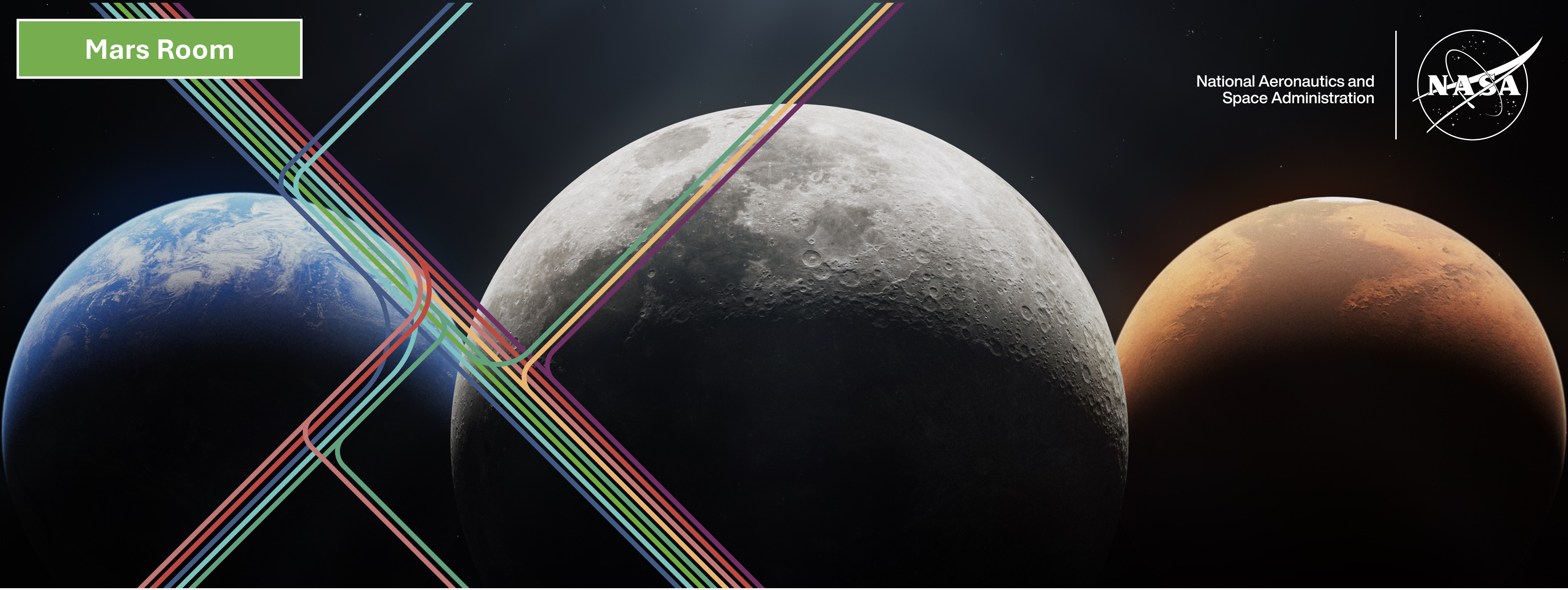

Mars Crew Complement Considerations

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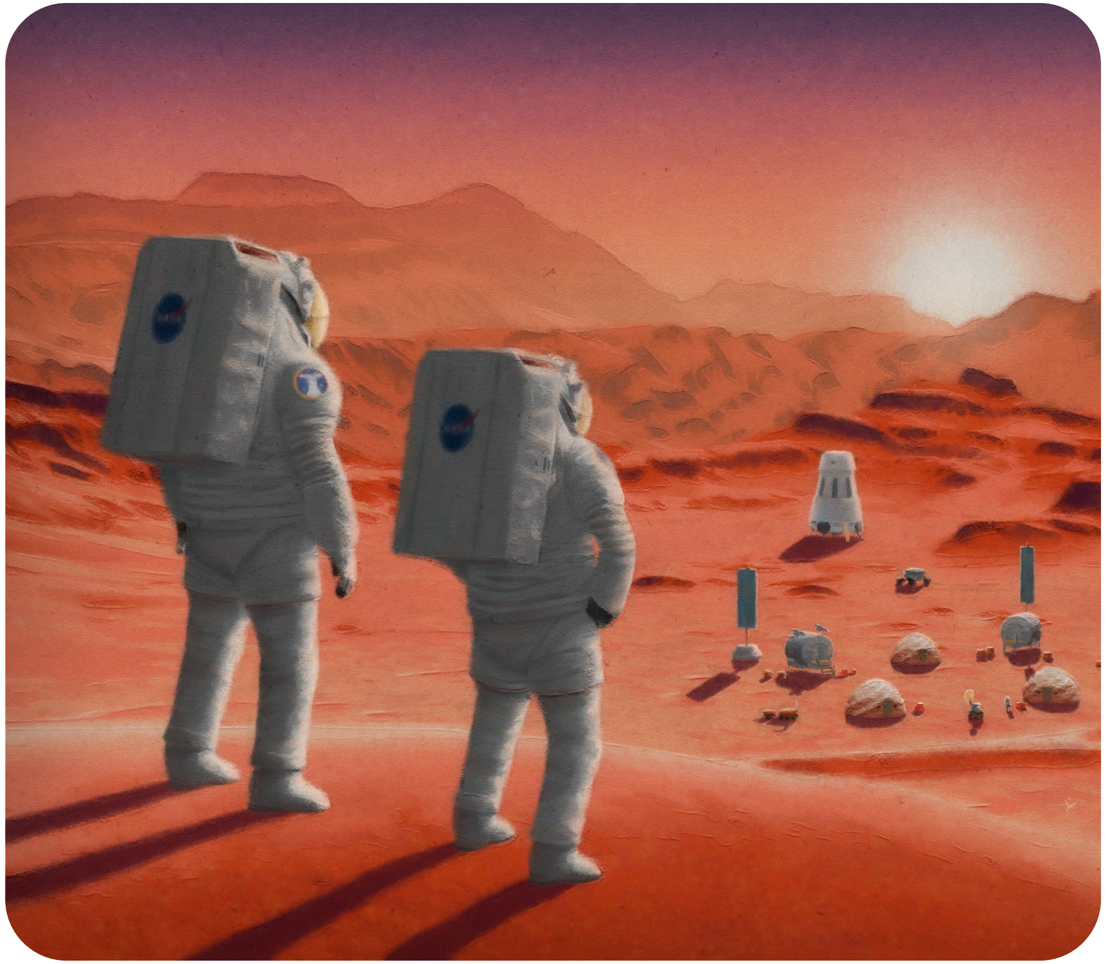
Crew Complement Impacts

National Aeronautics and Space Administration

Decisions about ***crew complement*** directly impact…

- Habitable element volume
- Environmental control and life support system performance
- Power needs
- Crew support systems
- Logistics (food, clothing, medical supplies, utilization)

Because of these flow-down impacts, it is critical that NASA establishes crew complement ***early in the stages of architecture development***

