Novel Analytics and Parameter-Space Estimations for Human Spaceflight Medical Risk with MEDPRAT V2.0:

Leveraging Computational Efficiency

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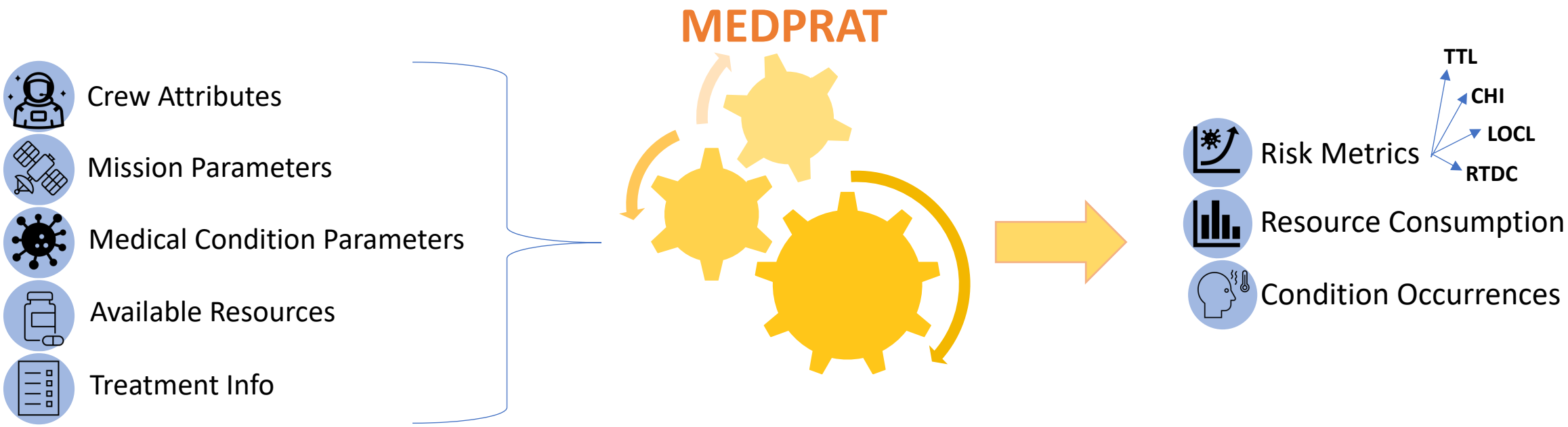
MEDPRAT

Medical Extensible Dynamic Probabilistic Risk Assessment Tool

MEDPRAT

- MEDPRAT is a computational PRA (probabilistic risk assessment) model for quantifying spaceflight medical risk
- An evolution of IMM – shares the basic functionality of IMM, but with a new underlying software architecture and many new features
- The ‘math engine’ that provides the modeling capability for ExMC’s IMPACT tool



Motivation

- Demonstrate computational efficiency: ability to do large (batches) simulations with a short turnaround
- Demonstrate versatility: provide examples of questions that MEDPRAT can address along with their associated scale and runtime
- Engage the community: bring forth ideas and discussions for other possible applications

Key Terms

Simulation

- a single run of MEDPRAT with given input configuration
- outputs risk metrics and resource consumption

Trial

- a single simulated mission
- most **simulations** are run for 100k to 300k trials

Loss of Crew Life (LOCL)
Removal To Definitive Care (RTDC)
Quality/Task Time Lost (QTL/TTL)

Optimization

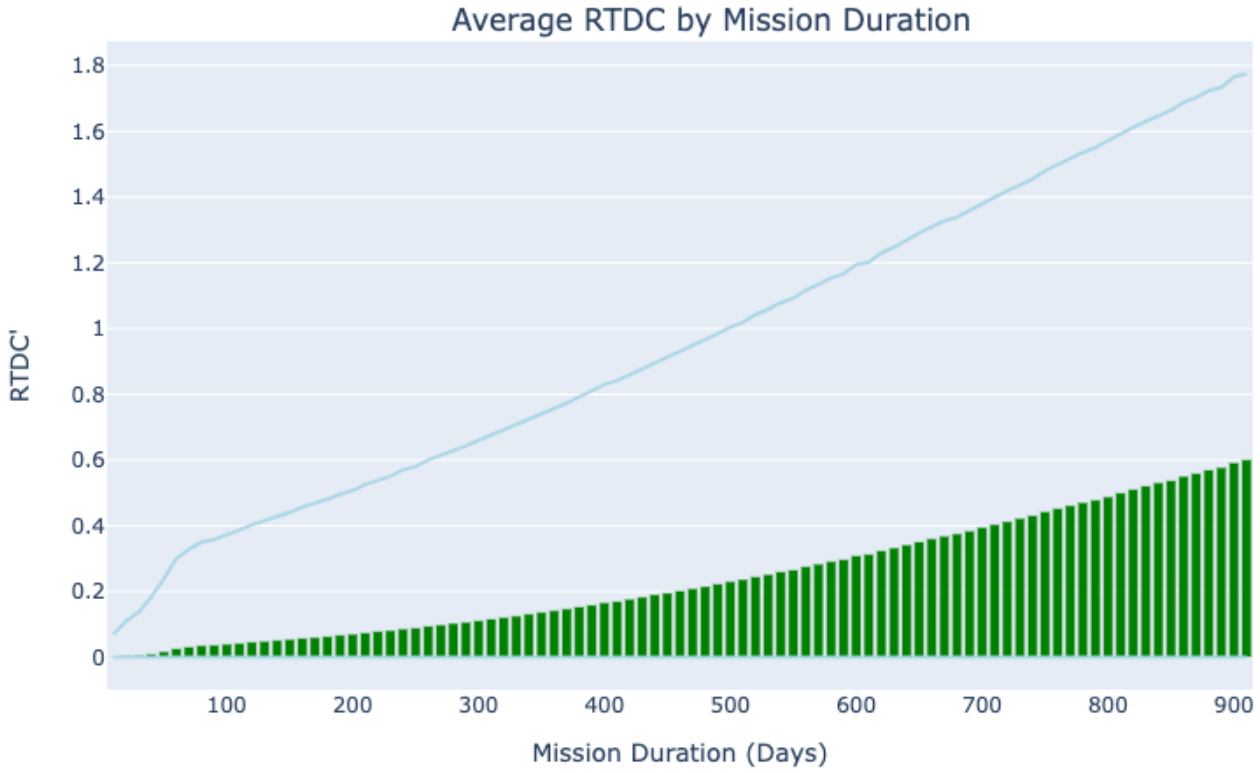
- a single run of the MEDPRAT set selector with optimization configuration
- provides as output an optimized medical kit
- runs usually consist of 8-15 **simulations**, each with 100k-300k **trials**

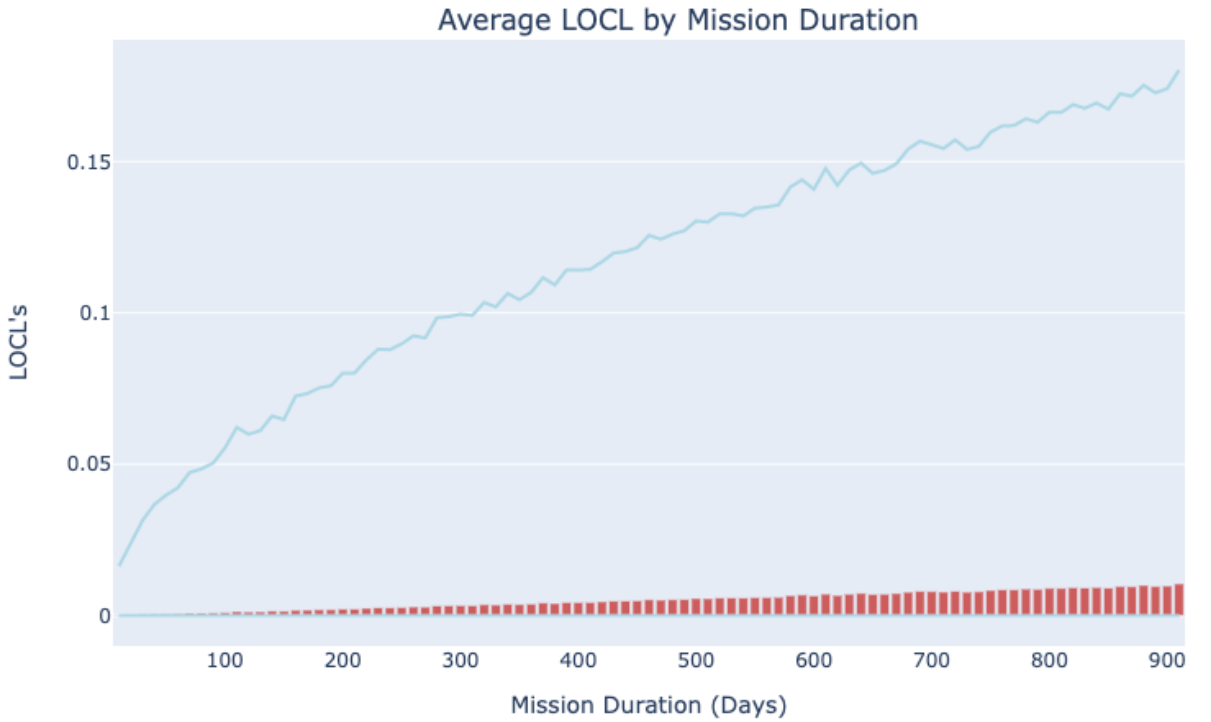
Runtime

- the amount of time an analysis took to complete on the HRP-GRC compute cluster (156 cores)

How does mission medical risk change with respect to mission duration when using the ISS medical kit?

Risk vs Mission Duration – LOCL/RTDC





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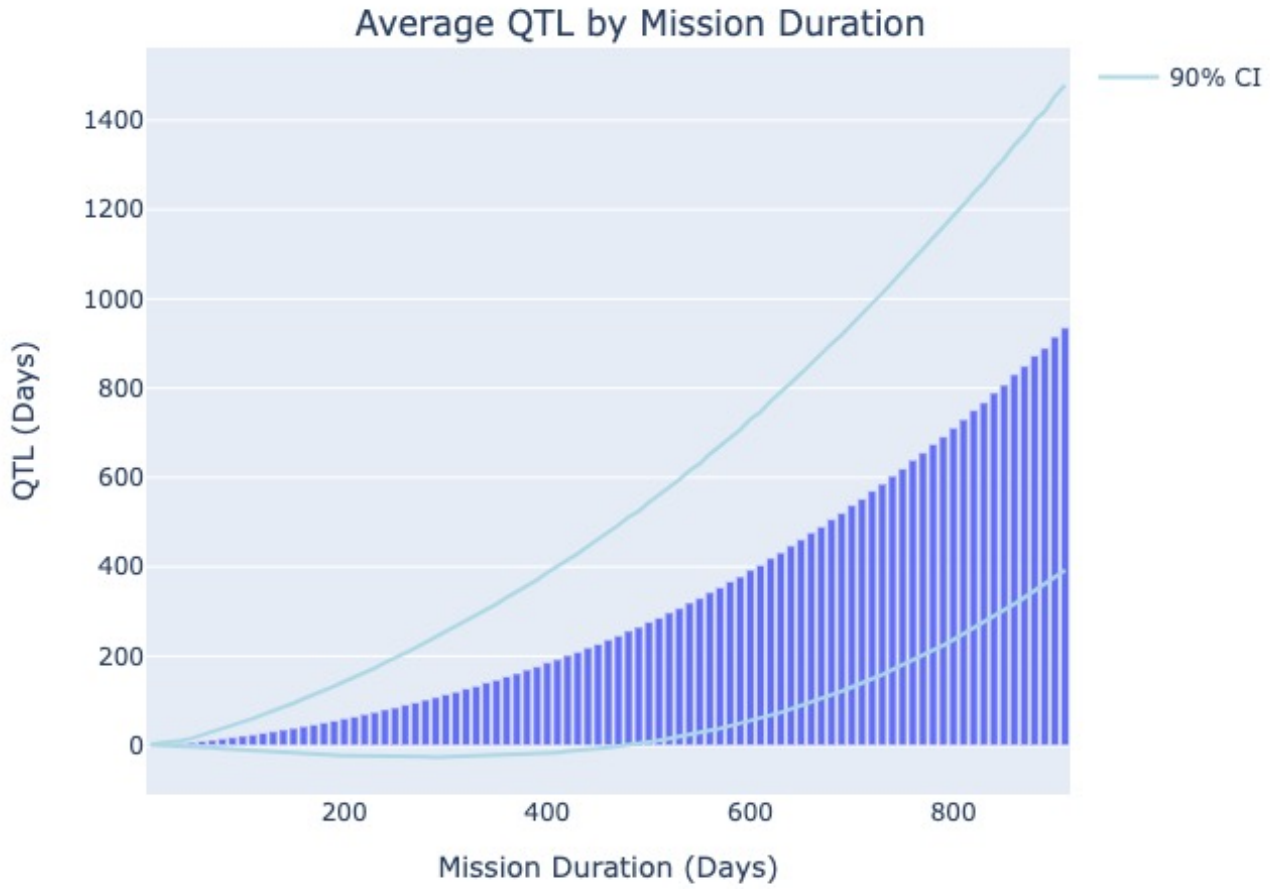
Risk vs Mission Duration - QTL



