Update on Planetary Science at JPL

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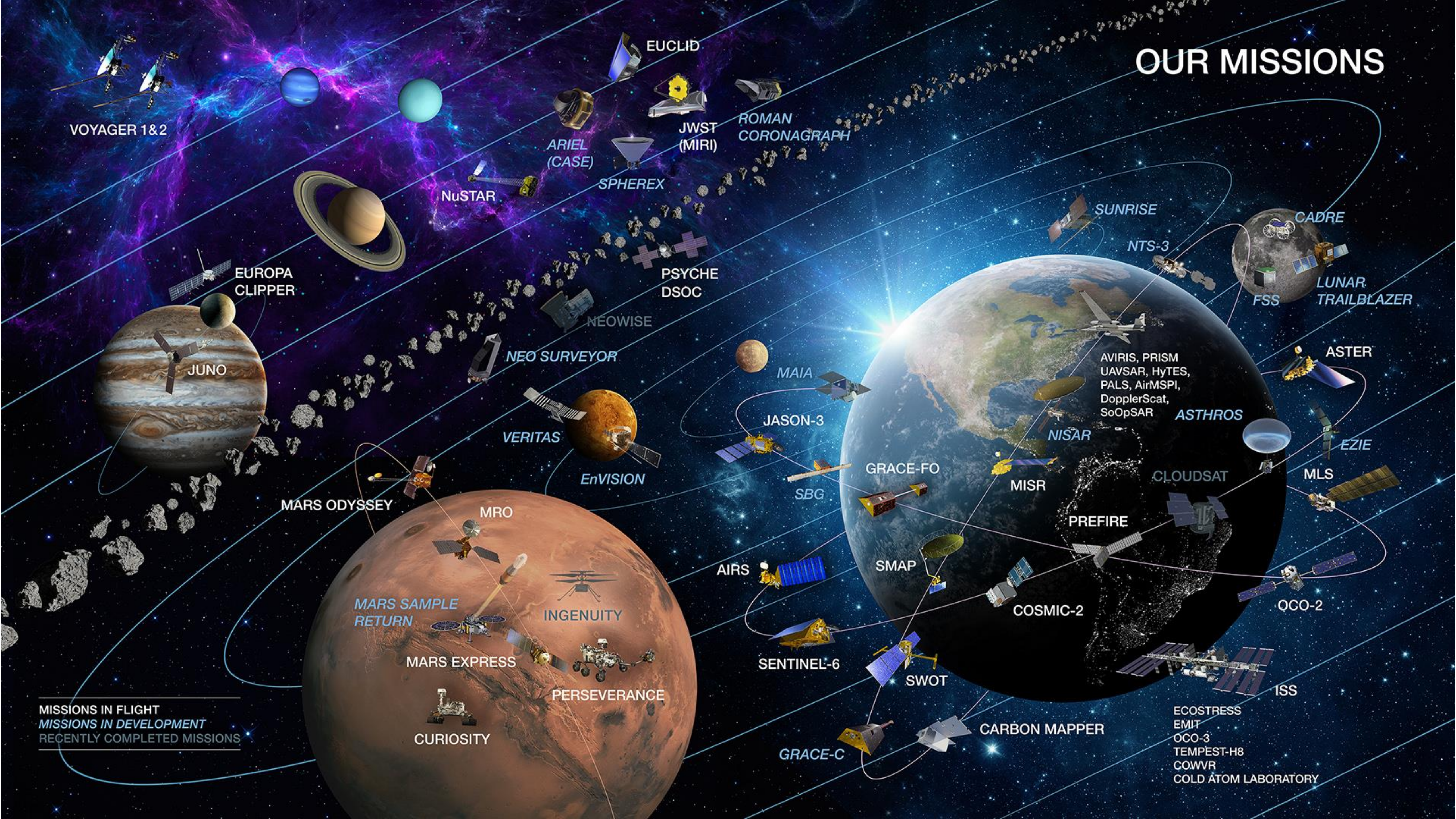
Planetary Science Directorate

JPL / California Institute of Technology

Presentation to CAPS

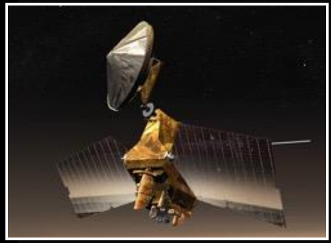
October 22, 2024


OUR MISSIONS
VOYAGER 1&2
EUCLID
ARIEL (CASE)
JWST (MIRI)
ROMAN CORONAGRAPH
SPHEREX
NuSTAR
EUROPA CLIPPER
PSYCHE DSOC
NEOWISE
NEO SURVEYOR
JUNO
VERITAS
EnVISION
MARS ODYSSEY
MRO
MARS SAMPLE RETURN
INGENUITY
MARS EXPRESS
PERSEVERANCE
CURIOSITY
MISSIONS IN FLIGHT
MISSIONS IN DEVELOPMENT
RECENTLY COMPLETED MISSIONS
SUNRISE
NTS-3
CADRE
FSS
LUNAR TRAILBLAZER
AVIRIS, PRISM
UAVSAR, HyTES,
PALS, AirMSPI,
DopplerScat,
SoOpSAR
ASTHROS
ASTER
EZIE
MAIA
JASON-3
NISAR
GRACE-FO
SBG
MISR
CLOUDSAT
MLS
PREFIRE
AIRS
SMAP
COSMIC-2
OCO-2
SENTINEL-6
SWOT
ISS
ECOSTRESS
EMIT
OCO-3
TEMPEST-H8
COWVR
COLD ATOM LABORATORY
CARBON MAPPER
GRACE-C

Planetary Science @JPL: Position Our Community to Execute the Planetary Science Missions of the Coming Decade

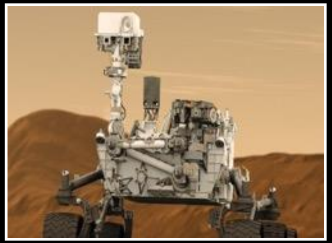
In Operations:

Mars Odyssey (2001)



Mars Reconnaissance Orbiter (2005)

Juno (2011)



Curiosity (2012)

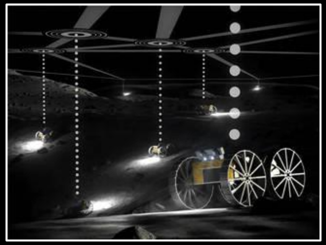
Perseverance (2020)

Psyche (2023)

Europa Clipper (2024)

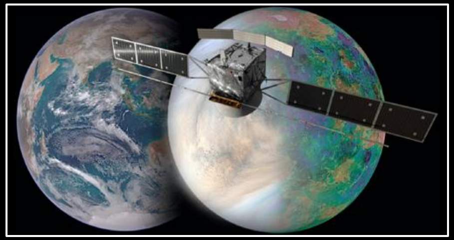
In Development:

Lunar Trailblazer (2025)



CADRE Rovers (TBD, IM-3)

FSS (2025)



VENSAR (2031)

VERITAS (TBD 2031?)

In Study:

Mars Sample Return

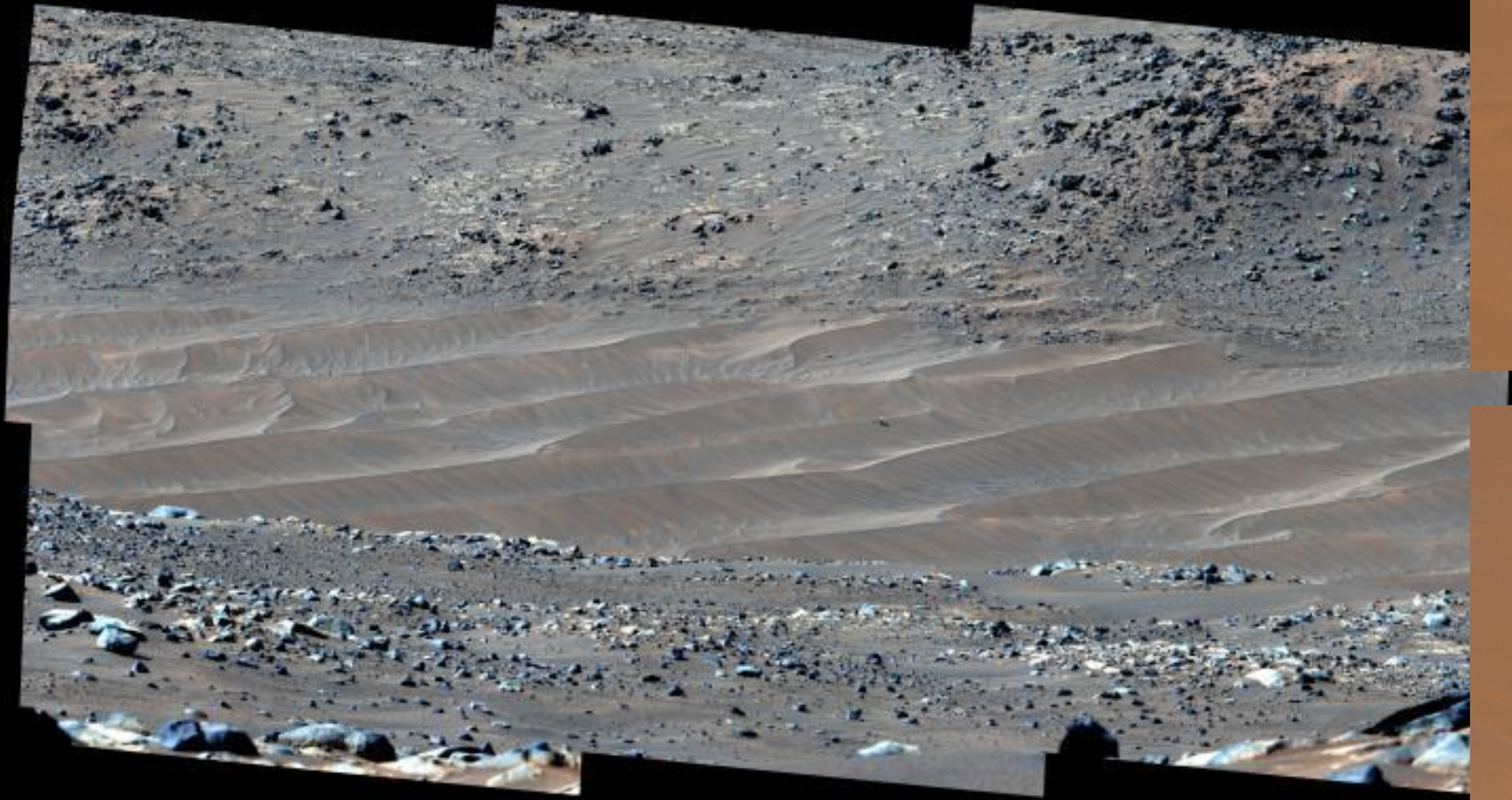
Endurance

Missions in Operations

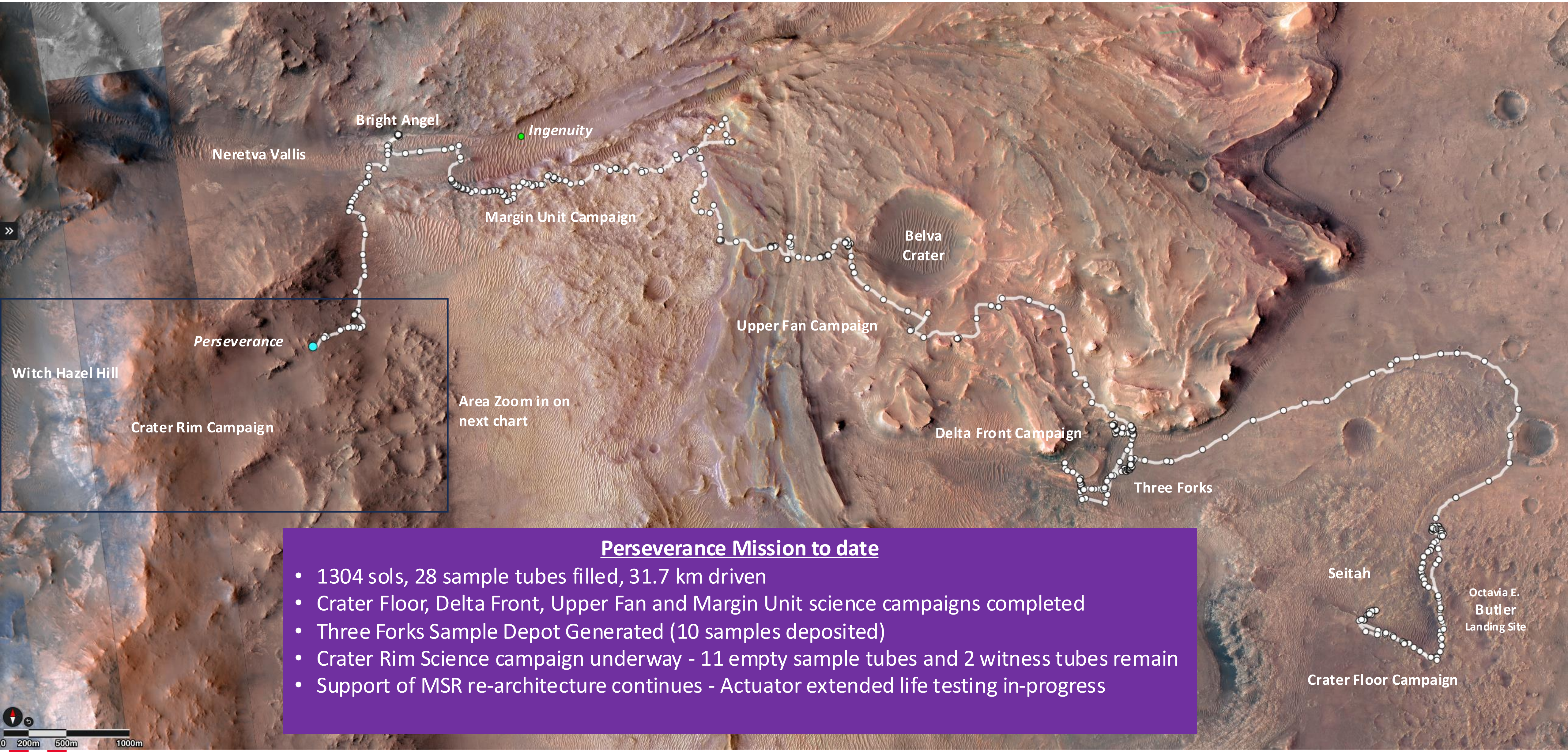
Mars 2020
Perseverance and Ingenuity

- Crater Floor and Fan Front Science Campaigns complete
- Three Forks Sample Depot Generated
- Now starting Crater Rim Campaign

Ingenuity final airfield



Mars 2020 Perseverance Status

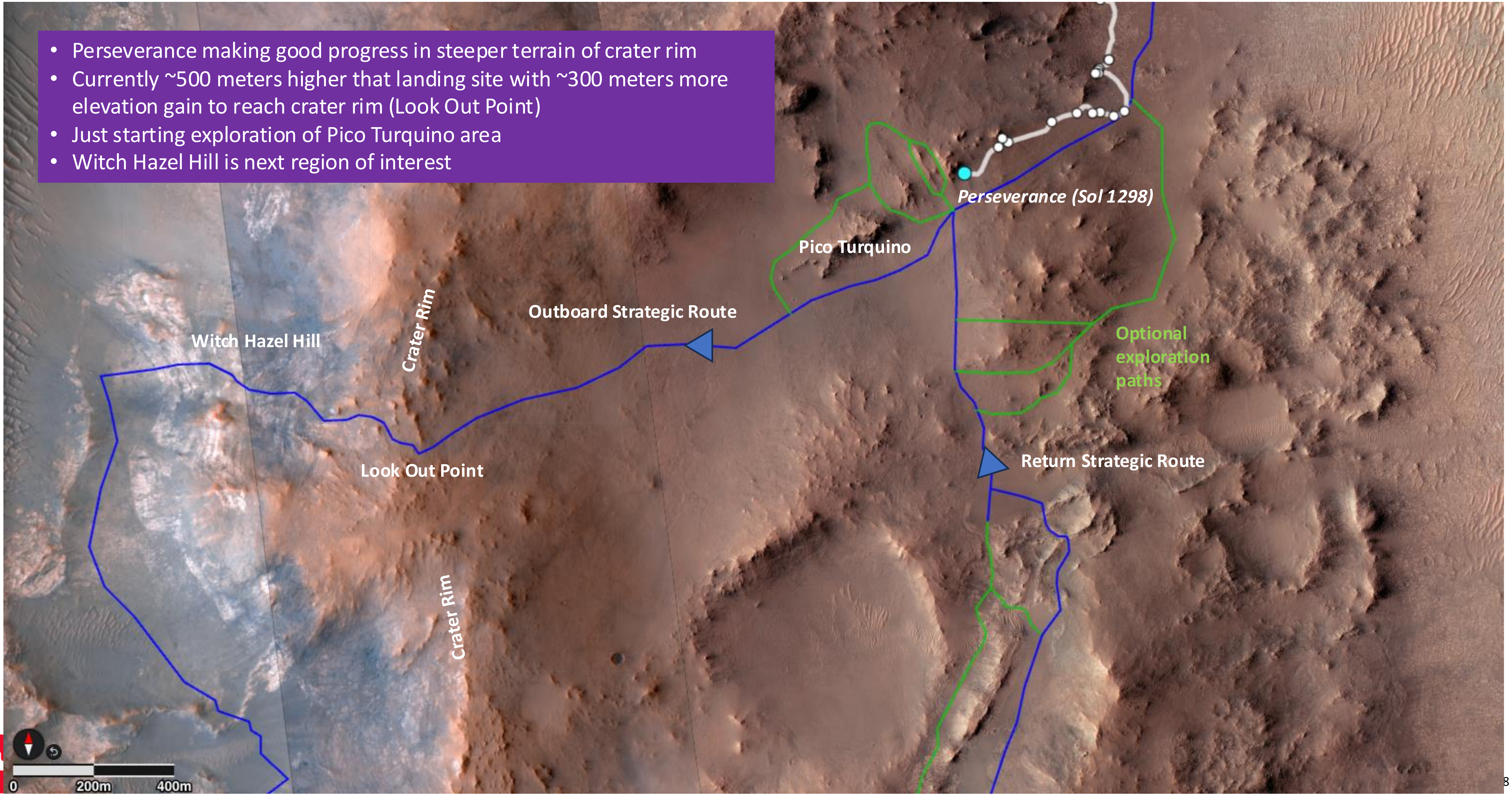


Perseverance Mission to date

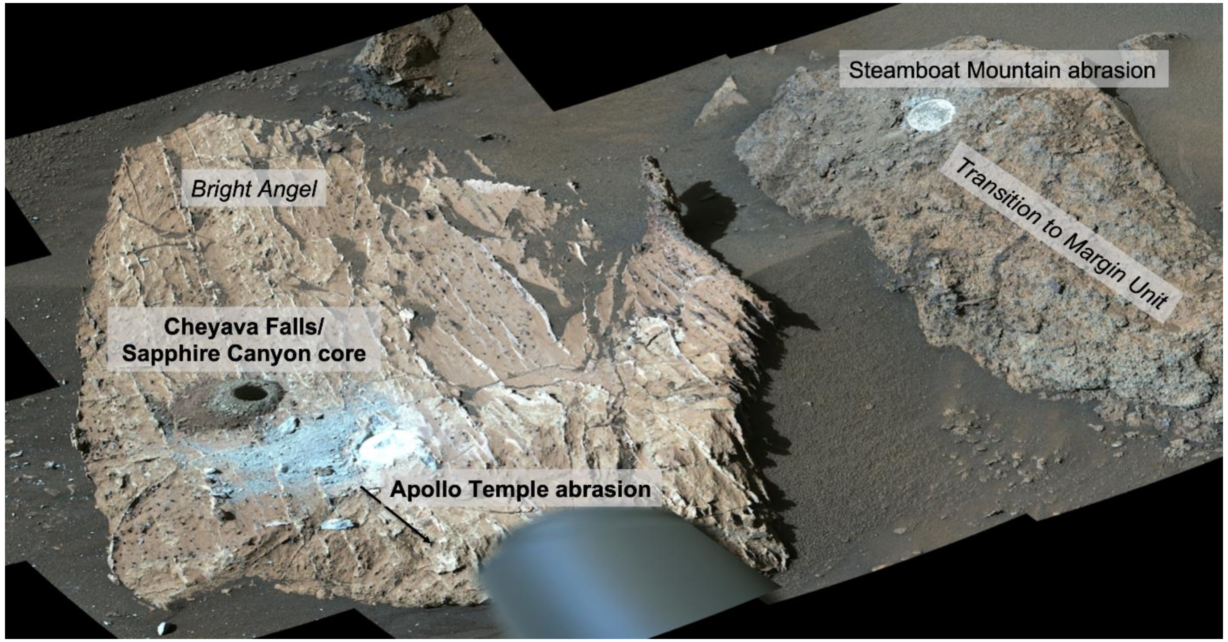
- 1304 sols, 28 sample tubes filled, 31.7 km driven
- Crater Floor, Delta Front, Upper Fan and Margin Unit science campaigns completed
- Three Forks Sample Depot Generated (10 samples deposited)
- Crater Rim Science campaign underway - 11 empty sample tubes and 2 witness tubes remain
- Support of MSR re-architecture continues - Actuator extended life testing in-progress

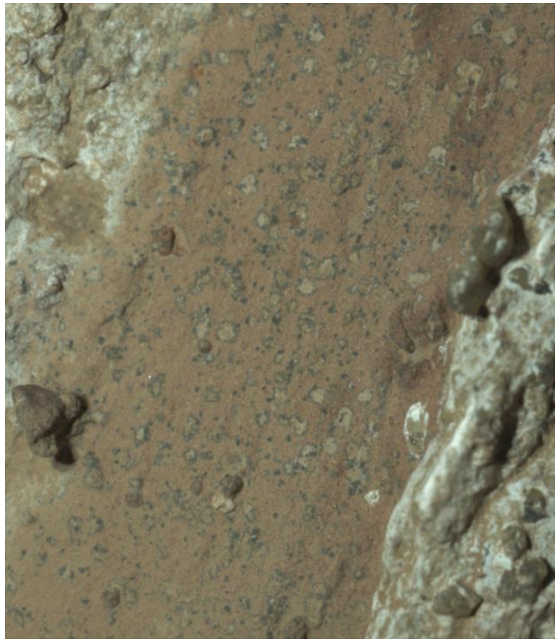
Beginning of Crater Rim Campaign

- Perseverance making good progress in steeper terrain of crater rim
- Currently ~500 meters higher that landing site with ~300 meters more elevation gain to reach crater rim (Look Out Point)
- Just starting exploration of Pico Turquino area
- Witch Hazel Hill is next region of interest



