NASA Human Research Program: A Discussion about Analogs

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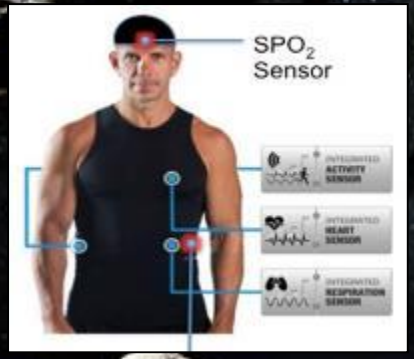
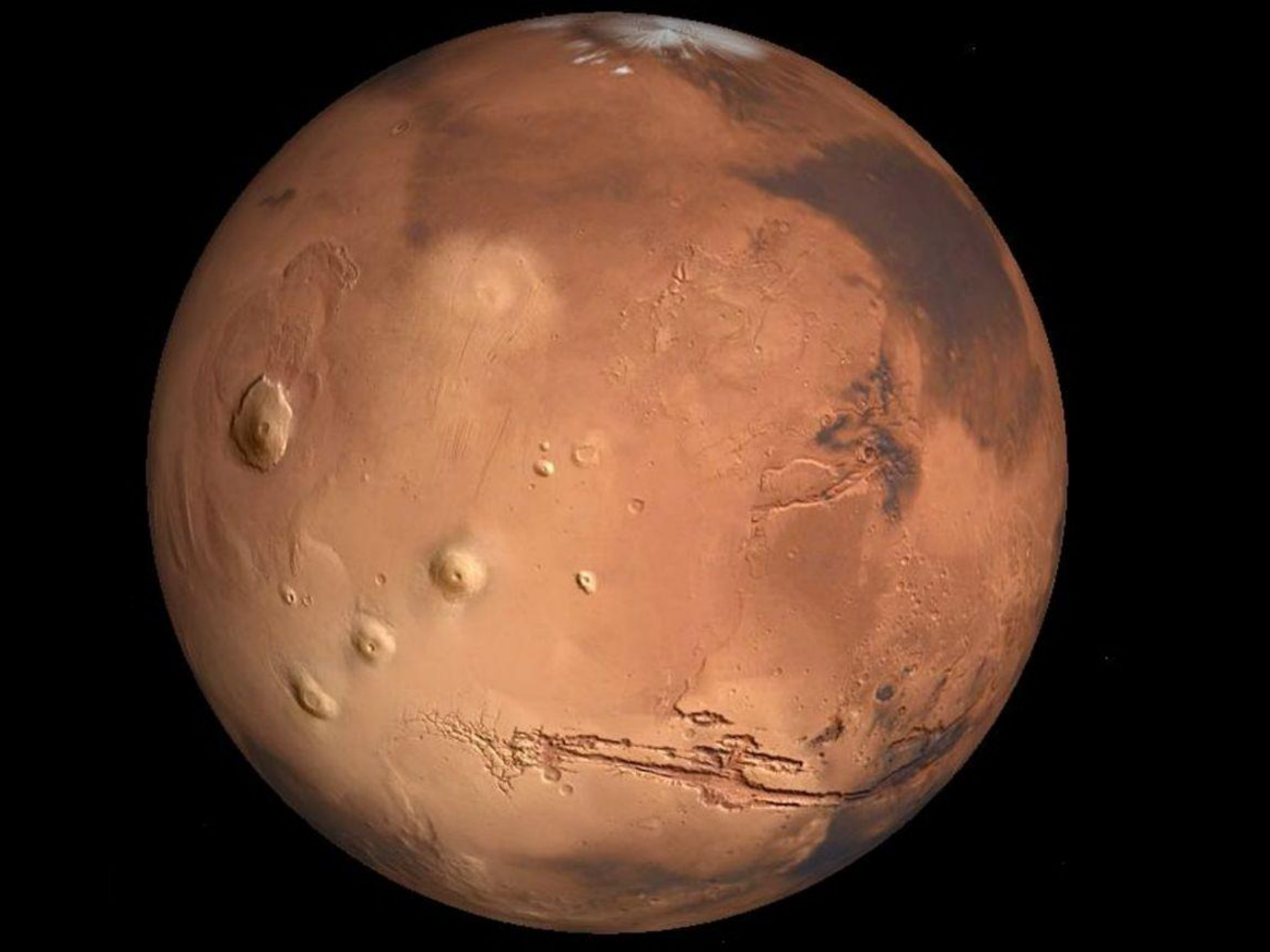
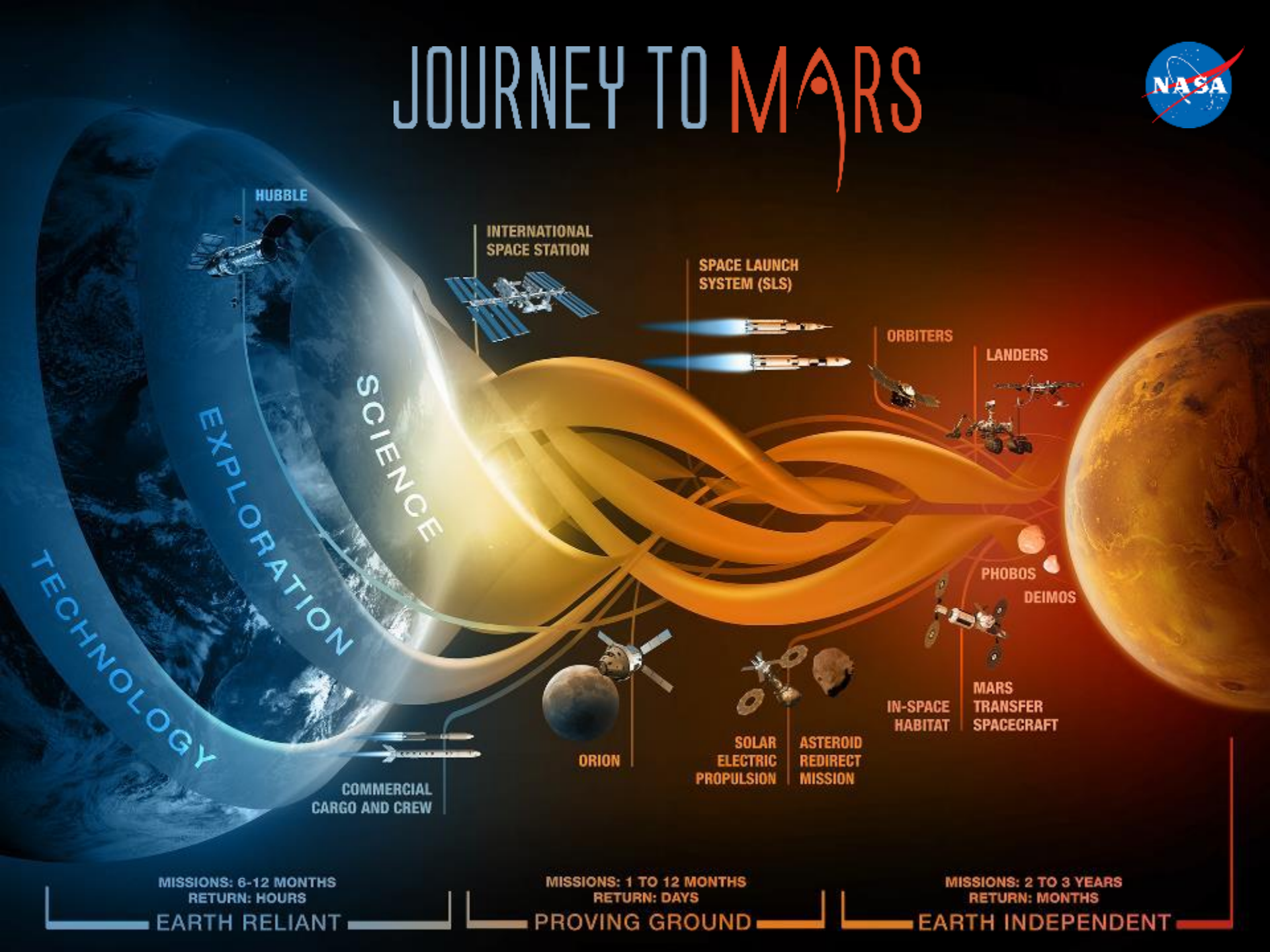
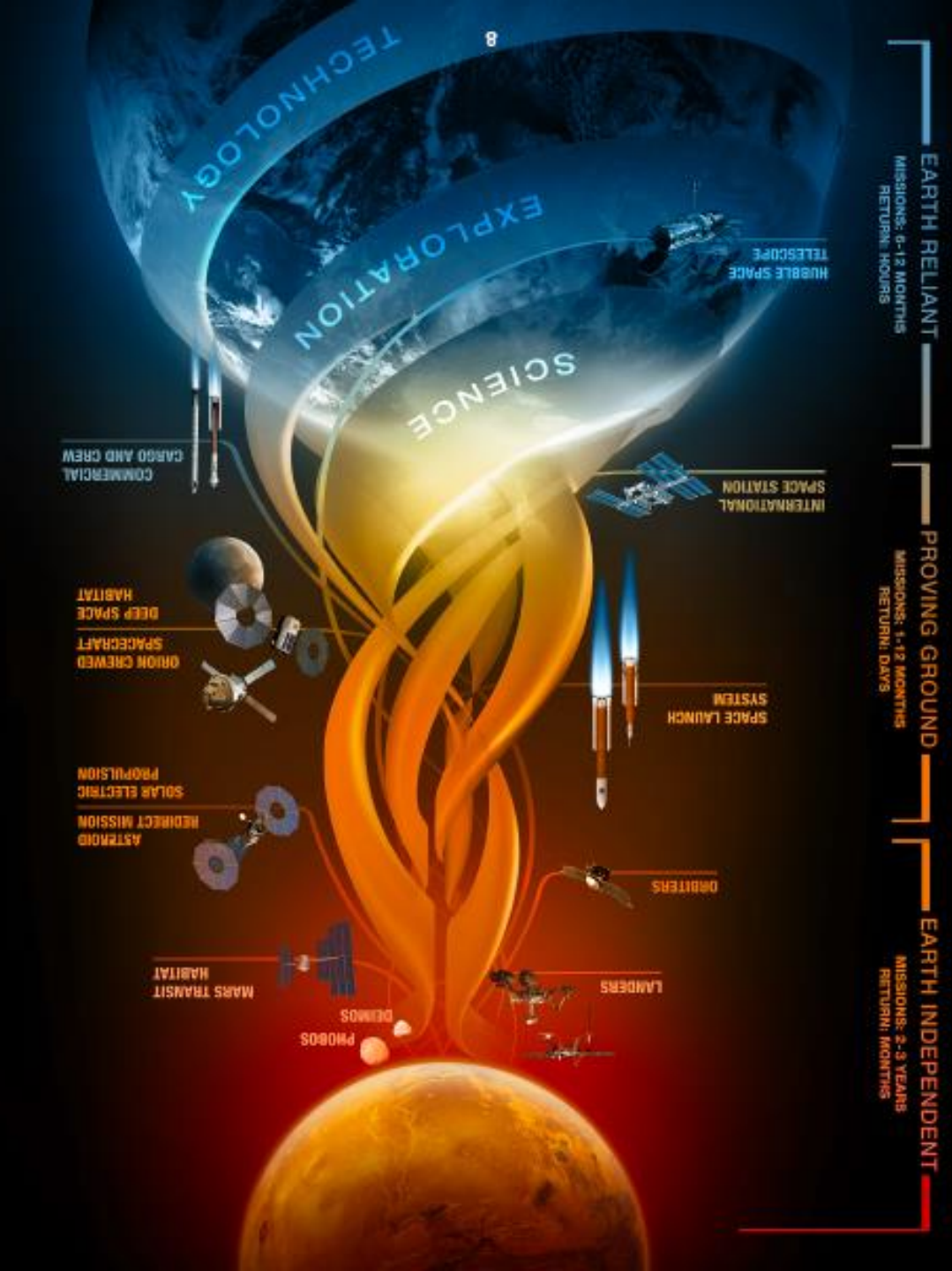