- 910 individual simulations
- 300,000 trials each
- 18-hour runtime

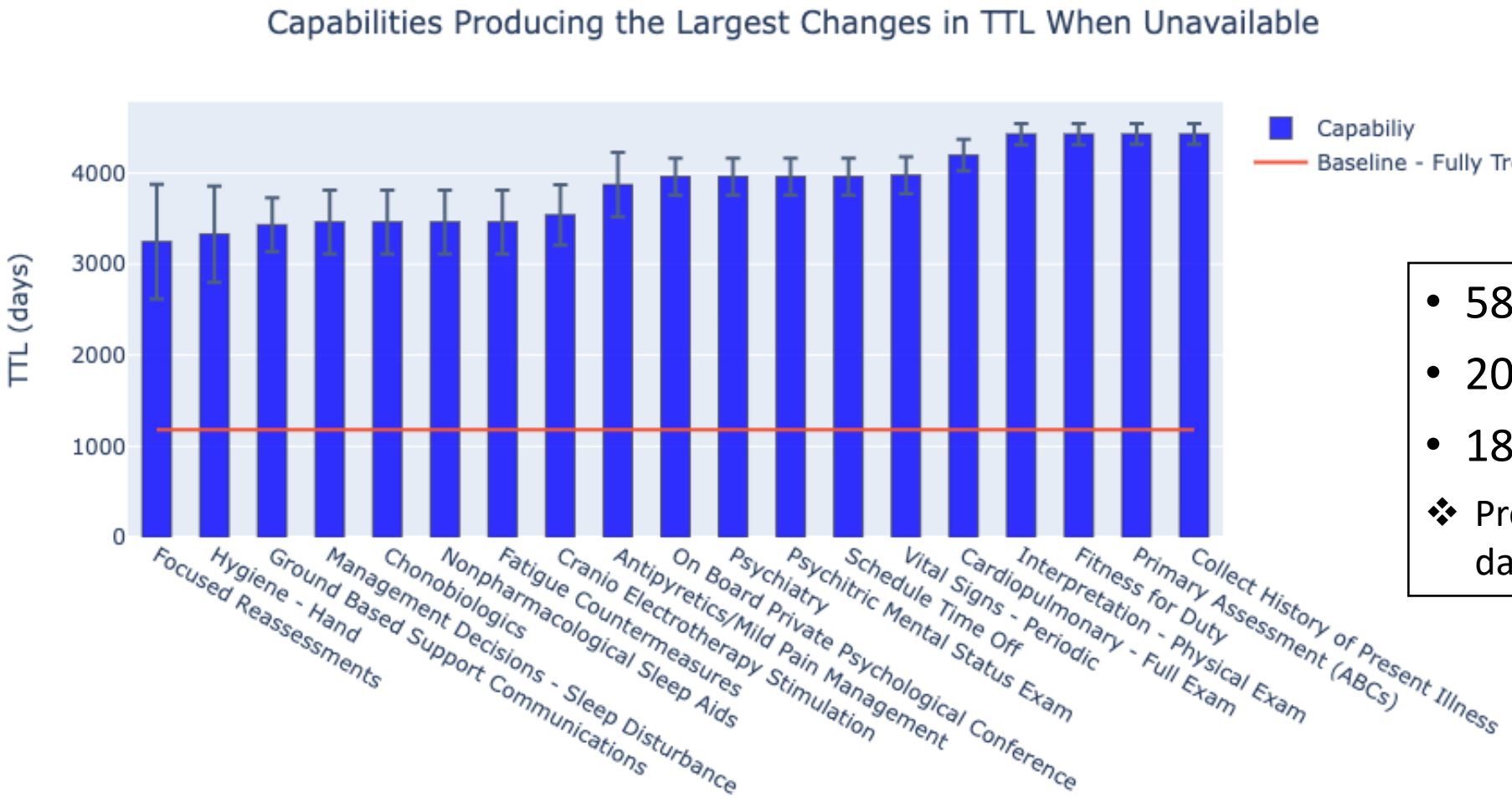
Which treatment capabilities are mission medical risk most sensitive to?

Leave-One-Out Sensitivity Analysis

Loss of Crew Life (LOCL)

Removal To Definitive Care (RTDC)

Quality/Task Time Lost (QTL/TTL)



- 588 individual simulations
- 200,000 trials each
- 18-hour runtime

❖ Preliminary result, unreviewed data set (Evidence Library)

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What effect does the Knowledge, Skills, and Ability (KSA) of the crew have on risk?

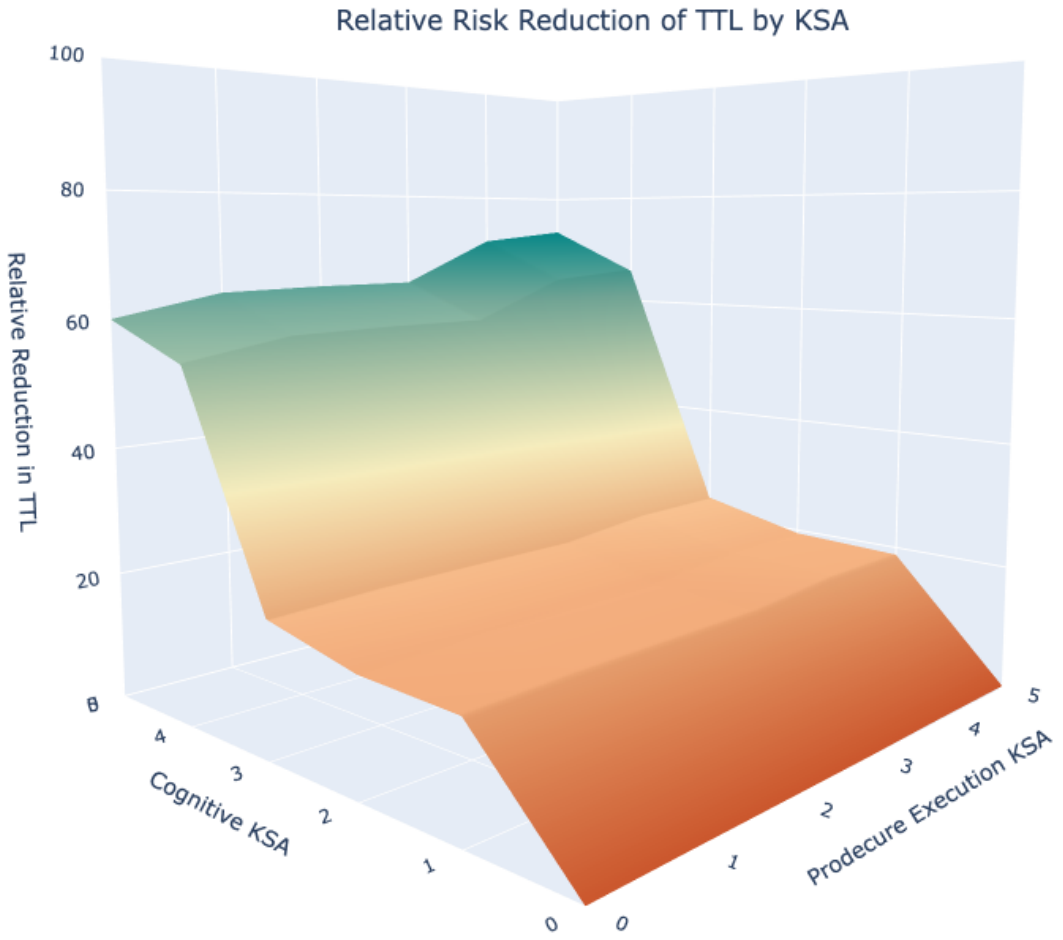
KSA	Description
1	National Registry Emergency Medicine Technician (EMT) - Basic
2	National Registry Paramedic
3	Certified Emergency Registered Nurse
4	First Year Resident Medical Doctor (Intern)
5	Attending Physician (not specialty specific)

Sensitivity to KSA – Task Time Lost (TTL)

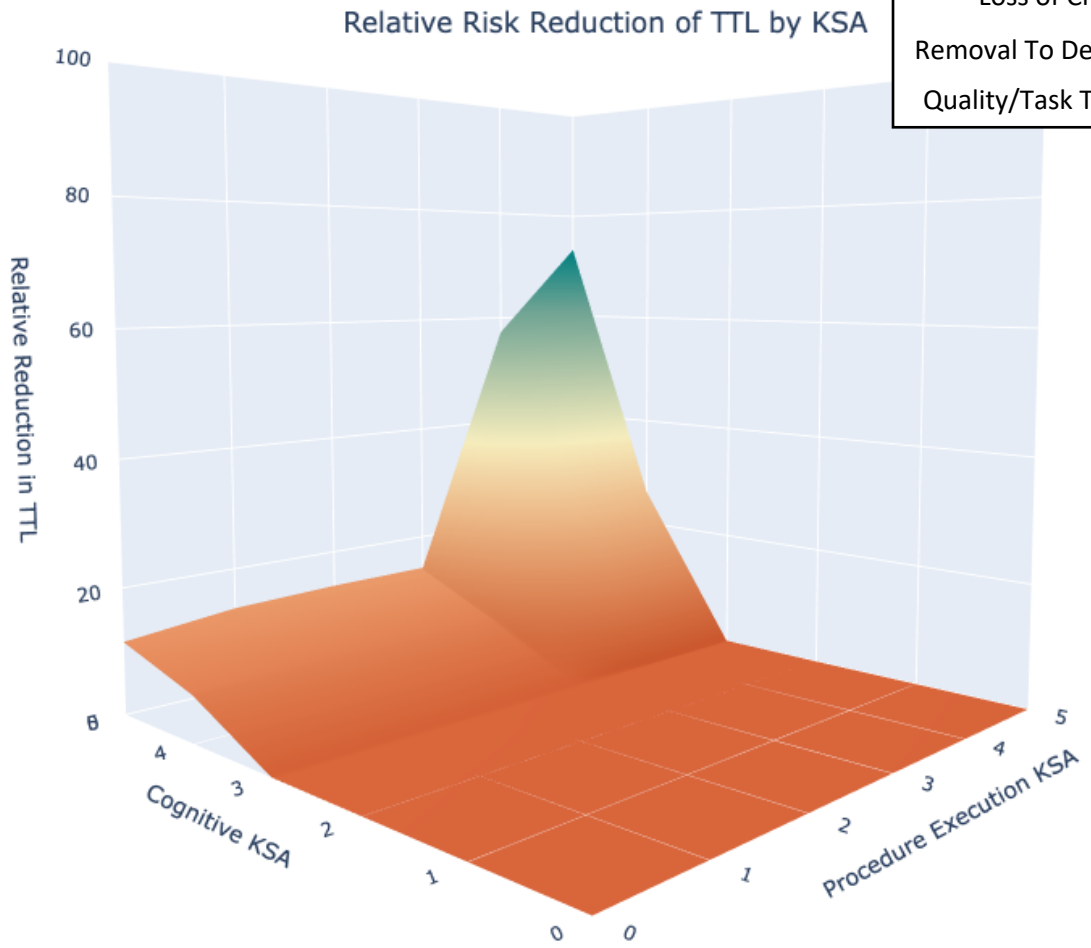
Loss of Crew Life (LOCL)

