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JPL and the Robotic Exploration of the Solar System

ISRO Lecture, VSSC, Trivandrum, India
July 2012

Gregg Vane
Solar System Exploration Directorate
NASA Jet Propulsion Laboratory
California Institute of Technology

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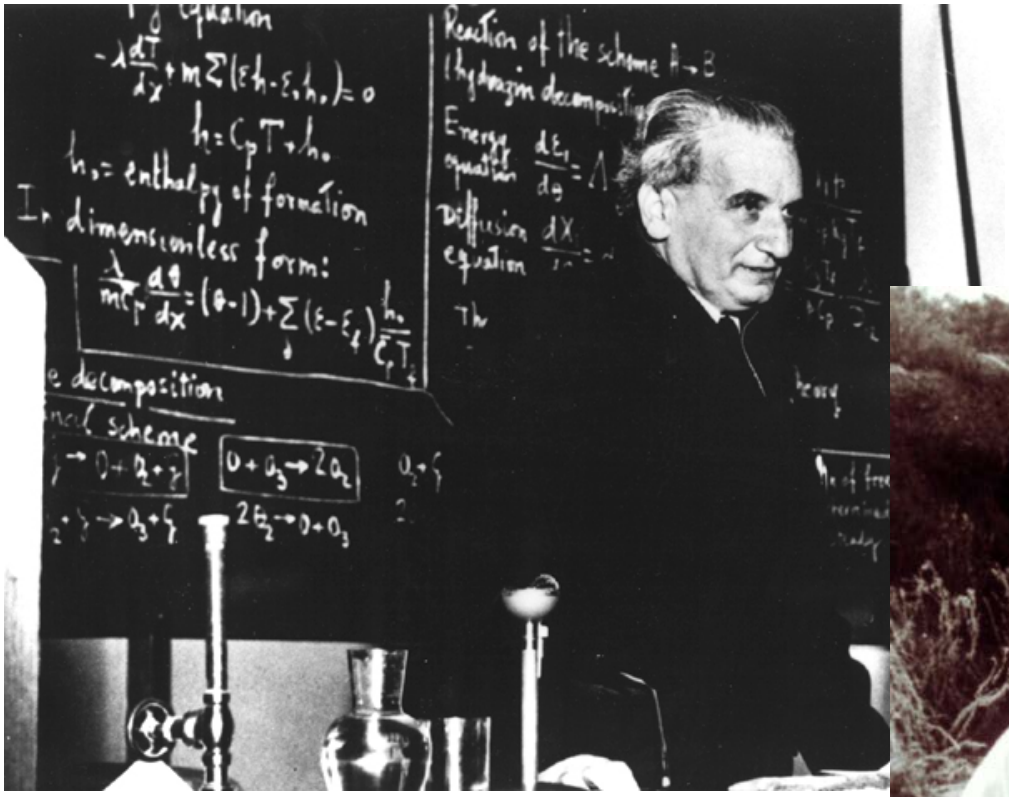
Our origins: von Kármán and his Caltech students in the 1930s



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JPL Today: Part of NASA and Caltech

- Caltech operates JPL under contract to NASA
- 5,000 employees
- Employees are members of the Caltech staff
- 177 acres (67 hectares)
- 139 buildings

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Explorer 1 “JPL/Caltech satellite” First US space flight on January 31, 1958