JOURNEY TO MARS





Now–2024

Develop/test mitigation approaches

- ISS
- Spaceflight analogs
- Ground-based laboratories

Inform deep-space hab designs

~2022–2030

Validate mitigation approaches

- Orion
- Deep-space hab
- Lunar surface (?)

Inform exploration system designs

~2035–20nn

Fine-tune mitigation approaches

- Exploration vehicles
- Planetary surfaces

HRP: Research to Enable Space Exploration

Human travelers to Mars will experience unprecedented physiological, environmental, and psychosocial challenges that could lead to significant health & performance decrements in the absence of effective mitigation strategies.

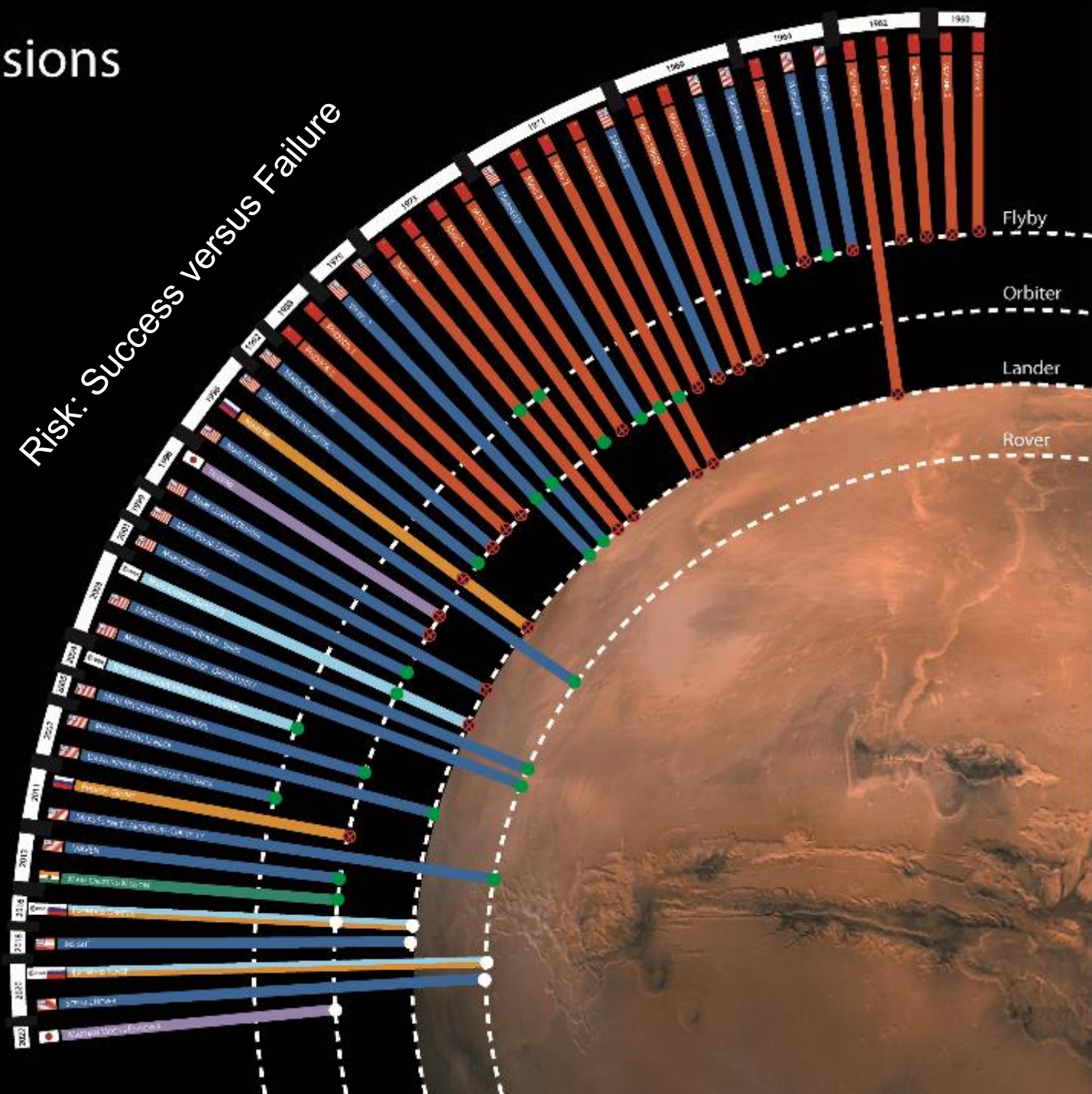
Success of any human mission to Mars will hinge on the mission designers' ability to develop and implement such strategies.

NASA's Human Research Program is responsible for identifying those strategies.

