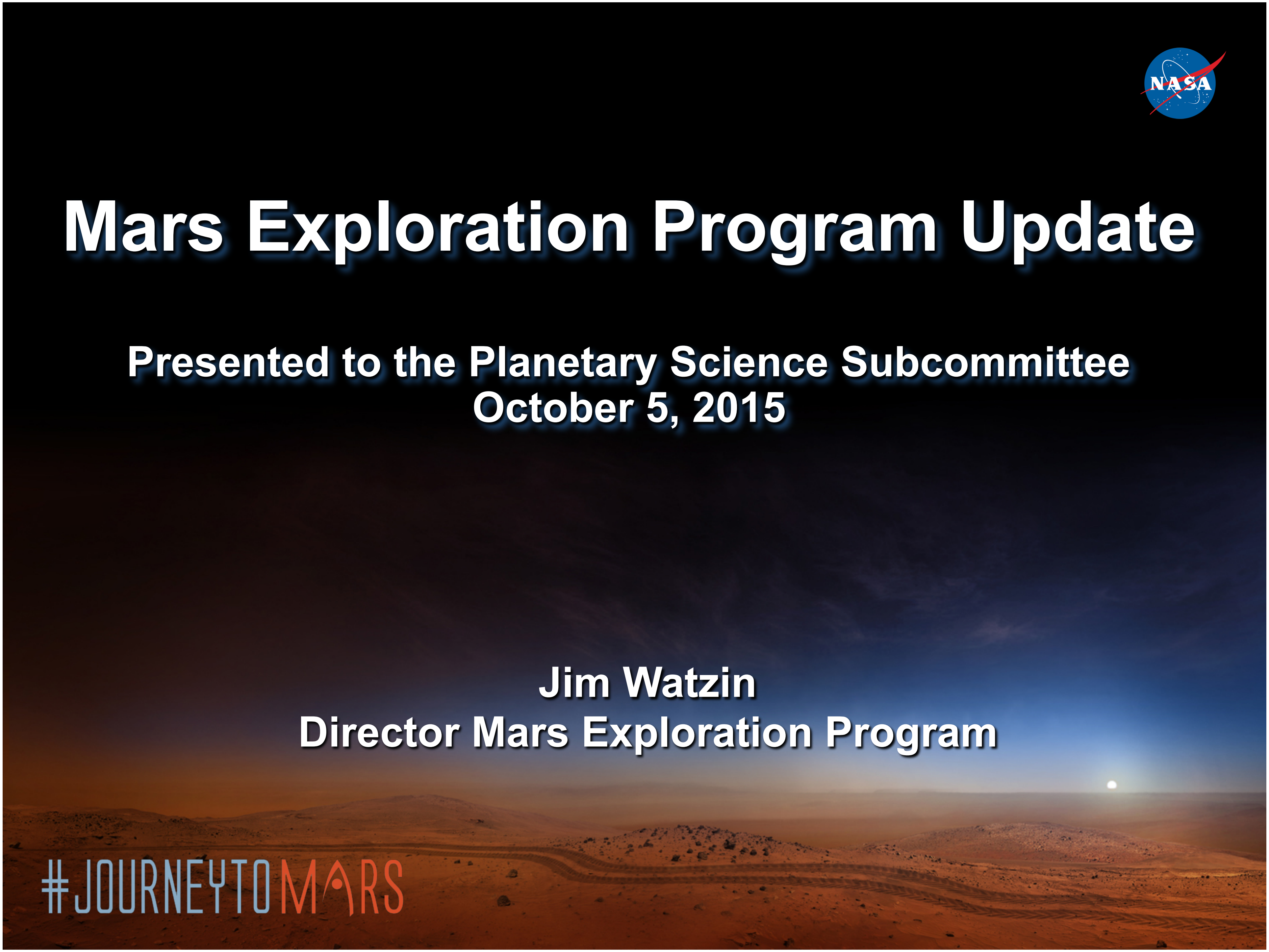


# Mars Exploration Program Update

Presented to the Planetary Science Subcommittee
October 5, 2015

Jim Watzin
Director Mars Exploration Program

#JOURNEYTOMARS

- **MEP is healthy**
  - Operational assets returning remarkable science
  - Budget supports current work
  - Mars 2020 development proceeding well, nearing PDR
  - MOMA fabrication underway

- **Planning for the future is a pressing priority, as the 2022 opportunity is only 5 years from the current budget planning horizon**
  - Replace and update aging infrastructure
  - M2020 is our only mission in development
  - Respond to NRC Decadal Survey science priority of MSR

- **Collaboration on Science/Exploration synergies critical for the 2020s**
  - MEP trade studies
  - Joint MEP/HEOMD/STMD trade studies
  - MEP/HEOMD co-chartered MEPAG SAG activities

