



Performance Risk Model Validation with Operationally Relevant Tasks

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Hunter Rehm¹, Mona Matar², Ian Lim², Christopher Gallo², Suleyman Gokoglu², Angela Harrivel³, Caroline Austin^{2,3}, Lauren McIntyre², and Jerry G. Myers, Jr.²

¹HX5, ²NASA Glenn Research Center, ³NASA Langley Research Center, ⁴University of Colorado Boulder



Performance Risk Model (PRisM)



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- Translating domain knowledge to operationally relevant tasks and missions.
- Answer questions for stakeholders.
- In this presentation we will show PRisM in action.



Human System Performance Categories

Lower Extremity

Lower-Body MIF

Cardiopulmonary

Plasma Volume

Fine Motor Control

Fine Motor Control Test

Upper Extremity

Upper-Body MIF

Sensorimotor Coordination

Tandem Walk

Cognitive

Activity Board

Sample Test Data

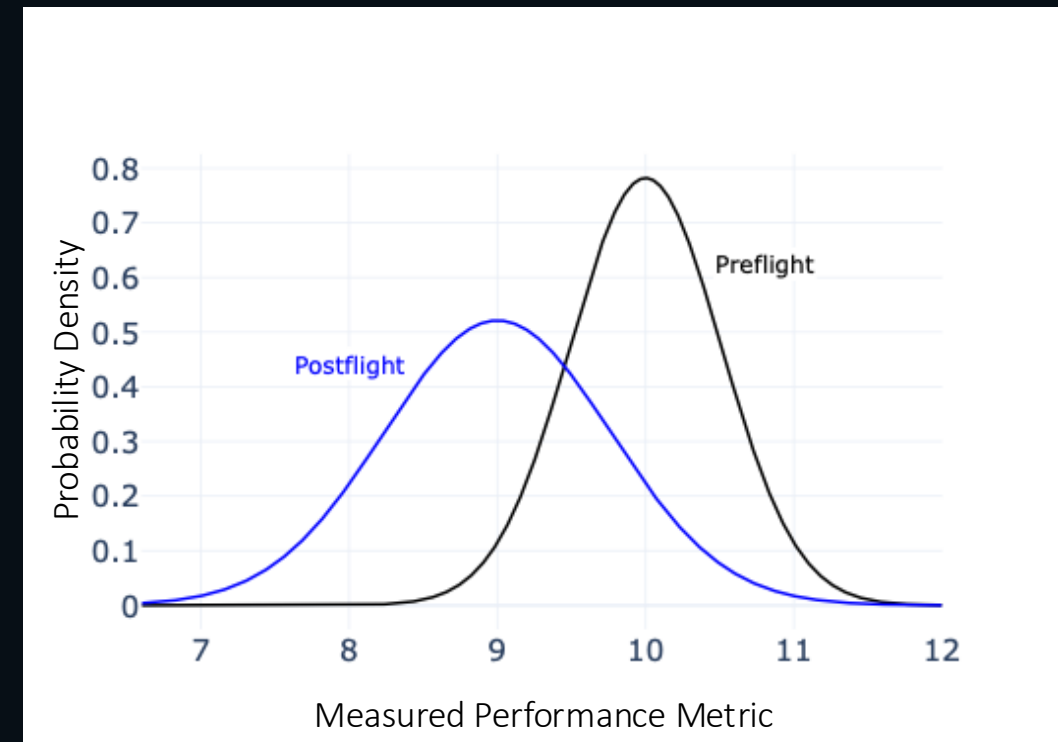
Description

Distribution of test scores for both preflight and postflight.

Assumption

The distribution represents the astronaut population.

