



30 years



# Investigating Risks Due To Artemis EVA Tempo Via Probabilistic Risk Assessment

Drayton Munster<sup>1</sup>, Prashant Parmar<sup>2</sup>,  
Eric Kerstman<sup>2</sup>, David Hilmers<sup>3</sup>,  
Lauren McIntyre<sup>1</sup>, Jerry G Myers, Jr.<sup>1</sup>

<sup>1</sup>NASA Glenn Research Center, <sup>2</sup>University of Texas Medical Branch,  
<sup>3</sup>Baylor College of Medicine



# Overview

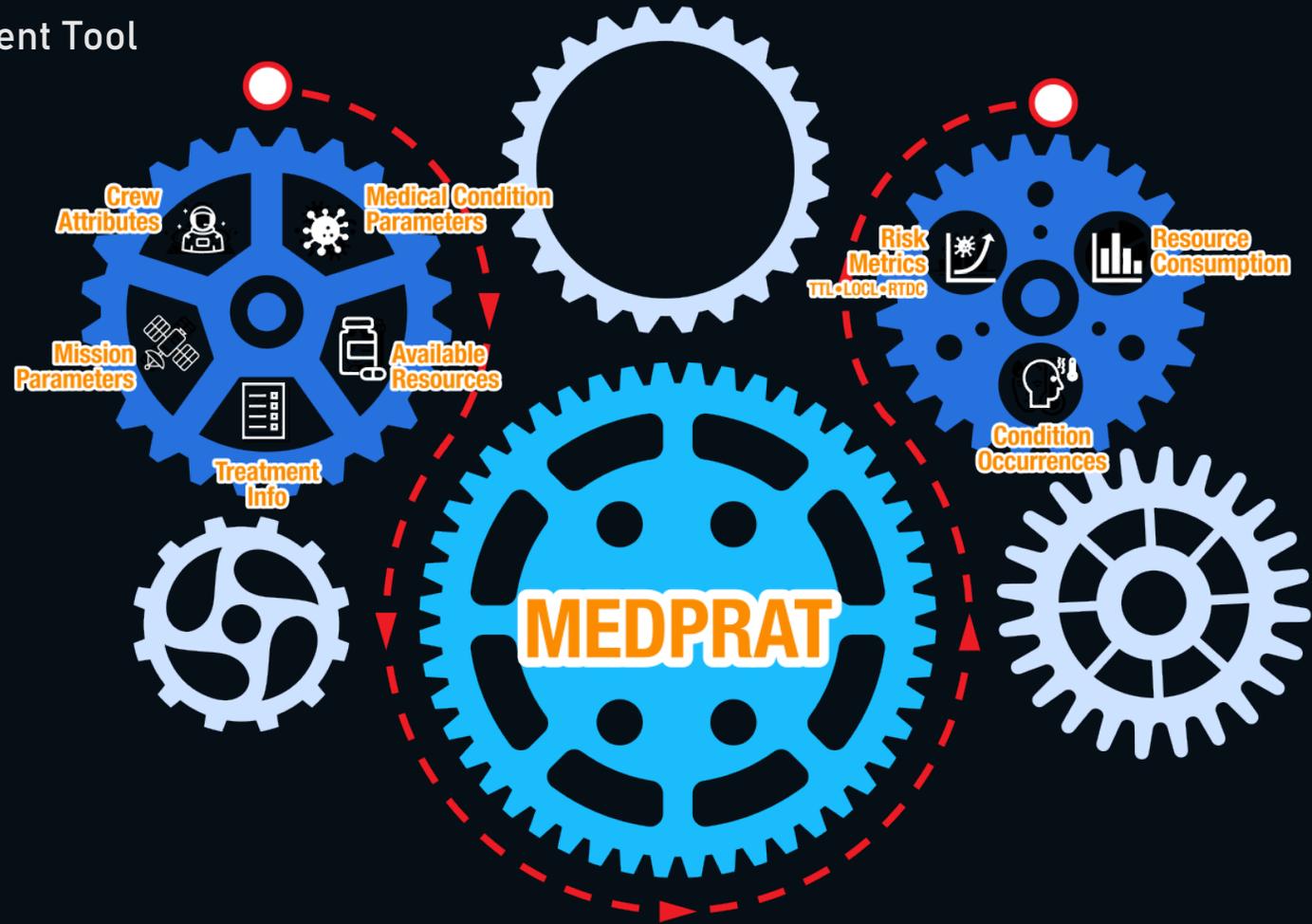
- Expecting a high frequency of EVAs on Artemis-class missions.
- Ask: How likely to complete all EVAs when considering medical events?
- Examine Decompression Sickness (DCS) as a motivating example.
- Describe our approach for extending this to other conditions and explore the simulation outcomes.

