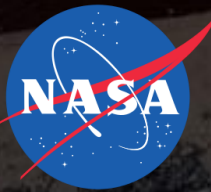
MULTIPLE SCIENCE AND CARGO PAYLOADS | INTERNATIONAL PARTNERSHIP OPPORTUNITIES | TECHNOLOGY AND OPERATIONS DEMONSTRATIONS FOR MARS



NASA's Plan for Sustained Lunar Exploration and Development  
[https://www.nasa.gov/wp-content/uploads/2020/08/a\\_sustained\\_lunar\\_presence\\_nspc\\_report4220final.pdf?emrc=5aa8ef](https://www.nasa.gov/wp-content/uploads/2020/08/a_sustained_lunar_presence_nspc_report4220final.pdf?emrc=5aa8ef)



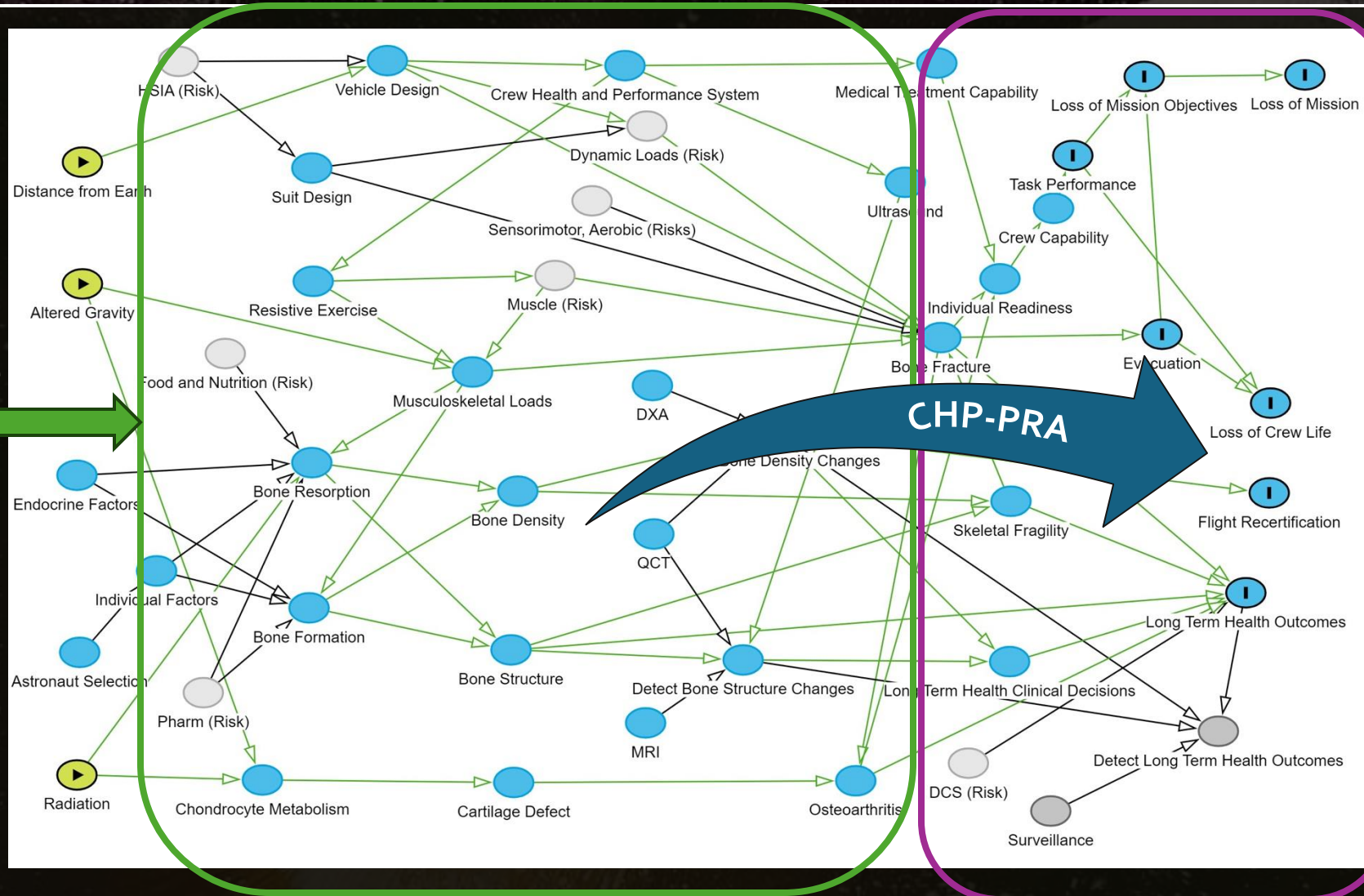
# Human Health and Performance Research





# CHP-PRA Motivation

Crew Health and Performance – Probabilistic Risk Assessment



Research/  
engineering data &  
domain knowledge

Metrics used by  
decision makers



# CHP-PRA Motivation

## What We Have

Spaceflight Data  
Research Data  
Terrestrial Analogs  
Domain Knowledge  
Engineered Systems and Functions  
Understanding of System Interactions