Removal To Definitive Care (RTDC)

Quality/Task Time Lost (QTL/TTL)



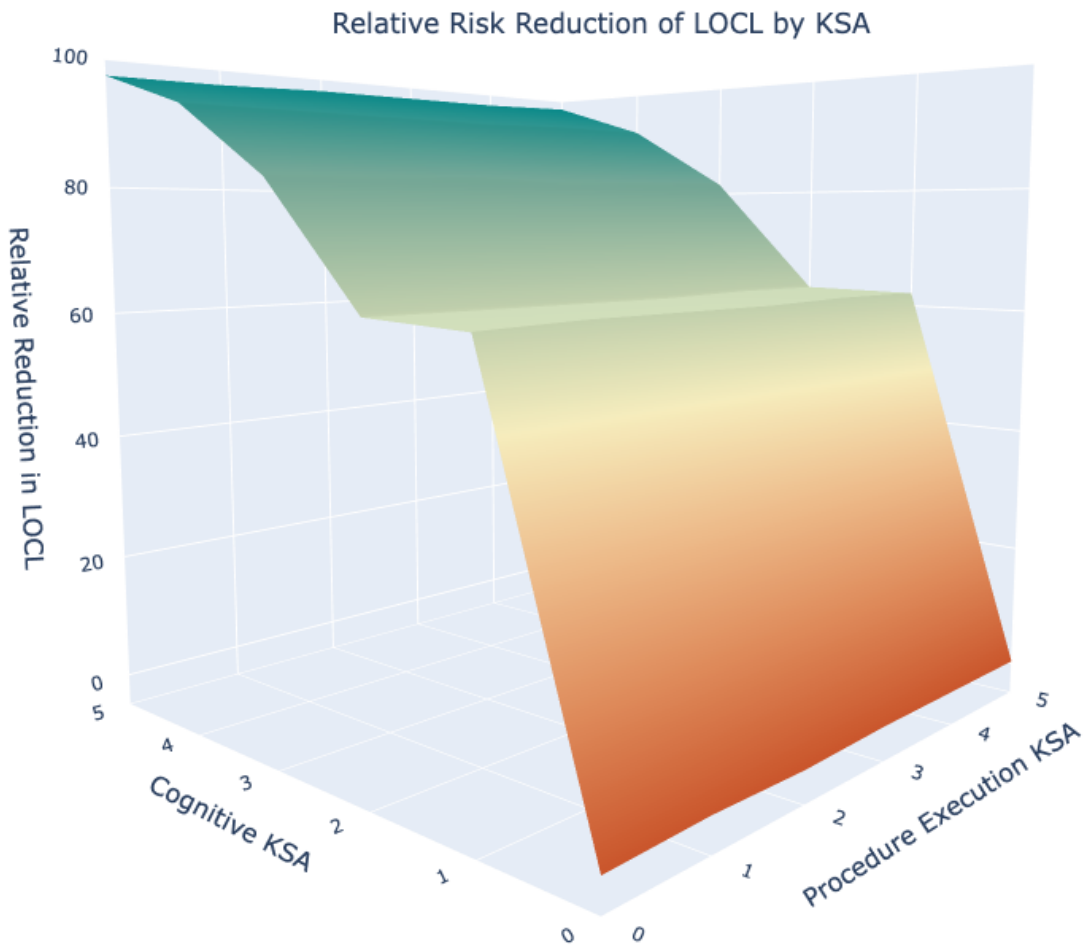
With partial credit/treatment for partially available resources



Fully untreated if any resources unavailable

Sensitivity to KSA – Loss of Crew Life (LOCL)

Loss of Crew Life (LOCL)
Removal To Definitive Care (RTDC)
Quality/Task Time Lost (QTL/TTL)



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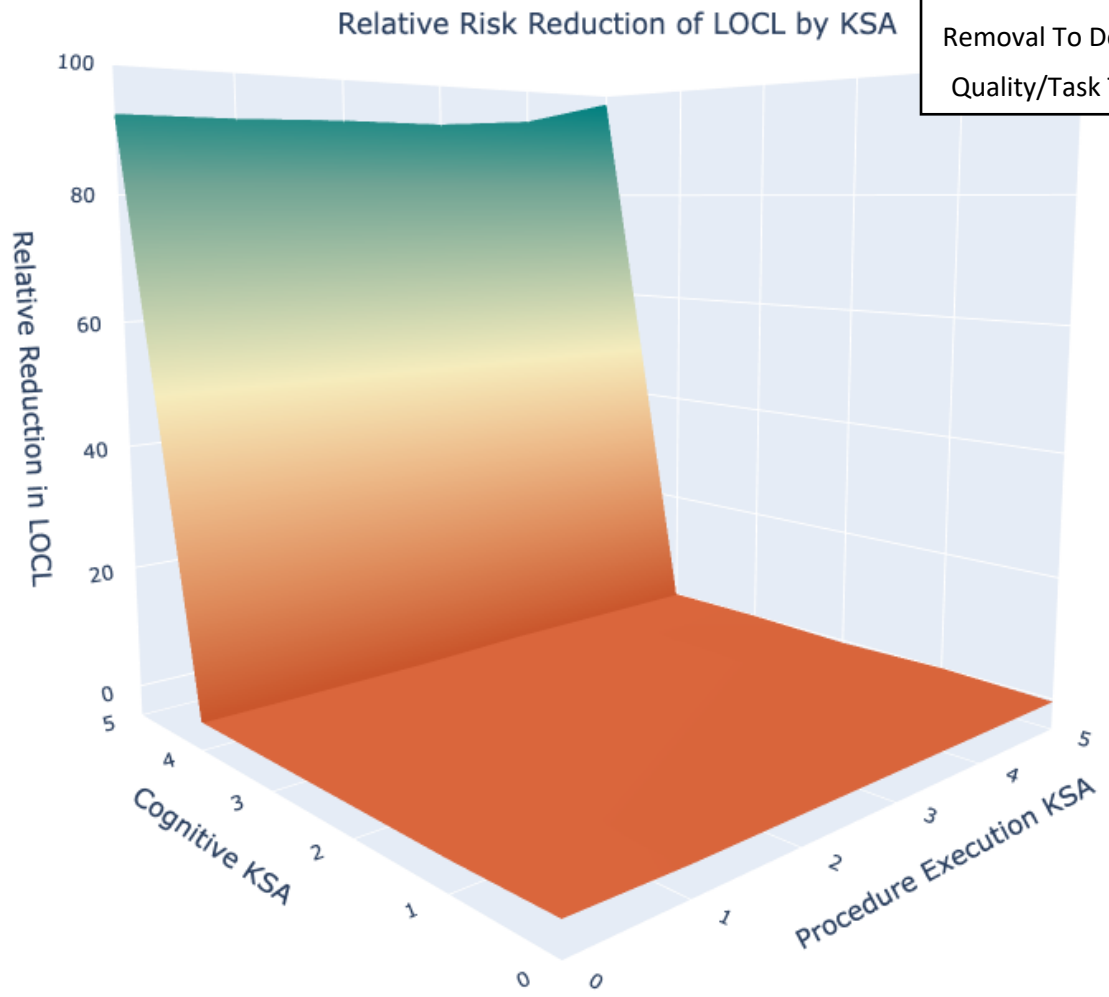

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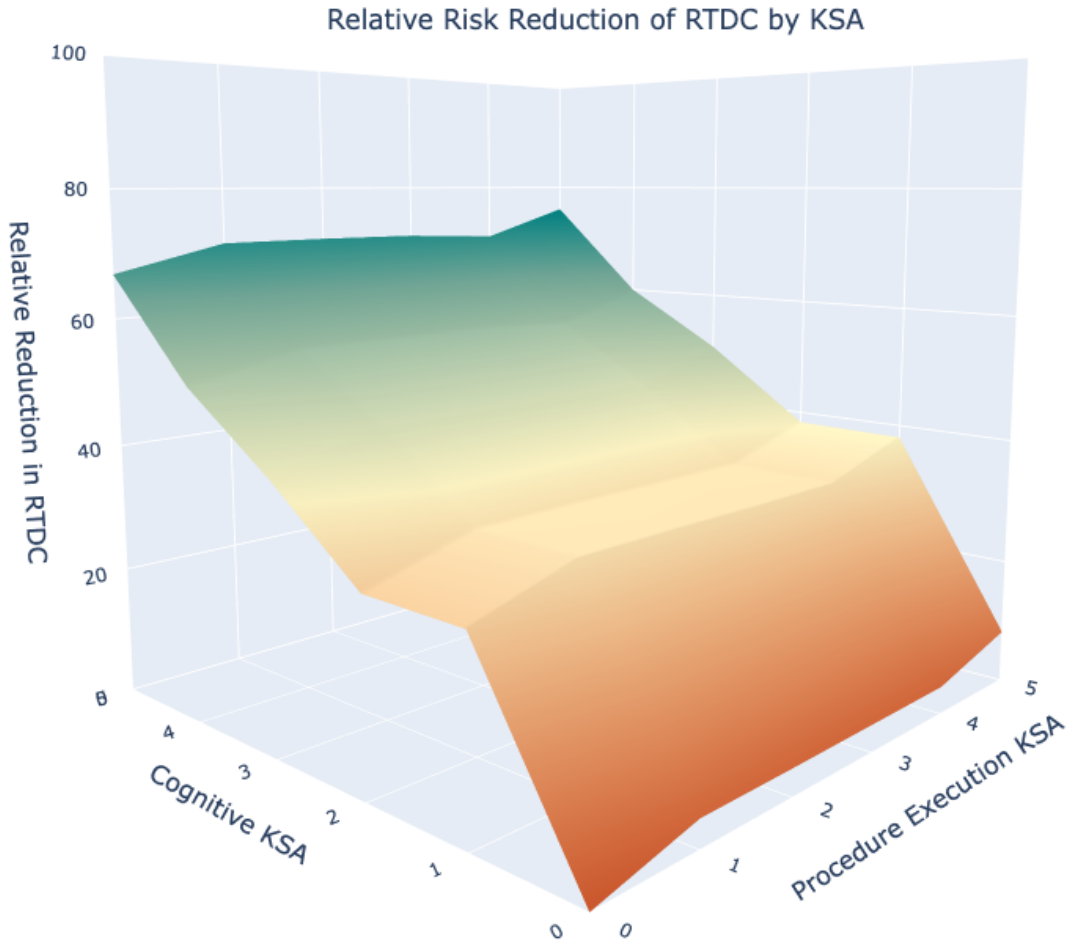
Sensitivity to KSA – Removal To Definitive Care (RTDC)

Loss of Crew Life (LOCL)

Removal To Definitive Care (RTDC)

Quality/Task Time Lost (QTL/TTL)



