National Aeronautics and
Space Administration

Architecture Approach for Human Mars Missions

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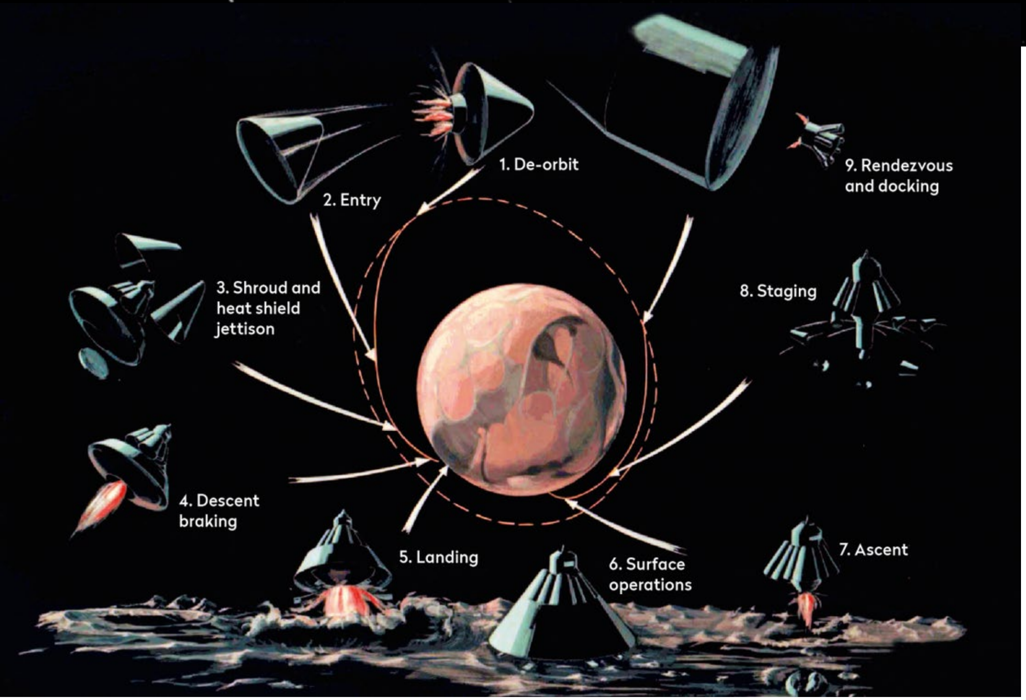
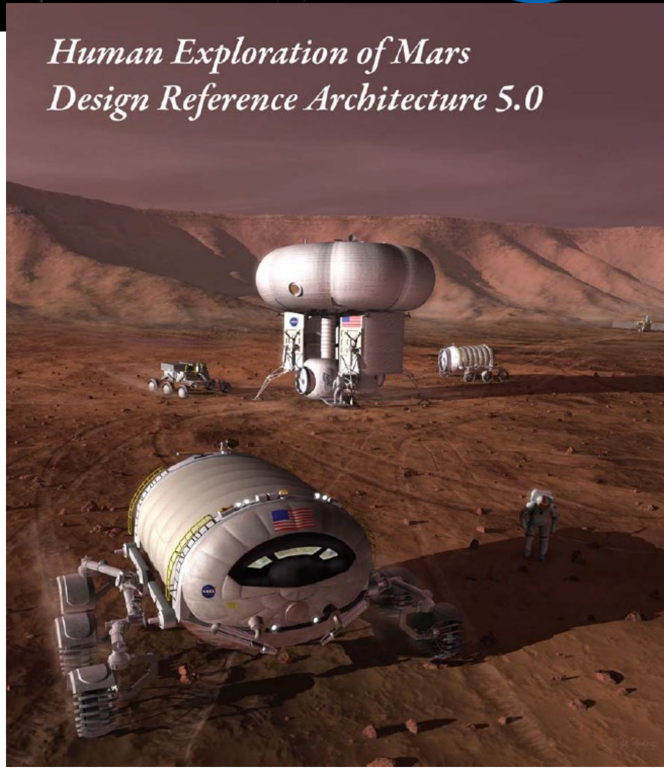
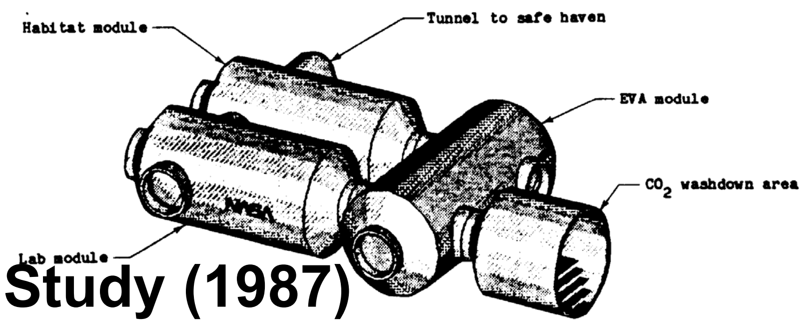
Historical Mars Architecture Approach



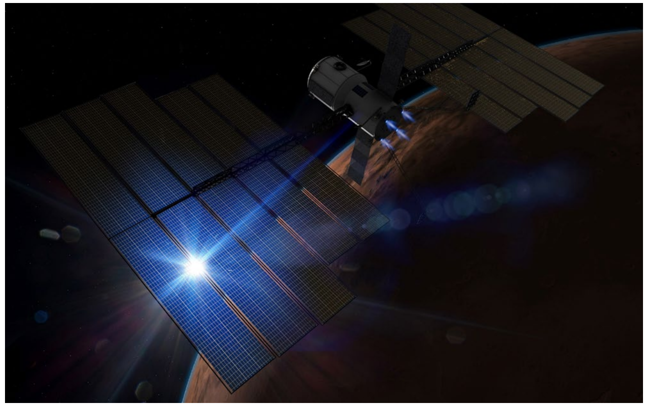
Von Braun Mars (1969)
Optimized around Apollo extensibility

Design Reference Architecture 5 (2009)
Optimized around a long-duration stay with minimal Mars landed mass