## PRA Mission Simulation

Integrate Data  
Capture Interactions  
Propagate Uncertainty  
Represent Relationships and Dependencies  
Characterize Risk



## Operational Metrics

Best Guess Given Current Data and Knowledge  
Quantifiable, Reproducible Results  
Easily Updated as Better Understanding and Data Becomes Available  
Act as a Barometer for Significant Change and Effect  
Support Tool for HHP Community

## Don't Chase Perfect – Be Good Enough

# MEDPRAT

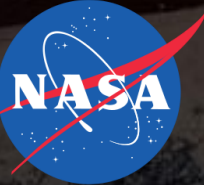
Medical Extensible Dynamic Probabilistic Risk Assessment Tool

- A computational PRA tool for quantifying *medical health*.
- An evolution of IMM (Integrated Medical Model) – shares the basic functionality of IMM, but with additional underlying software architecture and features/capabilities.
- In development from 2017 – 2022, releasing two major versions with the exploration version completed in 2022.
- Underwent independent technical review in Nov. 2022, investigative analyses performed for a variety of stakeholders.

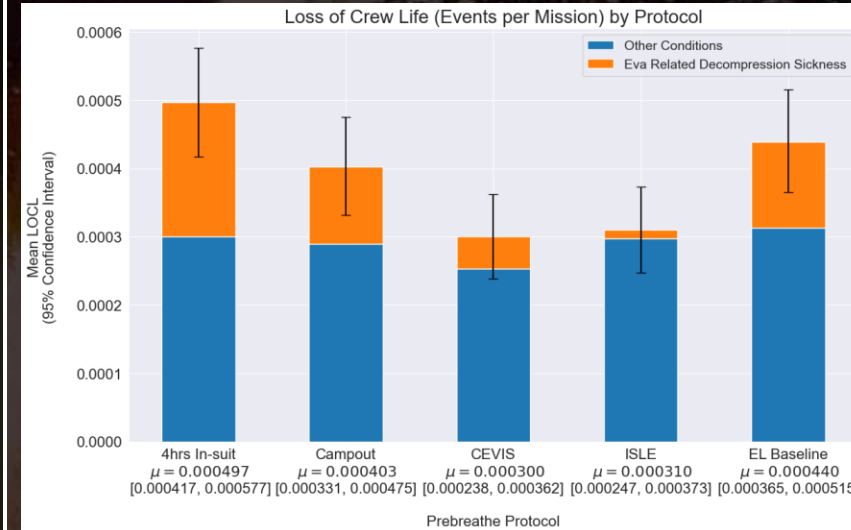
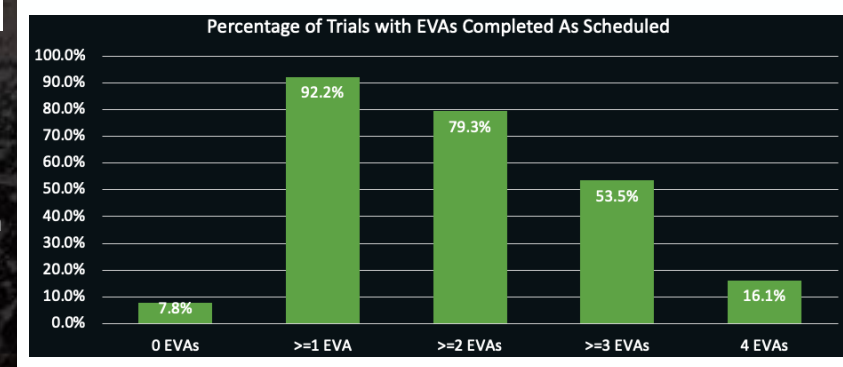