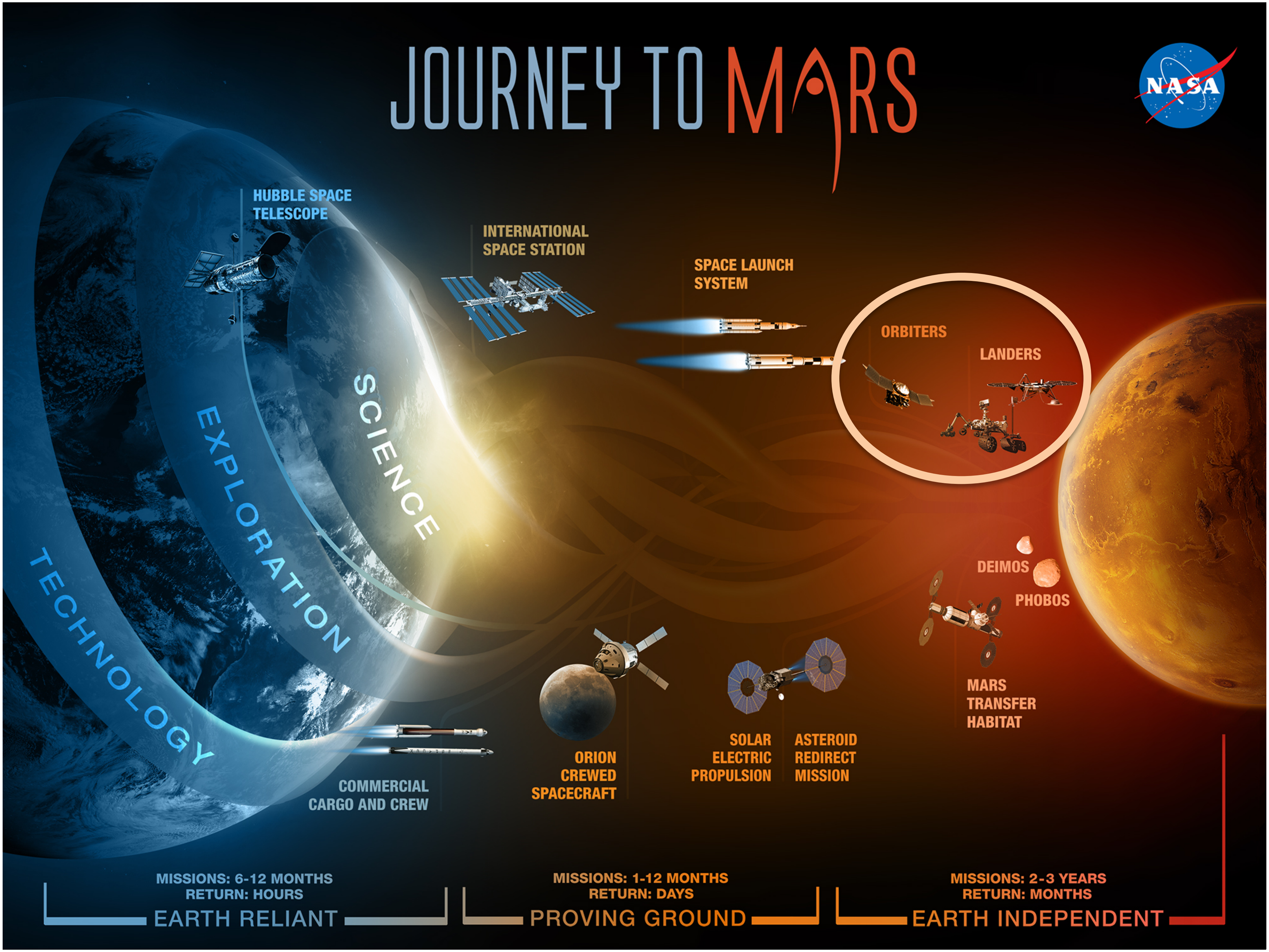
Panoramic view from Rocknest
October-November 2012
Curiosity Mast Camera

# Mars Panorama

“compliments of Curiosity”

9 Sept 2015

# JOURNEY TO MARS



HUBBLE SPACE TELESCOPE

INTERNATIONAL SPACE STATION

SPACE LAUNCH SYSTEM

ORBITERS

LANDERS

SCIENCE

EXPLORATION

TECHNOLOGY

DEIMOS

PHOBOS

MARS TRANSFER HABITAT

COMMERCIAL CARGO AND CREW

ORION CREWED SPACECRAFT

SOLAR ELECTRIC PROPULSION

ASTEROID REDIRECT MISSION

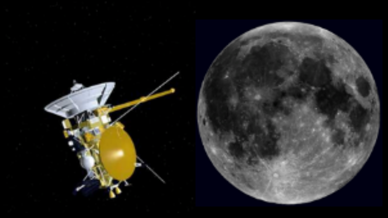
MISSIONS: 6-12 MONTHS
RETURN: HOURS
EARTH RELIANT

MISSIONS: 1-12 MONTHS
RETURN: DAYS
PROVING GROUND

MISSIONS: 2-3 YEARS
RETURN: MONTHS
EARTH INDEPENDENT

# What We’ve Learned and Still Need to Learn at Mars

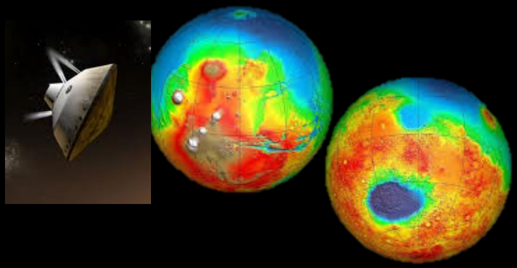
## Orbital environment and operations



**Learned:**
- Deep space navigation
- Orbit transfer near low-gravity bodies
- Gravity assist
- Aero-braking
- Gravitational potential
- Mars’ moons characteristics
- ISRU potential

**To Learn:**
- Return flight from Mars to Earth
- Autonomous Rendezvous & Docking
- ISRU feasibility
- Resource characterization of Mars moons
- High-power SEP

