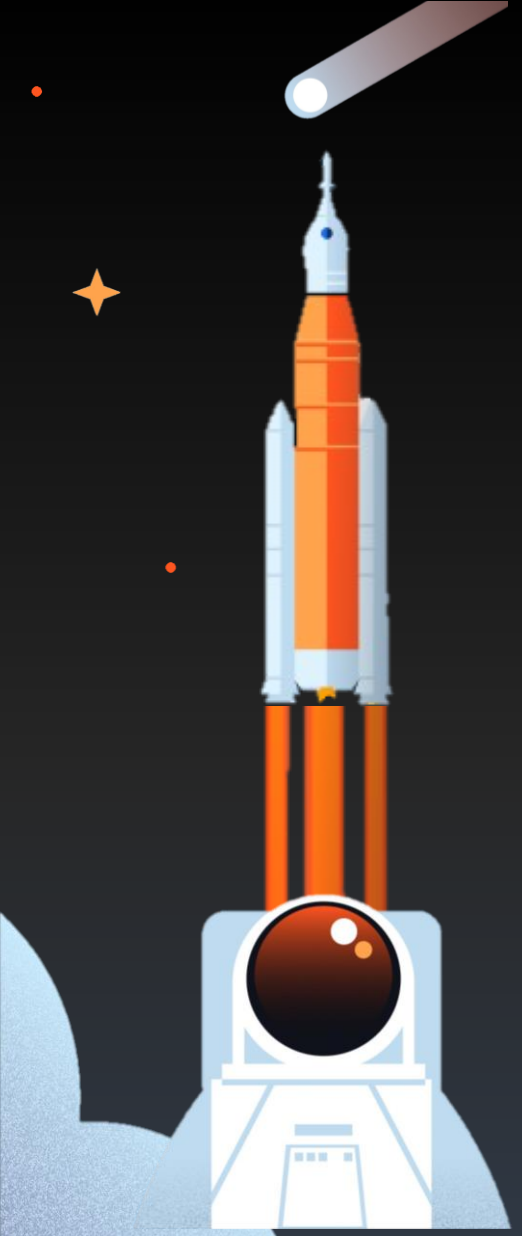

CHP-PRA PROOF-OF-CONCEPT [Simulation] SENSITIVITY ASSESSMENT

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2024 Human Research Program

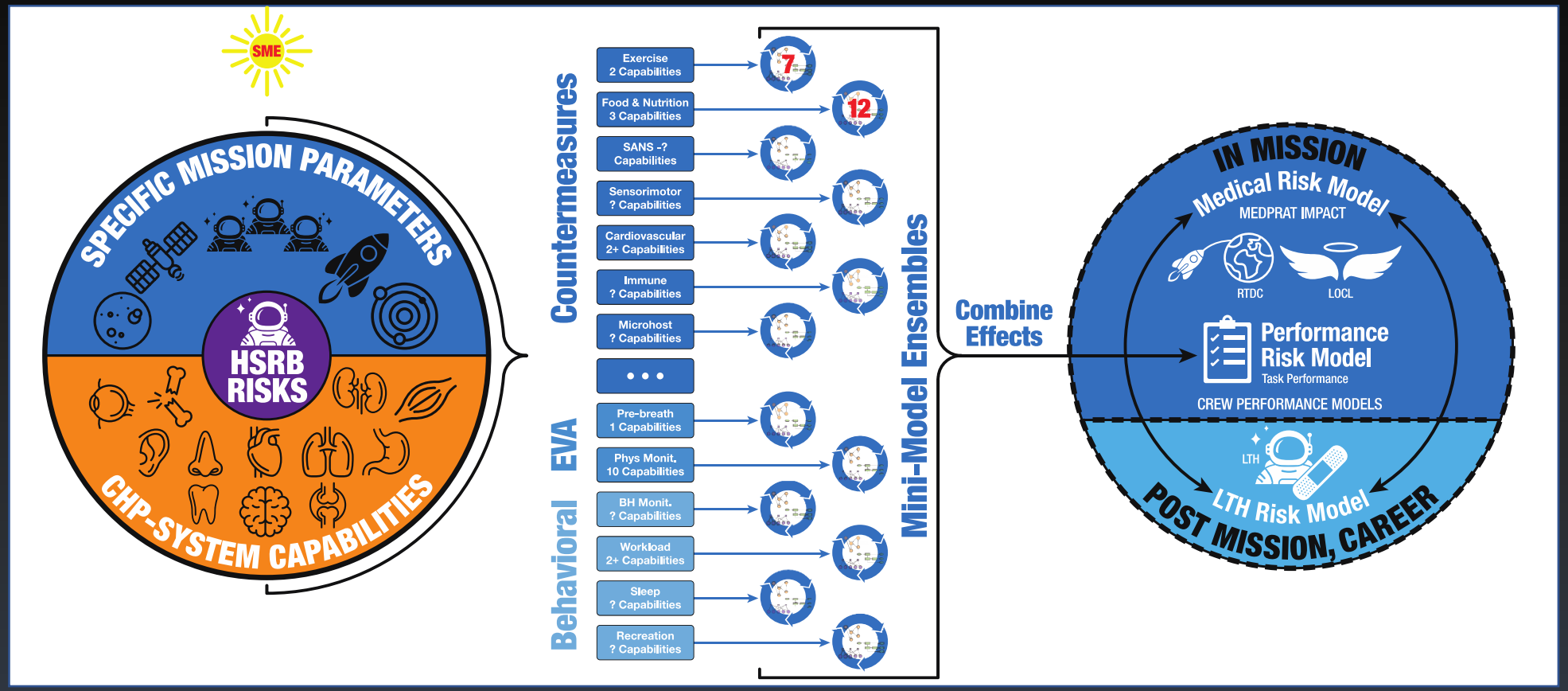
Investigators' Workshop

Overview

- Review 2023 development of CHP-PRA proof-of-concept (POC) model
- Describe the need for Model and Simulation (M&S) sensitivity and robustness assessments
- Demonstrate CHP-PRA POC sensitivity and robustness with respect to each of the sub-component Human System Risk (HSR) models

Bottomline, Up Front: *POC exercise model exhibits sensitivity primarily to two HSRs (Immune and Muscle+Aerobic) at nearly the same magnitude, but influencing cumulative results in opposing directions*

