Institute of Medicine Review of the NASA Human Research Program Evidence Reports

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Chief Scientist

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Outline

- Introduction
- Review of Evidence Reports
- Conclusion
HRP Mandate within NASA

NASA Administrator

- Aeronautics Research Mission Directorate
- Science Mission Directorate
- Human Exploration & Operations Mission Directorate
- Space Technology Mission Directorate

Human Research Program
Human Research Program Goal

The goal of HRP is to provide human health and performance countermeasures, knowledge, technologies, and tools to enable safe, reliable, and productive human space exploration.
Destination - Mars

**HUMAN EXPLORATION**
NASA’s Journey to Mars

**EARTH RELIANT**
MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS

- Mastering fundamentals aboard the International Space Station
- U.S. companies provide access to low-Earth orbit

**PROVING GROUND**
MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS

- Expanding capabilities by visiting an asteroid redirected to a lunar distant retrograde orbit
- The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion spacecraft

**MARS READY**
MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS

- Developing planetary independence by exploring Mars, its moons and other deep space destinations
Recent Exploration Activities

• ISS International Partners
  – Maximize human system risk reduction by 2020
  – Multilateral Human Research Panel for Exploration (MHRPE)
    • Sharing human subjects, data, hardware, protocols

• Orion Multi-Purpose Crew Vehicle (MPCV)
  • HRP research to target test flights in 2017 & 2021
    – Low frequency vibration, rotational oscillations, acoustics & dosimetry, exploration exercise hardware

• Deep Space Habitat, Exploration Augmentation Vehicle
Integration With Other Organizations

HRP

ISS, Orion & Space Launch Programs
External Scientific Community
Office of Chief Health and Medical Officer
Medical Operations
Flight Operations
Exploration Integration & Science
Engineering
HRP Research Environment

- HRP conducts research aimed at risk mitigation.
- Flexibility to replan or address new issues as needed.
- Limited time to get the “best” answer.
- Finite resources – budget, subject number, time, access to ISS
- Unique constraints.
  - Small “n”
  - Constrained environments and often poorly controlled, less than ideal research conditions
- Require access to exploration conditions, microgravity and space radiation.
- Identification of appropriate terrestrial analogs or disease models.
Integrated Path to Risk Reduction

Human Research Program
Integrated Path to Risk Reduction, Revision B PCN-1 (2014)
HRP is Focused on Risks

Understand and mitigate risks to crew health and performance in exploration missions

Evidence → Risks → Gaps → Tasks → Deliverables

- Evidence Reports
- HRP Program Requirements Document
- Integrated Research Plan
- Proposals Task Book
- Scientific Papers, Reports, Processes, Hardware, Software, etc.

humanresearchroadmap.nasa.gov
**Outline**

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Study Overview

• HRP currently has 32 risks and 2 concerns across 5 Elements:
  – Behavioral Health and Performance
  – Exploration Medical Capabilities
  – Human Health Countermeasures
  – Space Human Factors and Habitability
  – Space Radiation

• Each risk has an associated Evidence Report

• Evidence Reports include contributions from:
  – HRP
  – Internal investigators
  – NSBRI
  – External PIs
# Risks in HRP Research Portfolio

## Behavioral Health and Performance

1. Risk of Adverse Behavioral Conditions and Psychiatric Disorders
2. Risk of Performance Decrement Due to Inadequate Cooperation, Coordination, Communication, and Psychosocial Adaptation within a Team
3. Risk of Performance Errors Due to Fatigue Resulting from Sleep Loss, Circadian Desynchronization, Extended Wakefulness, and Work Overload

## Exploration Medical Capabilities

4. Risk of Adverse Health Outcomes and Decrement in Performance Due to In-flight Medical Conditions
5. Risk of Renal Stone Formation
6. Risk of Bone Fracture Due to Spaceflight Induced Changes to Bone
7. Risk of Early Onset Osteoporosis Due To Spaceflight
8. Risk of Ineffective or Toxic Medications Due to Long Term Storage

## Space Radiation

9. Risk of Acute Radiation Syndromes Due to Solar Particle Events (SPEs)
10. Risk of Radiation Carcinogenesis
11. Risk of Acute and Late Central Nervous System Effects from Radiation Exposure
12. Risk of Cardiovascular Disease and Other Degenerative Tissue Effects from Radiation Exposure