**Bottom Line Up Front:** Medical events may significantly reduce the ability to perform several back-to-back EVAs as scheduled.

# MEDPRAT

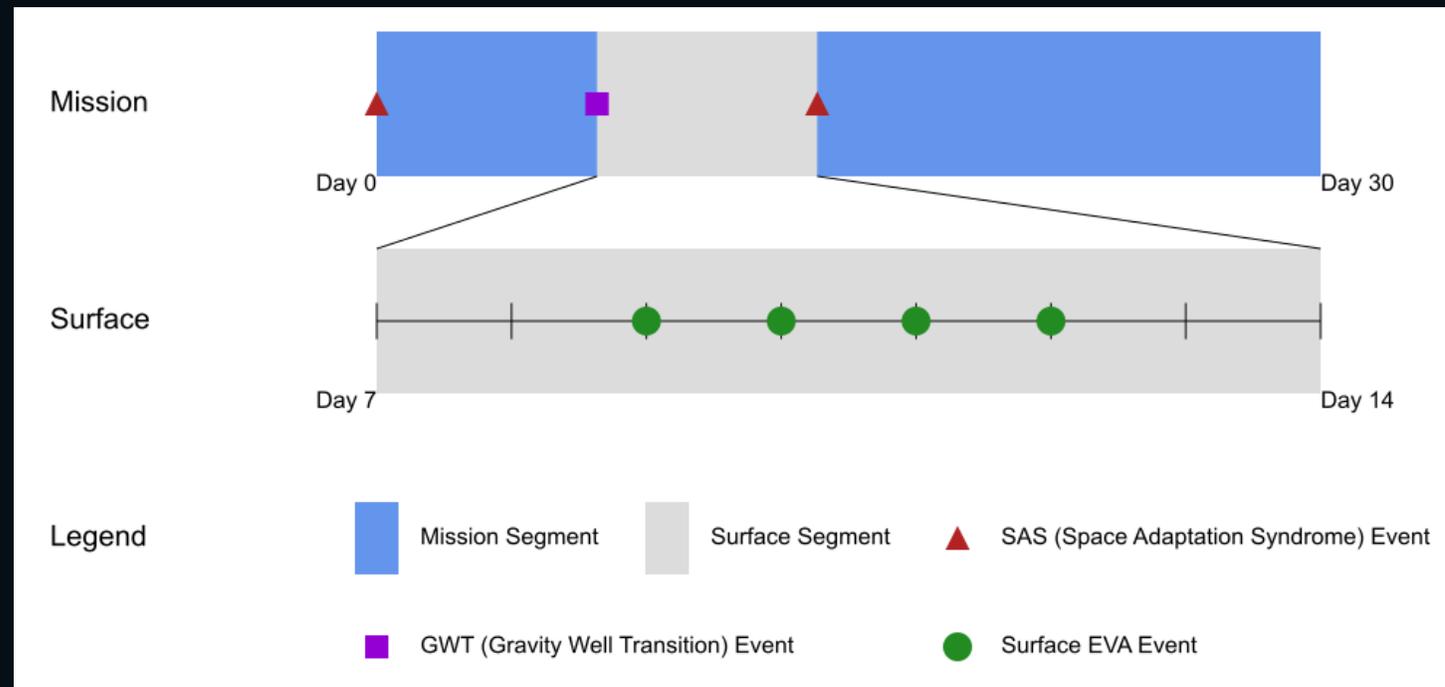
Medical Extensible Dynamic Probabilistic Risk Assessment Tool

- A computational PRA tool for quantifying spaceflight medical risk.
- One tool in the Crew Health and Performance Probabilistic Risk Assessment (CHP-PRA) portfolio.
- An evolution of IMM—shares the basic functionality of IMM, but with additional underlying software architecture and features/capabilities.



