National Aeronautics and Space Administration

Evolvable Mars Campaign, SKGs

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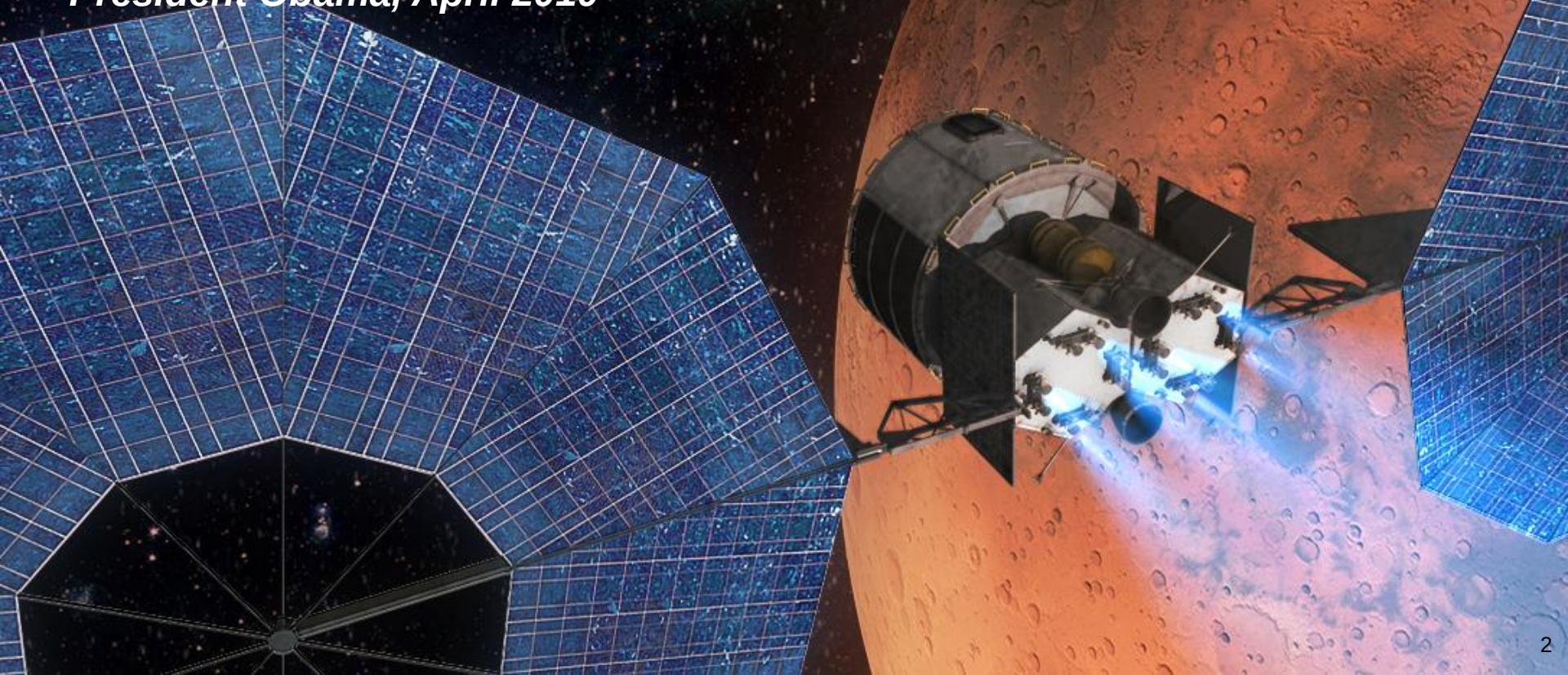
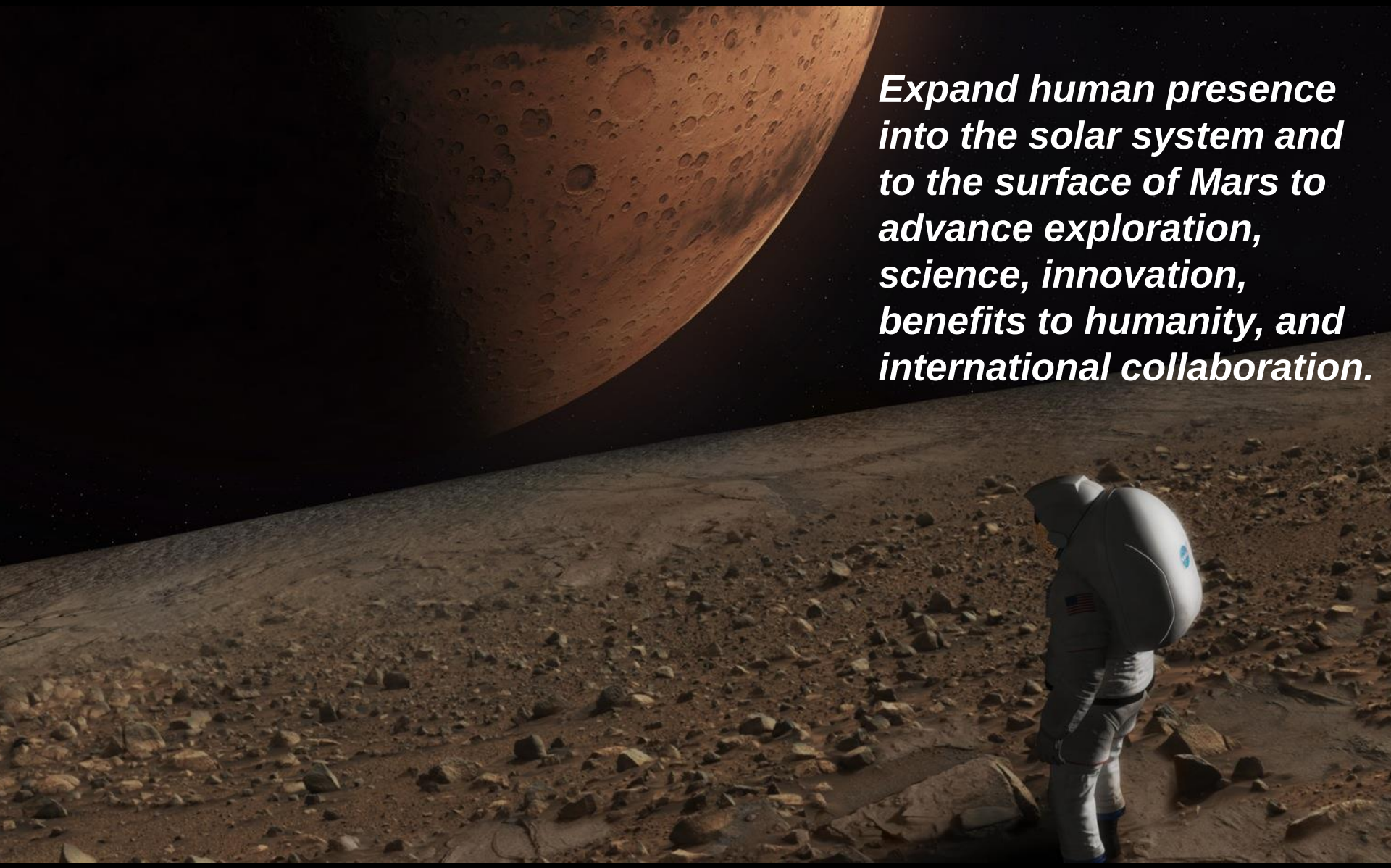
Pioneering Space - Goals

