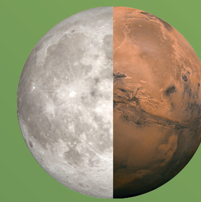
National Aeronautics and
Space Administration



2025
Moon to Mars
Architecture

white paper

Why Moon and Mars?
Building an Evolutionary Architecture

Introduction

NASA is sending humans back to the Moon and on to Mars to achieve its three pillars of exploration: national posture, science, and inspiration. Achieving these goals with the architecture requires consideration of the progressively more challenging destinations of the Moon and Mars.

The agency's Moon to Mars Architecture is an evolutionary roadmap that relies upon decades of historical and planned scientific research and technological advancement which allows human exploration to address progressively more complex science and exploration. Both the Moon and Mars have science and technology objectives in their own right, but advancing the operational skills, techniques, and systems to conduct that work successfully is critical.

This paper explores how returning to the Moon is empowering NASA to send the first humans to Mars and how the agency uses an incremental approach to address the massive engineering challenges of crewed missions to the Red Planet.

Over 55 years ago, NASA first sent astronauts to the Moon and returned them safely to Earth. The triumph and speed of the Apollo Program have left a lasting impression that planetary exploration is relatively easy. This is not the case.

The Apollo program's success[1] depended on significant government investments in the U.S. industrial base and iterative development of exploration capabilities. By taking a crawl-walk-run approach, NASA built on increasingly ambitious objectives to develop the technologies and operational experience necessary to land on the Moon and safely return to Earth.

This preparation and incremental development led to a historic event that set the United States' national posture for decades, significantly advanced lunar and planetary science, and continues to inspire people around the world. Only by learning to operate in space through this crawl-walk-run approach could NASA achieve one of humanity's most significant moments.

Today, as humanity sets its sights on Mars, NASA's Artemis program is returning crews to the lunar surface for the first time since Apollo. In doing so, NASA builds on the success of Apollo and the International Space Station, taking a similarly incremental, programmatic approach with its Moon to Mars Architecture. This approach will maintain American leadership in space, produce immense scientific opportunities, and inspire people around the world.

This paper highlights the benefits of this evolutionary approach. It examines the relative challenges of human exploration near Earth, on the Moon, and at Mars in terms of distance, gravity, and hazards. It also presents four programmatic considerations to ensuring the success of Moon to Mars exploration: American leadership, engineering and design, operations, and the human system.

NASA's Moon to Mars Architecture is an evolutionary roadmap for human exploration that achieves progressively more complex science and exploration objectives. Just as Mercury and Gemini laid the foundation for Apollo, the continued innovation in low Earth orbit and Artemis lunar campaign will empower parallel development and execution of the first crewed missions to the Red Planet.

Crawl

Project Mercury[2]

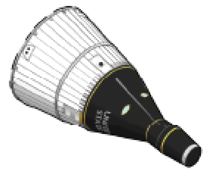
1961 – 1963

Six Crewed Flights

During Project Mercury, NASA developed foundational spaceflight capabilities, successfully placed astronauts in orbits, and returned them safely to Earth.

OBJECTIVES

Place a crewed spacecraft in orbit.
Investigate human performance in space.
Recover astronauts and spacecraft safely.



Walk

Project Gemini[3]

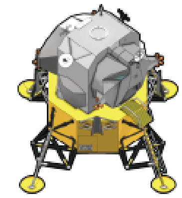
1964 – 1966

10 Crewed Flights

During Project Gemini, NASA bridged gaps between capabilities developed under Project Mercury and those needed to send humanity to the Moon.

OBJECTIVES

Test astronauts' ability to fly long-duration missions.
Understand spacecraft rendezvous and docking.
Perfect re-entry and landing methods.



Run

The Apollo Program[4]

1967 – 1972

Nine Crewed Flights

During Apollo, NASA leveraged lessons learned, technologies developed, and astronauts trained during Mercury and Gemini to send crews to the Moon.

OBJECTIVES

Land humans on the Moon and return them to Earth.
Live, work, and conduct science on the lunar surface
Establish capabilities that meet national interests.

Exploration Challenges

The United States has over 60 years of crewed spaceflight experience in low Earth orbit, starting with Project Mercury. The Space Shuttle program[5] flew 135 flights, carrying a total of 355 people over the course of more than 30 years.[6] NASA has also maintained a continuous human presence on the International Space Station for over 25 years.

