NASA Advisory Council

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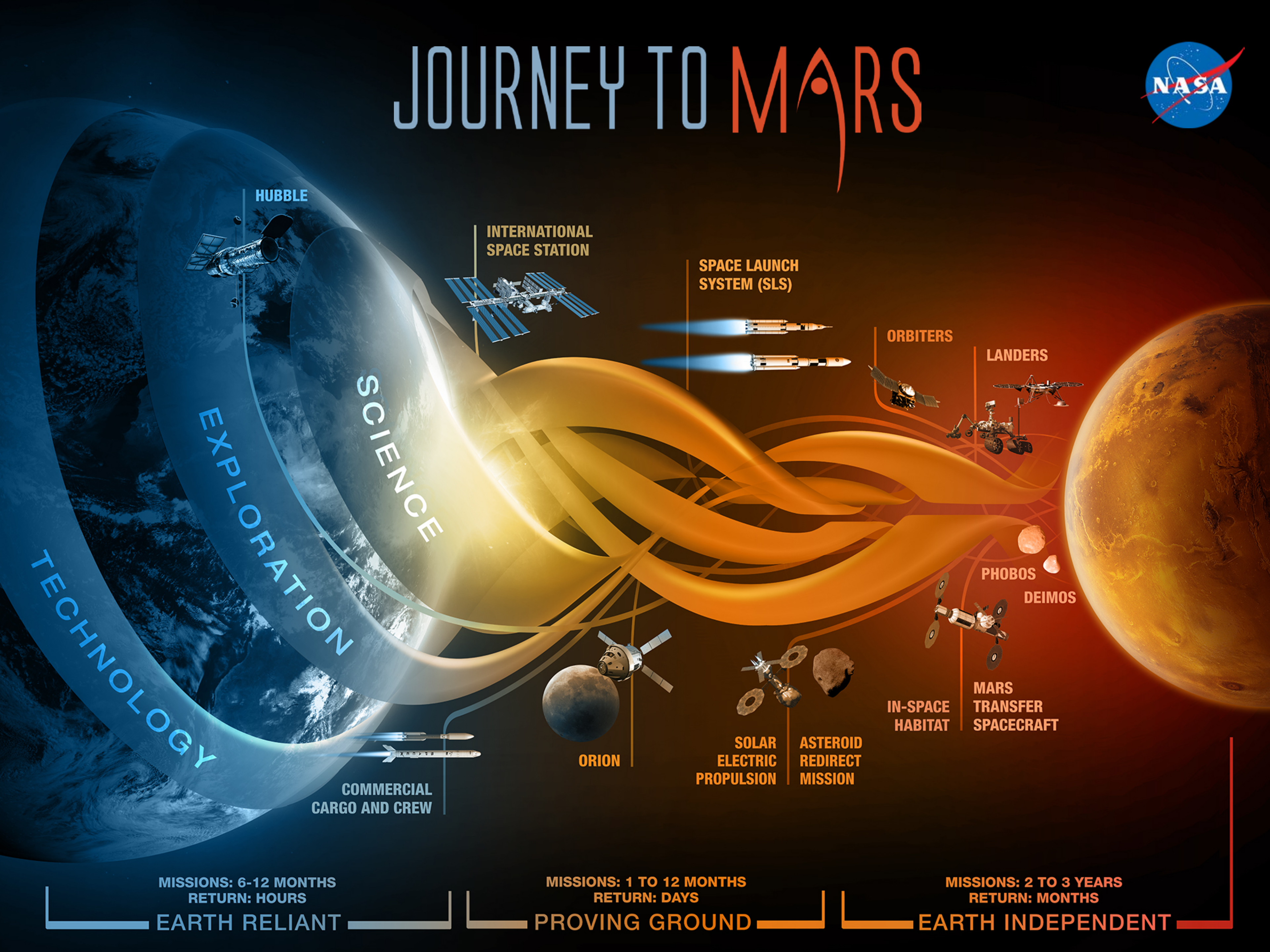

JOURNEY TO MARS
NASA
HUBBLE
INTERNATIONAL SPACE STATION
SPACE LAUNCH SYSTEM (SLS)
ORBITERS
LANDERS
SCIENCE
EXPLORATION
TECHNOLOGY
PHOBOS
DEIMOS
ORION
SOLAR ELECTRIC PROPULSION
ASTEROID REDIRECT MISSION
IN-SPACE HABITAT
MARS TRANSFER SPACECRAFT
COMMERCIAL CARGO AND CREW
MISSIONS: 6-12 MONTHS
RETURN: HOURS
EARTH RELIANT
MISSIONS: 1 TO 12 MONTHS
RETURN: DAYS
PROVING GROUND
MISSIONS: 2 TO 3 YEARS
RETURN: MONTHS
EARTH INDEPENDENT

