National Aeronautics and Space Administration

Decadal Stakeholder Perspective NASA Human Research Program

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From BPS presentation yesterday

- **The Human Research Program (HRP)**
  - HRP identifies, characterizes, and mitigates risks to crew health and performance
  - HRP research generally does not extend down to molecular mechanisms
    - Space Biology animal research generally seeks molecular level understanding
      - Identifies potential biomarkers for monitoring crew health
      - Identifies candidate approaches for countermeasure development
  - Space Biology plant research seeks to develop crop plants that can provide crew with micronutrients and increased behavioral health in exploration missions
  - Space Biology microbiological research studies the microbiome of animals/crew, plants, the built environment and the interactions between the three
    - HRP focuses on the impact of the microbiome on crew health

Human Research Program Mission

To enable space exploration beyond Low Earth Orbit by reducing the risks to human health & performance through a focused program of:

- **Basic, applied, and operational research**

leading to the development and delivery of:

- **Human health, performance, and habitability standards**
- **Countermeasures and other risk mitigation solutions**
- **Advanced habitability and medical support technologies**

Primary Customers: HEOMD Exploration Architecture/Vehicle/Mission designers, OCHMO/HMTA, FOD/CB

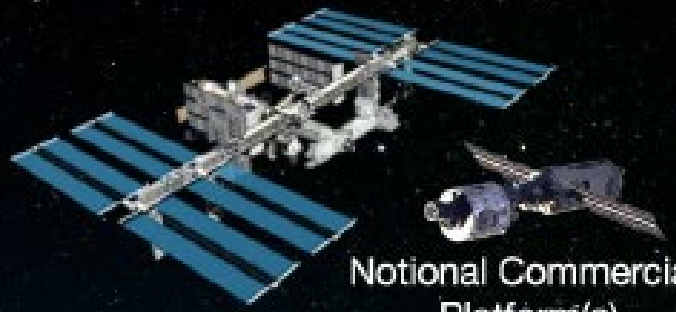
Human Research for Risk Reduction in

SUSTAINABLE HUMAN EXPLORATION

National Aeronautics and Space Administration

NASA

International Space Station (ISS)



Notional Commercial Platform(s)

Low-Earth Orbit (LEO) Platforms: Analogs for transit to Mars and crew performance after landing

Gateway

Integrated Missions with stays on the Gateway and activities on the lunar surface serve as analogs for crew health and performance on missions to Mars.

Successful Mars transit and surface missions will build on knowledge gained through analogs and research on all previous platforms

Mars-class Transportation

Mars missions will require advancements in how we mitigate the effects of all 5 hazards of human spaceflight:

- ☐ Isolation & Confinement
- ☐ Distance from Earth
- ☐ Changes in Gravity
- ☐ Radiation
- ☐ Hostile Closed Environments

Earth: Simulated habitats and operations analogs

Lunar Surface: Human experience of greater deep space hazards

HRP Standards, Technology and Countermeasures Deliverables

BMed

1. Study Results for Biomarker Thresholds linked to Performance
   - Risk Characterization
   - Standards for Clinical guidelines
2. Standards for Treatments, CMs, and Tools
3. Risk Characterization for Key Indicators of Cognitive Performance & Behavioral Conditions

Space Radiation

1. Baseline Cancer PEL
2. Cancer PEL Update
3. Integrated Radiation CM Toolkit
4. Radiation Recommendations for Clinical Practice Guidelines
5. Radiation Countermeasure Identification
6. Recommendation for Fitness for Duty Standards

Food

1. Storage Limit Requirements
2. Physiological CM
3. System Trades and Validations

Team

1. CMs and Tools
2. Risk Characterization: Key Indicators Team Performance

CVD

1. CM based on Weightlessness
2. CM combined effects
3. Standards based on Weightlessness
4. Standards Combined Effects

ExMC

Medical

1. IMPACT Version 1.0
2. IMPACT Version 2.0
3. Foundation: Level of Care IV Long-Duration Lunar Orbital/Surface
4. Foundation: Level of Care V

Pharm

5. Exploration Formulary v3.0

Human System Integration

1. Integrated CM Suite
2. Risk Characterization for op performance metrics
3. Standards recommendations for just-in-time training
4. Standards update: HAB, HARI, Training, and HCI
5. Validated CMs