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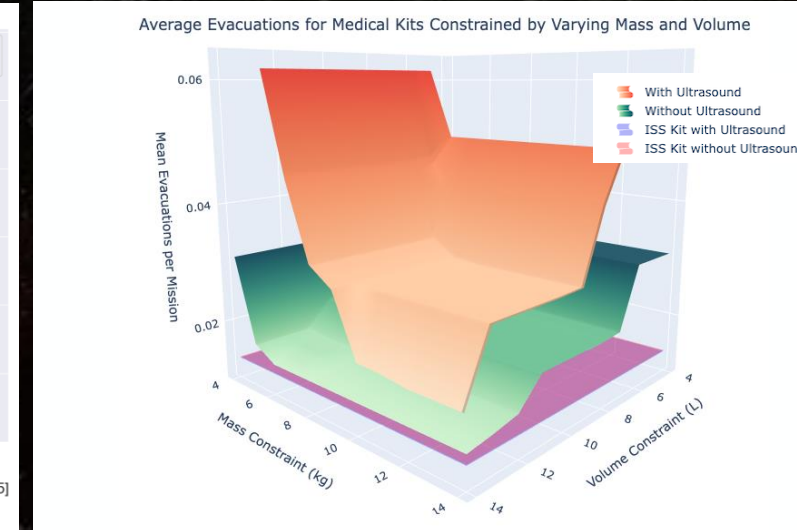
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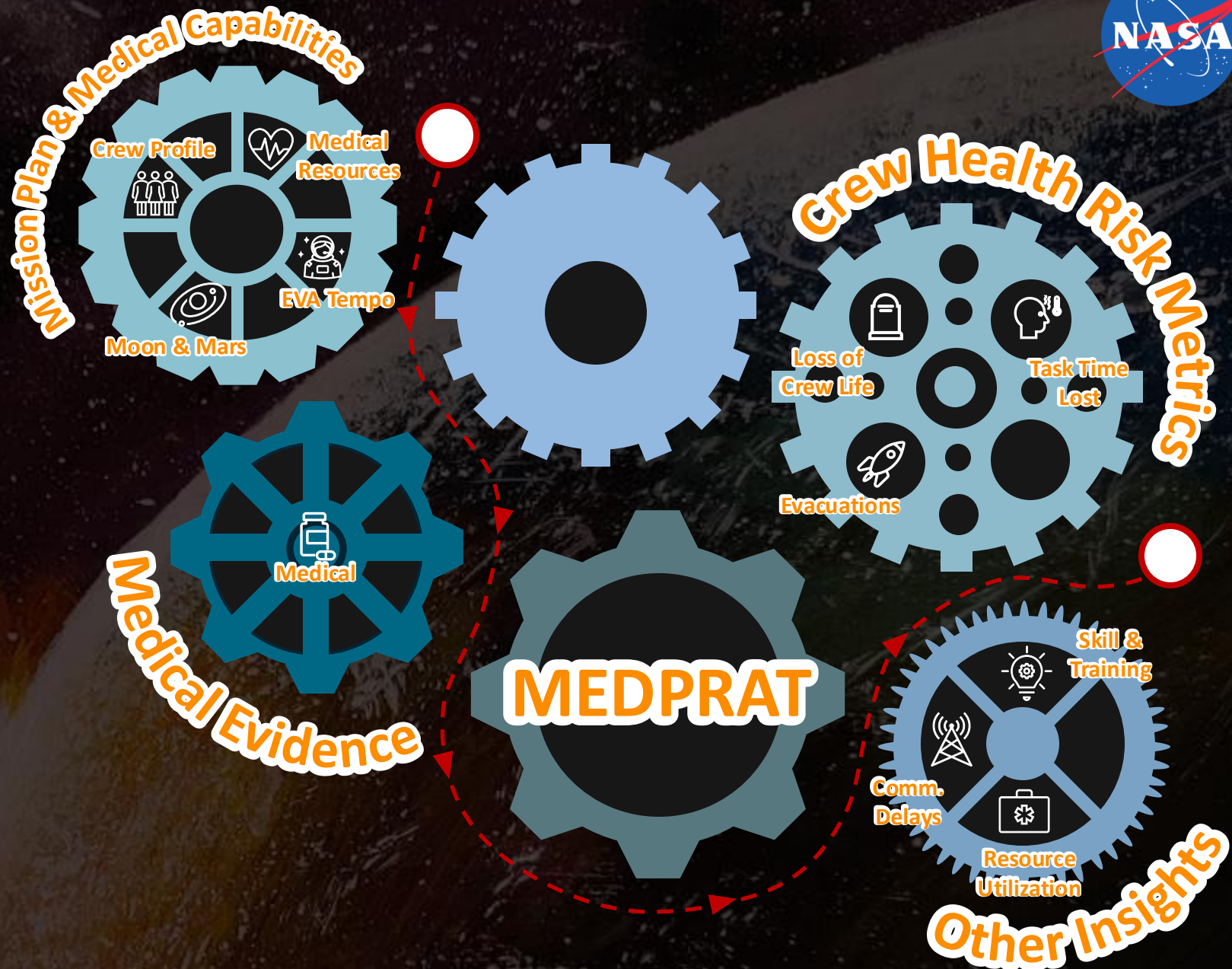
McIntyre, L., Leinweber, L., Myers, et. al., Novel Analytics and Parameter Space Estimations for Human Spaceflight Medical Risk with MEDPRAT V2.0: Leveraging Computational Efficiency. 2023 Human Research Program Investigators' Workshop, Galveston, TX, United States.

