National Aeronautics and Space Administration

MARS EXPLORATION PROGRAM (MEP)

Update to the PAC

July 2, 2018

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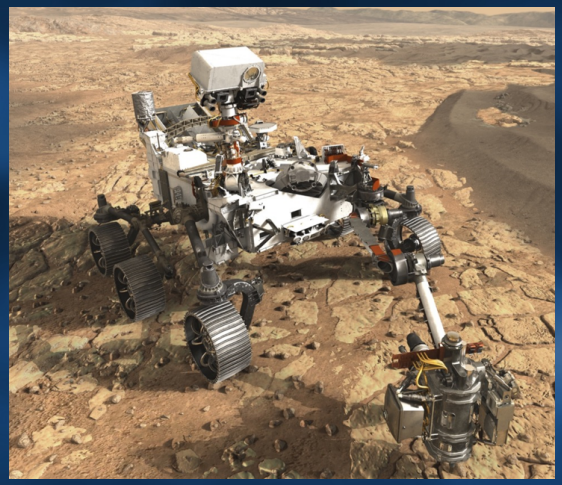
Director – Mars Exploration Program

MEP News & Status

- All Operating Missions are doing well
  - Opportunity status pending outcome after dust storm subsides
  - MRO battery charging issue resolved
  - MAVEN orbit adjustment (in 2019) to facilitate improved comm relay for Mars 2020
    - Apoapsis change from 6200 km to 4000/4500 km



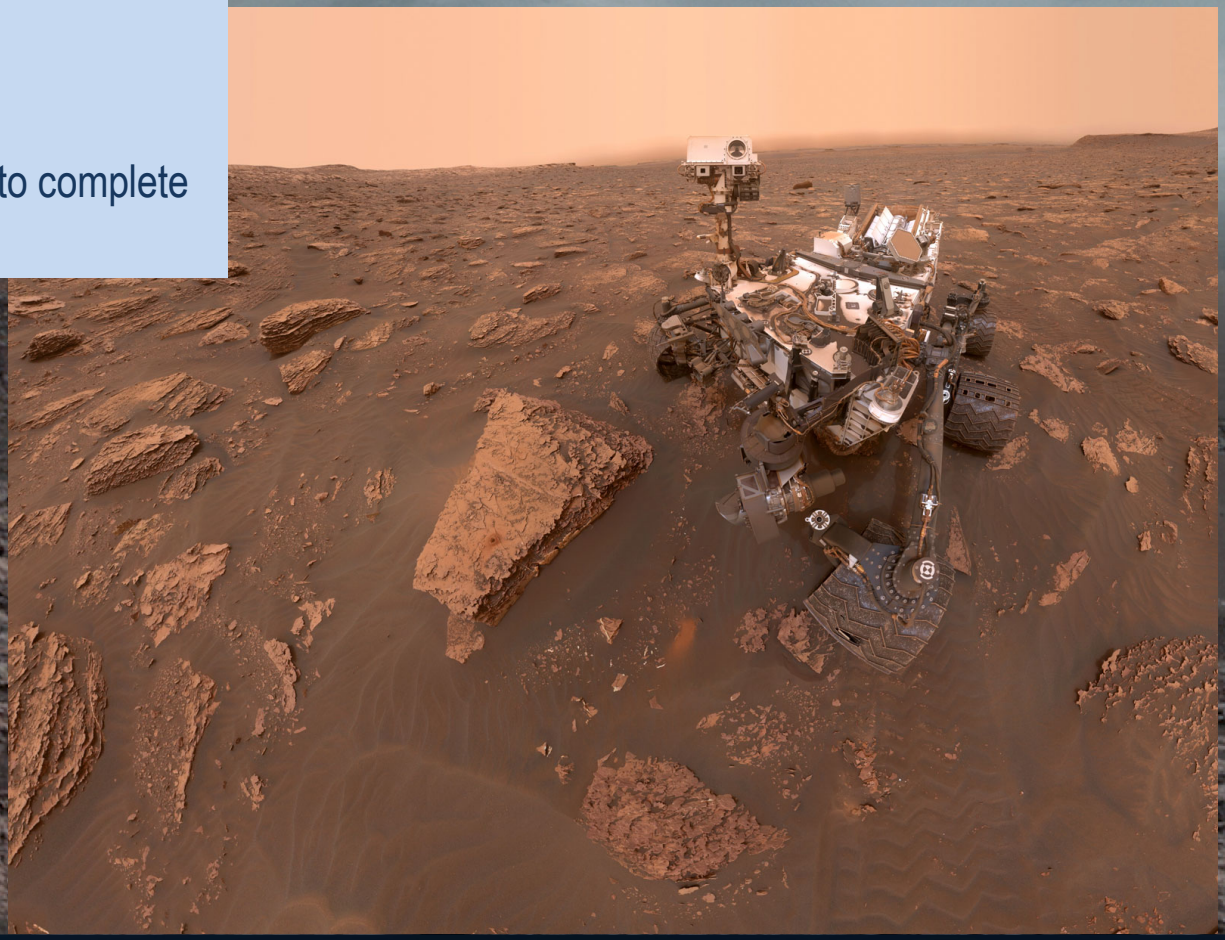
- All Development Missions and systems are doing well
  - Successful Mars 2020 Systems Integration Review (SIR) and Agency KDP-D
    - Excellent technical progress
    - Healthy schedule & budget reserves
  - MOMA instrument delivered for ExoMars Rover integration

- Progressing in our technology maturation program for key Mars Sample Return (MSR) technologies

- Beginning preparations for the next Decadal; considering studies and roadmap activities