"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



NASA Strategic Plan Objective 1.1



Expand human presence into the solar system and to the surface of Mars to advance exploration, science, innovation, benefits to humanity, and international collaboration.

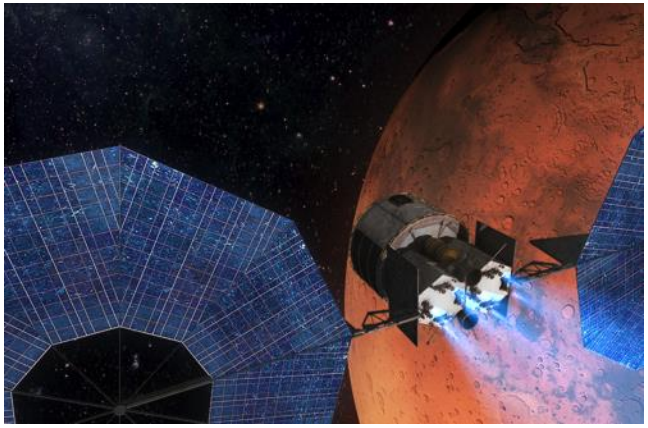
Strategic Principles for Sustainable Exploration

- 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, with each mission leaving something behind to support subsequent missions; and
- Substantial ***international and commercial participation***, leveraging current International Space Station and other partnerships.

Evolvable Mars Campaign Goal:

Define the pioneering strategy and operational capabilities required to extend and sustain human presence in the solar system including a journey towards the Mars system in the mid-2030s

Mars Vicinity Options Provide the "Pull"



Mars Orbit

- Opportunities for integrated human-robotic missions:
  - Real time tele-operation on Martian surface
  - Mars sample return
  - Other science objectives
  - Technology demonstrations
- Demonstrate sustainable human exploration split-mission Mars concept
- Validate transportation and long-duration human systems
- Validate human stay capability in zero/micro-g