Mars 2020 Perseverance

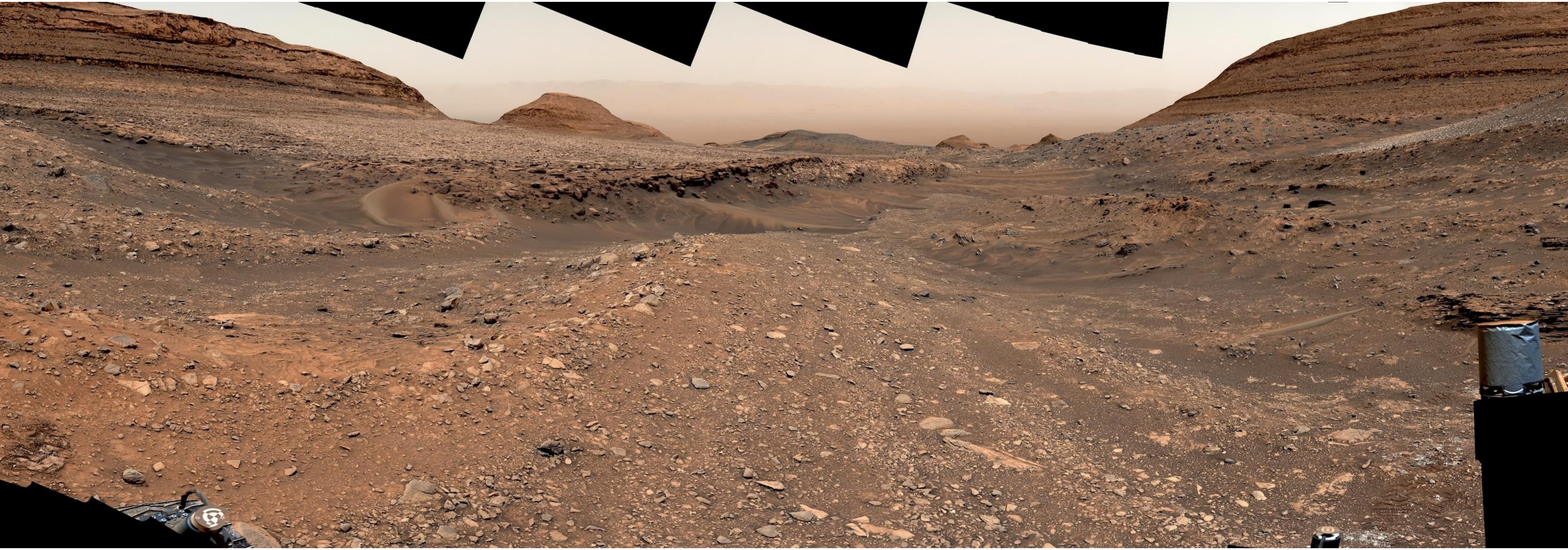




- Discovery of potential biosignatures in a plausibly habitable environment at Cheyava Falls
  - Sample collected (sample 28)
  - Multiple scans by SHERLOC indicate organic compounds
  - “leopard spots” indicate chemical reactions that microbial life could use for energy source (PIXL found iron and phosphate)
  - Calcium sulfate is evidence that water passed through rock

Jet Propulsion Laboratory
California Institute of Technology

Mars Science Laboratory
Curiosity Rover



NASA/JPL-Caltech/MSSS

Curiosity has Completed its Investigation of Gediz Vallis Channel

- After eight months exploring the channel cut into the bedrock of Mount Sharp and its interior mounds of debris (above, looking toward the crater floor), the mission is directing Curiosity to the southwest for a year-long journey toward a major valley that holds the scientific targets for the fifth extended mission (2025-2028).
- At Gediz Vallis Channel the team compiled evidence for flows of liquid water relatively late in the history of Mount Sharp and discovered a field of clasts composed of elemental sulfur, the origin of which remains enigmatic.

Psyche Spacecraft is Healthy and Stable

Currently: 2.5 au from the Sun
3.5 au from the Earth
One-way light time: 29 minutes
Traveling at 33,800 mph around the Sun

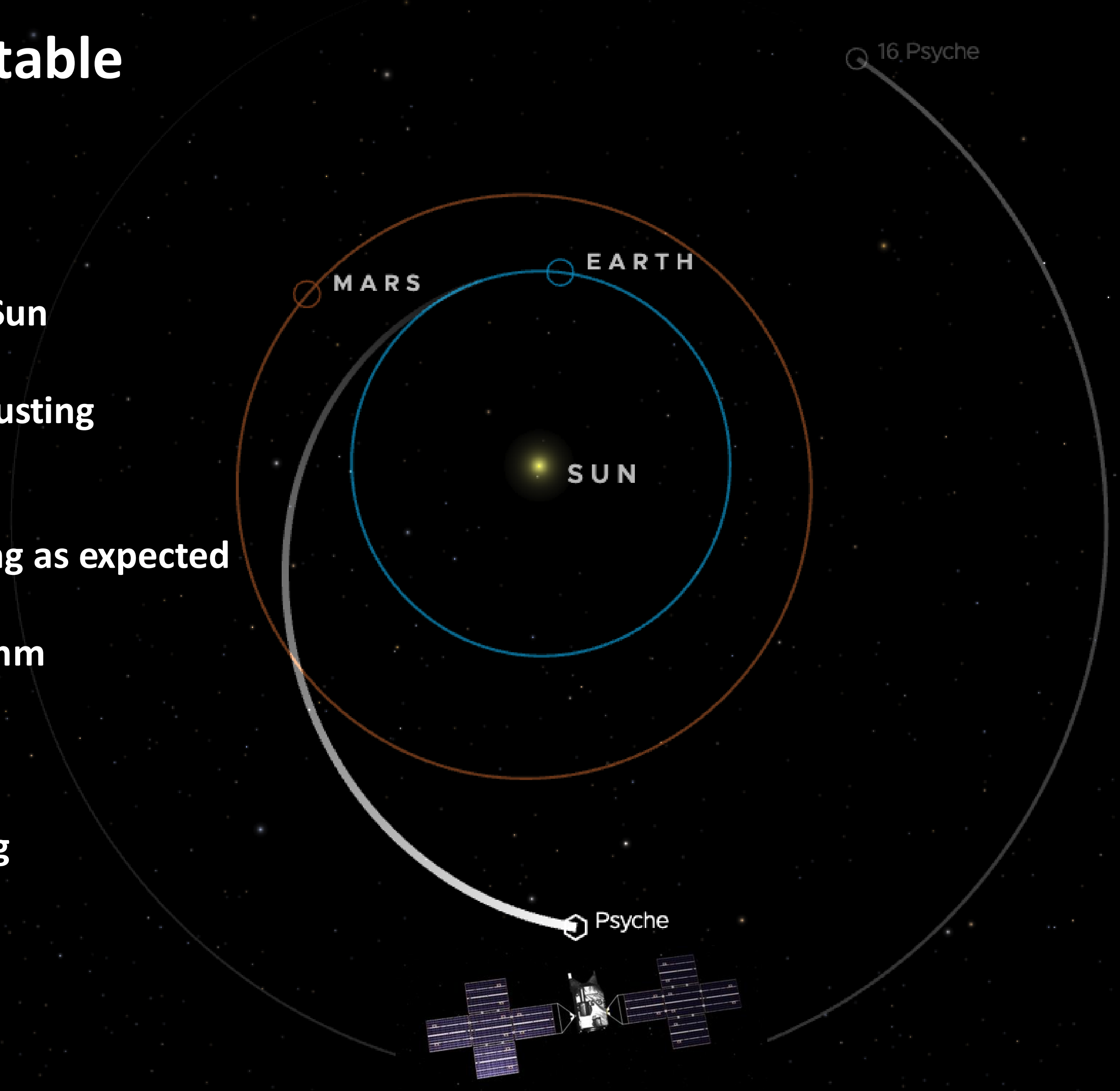
Have successfully accomplished >3000 hrs of EP thrusting
utilizing ~140 kg of Xenon

All spacecraft systems and instruments are operating as expected

Successfully supporting the Deep Space Optical Comm
(DSOC) Tech Demo

Upcoming Events:

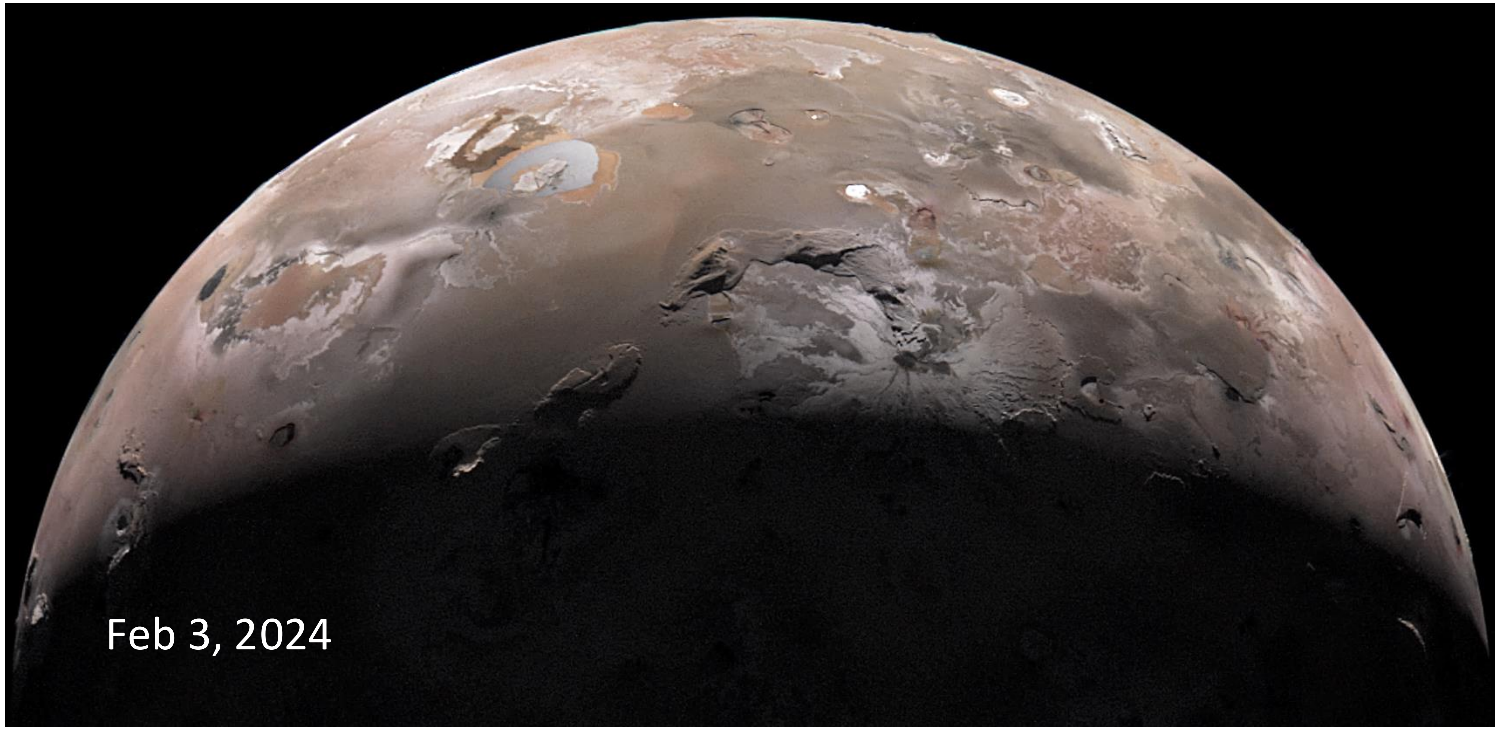
July 2025:	Completion of Cruise 1 Thrusting
May 2026:	Mars Flyby
Oct 2026:	Start of Cruise 2 Thrusting
Aug 2029:	Arrival at (16) Psyche