By comparison, human lunar exploration consists of nine Apollo missions on and around the Moon (plus two Earth orbit missions) over the course of five years. Only 12 humans have ever walked on the lunar surface. To date, only robotic missions have explored Mars.

Humanity's experiences at these three destinations inform one another, but there are also unique considerations that our experiences do not account for. This paper organizes them into three categories: **distance**, **gravity**, and **hazards**.

Distance

Exploring each destination presents unique challenges that NASA must address to ensure astronauts' safe return. Many of these challenges result from the destinations' sheer distance from Earth, which impacts travel time and communications delay.

The space station orbits around 250 miles above Earth;[7] crews can reach or return from the station in as little as a few hours.[8] The light-time communications delay due is essentially negligible — though there can be a few seconds of system latency. Station astronauts enjoy real-time conversations with flight controllers and loved ones on Earth and comforts like internet access through robust telecommunications infrastructure.[9]

At its farthest, the Moon is about 250,000 miles from Earth[10] — 1,000 times farther than the International Space Station. It takes a crew about three days to reach the Moon from Earth. The light-time delay to the Moon and back is only a few seconds, but Artemis astronauts can expect total latencies of up to 14 seconds.[11]

The distance between Earth and Mars varies greatly depending on where the planets are in their orbits around the Sun. Their closest recorded encounter was in 2003, at about 35,000,000 miles apart, but the two planets can be separated by as much as 250,000,000 miles.[12] Unlike the Moon, the journey from Earth to Mars would be measured in months, not days.[13] Once at the Red Planet, astronauts would experience a one-way light-time communications delay between 4 and 24 minutes, making real-time conversation with Earth impractical.[14]

The relative distance of each destination from Earth changes the magnitude of the challenge. Missions to low Earth orbit, to the Moon, and to Mars are measured in hours, days, and months, respectively. Autonomy and self-sufficiency become increasingly important as the light-time communications delay grows from negligible to a major operational consideration. Mission distance and duration can also have psychological and psychosocial effects that NASA must understand before sending crews into deep space.

Gravity

Overcoming gravity is one of the most fundamental challenges of spaceflight. Leaving a gravity well requires an incredible amount of energy. This energy is often described in terms of delta-v, the magnitude of change in velocity required to put a spacecraft on course to its destination.[15]

The delta-v to reach low Earth orbit can be considered a baseline, as a mission must first ascend out of Earth's gravity well before proceeding on to the Moon, Mars, or another destination. A mission requires additional delta-v to intersect a celestial body, descend into its gravity well, ascend back to orbit, and return to Earth, all of which vary based on the body's mass and distance from Earth.

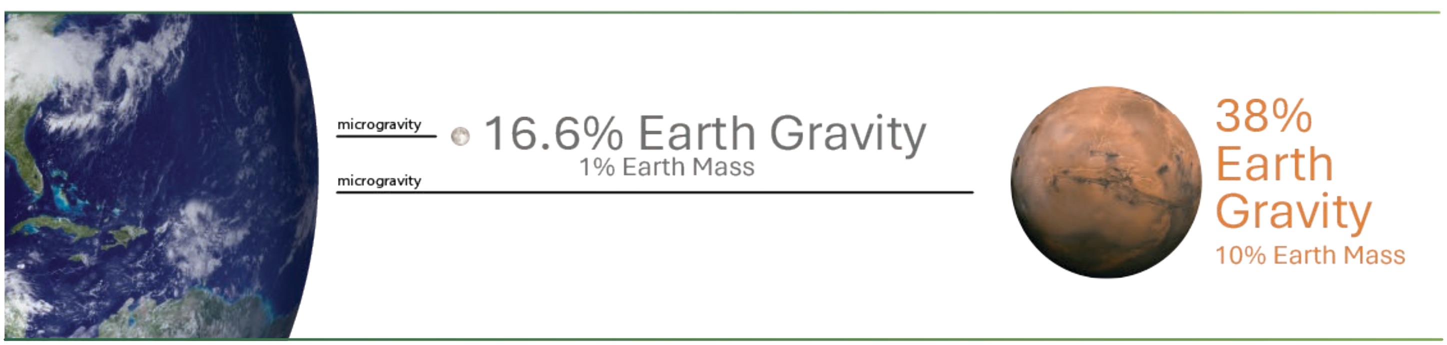
Exploration Challenges by Destination

DISTANCE FROM EARTH

ONE-WAY JOURNEY

LIGHT-TIME DELAY

GRAVITY



Visiting Mars requires significantly more delta-v than visiting the Moon, given the immense difference in distances from Earth. The propellant required to achieve this delta-v for a given payload is a mass multiplier often called a "gear ratio." The gear ratio for a Mars mission is much greater than a Moon mission. In other words, it takes significantly more energy to deliver one kilogram of mass to Mars.[16]