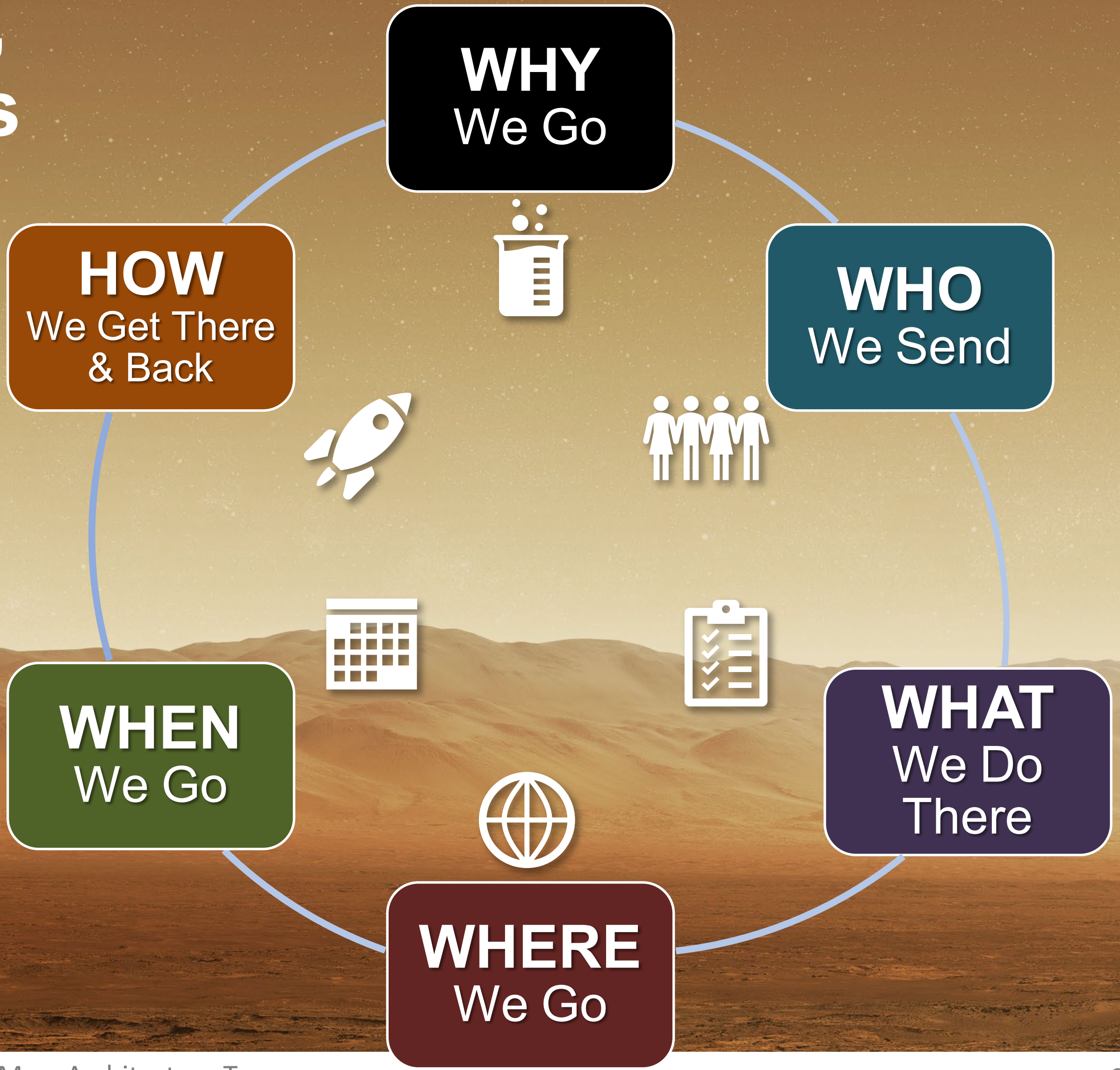
Mars Base Study (1987)
Optimized around ISS module extensibility



Evolvable Mars Campaign (2016)
Optimized around minimal Earth-launched mass and Solar Electric propulsion extensibility