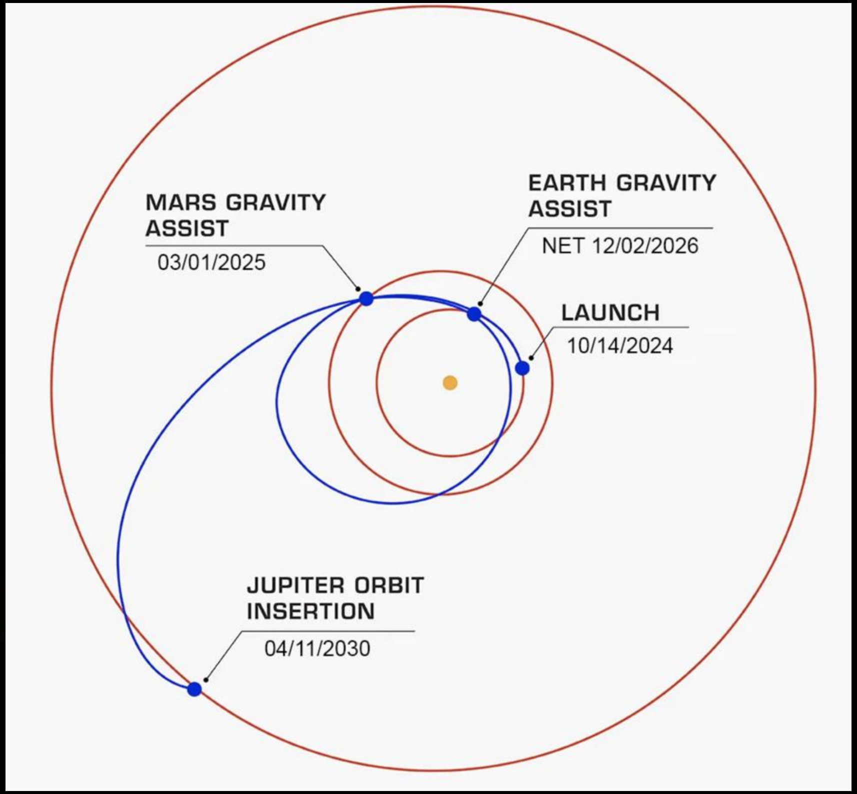
Juno

- Juno is on the third year of its extended mission, has performed 65 orbits of Jupiter and obtained data on Europa, Ganymede, and Io.

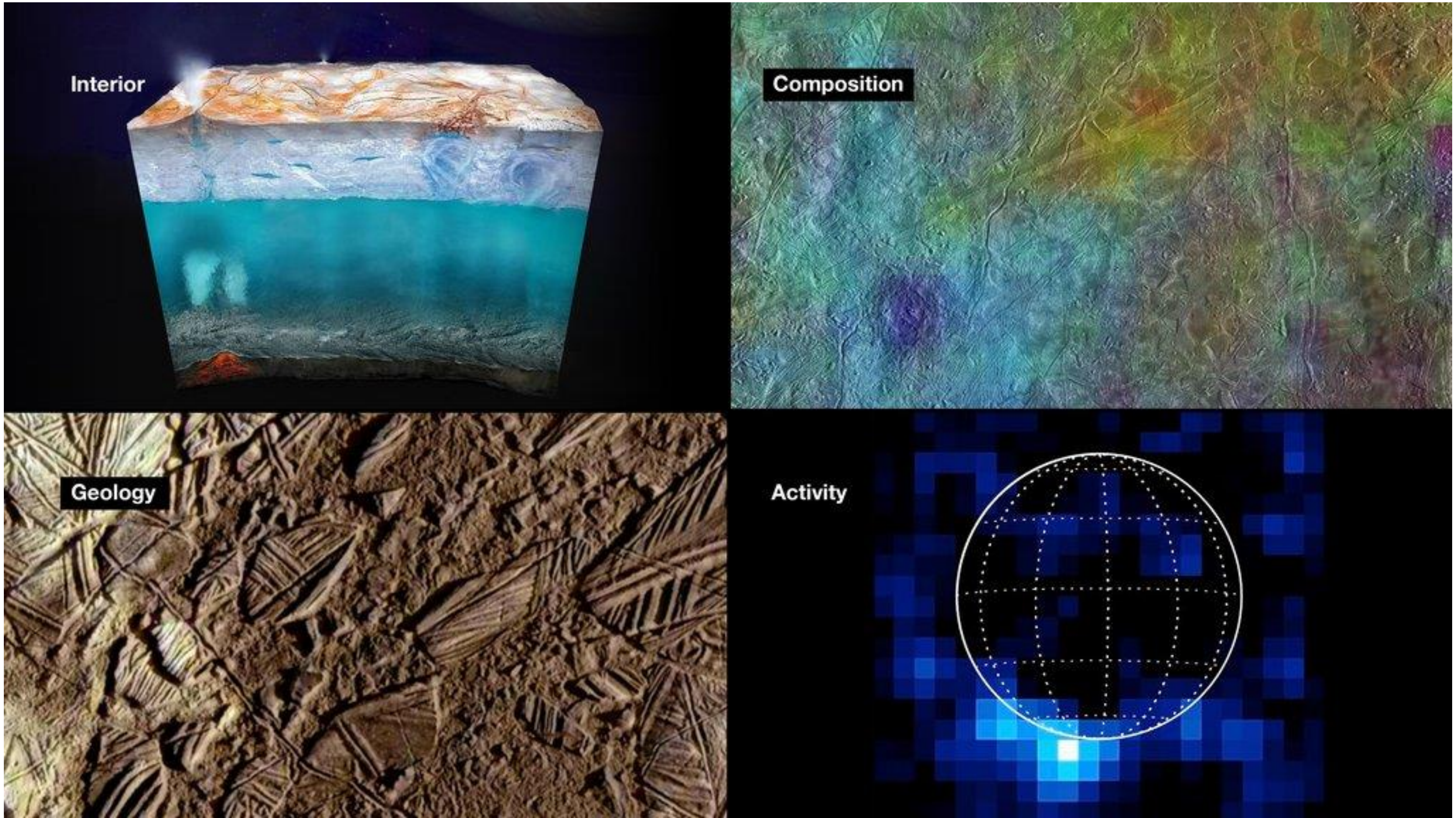
- Oct 15 Io flyby at 11,700 km
- Dec 30 ,2023 Io flyby at ~1,500 km
- Feb 3, 2024 Io flyby at ~1,500 km
- October 22 PJ-66, includes distant Io flyby



Europa Clipper following separation from the Space X Falcon Heavy second stage, on its way to Europa!



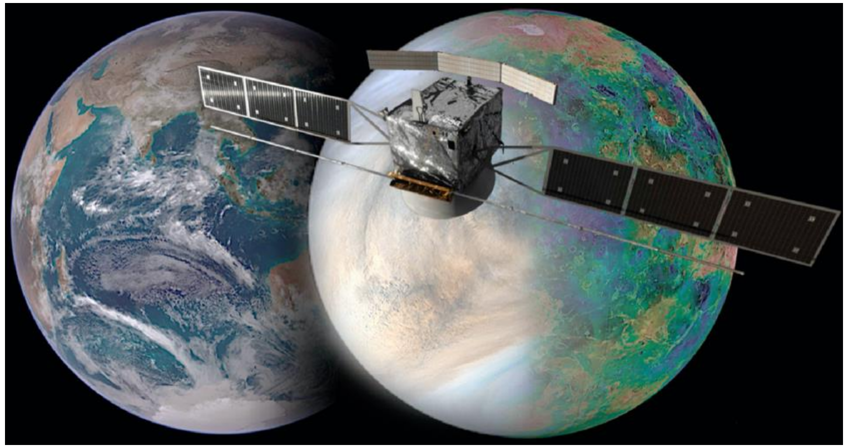
Europa Clipper's main science goal is to determine whether there are places below the surface of Jupiter's icy moon, Europa, that could support life.



Missions in Development

VenSAR
Project Overview

EnVision at Venus



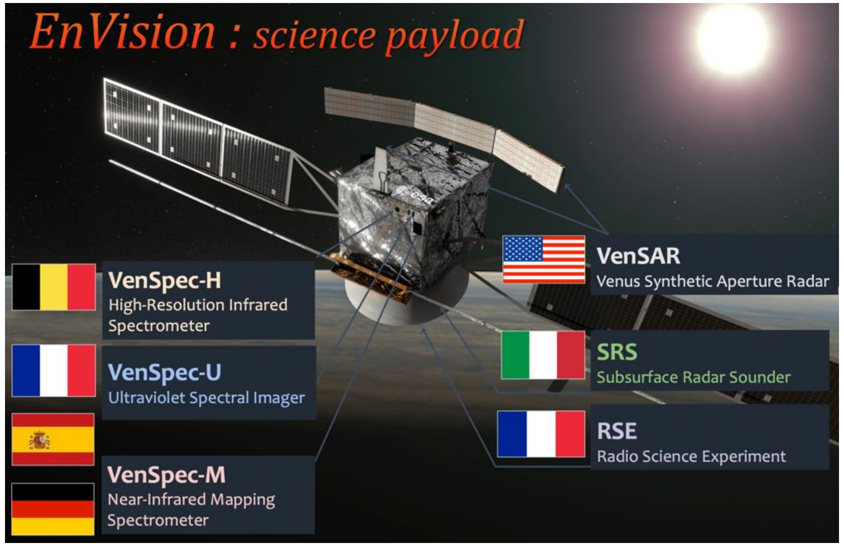
EnVision will address "Why is Venus so different?" with three lines of investigation

- **History:** How have the surface and interior evolved?
- **Activity:** How geologically active is Venus?
- **Climate:** How do geological processes shape the atmosphere and climate?

