

National Aeronautics and
Space Administration

Mars 2020 Perseverance & Mars Sample Return

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Mars Exploration Program

ISU SSP 2022

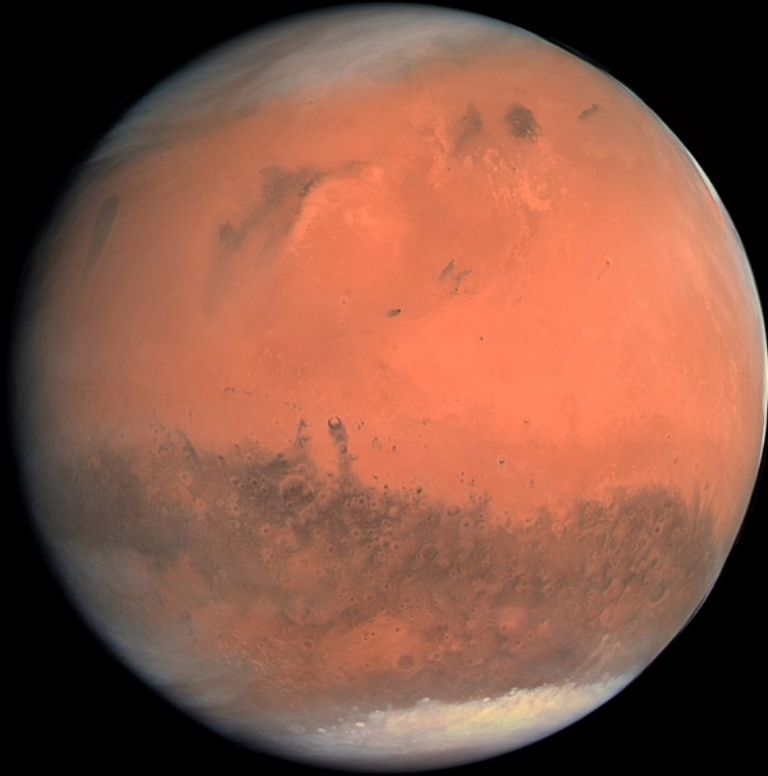


Mars Today: A Cold Desert

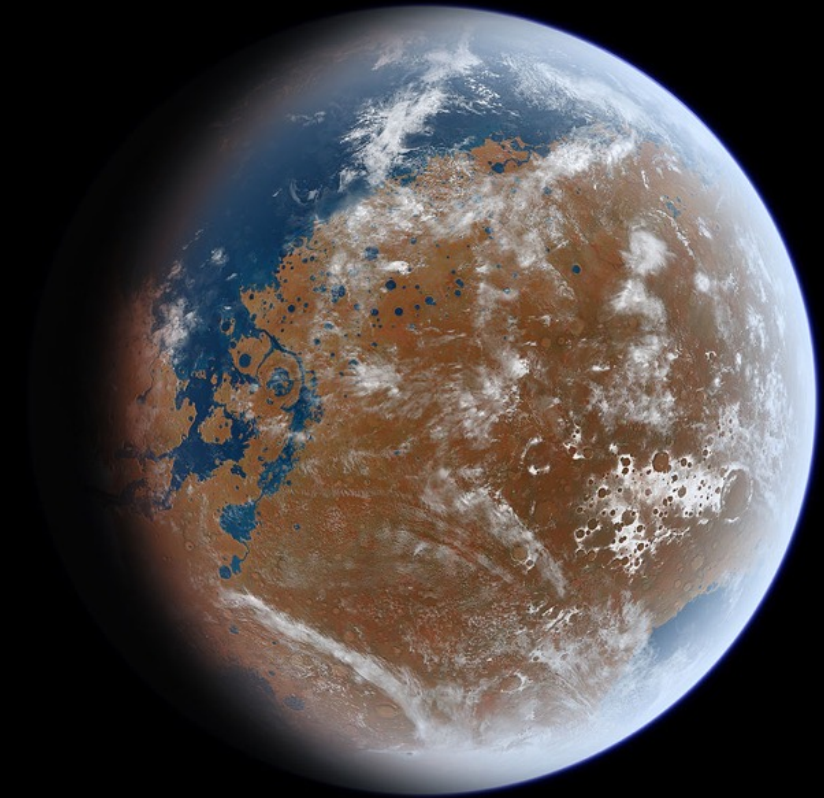


Dingo Gap, from *Curiosity*

Ancient Mars: Surface Liquid Water



Modern Mars



Mars ~ 3.6 billion years ago (?)

MARS EXPLORATION PROGRAM GOALS

1

WATER

LIFE

Determine if life ever arose on Mars

2

HABITABLE ZONES

CLIMATE

Understand Martian climate processes and history

3

SIGNS OF LIFE

GEOLOGY

Determine how the surface and interior of Mars evolved

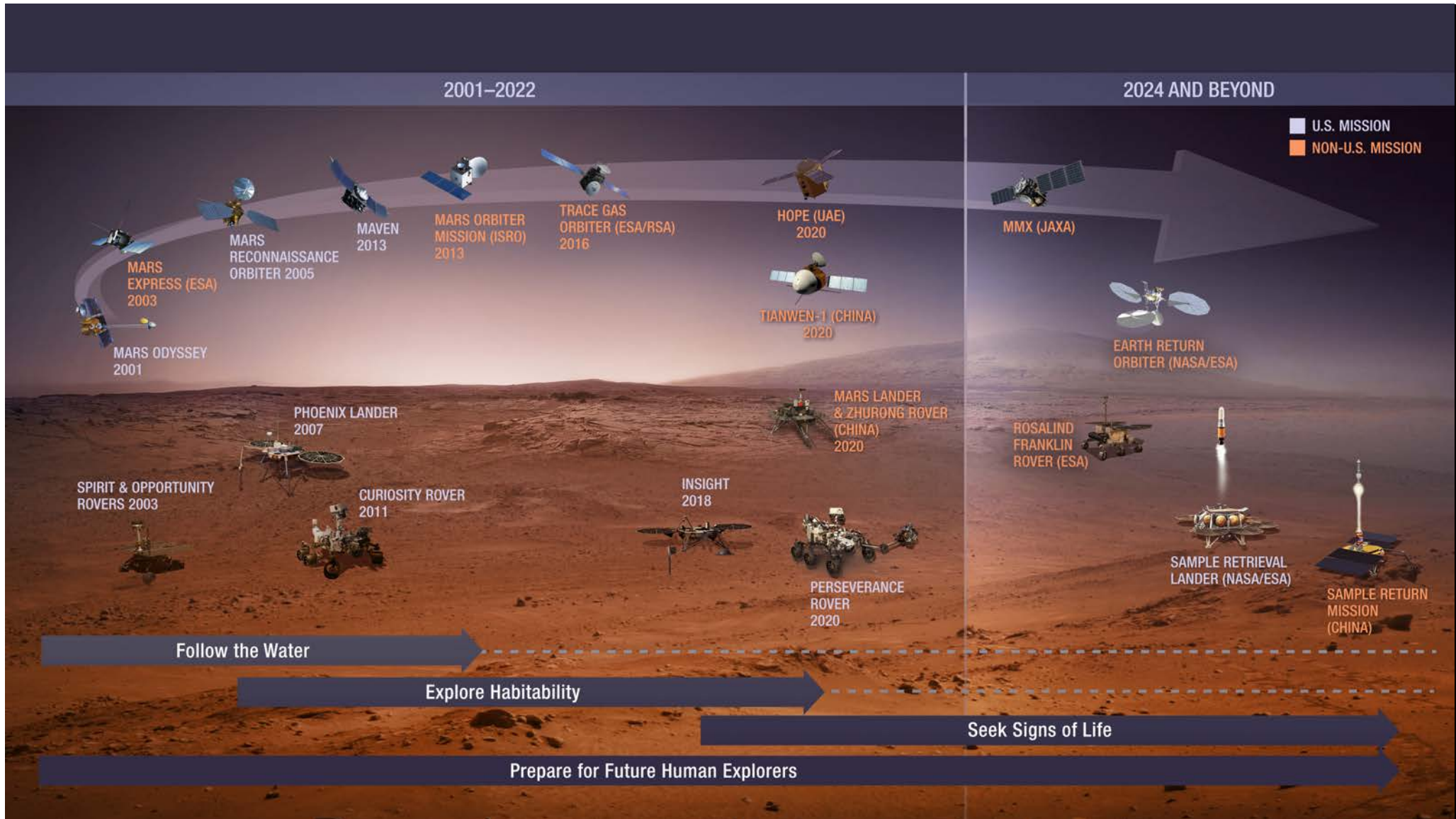
4

HUMANS

Prepare for human exploration



EVOLVING THEMES





GOAL — First Sample Return From Another Planet

A priority since 1980 and of three National Academy Decadal Surveys
A first-step “round-trip” in advance of humans to Mars

The oldest known life on Earth existed ~3.5 billion years ago,
a time when Mars was habitable. Today,
<<1% of the Earth’s surface is 3 billion years or older
>50% of the Mars’ surface is 3 billion years or older

***The first billion years and life’s beginning in the Solar System:
The record is on Mars***

What Should We Look For?