Curiosity Exploration of GALE Crater

- **Complex organics on Mars**
- Finished “Duluth” drilling campaign
  - **First successful drilling w/o drill feed**
- 400+ science papers published
- Explored 18+ km since landing
- Adequate MMRTG energy remaining to complete mission objectives

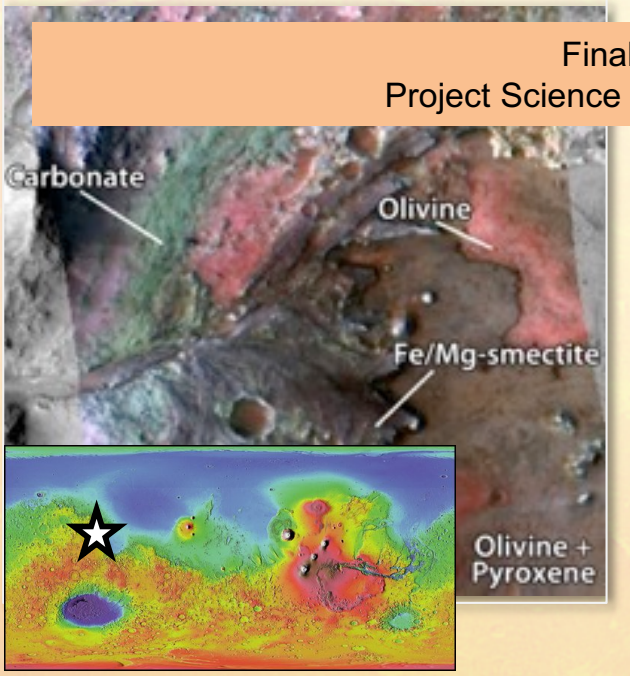


2018 Dust Storm

Curiosity looking at Crater Wall

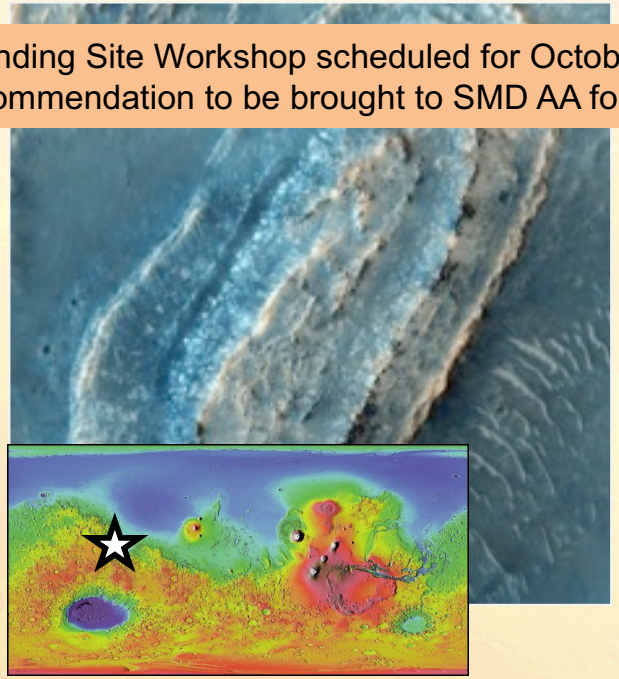
Candidate Mars 2020 Landing Sites

Final Landing Site Workshop scheduled for October 2018.
Project Science recommendation to be brought to SMD AA for decision late 2018.



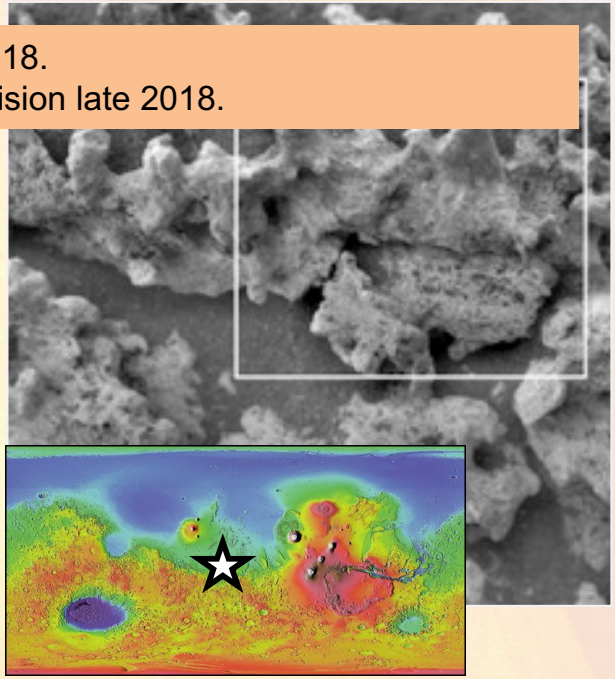
JEZERO

- Deltaic/lacustrine deposition with Hesperian lava flow and hydrous alteration
- Mineralogic diversity including clays and carbonates
- Evidence for hydrous minerals from CRISM, *including carbonates*



NE SYRTIS

- Extremely ancient igneous, hydrothermal, and sedimentary environments
- High mineralogic diversity with phyllosilicates, sulfates, carbonates, olivine
- Serpentinization and subsurface habitability?