Additionally, microgravity and partial gravity are completely different operational environments. The Moon's mass is just 1% of Earth; Mars's mass is roughly 10% of Earth.[17] Surface systems on the Moon and Mars will operate under in one-sixth and one-third of Earth's gravitational force, respectively. While we have many years of experience operating in microgravity and low Earth orbit, systems and operational paradigms designed for microgravity will not inherently work in these partial-gravity environments.

Hazards

While low Earth orbit missions have been — and continue to be — an excellent platform for developing exploration systems, missions to the Moon and Mars will subject explorers and exploration systems to challenges that cannot be tested on the microgravity platform.[18] These challenges include **radiation**, **dust**, and **transitions between a new set of gravity environments**.

While astronauts on the International Space Station experience more radiation than they would on Earth's surface, Earth's magnetosphere still protects low Earth orbit.[19] Neither the Moon nor Mars has a similar protective feature. NASA must must better understand these radiation environments and develop radiation mitigation technologies to keep explorers safe while in transit to and from and while at these destinations.

Dust contamination from lunar or Martian regolith can be detrimental to crew health, and can damage hatch seals or reduce solar array performance.[20] NASA will need to develop proper mitigations and ruggedize space systems developed for relatively pristine orbital environments so that they can operate in dusty planetary environments.

In addition to the gravity considerations above, transitions between gravity environments will impact the human system in ways that NASA must understand to ensure safety and success.[21] Journeys to the Moon and Mars will place astronauts in microgravity and reduced gravity environments that will impact their performance and health.

NASA can better understand these hazards by studying astronauts and testing systems at the Moon, where mission support is readily available from Earth and an abort could return crew relatively quickly. This paradigm would better prepare the agency for Mars missions, where support is limited and mission aborts may not be feasible or could take months.[22] \

Programmatic Considerations

Just as the Apollo Program required sustained, programmatic investments, a campaign of Moon to Mars exploration will be evolutionary. It will rely on thoughtful programmatic approaches that this paper organizes into four categories: **American leadership**, **engineering and design**, **operations**, and **human systems**.

American Leadership

The Moon to Mars campaign will require and enable the United States' global leadership in space exploration. This includes developing the nation's industrial base, advancing technologies, and expanding economic utilization at the Moon and Mars.

Space Leadership

NASA will lead exploration missions in a manner consistent with a safe, peaceful, and prosperous future in space. NASA-led collaborations with commercial and international space agency partners will follow the Artemis Accords,[23] which implement the commitments by signatory nations to 1967's Outer Space Treaty,[24] the United Nation's Convention on Registration of Objects Launched into Outer Space,[25] and the United Nation's Agreement on the Rescue of Astronauts.[26]

Partnerships

To realize Moon to Mars exploration missions, NASA will need to leverage the expertise of its commercial, federal, academic, and international partners. These partnerships enable NASA to engage a wider industrial and supply base, expand the range of ideas and systems that the agency can leverage, and increase the speed of innovation.[27] Partnerships can offer parallel development opportunities, improve robustness through redundancy, and contribute to economic development.

Technology Readiness

Advances in deep space exploration and the capabilities to safely deliver, sustain, and return humans to Mars necessitate improvements across many technologies. Technology innovation and iteration at the Moon will help NASA develop the high-reliability capabilities needed for Mars missions, where repair and replacement may be infeasible. For example, in 2024, NASA selected nuclear fission power as the primary surface power technology for initial Mars missions.[28] Using this same technology for NASA's lunar surface infrastructure accelerates technology development into a flight project and reduces risk for subsequent Mars applications.

Partnerships also help keep NASA on the cutting edge of technology. Commercial and international partners can invest in technology development efforts to fill architecture-driven technology gaps and enable exploration.