Sample Data



Individual Readiness

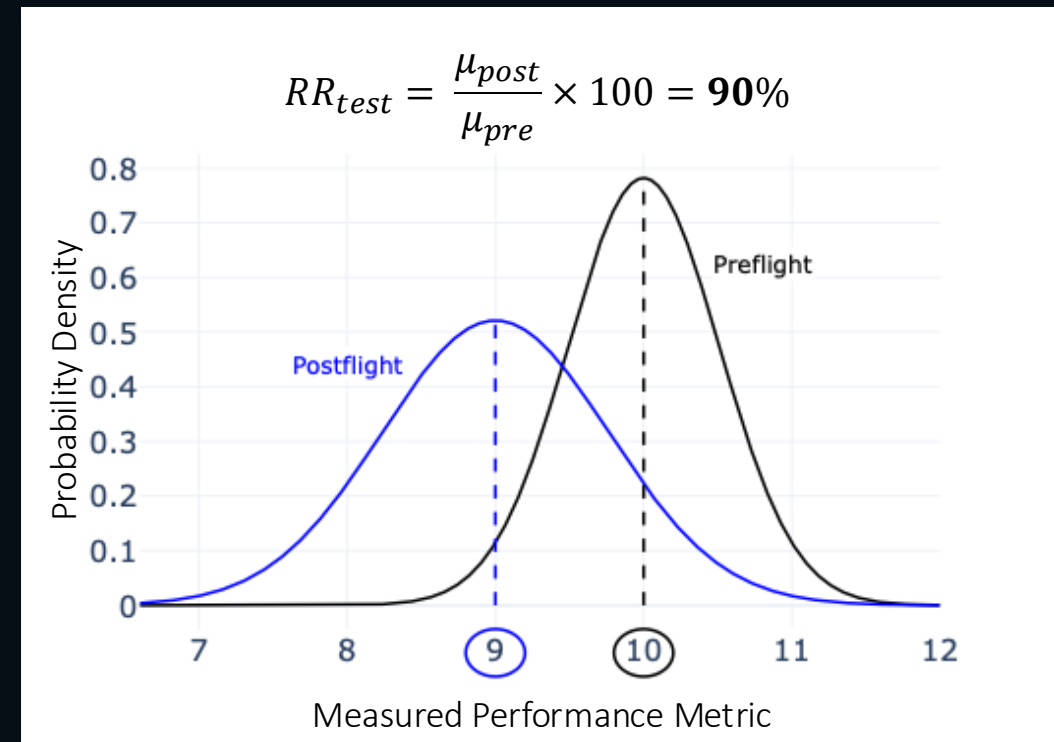
Definition

The level to which a crewmember is prepared mentally and physically to perform necessary tasks.

Relative Readiness from Preflight

$$RR_{test} = \frac{\mu_{post}}{\mu_{pre}} \times 100$$

Demonstration on Sample Data



Task Performance

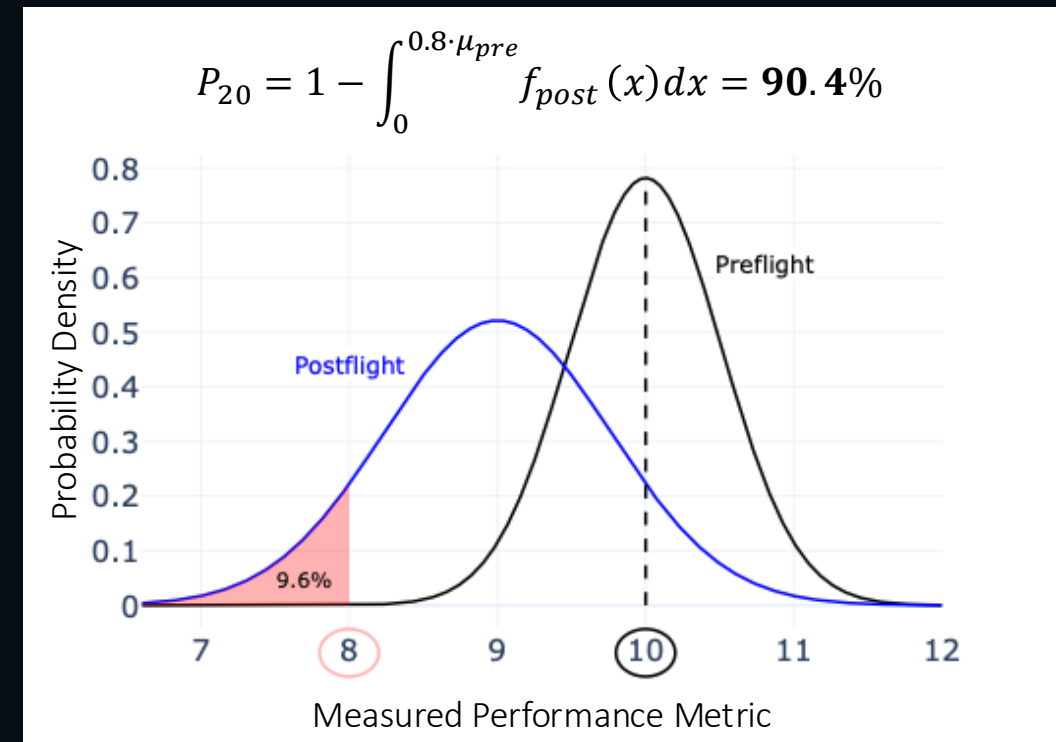
Definition

The likelihood of successful performance of a task by factors such as efficiency or accuracy.