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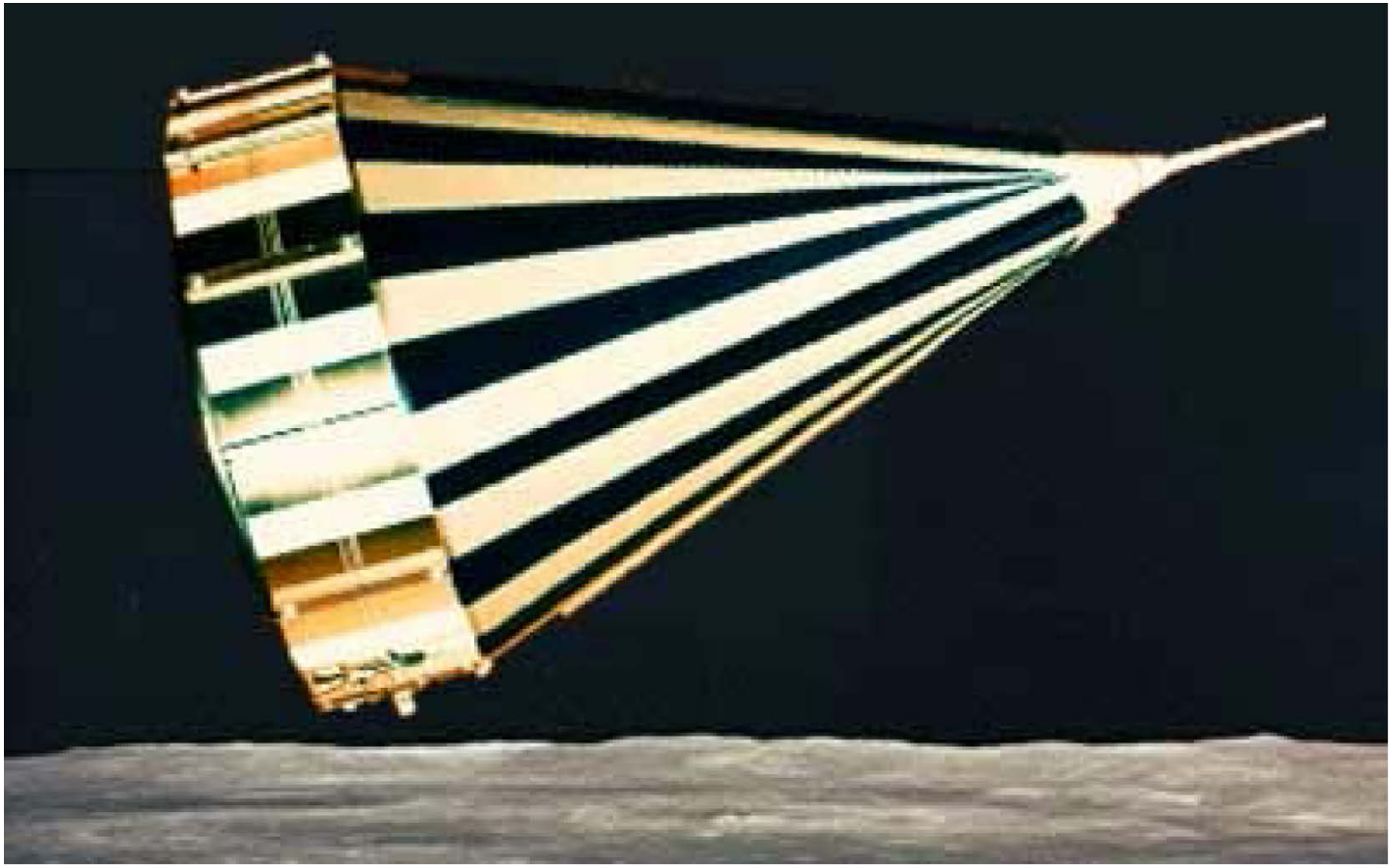
Pioneer 4



- Launched on March 3, 1959
- Became the first American spacecraft to escape Earth's gravitational pull

