



Overview of the Human Factors and Behavioral Performance Element Risk Mitigation Strategies

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NASA Human Research Program



Composed of Four Elements

- Space Radiation
Biological effects of radiation exposure – cancer
- Human Health Countermeasures
Physiological Changes
- Human Factors and Behavioral Performance (HFBP)
*Individual and interpersonal outcomes
Interfaces between humans, vehicles & habitats*
- Research Operations and Integration
Infrastructure for flight and analog experiments

Collaborate with other internal and external partners to help provide solutions for future spaceflight





**Human Factors / Earth
Independent Human-Systems
Operations**

NASA Human Research Program (HRP)

Human Factors and Behavioral Performance (HFBP)



Injury from Dynamic Loads



**Sleep, Circadian Rhythms,
Workload**



Behavioral Health



Team Cohesion and Performance

Lunar

- **Communication delays (~4 sec to 15 sec one-way) may negatively impact crew-ground interaction (e.g. family com, PPCs)**
- **High tempo operations (back-to-back EVAs), shifting schedules**
- **Non-earth day-night cycles**
- **As lunar missions extend in duration, radiation exposure increase**
- **Changing locations**
- **Limited volume reduces countermeasure capability**

Mars

- **Extended communication delays (~19 minutes one way) reducing crew-ground interaction**
- **High tempo operations (back-to-back EVAs), shifting schedules, with extended periods of monotony**
- **Mars Sol (24 hour 39 minutes)**
- **Extended duration mission with increased radiation exposure**
- **Limited volume and distance from earth reduces countermeasure capability**



What are we working towards?



“Deliverables that buy down risk for future exploration missions”



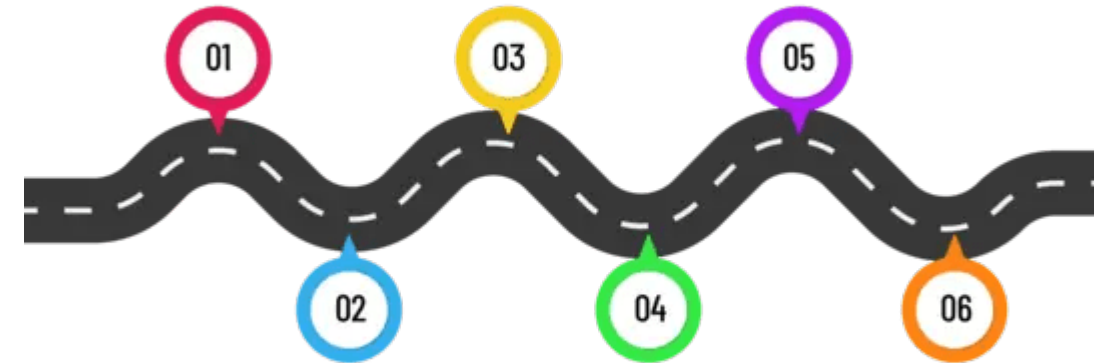
Recommendations for semi-autonomous behavioral health and performance monitoring system

- Communication delays



Guidelines for interface and touchscreen development

- Changes in fine motor screen manipulations





Collaborative Community



“Deliverables that buy down risk for future exploration missions”