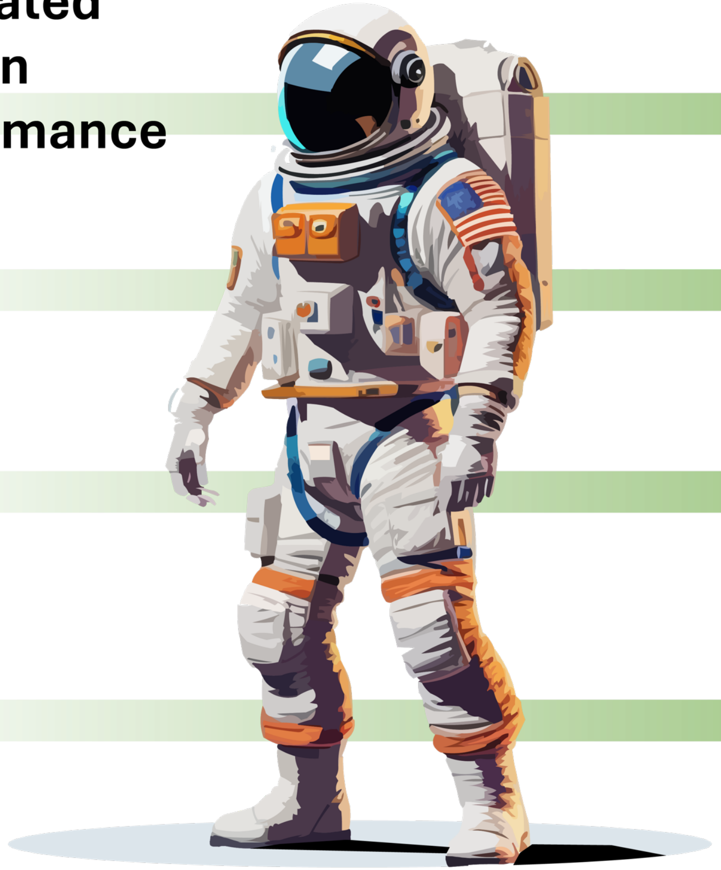


Crew Health and Performance Considerations

National Aeronautics and Space Administration

Crew complement must be appropriately sized to protect the ***physical and psychological health*** of the crew

Integrated Human Performance



Space Radiation

Acute In-flight Effects
(controlled by vehicle design and operational constraints)
Long-term Cancer Risk

Isolation & Confinement

Behavioral Aspects of Isolation
Individual Well Being
Circadian Misalignment and Sleep Difficulties
Team Cohesion and Performance

Distance from Earth

Drives the Need for Effective, On-board Systems that Facilitate Crew Readiness to Respond to Demands and Anomalies – They Cannot Come Home for Treatment

Altered Gravity Fields

Spaceflight Associated Neuro-ocular Syndrome
Balance Disorders
Fluid Shifts
Cardiovascular Deconditioning
Muscle Atrophy
Bone Loss