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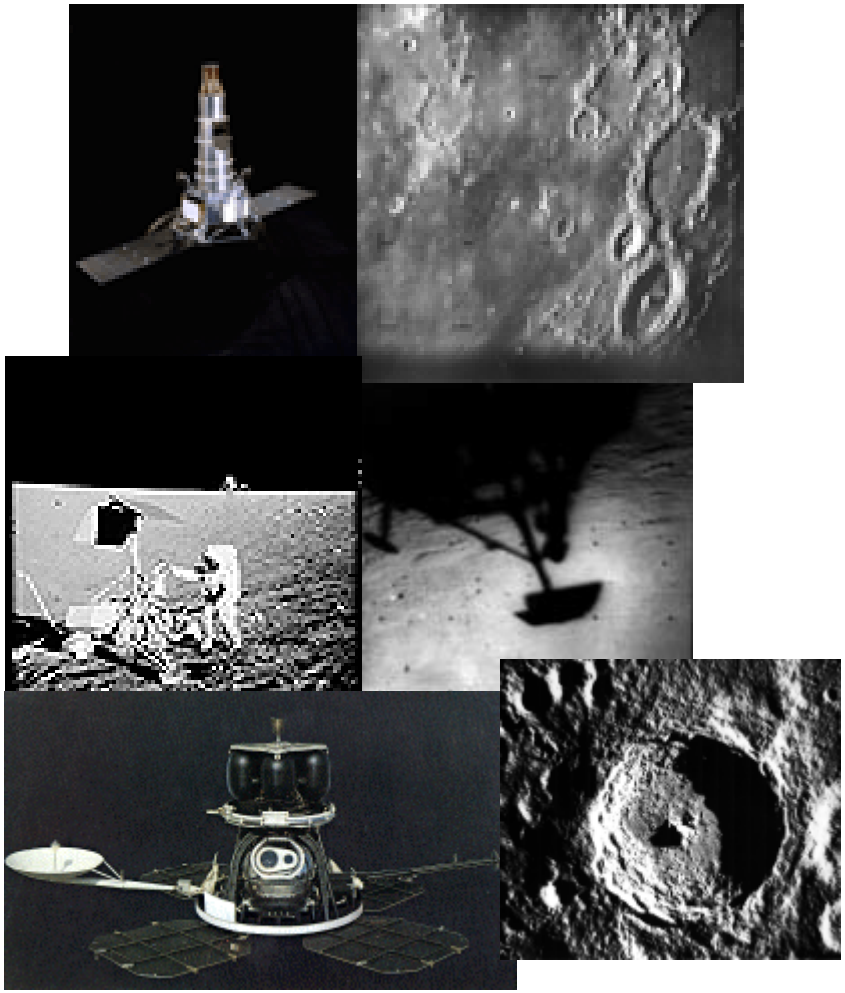
JPL's robotic lunar missions led the way to a safe Apollo landing

- **Ranger: 1961 – 1965**
- **Surveyor: 1966 – 1968**
- **Lunar Orbiter: 1966 – 1967**