2023 CHP-PRA Concept

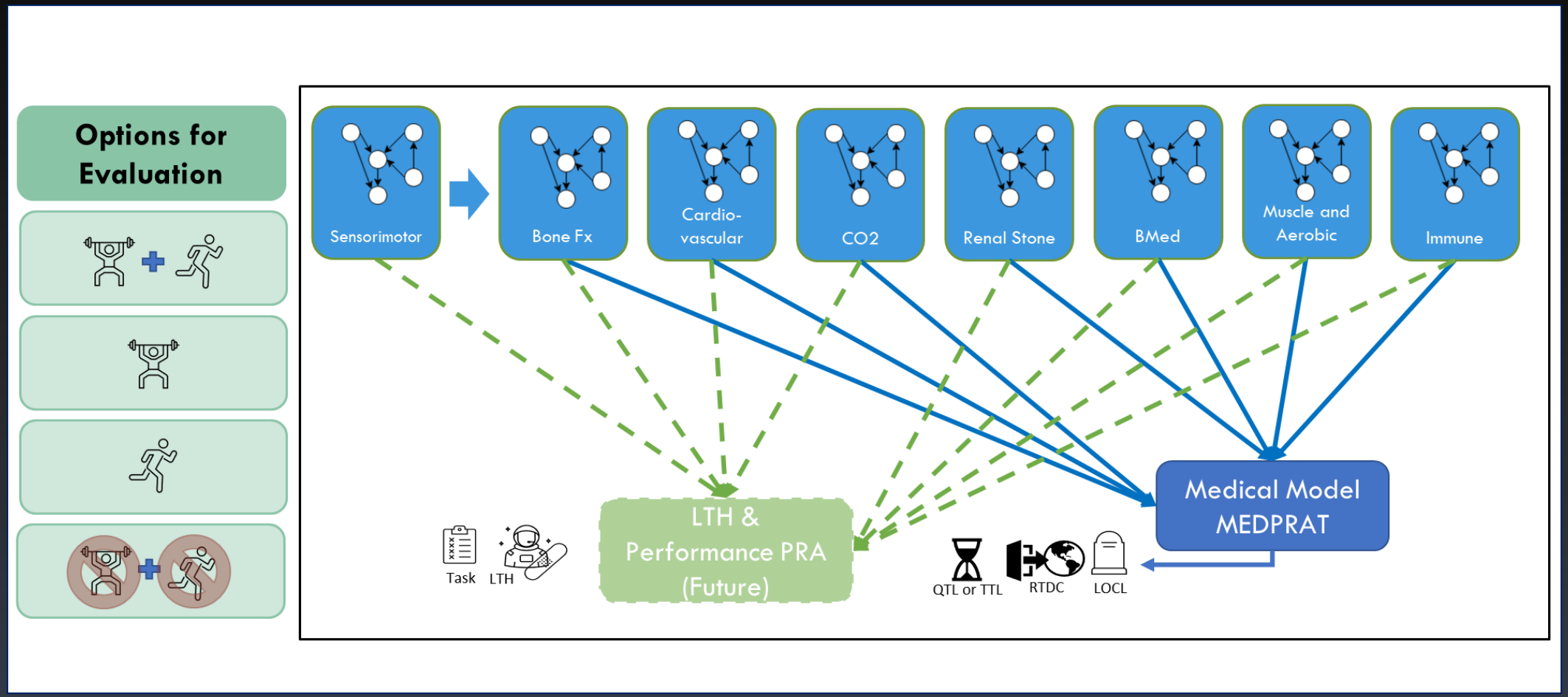


Define the context of the mission simulation

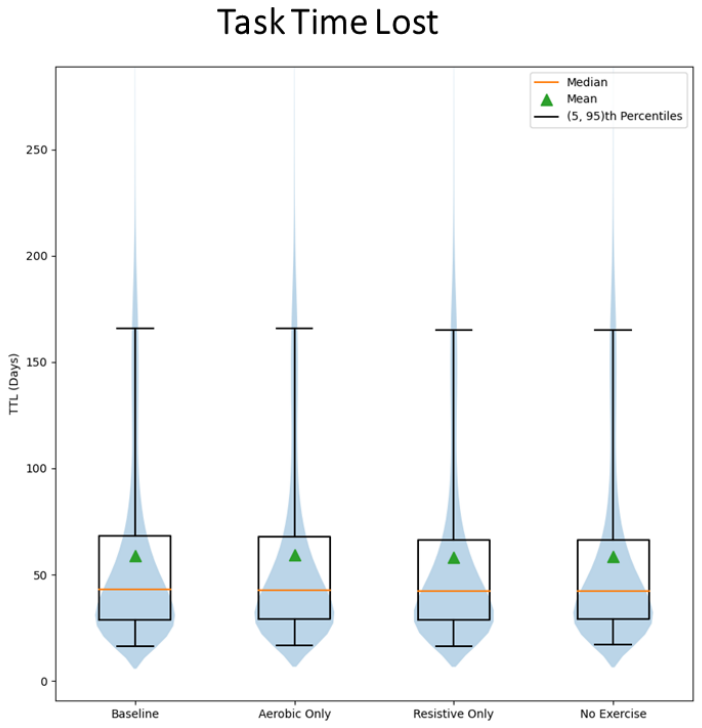
Define the state of the CHP/Human interaction