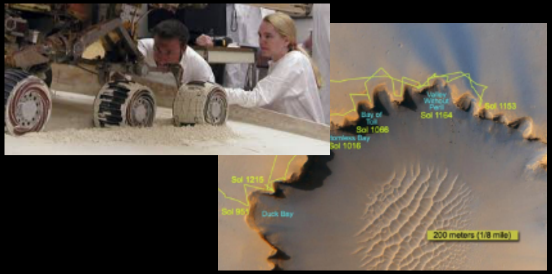
## Capture, EDL & Ascent at Mars



**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

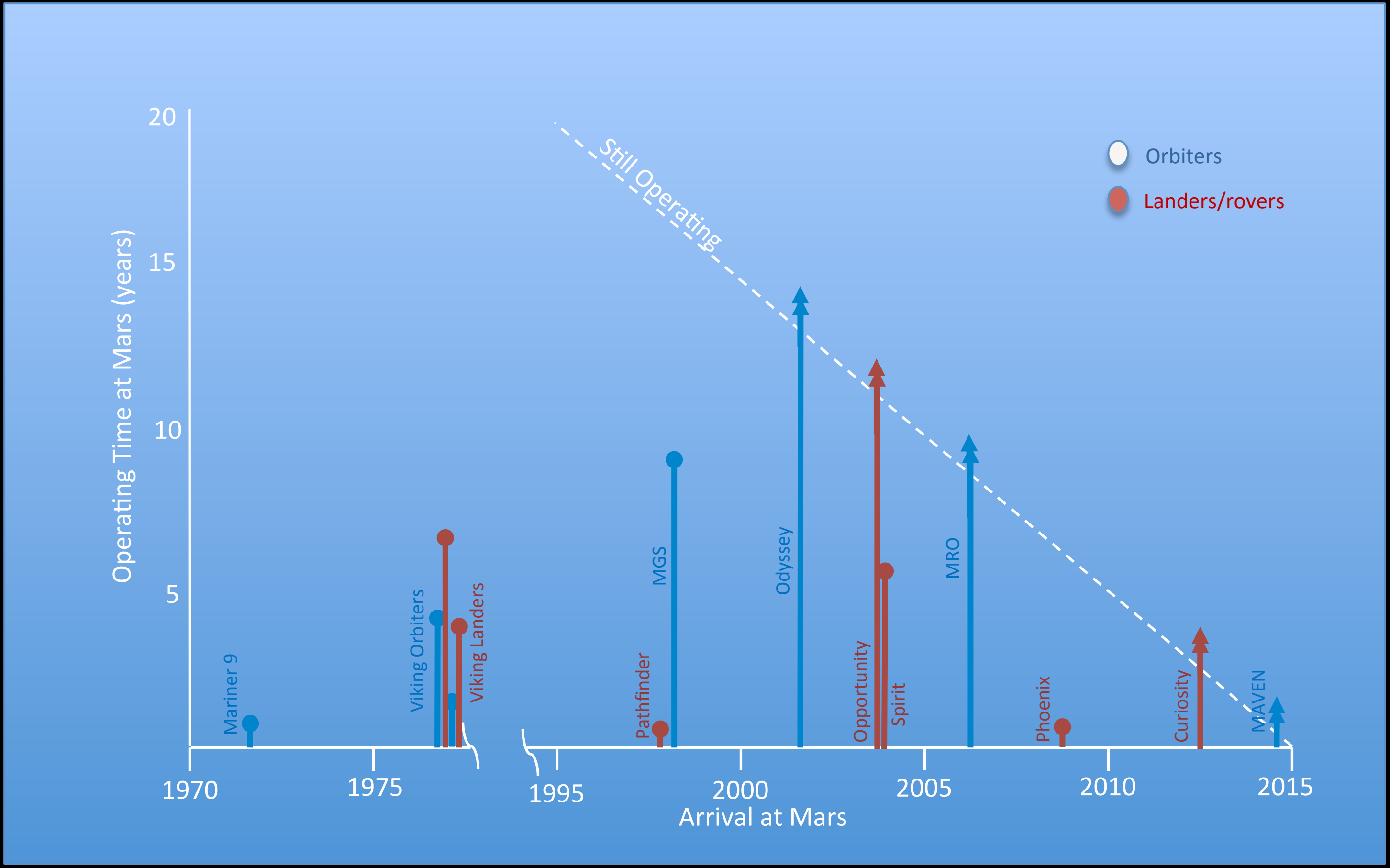


**Learned:**
- Water once flowed and was stable
- Global topography: elevation and boulder distributions
- Remnant magnetic field
- Dust impacts on Solar Power / Mechanisms
- Radiation dose
- Global resource distribution
- Relay strategies, operations cadence

**To Learn:**
- Landing site resource survey
- Dust effects on human health, suits & seals
- Rad/ECLSS in Mars in environment
- Power sufficient for ISRU
- Surface Navigation