Robotic Missions to Mars

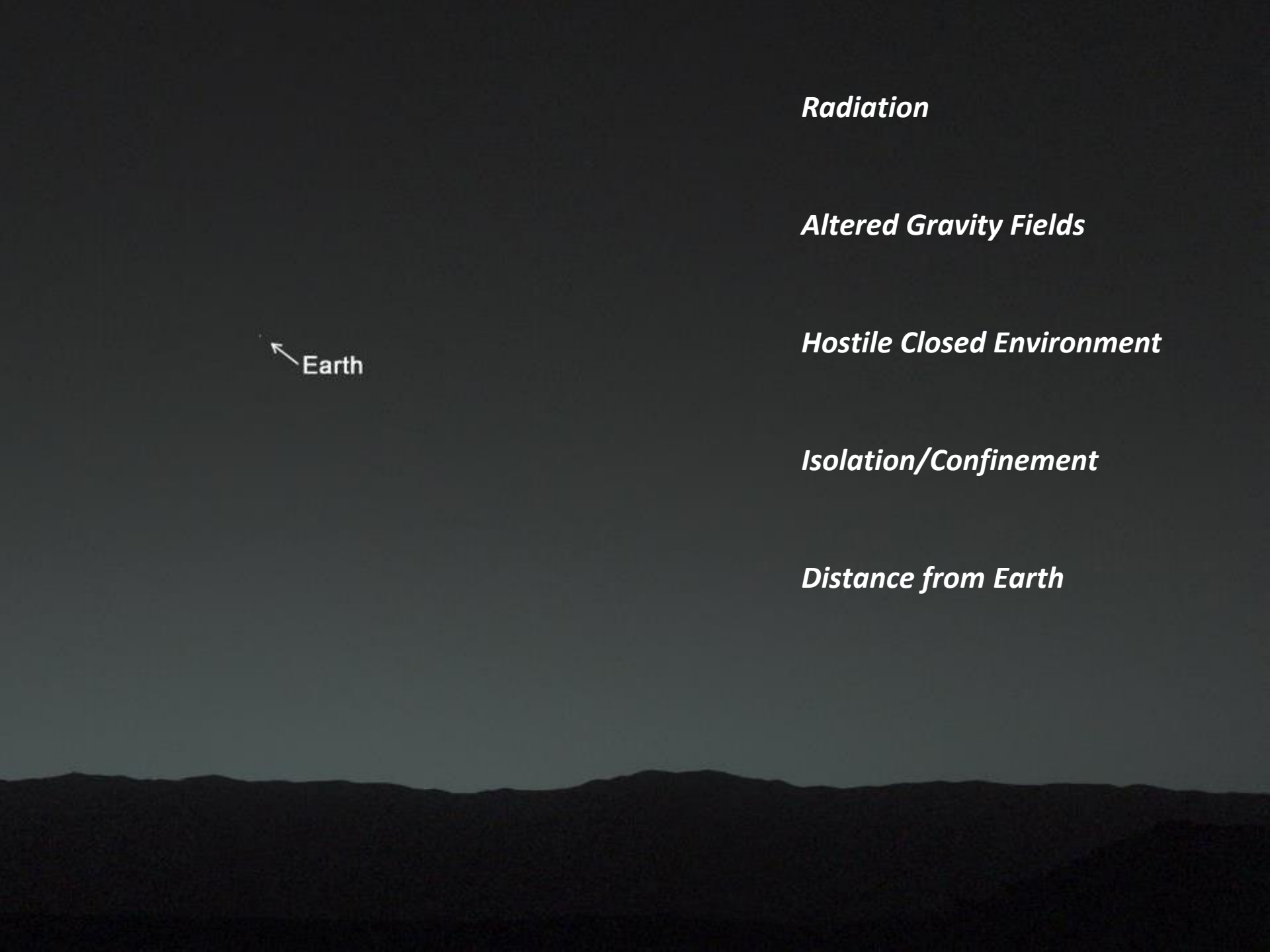
Mission Failure
Mission Success
Future Destination

Risk: Success versus Failure



Successes (1960-2013)

- Flyby: 7/13
- Orbiter: 12/24
- Lander: 3/11
- Rover: 4/4
- Overall: 19/44



Radiation

Altered Gravity Fields

Hostile Closed Environment

Isolation/Confinement

Distance from Earth

Exploration Health & Performance Risks

Altered Gravity Field

1. Spaceflight-Induced Intracranial Hypertension / Vision Alterations
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