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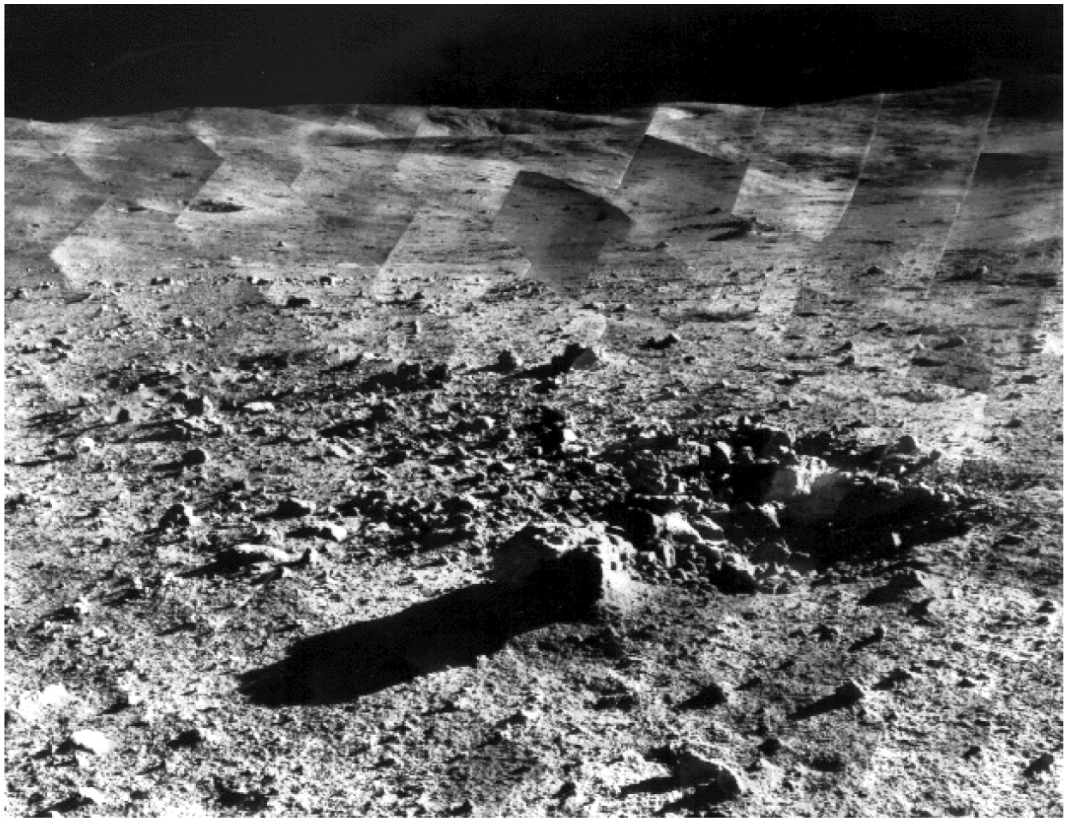
Lunar Panorama from Surveyor 7



This circular mosaic of hundreds of television photos taken by Surveyor 7 in January 1968 revealed a solid surface, safe for the the subsequent Apollo landings

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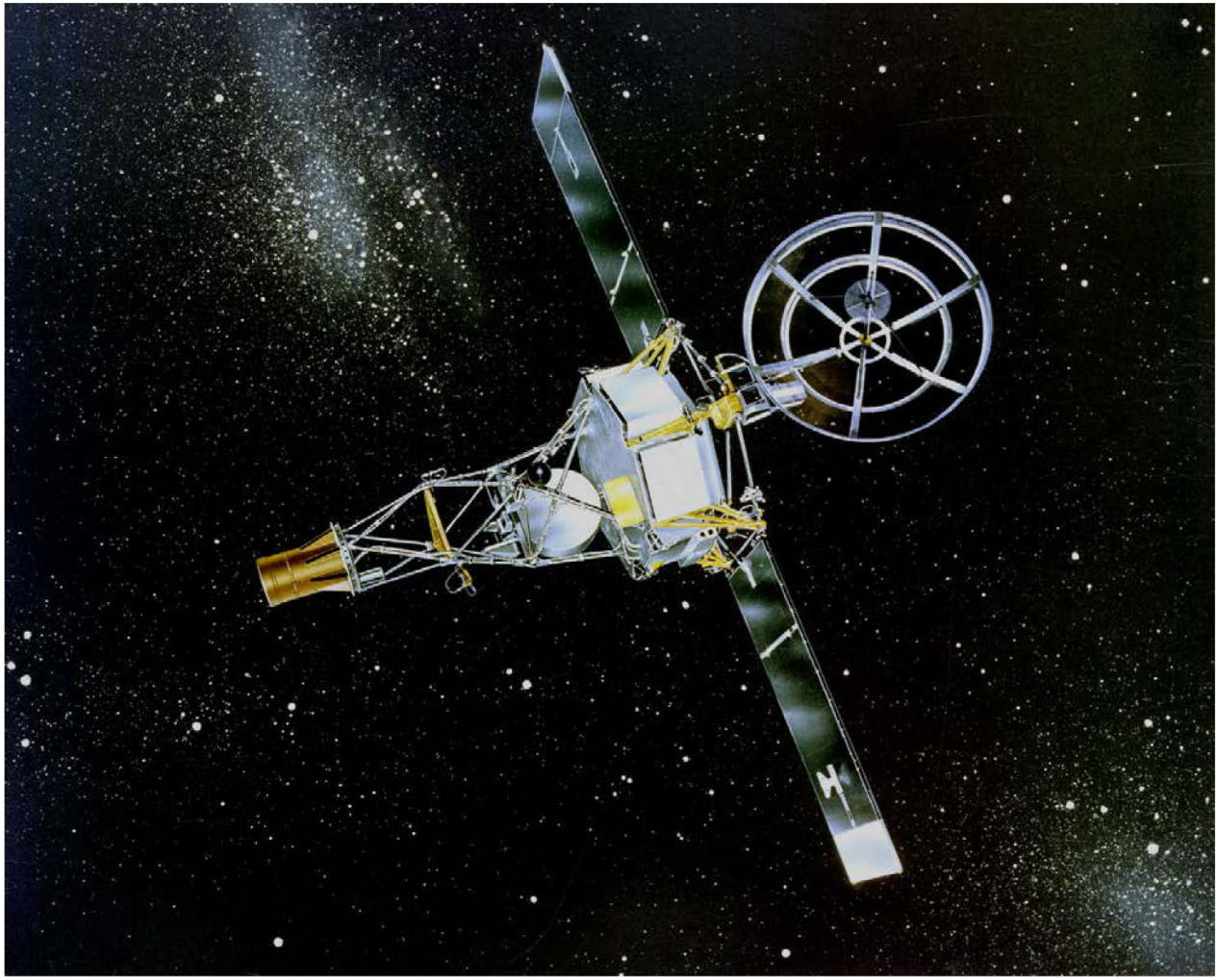
Mariner-2 to Venus:
The First Planetary Probe - 1962