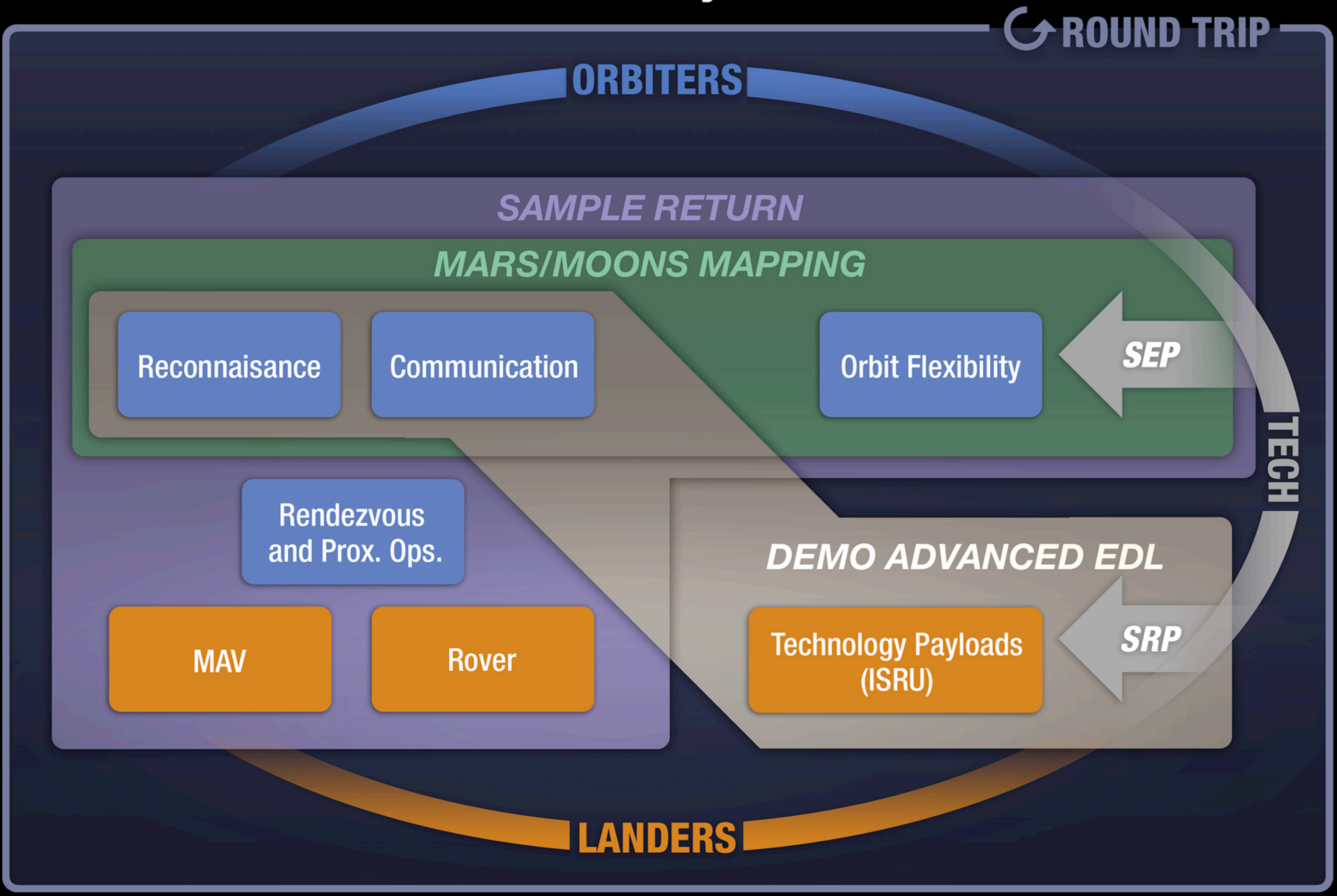
Strong Science and Exploration synergies motivate precursor collaboration

# Operating At and Around Mars



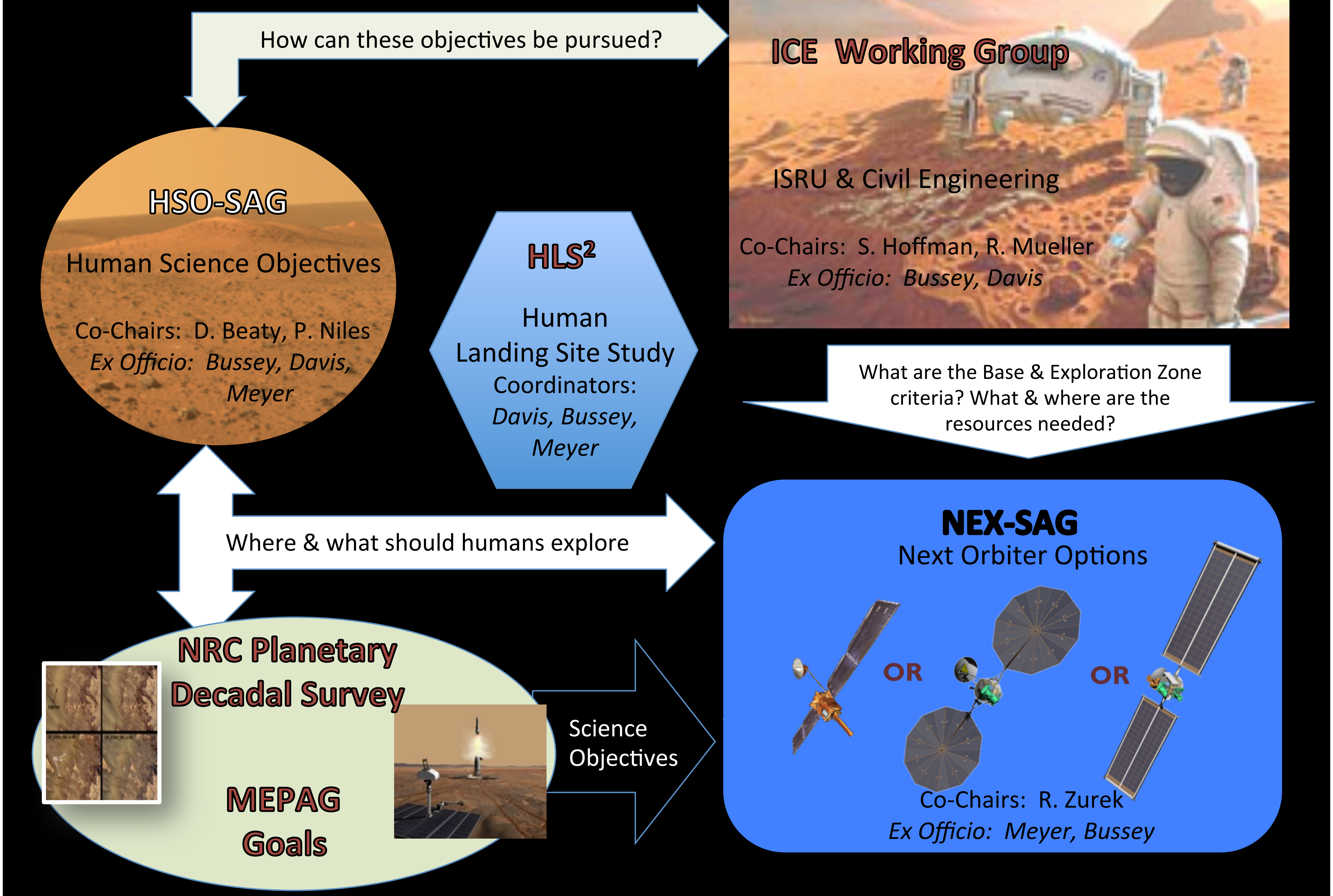
**MEP operates successfully and with longevity, but our infrastructure is aging**