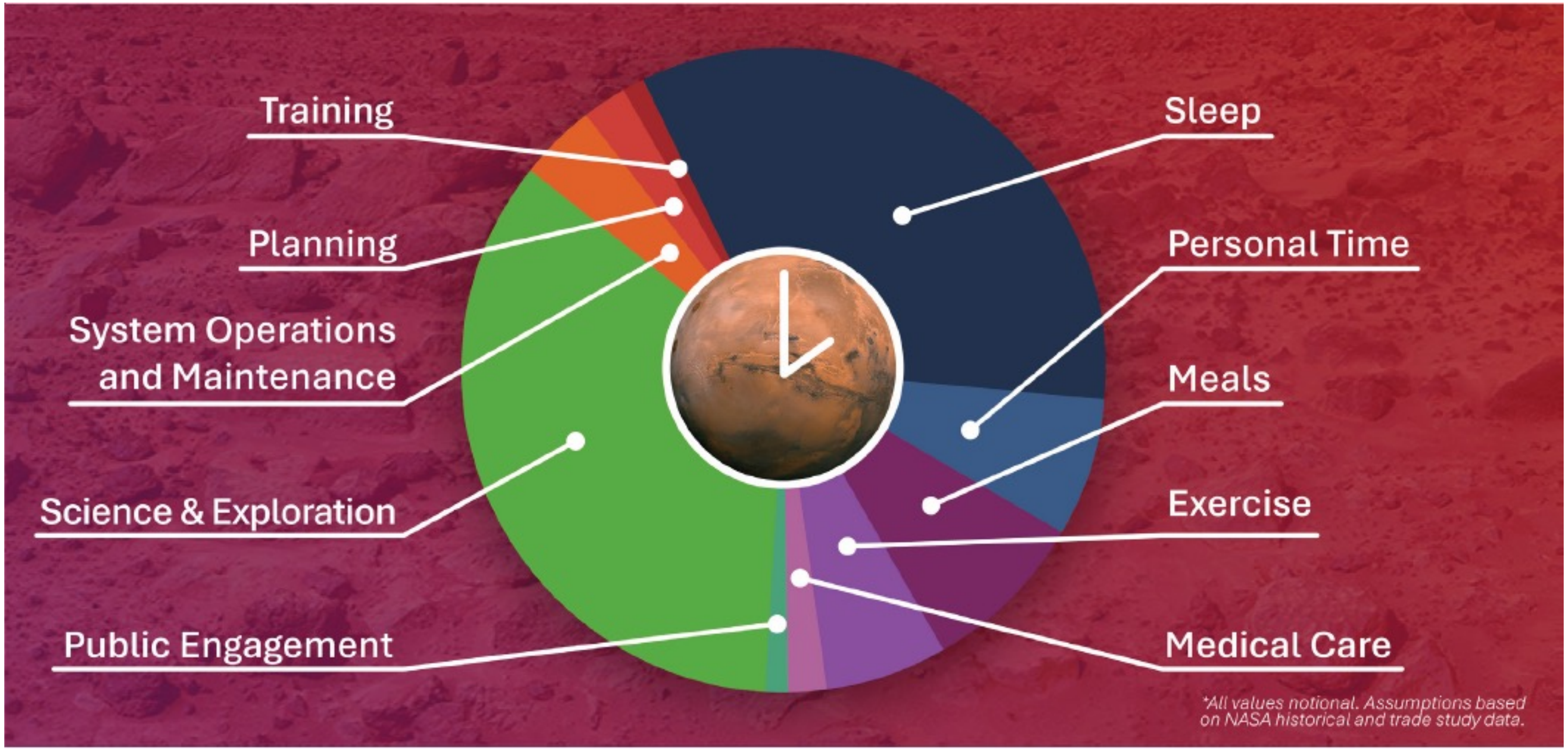
Hostile/Closed Environments

Vehicle Design
Environmental - CO_2 Levels, Toxic Explosures, Water, Nutrition/Food
Decreased Immune Functions, Microbiome Changes

Crew Responsibility and Workload Considerations

National Aeronautics and Space Administration

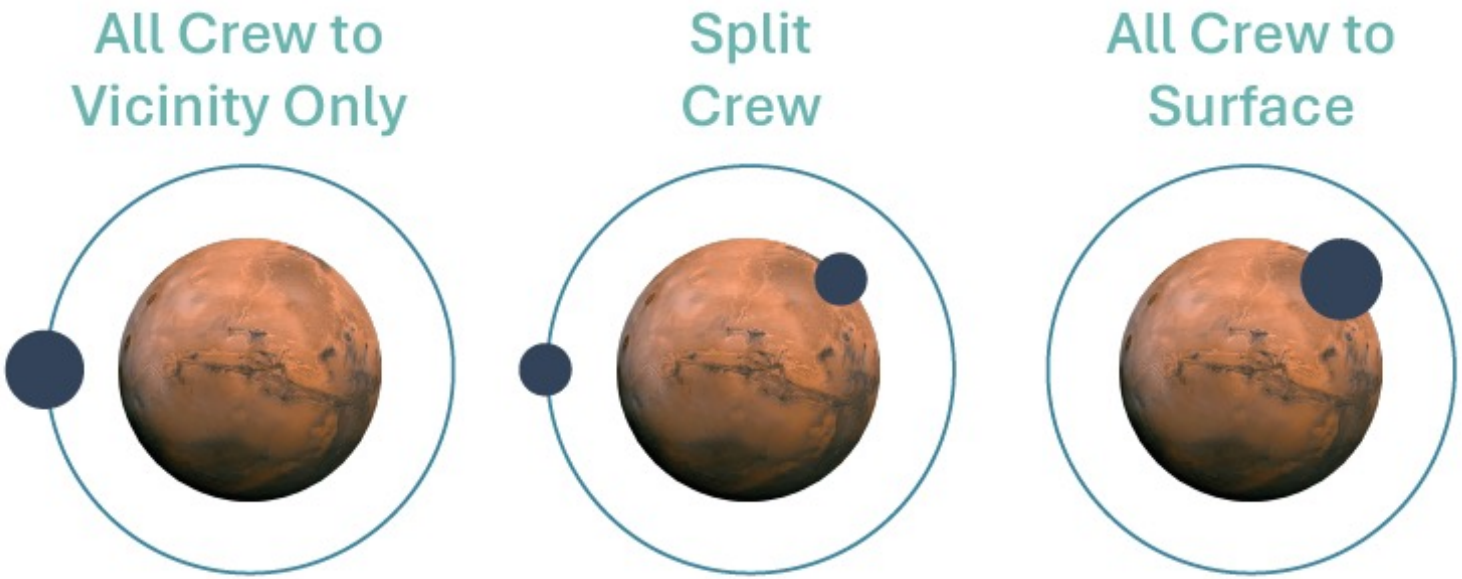
There are practical limitations on how many ***in-mission responsibilities*** a single crew member can support — crew complement must account for all mission tasks