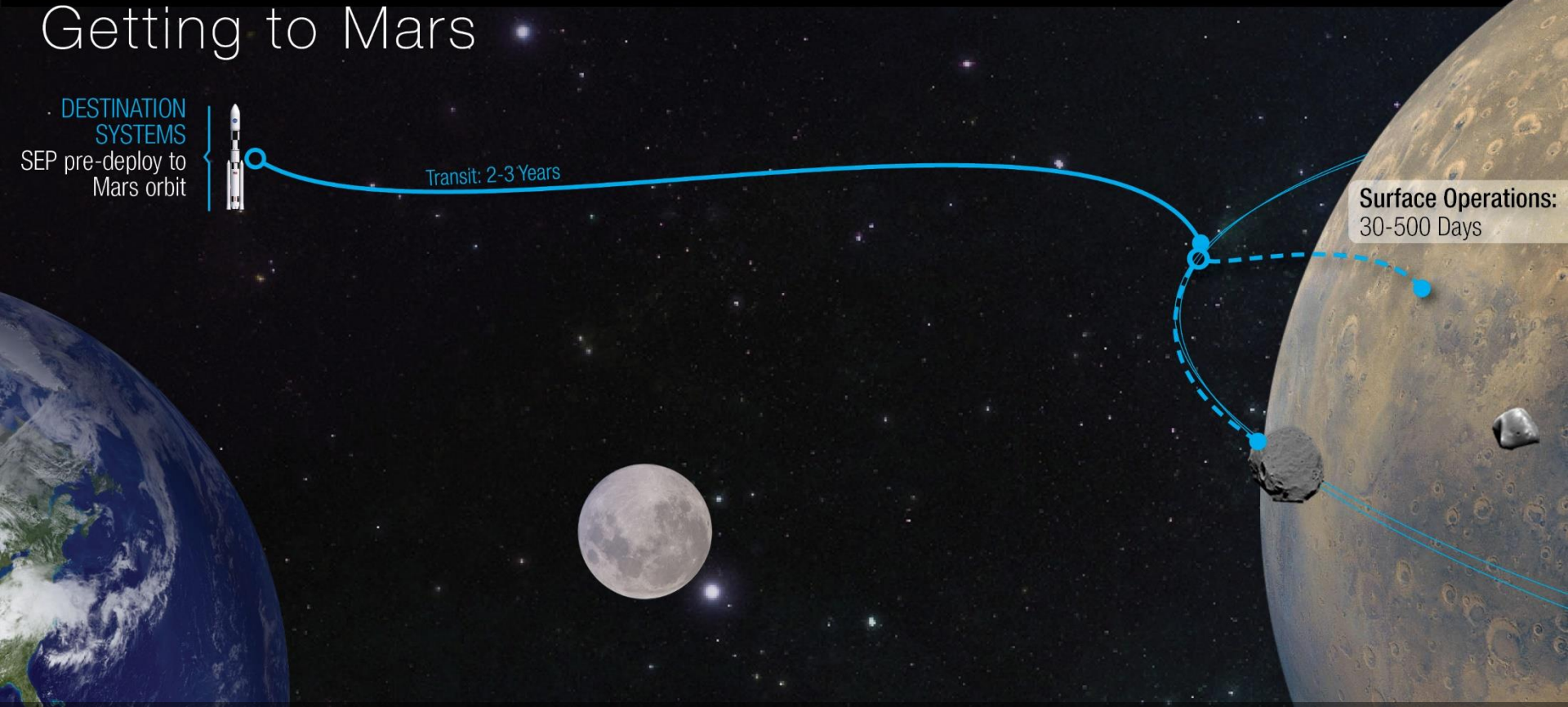
Mars Moons

- Opportunities for integrated human-robotic missions:
  - Real time tele-operation on Martian surface
  - Mars & moons sample return
  - Other science objectives
  - Technology demonstrations
- Demonstrate sustainable human exploration split-mission Mars concept
- Moons provides additional radiation protection
- In-situ resource utilization
- Validate human stay capability in low-g

Mars Surface

- Opportunities for integrated human-robotic missions:
  - Search for signs of life
  - Comparative planetology
  - Understanding Mars climate changes
  - Geology/geophysics
- Planet provides radiation protection
- Entry, descent, landing
- EVA surface suits
- In-situ resource utilization
- Validate human stay capability in partial-g

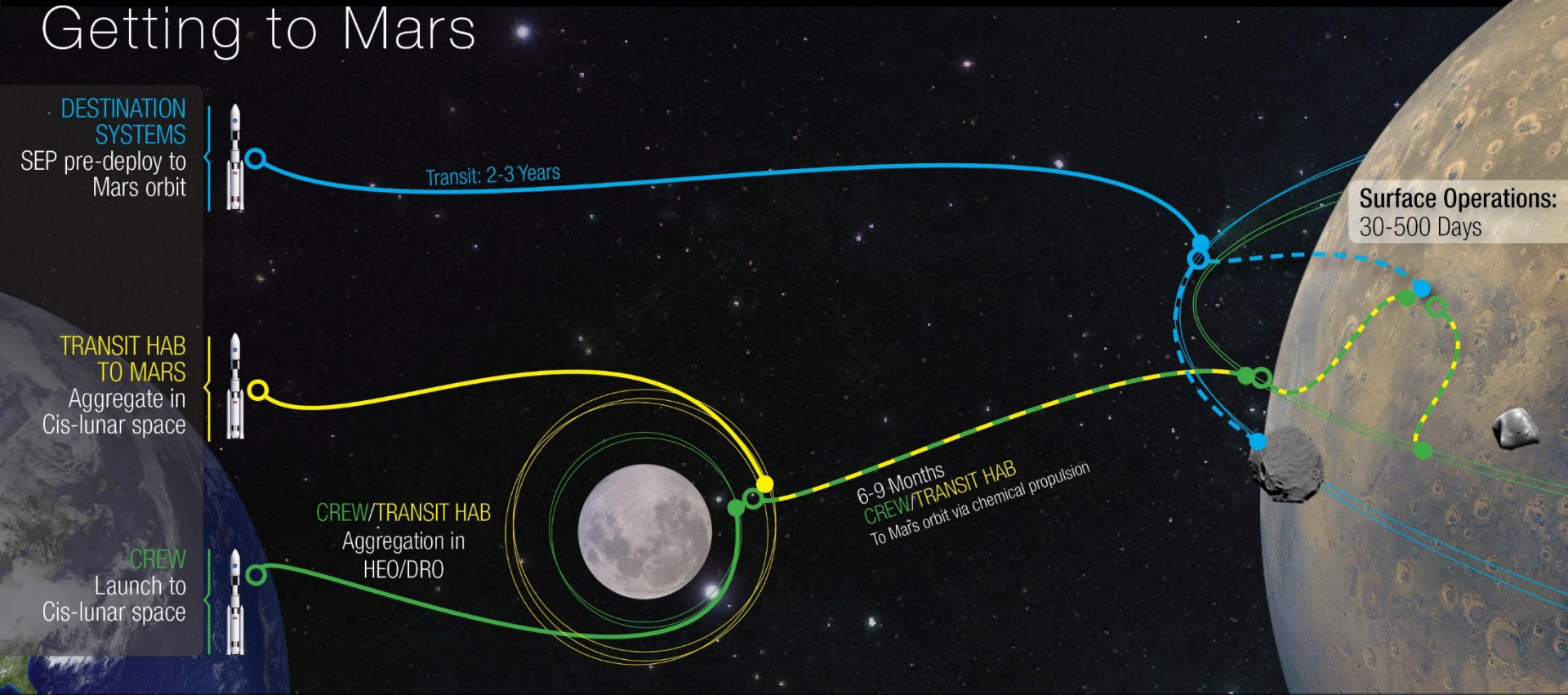
Split Mission Concept



Using SEP for pre-emplacement of cargo and destination systems enables sustainable Mars campaign

- Minimizes the cargo needed to be transported with the crew on future launches
- Enables a more sustainable launch cadence
- Pre-positions assets for crew missions allows for system checkout in the Mars vicinity prior to committing to crew portion of mission