# Mission Synthesis



**MSR provides a strong foundation to address Mars precursor objectives**

# Science Exploration Integration



How can these objectives be pursued?

**ICE Working Group**

ISRU & Civil Engineering

Co-Chairs: S. Hoffman, R. Mueller
*Ex Officio: Bussey, Davis*

**HSO-SAG**

Human Science Objectives

Co-Chairs: D. Beaty, P. Niles
*Ex Officio: Bussey, Davis, Meyer*

**HLS²**

Human Landing Site Study
Coordinators:
*Davis, Bussey, Meyer*

What are the Base & Exploration Zone criteria? What & where are the resources needed?

Where & what should humans explore

**NEX-SAG**

Next Orbiter Options

Co-Chairs: R. Zurek
*Ex Officio: Meyer, Bussey*

**NRC Planetary Decadal Survey**

**MEPAG Goals**

Science Objectives

# Conceptual Integrated Campaign for Mars in the 2020's

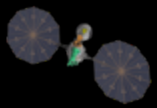
LEGEND

- 🟫 Exploration
- 🟦 Cross-Cutting (Exploration-Technology-Science)
- 🟥 Science

## Mars 2020

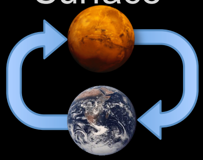
- 🟫 ISRU Prototype
- 🟦 EDL Instruments
- 🟥 Sample Acquisition
- 🟥 In Situ Science
- 🟥 Habitable Conditions
- 🟥 Ancient Life

## Mars Orbiter 2022



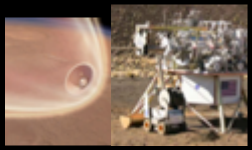
- 🟫 Resource Survey
- 🟦 Landing Site Selection
- 🟦 Optical Comm/Relay
- 🟦 SEP
- 🟦 Rendezvous
- 🟥 Remote Sensing Instruments

## Round-Trip Surface to Surface



- 🟫 Dust Toxicity
- 🟦 EDL Evolution/ Instruments
- 🟦 Mars Ascent
- 🟦 Surface Navigation
- 🟥 Returned Sample Analysis

## Exploration Precursors



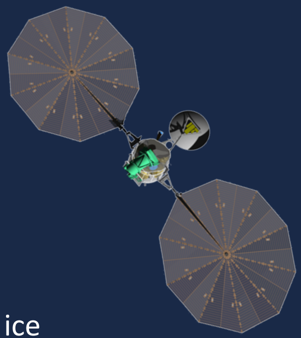
- 🟫 ISRU Production
- 🟦 Surface Power for ISRU
- 🟦 Rad/ECLSS Validation
- 🟦 Increased EDL Mass & Precision
- 🟥 Science Instruments

**Robotic precursors fulfilling the Mars Sample Return objective intrinsically inform strategic exploration planning by providing invaluable flight experience**

# Next Orbiter (NEX-SAG) Findings

***A 2022 Mars Orbiter utilizing Solar Electric Propulsion (SEP) and advanced telecom in a 5-year orbital mission, could meet challenging objectives for new science, resource prospecting, and support for future missions***

- Launch in 2022 to replenish infrastructure and to make progress on returning samples from Mars to Earth
    - Back-up relay for 2020 Mars rover support in final years of surface operation
    - Feed-forward for release, rendezvous and capture demonstration
    - Telecommunications support for future “sample fetch & return” flight mission



- SEP brings several advantages
    - Mission design and execution flexibility
    - More payload mass and power
    - Enables orbital plane changes for diurnal coverage (e.g., RSL) and polar/non-polar survey of ice
    - Provides fly-bys of Phobos and Deimos on way to low Mars orbit