4 May 2015
## Human Health Countermeasures

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<td><strong>13.</strong> Concern of Clinically Relevant Unpredicted Effects of Medication</td>
<td><strong>20.</strong> Risk of Cardiac Rhythm Problems</td>
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<td><strong>14.</strong> Risk of Spaceflight-Induced Intracranial Hypertension/Vision Alterations</td>
<td><strong>21.</strong> Risk of Decompression Sickness</td>
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<td><strong>15.</strong> Risk Factor of Inadequate Nutrition</td>
<td><strong>22.</strong> Risk of Compromised EVA Performance and Crew Health Due to Inadequate EVA Suit Systems</td>
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<td><strong>16.</strong> Risk of Impaired Performance Due to Reduced Muscle Mass, Strength and Endurance</td>
<td><strong>23.</strong> Risk of Orthostatic Intolerance During Re-Exposure to Gravity</td>
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<td><strong>17.</strong> Concern of Intervertebral Disk Damage upon and Immediately after Re-exposure to Gravity</td>
<td><strong>24.</strong> Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity</td>
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<td><strong>18.</strong> Risk of Crew Adverse Health Event Due to Altered Immune Response</td>
<td><strong>25.</strong> Risk of Reduced Crew Performance Due to Hypobaric Hypoxia</td>
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<td><strong>19.</strong> Risk of Impaired Control of Spacecraft, Associated Systems and Immediate Vehicle Egress Due to Vestibular/Sensorimotor Alterations Associated with Space Flight</td>
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<td>Risk of Adverse Health Effects Due to Alterations in Host-Microorganism Interactions</td>
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<td>26</td>
<td>Risk of an Incompatible Vehicle/Habitat Design</td>
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<td>Risk of Inadequate Design of Human and Automation/Robotic Integration</td>
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<td>Risk of Inadequate Human-Computer Interaction</td>
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<td>Risk of Inadequate Critical Task Design</td>
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<td>Risk of Performance Errors Due to Training Deficiencies</td>
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<td>31</td>
<td>Risk of Adverse Health Effects of Exposure to Dust and Volatiles During Exploration of Celestial Bodies</td>
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<td>32</td>
<td>Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System</td>
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<td>33</td>
<td>Risk of Injury from Dynamic Loads</td>
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Statement of Task

• NASA has requested a study from the Institute of Medicine (IOM) to provide an independent review of more than 30 evidence reports on human health risks for long-duration and exploration space flight. The evidence reports, which are publicly available, are categorized into four broad areas: (1) behavioral health and performance; (2) human health countermeasures (with a focus on bone metabolism and orthopedics, nutrition, immunology, cardiac and pulmonary physiology); (3) radiation; and (4) human factors issues. The reports are revised on an ongoing basis to incorporate new scientific information. In conducting this study, an IOM ad Hoc committee will build on the 2008 IOM report, *Review of NASA’s Human Research Program Evidence Books*. That report provided an assessment of the process used in developing the Evidence Reports and provided an initial review of the evidence reports that had been completed at that time and an update on the recent literature.

• Each year, NASA staff will identify a set of Evidence Reports for committee review. Over the course of the study, all of the Evidence Reports will be reviewed. In the first phase of the study, three Evidence Reports will be reviewed, with subsequent phases addressing the remainder of the Evidence Reports. The committee will hold an annual scientific workshop to receive input on the Evidence Reports it is reviewing that year and an update on the recent literature.
Statement of Task

• The committee will issue an annual letter report that addresses the following questions relevant to each Evidence Report:

1. Does the Evidence Report provide sufficient evidence, as well as sufficient risk context, that the risk is of concern for long-term space missions?
2. Does the Evidence Report make the case for the research gaps presented?
3. Are there any additional gaps in knowledge or areas of fundamental research that should be considered to enhance the basic understanding of this specific risk?
4. Does the Evidence Report address relevant interactions among risks?
5. Is input from additional disciplines needed?
6. Is the breadth of the cited literature sufficient?
7. What is the overall readability and quality?
8. Is the expertise of the authors sufficient to fully cover the scope of the given risk?
9. Has the Evidence Report addressed previous recommendations made by the IOM in the 2008 Letter Report?
Evidence Reports to be reviewed in Year 3

- Risk Factor of Inadequate Nutrition
- Risk of Impaired Performance Due to Reduced Muscle Mass, Strength, and Endurance
- Risk of Injury and Compromised Performance Due to EVA Operations
- Risk of Orthostatic Intolerance During Re-exposure to Gravity
- Risk of Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity
- Risk of Decompression Sickness
- Risk of Performance Decrement and Crew Illness Due to an Inadequate Food System
## Five-year Review Schedule

### Human Research Program

#### HRP Risks

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* Indicates a concern rather than a risk

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4 May 2015
Outline

• Introduction

• Review of Evidence Reports

• Conclusion
Conclusion

- The Human Research Program is an applied research program
  - Focus on solving problems and reducing risk
  - Subject to many types of constraints (e.g., budget, subject availability, operational restrictions)

- The IOM previously conducted a review of NASA’s Human Research Program Evidence Book (2008)

- The IOM is now facilitating a multi-year review of the HRP Evidence Reports

humanresearchroadmap.nasa.gov/Evidence