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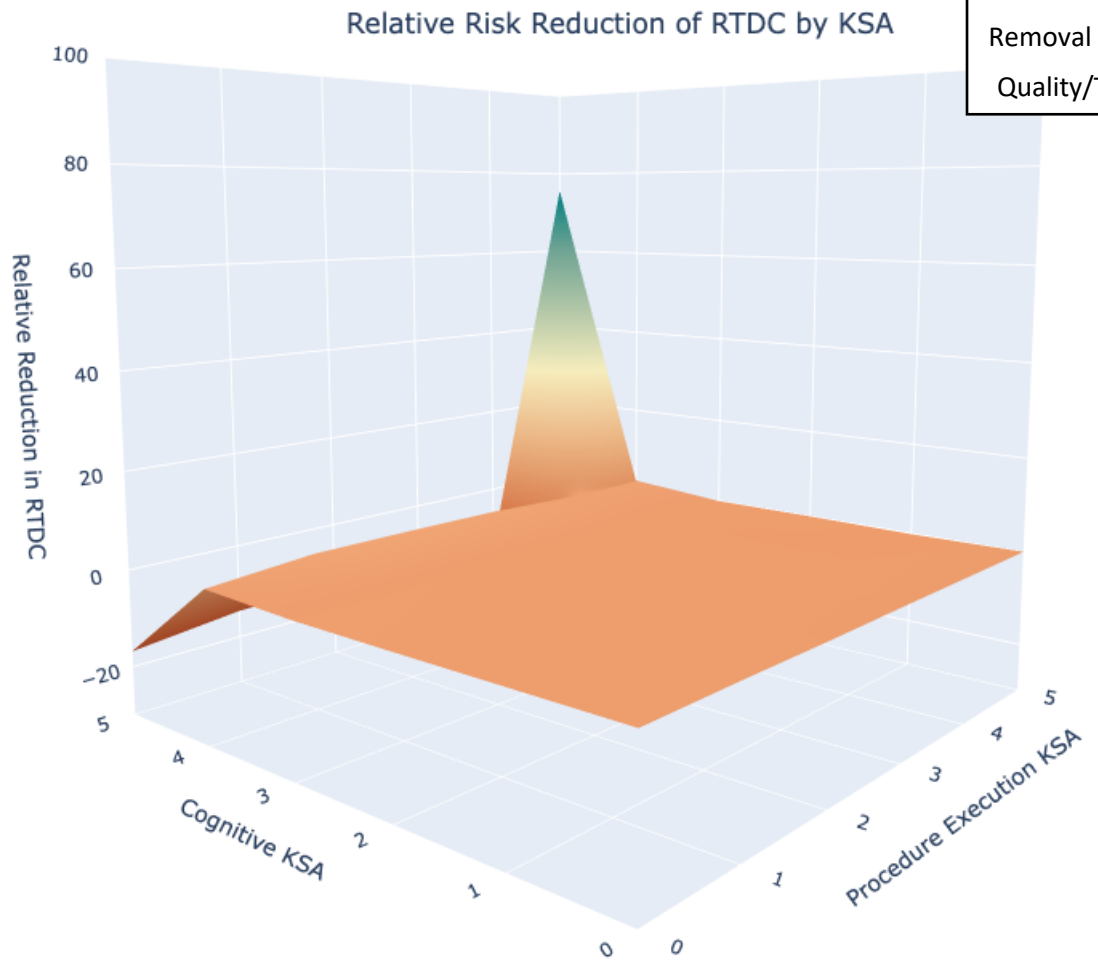


Fully untreated if any resources unavailable

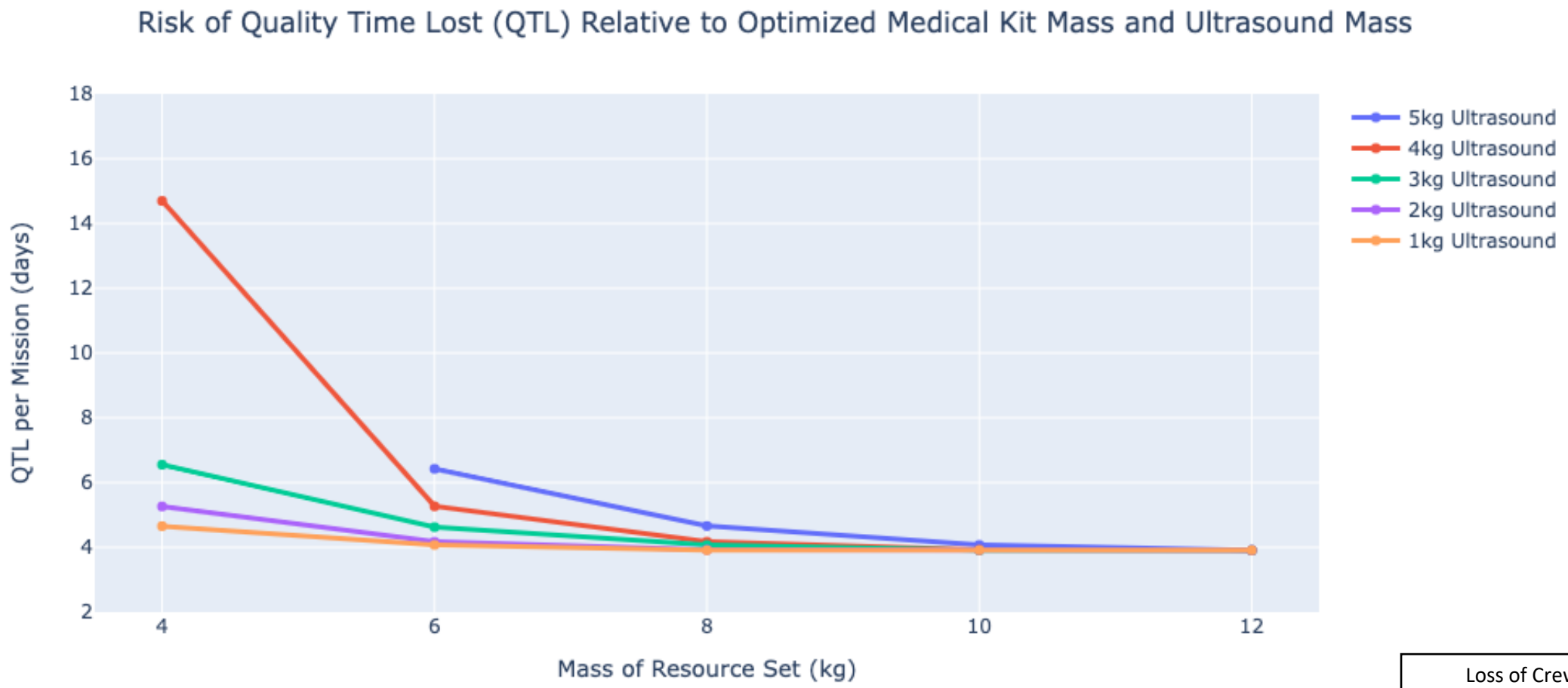
Sensitivity to KSA

- 36 individual simulations
- 200,000 trials each
- 3-hour runtime

❖ Preliminary result, an approximation to implemented feature

Should an investment be made to reduce the mass of a large device like an ultrasound machine?

Ultrasound mass vs medical set size - QTL

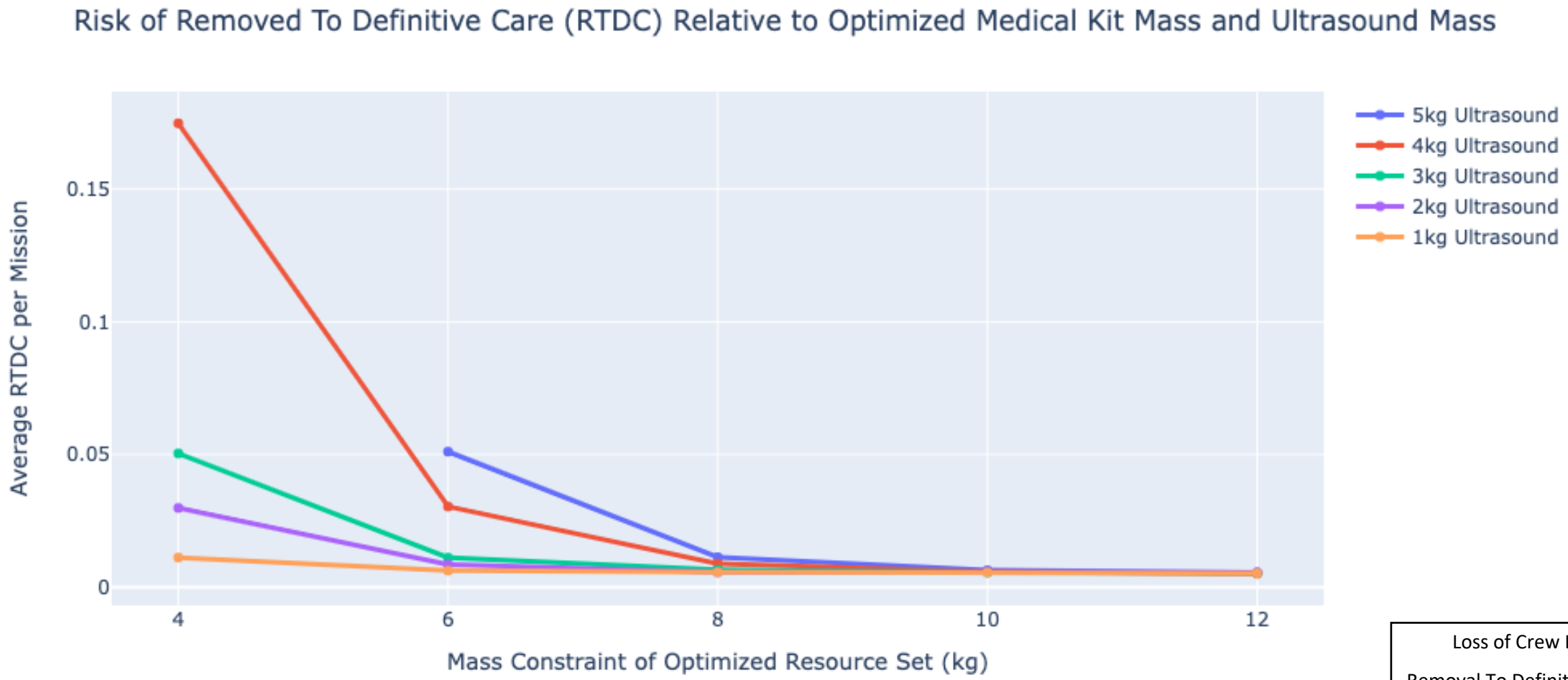


Loss of Crew Life (LOCL)

Removal To Definitive Care (RTDC)

Quality/Task Time Lost (QTL/TTL)

Ultrasound mass vs medical set size - RTDC

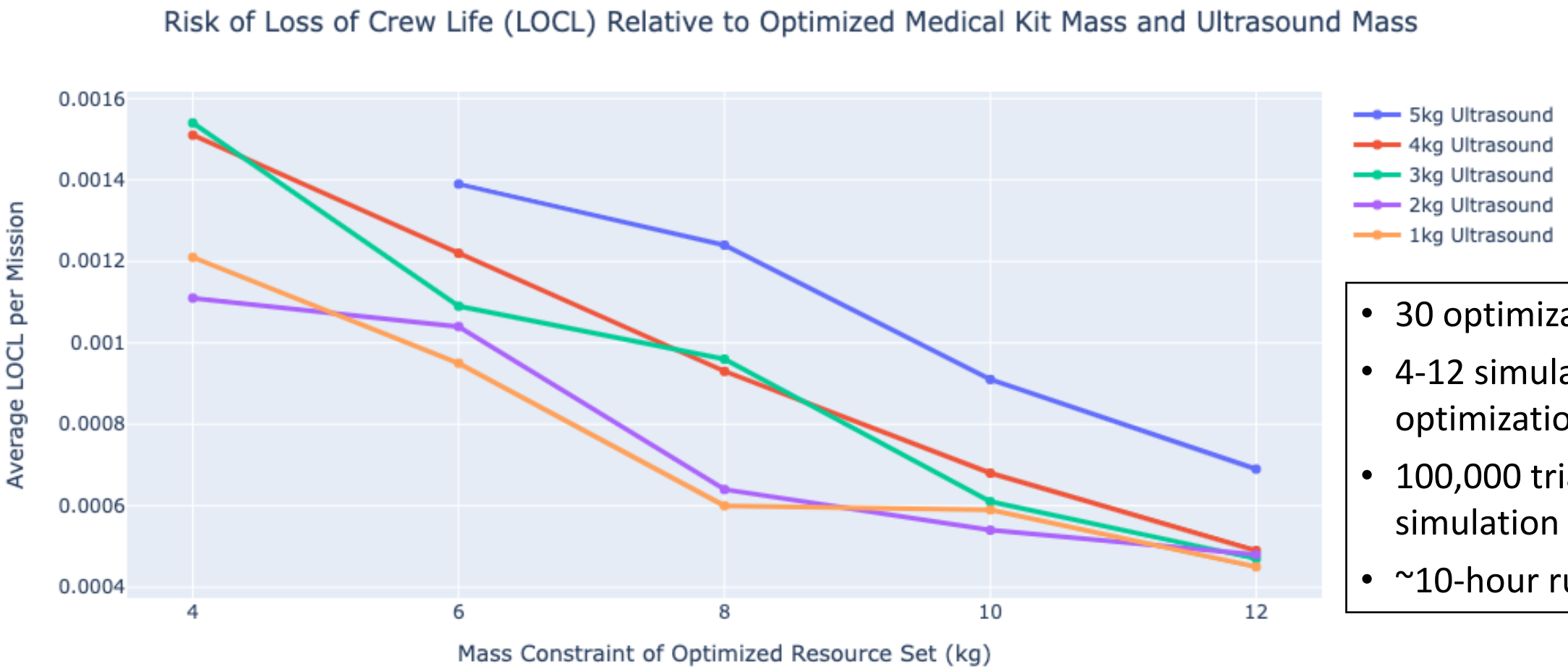


Loss of Crew Life (LOCL)