EVA

1. Injury Assessment Tool
2. Fitness for Duty Standards

Immune | MICRO

1. CM
2. Standards

Medical

1. Next Gen CHP Resource Scoping
2. Scoping Update

OP

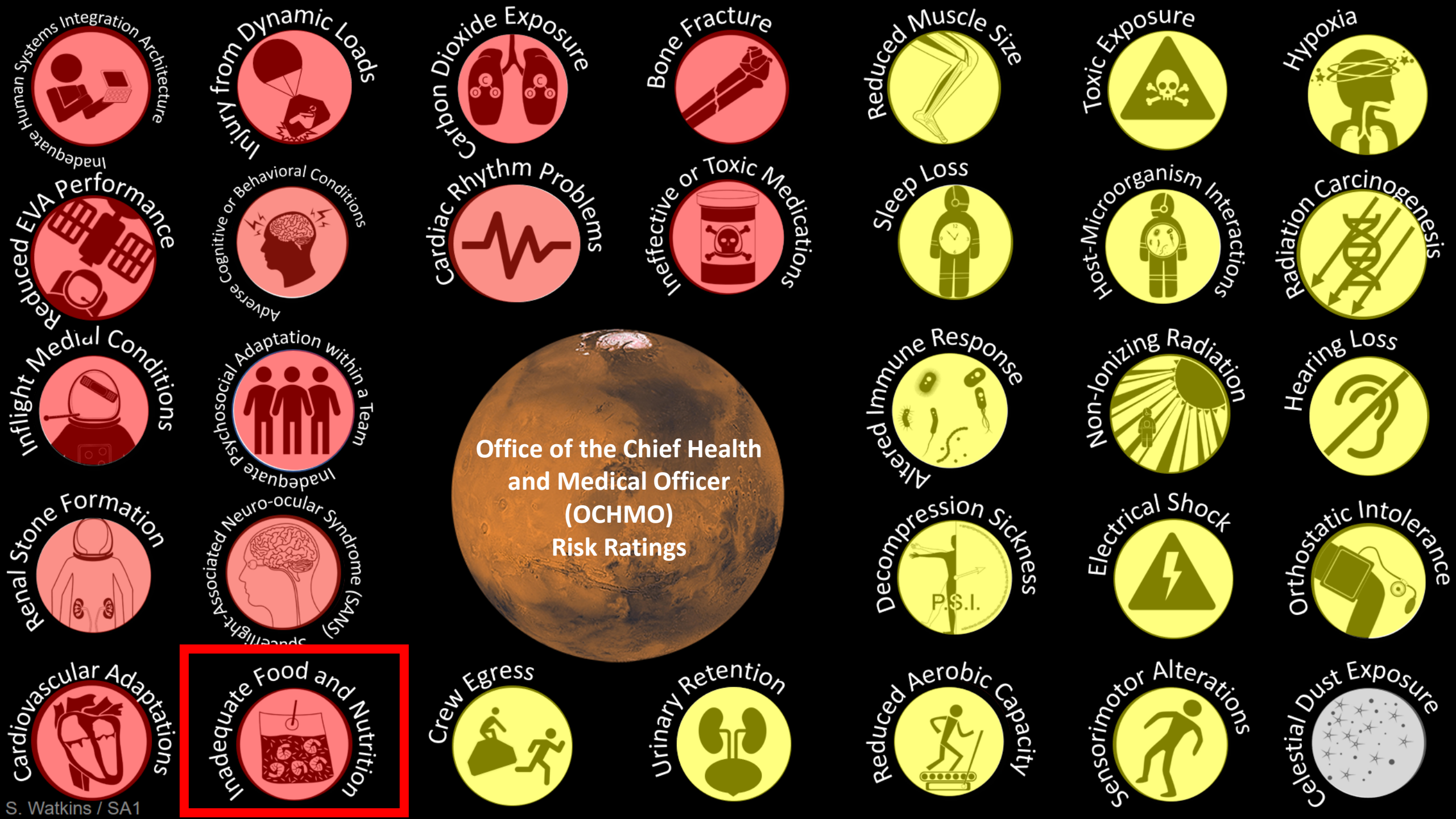
1. Standards for Initial/Interim IARVs & protecting crew during dynamic phases of spaceflight
2. Standards for Validated IARVs & protecting crew during seated/ standing dynamic phases
3. Risk Characterization related to Lunar Landings