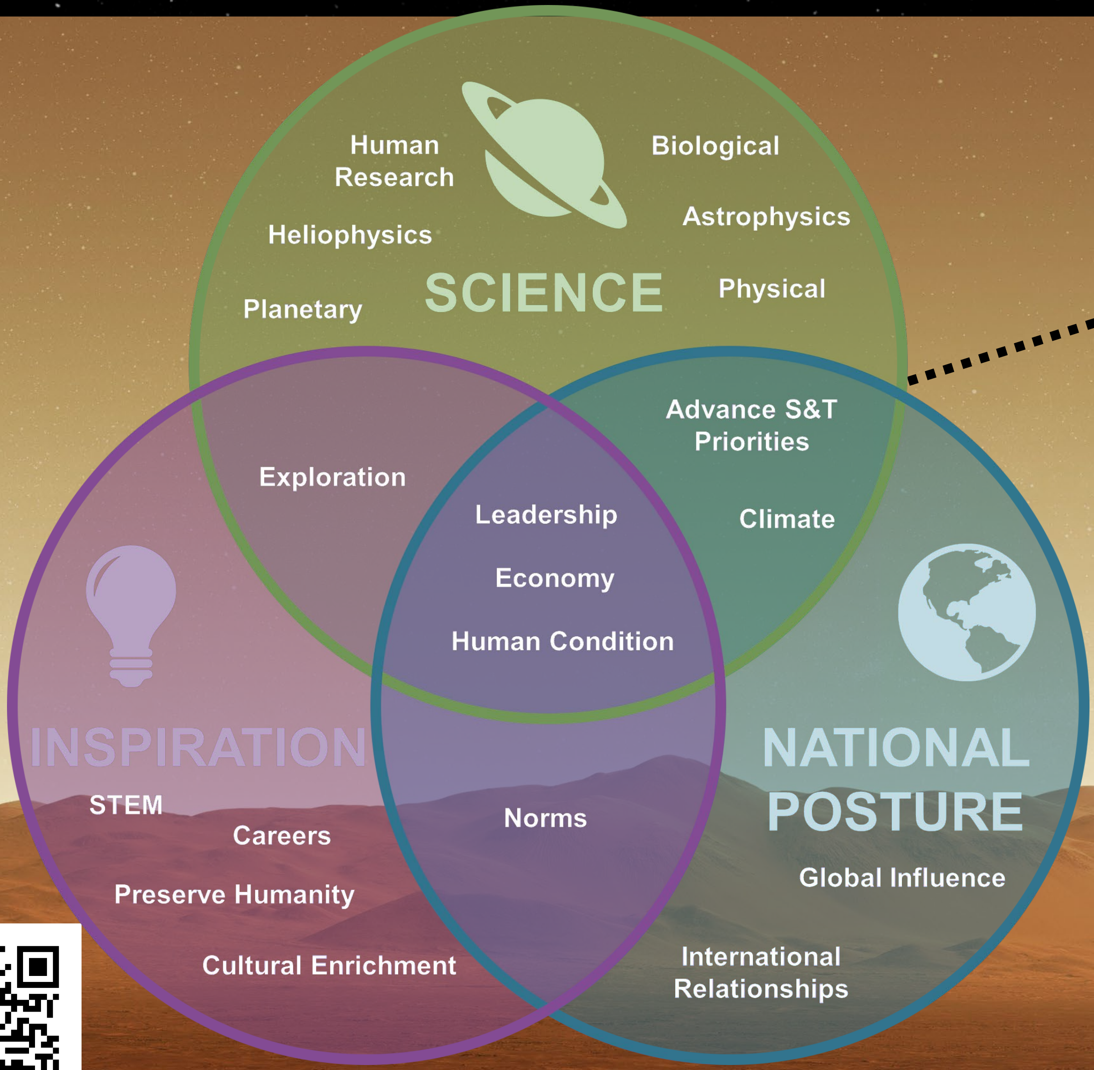
Current Mars Architecture Team Approach

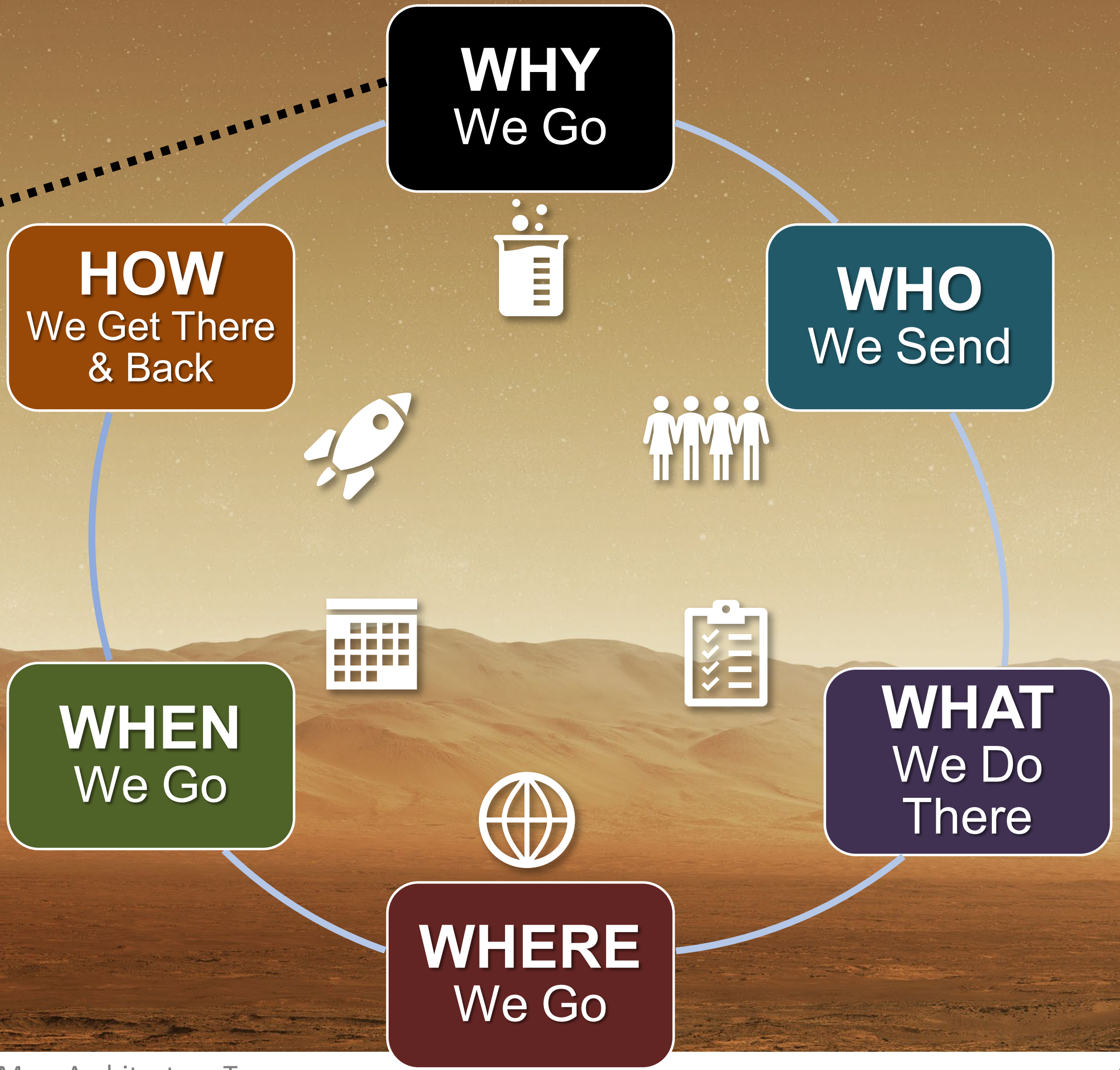
To define the Mars Architecture, we must answer 6 key questions



The answer to each question requires one or more decisions—*but all of these decisions are interrelated, and order matters*