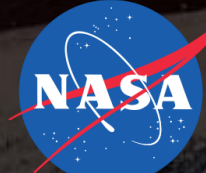
# MEDPRAT

Medical Extensible Dynamic Probabilistic Risk  
Assessment Tool



- Computational PRA tool to quantify *medical health*.
- Evolution of IMM (Integrated Medical Model) – same basic functionality + additional software architecture & features/capabilities.
- In development 2017 – 2022.
- 2 major versions. Exploration version completed in 2022.
- Underwent independent technical review in Nov. 2022, investigative analyses performed for a variety of stakeholders.





# +PRiSM

## Performance Risk Model

- In dev. computational model for quantifying performance.
- Initial version to merge data from:
  - Behavioral Health & Performance Lab
  - Exercise Physiology & Countermeasures Lab
  - Neuroscience Lab
  - Cardiovascular & Vision Lab.
- Proof-of-concept complete, looking to move to production development following technical review Q2 FY25.
- Future integration of other high-impact performance domains such as food & nutrition and sleep.

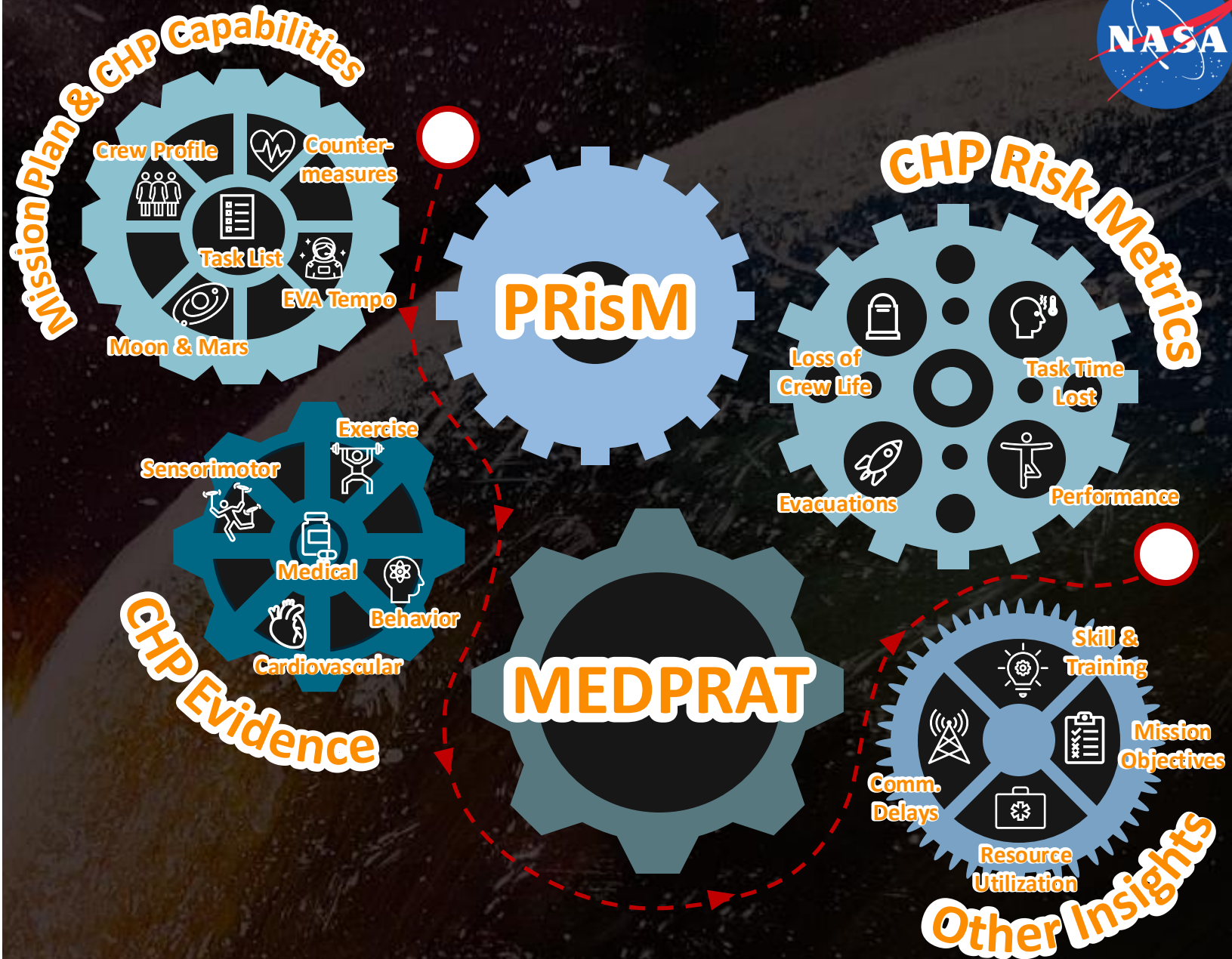


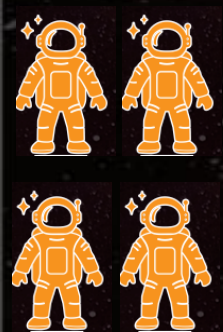
# CHP-PRA

MEDPRAT + PRisM



- Comprehensive mission risk estimates.
- Technical, cross-domain integration.
- Trade space analyses.
- Mission planning & decision support.
- Research prioritization.
- Risk buydown/color changes due to research investments.
- Characterizing and understanding complex mission scenarios.
- Insights into more nuanced human-focused Loss of Mission metric.



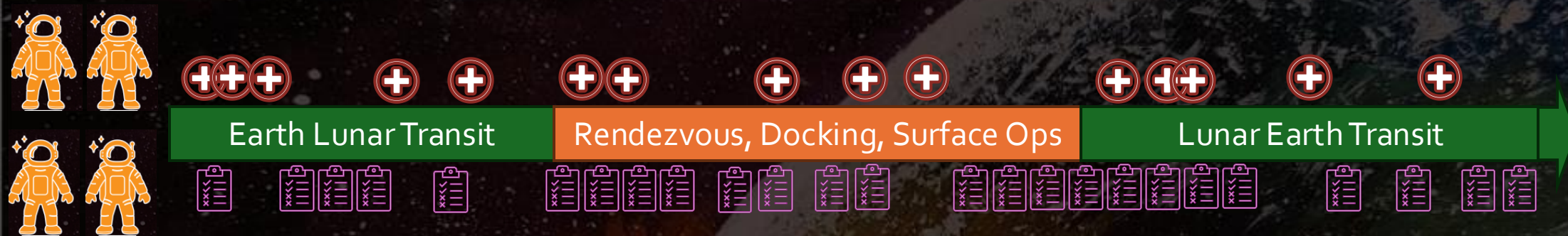


Earth Lunar Transit

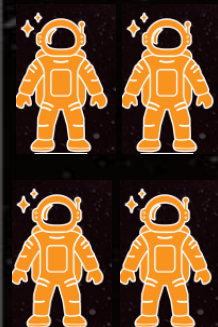
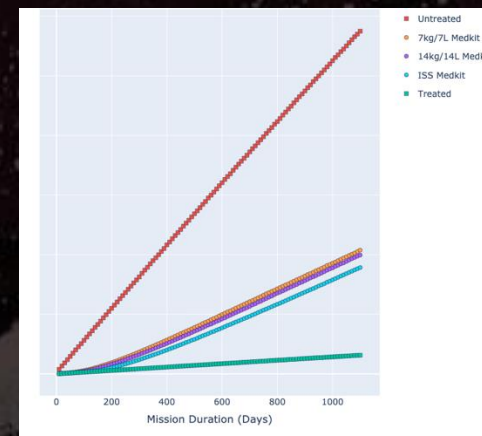
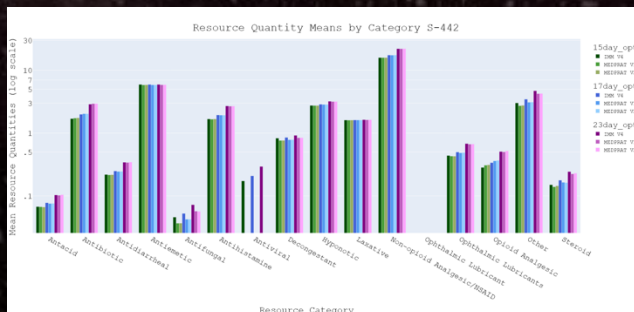
Rendezvous, Docking, Surface Ops