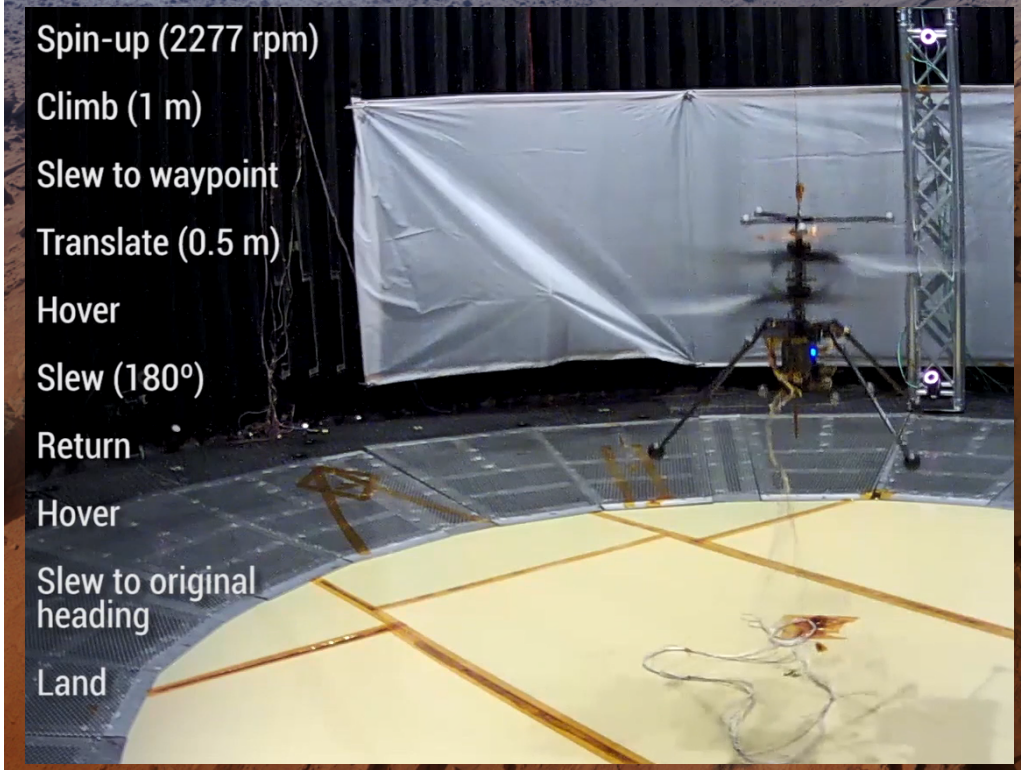
COLUMBIA HILLS

- Carbonate, sulfate, and silica-rich outcrops of possible hydrothermal origin and Hesperian lava flow
- Potential bio-signatures identified
- Previously explored by MER

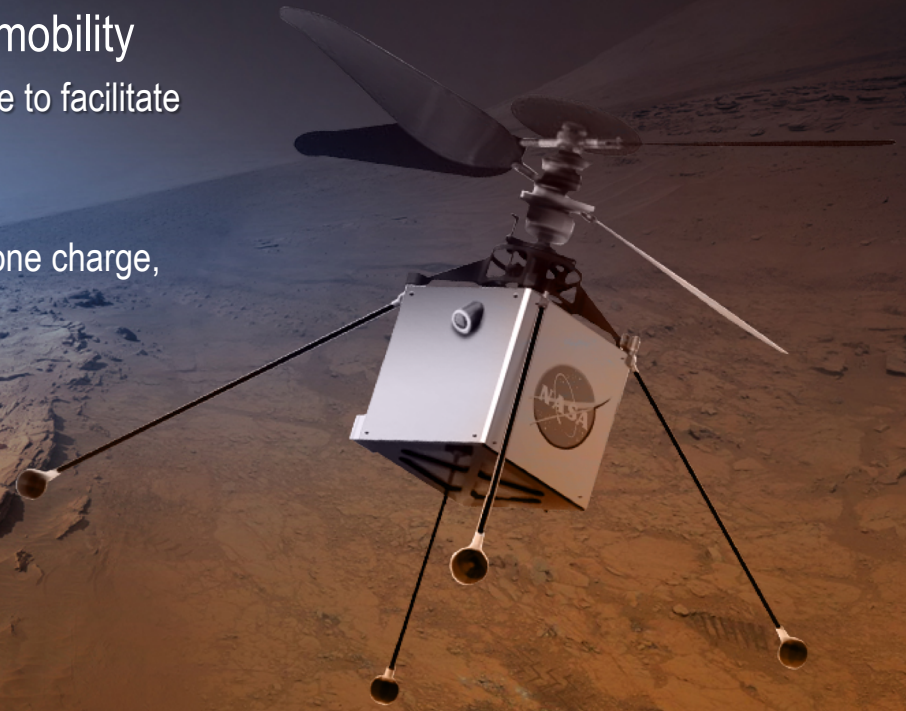
MARS HELICOPTER - TECHNOLOGY DEVELOPMENT

Objective - Explore utility of Mars aerial mobility

- Regional-scale high-resolution reconnaissance to facilitate surface operations of future robotic missions
- Access to extreme terrains, Rover scouting
- Mass < 2 kg, solar powered,300 m range on one charge, autonomous, dual cameras



Full-scale free flight testing in JPL Space Simulator



Technology Maturation Progress

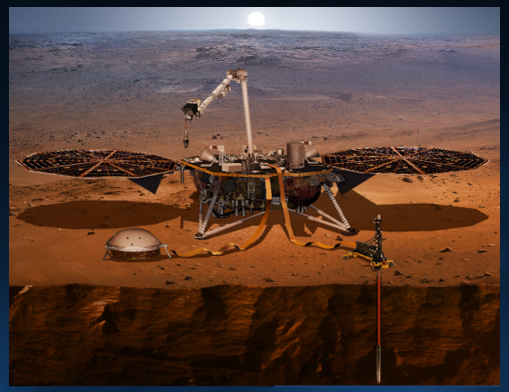
- ✓ Controlled-flight feasibility demonstration – June 2016
- ✓ Engineering Model build & test complete – Feb 2018
  - 86 mins accumulated flight time in Mars environment
- ✓ Decision to demonstrate on M2020 mission – May 2018