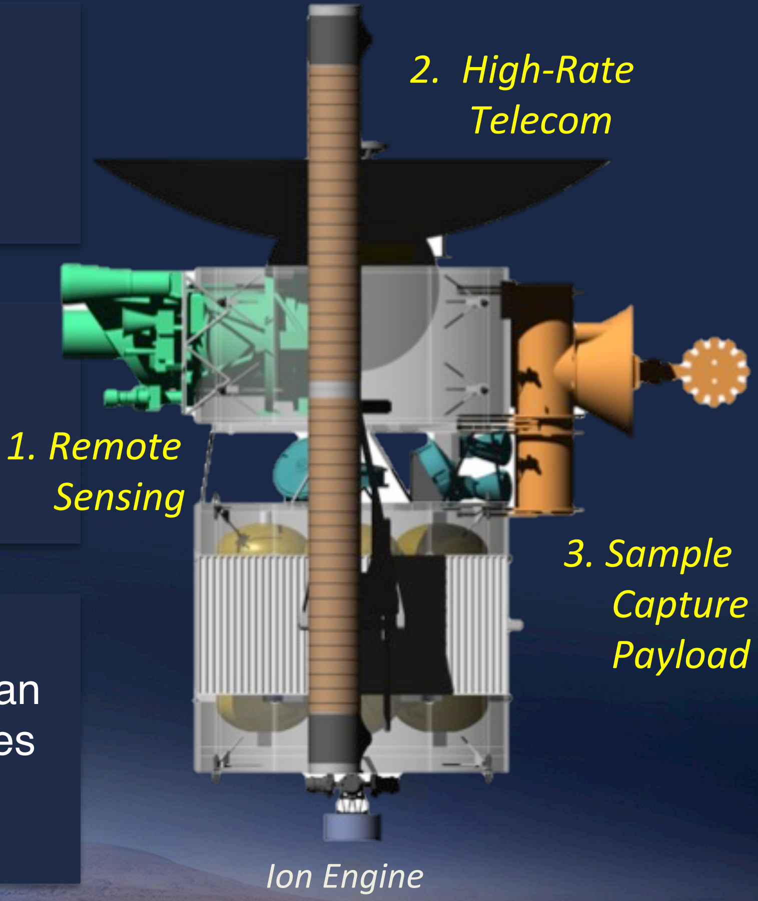
- Advanced telecom provides coverage for high-resolution data

***NEX-SAG finds considerable overlap between the science goals identified and the human exploration resource prospecting interests and derived objectives. Similar instrument approaches can address both.***

# Multi-function Orbiter Concept Accomplishes Three Core Functions

| | |
|---|---|
| **1: Remote Sensing** | Decadal Science, Resource identification, and Landing site reconnaissance to support future missions |
| **2: High-Rate Telecom** | High data rates for Orbiter Science, and proximity links to support future in-situ assets |
| **3: Sample Rendezvous Capture & Return** | Demonstrate sample rendezvous and capture capabilities, *and* play an *operational role* in return of samples *after* completion of all primary mission objectives |

Multi-Function Orbiter with
***Solar Electric Propulsion*** and
*High Power Solar Arrays*



# NEX-SAG:  Conceptual Payload Approaches

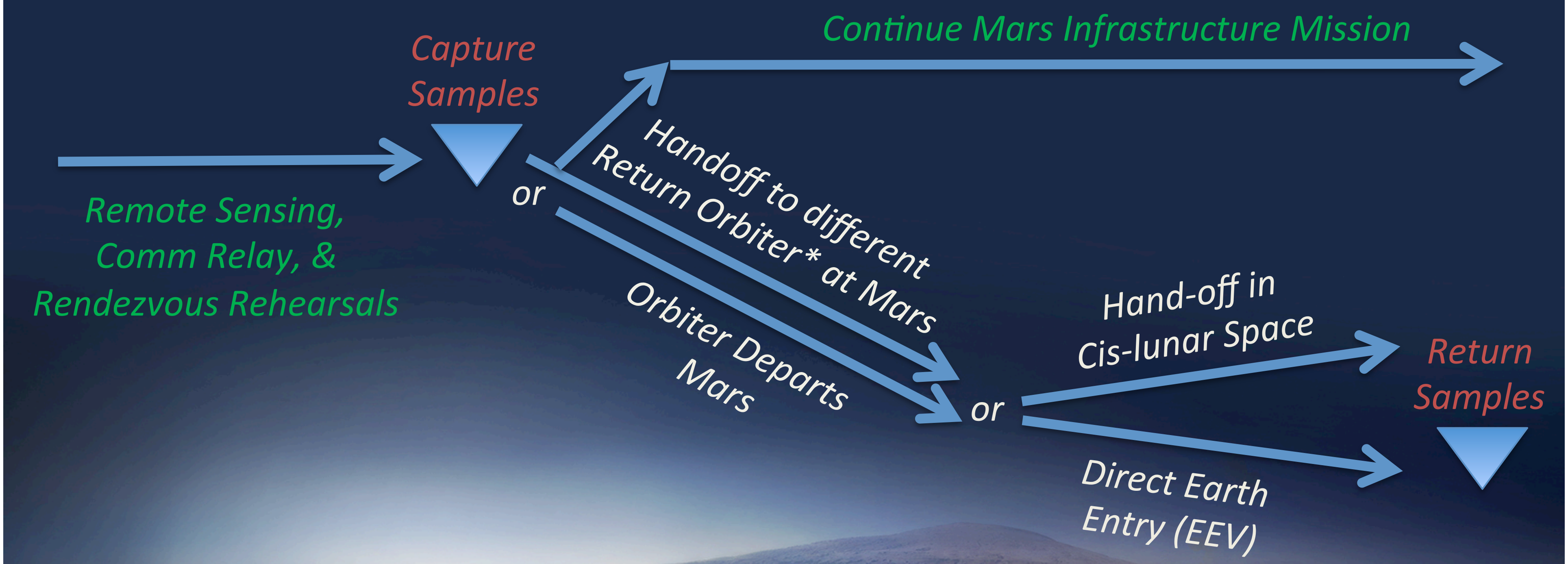
***Proof-of-concept instrument approaches* to meeting the science, resource, and reconnaissance objectives were identified; other approaches may be proposed in response to an open AO.**