Key Dates:

- **Launch Readiness Date:** 1 November 2031
- **Science Phase:** 6 Venus Cycles from 2035-2039

EnVision Payload



NASA Contributions (VenSAR Project)

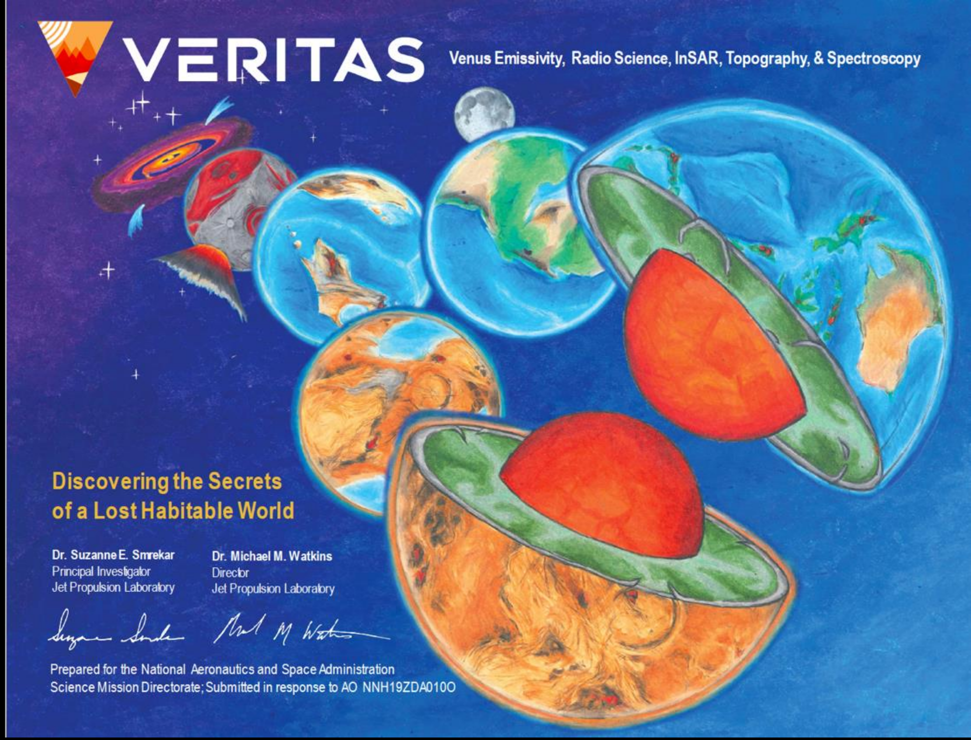
- NASA is contributing an S-band radar instrument that operates in SAR imaging and polarimetry, altimetry and microwave radiometer modes.
  - 30 m SAR imagery for 30% of surface
  - 10 m SAR imagery for 2-3% of surface
  - 30 m HH, HV polarimetric imagery for 7% of surface
  - Nadir altimetry at 3 km spatial and 2.5 m vertical resolution for 75% of surface
  - Radiometry with 1.7˚K accuracy and 1.0˚K precision for 75% of surface
- NASA also contributes DSN coverage for critical events and support for aerobraking navigation.
- VenSAR is a Type 1, Class B, Category B project.

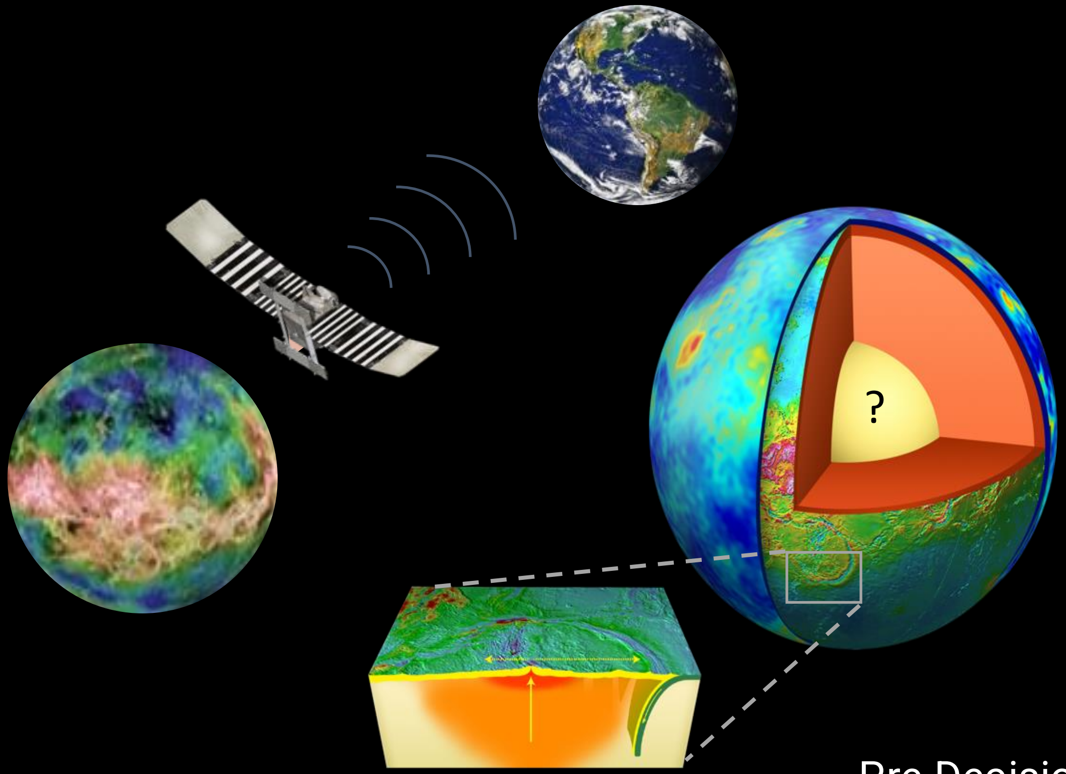
VERITAS

Sue Smrekar, PI

VERITAS is a Discovery Mission to Venus, selected June 2, 2021

The orbiter will explore the secrets of Earth's twin planet to search for chemical fingerprints of past water, present day tectonic and volcanic activity, and understand rocky planet evolution.





VERITAS' SAR radar (JPL/ASI) will create global, high resolution topography, radar images, and the first repeat pass deformation maps of another planet.

The Venus Emissivity Mapper (DLR/CNES) will create the first near-global map of surface rock type, and search for volcanism – recent, active, or outgassed water.

Gravity science (ASI/CNES) will provide crust/lithosphere thickness and the first meaningful constraint on core size and state.

VERITAS Status and Funding/Launch Date Issues

VERITAS impacts for an additional delay from June'31 to Nov'32 (FY31 to FY33):

Science Impacts:

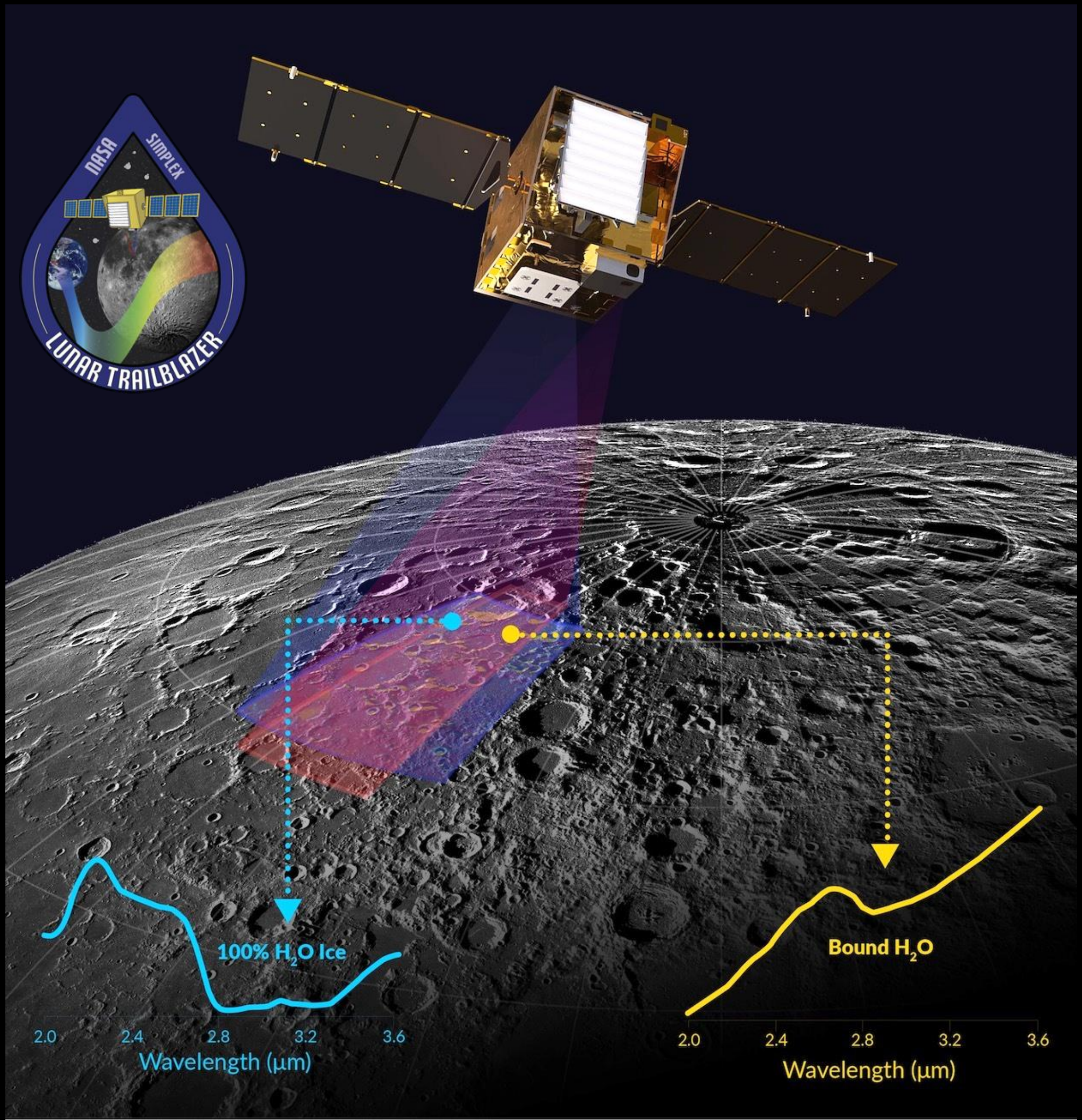
- **The Venus Emissivity Mapper (VEM) coverage in Nov'32 (vs. June'31) is degraded: 1) only 1 of 3 key Venera lander sites used for Fe content calibration is covered, and 2) there is NO coverage of DAVINCI's entry site, precluding valuable cross-calibration between missions.**
- **VERITAS' global datasets benefit ESA's Envision mission targeting of SAR images, and assist with data reduction (multiple products)**

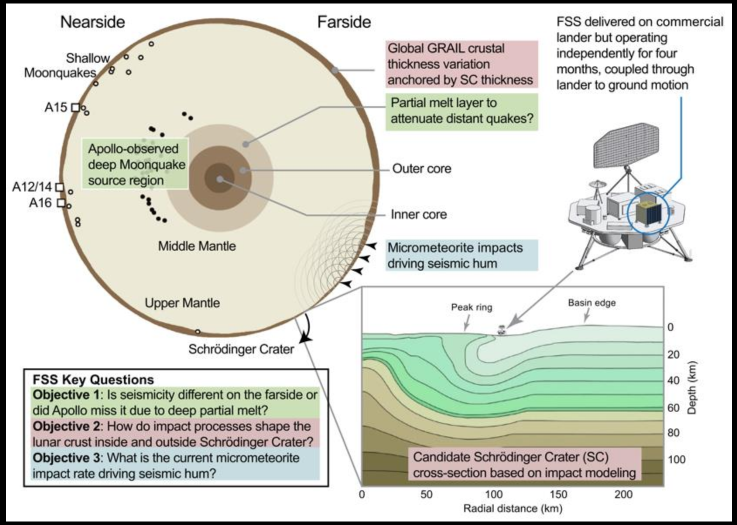
Foreign Partner Impacts:

- VERITAS has 7 foreign contributions (all required elements) from the Italian (ASI), German (DLR) and French (CNES) Space Agencies. All partners elected to continue developments in '23/'24 to protect agency funding commitments and retain personnel
- ASI, CNES & DLR expended considerable political capital to protect VERITAS commitments & re-phase funding for a '31 launch
- An additional delay to FY33 will:
  - Increase overall *costs*
  - Create *staffing* continuity challenges between earlier technical development and spacecraft I&T
  - Result in *delivery* of each contribution prior to *preliminary design reviews* of spacecraft subsystems
  - Create direct *schedule* conflicts between partner deliveries to Envision and VERITAS that are currently staggered
  - Increases the risk of losing senior Science Team members from each agency

***VERITAS** requires a steep funding increase in FY26 to make a '31 launch.*

Lunar Trailblazer is a low budget lunar orbiter that will directly detect and map water on the lunar surface to determine how its form, abundance, and location relate to geology.