Architecting from the Right

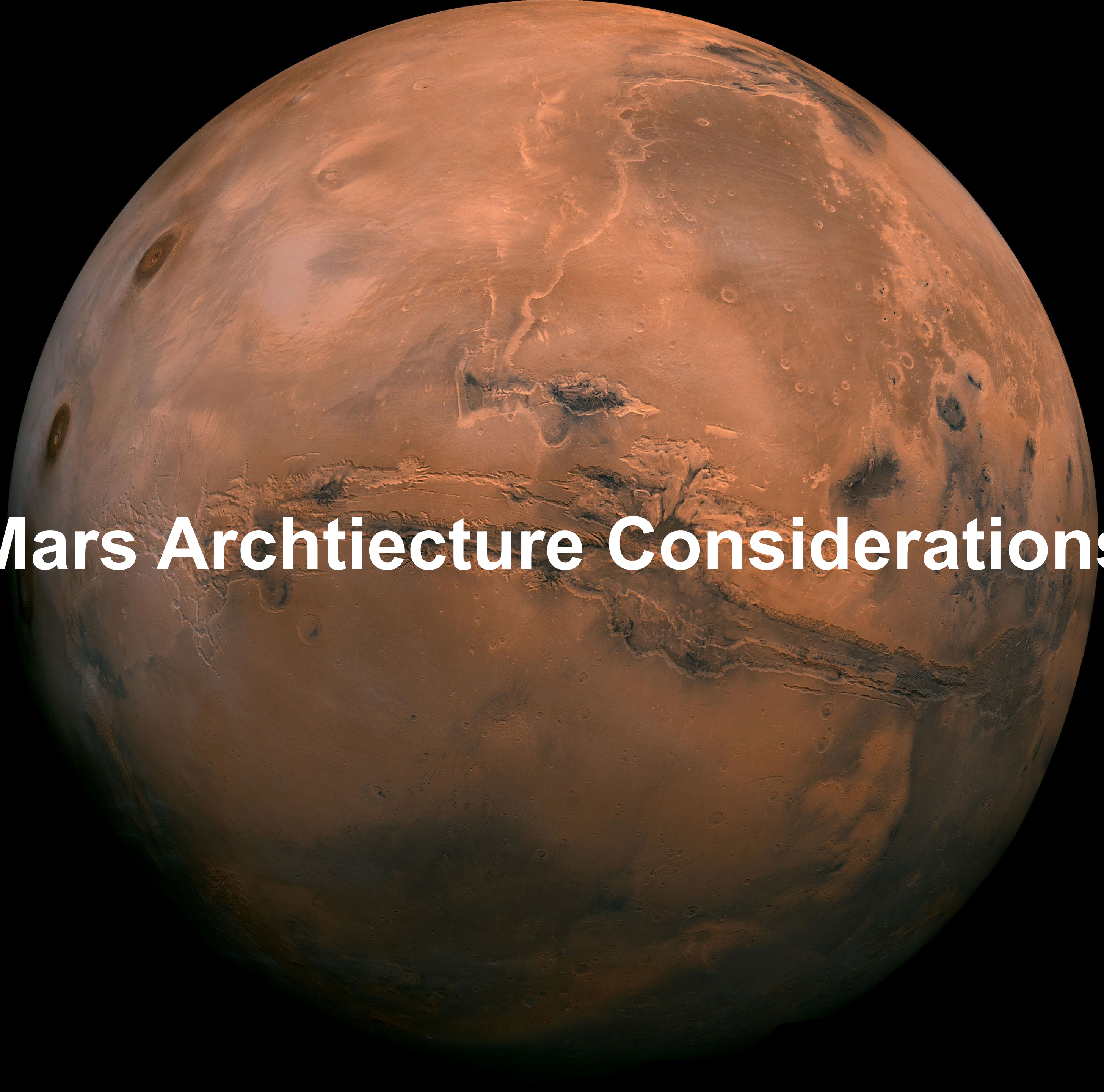




go.nasa.gov/3zzSNhp

The answers to "Why?" have been defined in the Agency's Moon-to-Mars Objectives

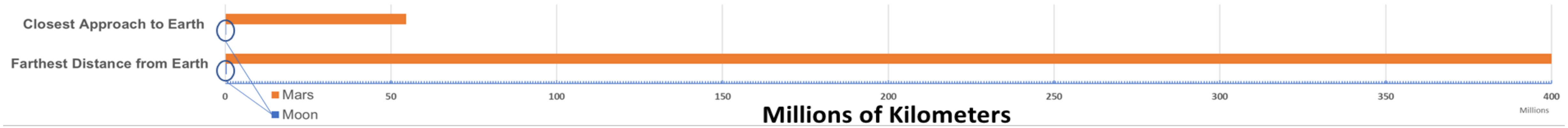
Mars Archtiecture Considerations



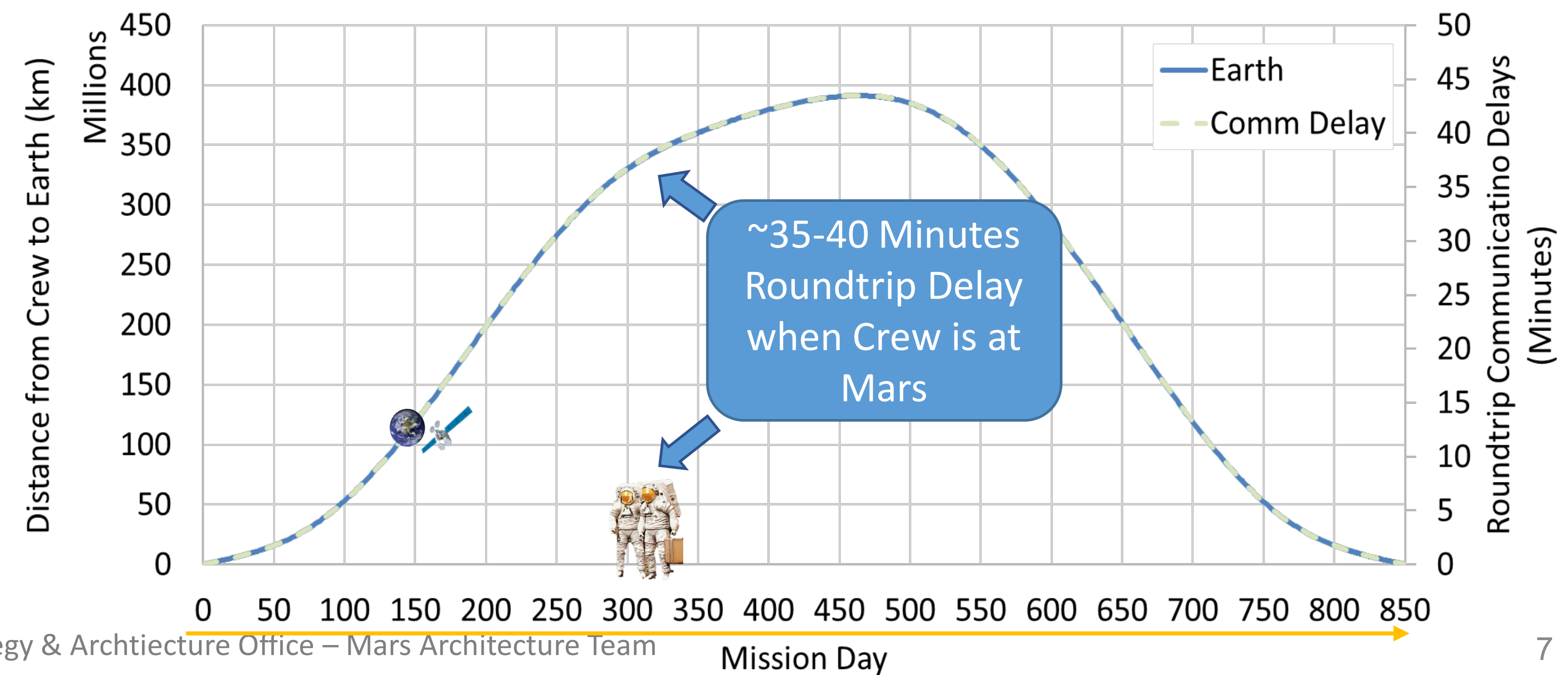
How/When – Mars Distance Considerations

Mars is *much* farther from Earth than the Moon is

