National Aeronautics and Space Administration

NASA Human Research Program

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May 2019

Human Research Program Mission

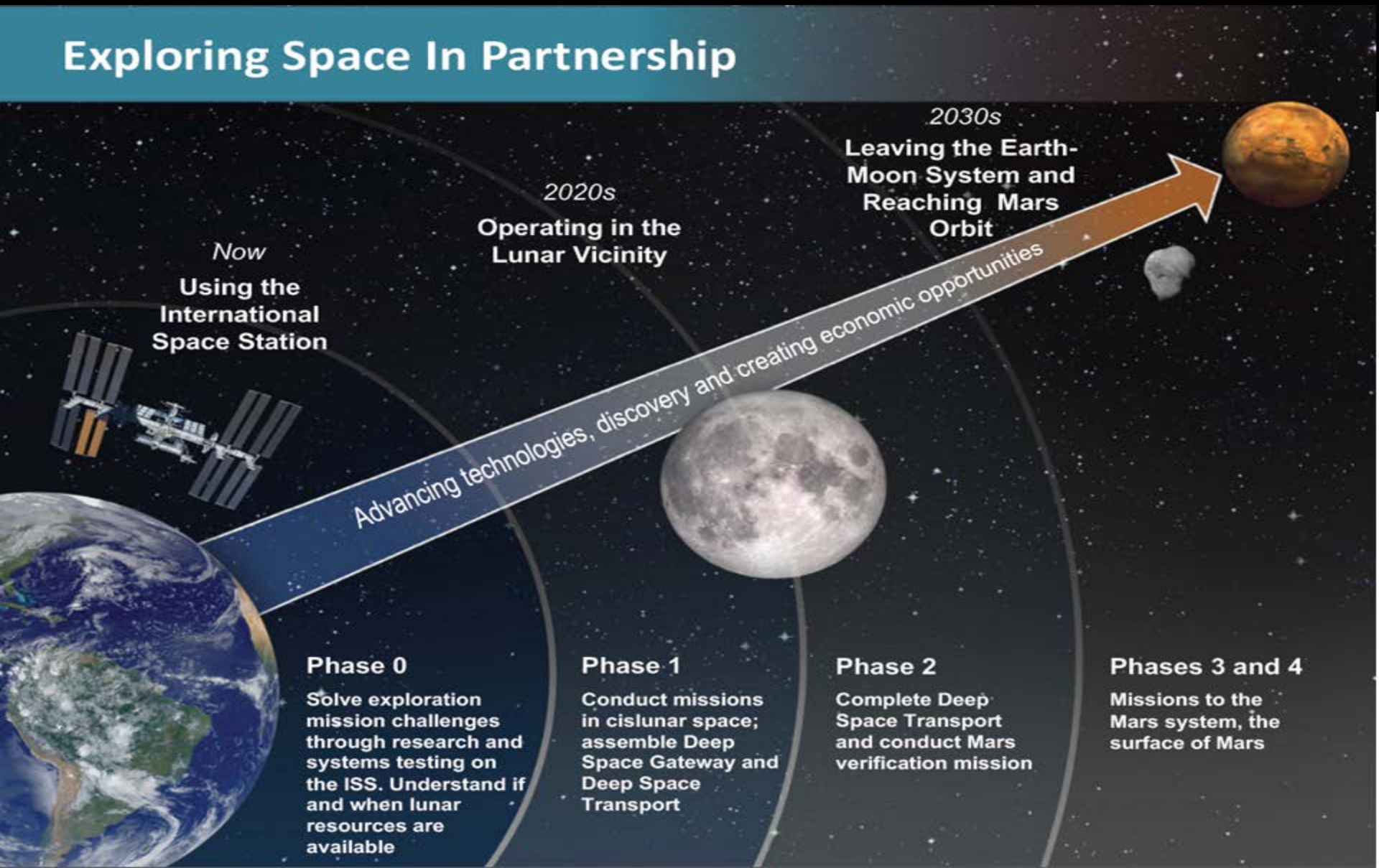
To enable space exploration beyond Low Earth Orbit
by reducing the risks to human health & performance
through a focused program of:

- **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**

Planned Exploration Activities



Deep Space Stressors

Altered gravity (hyper, hypo, transition)

bone, muscle, cardiovascular, sensorimotor, nutrition, , clinical medicine, behavior/performance, immunology, human factors

Radiation (lower earth orbit, deep space)

immunology, carcinogenesis, behavior/performance, tissue degeneration, pharmaceutical stability

Distance from Earth (medical care impacts)

behavior/performance, autonomy, food systems, clinical medicine

Isolation (psychological)

behavior/performance

Hostile/closed environment (spacecraft design)

behavior/performance, nutrition, immunology, toxicology, microbiology

Note that severity generally increases with mission duration.