Economic Development

The magnitude of Moon to Mars exploration requires the activation of the American industrial base. Robust, domestic engineering and manufacturing capabilities and expertise form the backbone of the Artemis program and the journey to Mars. It also means fostering new companies and industries that will compete to offer cost-effective services to the U.S. government and economic benefit to the American people.

Engineering and Design

The design and deployment of hardware necessary to reach a destination become increasingly challenging as the distance from Earth grows. The performance needed for a Mars mission is far greater than for a Moon mission, which is far greater than for a low Earth orbit mission.

Vehicle Design

Currently, many providers can support launches to low Earth orbit; fewer can support uncrewed missions to deep space destinations. Only one launch vehicle — the Space Launch System[29] — is certified for human launches beyond low Earth orbit today. Similarly, while the U.S. makes use of human-rated spacecraft to visit the International Space Station, it currently has only one vehicle rated for lunar exploration — the Orion spacecraft.[30] Mars transportation vehicles exist only as early concepts. Realizing a robust campaign of Moon to

Mars exploration will require development of new or enhanced vehicles to ensure a robust architecture with appropriate redundancy.

Supplies and Logistics

Lunar and Mars missions will have a significantly higher logistics and resupply needs than low Earth orbit due to increased mission durations and infrastructure needs. NASA projects annual logistics needs of 5,000 to 6,000 kgs for four crew members operating on the lunar surface for approximately 30 days.[31] Mars missions, which could last two to three years, would require significantly more logistics and would likely need them positioned on Mars prior to launching human explorers. Leveraging the lunar missions to plan for longer-duration deep space resupply will help NASA to optimize for efficiency, ensure appropriate shelf life of commodities, and develop techniques to minimize overhead.

Maintainability and Reusability

The International Space Station's longevity has depended upon the availability of spare or replacement parts and crew time to repair, maintain, or upgrade systems. NASA estimates that similar maintenance tasks could take up over 24 hours of crew time over the course of a 28-day lunar surface mission,[32] and a similarly large percentage of crew time for Mars missions.[33] These missions would not benefit from the frequent resupply opportunities in low Earth orbit and would need to operate uncrewed for long periods of time. NASA will need to demonstrate this advanced system reliability, which far exceeds the International Space Station's capabilities, to prepare for Mars missions.

Operations

While NASA and partner space agencies have decades of flight experience, that experience has mostly been near the Earth. Humanity must develop experience and competency to operate in increasingly remote environments. Closing this gap is a key facet of Moon to Mars activities.

Autonomy and Earth-Independence

Low Earth orbit operations benefit from real-time connectivity. Ground teams can manage, control, and monitor vehicles, minimizing in-space work for astronauts. This connectivity also provides robust support for troubleshooting, medical care, and other contingency situations. Increasing distance and communication delays at the Moon and Mars will greatly reduce Earth-based flight control operations support, necessitating development of Earth-independent and autonomous capabilities.

Coordination and Aggregation

As NASA's human spaceflight ambitions grow, so do the size and number of vehicles necessary to accomplish them. The Apollo Program used a relatively straightforward launch architecture; one Saturn V rocket launched everything needed for surface operations at the lunar equator. In contrast, Artemis campaign objectives for the lunar South Pole region[34] call for a multi-launch, multi-partner architecture that considers interoperability and aggregation of systems at exploration sites.

Mars architectures will be even more complex, requiring perhaps dozens of launches and landings to aggregate required systems. Developing operational experience and standards for coordination during lunar missions will help ensure success of Mars missions. As a comparison, the assembly of the International Space Station required more than 40 missions and over 260 spacewalks in the low Earth orbit environment.[35] Mars missions will require similar coordination and aggregation operations in far more complex orbital mechanics environments.

Risk and Contingency Planning

Human spaceflight is inherently dangerous, but NASA must balance risks through effective mission planning and systems engineering. Distance from Earth magnifies mission risk because abort opportunities become longer and fewer. Aborts from low Earth orbit are possible in a matter of hours, while aborts from cislunar space and the lunar surface would take days. During Mars missions, however, aborts could take much longer, on the order of months, or, depending on orbital dynamics and the phase of the mission, might not be possible at all.