Quantify the mission risk metrics

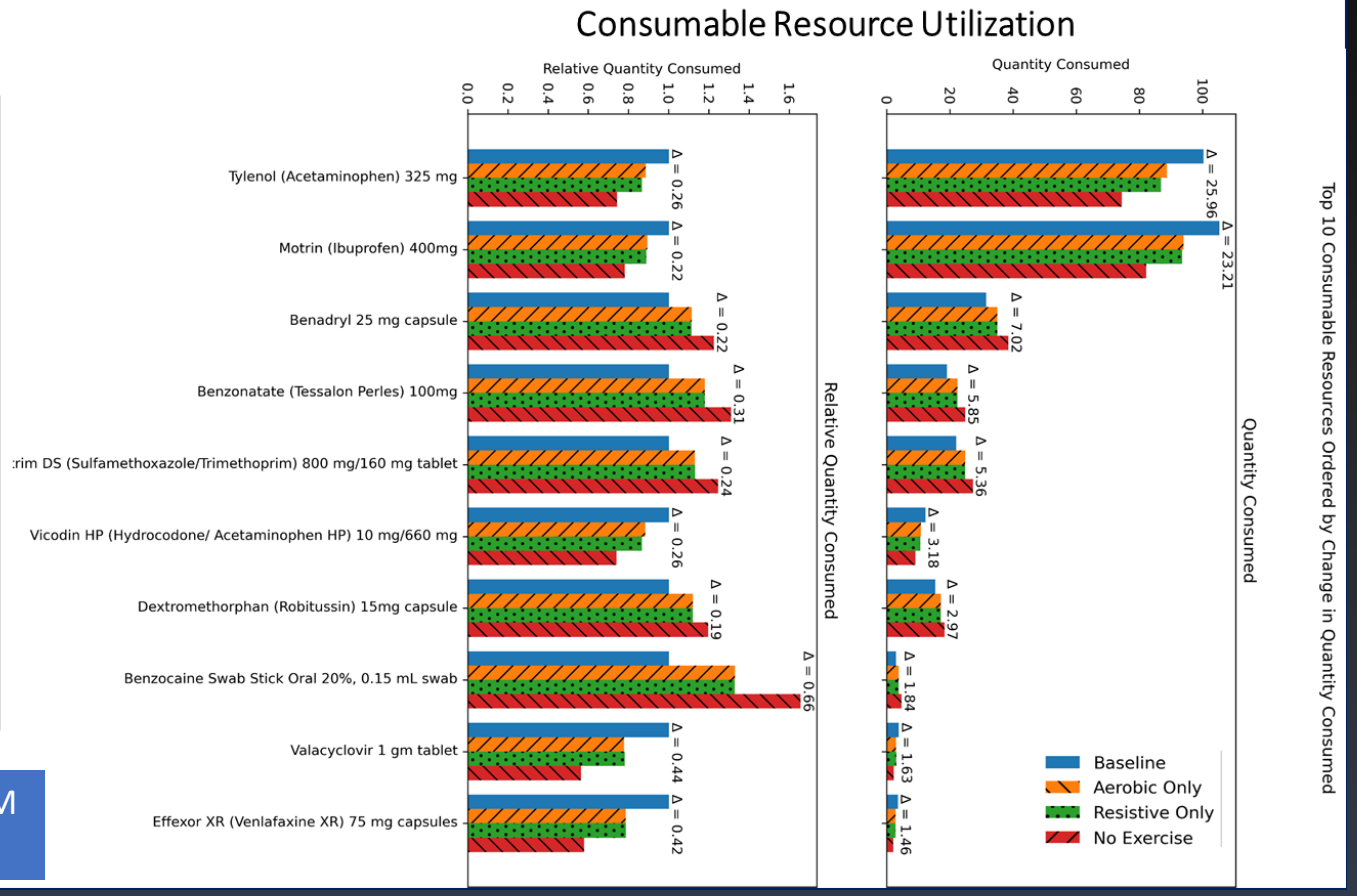
Conceptually straightforward, complex implementation