Removal To Definitive Care (RTDC)

Quality/Task Time Lost (QTL/TTL)

Ultrasound mass vs medical set size - LOCL

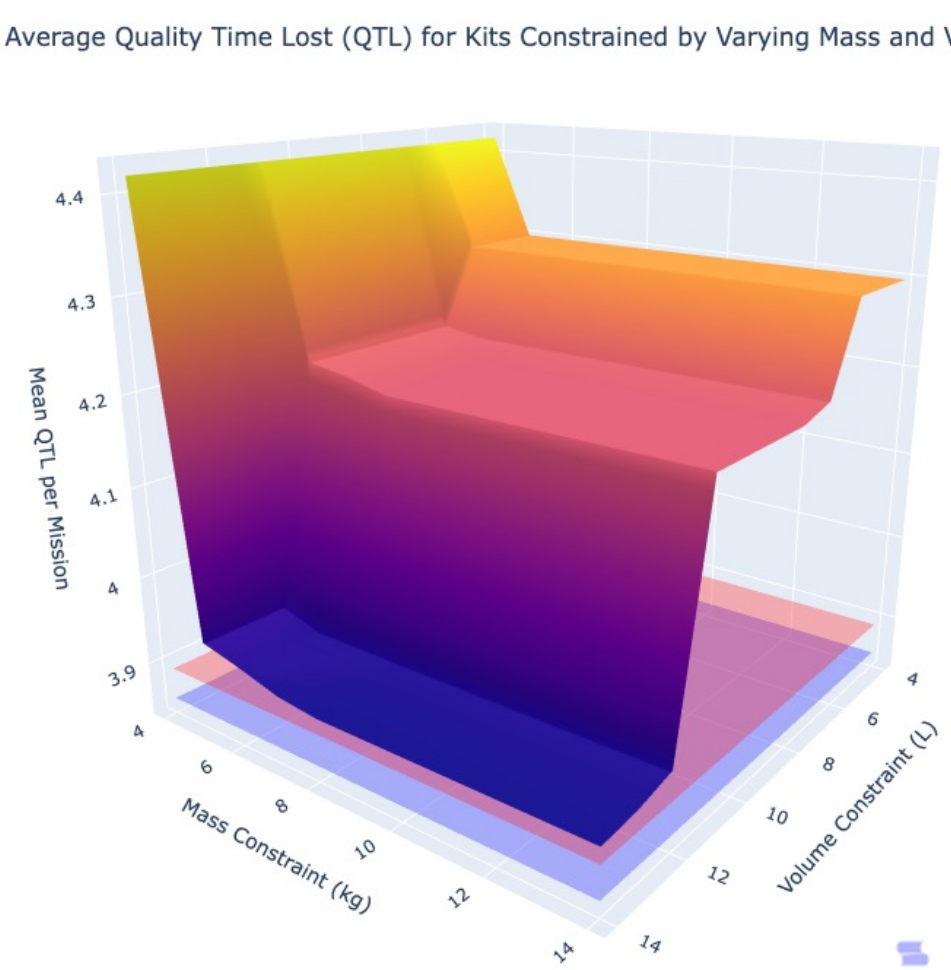


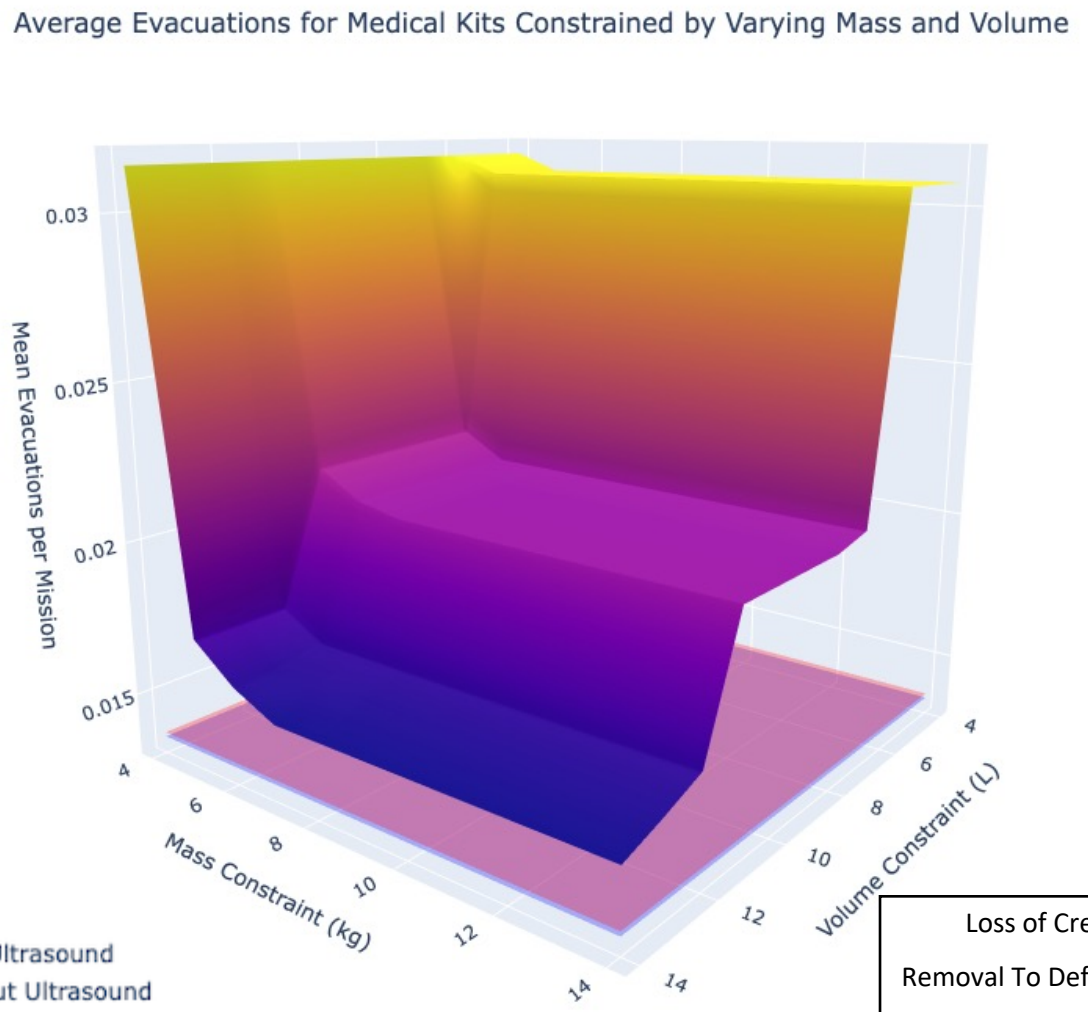
- 30 optimization runs
- 4-12 simulations per optimization run
- 100,000 trials per simulation
- ~10-hour runtime

Loss of Crew Life (LOCL)
Removal To Definitive Care (RTDC)
Quality/Task Time Lost (QTL/TTL)

How does risk for an Artemis like mission change with respect to medical kit mass and volume constraints?

Risk with varying medical set size constraints





ISS Kit with Ultrasound
ISS Kit without Ultrasound

Loss of Crew Life (LOCL)

Removal To Definitive Care (RTDC)

Quality/Task Time Lost (QTL/TTL)

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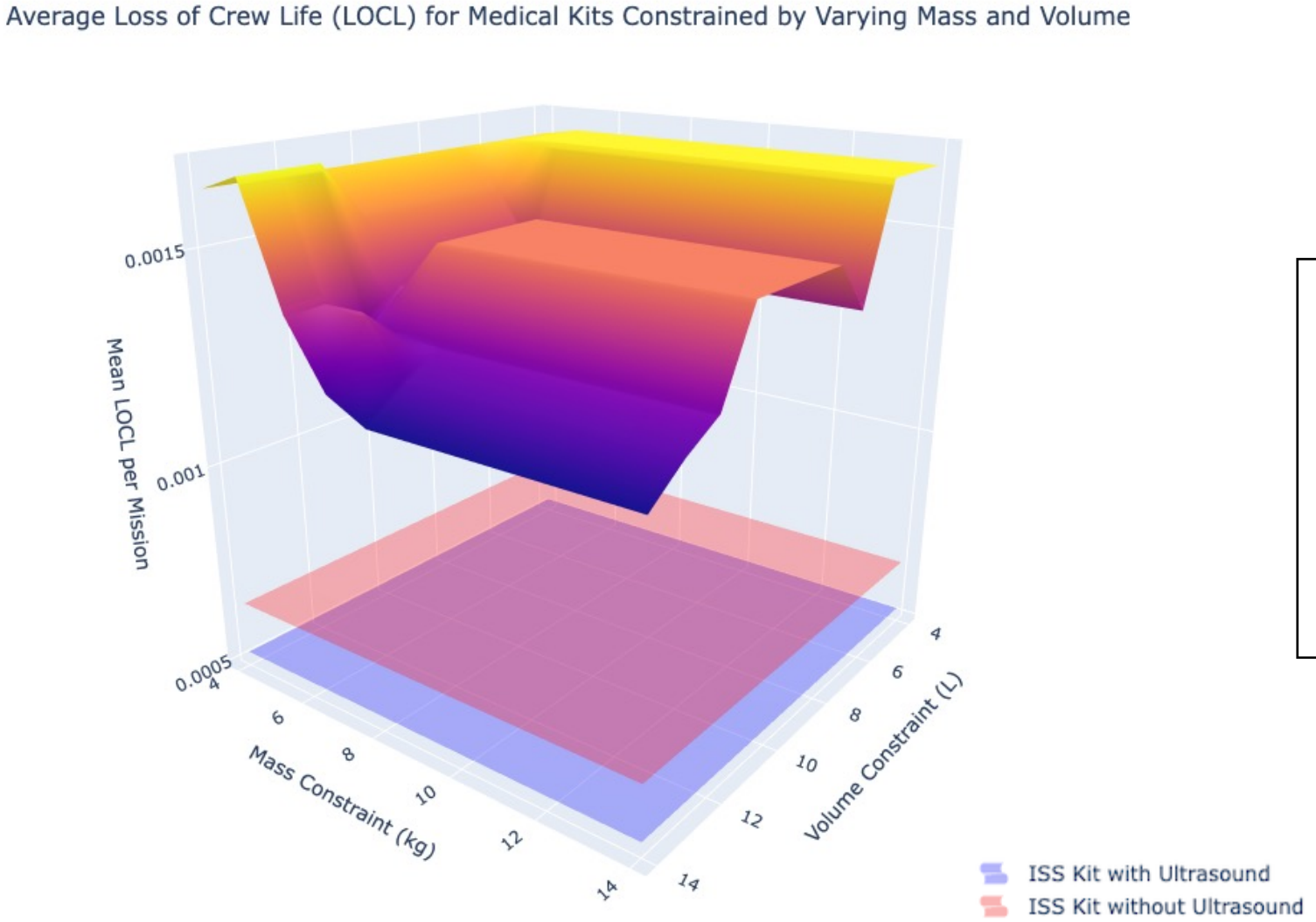
Risk with varying medical set size constraints