- ***Visible imaging*** *of HiRISE-class or better (~15-30 cm/pixel);*
- *Polarimetric* ***synthetic aperture radar*** *imaging with penetration depth of a few (<10) meters and spatial resolution of ~15 m/pixel to search for shallow ground ice and crustal structure;*
- ***Short-wave IR spectral*** *mapping with a spatial resolution of ~6 m/pixel (3 x CRISM) with sufficient spectral resolution to detect key minerals;*
- ***Long-wave atmospheric sounding*** *for wind (first–time from orbit), temperature, & water vapor profiles with 5 km vertical resolution;*
- ***Thermal IR sounding*** *for aerosol (dust & ice) profiles;*
- ***Multi-band thermal IR*** *mapping of thermo-physical surface properties (e.g., ice overburden) and surface composition;*
- *Global, km-scale,* ***wide-angle imaging*** *to monitor weather and surface frosts.*

***Many of these capabilities could be provided by international partners.***

# Orbiter Concept Planned to Provide Programmatic Flexibility

Multi-function Orbiter supports many scenarios for accomplishing sample return objectives



Remote Sensing, Comm Relay, & Rendezvous Rehearsals

Capture Samples

Continue Mars Infrastructure Mission

or

Handoff to different Return Orbiter* at Mars

Orbiter Departs Mars

or

Hand-off in Cis-lunar Space

Direct Earth Entry (EEV)

Return Samples

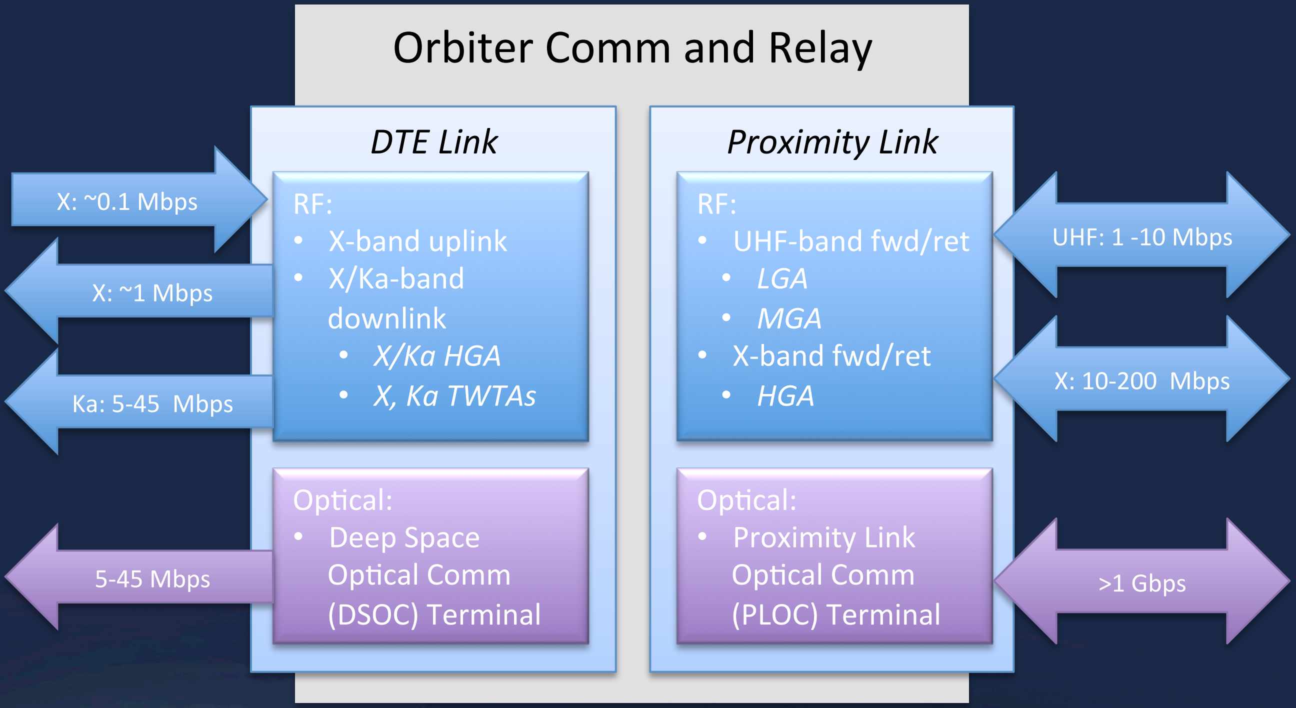
*With refueling, could become a nascent Mars tug

# Candidate Comm and Relay Capabilities

**Deep Space Network (DSN )**

**Palomar Telescope (receive)**

**Table Mountain Telescope (uplink)**



## Orbiter Comm and Relay

### *DTE Link*

RF:
- X-band uplink
- X/Ka-band downlink
  - *X/Ka HGA*
  - *X, Ka TWTAs*

Optical:
- Deep Space Optical Comm (DSOC) Terminal

### *Proximity Link*

RF:
- UHF-band fwd/ret
  - *LGA*
  - *MGA*
- X-band fwd/ret
  - *HGA*

Optical:
- Proximity Link Optical Comm (PLOC) Terminal

X: ~0.1 Mbps

X: ~1 Mbps

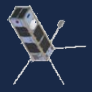
Ka: 5-45 Mbps

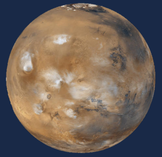
5-45 Mbps

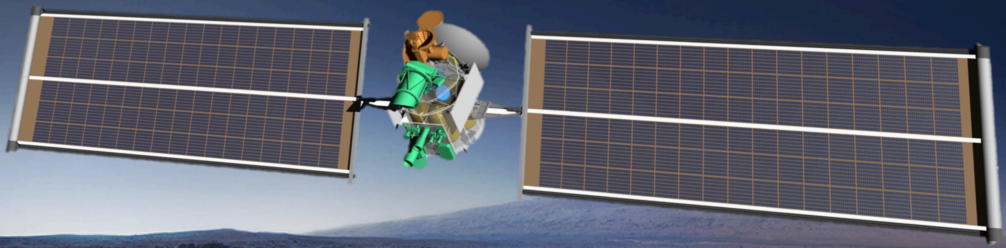
UHF: 1 -10 Mbps

X: 10-200 Mbps

>1 Gbps







Pre-Decisional: For planning and discussion purposes only.