Classic Earth Fossils:
Less than
~ 650 million years old

VS



Microbial Biosignatures:
up to 3.6 billion years old
(Australian stromatolite)



SuperCam
Laser Micro-Imager

Mastcam-Z
Zoomable Panoramic Cameras

SHERLOC
Ultraviolet Spectrometer
WATSON (Camera)



MEDA
Weather Station



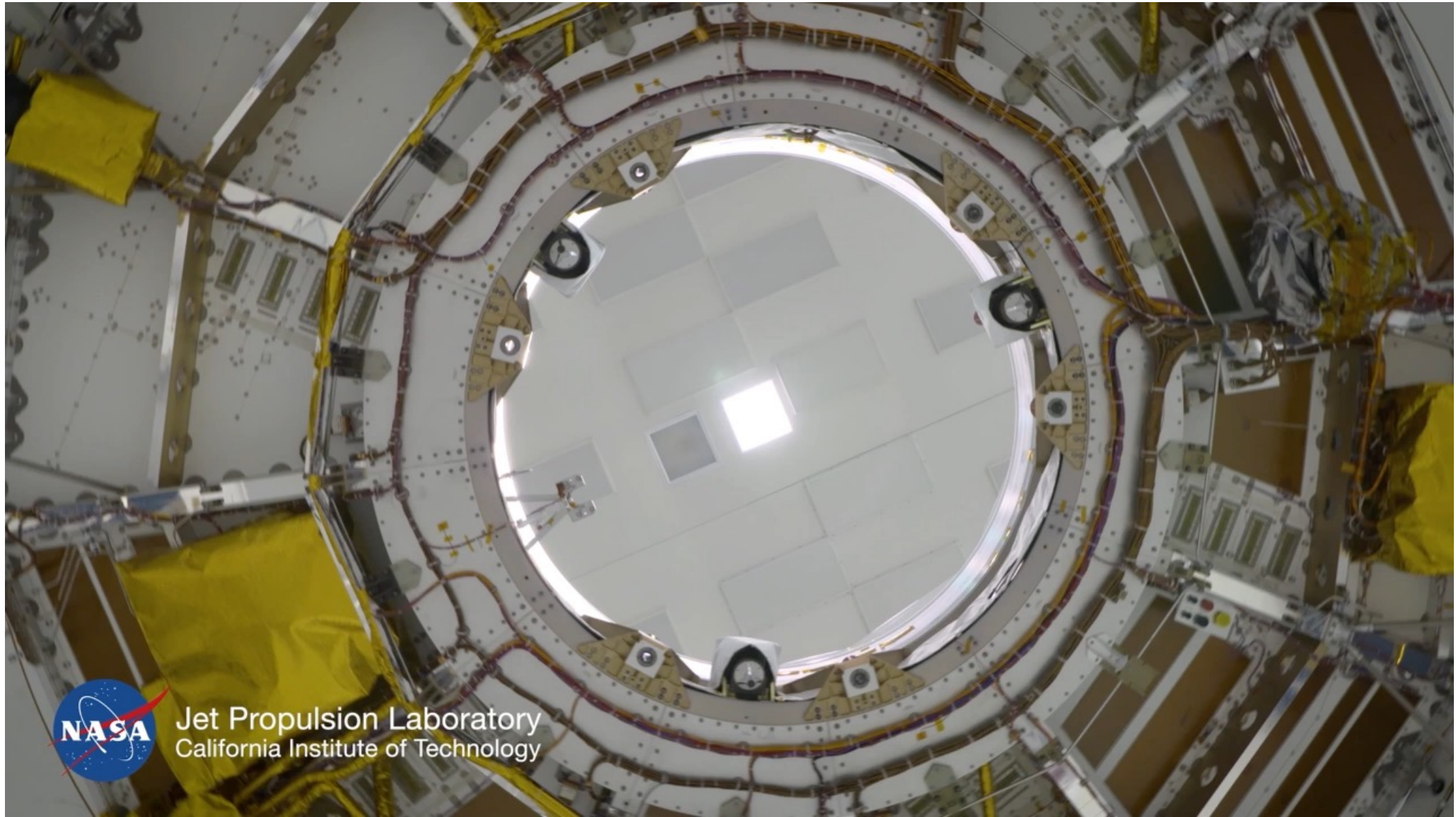
RIMFAX
Subsurface Radar

PIXL
X-ray Spectrometer

MOXIE
Produces Oxygen from Martian CO₂

SAMPLING SYSTEM
Collects samples for future return Earth



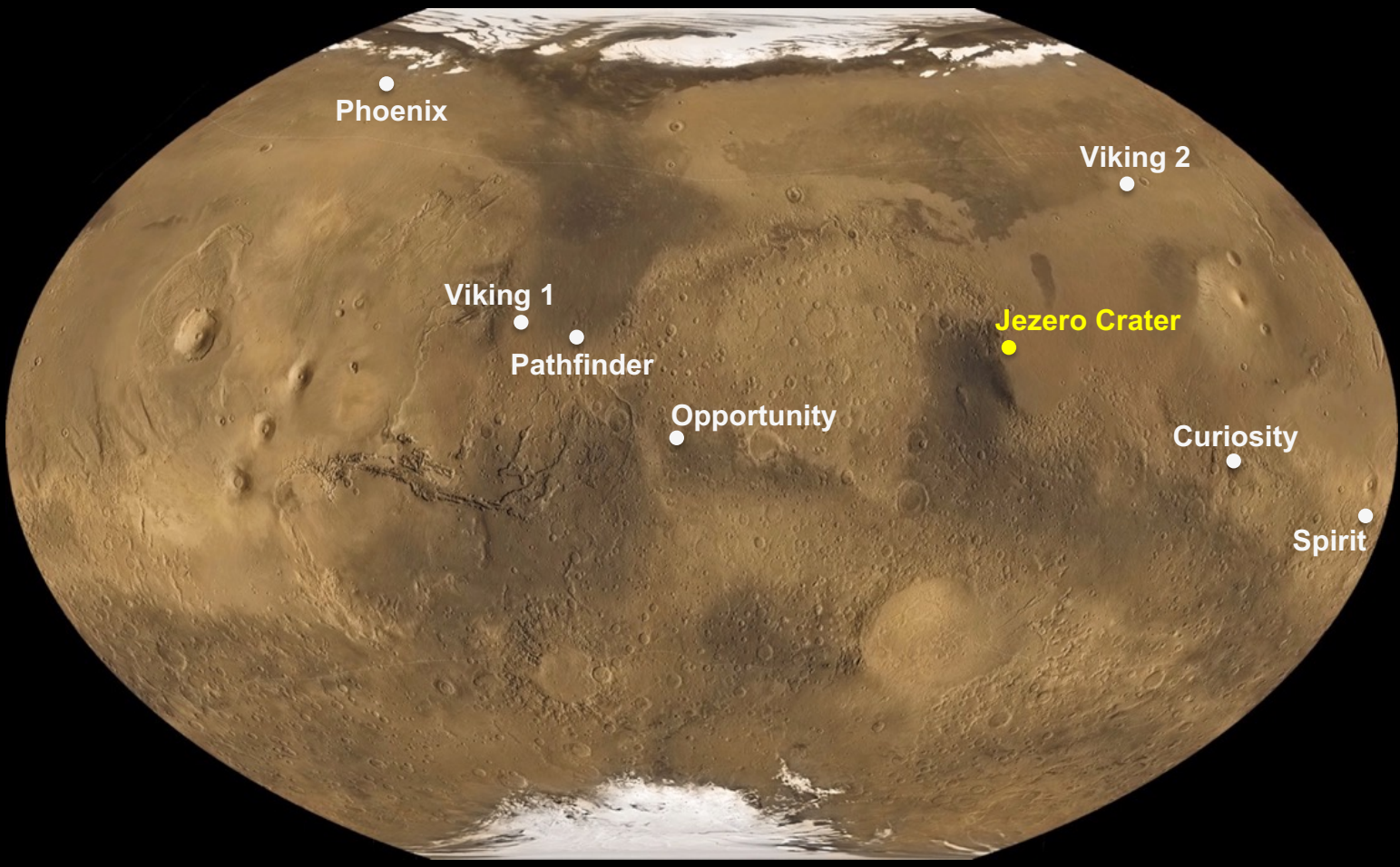


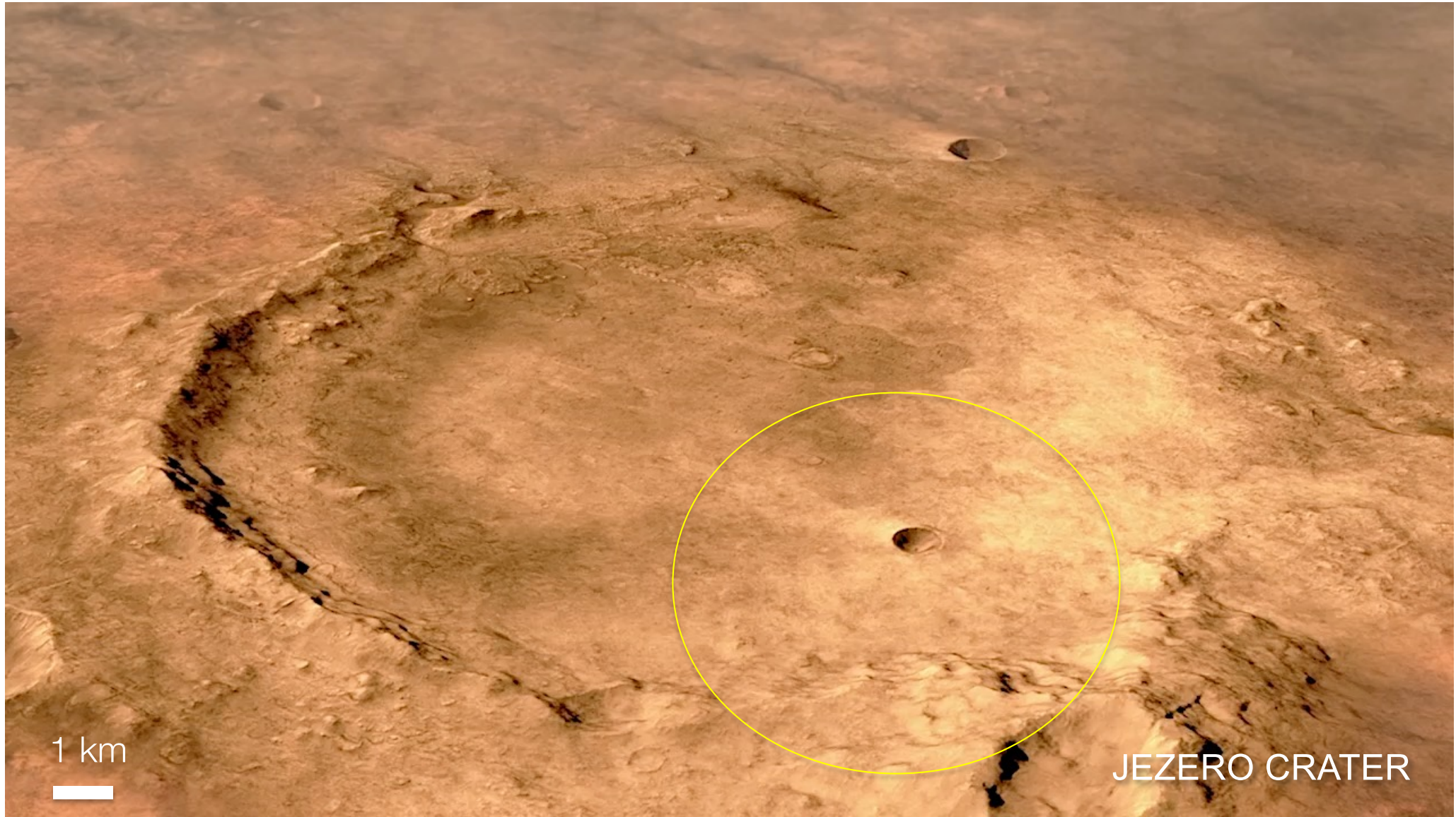
Jet Propulsion Laboratory
California Institute of Technology