Lunar Earth Transit





# MEDPRAT



Earth Lunar Transit

Rendezvous, Docking, Surface Ops

Lunar Earth Transit



Task Time Lost



0

Loss of Crew Life



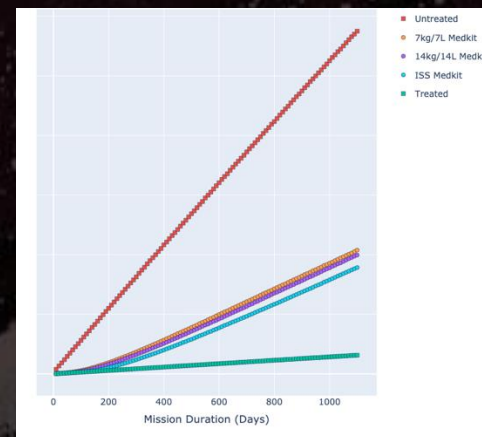
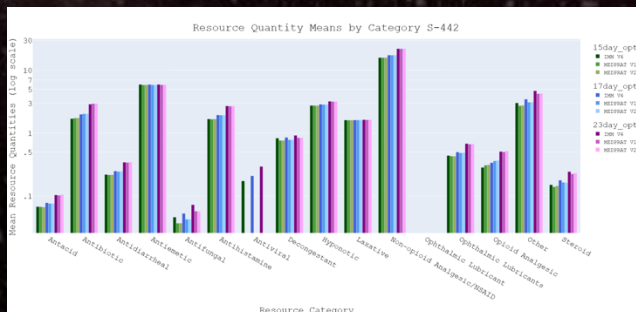
0

Evacuations



0

MEDPRAT



# CHP-PRA Metrics

Task Time Lost

0 s/step

Loss of Crew Life

0 b/yr

Evacuations

0 b/yr

Individual Readiness

100 %

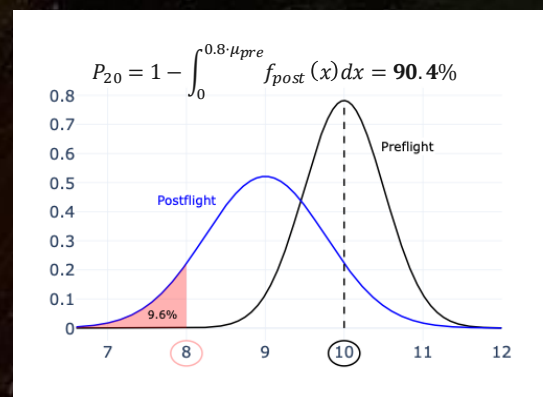
Task Performance

100 %

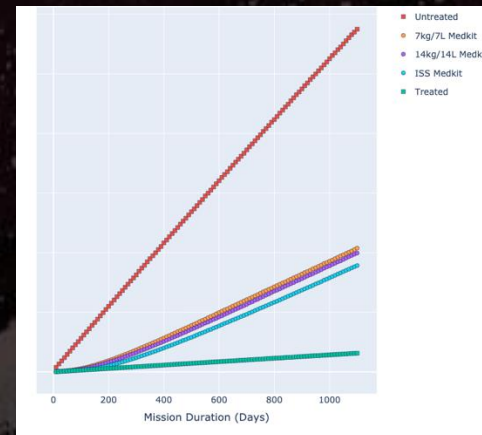
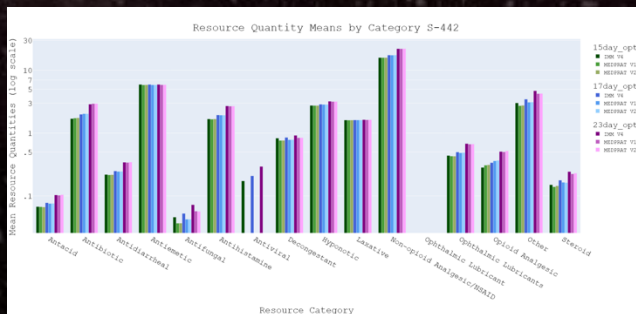
Earth Lunar Transit