SANS

1. CM
2. Standards: Long Term Health
3. Standards: Maintaining inflight health

Sensorimotor

1. CM
2. Standards
3. Lunar CM
4. Lunar Standards

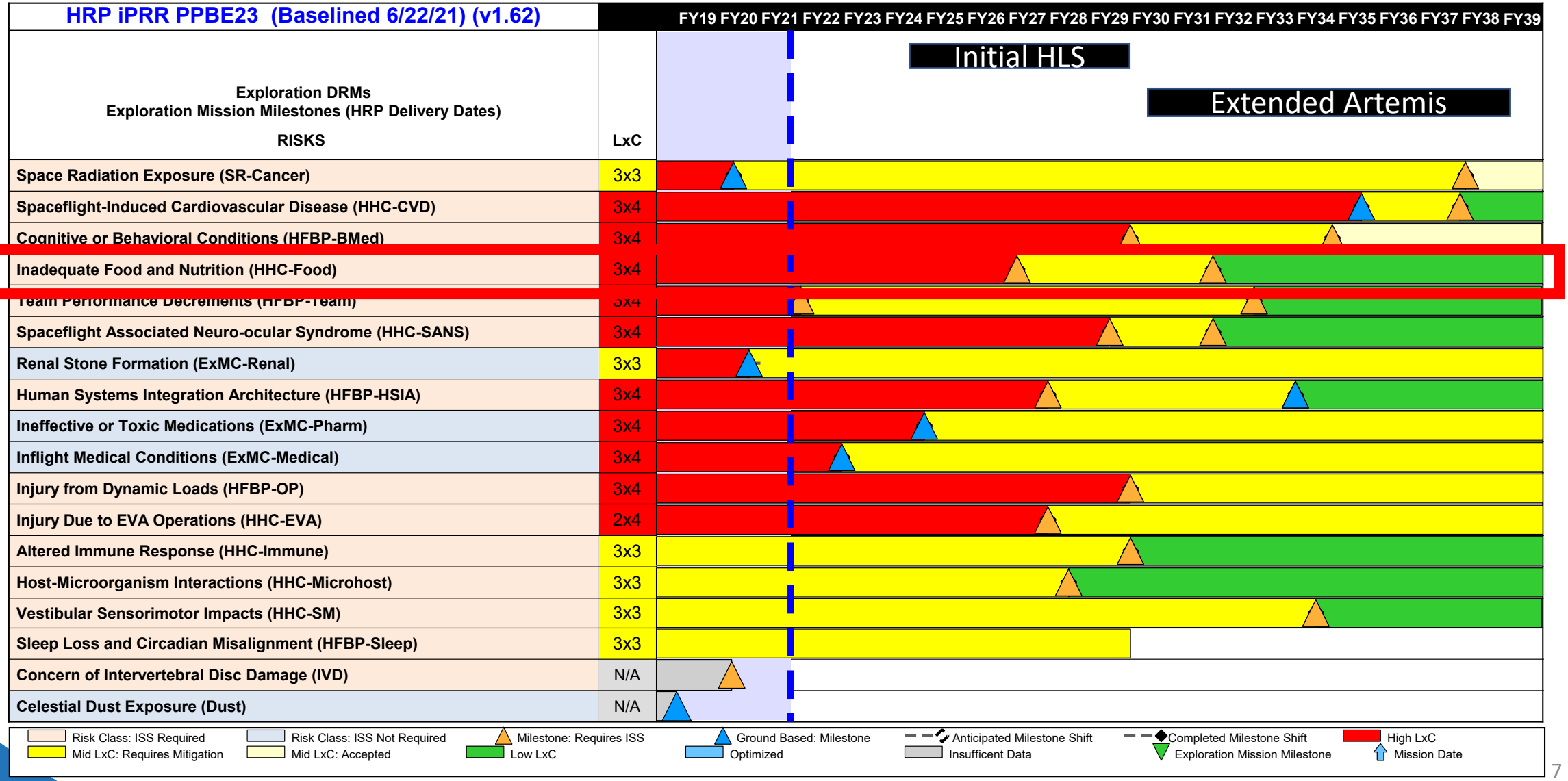


S. Watkins / SA1

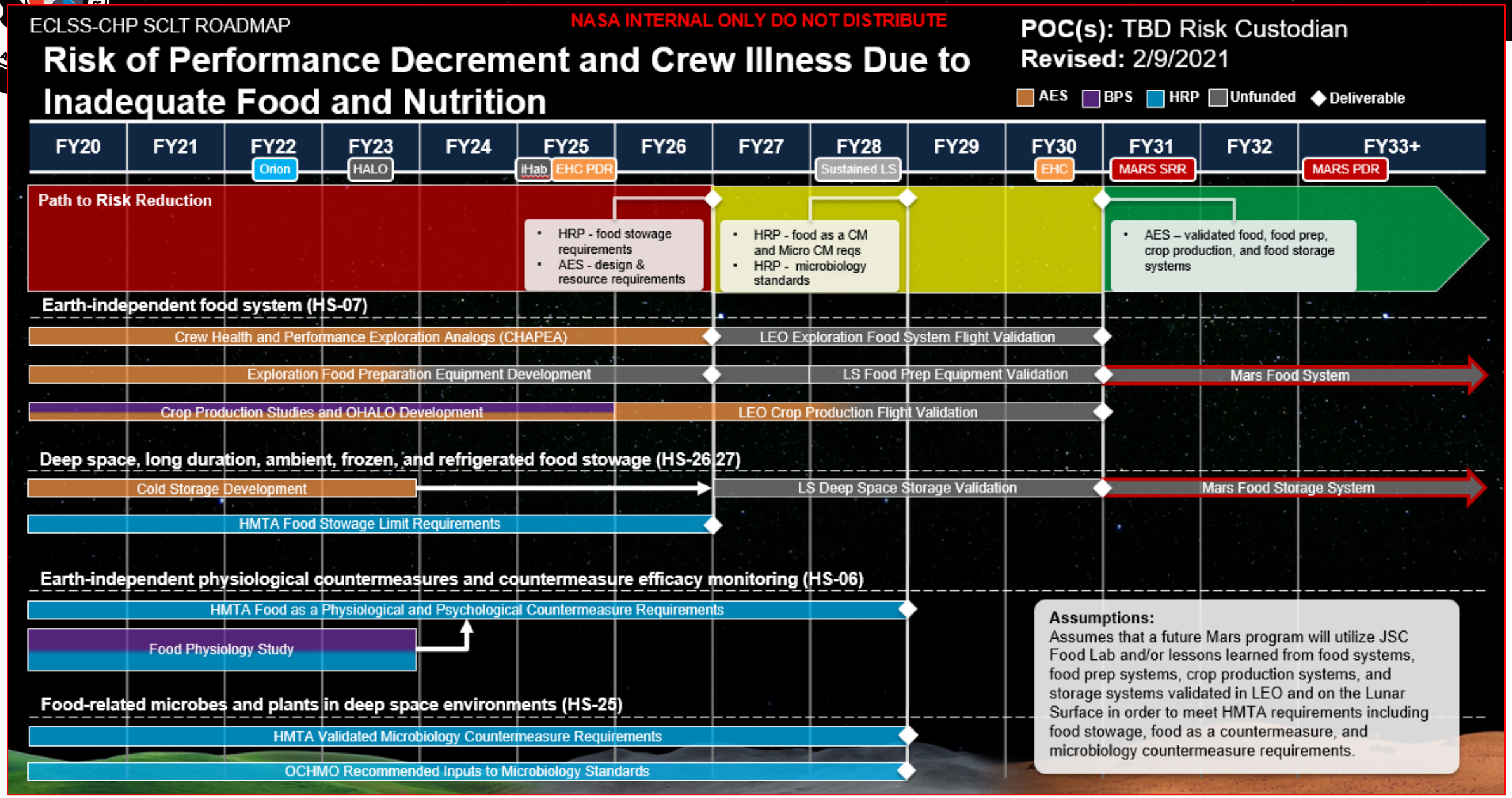
Path to Risk Reduction Schedule (FY21) – Mars DRM

HRP Integrated Schedule

FY21-Q3



Joint BPS/HRP/AES Roadmaps



NASA Life Sciences Translational Research

Space Biology	Synergism	Human Research Program
Study how life responds, adapts, develops, interacts and evolves in the space environment and across the gravitational spectrum	SB and HRP coordinate to update risk status, define research priorities and opportunities and develop countermeasures	Identify, characterize and mitigate the risks to human health and performance in space
• Plant and Animal Biology • Systems Biology & Omics (GeneLab) • Molecular, Cellular, & Microbial Biology • Development, Reproductive, & Evolutionary Biology	• Animal, Cell, Tissue & Animal Studies • Neurobehavior • Immunology, Wound Healing & Fracture Repair • Radiation/Microgravity Interactions • Oxidative Stress and Damage • Microbe-Host Interactions • Spaceflight-Associated Neuro-Ocular Syndrome • Artificial Gravity	• Exercise Countermeasures • Physiological Countermeasures • Space Radiation Biology • Behavioral Health and Performance • Space Human Factors and Habitability • Exploration Medical Capability