We have: Principles for Sustainable Exploration

- Implementable in the ***near-term with the buying power of current budgets*** and in the longer term with budgets commensurate with economic growth*;*
- ***Exploration enables science*** **and science enables exploration***, leveraging robotic expertise for human exploration of the solar system*
- Application of ***high Technology Readiness Level*** (TRL) technologies for near term missions, while focusing sustained investments on ***technologies and capabilities*** to address challenges of future missions;
- ***Near-term mission opportunities*** with a defined cadence of compelling and integrated human and robotic missions providing for an incremental buildup of capabilities for more complex missions over time;
- Opportunities for ***U.S. commercial business*** to further enhance the experience and business base
- ***Multi-use, evolvable*** space infrastructure, minimizing unique major developments;
- Substantial ***international and commercial participation***, leveraging current International Space Station and other partnerships.

Interesting Study Findings

- **Asteroid redirect mission has shown the benefits of:**
  - Solar Electric propulsion to move large masses in space
  - Lunar vicinity as a staging point for Mars and solar system
  - Advantages of a split mission concept cargo goes first and then crew
- **Science results show water availability at Mars and possibly moon**
- **A review or other external studies and concepts points to new considerations:**
  - Recent papers are showing large benefit to lunar resources to be used as propellant
  - Buzz Aldrin cycler study shows potential advantages of modularity and building a sustainable architecture
  - Recent study of Mars One shows difficulty of sustaining humans on Mars
- **ISS confirms difficulty in maintaining continuous presence beyond Earth**
  - Life support system fragility
  - Adaptive manufacturing on ISS to build spares shows advantages over sparing
  - High reliability may not be as helpful as thought

We are not ready for another design reference mission or pathway; we need to better understand the trades and framework---This is the Evolvable Mars Campaign

Evolvable Mars Campaign

EMC Goal: Define a pioneering strategy and operational capabilities that can extend and sustain human presence in the solar system including a human journey to explore the Mars system starting in the mid-2030s.

- **Identify a plan that:**
  - Expands human presence into the solar system to advance exploration, science, innovation, benefits to humanity, and international collaboration.
  - Provides different future scenario options for a range of capability needs to be used as guidelines for near term activities and investments
    - In accordance with key strategic principles
    - Takes advantage of capability advancements
    - Leverages new scientific findings
    - Flexible to policy changes
  - Identifies linkages to and leverage current investments in ISS, SLS, Orion, ARM, EAM, technology development investments, science activities
  - Emphasizes prepositioning and reuse/repurposing of systems when it makes sense
    - Use location(s) in cis-lunar space for aggregation and refurbishment of systems

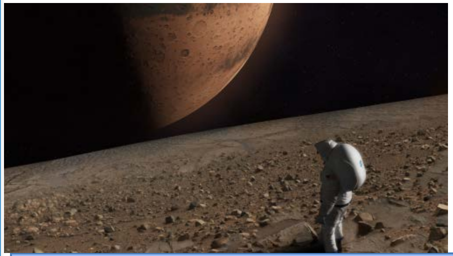
<u>Internal analysis team members:</u>

- ARC, GRC, GSFC, HQ, JPL, JSC, KSC, LaRC and MSFC
- HEOMD, SMD, STMD, OCT, OCS

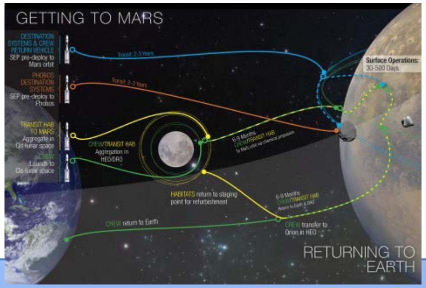
<u>External inputs from:</u>

- International partners, industry, SKG analysis groups

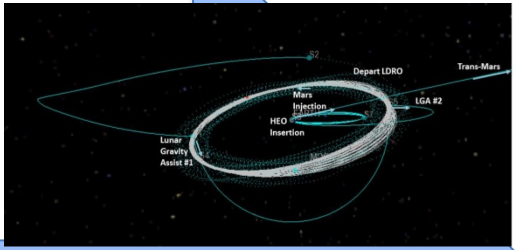
Evolvable Mars Campaign Studies in FY14 - Pointing the Way Forward