Reliable, redundant, and mission-tested hardware helps to reduce mission risks. Additionally, all planetary exploration experiences will help NASA to prepare appropriate procedures for emergency and contingency operations when abort isn't feasible.

Human Systems

The survival of the human system is the most important aspect of any crewed exploration mission. For NASA, safety is paramount to mission success.

Health Hazards

The five main hazards of human spaceflight are space radiation, isolation and confinement, distance from Earth, altered gravity fields, and hostile/closed environments.[36] These hazards are especially heightened by the distance, duration, and complexity of Mars missions. Crew members will need to survive the trip to Mars, which will likely exceed current spaceflight duration records, adjust after landing on the Red Planet, and then complete the return journey to Earth, all while mitigating the physiological and psychological challenges of spaceflight.

Understanding the effects of spaceflight on human physiology, psychology, and individual and team performance will keep astronauts safe and healthy as they explore the Moon, Mars, and beyond. Many techniques developed in low Earth orbit, such as exercise protocols, will be extensible to lunar and Mars missions, but these missions will also require new design solutions, health countermeasures, operational paradigms.

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Operational Experience

Experience, medical data, and lessons learned from lunar operations will buy down risk for future Mars missions (i.e., the risks of a Mars mission attempted today). For example, lunar surface missions will require astronauts to transition from microgravity to partial gravity and back again.

Astronauts returning to gravity after long durations in microgravity undergo a range of physiological adjustments that require time for readaptation. Astronauts on Earth enjoy extensive assistance during these adjustments; astronauts on Mars will not have this luxury. NASA's longest human spaceflight record, 371 days, is only about half of the duration of the shortest anticipated Mars mission.[37]

It could take days of readaptation to Martian gravity for astronauts to perform an EVA. Residual effects of the sustained period in microgravity during the journey to Mars could persist for longer.[38]

NASA does not yet have a complete picture of how a journey to Mars would affect astronauts' health and performance. Increasing the duration of lunar surface missions, with the Moon serving as an analog for Mars, will give NASA the opportunity to study how the human body reacts to those transitions and refine its operational approach and medical countermeasures for the first human Mars missions.

The challenge of adapting to gravitational transitions is just one example. NASA will need to develop new operational competencies to address the many challenges outlined in this paper. In many cases, the capability gaps that NASA must address are not limited to technology. They also include experience and operational know-how. Just as early spaceflight missions paved the way for Apollo and decades of experience in low Earth orbit contributed to the Artemis program, lunar exploration will teach NASA to operate at Mars.