	Closest Approach to Earth	Farthest Distance from Earth	Typical Round-Trip "Odometer" Reading	Round-trip Duration
Moon	360,000 km	405,000 km	1,900,000 km	**Weeks**
Mars	54,600,000 km	400,000,000 km	1,800,000,000 km	**Years**



Communications delay is proportional to how far away from Earth we are



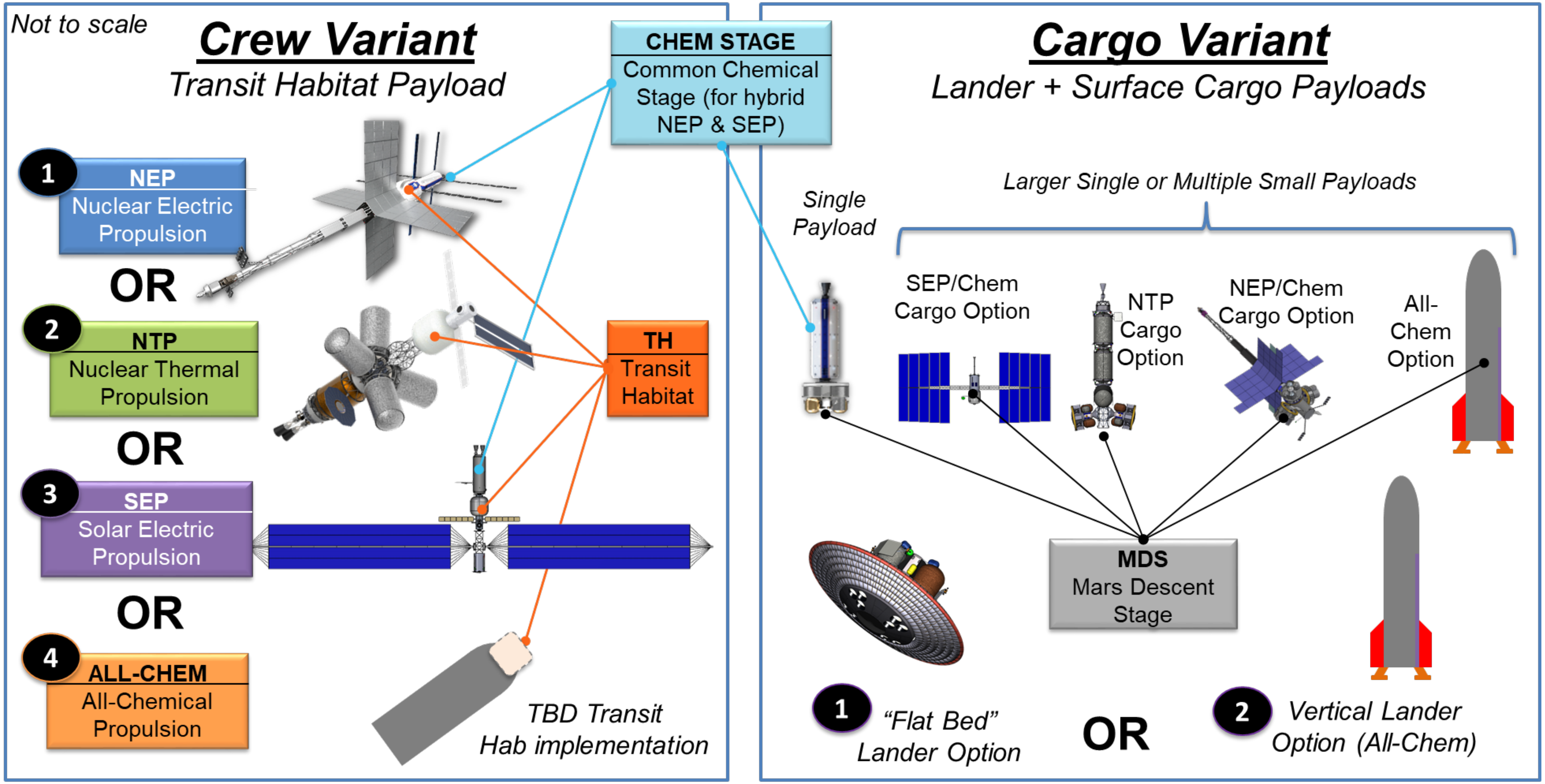
Mars is so far from home there is no way to abort quickly to Earth