# Artemis III Mission Example

- Four crew on a 30-day mission
- Two crew will perform four EVAs on days 9, 10, 11, and 12





# Motivating Example: Decompression Sickness (DCS)

- Type I DCS (“Best Case”):
- Type II DCS (“Worst Case”):



See also: Gasiewski, C., et. al, Assessing the Influence of Decompression Sickness on Medical Risk for Artemis. SESS-52, Thu., 9 – 10:30 AM.



# Motivating Example: Decompression Sickness (DCS)

- Type I DCS (“Best Case”): 24H Block on EVAs
- Type II DCS (“Worst Case”):





# Motivating Example: Decompression Sickness (DCS)

- Type I DCS (“Best Case”): 24H Block on EVAs
- Type II DCS (“Worst Case”): Blocked for all future EVAs





# Extending to Other Conditions

- The Exploration Medical Capability Evidence Library<sup>1</sup> contains a total of 119 medical conditions relevant to human spaceflight.
  - 20 EVA-related conditions
- With the support of the SIO Clinical Science Team, evaluated the “best case” and “worst case” impacts for each condition:
  - No effect on EVA schedule
  - Cancelled/Delayed During Treatment
  - Cancel all subsequent EVAs

<sup>1</sup>HRP-48036. Rev. B — Evidence Library Methods Document

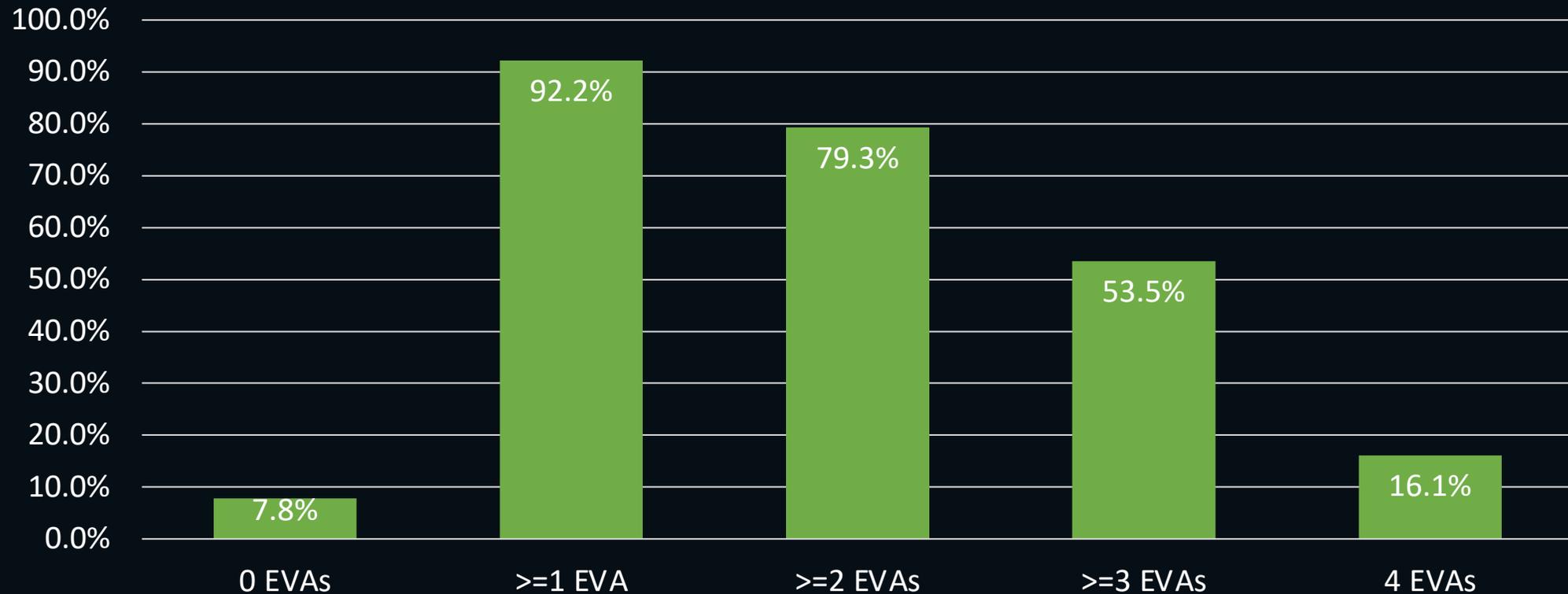


# Caveats

- Results are preliminary, have not been subject to review, and must not be used on a decisional basis.