MEP Budget News

- FY18 Budget Appropriation included ~$75M increase over President's request
  - Maintain the high pace of development on Mars 2020, preserving maximum schedule reserves for ATLO
  - Continue all our operating missions
  - Continue our technology maturation activities
  - Fully fund R&A
- FY19 President's Budget Request was also favorable for the MEP, requesting $50M for planning MSR

More Mars News

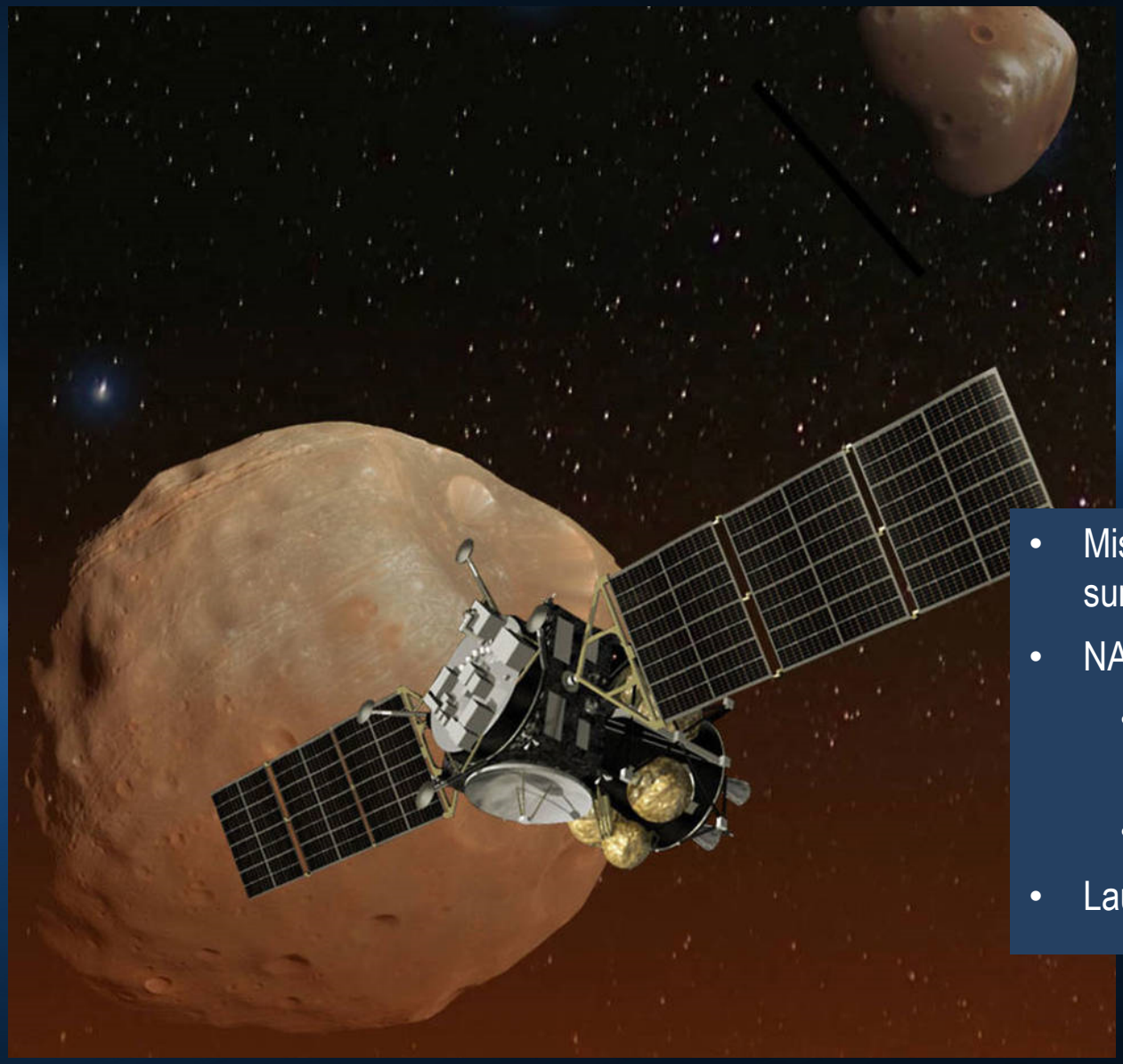
- InSight on its way to Mars
  - Landing on Nov 26, 2018
    - MARCO CubeSat flyby/relay



- ESA Trace Gas Orbiter (TGO) reached its operational mission orbit

- UAE plans building a Mars City
  - Seeking input for science laboratory facility