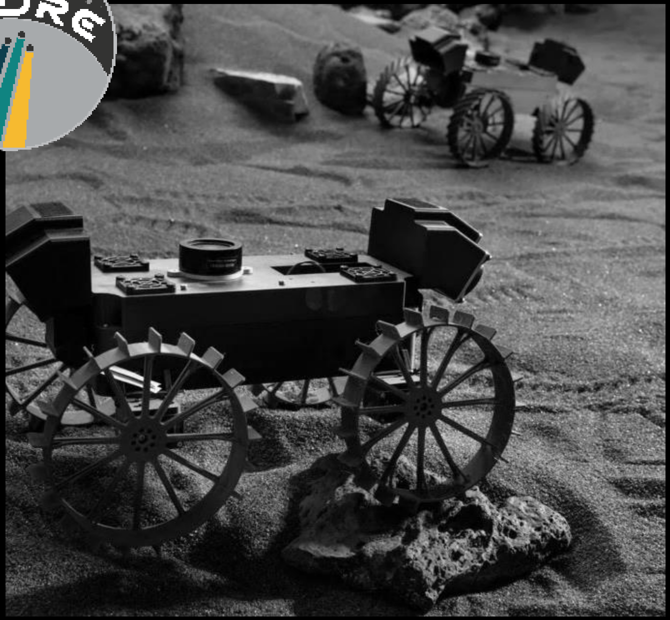




Far-Side Seismic Suite (FSS) delivers two seismometers to the lunar far side at Schrödinger Basin, both based on the instrumentation of the InSight Mars mission.

CADRE* is a technology demonstration show that a network of mobile **robots** can **work together** (cooperatively) and **without human intervention** (autonomously), to accomplish a task (exploration and distributed measurement).

**Cooperative Autonomous Distributed Robotic Exploration*

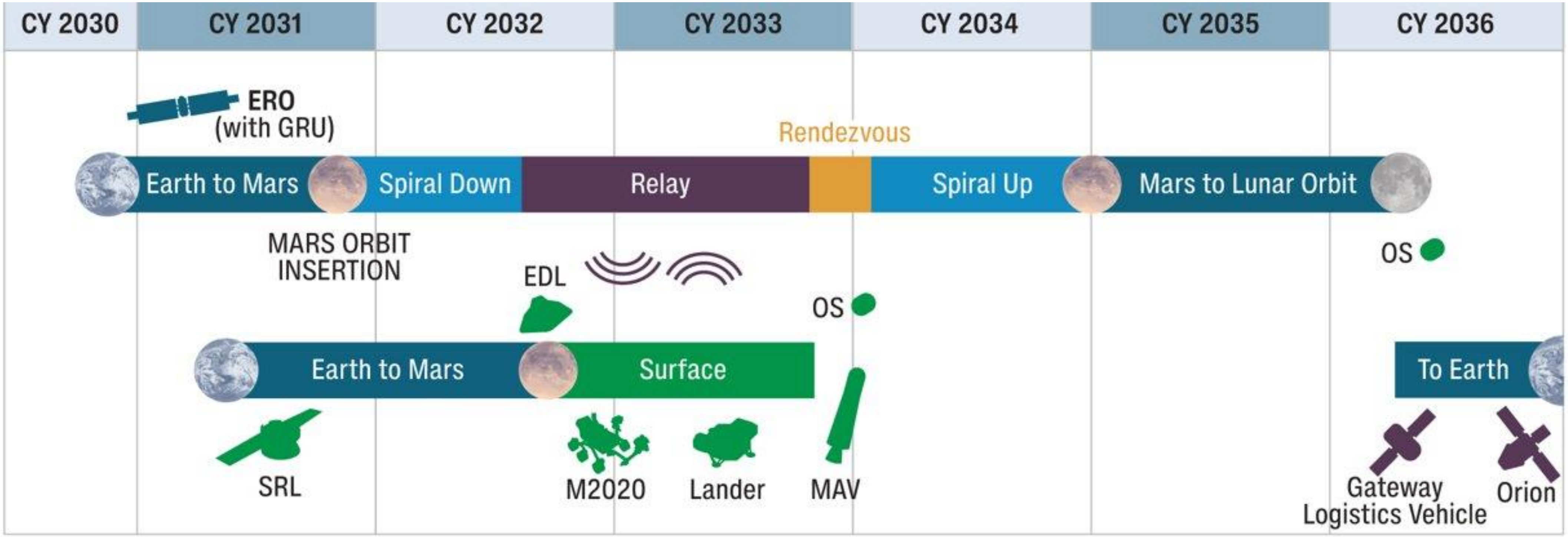


Missions in Study

Mars Sample Return – JPL Study

JPL Study. Completed and submitted after extensive review, key features:

- 2036 return of full 30 diverse samples
- << Cost-to-go, total cost consistent with DS range
- Lower FY budgets, support broad PSD portfolio
- Major descopes: Helicopters, CCRS
- Simplified organizational structures
- Expanded industry roles; leveraging Artemis capabilities
- Skycrane flight-demonstrated heritage architecture
- Rapid hardware prototyping, accelerated decision velocity

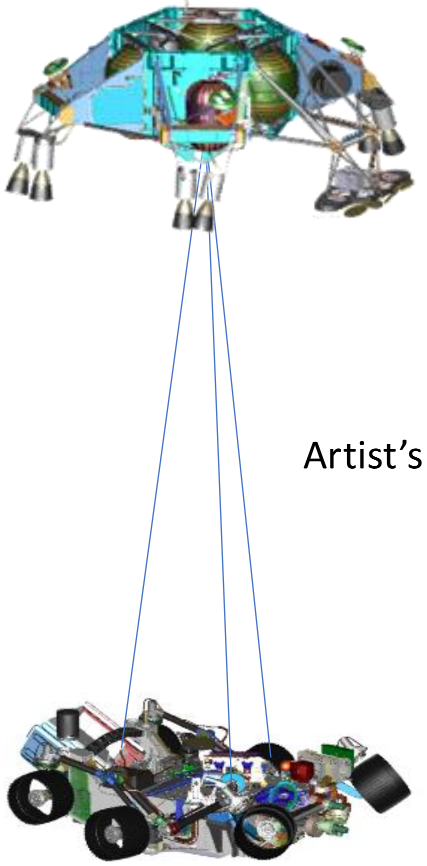


Pre-Decisional Information – For Planning and Discussion Purposes Only

Mars Sample Return – Skycrane Approach

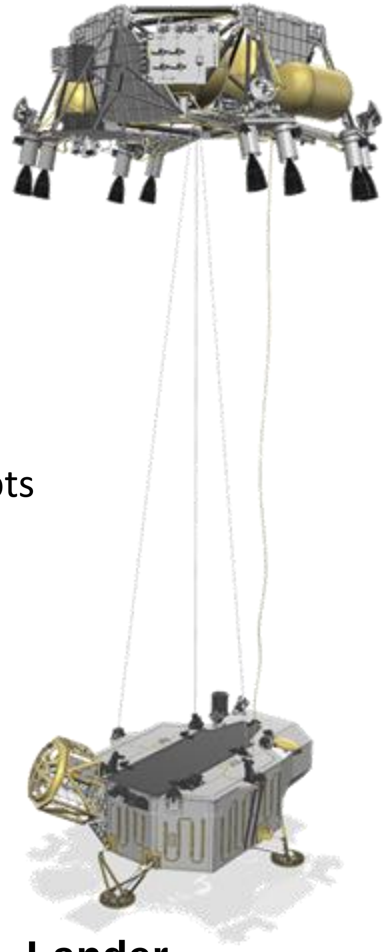
MSR
SAMPLE RETRIEVAL LANDER

Mars 2020 Sky Crane



Rover
1100 kg capability

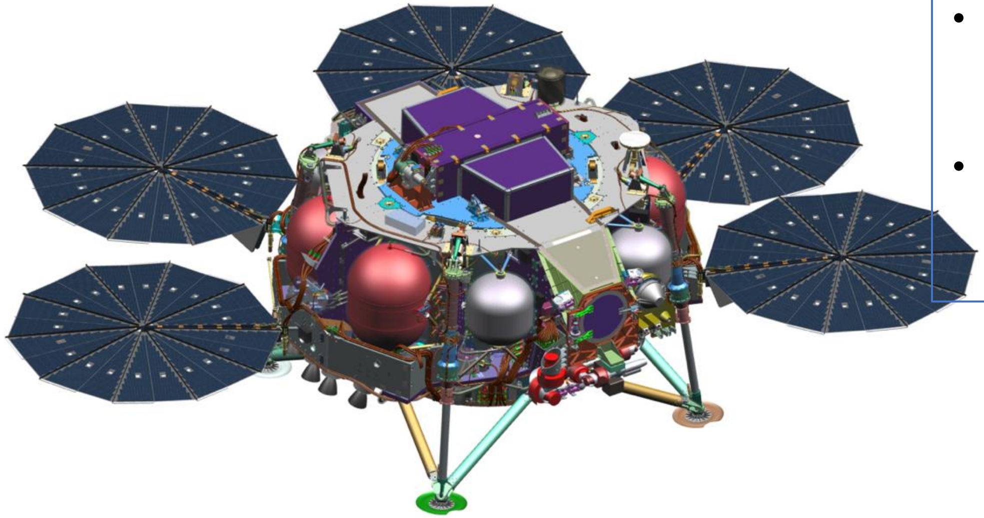
SRL Sky Crane



Artist's concepts

Lander
1174 kg predicted mass
1340 kg allocation (14% margin)