- Delays and cancellations of EVAs have been combined into a single measure, potentially over-estimating the impact to schedule.
- Conservative estimates of EVA scheduling effects will over-estimate impact to schedule.

# Simulation Results

Percentage of Trials with EVAs Completed As Scheduled



Preliminary – Non-decisional



# Simulation Results

Mean EVAs Completed As Scheduled Per Trial: 2.4

Outcome	Percentage of EVAs
Successful	60.3%
Affected by EVA-Related Shoulder Injury	6.1%
Affected by EVA-Related Decompression Sickness	4.8%
Affected by Gravity Well – Entry Sensorimotor/Neurovestibular Disturbance	3.1%
Affected by Gravity Well - Orthostatic Intolerance	2.9%
Affected by Gravity Well Entry Motion Sickness	2.5%
Affected by EVA-Related Hand Injury	2.3%
Affected by other conditions	18%

Preliminary – Non-decisional



# Conclusions

- While likely a conservative over-estimate of the risks, these results illustrate that the planned tempo of EVAs has a lower likelihood of achieving mission EVA objectives.
- Future efforts include refinement by tracking delays and cancellations separately as well as refining the per-condition effects to allow more nuance in scheduling impact.
- Integration with CHP-PRA PRisM<sup>1</sup> planned to understand the combined effect of medical and performance risks.

<sup>1</sup>Performance Modeling & Risks session. Friday, 9-10:30 AM, Galleon I,II,III.