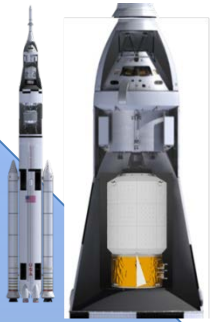
Mars and Mars Moons Surface Exploration



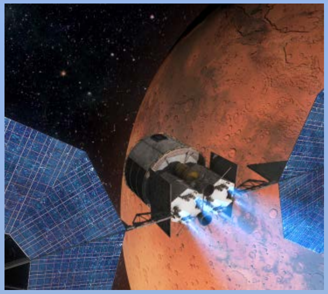
Transportation Analysis

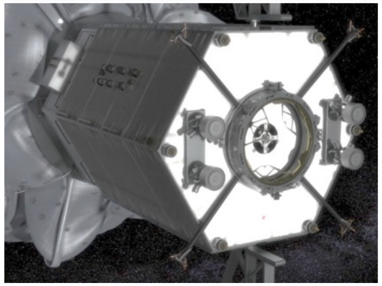


Staging Point Location



SLS Exploration Upperstage and Co-Manifested Cargo

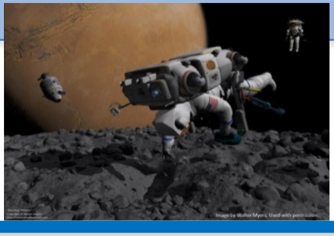




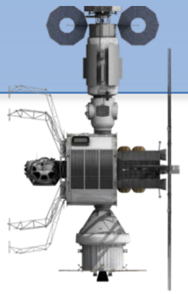
SEP

ARM Extensibility

Deep Space Surface Operations in micro-g



Human Class Mars Surface Lander



Mars Campaign Habitation

Capability Development Analysis

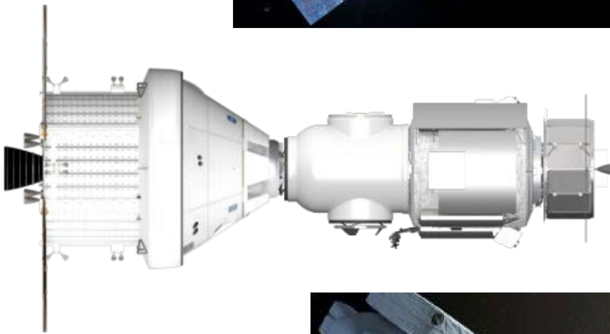
FY15 Forward Study Work

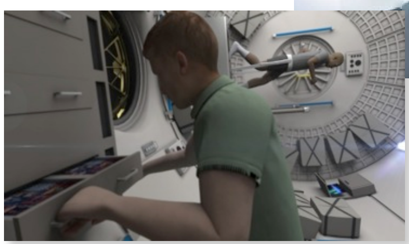
- Launch Vehicle
  - Exploration Upper Stage (ESD, EMC)
  - Co-manifested cargo opportunities (ESD, EMC, SMD, STMD)
- Concept development in coordination with Science and STMD
  - Human Mars site selection options (EMC, Mars Exploration Program (MEP)/SMD)
  - Human assisted Mars /lunar/other planetary body sample return study (ISECG, and MEP/SMD)
  - Lunar polar volatile study (ISECG, LEAG)
  - Pathfinder development (Phobos / Deimos pathfinder, Mars surface pathfinder) (EMC, SMD, STMD)
  - Phobos / Deimos human exploration (EMC, SSERVI)
  - ISRU Integrated Test Plan (EMC, STMD)
- Habitation Refinement
  - Cis-lunar Habitation study (HEO)
  - NextSTEP BAA (AES)
  - Mars transit habitat – large monolithic versus modular (EMC)
  - Mars ascent cabin, Mars taxi commonality (EMC)
- In-space Transportation
  - Continue investigation into extensibility and utilization of ARM/ARV bus for human Mars exploration missions (EMC/ARM, STMD)
  - NextSTEP BAA (AES)
  - Mars lander sizing refinement and impact to EDL technology selection (EMC, STMD)

Proving Ground Objectives Enable Mars Missions

- **Demonstrate SLS and Orion in deep space**
  - Critical Mission Events
    - Separation Events, Key Maneuvers, Re-entry, Landing and Recovery
  - Co-manifested cargo capability with Orion, including loads, dynamics.
  - Demonstrate integrated vehicle systems in flight
    - Deep space communications, power and thermal systems, in-space maneuvering
  - Validate environments
  - Autonomous operations
- **Demonstrate use of LDRO as a staging point for large cargo masses en route to Mars**
- **Conduct deep-space EVAs with sample handling**
- **Integrated human and robotic mission operations**
- **Evaluate crew health and performance in a deep space environment**
- **Demonstrate advanced Solar Electric Propulsion (SEP) systems to move large masses in interplanetary space**
- **Demonstration of In-Situ Resource Utilization in micro-g**
- **Learn to operate with reduced logistics capability**
- **Demonstrate long duration, deep space habitation systems**
- **Demonstrate structures & mechanisms**
  - Low temperature and mechanisms for long duration, deep space missions
  - Inflatable structures







Pioneering Space

"Fifty years after the creation of NASA, our goal is no longer just a destination to reach. Our goal is the capacity for people to work and learn and operate and live safely beyond the Earth for extended periods of time, ultimately in ways that are more sustainable and even indefinite. And in fulfilling this task, we will not only extend humanity's reach in space -- we will strengthen America's leadership here on Earth."

- President Obama, April 2010