Probability of Significant Performance Decrement

$$TP_{20} = 1 - \int_0^{0.8 \cdot \mu_{pre}} f_{post}(x) dx$$

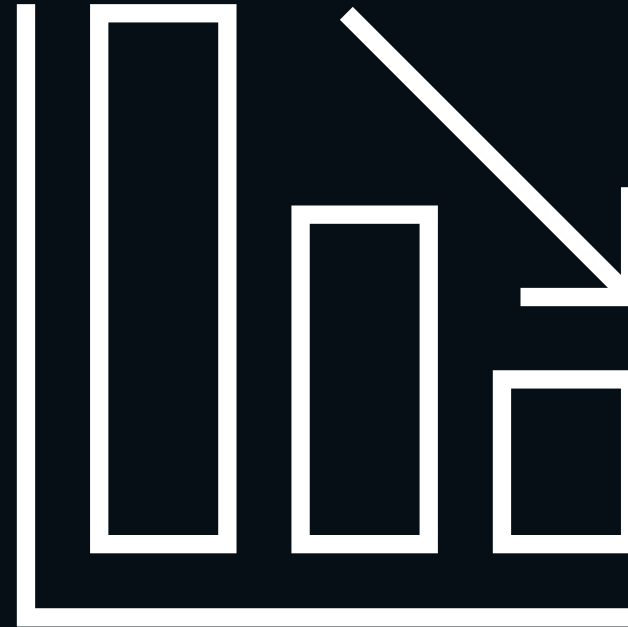
Demonstration on Sample Data





Performance Thresholds

“We defined high risk as a 20% or greater reduction in an endpoint because that threshold was associated with significant performance decrements in a ground-based analog study that evaluated simulated EVA and egress task performance.”¹



¹Scott, J. M. "Effects of exercise countermeasures on multisystem function in long duration spaceflight astronauts. NPJ Microgravity 9, 11 (2023)." PMID: 367374419898566(2022).



Performance Metrics

Individual Readiness

*Relative change from preflight
when they are the most prepared.*

$$RR_{test} = \frac{\mu_{post}}{\mu_{pre}} \times 100$$

Task Performance

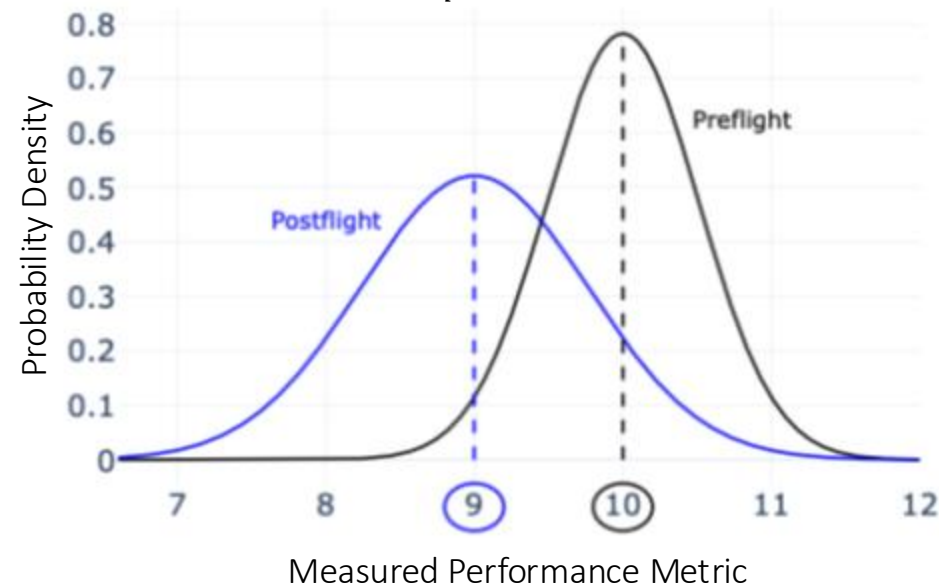
*Probability the task is completed
without significant decrements.*