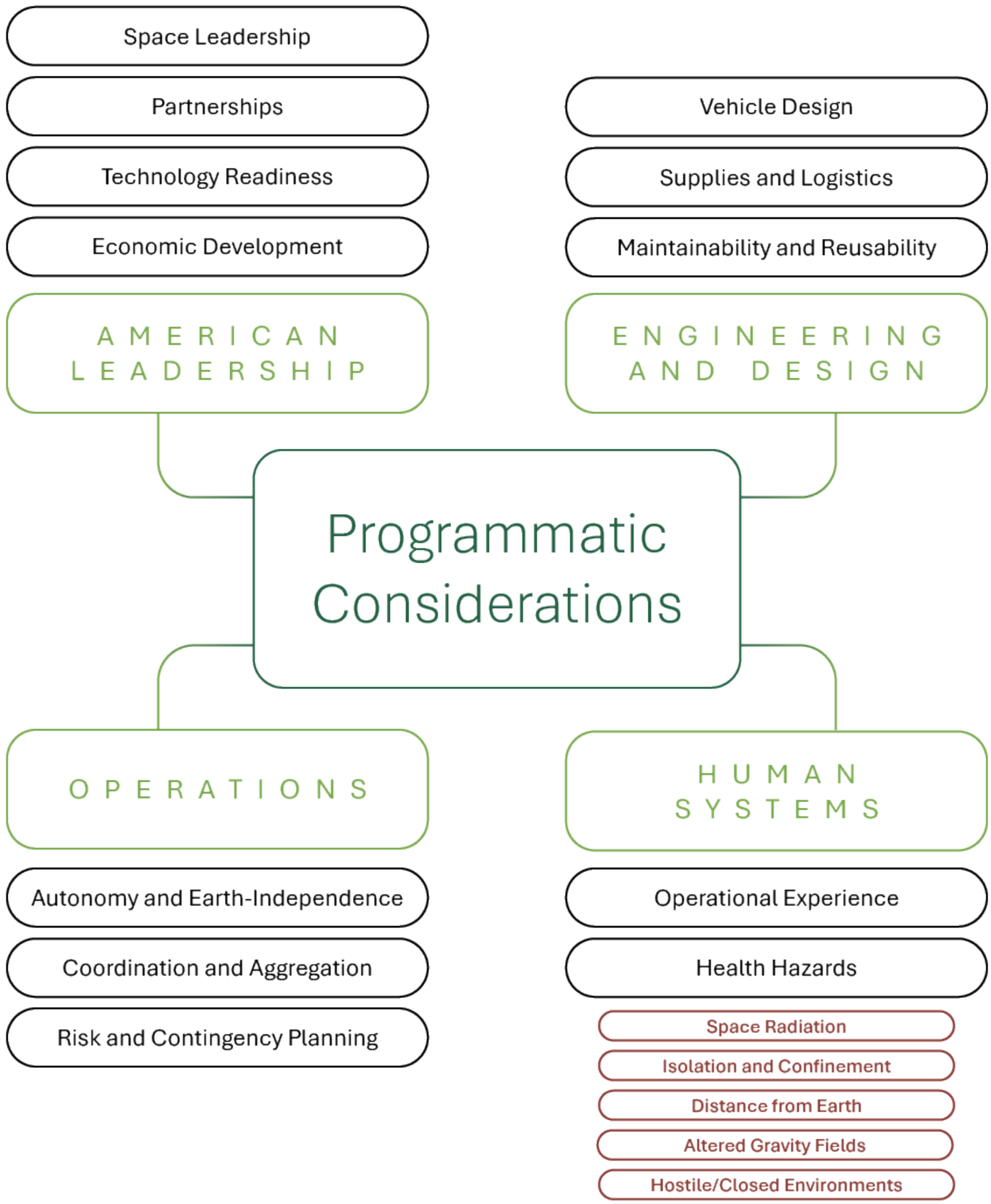
Conclusion

NASA's Moon to Mars Architecture seeks to achieve a sustained, evolvable campaign of exploration that maximizes scientific return and technology development for the benefit of all. It aims to realize a lasting campaign of science and discovery that feeds forward to future exploration while returning value to everyone on Earth.

Exploration of the cosmos remains a great calling for humanity. Each step from our home planet offers increasing opportunity, challenge, and risk. To enable sustained exploration, NASA must take the next giant leap, leveraging lessons learned from Apollo, the International Space Station, and the Artemis program as a testbed to send the first humans to Mars.

Human exploration at the Moon and Mars significantly expands our understanding of our planet, solar system, and universe. The incremental approach described in this paper will unlock increasing scientific value by enabling direct observations by human explorers at a growing range of destinations.

NASA will develop essential technology, capabilities, and operational experience at the Moon to reduce risk for Mars missions. Returning to the Moon is not in opposition to humanity's journey to the Red Planet. Lunar exploration will put Mars within our reach.


Space Leadership
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Key Takeaways

Human space exploration becomes increasingly challenging as missions ascend beyond low Earth orbit to the Moon and Mars. These challenges grow due to many factors, including **distance**, **gravity**, and **hazards** at each destination.

Learning from the success of the Apollo Program, NASA must take an iterative, programmatic approach that leverages lunar exploration to realize the first crewed missions to the Red Planet. These considerations include **national posture**, **engineering design**, **mission operations**, and **human systems**.

Sustaining an exploration campaign from the Moon to Mars will foster continued American leadership in space, maximize the benefits of space exploration, and ensure humanity is ready for the next giant leap.

References

1. **What Made Apollo a Success?**
   https://ntrs.nasa.gov/api/citations/19720005243/downloads/19720005243.pdf
2. **Project Mercury**
   https://www.nasa.gov/project-mercury/
3. **Project Gemini**
   https://www.nasa.gov/gemini/
4. **The Apollo Program**
   https://www.nasa.gov/the-apollo-program/
5. **The Space Shuttle**
   https://www.nasa.gov/space-shuttle/
6. **Space Shuttle Era Facts**
   https://www3.nasa.gov/centers/kennedy/pdf/566250main_SHUTTLE%20ERA%20FACTS_040412.pdf