**Spaceflight
Operations**



**Flight Operations Directorate
Behavioral Health &
Performance (BHP) Operations
Human Factors Practitioners**



**Human Research
Program**



HFBP Element



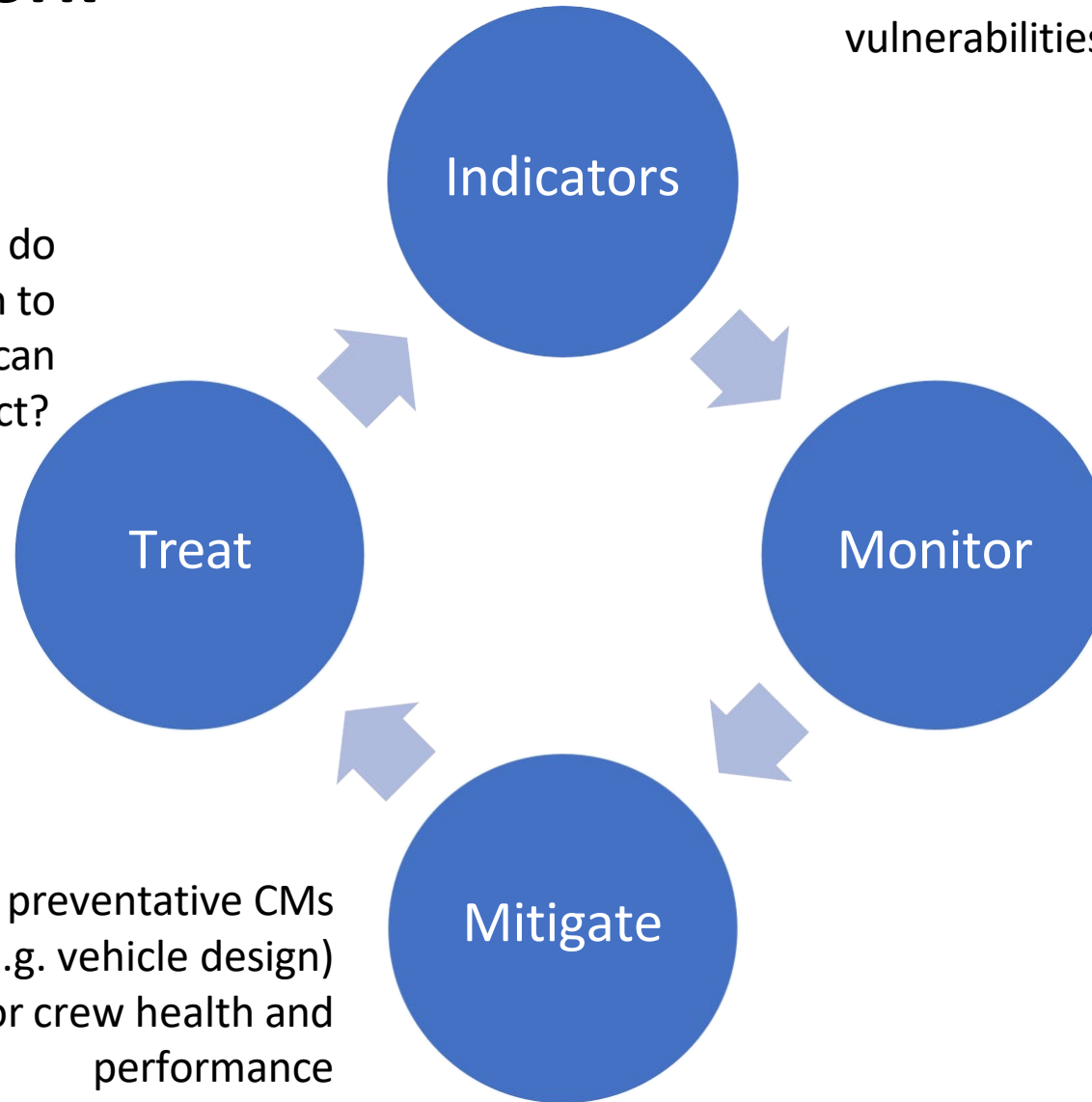
**Research
Institutions/Labs**



**BHP
Human Factors Engineering Lab
Human Health and Performance
Fatigue Countermeasures - NASA Ames
External Institutions**

HFBP Framework

- If adverse outcomes do occur (on a mission to Mars), what treatments can be given to reduce impact?



- Pre-Mission preventative CMs (e.g. vehicle design)
- In-mission support for crew health and performance

- What are **the key indicators** that suggest vulnerabilities and resiliencies?

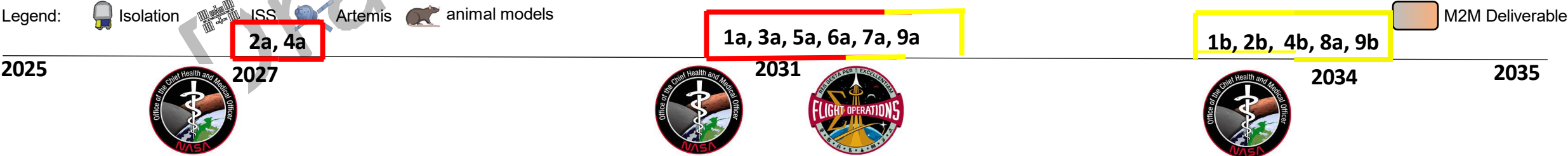
- What/how do you monitor in flight? Best **measures** and methods?
- What are meaningful thresholds?
- How can feedback equip future crews for self-monitoring?