**Mars 2020 / Perseverance - Atlas V Launch
July 30, 2020**



Mars 2020 Landing Site

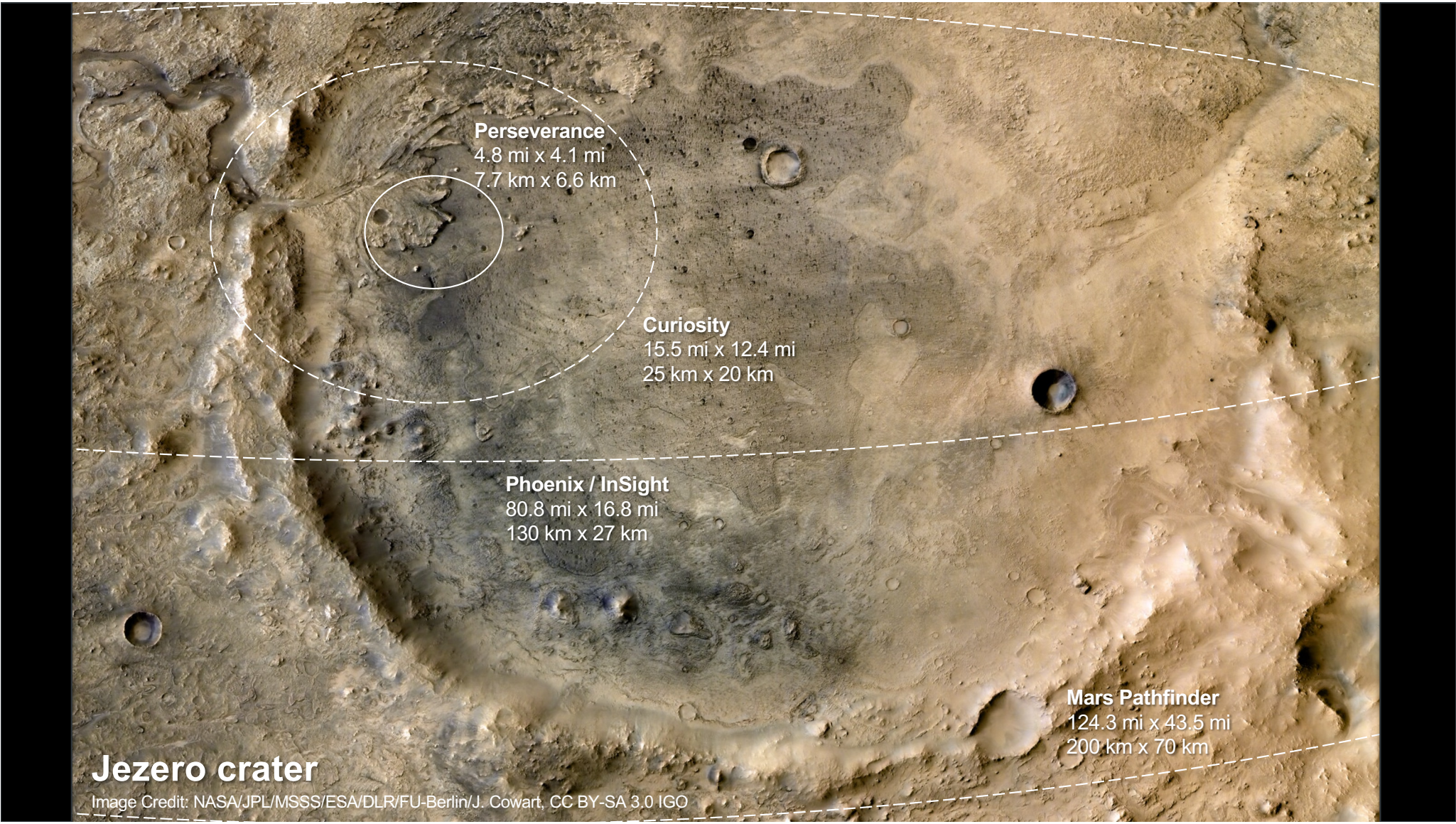




1 km



JEZERO CRATER



Perseverance
4.8 mi x 4.1 mi
7.7 km x 6.6 km

Curiosity
15.5 mi x 12.4 mi
25 km x 20 km

Phoenix / InSight
80.8 mi x 16.8 mi
130 km x 27 km

Mars Pathfinder
124.3 mi x 43.5 mi
200 km x 70 km

Jezero crater

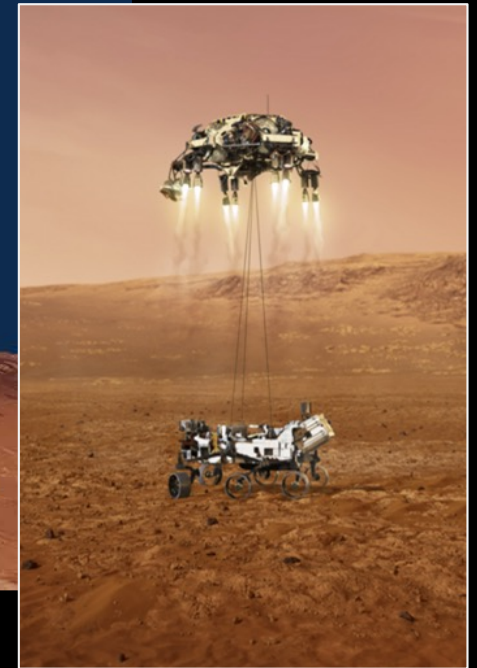
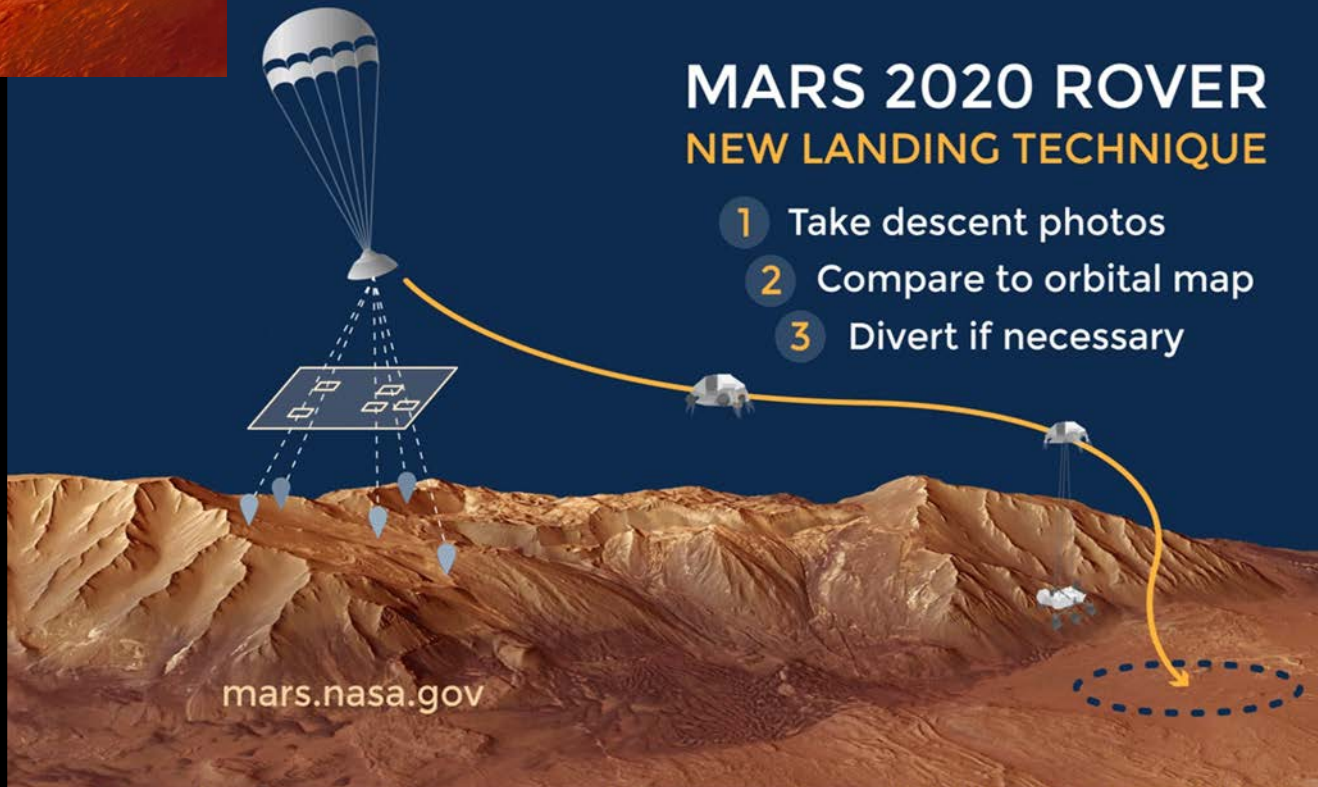
Image Credit: NASA/JPL/MSSS/ESA/DLR/FU-Berlin/J. Cowart, CC BY-SA 3.0 IGO