Rendezvous, Docking, Surface Ops

Lunar Earth Transit



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## CHP-PRA Metrics

Task Time Lost

0.1 s/step

Loss of Crew Life

0 b/yr

Evacuations

0 b/yr

Individual Readiness

98 %

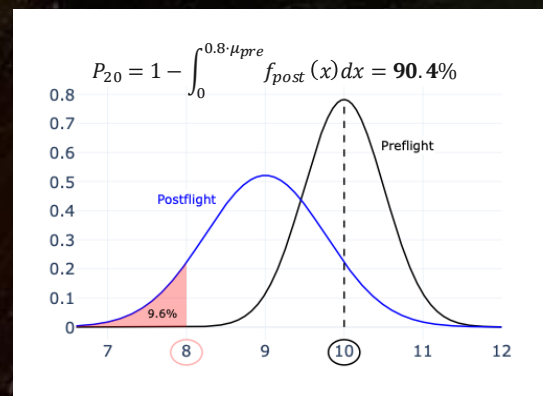
Task Performance

99.8 %

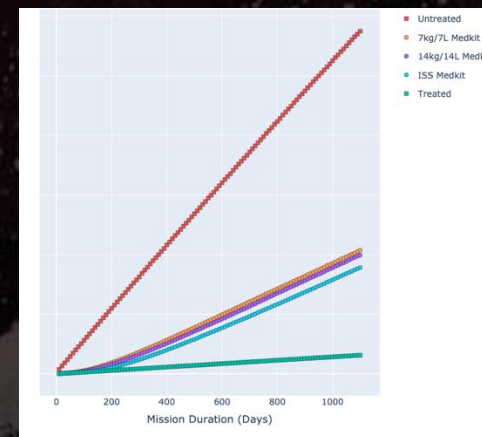
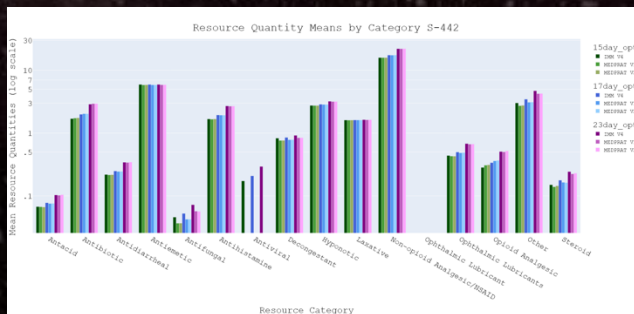
Earth Lunar Transit

Rendezvous, Docking, Surface Ops

Lunar Earth Transit



MEDPRAT



## CHP-PRA Metrics

Task Time Lost

0.4 s/step

Loss of Crew Life

0 b/yr

Evacuations

0 b/yr

Individual Readiness

98 %

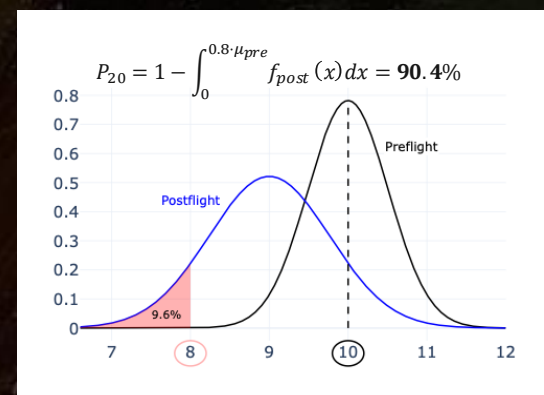
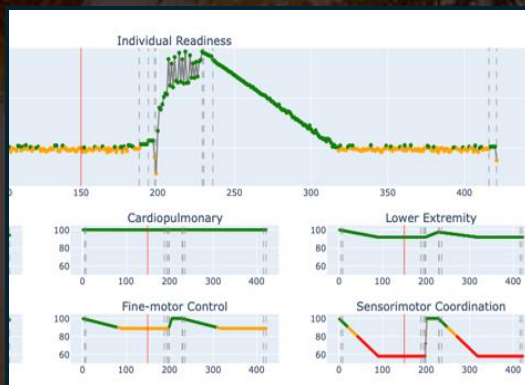
Task Performance

99.8 %

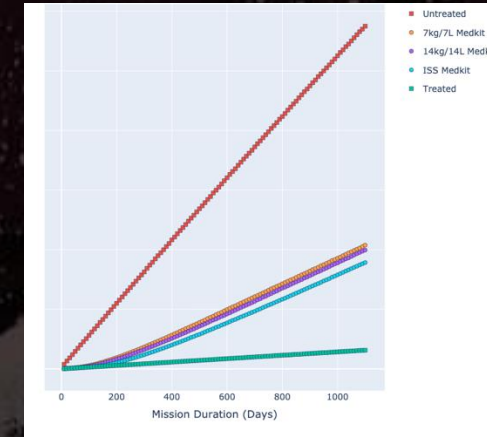
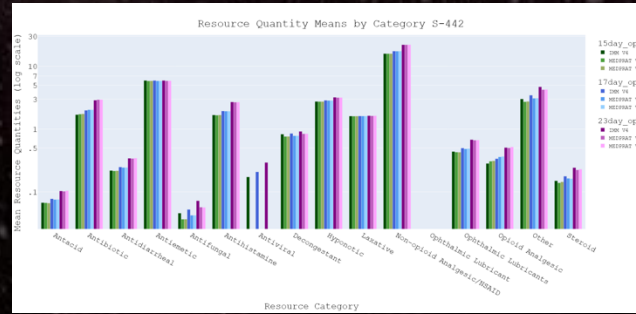
Earth Lunar Transit