# Efficient Sample Retrieval can be Achieved with Evolved Systems

**Key functions**:

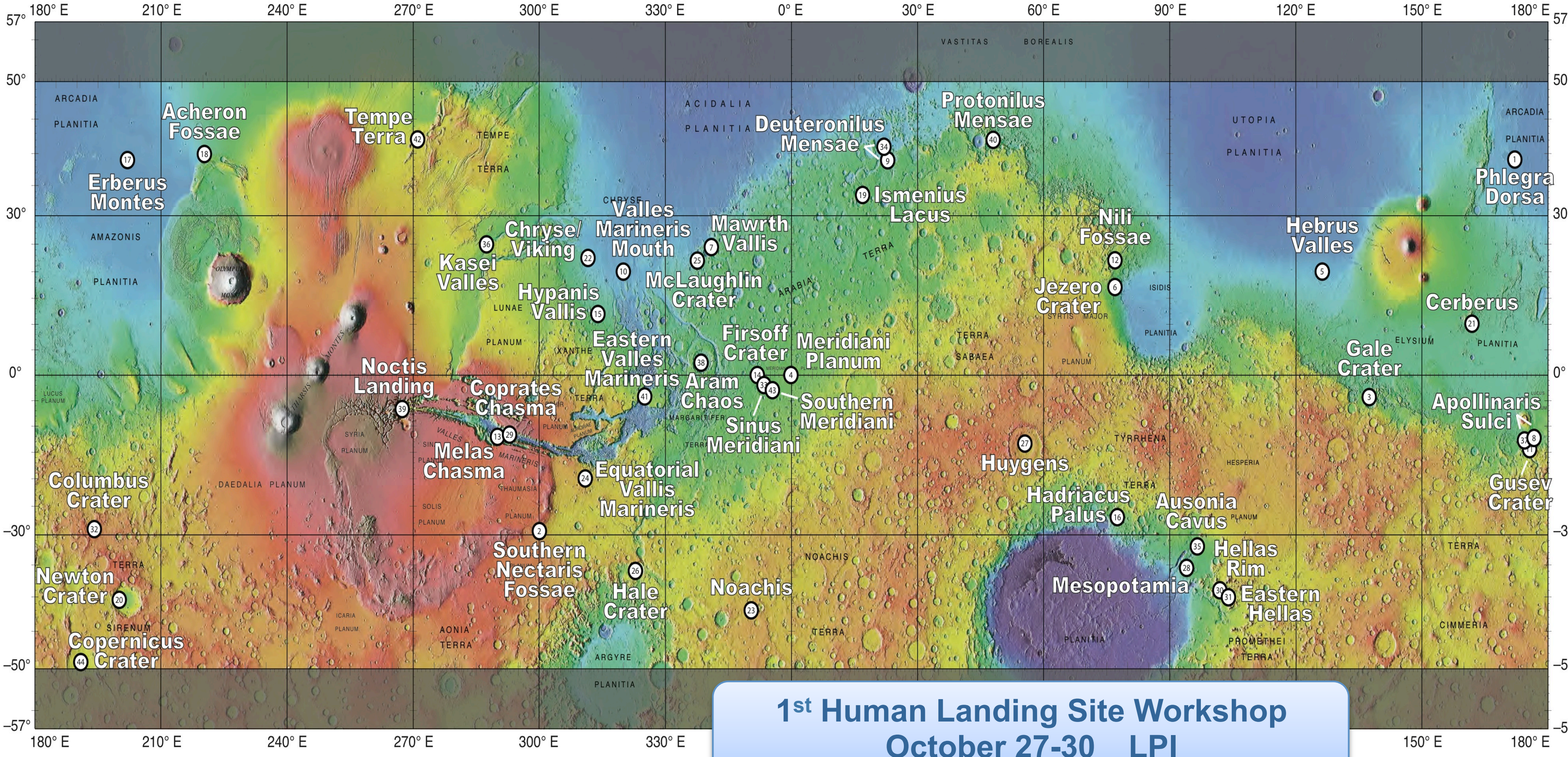
- Retrieve Samples
- Launch to Orbit

**Key enablers for efficient sample retrieval:**

- Improved landing accuracy (order of magnitude)
  - TRN sensors and control
  - Improved velocity triggered parachute deployment
  - 25% more EDL fuel

- Evolved EDL capability – 1.5mT (50% improvement in landed mass)
  - Larger (4.7m) heat shield (MSL 4.5m )
  - Larger (27m) parachute (MSL 21.5m)
  - Small fetch rover (simple retrieval tasking)
  - Hybrid fuel MAV

# Potential Exploration Zones for Human Missions to the Surface of Mars



## 1st Human Landing Site Workshop
## October 27-30 LPI

00 Exploration Zones proposed for humans to Mars.
At the equator, circles are ~100km radius

version 2.0 Sept 11, 2015

Prepared By: Lindsay Hays, Mars Program Office
lhays@jpl.nasa.gov

Astronaut footprints on the Moon

MEP wheelprints on Mars

**Next steps in-work**