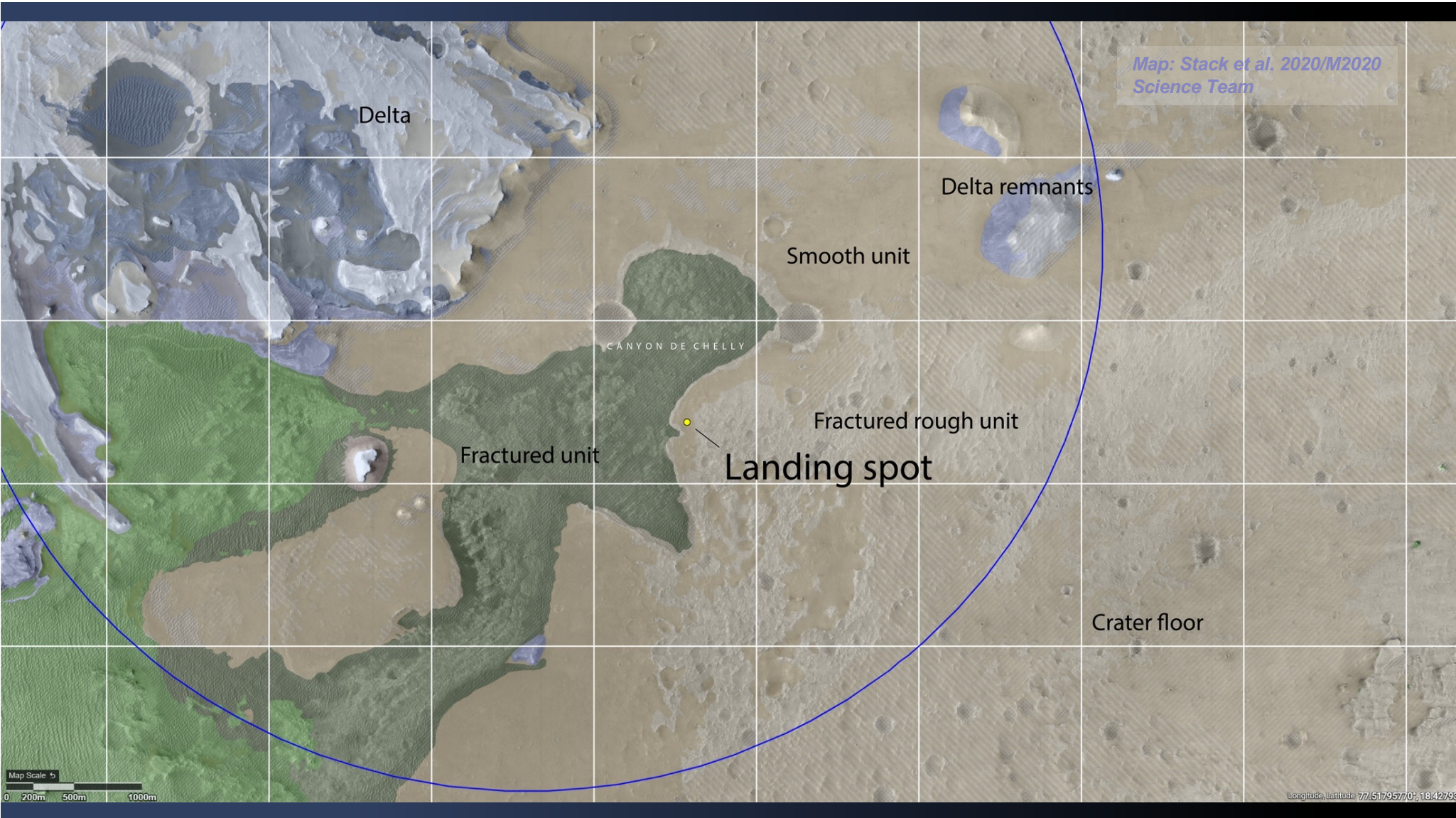
Entry, Descent, and Landing with Terrain Relative Navigation

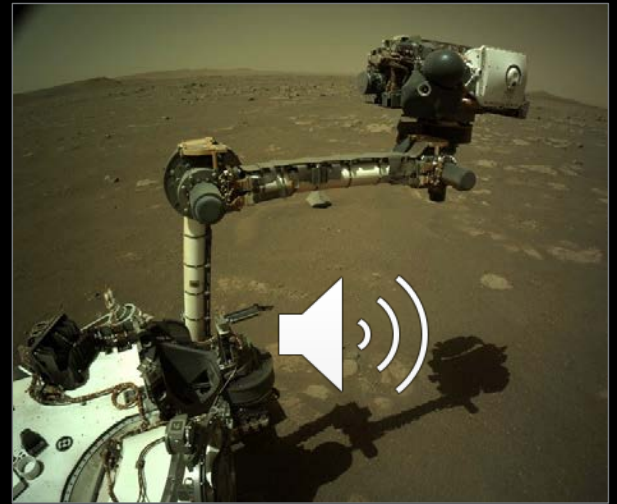
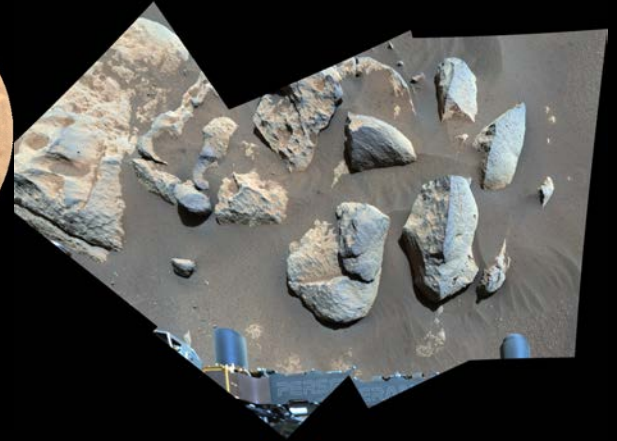
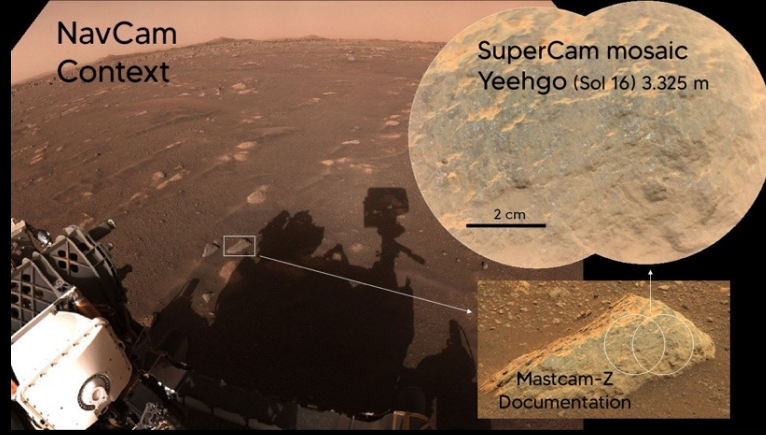


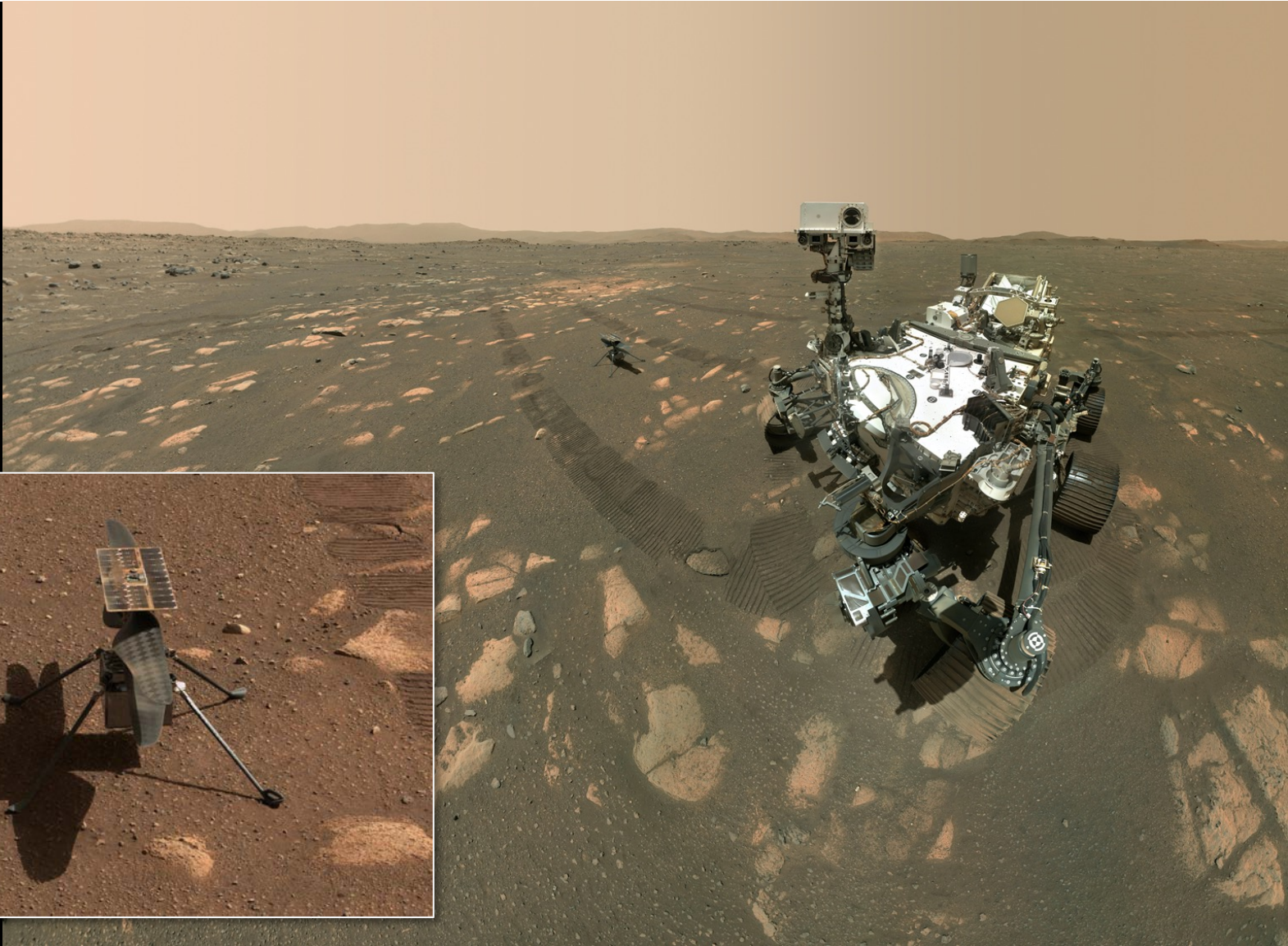
MARS 2020 ROVER NEW LANDING TECHNIQUE

- 1 Take descent photos
- 2 Compare to orbital map
- 3 Divert if necessary

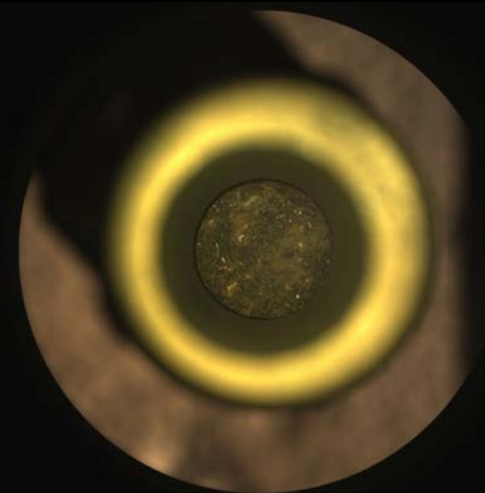
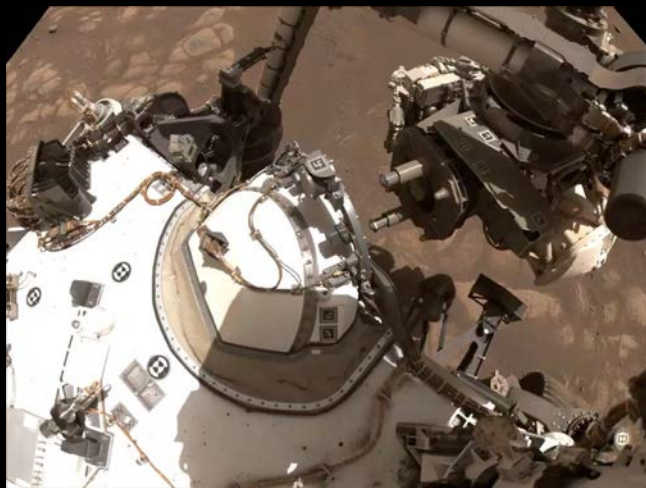