Science Exploring the Unknown

More Applied

More Basic

Science Addressing Known Risks

HRP Prioritization and Coordination with BPS

HRP Research and Technology Investment Priority Drivers

- Risk Color (HSRB)
- Scientific/technical challenge
- Need date (exploration schedules)
- Facility availability (ISS, HERA, NEK, enviHab, NSRL, Antarctic Stations, Parabolic Flight…)
- Budget availability (OMB, Congress, HEOMD)

Space Biology is an important partner to HRP (fundamental science, mechanisms, maturation)

- Microbiome (crew and environment), plants (crops, psychological support), gravity as a continuum
- Genelab as a repository, Tissue Chip validation, pharmaceutical testing, …
- This synergistic relationship could be bolstered by recommendations in the Decadal Survey
- Joint Roadmaps

Potential HRP White Paper Topics

- Tissue Chips
- Personalized Medicine/Precision Health
- Translational Science, Animal to Human
- Genomics/GeneLab repository
- Crop Growth
- Common Medical & Diagnostic Research Hardware Development for Future Collaborations
- Microbiome (crew and environment)
- Artificial Gravity

Summary

- HRP has a long-standing relationship with Biological and Physical Sciences and with Space Biology in particular
- HRP will be participating in White Paper generation to further articulate the work that we rely on BPS to perform going forward for reducing human system risks for exploration missions.