Valid, Reliable, Sensitive
Minimally Obtrusive
Acceptable
Feasible
Effective

Risk of Adverse Cognitive or Behavioral Changes and Psychiatric Disorders Leading to In-Mission Health and Performance and Long-Term Health Effects Risk Approach Plan

Draft Version - In Work

HRR Knowledge Gaps	Risk Characterization / Formulation	CM Development / Evaluation
	BH-109: Characterize in-mission and long-term effects of long-duration spaceflight on behavioral health and performance. 1 Impacts of exploration spaceflight on in-mission and long-term behavioral health and performance: BHP Ops by 2031 (interim), 2034	BH-201: Identify indicators, measures, and thresholds, to inform semi-autonomous behavioral health and performance monitoring 2 Recommendations to inform crew selection for Mars: BHP Ops by 2027 (interim), 2034 3 Recommendations for semi-autonomous monitoring system, integrating relevant measures and evidence/threshold-based guidelines for countermeasures: BHP Ops by 2031
		BH-202: Identify evidence-based design recommendations for habitat/vehicle interfaces, to mitigate impacts to behavioral health and performance 4 Recommendations to inform habitat/sub-system design: HMTA by 2027 (interim), 2034
		BH-203: Develop, test/refine, and validate countermeasures to support behavioral health and performance for future exploration missions 5 Behavioral health training curriculum/modules: BHP Ops by 2031 6 Countermeasures for in-mission behavioral health support: BHP Ops by 2031 7 Family and crew social support toolbox to enable post-mission re integration: BHP Ops by 2031 8 Validated countermeasures to support behavioral health & performance: BHP Ops by 2034
		BH-204: Identify, test and refine therapeutic interventions for treating adverse behavioral outcomes associated with exploration missions 9 Therapeutic interventions to treat adverse health outcomes: BHP Ops by 2031, 2034



Risk of Performance and Behavioral Health In-Mission Decrements Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team - Risk Approach Plan

Draft Version - In Work

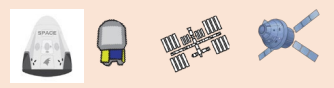
HRR Knowledge Gaps

Risk Characterization / Formulation

CM Development / Evaluation

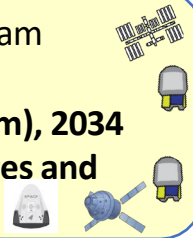
Team-101: Characterize the key threats, indicators, and evolution of the multi-team system under shifting autonomy, for exploration missions

- 1 **Impacts of exploration mission on multi-team performance: FOD, BHP Ops 2027 (interim); update 2034**



Team-201: Define indicators, measures, and thresholds, to inform semi-autonomous monitoring of team functioning and performance

- 2 • **Interim recommendations to inform crew composition for Mars: BHP Ops by 2027 (interim), 2034**
- 3 **Recommendations for semi-autonomous monitoring system, integrating relevant measures and evidence/threshold-based guidelines for countermeasures: BHP Ops by 2031, 2034**



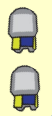
Team-202: Inform design recommendations for habitat/vehicle interfaces, to mitigate impacts to team functioning and performance

- 4 **Recommendations to inform habitat/sub-system design: HMTA by 2027 (interim), 2034**



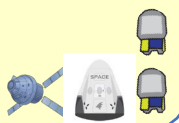
Team-203: Develop, test/refine, and validate countermeasures to support team functioning and performance during exploration missions

- 5 **Countermeasures for maintaining team functioning & performance: BHP Ops by 2031**
- 6 **Countermeasures for within-crew social support: BHP Ops by 2031**