$$TP_{20} = 1 - \int_0^{0.8 \cdot \mu_{pre}} f_{post}(x) dx$$

Sample Performance Data

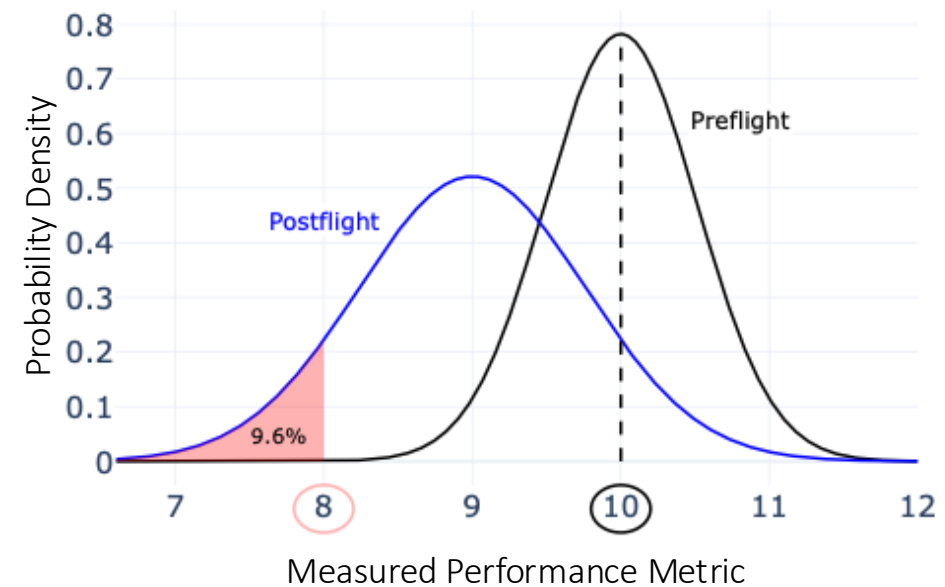
Individual Readiness

$$\Delta_{\%}\mu = \frac{\mu_{post}}{\mu_{pre}} \times 100 = \mathbf{90\%}$$



Task Performance

$$P_{20} = 1 - \int_{-\infty}^{0.8 \times \mu_{pre}} f_{post}(x) dx = \mathbf{90.4\%}$$





Human System Performance Categories

Lower Extremity

Individual Readiness: ??

Task Performance: ??

Cardiopulmonary

Individual Readiness: ??

Task Performance: ??

Fine Motor Control

Individual Readiness: ??

Task Performance: ??

Upper Extremity

Individual Readiness: ??

Task Performance: ??

Sensorimotor Coordination

Individual Readiness: ??

Task Performance: ??

Cognitive

Individual Readiness: ??

Task Performance: ??



Human System Performance Categories

Lower Extremity

Individual Readiness: 91.79%

Task Performance: 94.15%

Cardiopulmonary

Individual Readiness: ??

Task Performance: ??

Fine Motor Control

Individual Readiness: ??

Task Performance: ??

Upper Extremity

Individual Readiness: ??

Task Performance: ??

Sensorimotor Coordination

Individual Readiness: ??

Task Performance: ??

Cognitive

Individual Readiness: ??

Task Performance: ??



Human System Performance Categories

Lower Extremity

Individual Readiness: 91.79%

Task Performance: 94.15%

Cardiopulmonary

Individual Readiness: 99.93%

Task Performance: 100.00%

Fine Motor Control

Individual Readiness: 88.91%

Task Performance: 98.95%

Upper Extremity

Individual Readiness: 98.50%

Task Performance: 99.43%

Sensorimotor Coordination

Individual Readiness: 57.90%

Task Performance: 0.08%

Cognitive

Individual Readiness: 93.99%

Task Performance: 99.34%



Application to Mission





Application to Mission

Task Description	Lower Extremity	Cardiopulmonary	Fine Motor Control	Upper Extremity	Sensorimotor Coordination	Cognitive
Communicate status of systems to mission control immediately post landing.			1			1



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PRisM Validation



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Task Description	Lower Extremity	Cardiopulmonary	Fine Motor Control	Upper Extremity	Sensorimotor Coordination	Cognitive
<i>Rehearse docking and grappling maneuvers using the robotic arm on the ISS. That is, use ROBot-r.</i>			1			1