JAXA Mars Moons eXploration - MMX

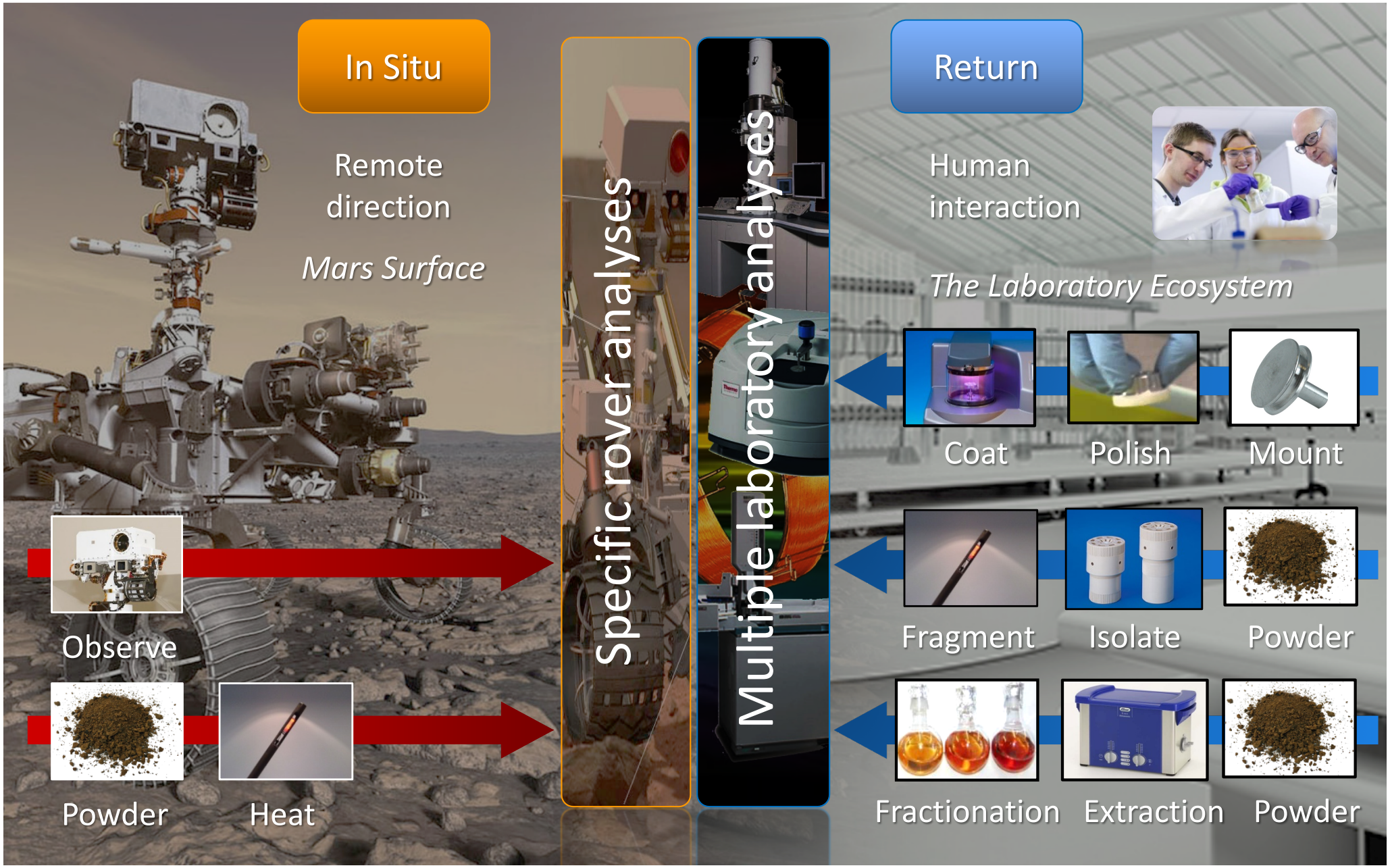


- Mission to study Mars moons & return surface samples from Phobos
- NASA providing:
  - MEGANE (JHUAPL) neutron and gamma-ray spectrograph
  - Pneumatic sampler (HBR)
- Launch 2024