Research Solicited to Address Specific Risks

Altered Gravity Field

1. Spaceflight-Associated Neuro-ocular Syndrome (SANS)
2. Renal Stone Formation
3. Impaired Control of Spacecraft/Associated Systems and Decreased Mobility Due to Vestibular/Sensorimotor Alterations Associated with Space Flight
4. Bone Fracture due to spaceflight Induced changes to bone
5. Impaired Performance Due to Reduced Muscle Mass, Strength & Endurance
6. Reduced Physical Performance Capabilities Due to Reduced Aerobic Capacity
7. Adverse Health Effects Due to Host-Microorganism Interactions
8. Urinary Retention
9. Orthostatic Intolerance During Re-Exposure to Gravity

Concerns

1. Concern of Clinically Relevant Unpredicted Effects of Medication
2. Concern of Intervertebral Disc Damage upon and immediately after re-exposure to Gravity

Radiation

1. Risk of Space Radiation Exposure on Human Health:
   - Acute solar events
   - Cancer
   - CNS impairment
   - Tissue degeneration (cardio)

Distance from Earth

1. Adverse Health Outcomes & Decrements in Performance due to inflight Medical Conditions
2. Ineffective or Toxic Medications due to Long Term Storage

Isolation/Confinement

1. Adverse Cognitive or Behavioral Conditions & Psychiatric Disorders
2. Performance & Behavioral health Decrements Due to Inadequate Cooperation, Coordination, Communication, & Psychosocial Adaptation within a Team

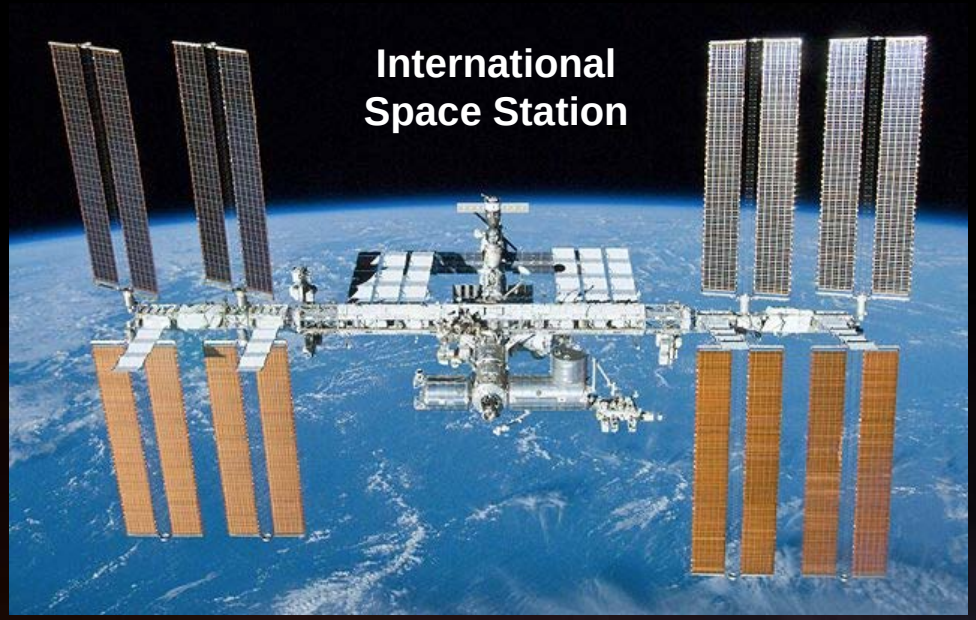
Hostile Closed Environment

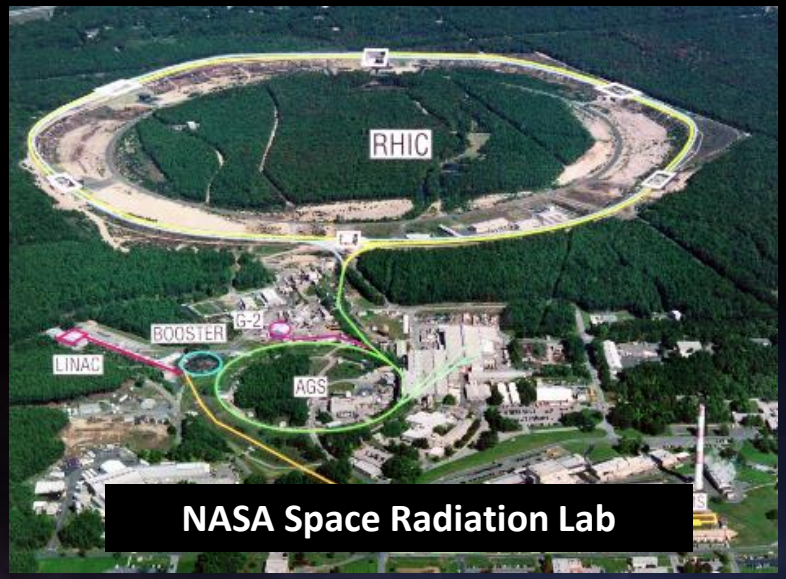
1. Acute and Chronic Carbon Dioxide Exposure
2. Performance decrement and crew illness due to inadequate food and nutrition
3. Injury from Dynamic Loads
4. Injury and Compromised Performance due to EVA Operations
5. Adverse Health & Performance Effects of Celestial Dust Exposure
6. Adverse Health Event Due to Altered Immune Response
7. Reduced Crew Performance Due to Hypobaric Hypoxia
8. Performance Decrements & Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, & Work Overload
9. Reduced Crew Performance Due to Inadequate Human-System Interaction Design
10. Decompression Sickness
11. Toxic Exposure
12. Hearing Loss Related to Spaceflight

Key: High LxC Medium LxC Low LxC TBD LxC

Risks Managed by NASA Human Systems Risk Board

Venues for Conducting Research





Research Opportunities

- Flagship solicitations
  - NASA Research Announcements (NRA) entitled Human Exploration Research Opportunities (HERO)
  - https://nspires.nasaprs.com/external/
- Omnibus solicitations (July)
  - Short-term investigations that address any risk and gap in the Integrated Research Plan
  - Omnibus grants up to one year and $150K total
  - Recommended mechanism to supplement current ONR grants with synergistic specific aims