Sample Results From Mars Transit Analog (MTA) – Medical Risk Path Only

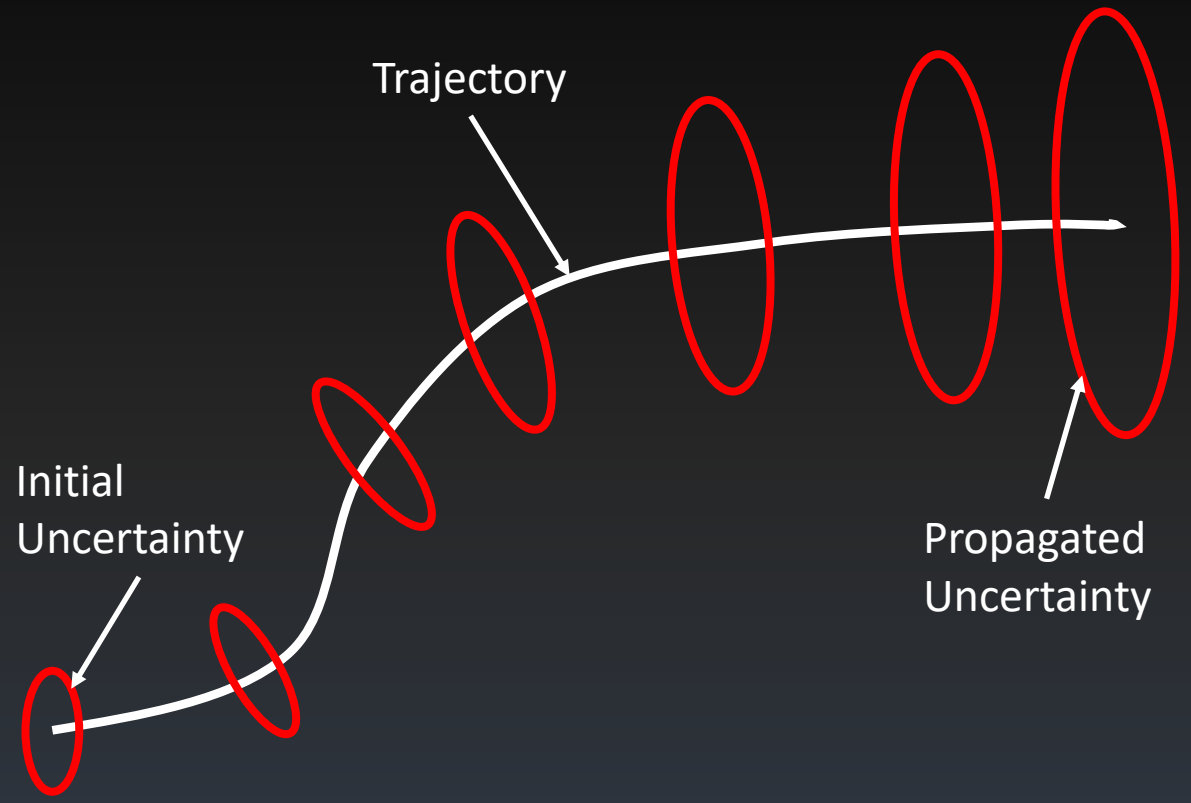


Medical risk insensitive to changes in ECM presumably to the medical capabilities.



