National Aeronautics and Space Administration

NASA's Human Missions to Mars

An Introduction

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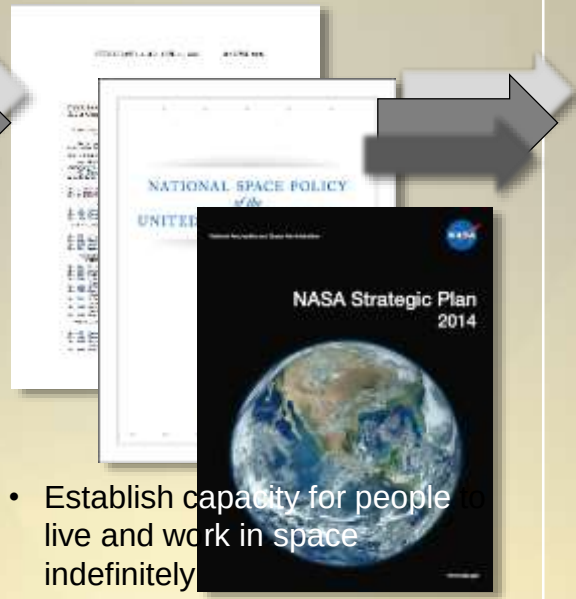
NASA's Human Missions to Mars

Body of Previous Architectures, Design Reference Missions, Emerging Studies and New Discoveries

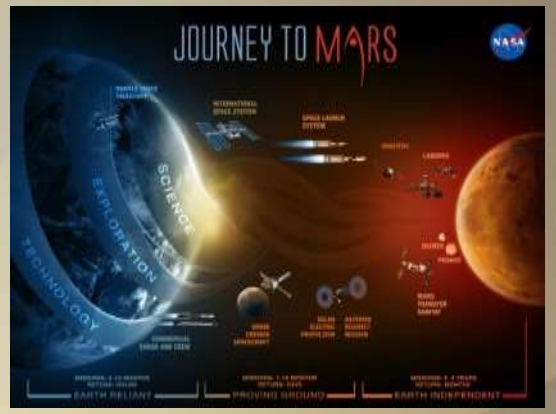
- Internal NASA and other Government
- International Partners
- Commercial and Industrial
- Academic
- Technology developments
- Science discoveries

2010 Authorization Act, National Space Policy, NASA Strategic Plan



- Establish capacity for people to live and work in space indefinitely
- Expand human presence into the solar system and to the surface of Mars

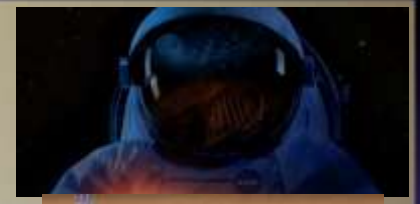
Evolvable Mars Campaign

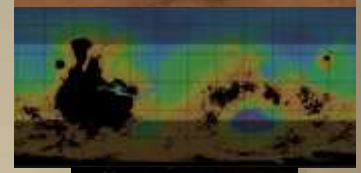


- An ongoing series of architectural trade analyses, guided by Strategic Principles, to define the capabilities and elements needed for a sustainable human presence on Mars
- Builds off of previous studies and ongoing assessments
- Provides clear linkage of current investments (SLS, Orion, etc.) to future capability needs

Human Missions to Mars Overview

- **Who? Humans**
  - The first humans to set foot on Mars are living among us today. For the purpose of system sizing, we currently assume 4 crew per round-trip Expedition
- **What? Surface Field Station**
  - Unlike Apollo, where we explored (and abandoned) several sites, it will be more affordable to establish a base where assets can be re-used. Subsequent expeditions would return to the same site, using surface mobility assets to explore farther from base
- **Where? +/- 50º latitude**
  - NASA is conducting joint HEO/SMD landing site selection workshops to solicit public input on sites that are both accessible and offer scientific value or natural resources
- **When? Late 2030s**
  - Each expedition crew would spend up to 500 days on Mars, and expeditions would depart from Earth about every ~4 years
- **How? Technology**
  - NASA's priority is to focus on the critical things that we don't yet know how to do, such as slowing down and landing a habitat capable of supporting the crew for 500 days
- **Why? Discovery**
  - Throughout history, exploration has brought discoveries that benefit all of humanity—even for those of us who remained at home. Learning to travel to, and live on, Mars will inevitably lead to new discoveries that will help us on Earth



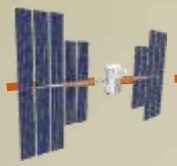


Human Missions to Mars Architecture Elements

Earth

Earth Launch System

Deliver payloads to cislunar space



In-Space Transportation and Habitat

Transport aggregated payloads and crew between Earth and Mars

Entry-Descent Lander

Land payloads on Mars

Mars

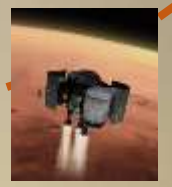
Earth-to-Mars, Mars surface-to-Mars orbit, and Mars surface-to-surface communication

Orion

Transfer crew and cargo from Earth to cis Lunar space and back to Earth

Communications System

Mars Ascent Vehicle



Transfer crew and cargo from the Mars surface to Mars orbit

Surface Habitat and Science Lab

Sustain 4 crew for up to 500 days per Expedition

Logistics Carrier

Deliver equipment and consumables

Surface Mobility

Planetary Space Suits and robotic or pressurized rovers

Surface Utilities

Power, In Situ Resource Utilization

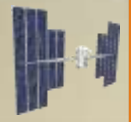
Human Missions to Mars Challenges

Getting There

500+ t Launched

Mass From Earth
Multiple Launches per Mission

2000x Farther than the Moon



Reliable, Efficient
In-Space Transportation

20-30t Landed Payload

Entry/Descent
Landing Accuracy, Payload Protection

Living There

4 Month Dust Storms

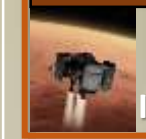
Visibility, Abrasion, Performance
Material Selection, Operations, Risk

100+ km Excursions

Terrain Hazards
Risk, Reliability, Maintenance

Coming Home

16-38 t Ascent Propellant



Mars has gravity and atmosphere
In Situ Resource Utilization

11+ km/sec Earth Entry

High Temperatures
Advanced Heat Shields

Up to 2-Week Radio Silence

Up to 44 minutes for an answer, Low Data Rates
Autonomous Operations

3 Year Missions

Microgravity, Radiation, Logistics
Crew Health, Equipment Reliability

What "Unknowns" Need to be Addressed?

Known unknowns (to achieve Earth independence) – examples include:

- Human physiology in the Mars environment
  - Gravity
  - Radiation
  - Dust (e.g., perchlorates)
- Plant/animal physiology in the Mars environment
  - Gravity; Radiation; Light
- Search for life
  - How do we detect it? (And how do we decide it is not something brought from Earth?)
  - How do we learn more about it without contaminating it and without exposing the crew to it?
- Local resources, with priority on sources of usable water
  - If in the form of H_2O then where is it and how can it be collected
  - If in the form of hydrated minerals then where is it, how is the raw material collected, and what is the "best" process (given local environmental conditions and available infrastructure) to extract the water
- Martian civil engineering "best practices"
  - Surface preparation/stabilization
- Martian chemical engineering "best practices"
- TBD others

Unknown unknowns

- By definition unknown, but not unanticipated
- Surface infrastructure should be implemented in such a way that it is adaptable and has built-in margin to accommodate different (than originally planned) activities without requiring a complete redesign and redeployment

Backup

Example Mars Exploration Zone
Containing Several Regions of Interest (ROI's)