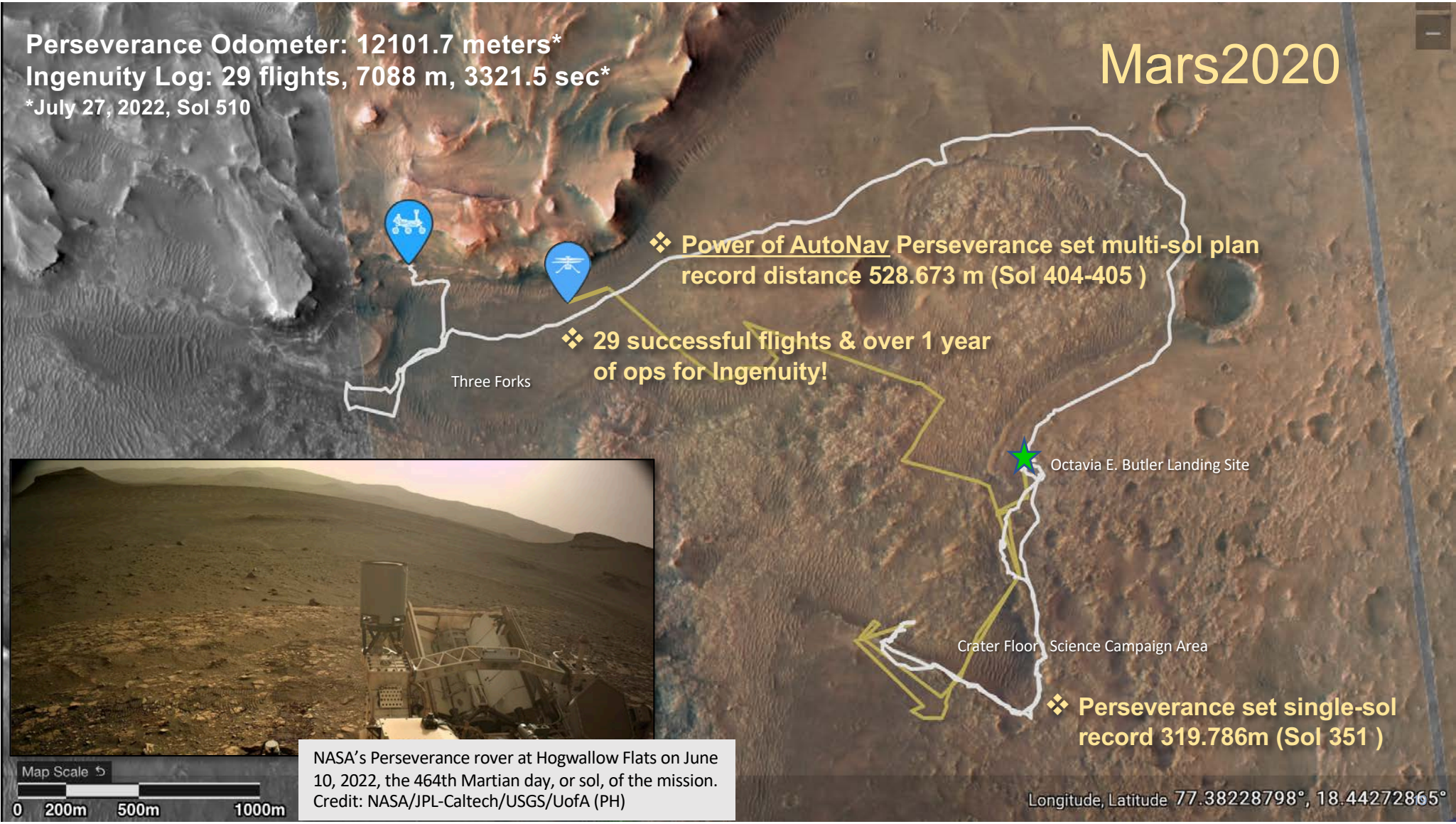


Core Drilling on "Rochette"



Perseverance Odometer: 12101.7 meters*
Ingenuity Log: 29 flights, 7088 m, 3321.5 sec*
*July 27, 2022, Sol 510

Mars2020





Samples Collected by Perseverance



Perseverance has arrived at the delta front.
Has 12 rock samples collected.

Total 15 tubes sealed:

2 Witness blanks

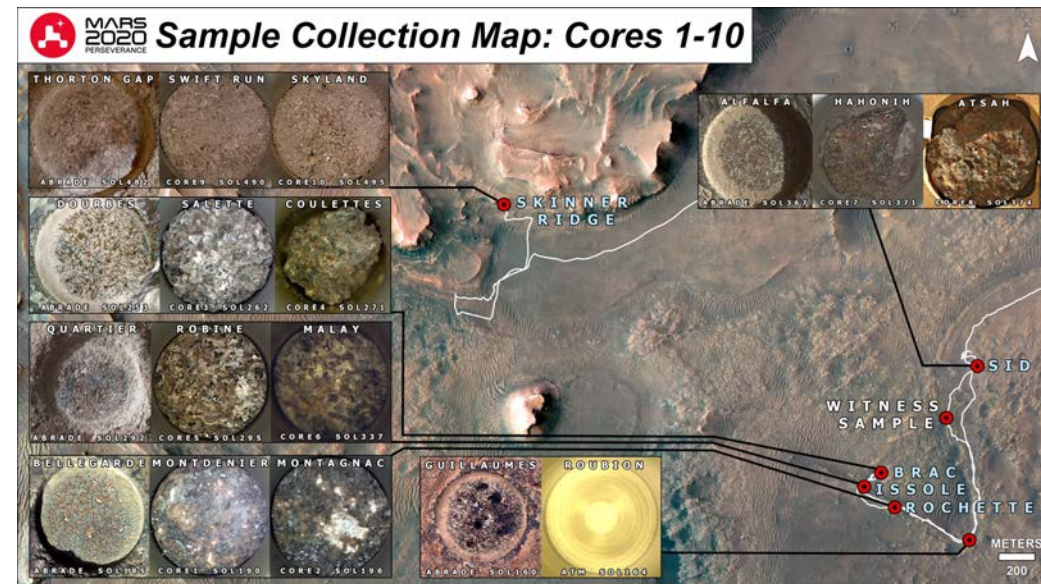
1 Atmospheric sample

6 pairs of rock core samples

An initial 30-day report is prepared for each sample that will provide contextual information on the returned samples.

Landing site characterization for the first depot at “Three Forks” are underway.

Science Community Workshop for depot of the first sample set is being planned for last week in September 2022



 Sampling Sites



Mars Sample Return:

Potential benefits from samples already cached

- Igneous rocks will provide absolute age of the Jezero crater region and anchor the ages of Martian epochs
- Salts and other products of aqueous alteration will provide insights into the history of water in this region on Mars
- Organic compounds already detected in some samples – will be able to determine the specific compound(s) and potentially deduce their origin (biogenic vs abiogenic)
- The samples will help address major gaps in our knowledge for future human exploration

NASA/ESA MSR Campaign

Mars Sample Return Program

1



Sample Caching

- *Collect samples of rock and sediment*
- *Cache samples on the surface for retrieval*

2



Sample Retrieval

- *Retrieve samples cached by Mars 2020 rover*
- *Launch samples into orbit around Mars*

3



Earth Return

- *Capture and contain samples in Mars orbit*
- *Safely return samples to Earth for recovery at landing site*

4



Sample Receiving

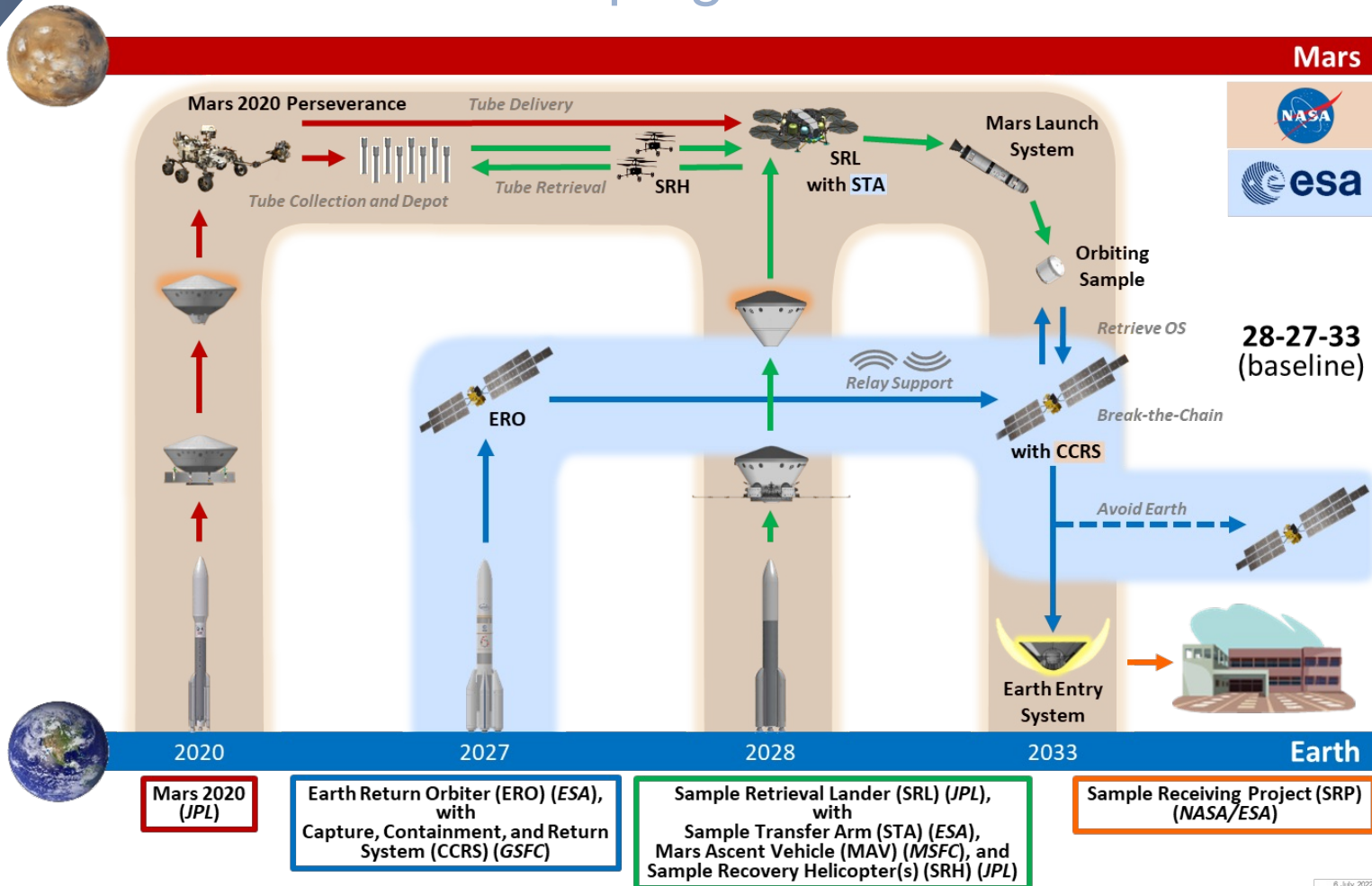
- *Transport contained samples to receiving facility*
- *Safety assessment and sample containment*
- *Initial sample science and curation*