Noted From This Analysis

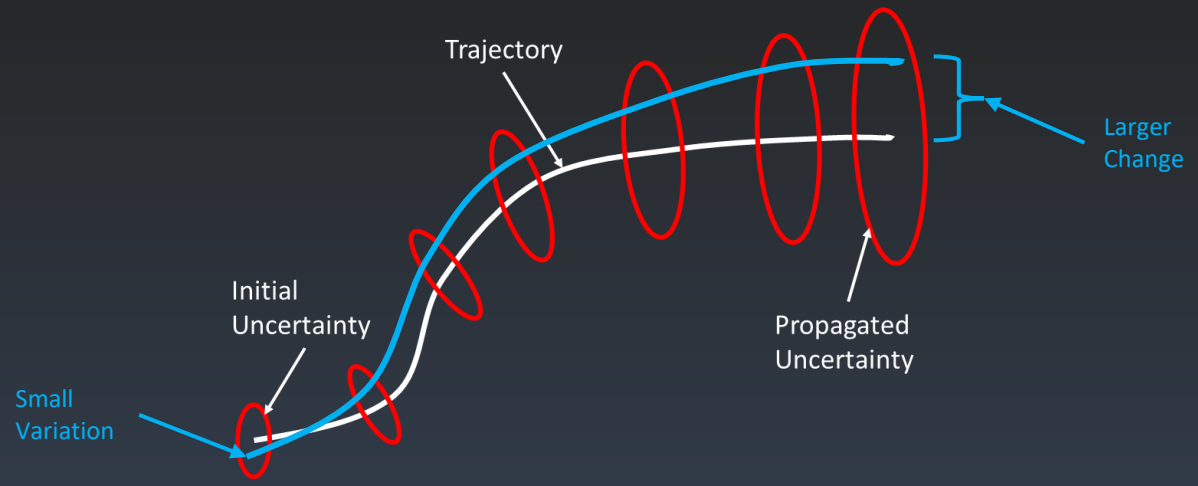
- Focus on Medical Risk Path does not communicate the entire risk story
  - Efforts for performance and LTH risk integration underway
- *Diminishing returns "chasing" all paths*
- *Does not account for all interactions of CHP sub-systems*
- *Does not propagate all potential uncertainty*



Sensitivity Analysis, i.e. robustness of the model

Sensitivity Analysis: uncertainty in the output of a mathematical model can be allocated to different sources of uncertainty in its inputs.

Robustness*: The characteristic whereby the result from an M&S does not change in a meaningful way with minor variations in parameters.



* A critical part of M&S Credibility Assessment per NASA-STD-7009B and NIH Ten Simple Rules for M&S Credible Practice in Health Care

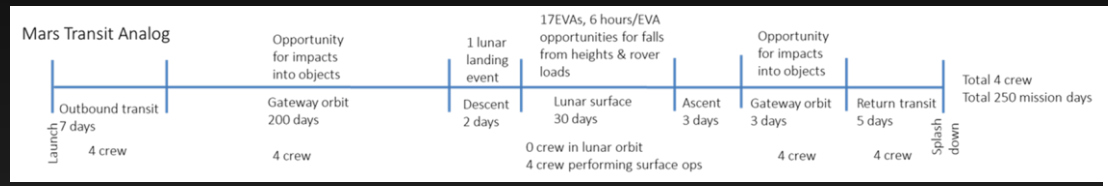
Cumulative Risk Model Parameters

- Identify how robust the model is to each risk
- Identify the risks that most influence the model predictions

Approach

- "Leave-One-Out"
  - Remove one of the components
  - Compare change to baseline