Mars missions will be at least **twice as long as our longest duration** experience base

Pack for a long trip:
on-demand resupply is not possible

How – Transportation Considerations

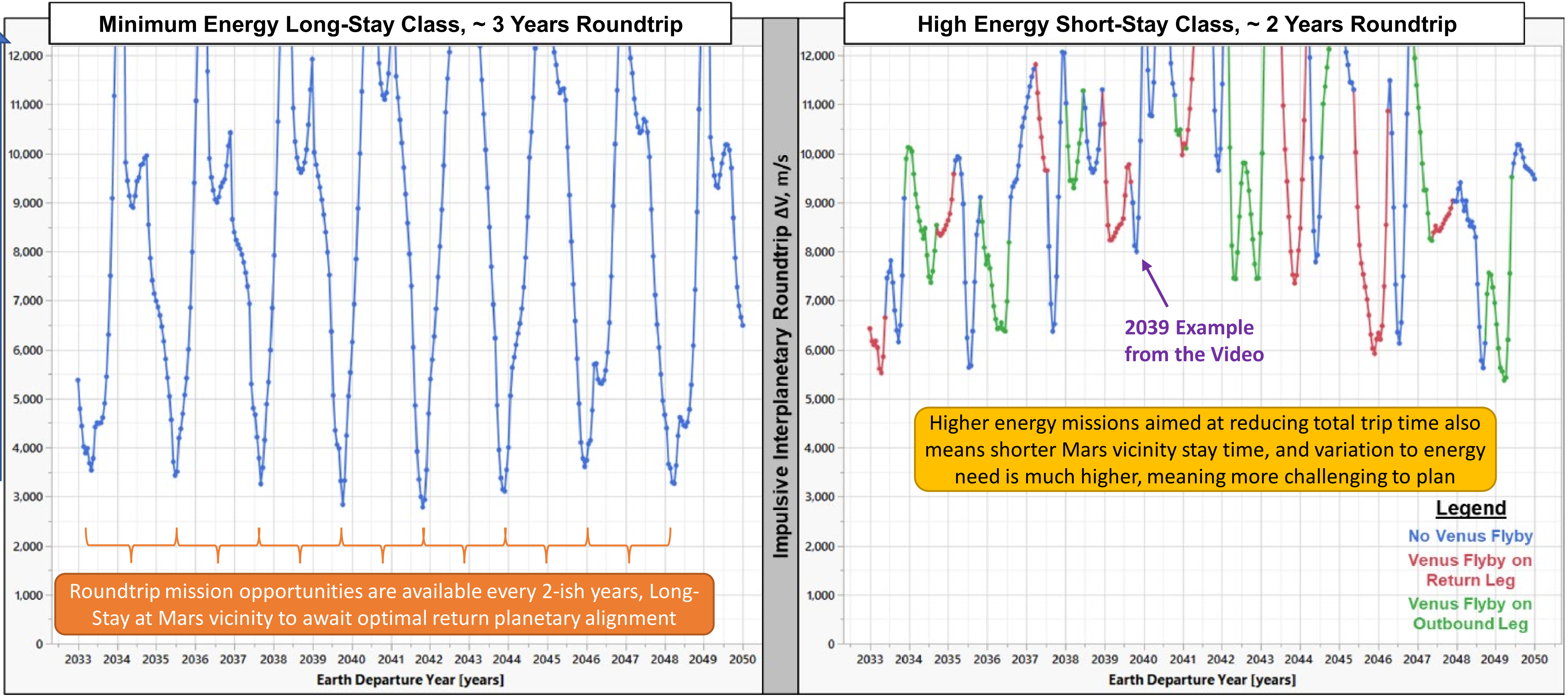
Trade space includes 4 transportation options, 2 lander options, and a range of surface systems



When – Mission Opportunity Considerations

Increasing Energy = Exponential Increase in Mass Required

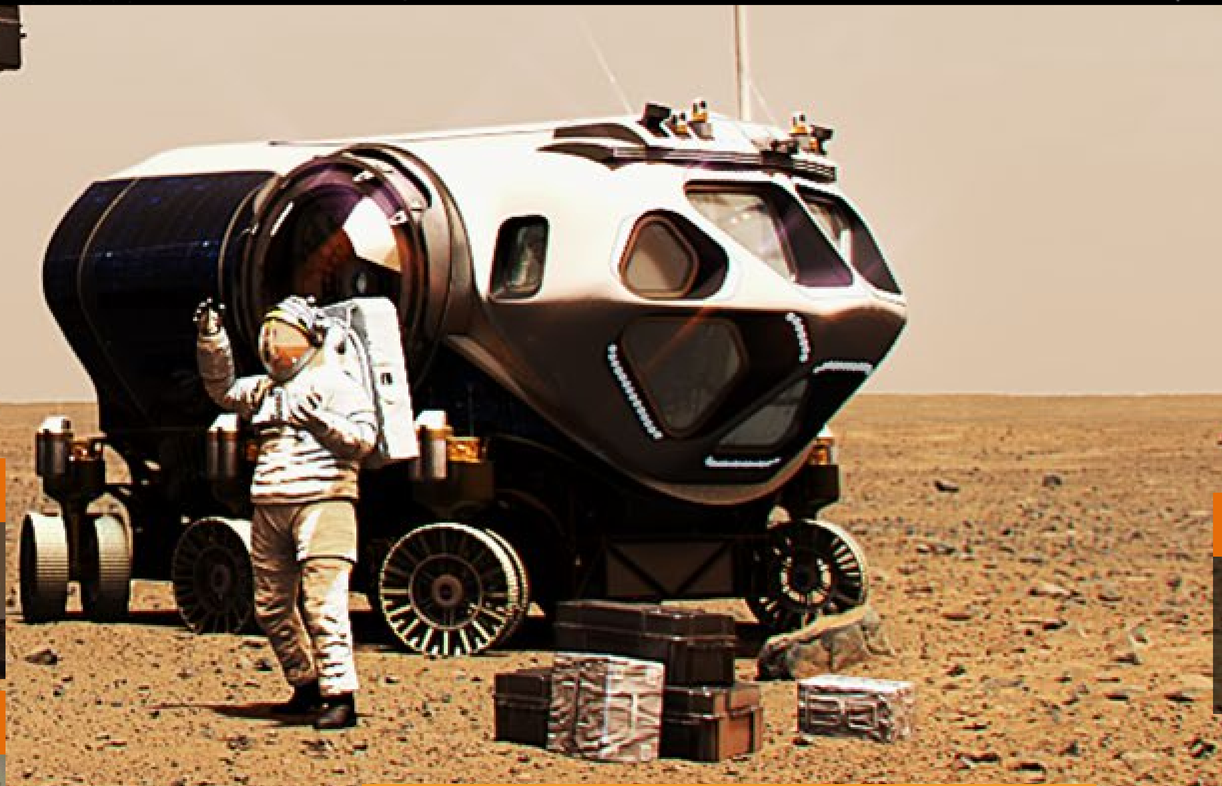
Multiple ISS Mass Needed For Higher Energy Missions