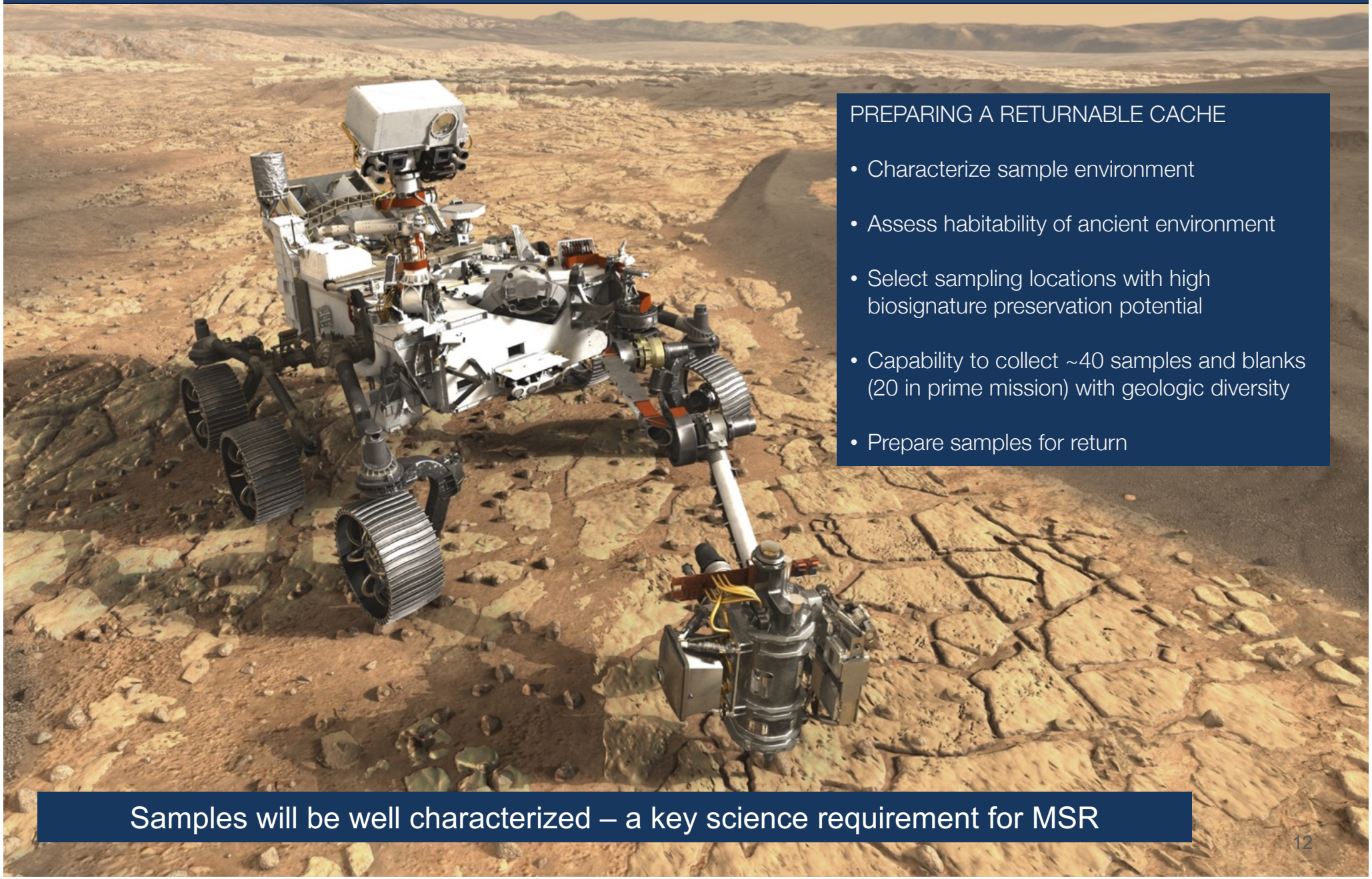
Mars Sample Return (MSR) Highlights

Analytical Benefits of Sample Return

International MSR Objectives & Samples Team



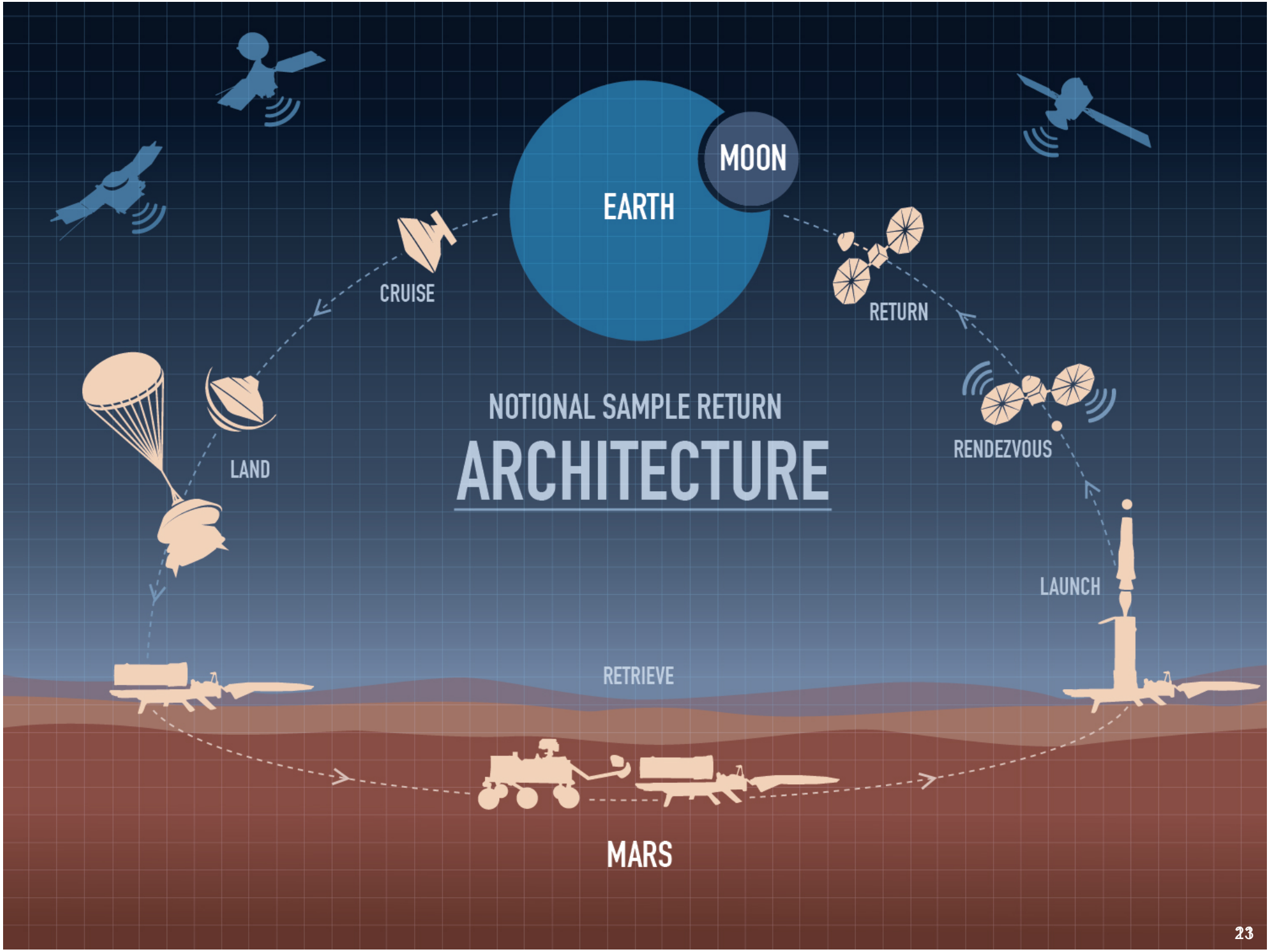
Mars 2020 – First Step for MSR



PREPARING A RETURNABLE CACHE

- Characterize sample environment
- Assess habitability of ancient environment
- Select sampling locations with high biosignature preservation potential
- Capability to collect ~40 samples and blanks (20 in prime mission) with geologic diversity
- Prepare samples for return