Mission Concepts of Operation

National Aeronautics and Space Administration

Crew allocation results in different concepts of operations ***— and flow-down impacts*** to the rest of the mission architecture

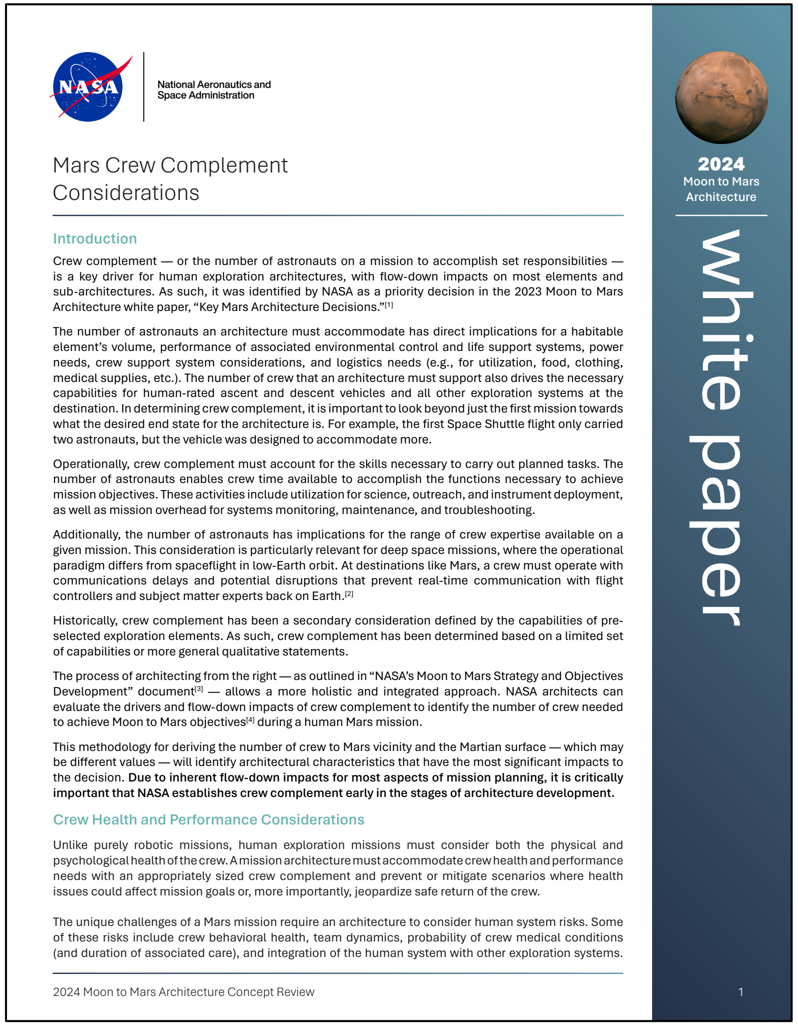


Three concepts of operation for a Humans to Mars segment mission

Crew Complement Considerations

White Paper

National Aeronautics and Space Administration


National Aeronautics and Space Administration

2024 Moon to Mars Architecture

white paper

Mars Crew Complement Considerations

Introduction

Crew complement — or the number of astronauts on a mission to accomplish set responsibilities — is a key driver for human exploration architectures, with flow-down impacts on most elements and sub-architectures. As such, it was identified by NASA as a priority decision in the 2023 Moon to Mars Architecture white paper, "Key Mars Architecture Decisions."[1]