SRL Propulsive Legged Lander

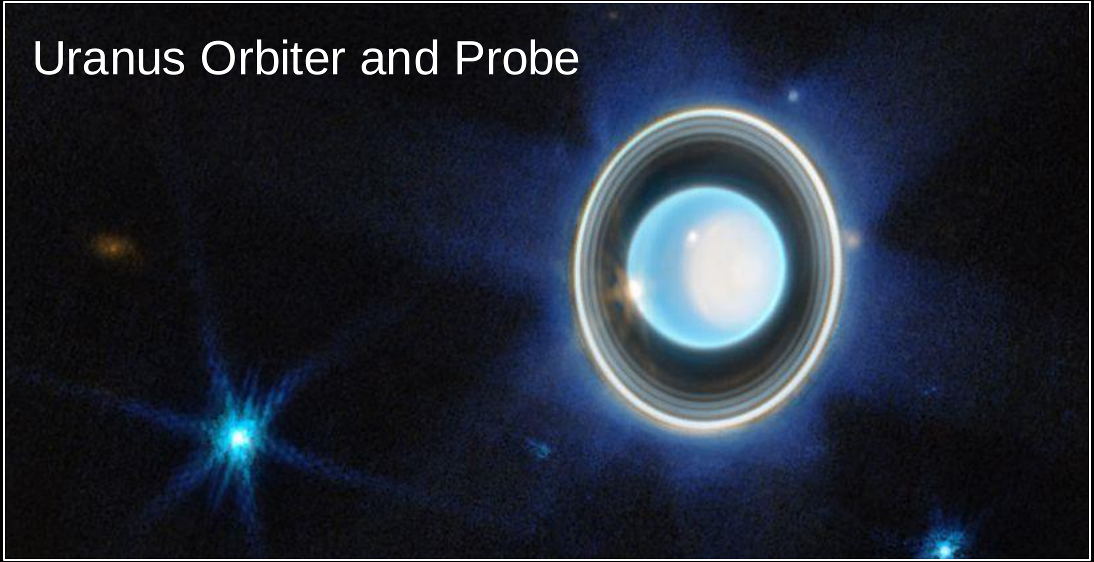


PDR Baseline
3165 kg predicted mass
3450kg allocation (9% margin)

<u>Sky Crane</u>

- Touchdown Kinetic Energy is much lower: 1/30th of legged lander
- No ground-plume interaction or surface fuel management
- ~20% scaling. PLL 7x larger than InSight, Phoenix, Viking
- Hardware commonality leverages investments to-date

Planetary Science and Astrobiology Decadal Survey (2023-2032)

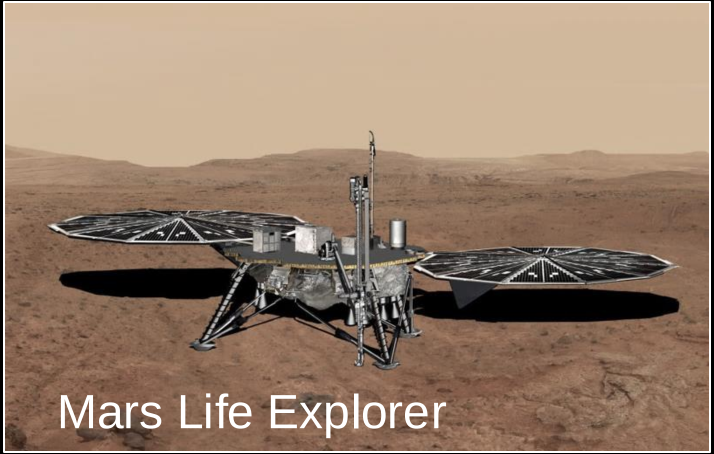

Uranus Orbiter and Probe

New Frontiers-5 Targets:
- Comet Surface Sample Return
- Lunar South Pole-Aitken Basin Sample Return
- Ocean Worlds (only Enceladus)
- Saturn Probe
- Io Observer
- Lunar Geophysical Network

New Frontiers-6 Targets:
- Centaur Orbiter & Lander
- Ceres Sample Return
- Comet Sample Return
- Enceladus Flyby
- Lunar Geophysical Network
- Saturn Probe
- Titan Orbiter
- Venus Insitu Explorer

NF-7 additional Target:
- Triton Ocean World Surveyor


Enceladus Orbilander


Mars Life Explorer

UOP: Challenges That Influence Mission Design

NASA’s tight budget has created launch challenges for Uranus Orbiter and Probe

- The President’s FY25 Budget Request does not support NASA funding for studies until 2027
  → Launch in **2036 or beyond** → miss Jupiter Gravity Assist (JGA)
- Thus, we need to significantly reduce mass, while maintaining flagship-class science, to:
  - Avoid flight times >13.5 yrs which erode Radioisotope Thermoelectric Generator (RTG) power output
  - Enable a trajectory that can launch any year, providing NASA with budget profile flexibility

RTGs are scarce

- With Uranus 19 AU from the Sun, RTGs are the best choice for power
- However, planned RTG production rates are limited in this timeframe, with delivery of the **first** NextGen RTG in ~2030 and 2 more units by 2036, with many other interested customers
  → We have also been looking at ways to reduce power to decrease the number of required RTGs from 3 to 2

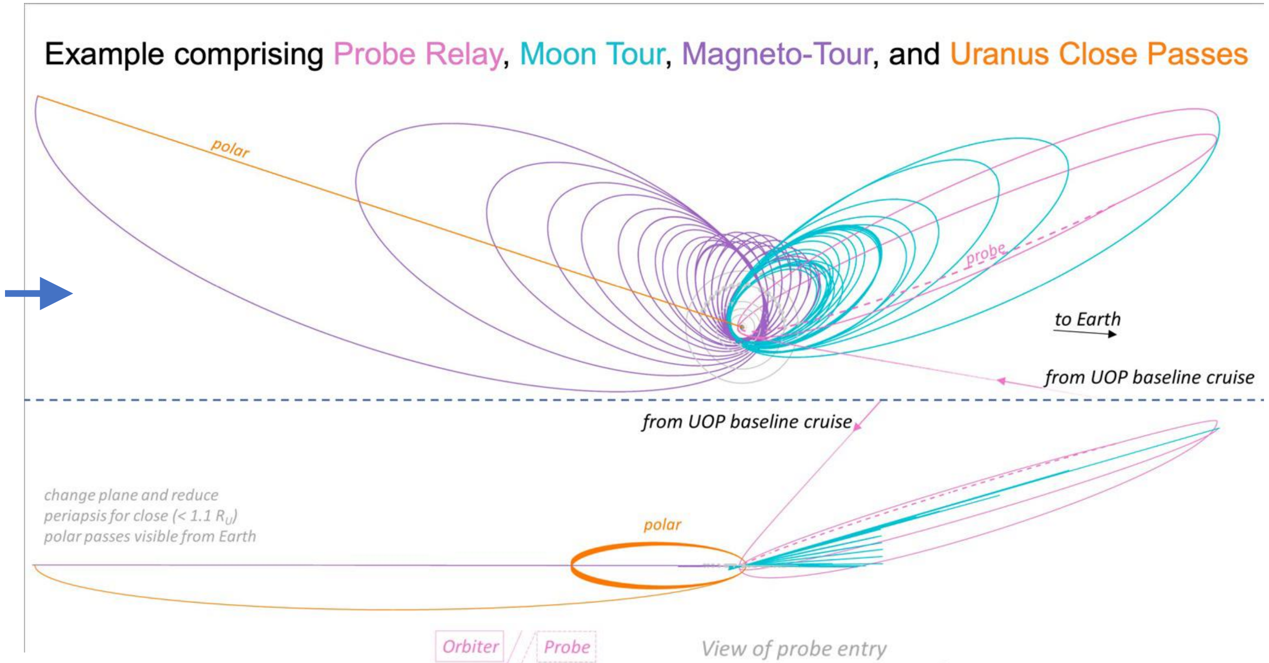
The Decadal was written before these challenges were known, requiring a new approach

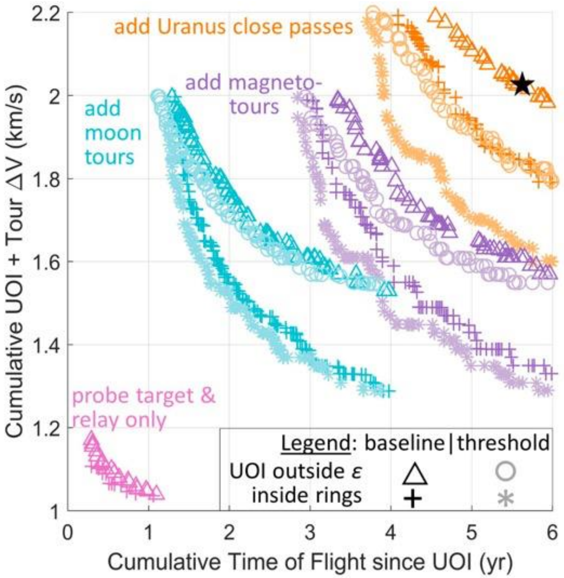
JPL Design Activities for Uranus Orbiter and Probe

- JPL is investigating UOP designs to identify ways to meet Decadal Survey science priorities while addressing these launch and RTG power challenges by:
  - Exploring cruise trajectory options, including ways to reduce flight time and ensure launch date flexibility
  - Developing a notional science traceability matrix to inform payload requirements and tour design (see next slide)
  - Identifying opportunities to reduce payload mass, power, and cost while maintaining science return
  - Determining whether near-term, evolutionary spacecraft technologies can be infused on the mission with acceptably low risk
  - Assessing whether automation/autonomy can be used to increase science return and/or lower operational costs
  - Investigating options to enrich the science return quality

Uranus Tour: Comprehensive Understanding of Design Drivers

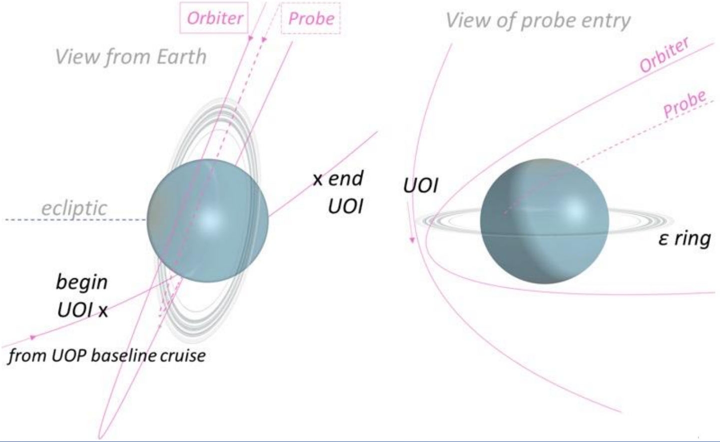
Example complete UOP tour that includes Probe Relay, Moon Tour, Magneto-Tour, and Uranus Close Passes →

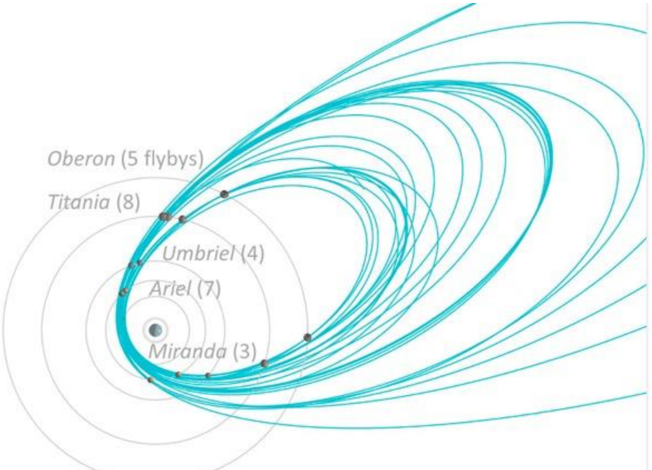




← Delta-V and flight time impact of adding **more** Uranus close passes, moon tours, and magneto-tours