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

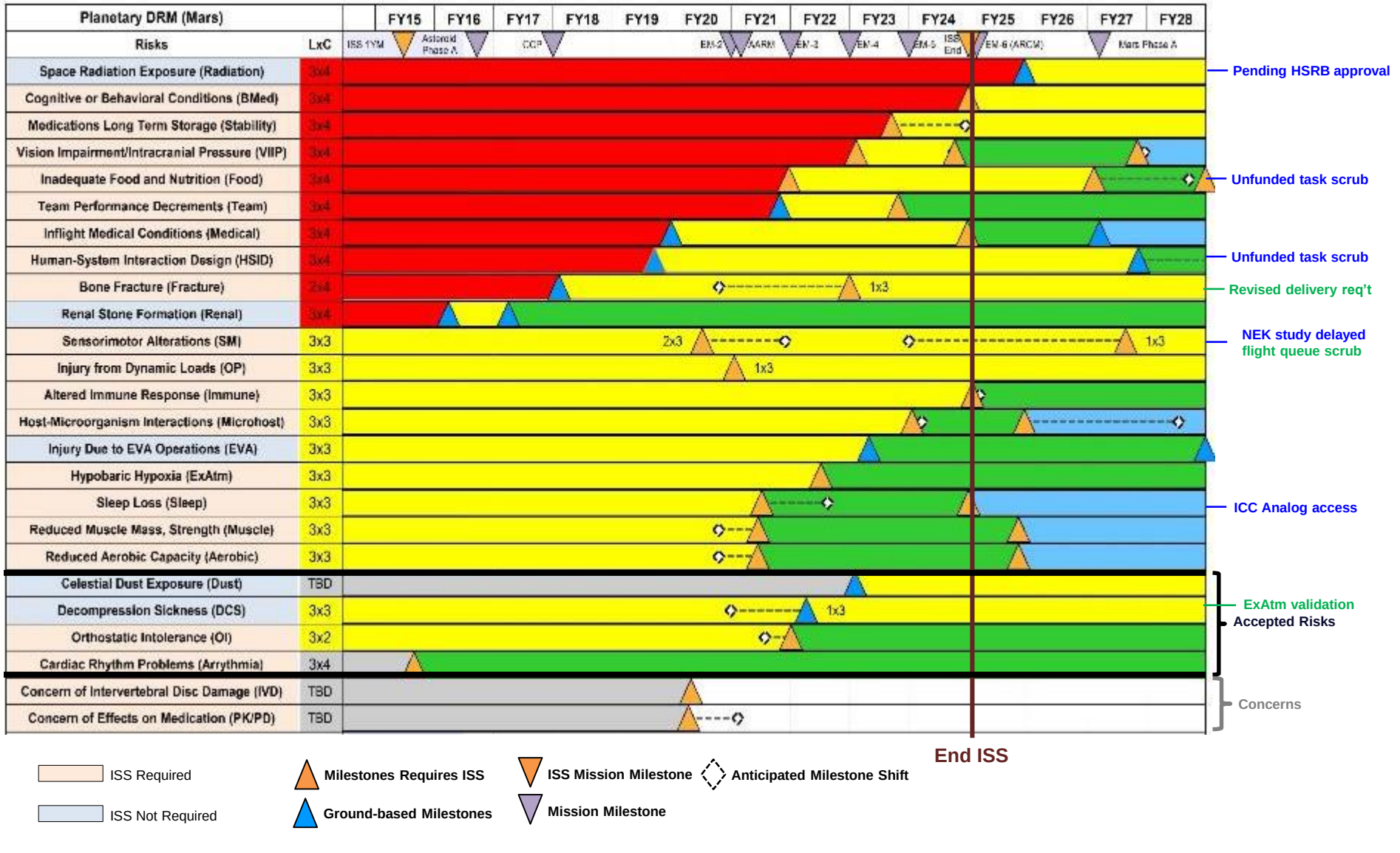
1. Adverse Cognitive or Behavioral Conditions & Psychiatric Disorders
2. Performance & Behavioral health Decrements Due to Inadequate Cooperation, Coordination, Communication, & Psychosocial Adaptation within a Team

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

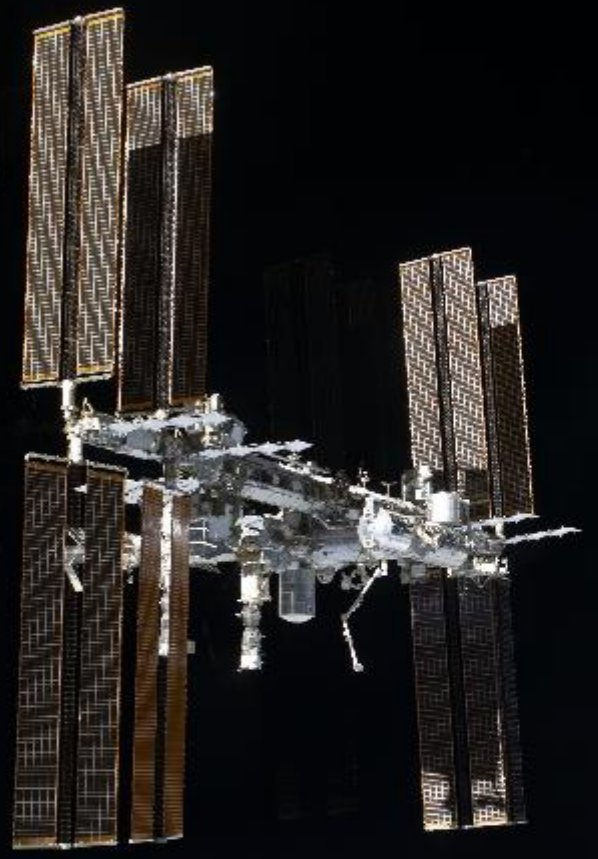
NASA Human Systems Risk Board: Risks Identified for all DRMs (Jan 2015)

HRP Integrated Path to Risk Reduction



ISS: Primary Space Platform for HRP Studies

- ✓ altered gravity fields (+)
- ✓ isolation/confinement (+/-) & altered light-dark cycles (+)
- ✓ hostile/closed environment (+)
- ✓ increased radiation (+/-)
- ✓ distance from Earth (+/-)



HRP studies receive highest priority for NASA science payloads aboard ISS.

Each USOS crewmember participates in 10-15 separate HRP experiments.

Exploration Spaceflight Analogs

- ✓ altered gravity fields
- ✓ isolation/confinement & altered light-dark cycles
- ✓ hostile/closed environment
- ✓ increased radiation
- ✓ distance from Earth

NASA Space Radiation Lab (NSRL) DOE/BNL

- ✓ altered gravity fields (n/a)
- ✓ isolation/confinement (n/a) & altered light-dark cycles (n/a)
- ✓ hostile/closed environment (n/a)
- ✓ increased radiation (+)
- ✓ distance from Earth (n/a)

- Simulates the space radiation environment- high energy ion beams (H^+, Fe, Si, C, O, Cl, Ti, etc.)
- Beam line, target area, dosimetry, biology labs, animal care, scientific, logistic and administrative support
- 3 experimental campaigns per year
- Space Radiation Summer School

NSRL Beam Line

Images Courtesy of Brookhaven National Laboratory (BNL)