# Questions

Drayton Munster

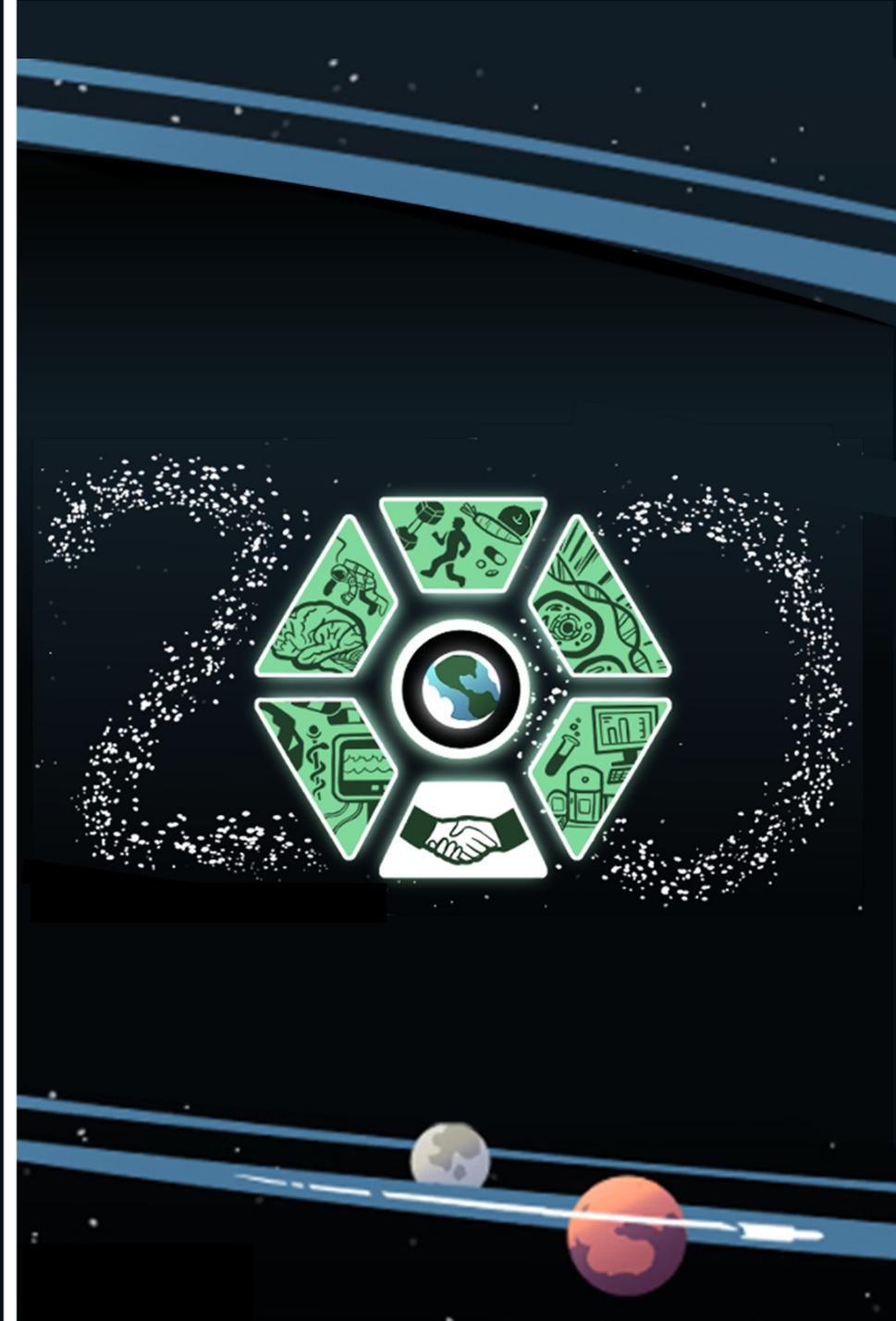
[drayton.w.munster@nasa.gov](mailto:drayton.w.munster@nasa.gov)

Lauren McIntyre

[lauren.p.mcintyre@nasa.gov](mailto:lauren.p.mcintyre@nasa.gov)

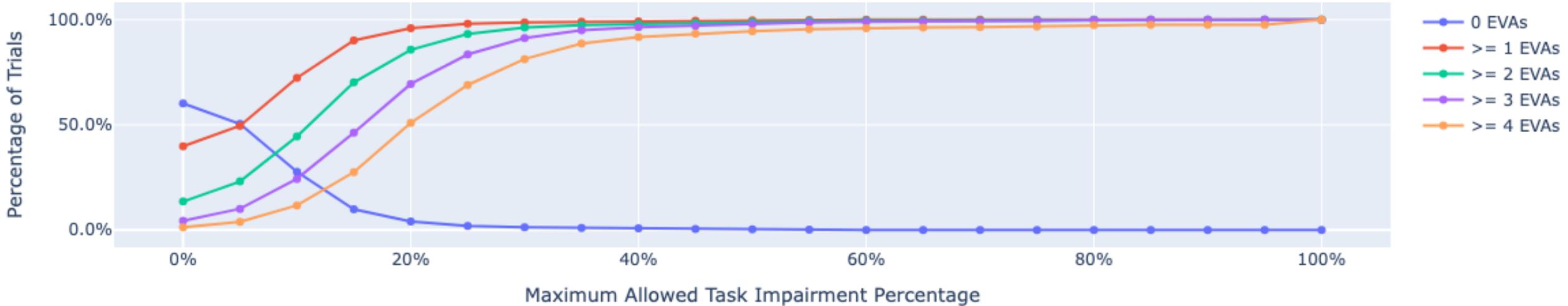
Jerry Myers

[jerry.g.myers@nasa.gov](mailto:jerry.g.myers@nasa.gov)



# EVA Scheduling as a Function of Task Impairment

Percentage of Trials with EVAs Completed as Scheduled



Preliminary – Non-decisional