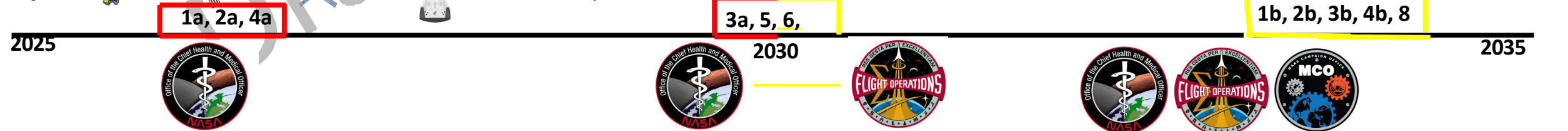
Team-204: Identify, test, and refine monitoring approaches and countermeasures to address the multi-team system, for exploration missions

- 7 **Measures & Countermeasures for multi-team system: BHP Ops/FOD by 2031**
- 8 **Validated measures and CMs for multi-team system for Mars: BHP Ops by 2034**



M2M Deliverable

Legend: Isolation ISS Artemis Commercial Freeflyers/PAM



Risk of Adverse Outcomes due to Earth Independent Human-System Operations Risk Approach Plan

Draft Version - In Work

HRR Knowledge Gaps

Risk Characterization / Formulation

EIHSO – 102: Characterize human-system performance impacts due to increasingly Earth-independent missions (e.g. communication delays) and determine indicators of meaningful change to enable mission objectives

1 Impacts of increasingly earth-independent mission on human-system performance: FOD, MCO by 2027 (interim), 2034



CM Development / Evaluation

EIHSO – 202: Develop and validate monitoring countermeasures of human-system performance (procedure execution, anomaly resolution) during increasingly Earth-independent operations (e.g. communication delays)

2 Recommendations for semi-autonomous monitoring dashboard: BHP Ops, FOD by 2031 (interim), 2034



EIHSO – 203: Develop & validate candidate requirements for design of vehicles, habitats, interfaces (e.g. displays for complex info presentation, fine motor decrements) to support increasingly Earth-independent operations

3 Recommendations to inform habitat/sub-system design: HMTA by 2027, 2031



4 Guidelines and multi-modal methods to mitigate touch screen manipulation decrements: HLS by 2027 (interim), 2031



EIHSO – 204: Develop and validate countermeasures to enable human-system performance (procedure execution, decision support) for increasingly earth independent crews

5 Task simulation tools for anomaly resolution and decision support under communication delays: FOD by 2031



6 Procedure execution guidance & requirements under communication delays: MCO, FOD by 2027 (interim), 2031



7 Recommendations for personalized, adaptive VR training regimens & platforms: BHP Ops, FOD by 2031



EIHSO – 205: Develop and validate countermeasures to enable safe human-robot interaction

8 Safe human robot interaction guidelines and countermeasures: FOD by 2031 (interim); 2034



Legend:



Isolation



ISS



Artemis



Commercial Freeflyers/PAM

1a, 3a, 4a, 6a

2a, 3b, 4b, 5a, 6b, 7a, 8a

1b, 2b, 8b

M2M Deliverable

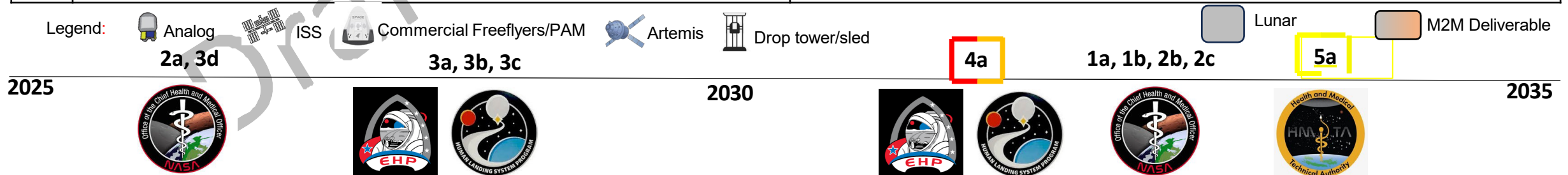
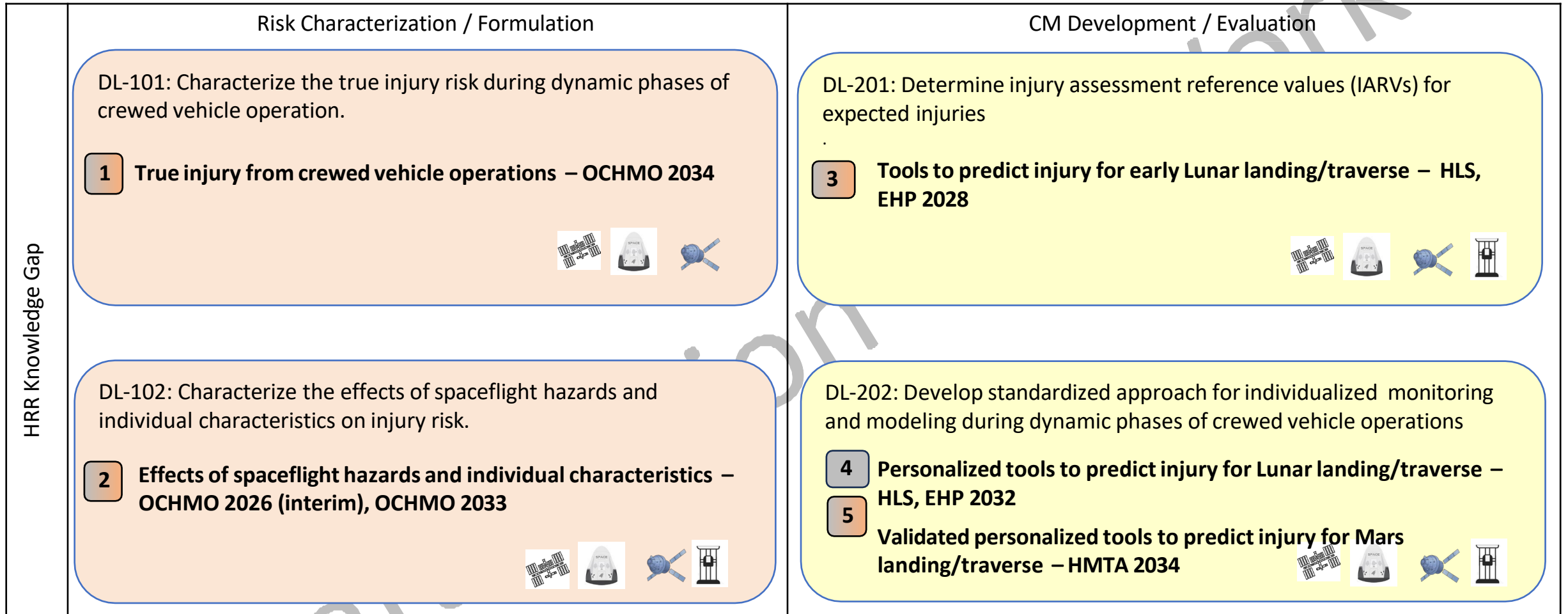
2025

2035



Risk of In-Mission Injury and Performance Decrements and Long-term Health Effects due to Dynamic Loads

Draft Version – In Work





Countermeasures for Exploration



Vehicle and Subsystem
Design

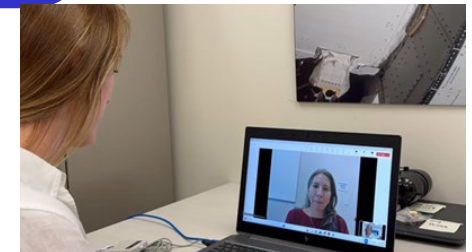


Team Training
Recommendations and
Communication
Protocols

Family and Social
Support



Workload / Operational
Performance





Future Research Approaches- Analogs



- Planning extended duration missions
- Improve fidelity of habitat and mission scenarios, including with ground control operations – **Operational Fidelity**
- **Countermeasure testing** and capability demonstration with other stakeholders
- “Test bed” between operations and research to test and validate measures and countermeasures for Mars
- Address questions for lunar missions while addressing Mars

Areas of focus – joint efforts between Operations Teams & Research

- Behavioral Health Monitoring and Support for Exploration
 - Family support countermeasures and post-mission reintegration
 - Distributed teams (EVAs) & communication delay protocols
- Earth Independent Human- System Operations
 - Adaptive training
 - Decision support tools



Current spaceflight research approach: high priority research question *requires* spaceflight environment



Thank you