- 28 optimization runs
- 10-18 simulations per optimization run
- 200,000 trials per simulation
- ~18-hour runtime

Loss of Crew Life (LOCL)
Removal To Definitive Care (RTDC)
Quality/Task Time Lost (QTL/TTL)

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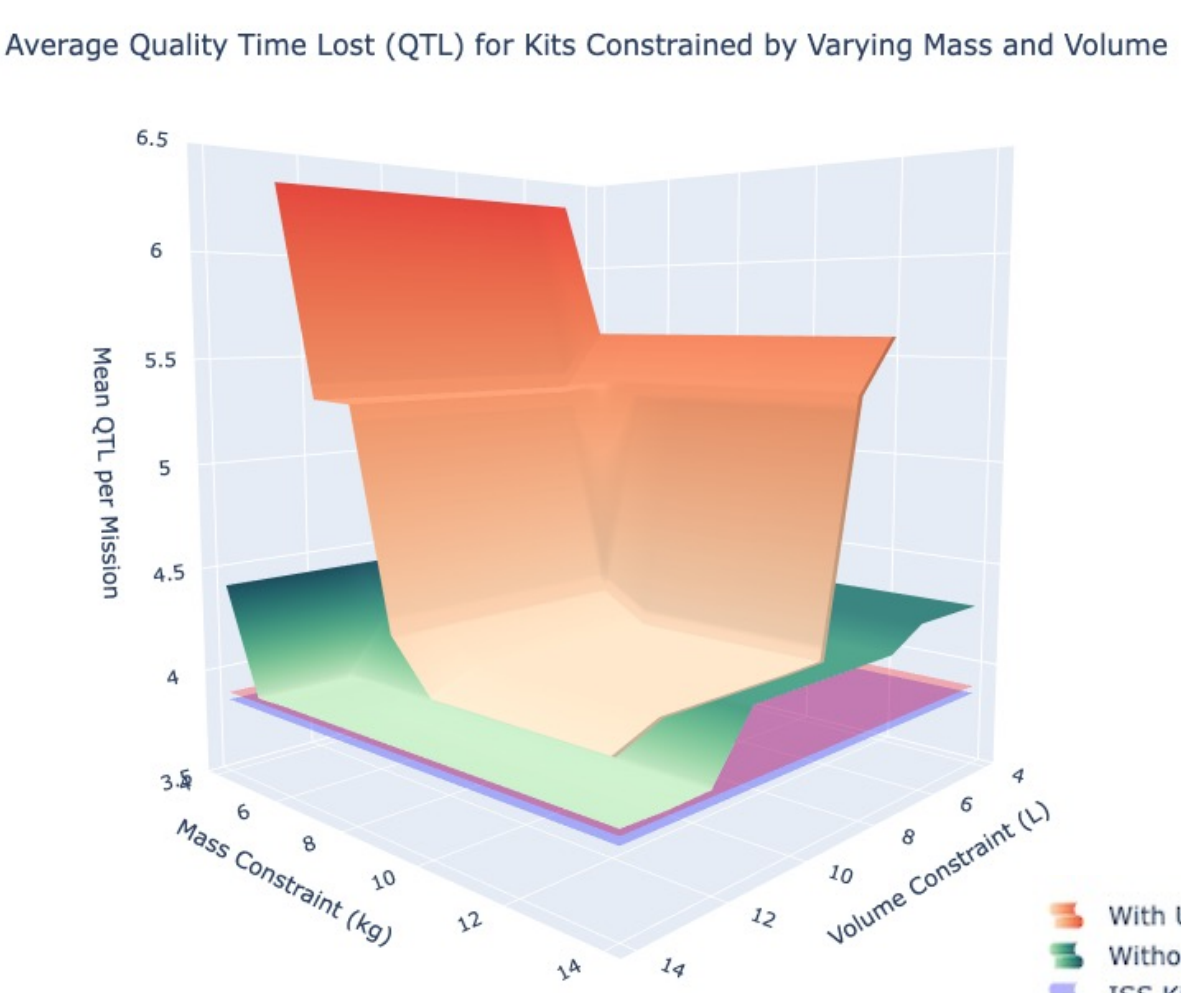
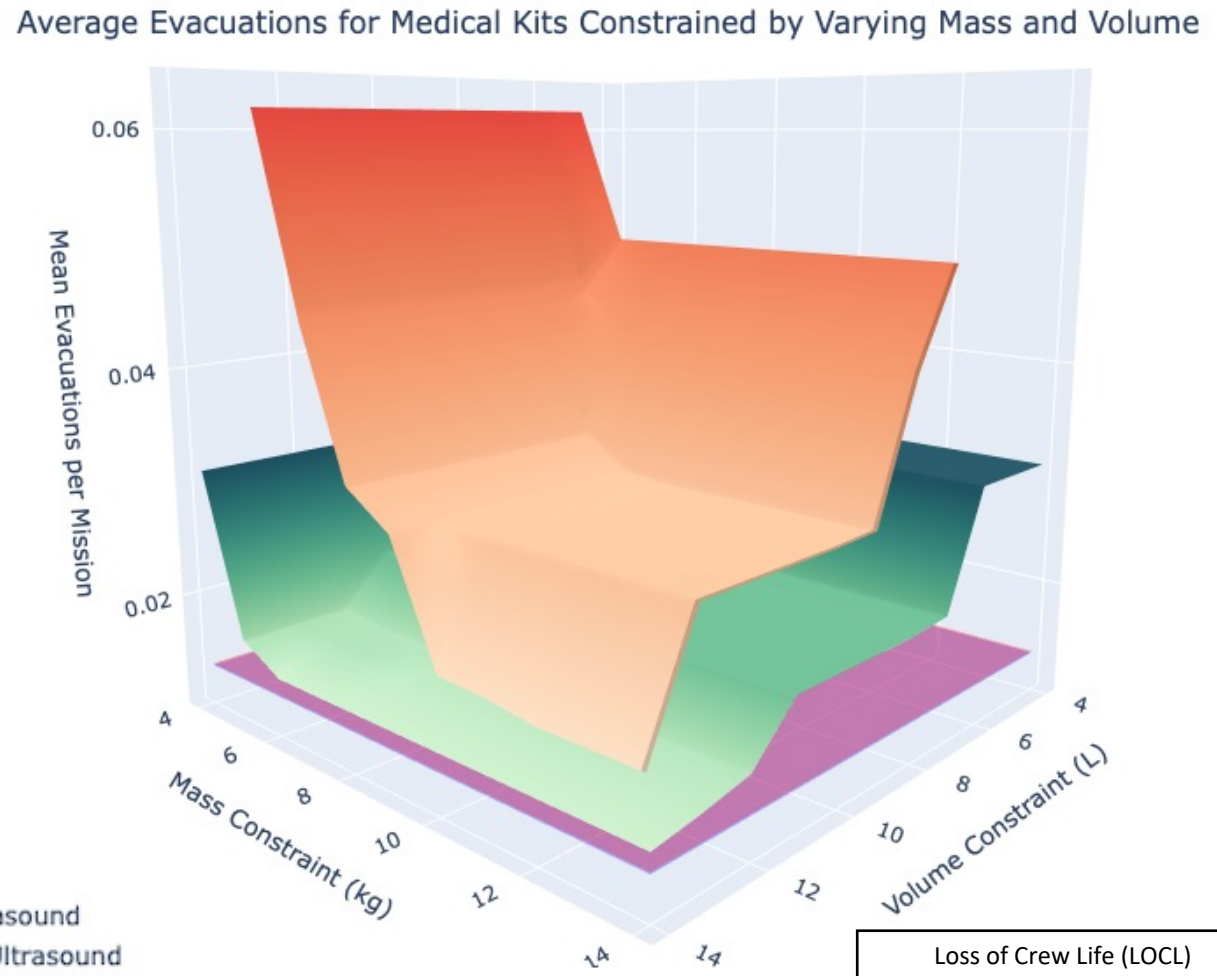
How does risk for an Artemis like mission change with respect to medical kit mass and volume constraints?

Should we send an ultrasound machine?

Risk with and without Ultrasound Machine





With Ultrasound
Without Ultrasound
ISS Kit with Ultrasound
ISS Kit without Ultrasound

Loss of Crew Life (LOCL)
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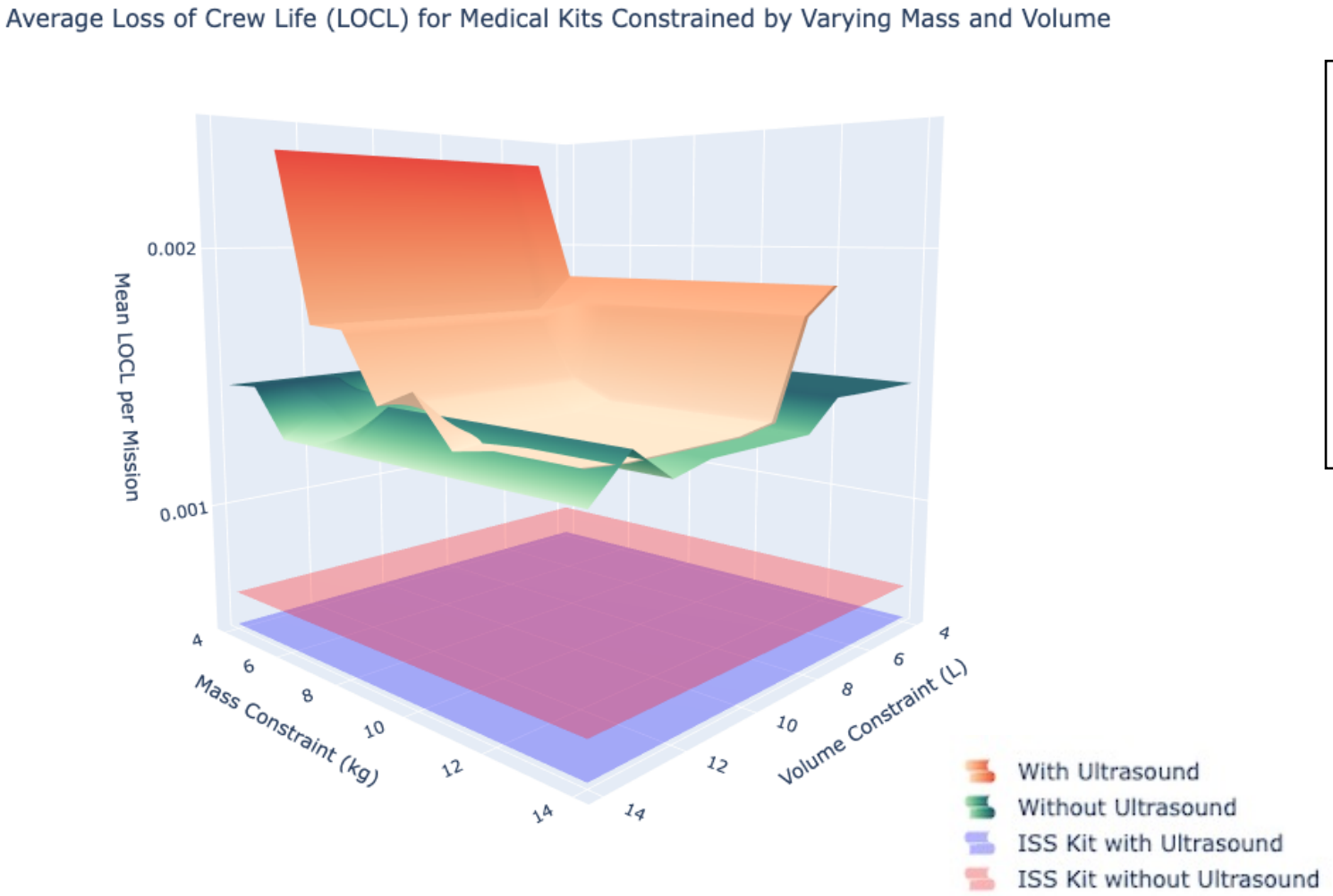
Risk with and without Ultrasound Machine