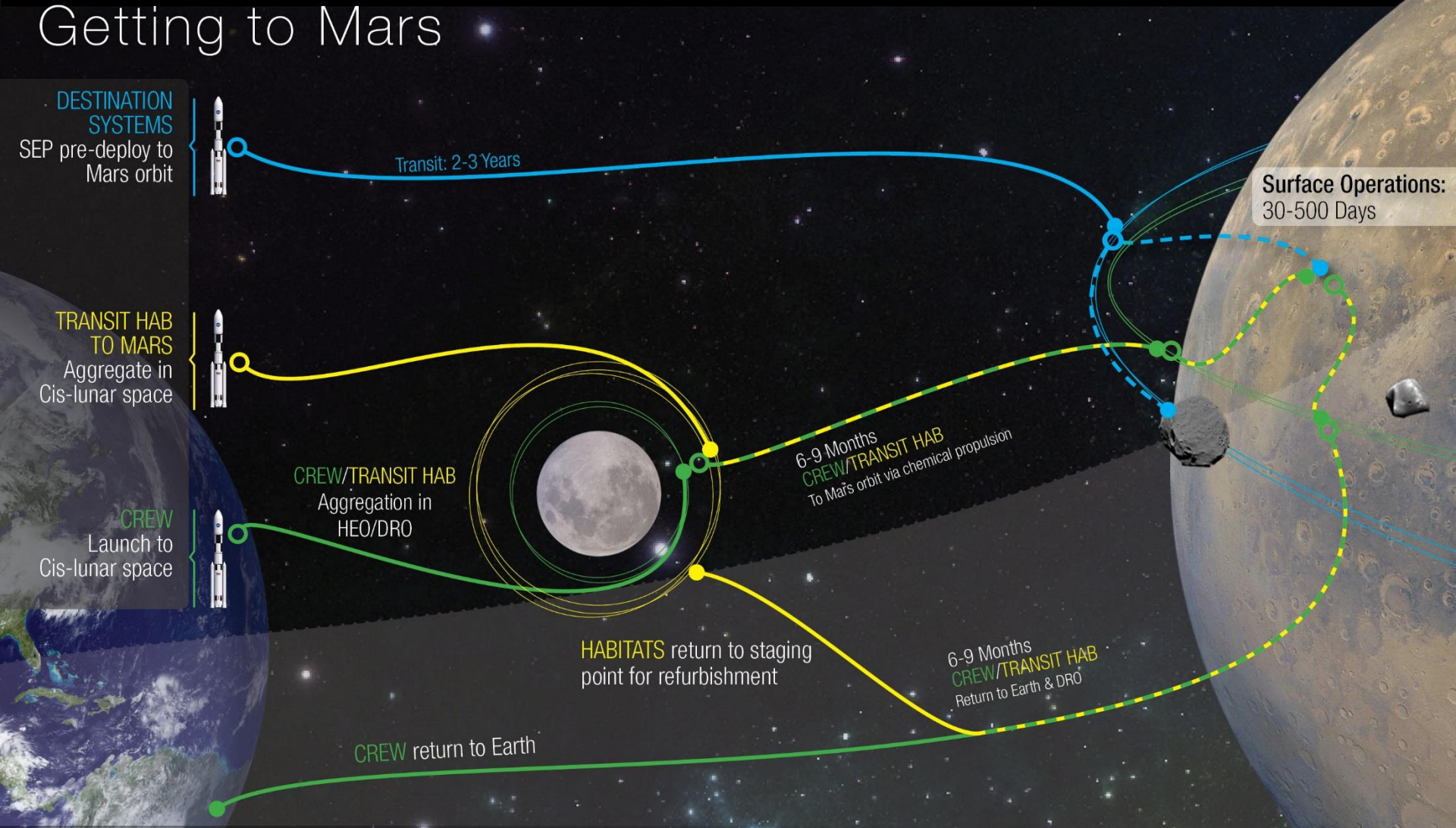
Split Mission Concept



DRO as an aggregation point for Mars habitation systems

- Provides a stable environment and ease of access for testing Proving Ground capabilities
- Allows for Mars transit vehicle build-up and checkout in the deep-space environment prior to crew departure
- Able to transfer Mars Transit Vehicle from DRO to High Earth Orbit with small amount of propellant to rendezvous with crew in Orion – HEO is more efficient location to leave Earth-moon system for Mars vicinity

Split Mission Concept



- Returning from Mars, the crew will return to Earth in Orion and the Mars Transit Habitat will return to the staging point in cis-lunar space for refurbishment for future missions