**Long-term
Curation &
Science
Investigations
NASA/ESA**

- The MSR Campaign spans flight elements and one ground element
- The MSR Program manages development and operations of Sample Retrieval and Earth Return and interfaces to Sample Caching and Sample Receiving; program concludes upon safe return at the landing site
- The MEP Program manages M2020 Phase E operations and is the home of the future Sample Receiving Project



MSR Campaign Architecture

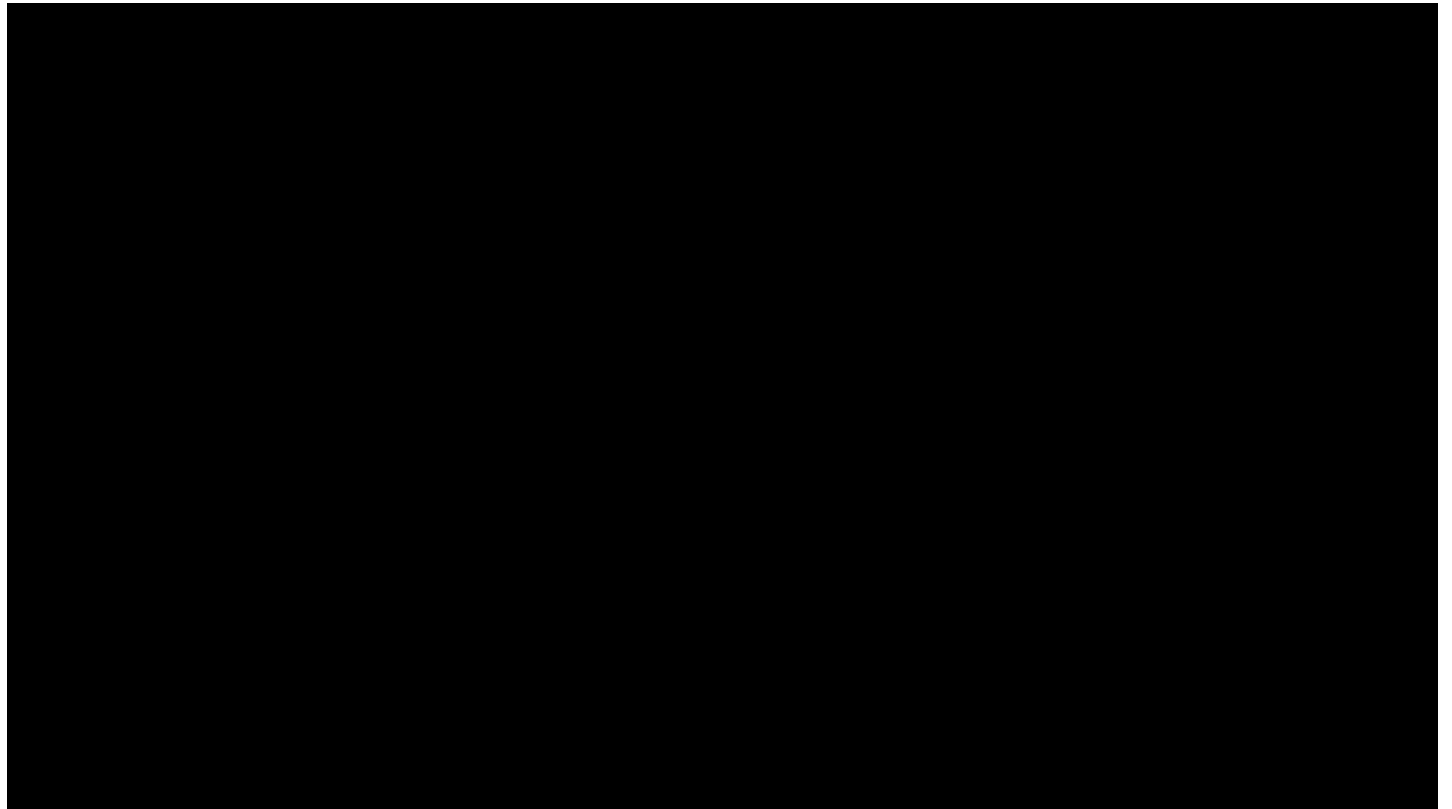




Vertically Ejected Controlled Tip-Off Release (VECTOR)



- VECTOR is a pre-ignition separation mechanism for the Mars Ascent System (MAS)
- VECTOR provides a MAS separation state with a vertical velocity and pitch rate
- MAS ignition occurs a set time after separation within an established window that allows for successful flyaway





Earth Entry Vehicle

Manufacturing Demonstration Unit #1

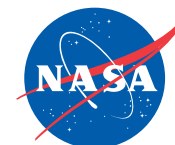
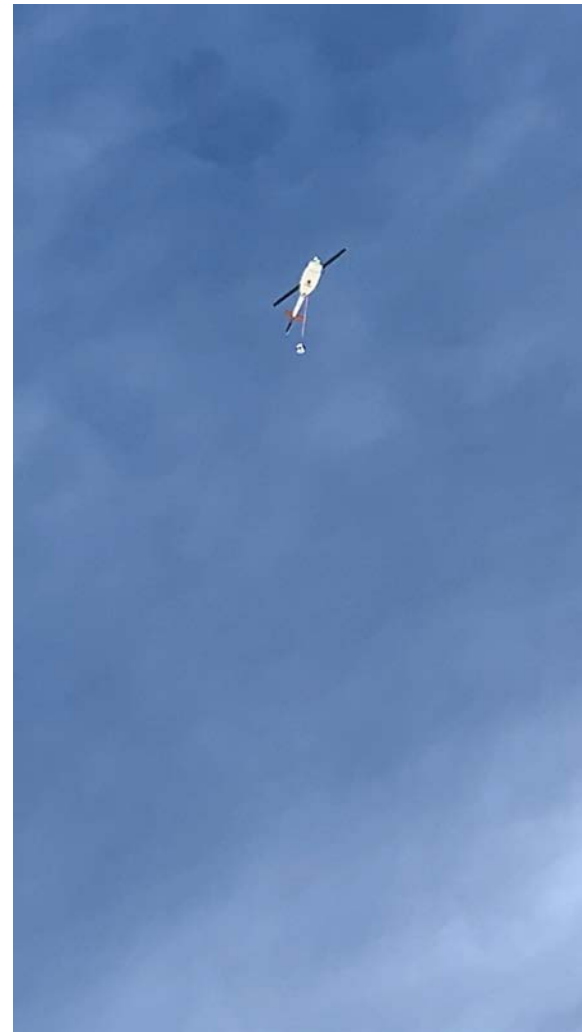
Drop Altitude: ~1000 ft