- 56 optimization runs
- 10-18 simulations per optimization run
- 200,000 trials per simulation
- ~1.5 day runtime

Ultrasound: 5kg, 6.3L

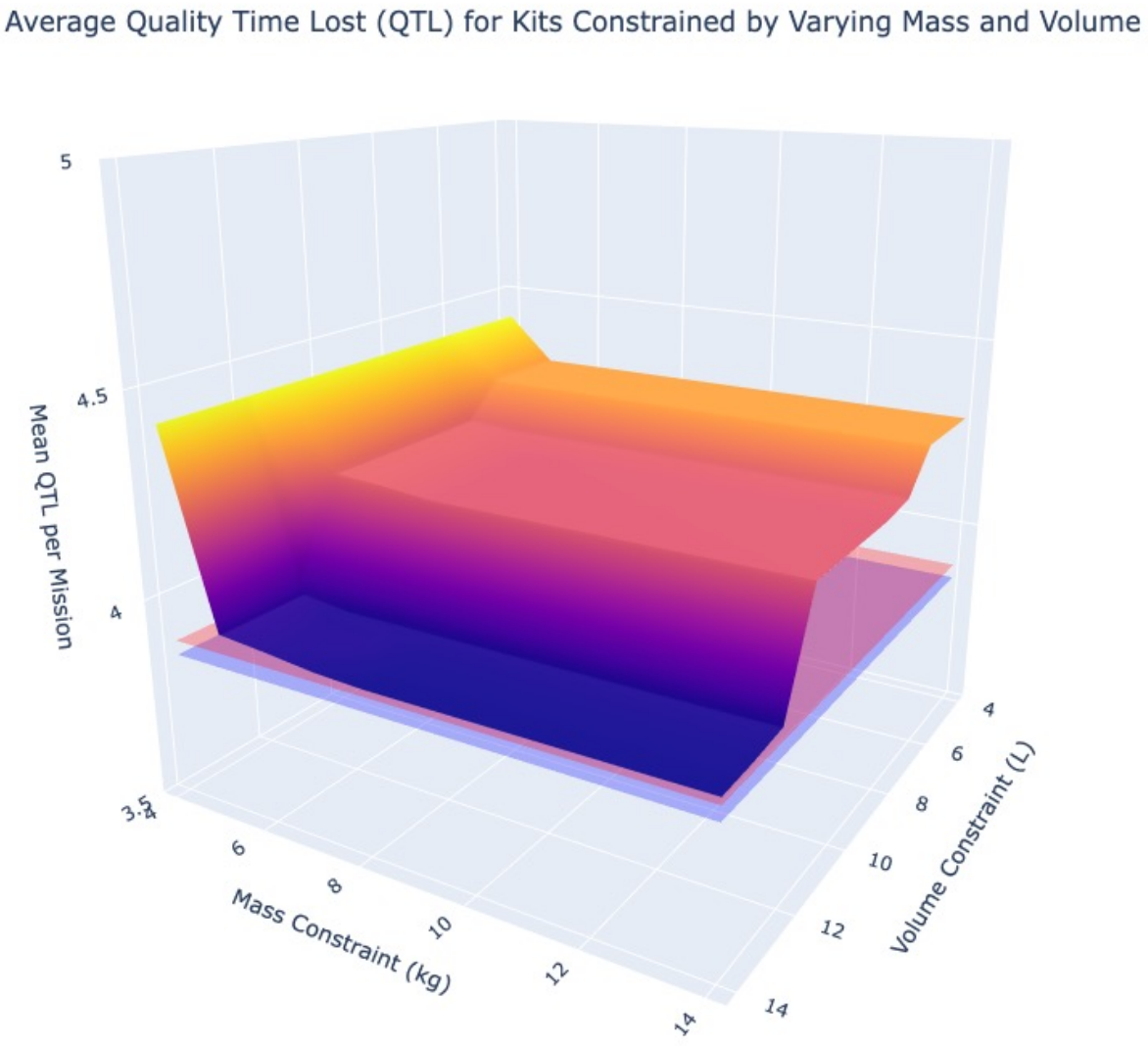
Loss of Crew Life (LOCL)
Removal To Definitive Care (RTDC)
Quality/Task Time Lost (QTL/TTL)

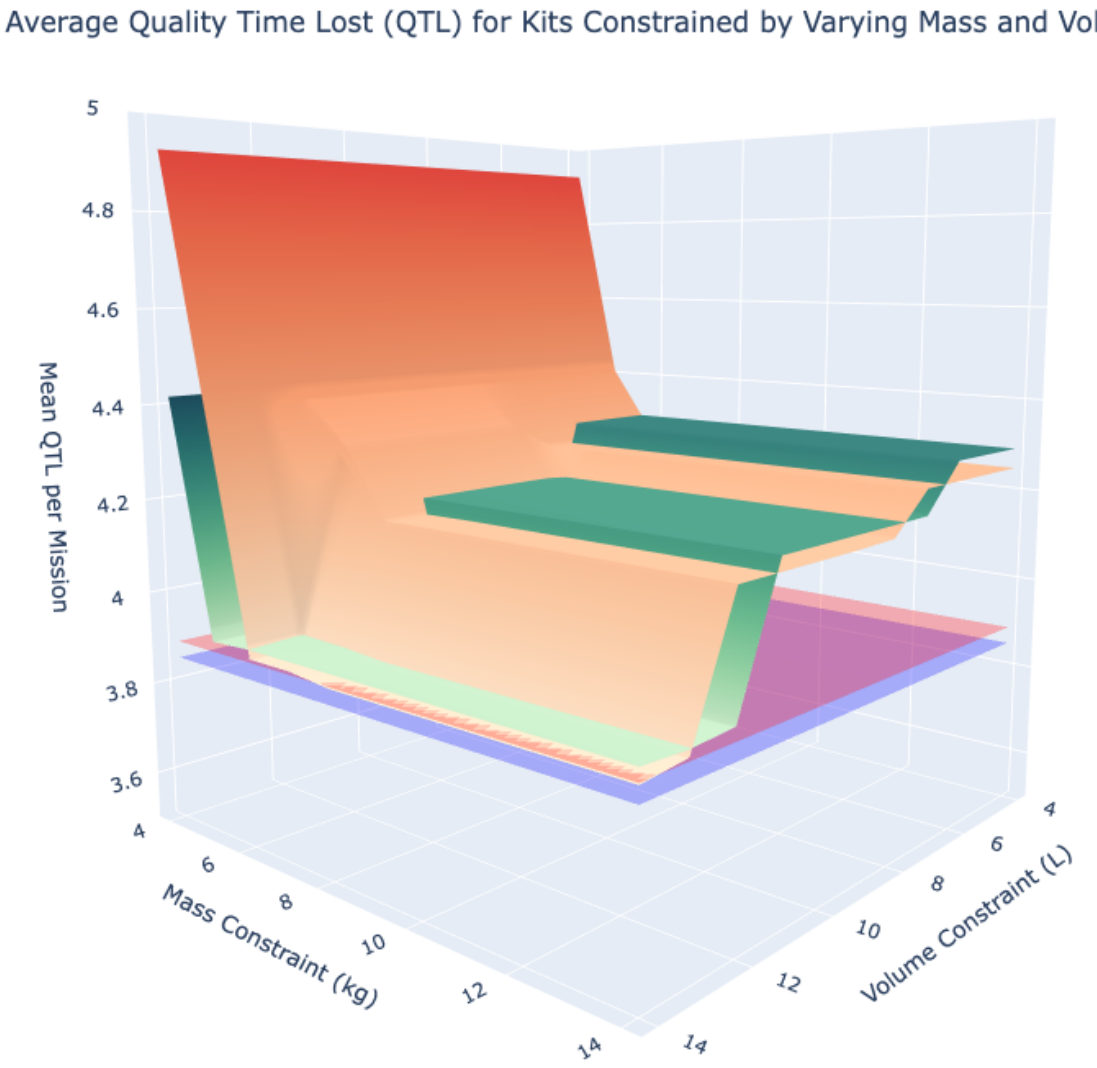
How does risk for an Artemis like mission change with respect to medical kit mass and volume constraints?

Should we send an ultrasound machine?

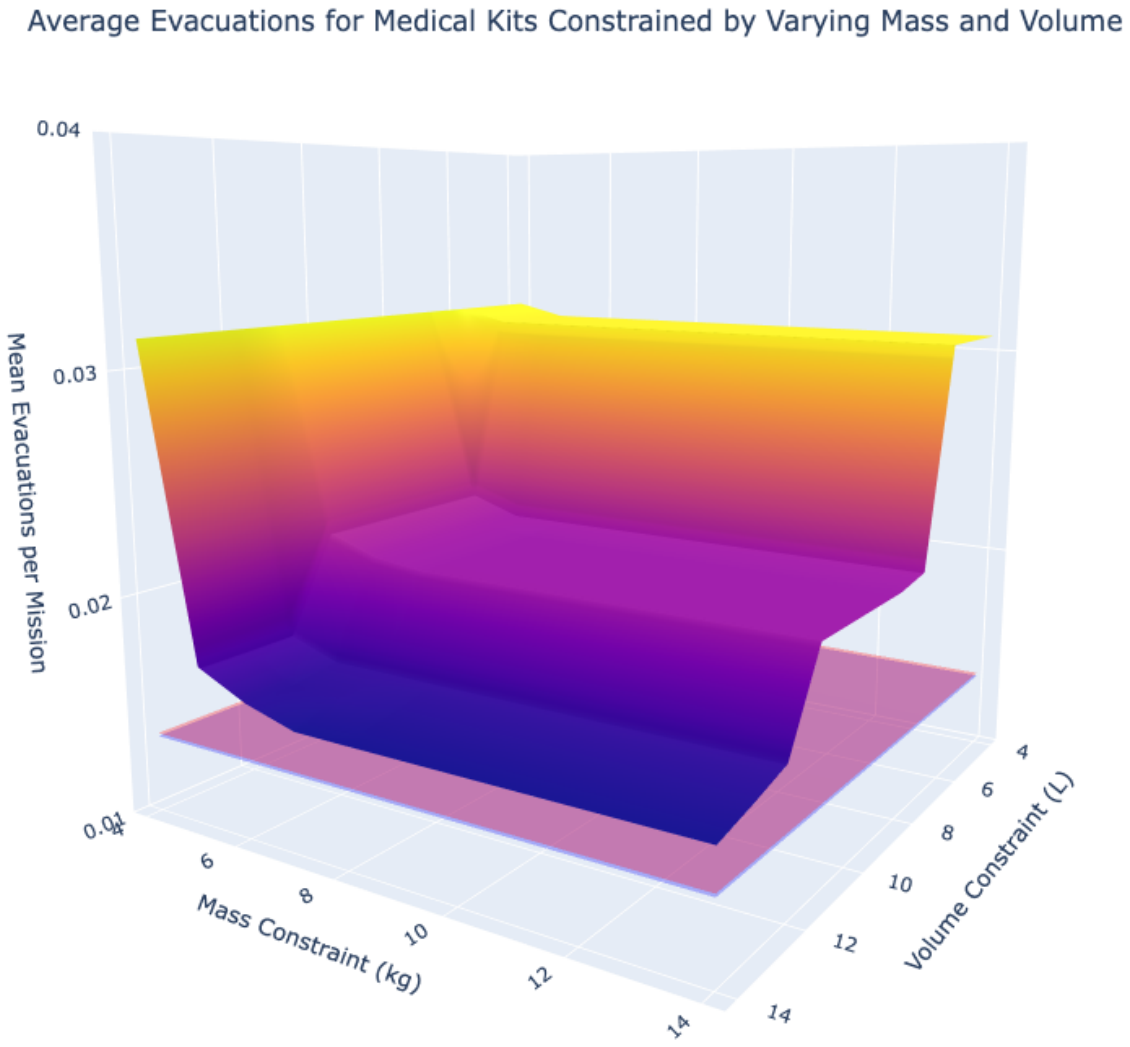
The new ultrasound machine will be 1kg/1L instead of 5kg/6.3L, how does this change the result?