PROVING GROUND

NEAR-TERM OBJECTIVES

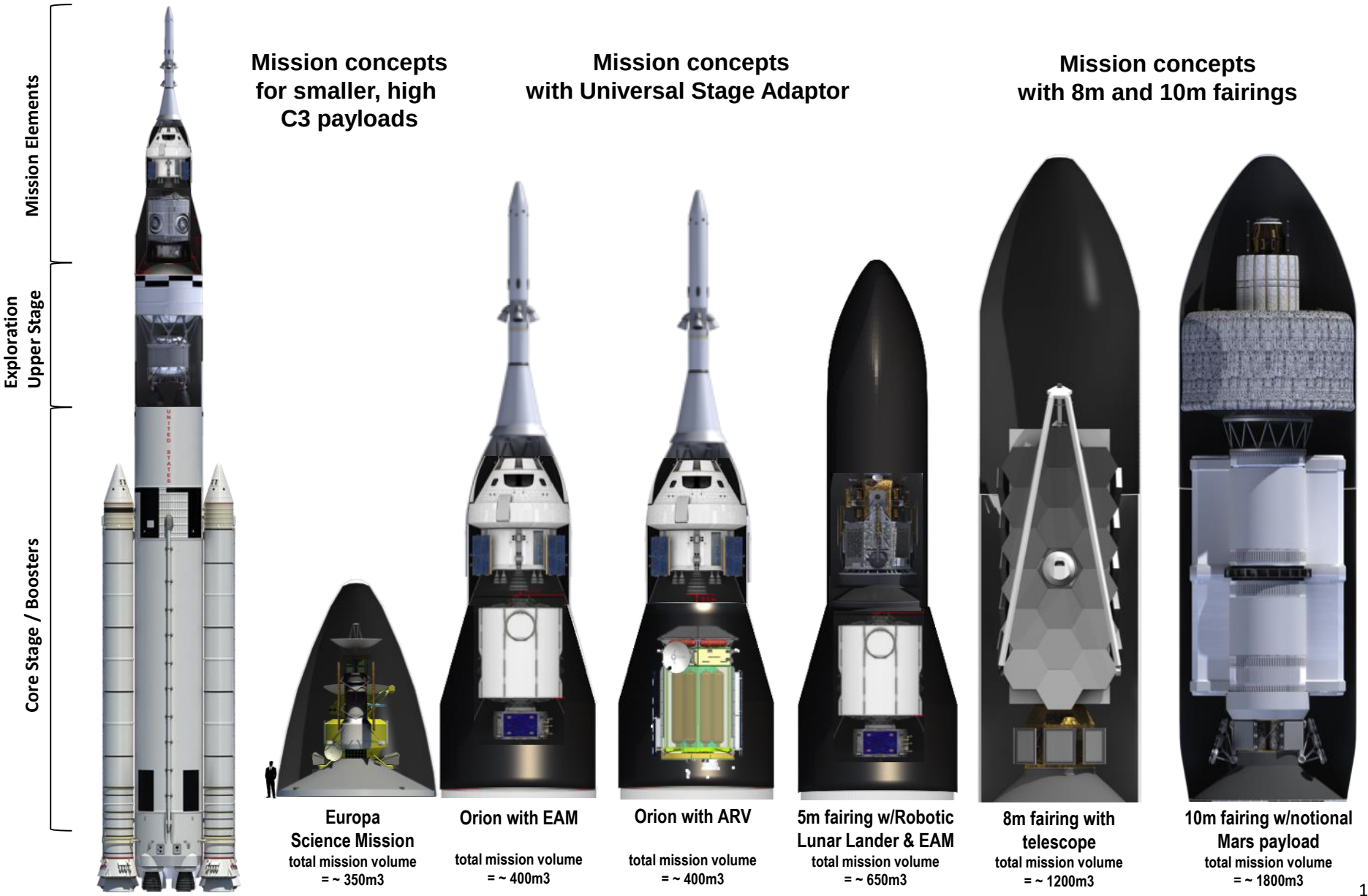
VALIDATE

- SLS and Orion in deep space
- Solar Electric Propulsion (SEP) systems
- Long duration, deep space habitation systems
- Mitigation techniques for crew health and performance in a deep space environment
- In-Situ Resource Utilization
- Operations with reduced logistics capability

CONDUCT

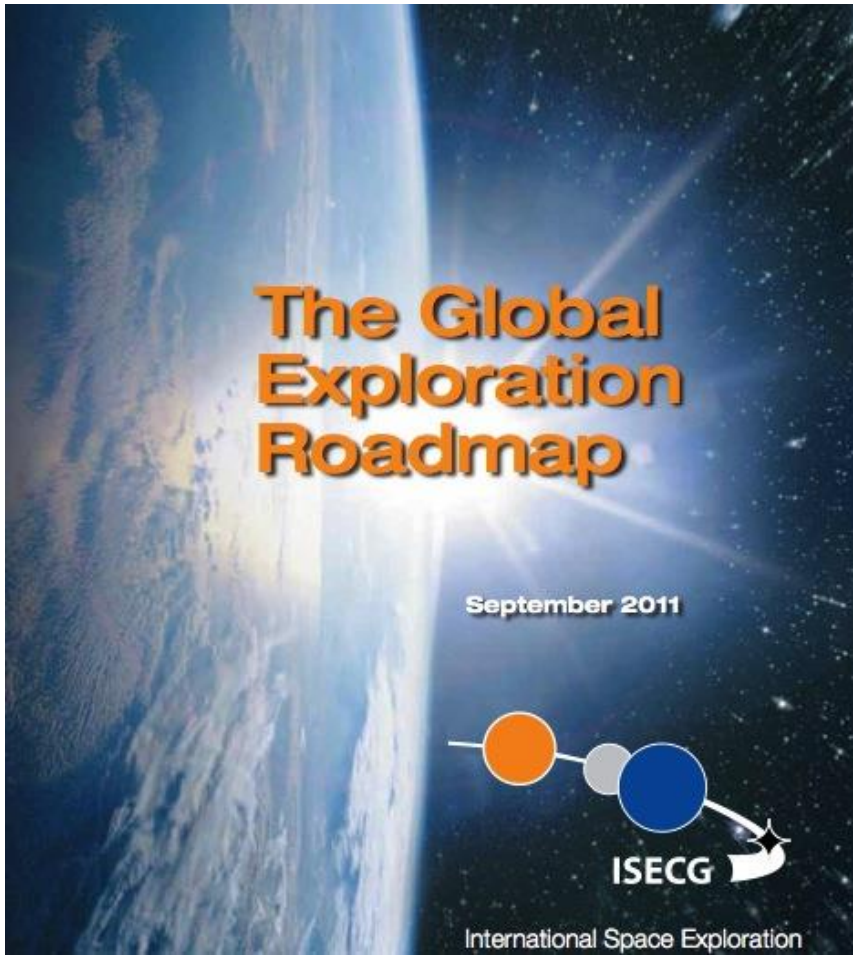
- EVAs in deep space, micro-g environments
- Human and robotic mission operations
- Capability Pathfinder and SKG missions

Block 1B Payload Accommodation Options



GER

- **Global Exploration Roadmap (GER) outlines multi-agency plan for human exploration**
  - Includes consensus principles, notional mission scenarios, preparatory activities
- **Two scenarios: Asteroid Next, Moon Next**