"When" is a very complicated decision to address.

What are the acceptable roundtrip duration?
How many rockets do we have and how often can we launch them?
What are the Surface Cargo pre-deployment needs?
What is the performance of the transportation system?

What/Where – Surface Considerations



TERRAIN HAZARDS

Sand traps, dramatic elevation changes, line of sight comm

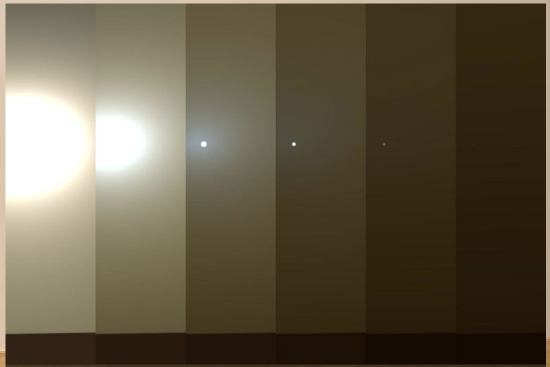
PLANETARY PROTECTION

Protect science from the humans & protect humans from Mars

COMMUNICATIONS LATENCY/BLACKOUT

Up to 44 minutes roundtrip comm, periodic communications blackout, low data rates

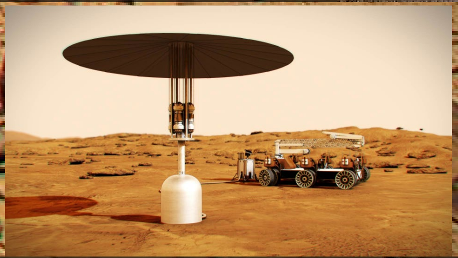
There may be no surface habitat in a *short-stay, first mission architecture*: 2 crew could live in a pressurized rover for 30 sols



Opportunity's view of the Sun during it's fatal dust storm encounter

DUST STORMS

Reduced visibility, solar energy disruption, material abrasion



NASA STMD is developing Fission Surface Power (FSP) for Moon and Mars

Who – Crew Considerations

How many crew to send to Mars?

Need to send enough crew to:

- Complete mission objectives and tasks
- Maintain nominal vehicle functions
- Be able to respond to contingency events

How many crew to land on the surface of Mars?

Perhaps some stay in orbit, some to surface and all / some do EVAs, or

All go to surface, all / some do EVAs,

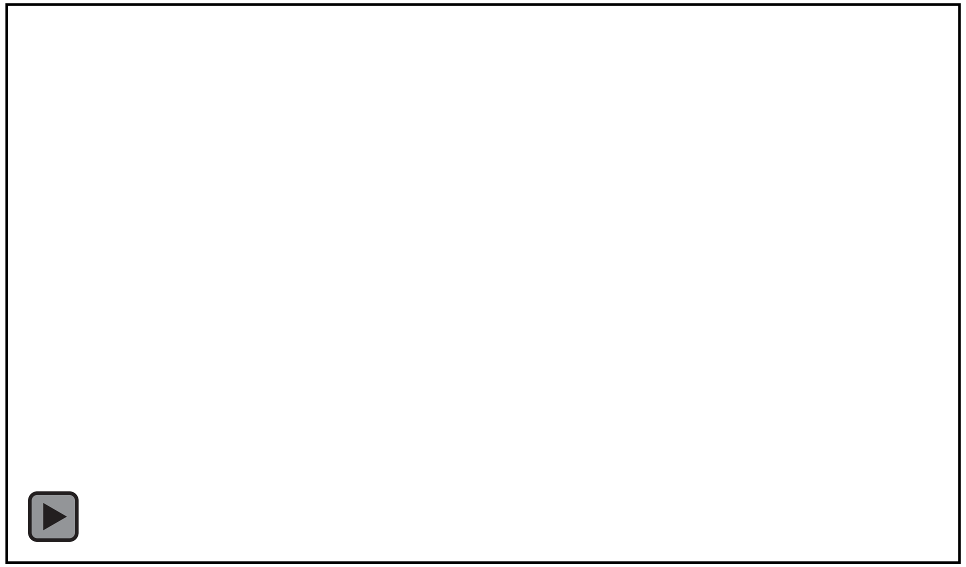
What roles do they need to be trained for?

SPACEFLIGHT HUMANS SYSTEMS RISKS

Summary

Mars Architecture / Mission Planning is like a balloon animal

- A decision on one element/area will ripple across the architecture



Mars crews will be away from Earth *at least* 2x longer than human spaceflight mission experience to date

Mars surface exploration will be similar to lunar exploration, but with some key differences:

- More gravity
- More weather
- Different departure windows
- No resupply
- More planetary protection
- Longer comm lags/disruptions
- Limited abort options
- Less sunlight

Mars transit will be similar to ISS / Gateway operations, but with some key differences:

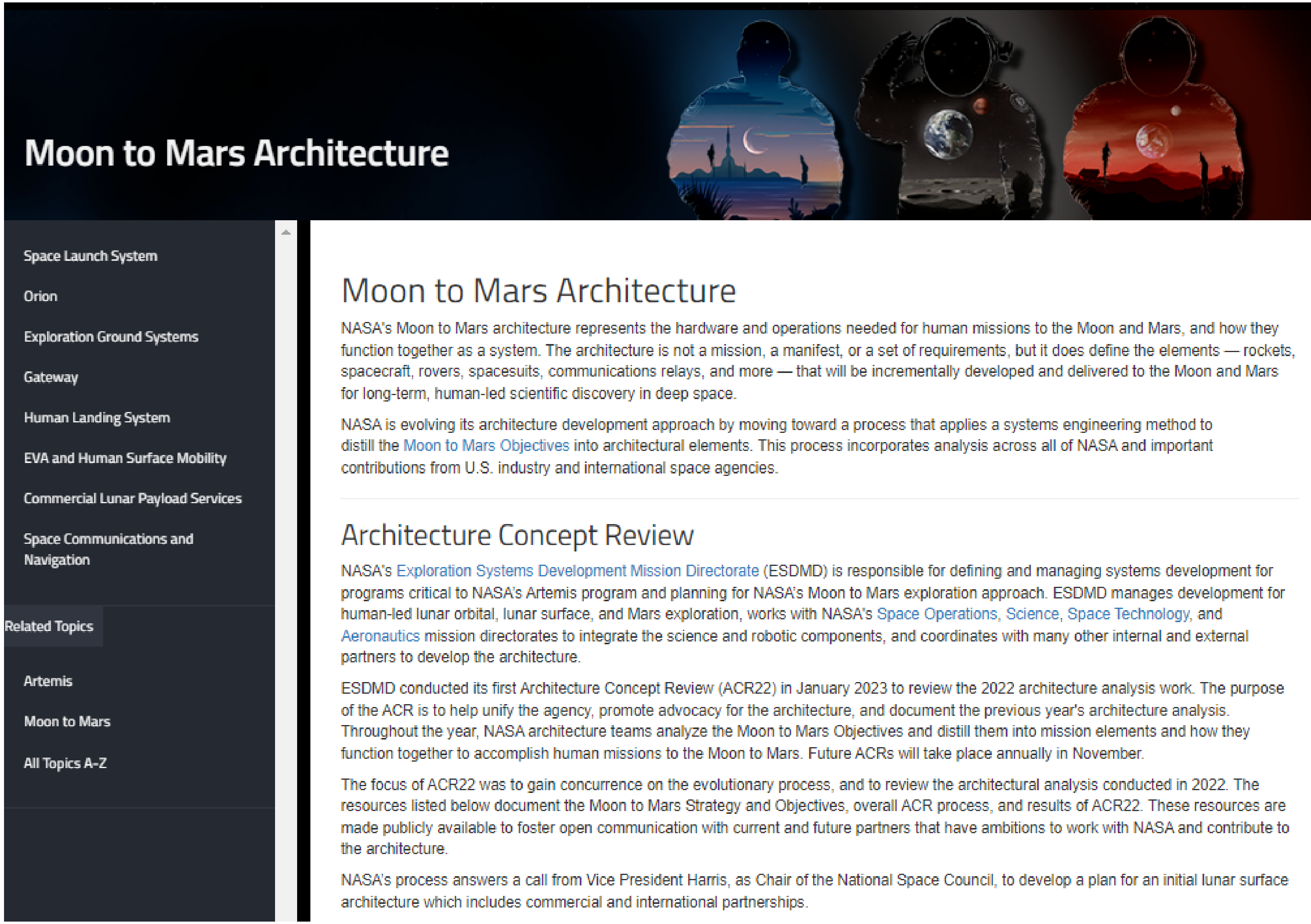
- Fewer departure windows
- Longer comm lags / disruptions
- Limited abort options
- No resupply
- Longer microgravity / radiation exposure durations
- Much, much longer distances and durations

Interested in Learning More?

Visit NASA's Moon to Mars Architecture page:

- Moon to Mars Objectives
- Architecture Definition Document ESDMD-001
- Various short white papers on several Mars related topics

NASA.gov/MoonToMarsArchitecture



Moon to Mars Architecture

Space Launch System
Orion
Exploration Ground Systems
Gateway
Human Landing System
EVA and Human Surface Mobility
Commercial Lunar Payload Services
Space Communications and Navigation

Related Topics

Artemis
Moon to Mars
All Topics A-Z

Moon to Mars Architecture

NASA's Moon to Mars architecture represents the hardware and operations needed for human missions to the Moon and Mars, and how they function together as a system. The architecture is not a mission, a manifest, or a set of requirements, but it does define the elements — rockets, spacecraft, rovers, spacesuits, communications relays, and more — that will be incrementally developed and delivered to the Moon and Mars for long-term, human-led scientific discovery in deep space.

NASA is evolving its architecture development approach by moving toward a process that applies a systems engineering method to distill the Moon to Mars Objectives into architectural elements. This process incorporates analysis across all of NASA and important contributions from U.S. industry and international space agencies.

Architecture Concept Review

NASA's Exploration Systems Development Mission Directorate (ESDMD) is responsible for defining and managing systems development for programs critical to NASA's Artemis program and planning for NASA's Moon to Mars exploration approach. ESDMD manages development for human-led lunar orbital, lunar surface, and Mars exploration, works with NASA's Space Operations, Science, Space Technology, and Aeronautics mission directorates to integrate the science and robotic components, and coordinates with many other internal and external partners to develop the architecture.

ESDMD conducted its first Architecture Concept Review (ACR22) in January 2023 to review the 2022 architecture analysis work. The purpose of the ACR is to help unify the agency, promote advocacy for the architecture, and document the previous year's architecture analysis. Throughout the year, NASA architecture teams analyze the Moon to Mars Objectives and distill them into mission elements and how they function together to accomplish human missions to the Moon to Mars. Future ACRs will take place annually in November.

The focus of ACR22 was to gain concurrence on the evolutionary process, and to review the architectural analysis conducted in 2022. The resources listed below document the Moon to Mars Strategy and Objectives, overall ACR process, and results of ACR22. These resources are made publicly available to foster open communication with current and future partners that have ambitions to work with NASA and contribute to the architecture.

NASA's process answers a call from Vice President Harris, as Chair of the National Space Council, to develop a plan for an initial lunar surface architecture which includes commercial and international partnerships.

Questions?

Artist’s Vision