Science impact of different Uranus Orbit Insertion (UOI) strategies →

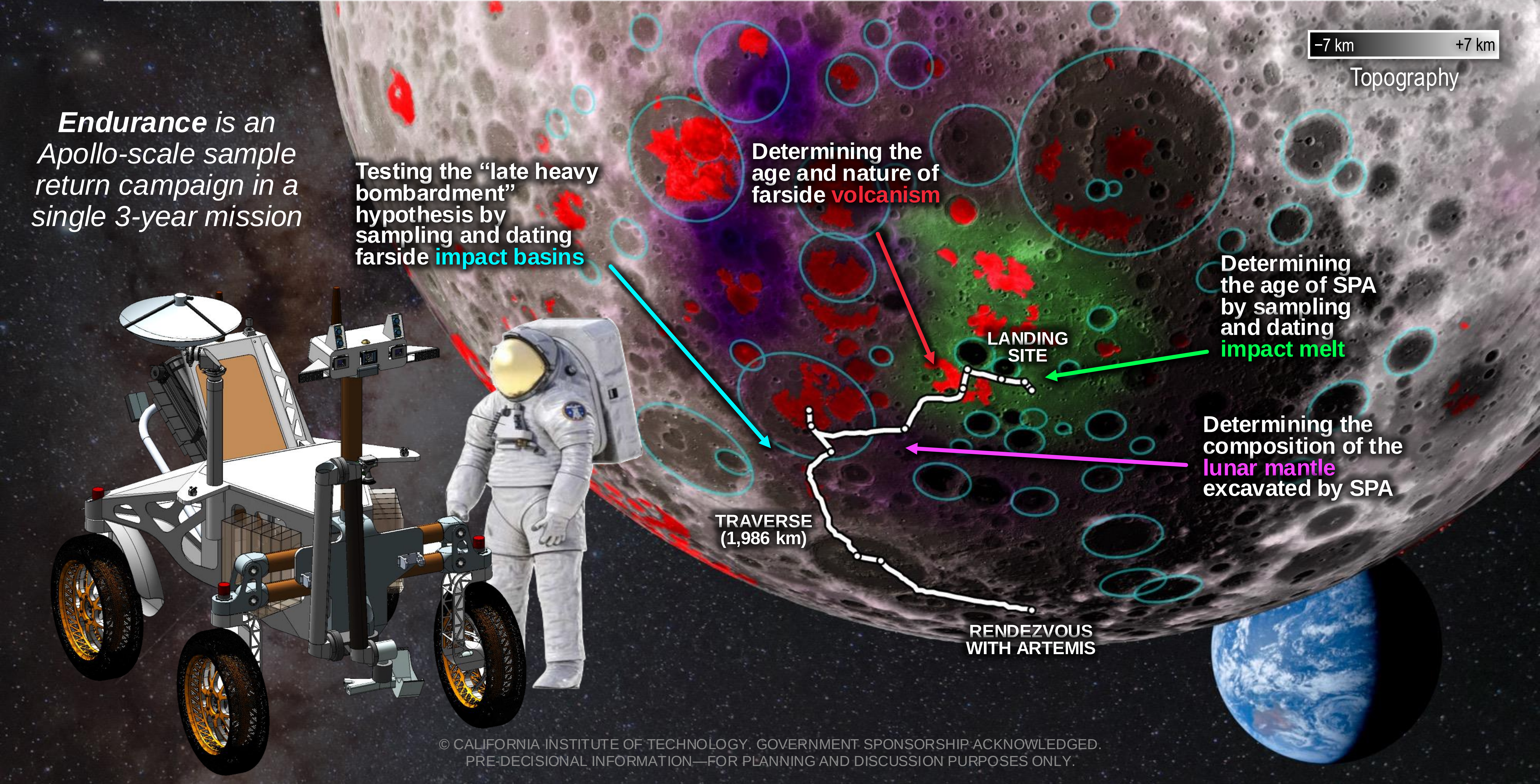




← Trajectory options to optimize science return from moon flybys

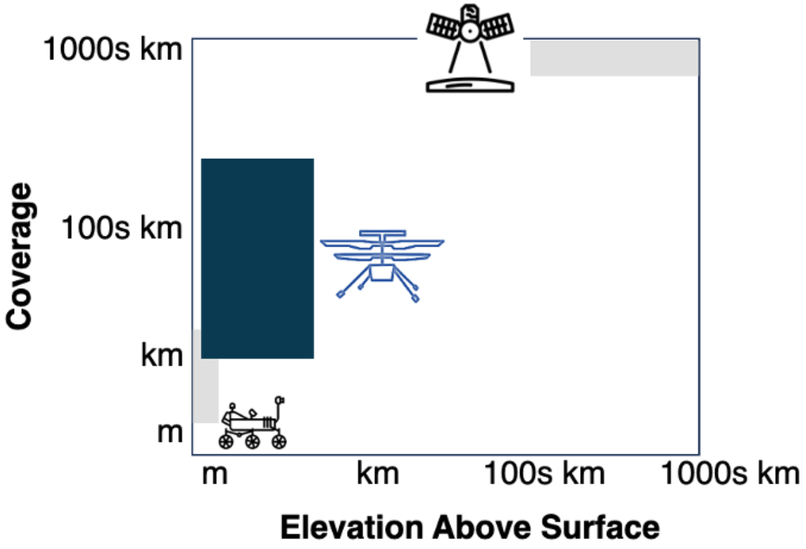
JPL has extensive experience with trading science requirements and mission design for giant planet system exploration missions (Galileo, Cassini) involving probes, many target bodies, and many instruments

Endurance: A Long-Range Lunar Exploration and Sample Return Mission



Transformational Platform for Mars Science: Chopper

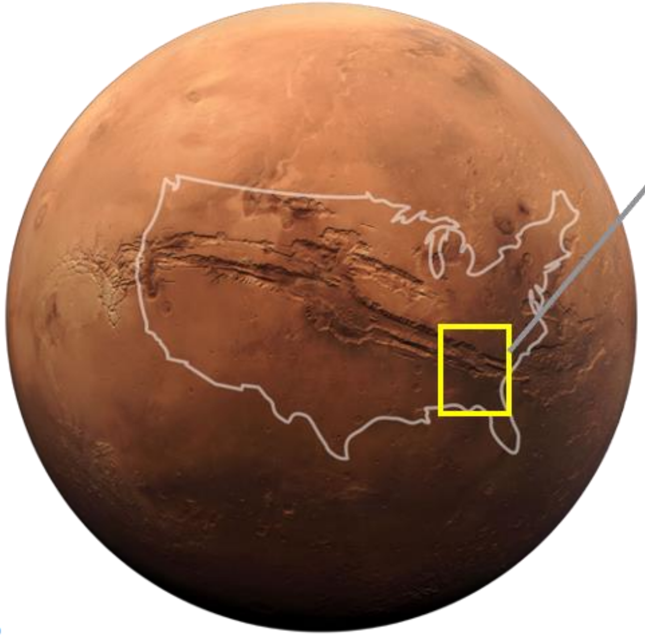
- Chopper will:
  - Enable *in situ* investigation at regional scales
  - Access previously inaccessible terrain
  - Bridge the gap between orbiters and rovers
- Novel EDL reduces cost, opens door for mobile surface mission in Discovery cost cap

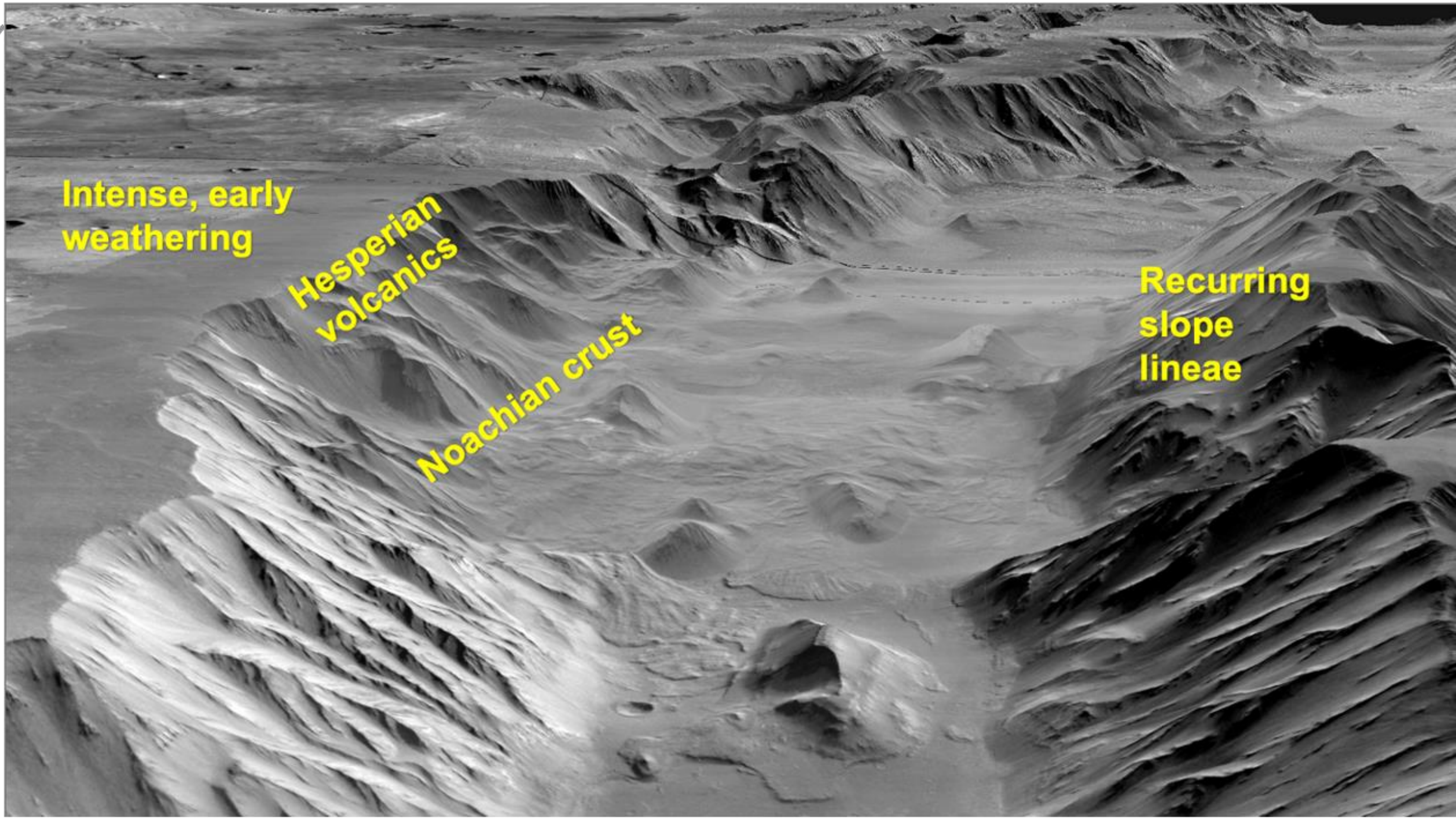


In the last decade, terrestrial field geologists have started using aerial platforms to answer new science questions.

Pictured: Field work with a UAS carrying a commercial microwave radiometer (left) and imaging spectrometer (right) in Oregon's Alvord Desert in Aug 2024.

Potential use of Mars Helicopter: Valles Marineris: A Window into Deep Time





Worlds & Processes

Life & Habitability

We can learn about:

1. Formation of planetary crusts
2. Formation & evolution of dynamos
3. Drivers of climate evolution
4. Existence of modern habitats

Thank you