Rendezvous, Docking, Surface Ops

Lunar Earth Transit



MEDPRAT



# CHP-PRA Metrics

Task Time Lost

0.4 s/step

Loss of Crew Life

0 b/yr

Evacuations

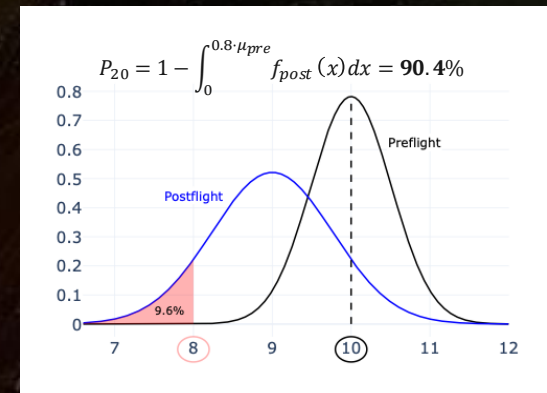
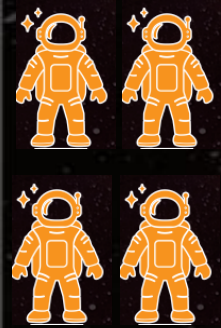
0 b/yr

Individual Readiness

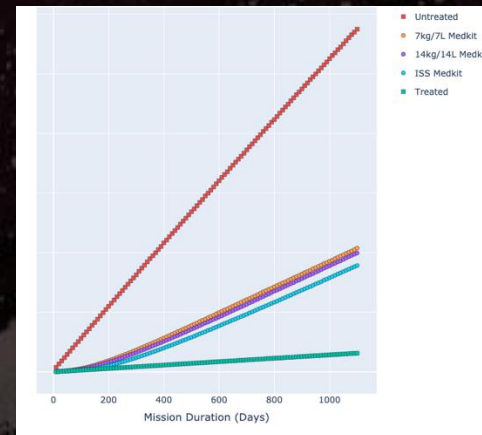
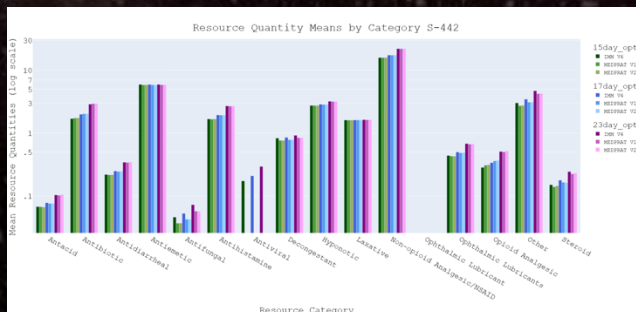
97.5 %

Task Performance

98.7 %



MEDPRAT



## CHP-PRA Metrics

Task Time Lost

6.2 s/step

Loss of Crew Life

0.01 b/yr

Evacuations

0.2 b/yr

Long Term Health/  
End of Mission  
Health Status

Individual Readiness

92 %

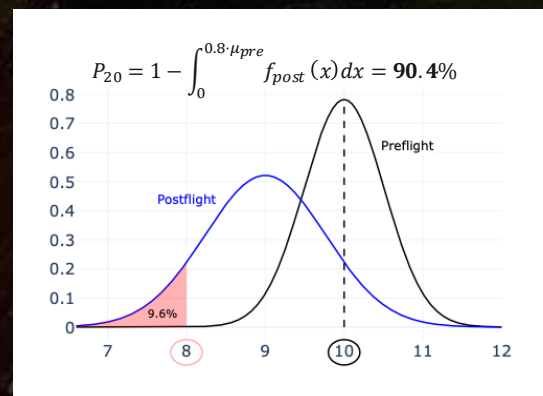
Task Performance

95.4 %

Earth Lunar Transit

Rendezvous, Docking, Surface Ops

Lunar Earth Transit





# Where can CHP-PRA provide insight?



How severely might the crew be impacted by communication delays and lack of ground support?

Which tasks have the highest likelihood of failure? What human systems drive that risk?

How have research investments bought down health and performance risk?

How does the CHP risk vary from Artemis II to Artemis III due to EVA Tempo?

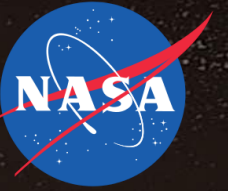
How does a reduced exercise capability impact the crew's health and their ability to successfully perform surface operations for Artemis vs Mars?

During which phases of the mission are the crew at the highest risk? What factors drive that risk?

How does individual readiness change throughout a mission?

What countermeasures best improve the chance that the crew can perform all scheduled EVA's?

**Provide the community with evidence-based insight into the factors, hazards, and capabilities that influence crew health and performance.**



Thank you

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Artwork by Dr. Mona Matar