Terminal Velocity at impact: ~33 m/s / ~74 mph

Utah Test and Training Range – March 1, 2022



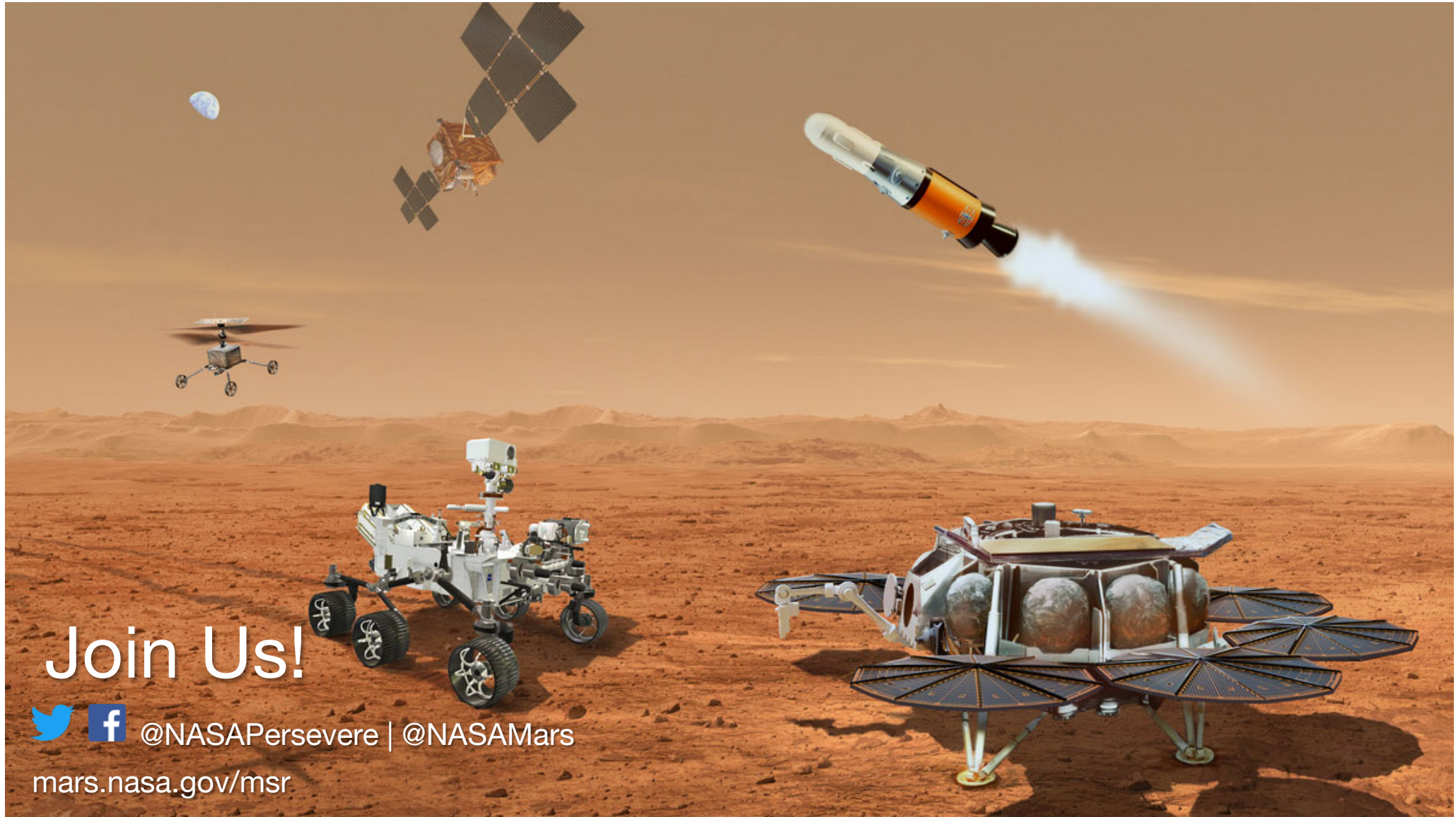
NASA / USAF Team Photo



Summary

- This is the most significant planetary science undertaking in a generation
- Now is the time!
 - Perseverance on surface of Mars collecting samples
 - Orbital Relay assets in place around Mars
- MSR is made possible by strong and significant partnerships with European colleagues at ESA and their industrial consortiums





Join Us!

  @NASAPersevere | @NASAMars

mars.nasa.gov/msr

An aerial photograph of the Perseverance rover on the surface of Mars. The rover is a large, six-wheeled vehicle with a complex array of instruments and cameras. It is positioned on a dark, rocky terrain with scattered reddish-brown patches. In the distance, a small helicopter, the Ingenuity, is visible on the ground. The sky is a hazy, orange-brown color, typical of the Martian atmosphere.

Join Us!



@NASAPersevere | @NASAMars

mars.nasa.gov/mars2020

mars.nasa.gov/people

Backup



MARS
2020
PERSEVERANCE

UNDERSTANDING THE POSSIBILITIES FOR LIFE ON MARS

ANCIENT MICROBIAL LIFE

HUMAN LIFE

Objective A:
Geology



Objective B:
Astrobiology



Objective C:
Sample Caching



Objective D:
Prepare for Humans



LAUNCH

- Atlas V 541 vehicle
- Launched July 30, 2020

CRUISE/APPROACH

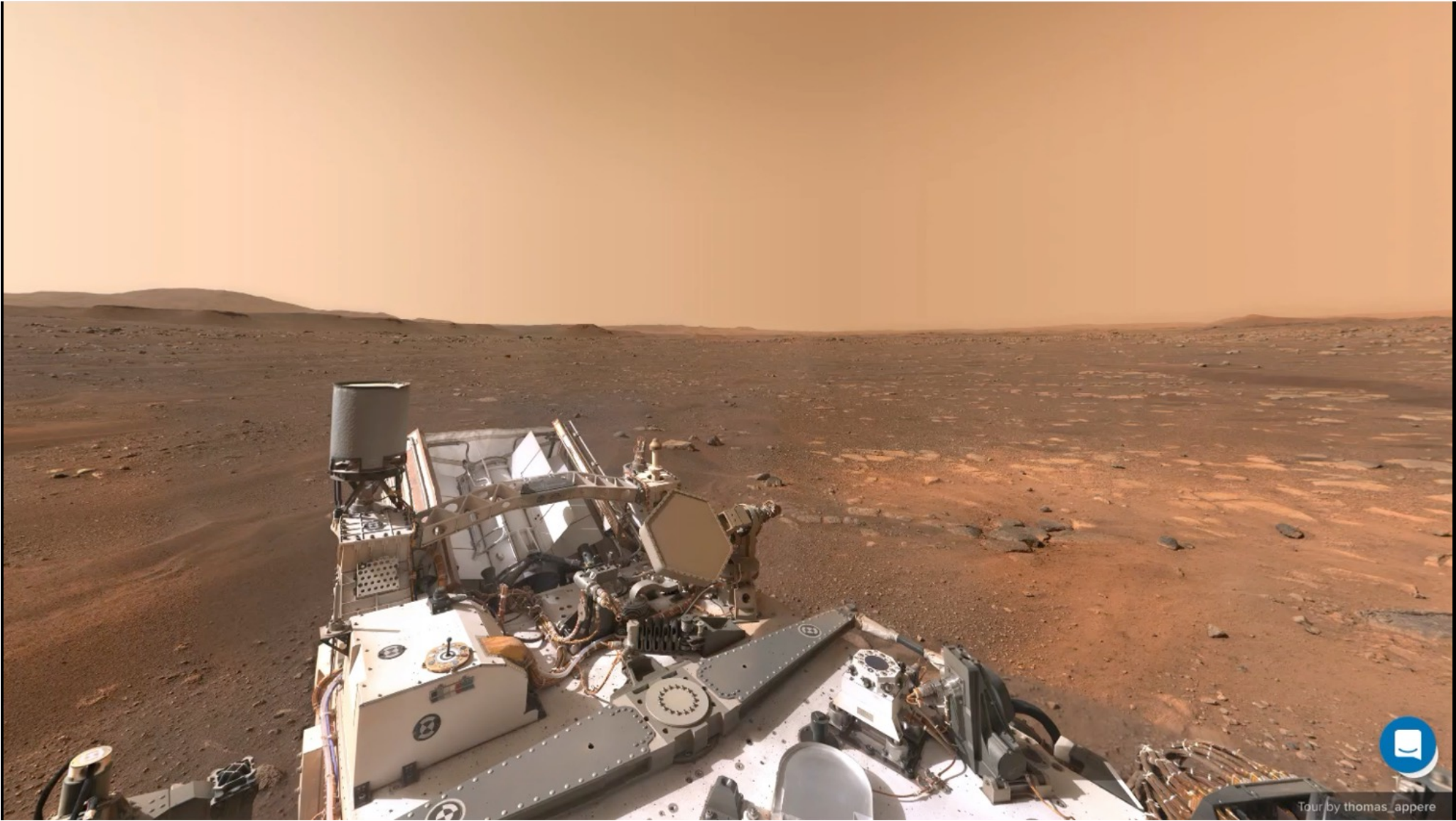
- ~7 month cruise
- Arrived Feb 18, 2021

ENTRY, DESCENT & LANDING

- Curiosity-based EDL system: guided entry and powered descent/Sky Crane
- Access to landing sites $\pm 30^\circ$ latitude, ≤ -0.5 km elevation

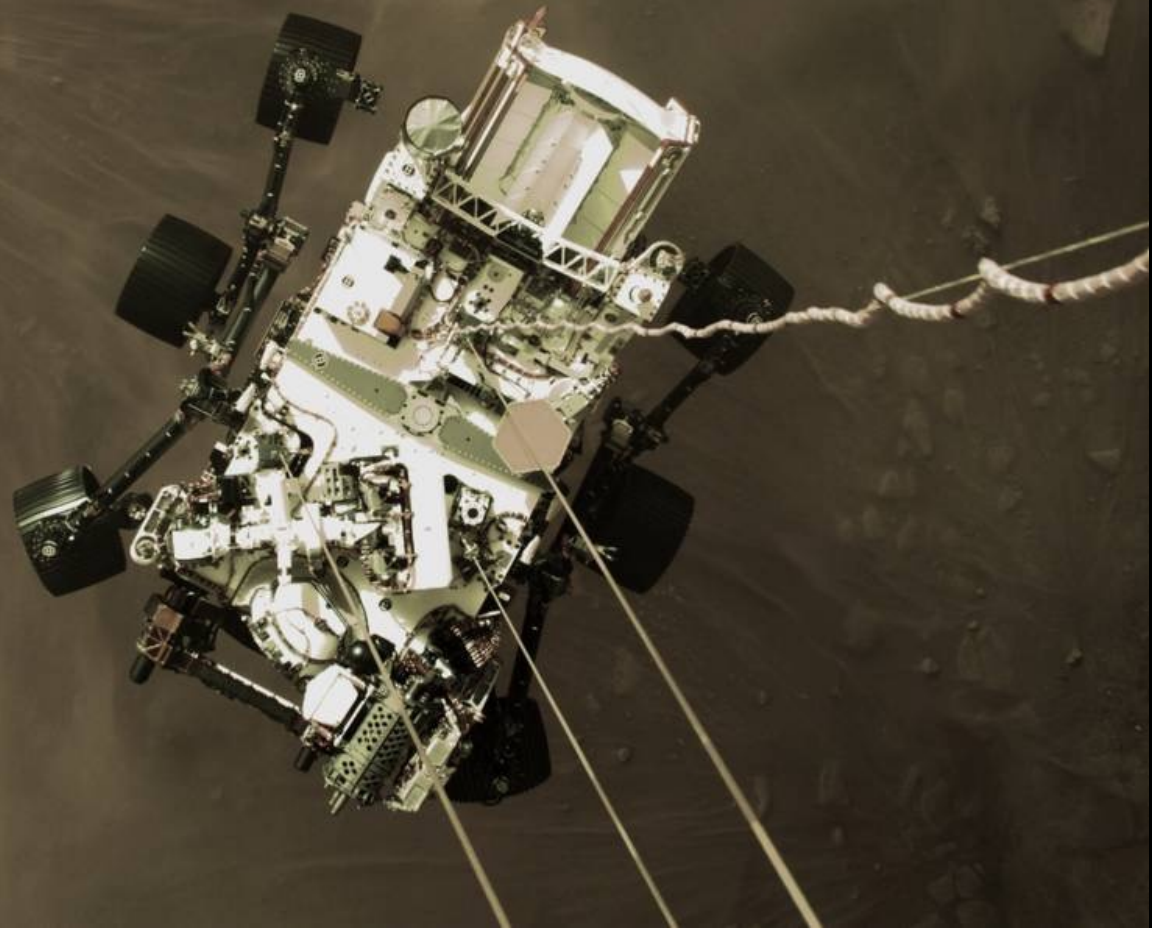
SURFACE MISSION

- Curiosity-class Rover
- 20 km traverse distance capability
- Qualified to 1.5 Martian year lifetime



