Human Exploration & Operations Progress and Plans on the Journey to Mars

NAC HEO Committee
March 2016
Human Exploration of Mars Is Hard

Common Capability Needs Identified from Multiple Studies

- **800-1,100 Days**
  - Total time crew is away from Earth – for orbit missions all in Micro-g and Radiation

- **44 min**
  - Maximum two-way communication time delay – Autonomous Operations

- **500 Days**
  - Long Surface Stay

- **130 t**
  - Heavy-Lift Mass

- **Multiple**
  - Launches per mission

- **11.2 km/s**
  - Earth Entry Speed

- **Reliable In-Space Transportation**
  - Total continuous transportation power

- **20-30 t**
  - Ability to land large payloads

- **20 t**
  - Oxygen produced for ascent to orbit - ISRU

Surface Operations

Dust Toxicity and Long Range Exploration
Mars is Achievable If We Take the Long View

- **Space Launch System**
  - Engines
  - Stages (including EUS)
  - Boosters

- **Orion Crew Vehicle**

- **Ground System Development and Operations**

- **Commercial Crew & Cargo Vehicles**

- **Asteroid Redirect Mission**
  - Capture mechanism
  - Solar electric propulsion
  - Spacecraft bus and solar arrays

- **ISS Experiments & Research**

**HEOMD has more space systems development ongoing today than at any time since Apollo!**
Transition from ISS to Cislunar Space: Framework

Today

Phase 0: Exploration Systems *Testing on ISS*

Ends with testing, research and demos complete*

Asteroid Retrieval Crewed Mission Marks Move from Phase 1 to Phase 2

Phase 1: *Cislunar Flight Testing* of Exploration Systems

Phase 2: *Cislunar Validation* of Exploration Capability

*There are several other considerations for ISS end-of-life

Mid-2020s

2030
**What We’ve Learned Thus Far and Still Need to Learn**

### Orbital Environment and Operations
- **Learned:**
  - Deep space navigation
  - Orbit transfer near low-gravity bodies
  - Gravity assist
  - Aero-braking
  - Gravitational potential
  - Mars's moons' characteristics
  - ISRU potential
- **To Learn:**
  - Return flight from Mars to Earth
  - Autonomous rendezvous and docking
  - ISRU feasibility
  - Resource characterization of Mars’s moons
  - High-power SEP

### Capture, EDL, and Ascent at Mars
- **Learned:**
  - Spatial/temporal temperature variability
  - Density and composition variability
  - Storm structure, duration, and intensity
  - 1 mT payload
  - ~10 km accuracy
- **To Learn:**
  - Ascent from Mars
  - Large-mass EDL
  - Precision EDL
  - Aero-capture
  - Site topography and roughness
  - Long-term atmospheric variability

### Surface Operations at Mars
- **Learned:**
  - Water once flowed and was stable
  - Global topography: elevation and boulder distributions
  - Remnant magnetic field
  - Dust impacts on solar power/mechanisms
  - Radiation dose
  - Global resource distribution
  - Relay strategies, operations cadence
- **To Learn:**
  - Landing site resource survey
  - Dust effects on human health, suits, and seals
  - Rad/ECLSS in Mars environment
  - Power sufficient for ISRU
  - Surface navigation
“In preparation for the 2017 transition of Administrations, the Council recommends that NASA further develop their plan for future Human Exploration, such that it:

(1) Provides a consistent vision across all elements of the program;

(2) Allows selection of technology investments on a timely basis;

(3) Enhances advocacy and continuity of support that transcends Administrations; and

(4) Provides the ability to respond to changes in the external environment (e.g., funding changes or technology breakthroughs).”
## Capabilities for Pioneering Space: Steps on the Journey to Mars

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**EARTH RELIANT** | **PROVING GROUND** | **EARTH INDEPENDENT**
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EARTH RELIANT PROVING GROUND EARTH INDEPENDENT
System Maturation Teams

SMTs comprise technical experts from across Centers and Programs

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System Maturation Team Data Hierarchy

- System Maturation Teams (e.g. Propulsion) – divided into Capability Areas
  - **Capability Areas** (e.g. High Thrust Propulsion) – divided into Gaps
    - **Gap** (e.g. Pump-Fed LOX/CH4 In-Space Engine) – defines a capability advancement over the current state of the art along with mission criticality and mission need date; gap is closed by performing multiple Gap Closing Tasks
    - **Gap Closing Tasks** (e.g. Power Pack Development) – defines task duration and phasing, cost and funding status, and development testing locations (ISS or cis-lunar)
2017 Astronaut Selection Timeline

18,300 Applicants
(3x more than received in 2012)

- Dec 14 2015: Vacancy Announcement opens in USAJOBS
- Feb-Sep 2016: Qualifications Inquiry form sent to Supervisors/References and civilian applicants contacted by mail to obtain an FAA medical exam
- Oct-Dec 2016: Highly Qualified applications reviewed to determine Interviewees
- Feb-Apr 2017: Interviewees brought to JSC for initial interview, medical evaluation, and orientation
- May 2016: Finalists determined
- June 2017: Astronaut Candidate Class of 2017 announced
- August 2017: Astronaut Candidate Class of 2017 reports to the Johnson Space Center
THE JOURNEY TO MARS HAS ALREADY BEGUN.