Samples will be well characterized – a key science requirement for MSR


MOON
EARTH
CRUISE
RETURN
NOTIONAL SAMPLE RETURN
ARCHITECTURE
LAND
RENDEZVOUS
LAUNCH
RETRIEVE
MARS

STRATEGIC APPROACH FOR MSR

- *"Ensure Affordability"*
  - Treat as a Cost-Capped Mission
    - Retain flexibility on requirements; keep cost as part of the essential trade-space; returning scientifically selected samples is the Level 1 requirement
  - Take calculated risk
  - Focused scope; *no ornaments*
  - Capitalize on experience base; Limit new development
  - Continue early technology investments to mature readiness and minimize cost risks
  - Leverage partnerships
  - Strong programmatic discipline in execution

Discipline and Rigor are KEY

MSR - Why now?

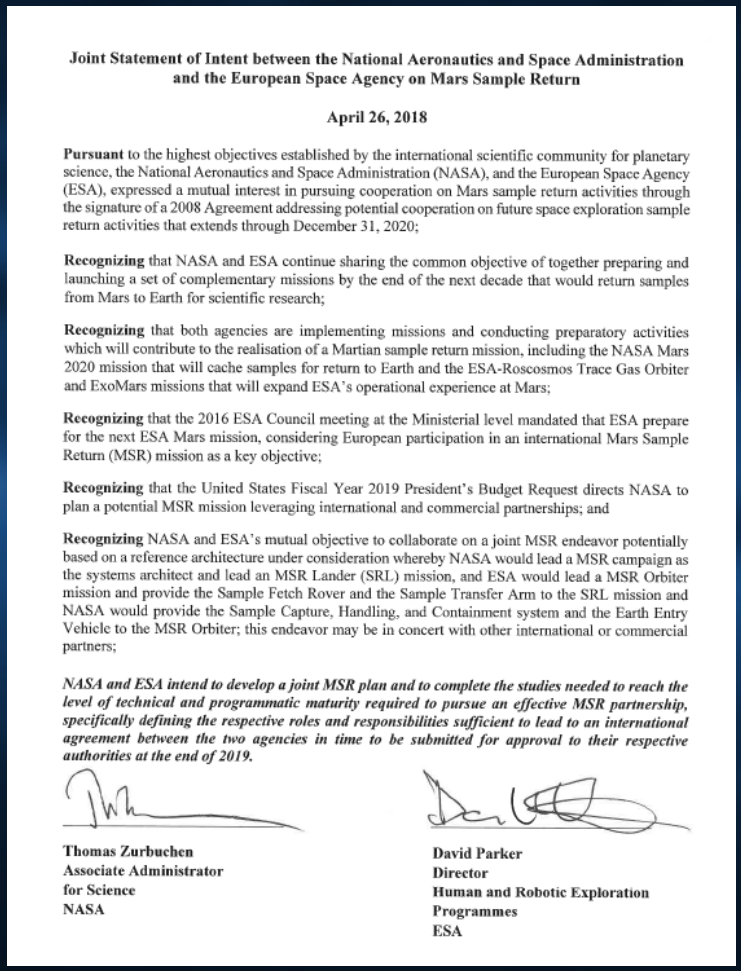
- Our operational infrastructure is aging but healthy
- Are operationally and scientifically mature enough to select compelling samples
- Science has evolved to an informed recognition of the need to bring modern diagnostic tools to the table to explore at granular scales and below to interrogate chemistries and textures not possible at Mars
- Foresee that interrogating these samples using state-of-the-art instrumentation will move the science from characterizing the environment to being able to explain what was and is happening at Mars today, and into the future
- Critical technology is understood and ready
  - Mars 2020 entering ATLO
  - Mars Ascent Vehicle (MAV) and Planetary Protection containment approaches in prototype phase

MSR News

- FY19 President's Budget Request includes $50M to *"Plan a potential Mars Sample Return mission, a decadal survey priority, leveraging international and commercial partnerships"*

- April 26, 2018 NASA and ESA signed a Statement of Intent to jointly plan MSR
  - End of 2019 decision

- This is the opportunity to pursue >30 year quest of the community; fulfill a Decadal priority
  - Will demand the best of our experience, innovation, compromise and discipline in execution



Joint Statement of Intent between the National Aeronautics and Space Administration and the European Space Agency on Mars Sample Return

April 26, 2018

Pursuant to the highest objectives established by the international scientific community for planetary science, the National Aeronautics and Space Administration (NASA), and the European Space Agency (ESA), expressed a mutual interest in pursuing cooperation on Mars sample return activities through the signature of a 2008 Agreement addressing potential cooperation on future space exploration sample return activities that extends through December 31, 2020;

Recognizing that NASA and ESA continue sharing the common objective of together preparing and launching a set of complementary missions by the end of the next decade that would return samples from Mars to Earth for scientific research;

Recognizing that both agencies are implementing missions and conducting preparatory activities which will contribute to the realisation of a Martian sample return mission, including the NASA Mars 2020 mission that will cache samples for return to Earth and the ESA-Roscosmos Trace Gas Orbiter and ExoMars missions that will expand ESA's operational experience at Mars;