National Aeronautics and Space Administration

EMC Landing Site Study

Steve Hoffman, Larry Toups, Alida Andrews, Kevin Watts

NASA JSC

Marianne Bobskill

NASA Langley

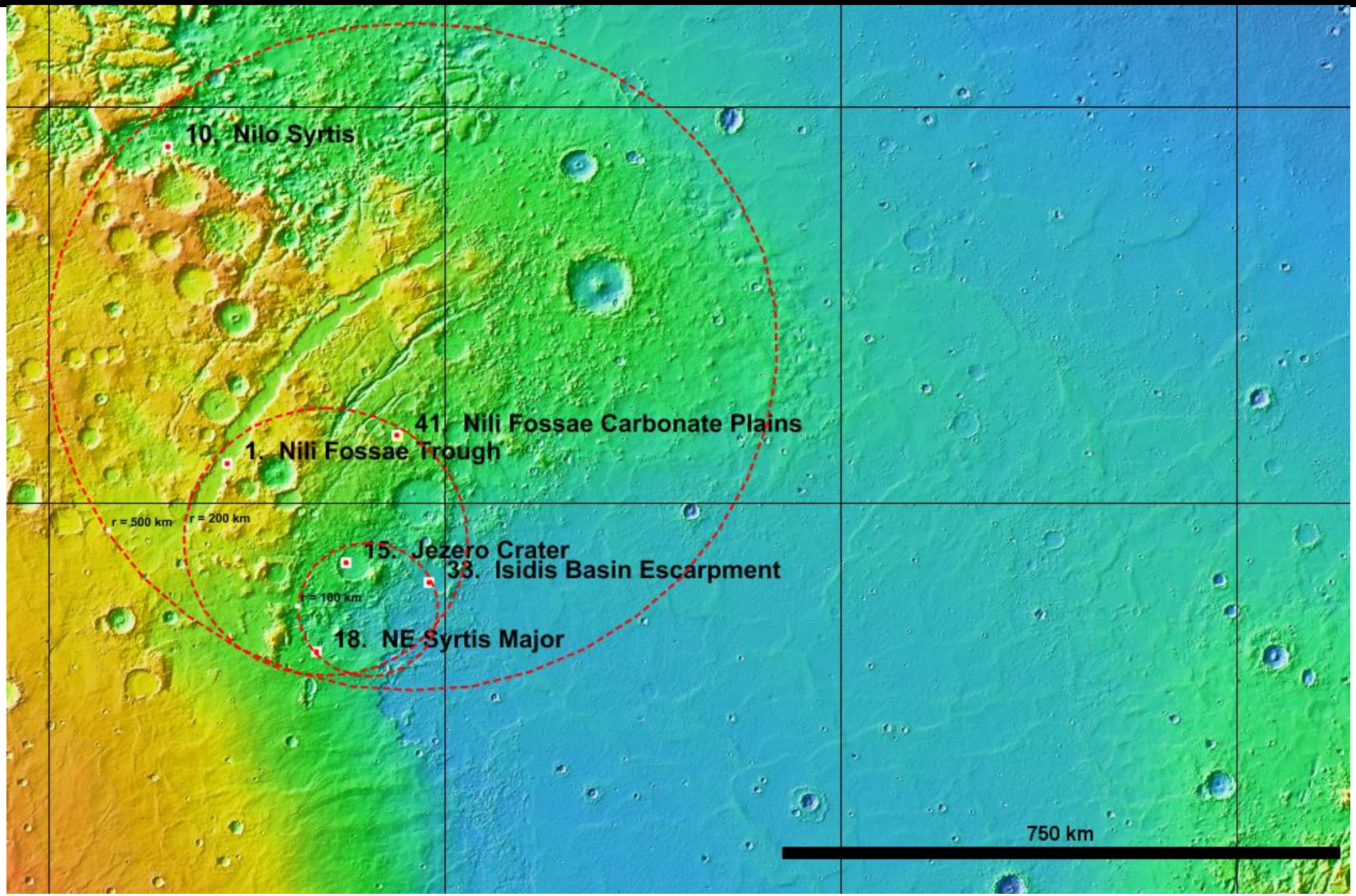
Several Key Parameters Affecting Site Selection

- **Surface system capability:**
  - Horizontal range accessible from the landing site, ~100 km

- **On Landing Area**
  - Assuming repeated visits to a single area
    - Builds up Infrastructure
    - Enhances Crew Safety (spares etc)

- **Proposed Strategy:**
  - Maximize the scientific utility of a single landing site, visited by multiple crews, by looking for "**groups**" of proposed science sites (preferably with diverse science objectives) located within the specified traverse range available to the crew.
  - This region is referred to as a 'megasite'

Jezero Groups (100, 200, and 500 km radius)



Mars Single Landing Site Factors

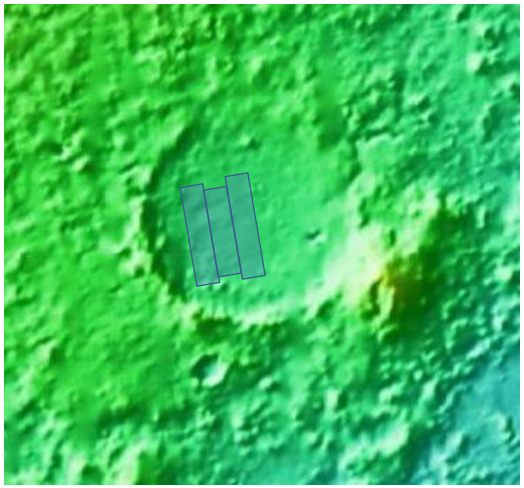
- **A human mission will require multiple landings to provide the required infrastructure for a human mission**
- **We expect a precision landing capability, ~100 meters**
  - ALHAT derived/demonstrated
- **Rocket engine plume ejecta analyses indicate that each lander must be separated by ~1000 meters from other landers to reduce risk of damage to acceptable levels**