FEBRUARY 18, 2021

First image ever of a spacecraft landing on another planet



Rover first driving test at Jet Propulsion Laboratory

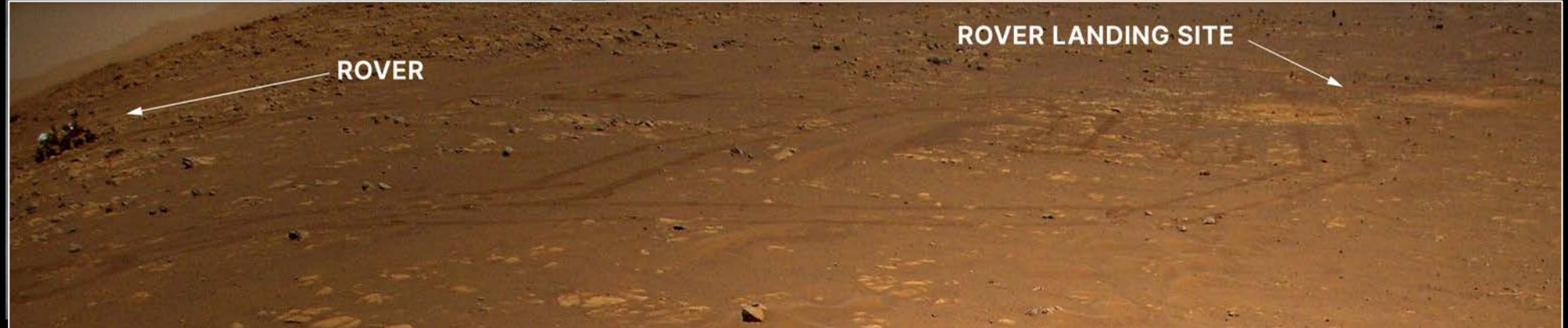
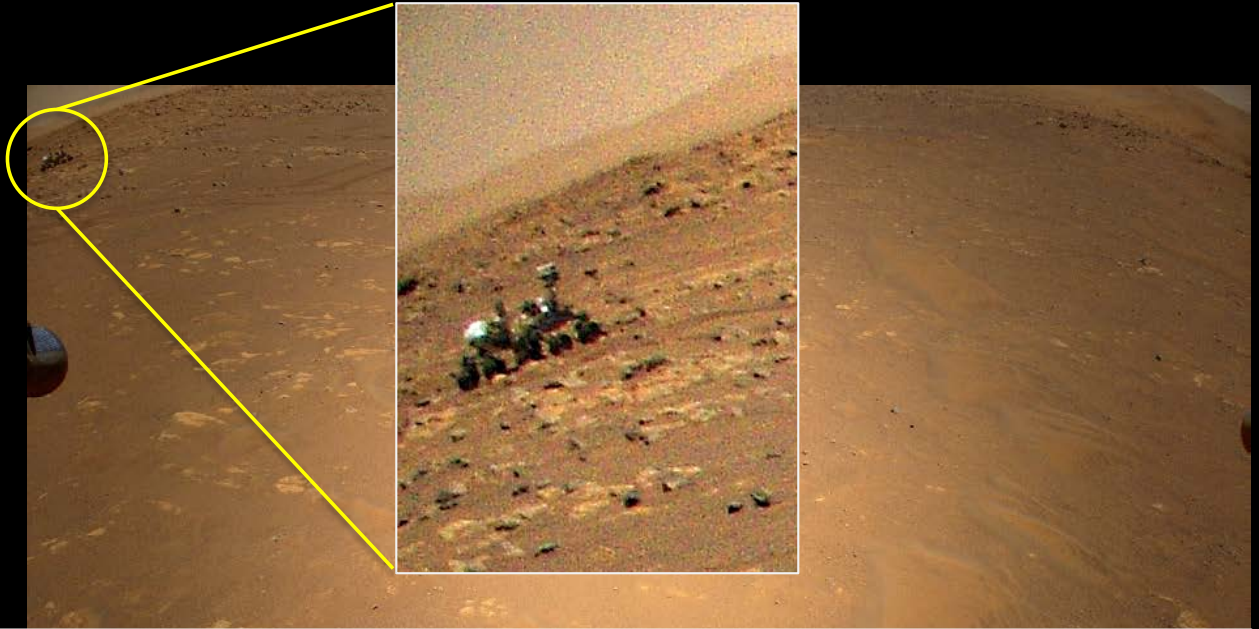


Rover and "Skycrane" Separation Test



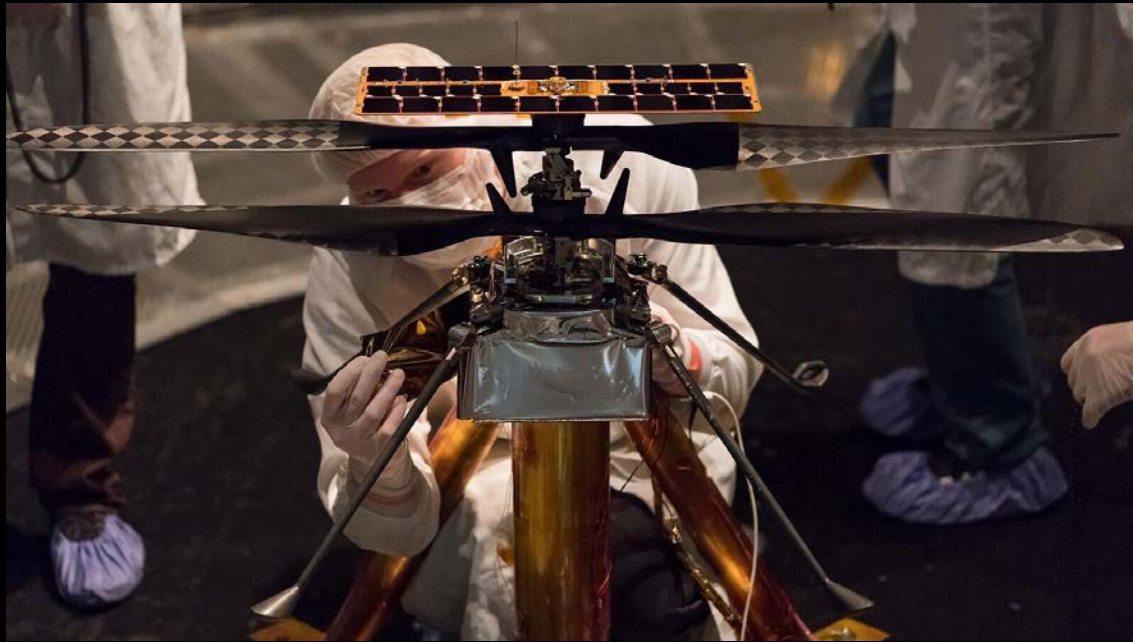
Spacecraft Thermal Vacuum Test





ROVER

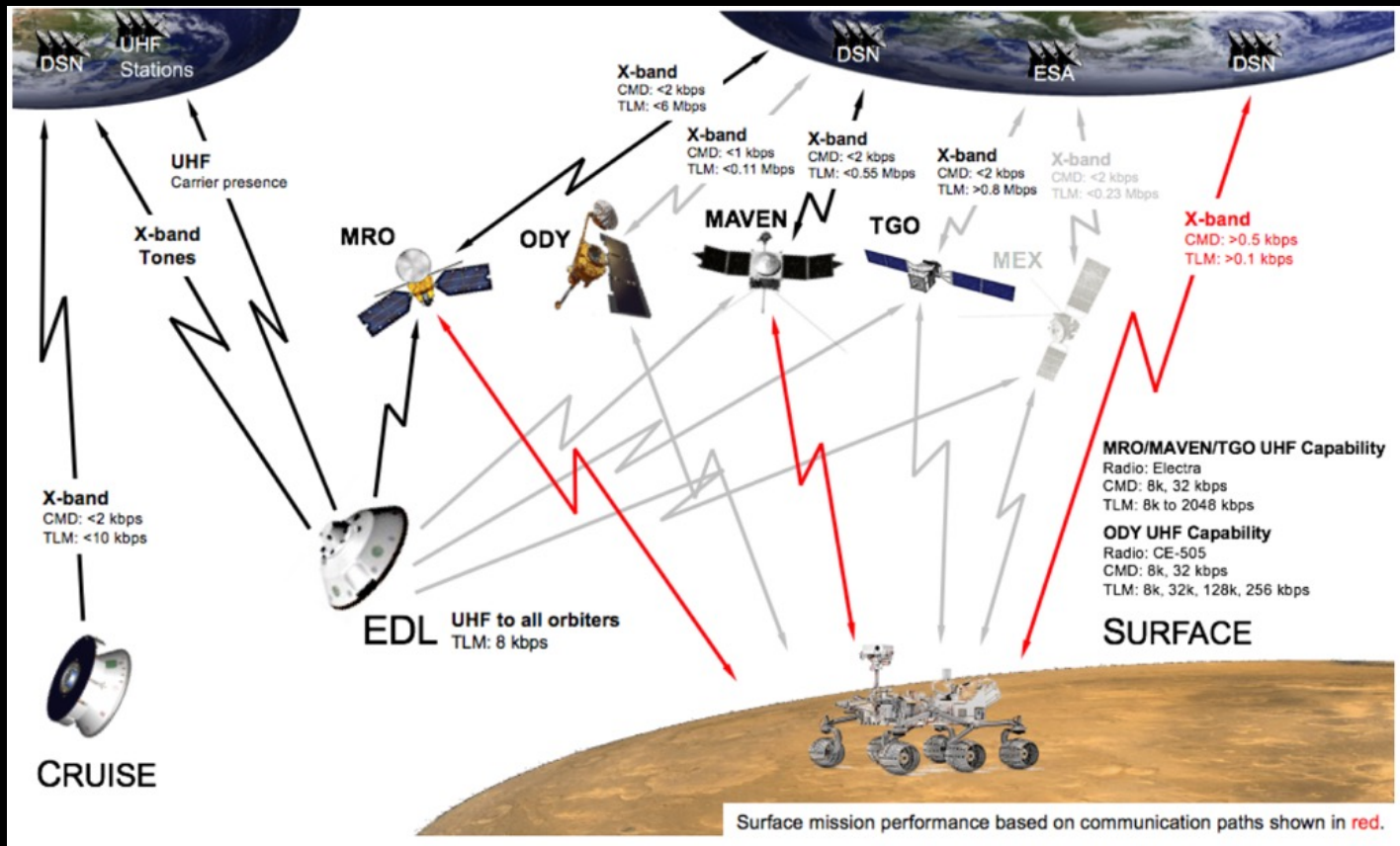
ROVER LANDING SITE



Mars helicopter "Ingenuity"



M2020 Communication Links



*Mars 2020 requires substantially more data downlink volume than MSL.
Planning use of both MRO and MAVEN for relay.*