Recognizing that the 2016 ESA Council meeting at the Ministerial level mandated that ESA prepare for the next ESA Mars mission, considering European participation in an international Mars Sample Return (MSR) mission as a key objective;

Recognizing that the United States Fiscal Year 2019 President's Budget Request directs NASA to plan a potential MSR mission leveraging international and commercial partnerships; and

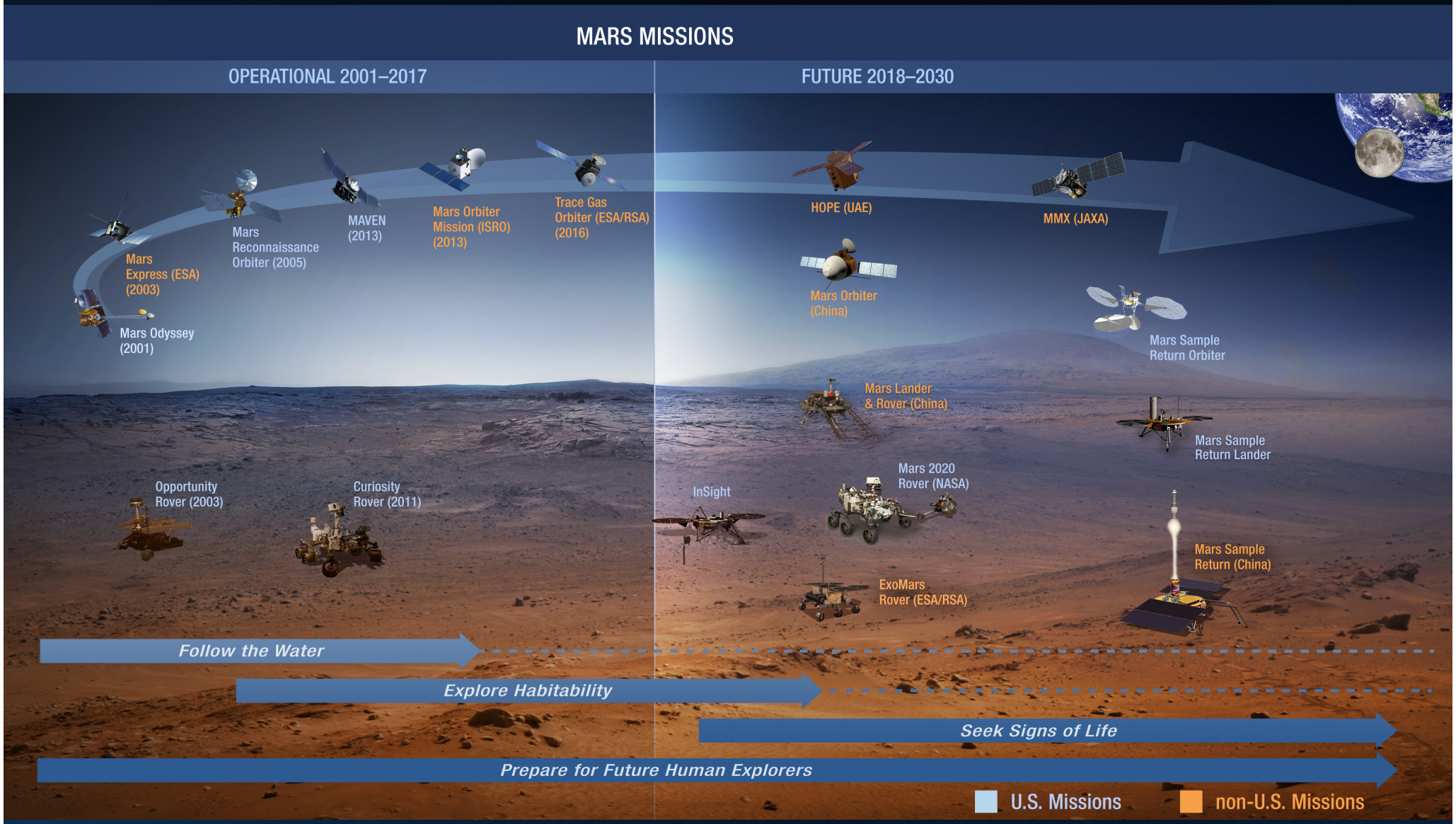
Recognizing NASA and ESA's mutual objective to collaborate on a joint MSR endeavor potentially based on a reference architecture under consideration whereby NASA would lead a MSR campaign as the systems architect and lead an MSR Lander (SRL) mission, and ESA would lead a MSR Orbiter mission and provide the Sample Fetch Rover and the Sample Transfer Arm to the SRL mission and NASA would provide the Sample Capture, Handling, and Containment system and the Earth Entry Vehicle to the MSR Orbiter; this endeavor may be in concert with other international or commercial partners;

NASA and ESA intend to develop a joint MSR plan and to complete the studies needed to reach the level of technical and programmatic maturity required to pursue an effective MSR partnership, specifically defining the respective roles and responsibilities sufficient to lead to an international agreement between the two agencies in time to be submitted for approval to their respective authorities at the end of 2019.

Thomas Zurbuchen
Associate Administrator
for Science
NASA

David Parker
Director
Human and Robotic Exploration
Programmes
ESA

MARS Exploration International Portfolio, Existing & Future Plans



MARS EXPLORATION PROGRAM – SUMMARY

MEP is a healthy program

- Current missions highly productive
- Development missions/systems doing well
- Beginning early-stage work on a potential lower cost MSR mission,
  - A Decadal priority
  - Leveraging international and commercial partnerships
- Beginning preparations for 2019 next Decadal activities