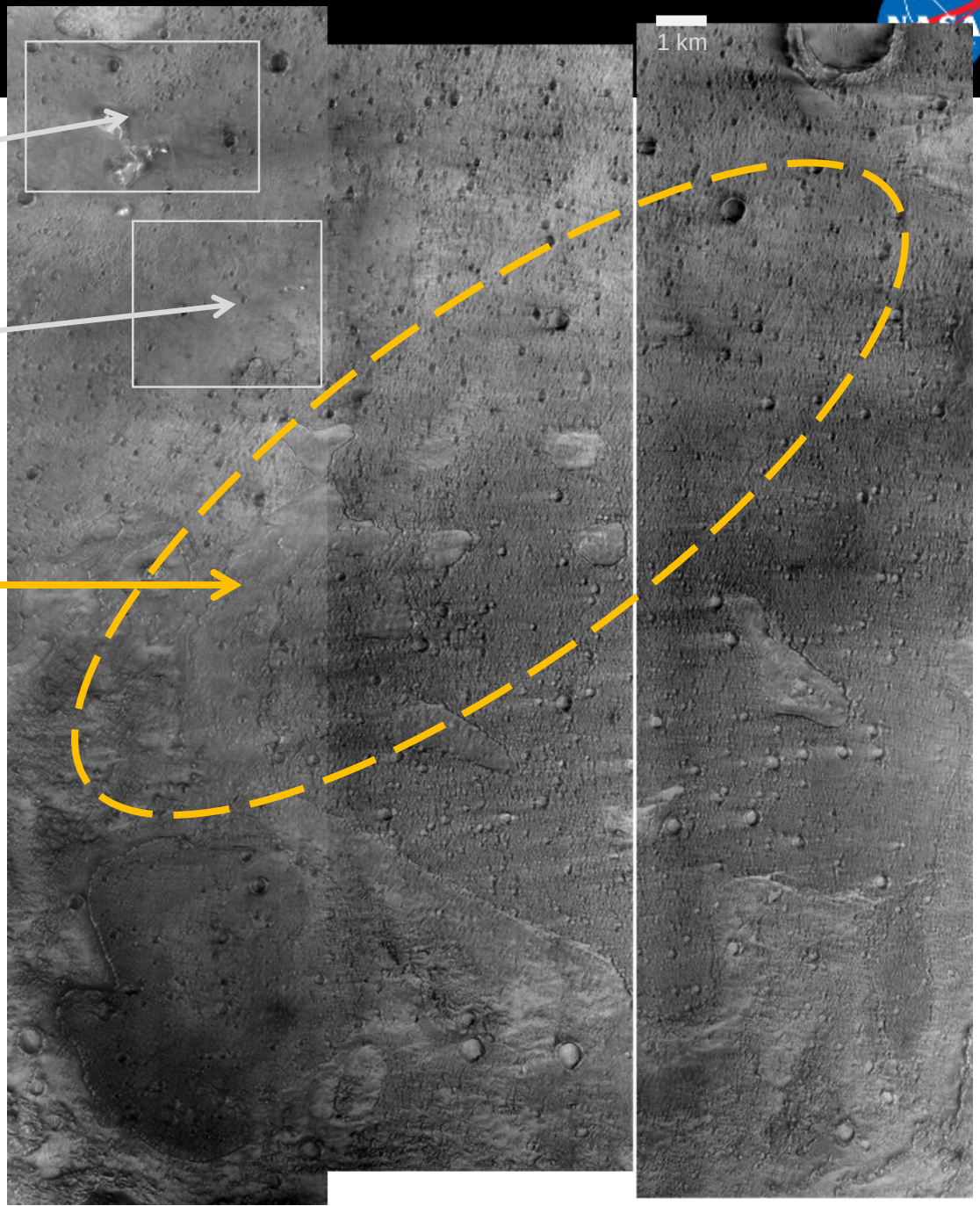
HiRISE images inside Jezero Crater gathered to support MSL landing site assessment.