Altered Gravity Analogs

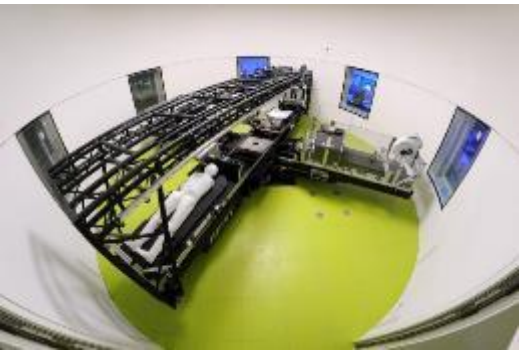
- ✓ altered gravity fields (+/-)
- ✓ isolation/confinement (+/-) & altered light-dark cycles (+/-)
- ✓ hostile/closed environment (+/-)
- ✓ increased radiation (n/a)
- ✓ distance from Earth (n/a)

Parabolic Flight

Neutral Buoyancy

Head-Down-Tilt Bedrest

:enviHab (DLR/IAM, Cologne, Germany)



:enviHab Shake-Down Study (NSBRI)

Bedrest-Study 'SpaceCOT': Head down tilt for 28 hours

At :envihab, a DLR (German Aeorpace Center) research facility, the Institute of Aerospace Medicine together with the US NSBRI (National Space Biomedical Research Institute) conduct a bedrest study. Here, for 28 hours, six subjects remain lying down and tilted at 12 degrees, from time to time in a carbon dioxide enriched atmosphere. With this 'SpaceCOT' study, the researchers are investigating how brain and eyes are affected by the shift of body fluids towards the head as well as the increased carbon dioxide content in the air. Either could be responsible for causing the visual impairments that are experienced by about 70 percent of astronauts during and after several months of long-term missions. At the DLR research facility :envihab the conditions under which astronauts in the International Space Station (ISS) live and work can be simulated.

http://www.dlr.de/me/en/desktopdefault.aspx/tabid1776/2384_read43061/

Isolated, Confined, Extreme (ICE) Analogs

- ✓ altered gravity fields (n/a)
- ✓ isolation/confinement (+) & altered light-dark cycles (+)
- ✓ hostile/closed environment (+/-)
- ✓ increased radiation (n/a)
- ✓ distance from Earth (+/-)

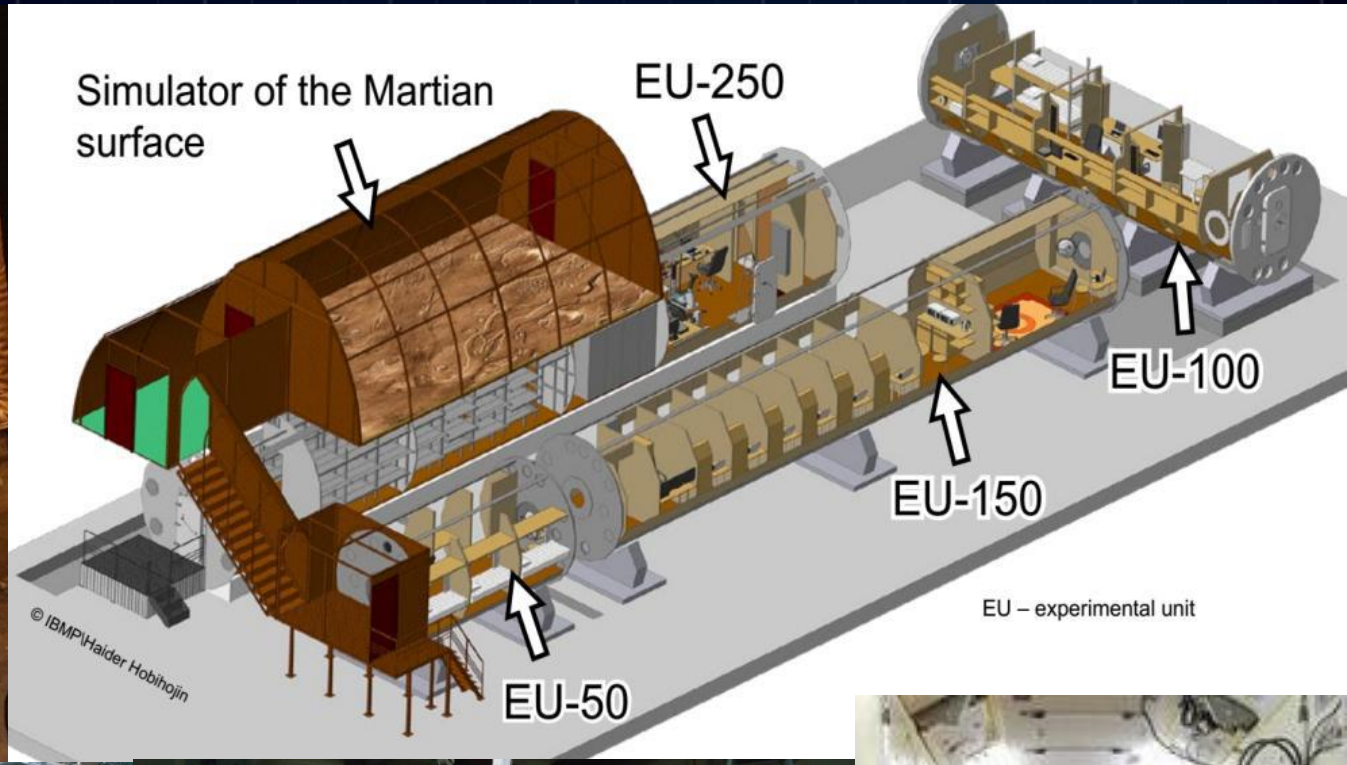
NSF:
Multiple Stations
winter overs+

HERA:
3-4 Missions/yr
4 Crew
14, 30, 60 Days

IMBP/NEK:
4, 8, 12 month

Human Exploration Research Analog (HERA)