Mars Transit Analog Analysis – Medical Risk Path

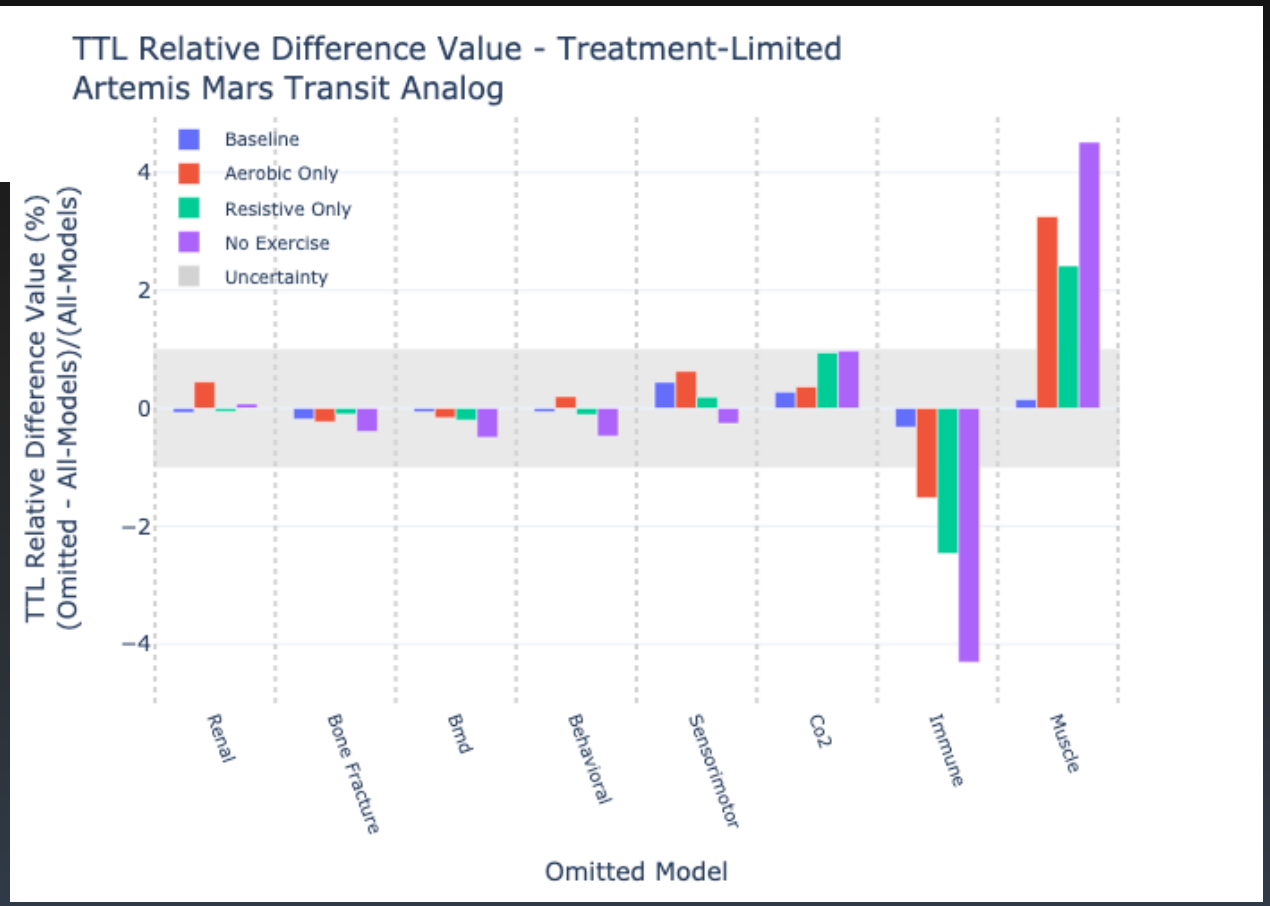


MTA: 250 Mission days, 4-crew (mixed), 17 EVAs

Database: iMed

Simulations: 32 simulations, 100K trials, Limited to ISS medical resources

Gray area – Expected variations due to noise and # of trials



Key Finding MTA Simulation:
Medical risk robustness to changes in exercise countermeasure is due to limited sensitivity to all but Immune and Muscle+Aerobic risk, and they nearly balance.

Takeaways and Ongoing work

Takeaway

- CHP-PRA POC Robustness results from give and take between risks
- The overall effect on global risk metrics is negligible from baseline, although the affected constituents differ (i.e. medical resources used)
- Designates the sensitive risk component of the models that can provide further insights in areas where new data or interventions may have the most influence on the global risk

Ongoing work

- Expanding CHP capabilities models beyond Exercise Countermeasures
- Examples: ECLSS, Pharm, and Sensorimotor countermeasures targeted for inclusion (See Dr. Rehm's IWS presentation on date, time).

QUESTONS

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For more info on CHP-PRA modeling activities, visit

https://ccmp.gitlab.grc.nasa.gov/chp-pra/results/