The number of astronauts an architecture must accommodate has direct implications for a habitable element's volume, performance of associated environmental control and life support systems, power needs, crew support system considerations, and logistics needs (e.g., for utilization, food, clothing, medical supplies, etc.). The number of crew that an architecture must support also drives the necessary capabilities for human-rated ascent and descent vehicles and all other exploration systems at the destination. In determining crew complement, it is important to look beyond just the first mission towards what the desired end state for the architecture is. For example, the first Space Shuttle flight only carried two astronauts, but the vehicle was designed to accommodate more.

Operationally, crew complement must account for the skills necessary to carry out planned tasks. The number of astronauts enables crew time available to accomplish the functions necessary to achieve mission objectives. These activities include utilization for science, outreach, and instrument deployment, as well as mission overhead for systems monitoring, maintenance, and troubleshooting.

Additionally, the number of astronauts has implications for the range of crew expertise available on a given mission. This consideration is particularly relevant for deep space missions, where the operational paradigm differs from spaceflight in low-Earth orbit. At destinations like Mars, a crew must operate with communications delays and potential disruptions that prevent real-time communication with flight controllers and subject matter experts back on Earth.[2]

Historically, crew complement has been a secondary consideration defined by the capabilities of pre-selected exploration elements. As such, crew complement has been determined based on a limited set of capabilities or more general qualitative statements.

The process of architecting from the right — as outlined in "NASA's Moon to Mars Strategy and Objectives Development" document[3] — allows a more holistic and integrated approach. NASA architects can evaluate the drivers and flow-down impacts of crew complement to identify the number of crew needed to achieve Moon to Mars objectives[4] during a human Mars mission.

This methodology for deriving the number of crew to Mars vicinity and the Martian surface — which may be different values — will identify architectural characteristics that have the most significant impacts to the decision. **Due to inherent flow-down impacts for most aspects of mission planning, it is critically important that NASA establishes crew complement early in the stages of architecture development.**

Crew Health and Performance Considerations

Unlike purely robotic missions, human exploration missions must consider both the physical and psychological health of the crew. A mission architecture must accommodate crew health and performance needs with an appropriately sized crew complement and prevent or mitigate scenarios where health issues could affect mission goals or, more importantly, jeopardize safe return of the crew.

The unique challenges of a Mars mission require an architecture to consider human system risks. Some of these risks include crew behavioral health, team dynamics, probability of crew medical conditions (and duration of associated care), and integration of the human system with other exploration systems.

2024 Moon to Mars Architecture Concept Review

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KEY TAKEAWAYS

- The number of crew an architecture must support has ***flow-down impacts on most sub-architectures and elements***, with profound implications for key exploration systems, including launch vehicles, transit systems, ascent vehicles, communications infrastructure, and power generation.
- ***Splitting a crew between locations*** (e.g., in space, inside habitat, on EVA, etc.) significantly impacts the architecture necessary to support them.
- Key considerations for establishing the ***number of crew to the vicinity and the surface of Mars*** include balancing crew health, performance, operations, safety, utilization, technology integration, and exploration objectives.
- Due to these flow-down impacts, it is critically important that NASA makes a decision regarding crew complement ***early in the stages of architecture development***.
- NASA will continue to ***analyze the trade space*** in support of a decision on crew complement, developing a decision package for review by agency leadership.

Read the white paper
nasa.gov/architecture

Questions and Discussion

National Aeronautics and
Space Administration

Discussion Prompts

- How do the key crew complement considerations (e.g., crew time, autonomous systems) relate to your organization's work?
- What human performance and workload limits are expected to drive crew complement needs? Are there communities of practice we should engage?
- What near-term technology development opportunities could support achieving Earth-independent mission operations due to communication delays?
- How can lunar missions demonstrate crew complement alignment with mission objectives?

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NASA's Moon to Mars Architecture Website
www.nasa.gov/architecture