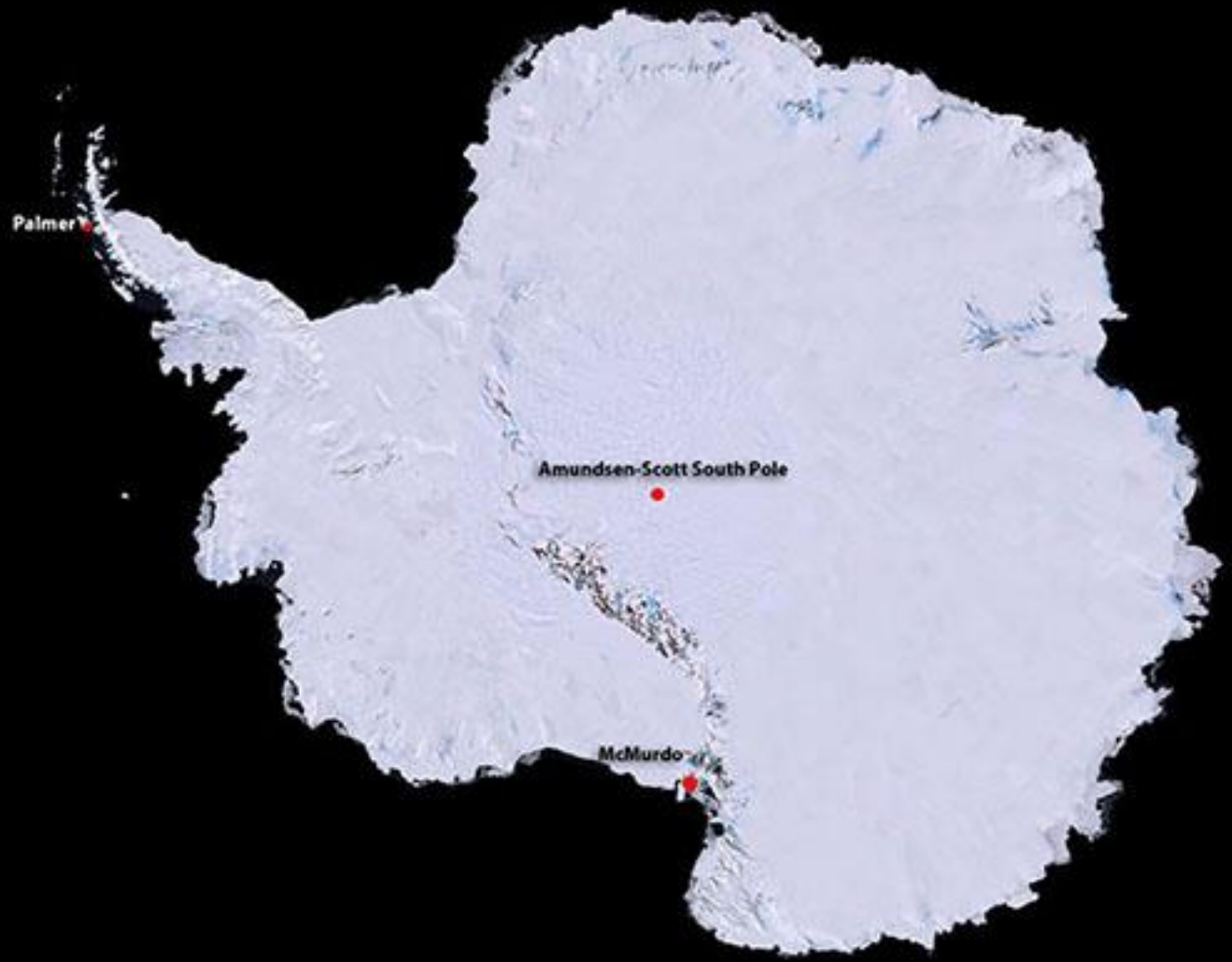
NEK (RAS/IMBP, Moscow, Russia)