References *(continued)*

7. **What is the International Space Station?**
https://www.nasa.gov/learning-resources/for-kids-and-students/what-is-the-international-space-station-grades-5-8/
8. **Station Facts**
https://www.nasa.gov/international-space-station/space-station-facts-and-figures/
9. **Space Communications: 7 Things You Need to Know**
https://www.nasa.gov/missions/tech-demonstration/space-communications-7-things-you-need-to-know/
10. **Supermoons**
https://science.nasa.gov/moon/supermoons/
11. **Effects of Communication Delay on Human Spaceflight Missions**
https://ntrs.nasa.gov/api/citations/20230002268/downloads/AHFE%202023%20-%20no%20logo.pdf
12. **Mars Closest Encounter**
https://science.nasa.gov/missions/hubble/mars-closest-encounter/
13. **Mars Transportation, 2022 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2023/10/acr22-wp-mars-transportation.pdf?emrc=1a6c54
14. **Mars Communications Disruption and Delay, 2023 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/01/mars-communications-disruption-and-delay.pdf?emrc=1adf04
15. **Chapter 13: Navigation**
https://science.nasa.gov/learn/basics-of-space-flight/chapter13-1/
16. **Round-trip Mars Mission Mass Challenges, 2023 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/01/round-trip-mars-mission-mass-challenges.pdf?emrc=c0d7c4
17. **Planetary Fact Sheet – Ratio to Earth Values**
https://nssdc.gsfc.nasa.gov/planetary/factsheet/planet_table_ratio.html
18. **Five Hazards of Human Spaceflight**
https://www.nasa.gov/hrp/hazards/
19. **Earth's Magnetosphere: Protecting Our Planet from Harmful Space Energy**
https://science.nasa.gov/science-research/earth-science/earths-magnetosphere-protecting-our-planet-from-harmful-space-energy/
20. **Surface EVA Architectural Drivers, 2023 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/01/surface-eva-architectural-drivers.pdf?emrc=1b5505
21. **Human Health and Performance, 2023 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/01/human-health-and-performance.pdf?emrc=ba0f7b
22. **Mars Mission Abort Considerations, 2023 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/01/mars-mission-abort-considerations.pdf?emrc=a46442
23. **The Artemis Accords**
https://www.nasa.gov/artemis-accords/
24. **Outer Space Treaty – 1967**
https://www.nasa.gov/history/SP-4225/documentation/cooperation/treaty.htm
25. **Convention on Registration of Objects Launched into Outer Space**
https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/registration-convention.html
26. **Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space**
https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introrescueagreement.html
27. **Architecture-Driven Technology Gaps, 2024 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/12/acr24-architecture-technology-gaps.pdf?emrc=363045
28. **Mars Surface Power Technology Decision, 2024 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/12/acr24-mars-surface-power-decision.pdf?emrc=90a15b
29. **Space Launch System**
https://www.nasa.gov/humans-in-space/space-launch-system/
30. **Orion Spacecraft**
https://www.nasa.gov/humans-in-space/orion-spacecraft/
31. **Lunar Surface Cargo, 2024 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/06/acr24-lunar-surface-cargo.pdf?emrc=641f61
32. **Assessment of Crew Time for Maintenance and Repair Activities for Lunar Surface Missions**
https://ntrs.nasa.gov/api/citations/20210026843/downloads/IEEE%20Assessment%20of%20Crew%20Time%20for%20Maintenance%20and%20Repairs%20Activities%20for%20Lunar%20Surface%20Missions.pdf
33. **Mars Crew Complement Considerations, 2024 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/12/acr24-mars-crew-complement.pdf?emrc=84503d
34. **Why Artemis Will Focus on the Lunar South Pole Region, 2022 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2023/10/acr22-wp-why-lunar-south-polar-region.pdf?emrc=ced2ac
35. **International Space Station**
https://www.nasa.gov/reference/international-space-station/
36. **Mars Mission Abort Considerations, 2023 Moon to Mars Architecture White Paper**
https://www.nasa.gov/wp-content/uploads/2024/01/mars-mission-abort-considerations.pdf?emrc=a46442
37. **Station Record Holders**
https://www.nasa.gov/international-space-station/space-station-astronaut-record-holders/
38. **Hazard: Gravity Fields**
https://www.nasa.gov/hrp/hazard-gravity-fields/