PRisM Validation

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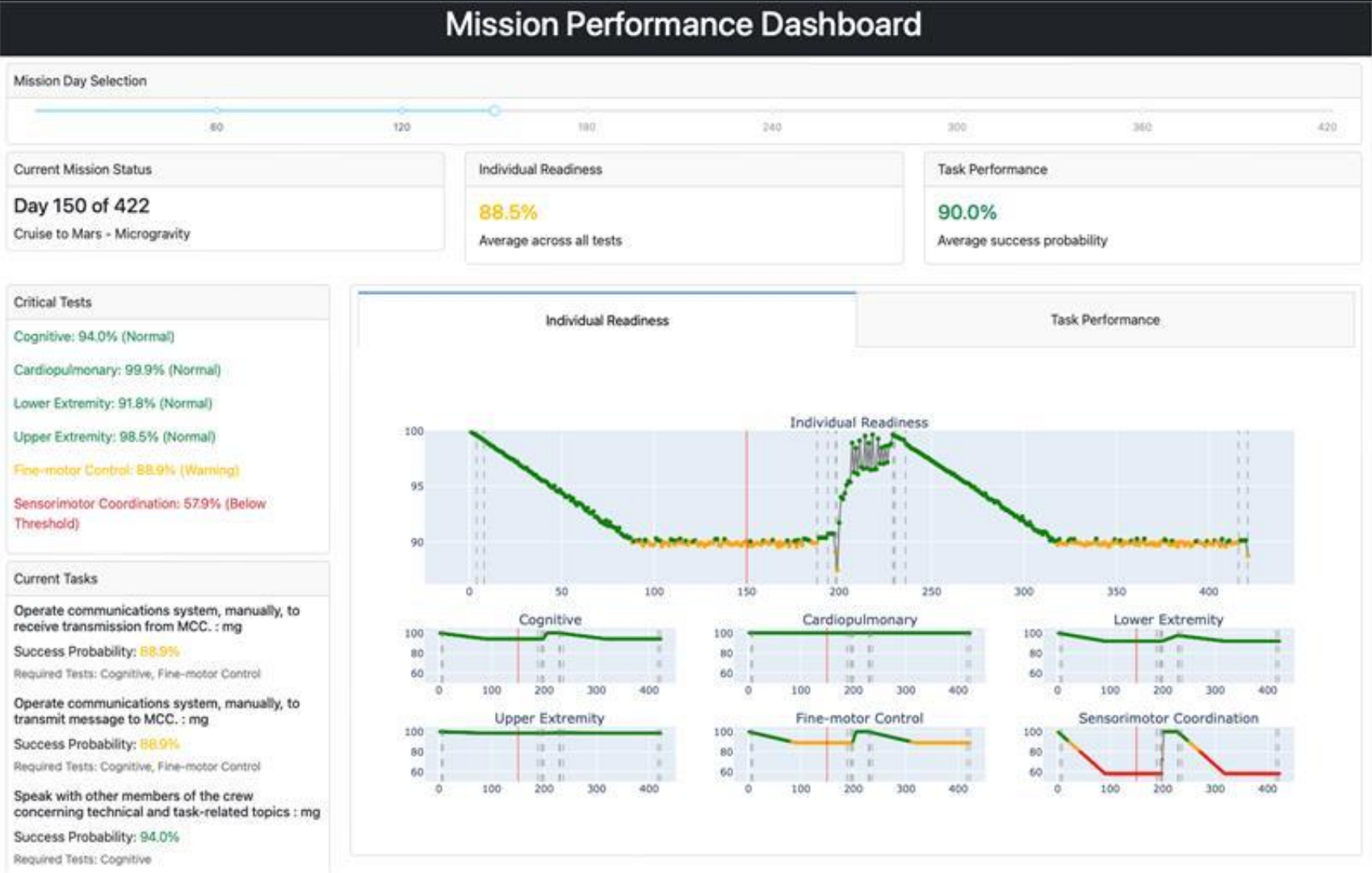


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Next Steps:

- Check if the Individual Readiness and Task Performance scores are **correlated** with ROBot-r data.
- Test other ways of calculating the final score.





Future Work



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- Develop appropriate validation of PRisM



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- Develop appropriate validation of PRisM
- Improve input data





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- Develop appropriate validation of PRisM
- Improve input data
- Implement a system for trading on countermeasures





Future Work

- Develop appropriate validation of PRisM
- Improve input data
- Implement a system for trading on countermeasures
- Investigate the use of GenAI in performance modeling



Thank you!