Cosmonauts V.V. Polyakov and S.K. Krikalev

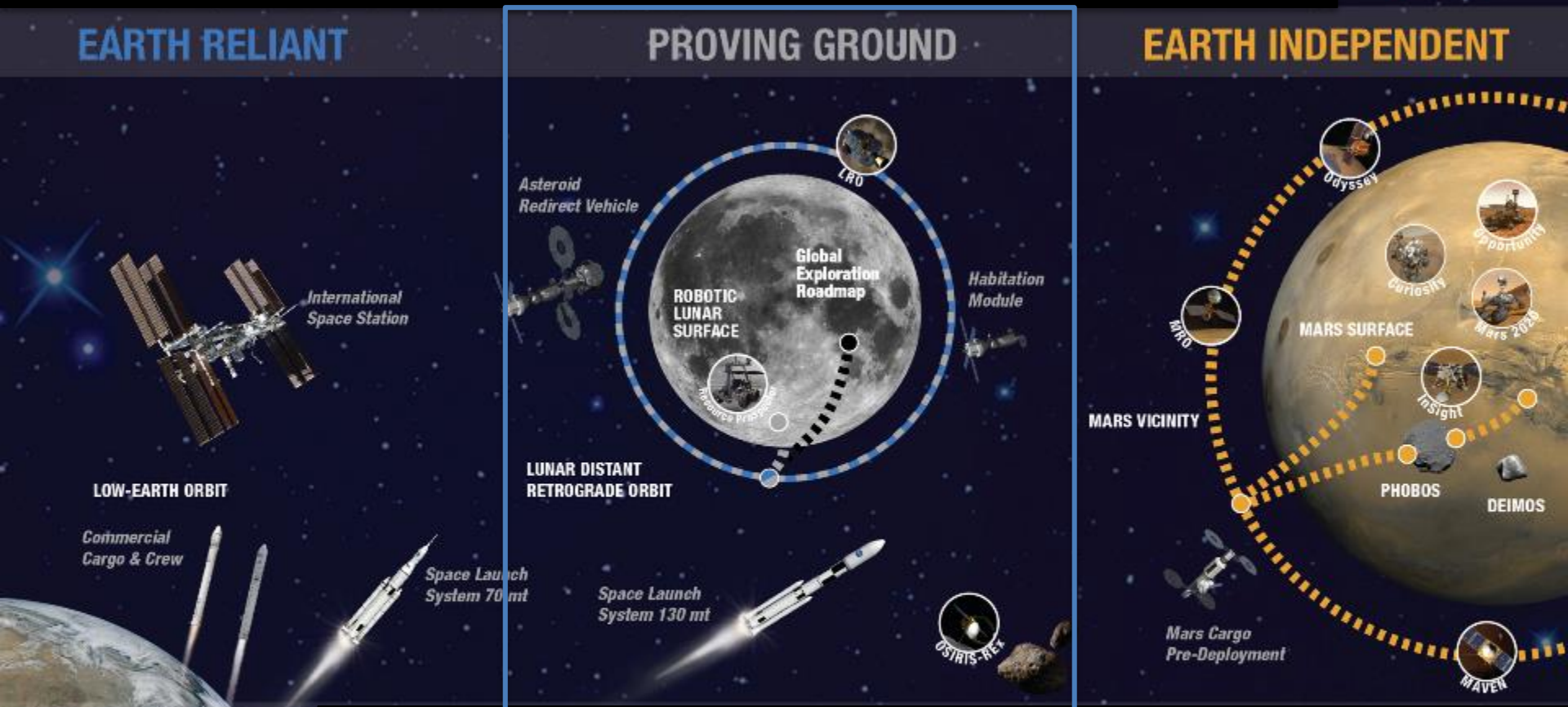
Cosmonaut S.N. Ryazanskiy

Antarctic Stations NSF+



NSF/ South Pole Station

Cis-Lunar Outposts: key to HRP validation

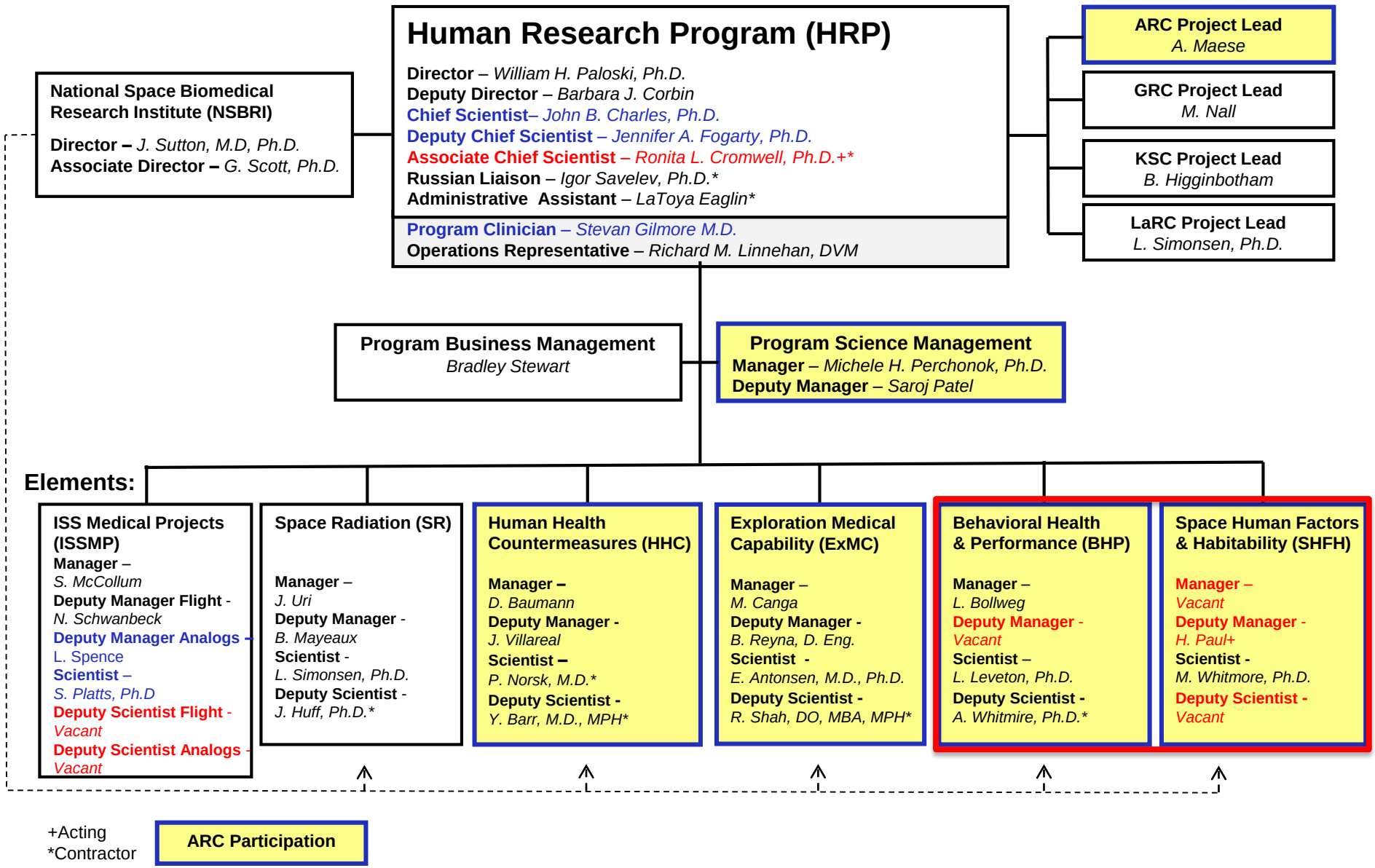


- ✓ altered gravity fields (+)
- ✓ isolation/confinement (+) & altered light-dark cycles (+)
- ✓ hostile/closed environment (+)
- ✓ increased radiation (+)
- ✓ distance from Earth (+)


Earth


NASA

HRP Organization Chart



+Acting
*Contractor

ARC Participation