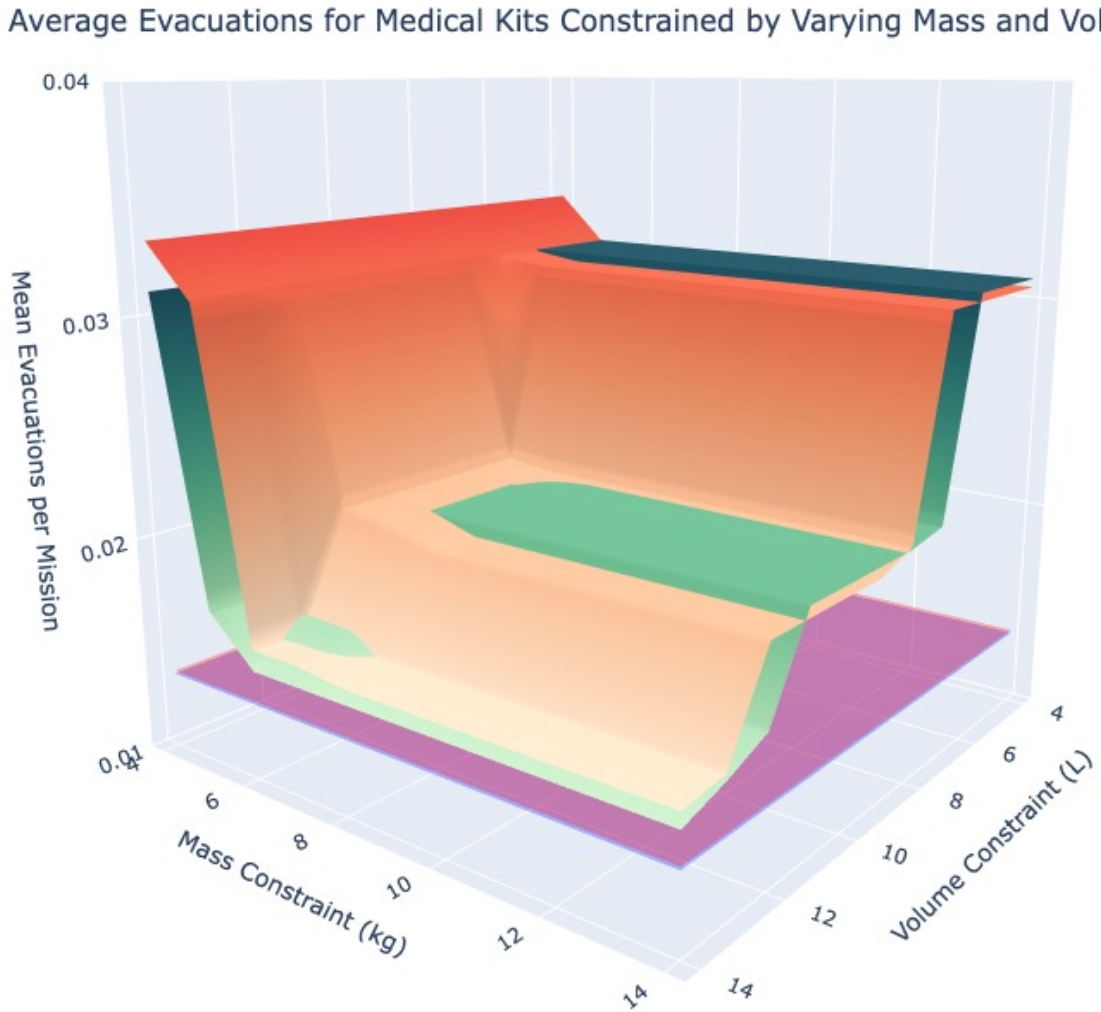
Risk with and without Ultrasound Machine (1kg/1L)



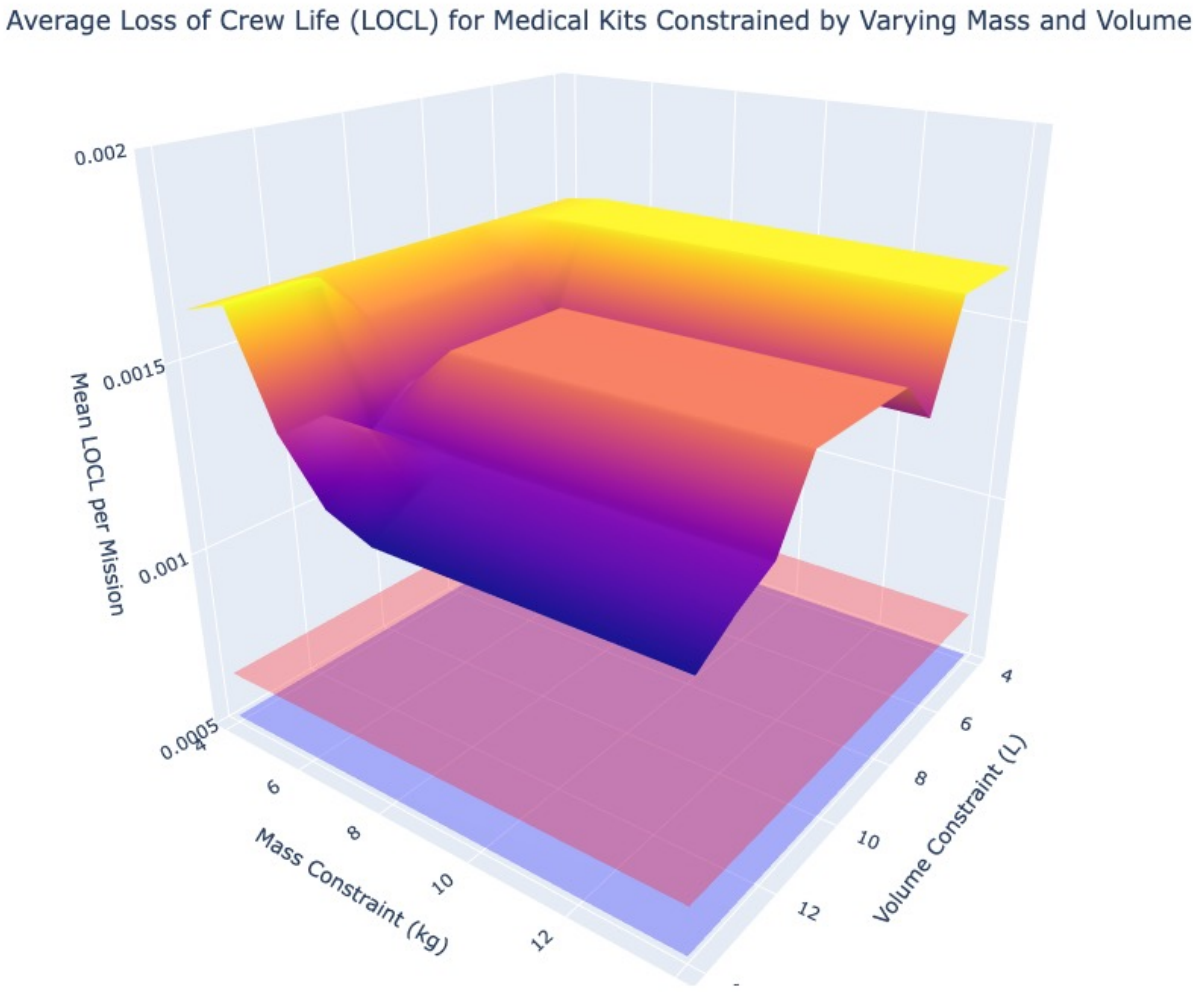


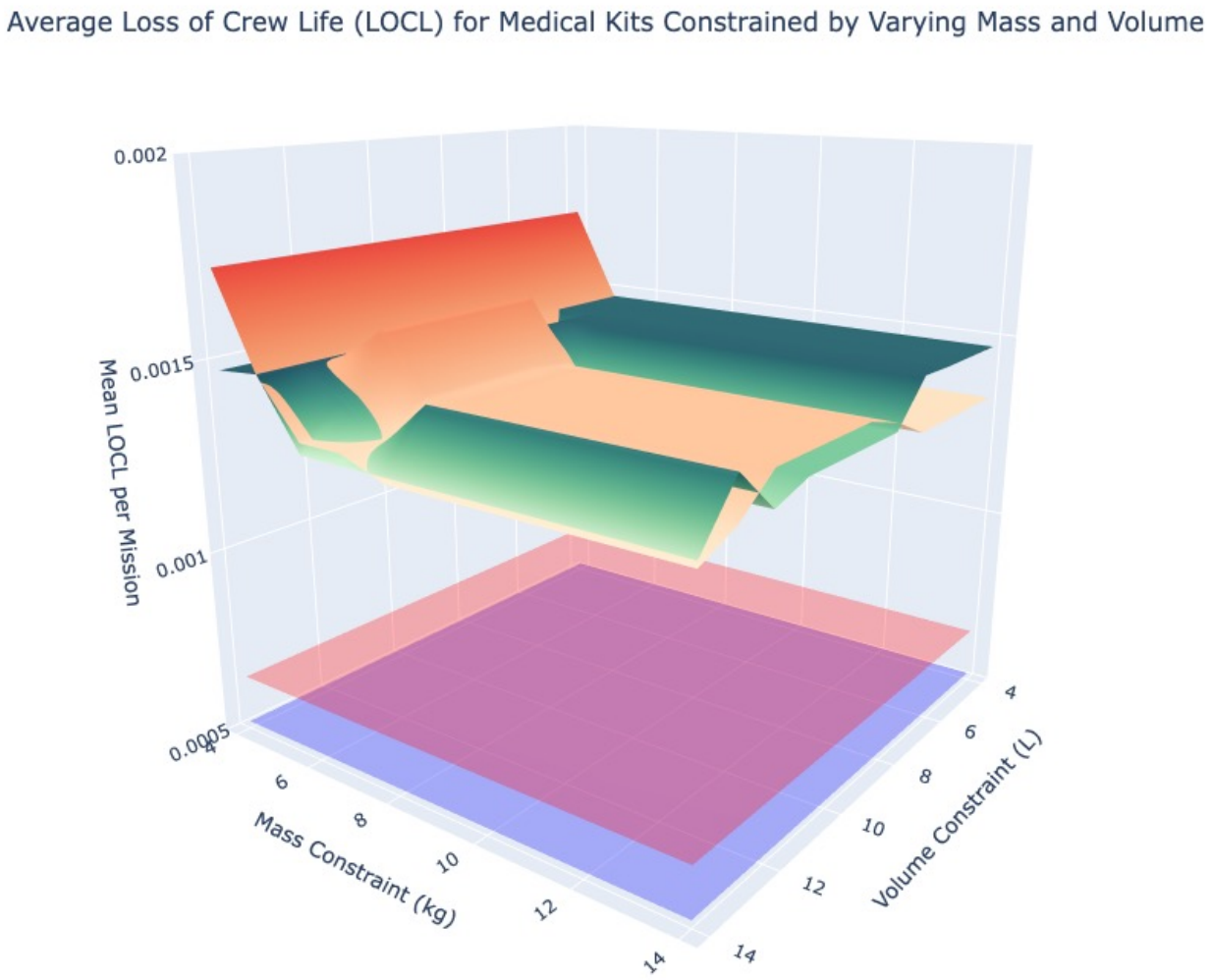
Risk with and without Ultrasound Machine (1kg/1L)





Risk with and without Ultrasound Machine (1kg/1L)






HUMAN RESEARCH PROGRAM
NASA
Thank you
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Artwork by Dr. Mona Matar