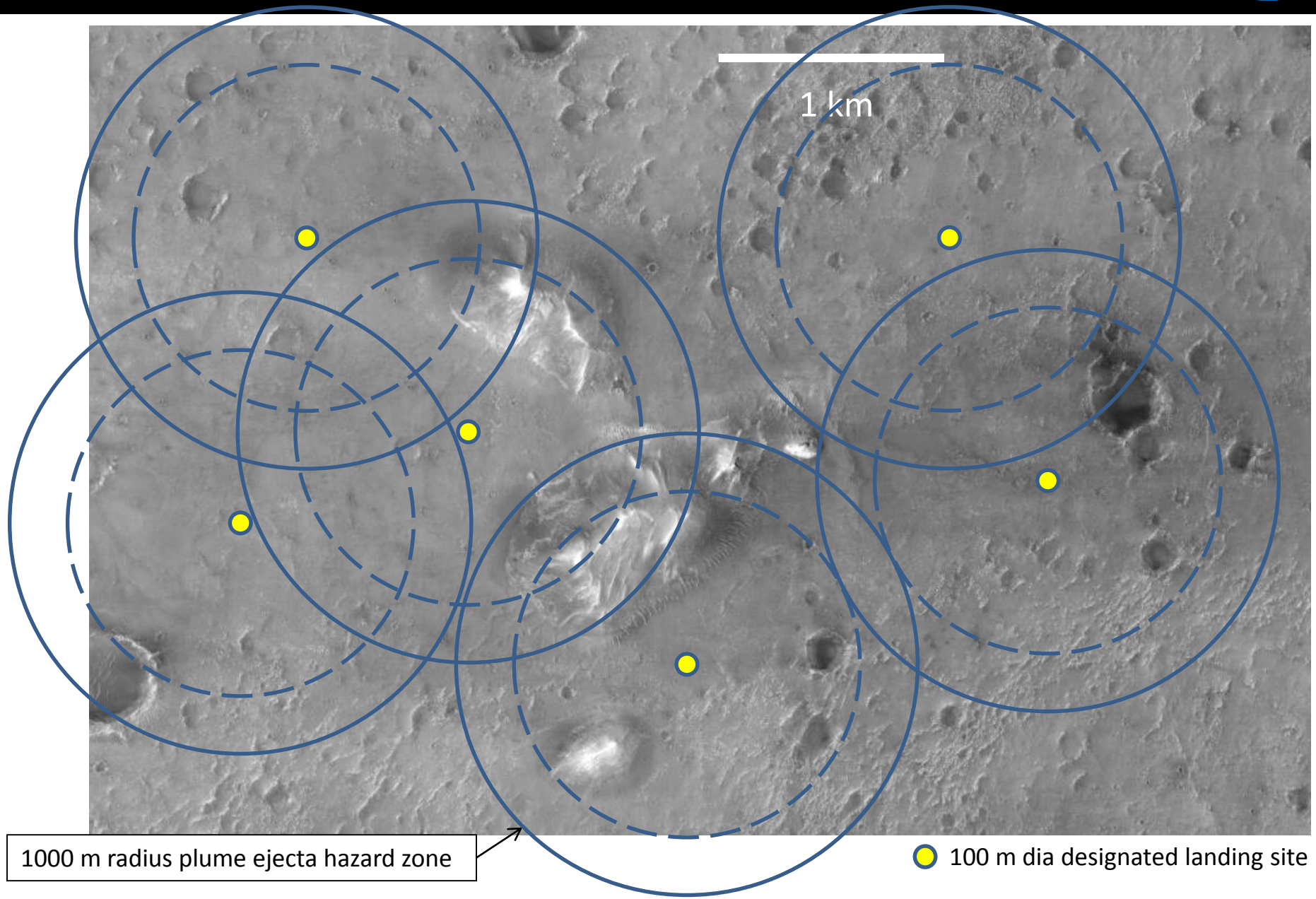
Site A

Site B

For comparison, the Mars Science Laboratory final landing ellipse (19.7 km x 6.9 km with arbitrary orientation) is shown to scale.





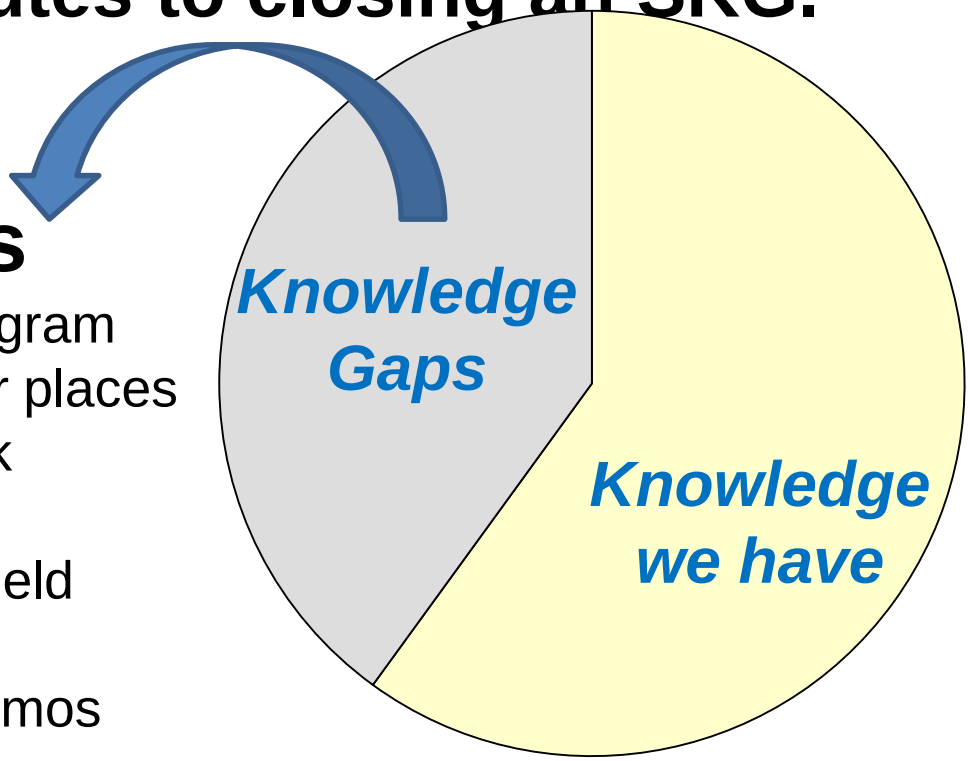

1 km
1000 m radius plume ejecta hazard zone
100 m dia designated landing site

SKG and GFA: Definitions

1. **Strategic Knowledge Gap (SKG): The Gaps in Knowledge Needed to Achieve a Human Spaceflight Capability.**
2. **Gap-Filling Activity (GFA): Work that contributes to closing an SKG.**

GFA areas

- Mars flight program
- Flights to other places
- Non-flight work (models, lab experiments, field analogs, etc.)
- Technology demos



Total knowledge needed to achieve a goal

4 potential HEO Goals in the Martian system

SKGs can only be defined w.r.t. a specific goal.

Goals evaluated, this study

Ref.	*Goal*	*MEPAG*	*Linkage*
A.	**Achieve the first human mission to Mars orbit**	**Goal IV-**	
B.	**Achieve the first human mission to the martian surface**	**Goal IV**	Group A SKGs also needed
C.	**Achieve the first human mission to the surface of Phobos and/or Deimos**		Group A SKGs also needed
D.	**Sustained human presence on Mars**	**Goal IV+**	Group A,B, (C?) SKGs also needed

SKGs and Decomposition

- **17 SKGs were identified associated with the four HEO goals.**

- **About 60 Gap-Filling Activities (GFAs) have been identified that would address the 17 SKGs.**
  - ✓ **The GFAs have different priorities and degrees of urgency**
  - ✓ **Only about half of the GFAs would require use of the Mars flight program.**

SKG Path Forward

- **All three AG documents are comprehensive**
- **Goal is to revisit**
  - MEPAG already doing this
- **Are the same questions being asked by the Human Architecture Teams?**
- **Have any of the SKGs been closed by recent data analysis?**
- **Make all three SKGs consistent in format/depth**