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First Spacecraft to Mars - 1965: President Lyndon B. Johnson Presented with Mariner 4's picture of Mars.

Mariner 4's famous picture Number 11, revealed large impact craters and other topographical features of Mars, July 1965

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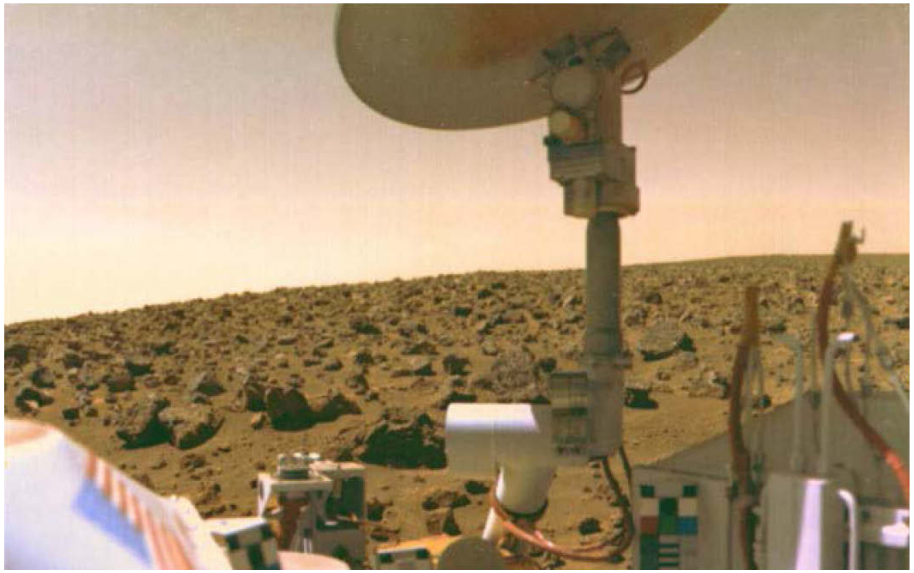
Viking Arrives at Mars



NASA's Viking Project, managed by JPL, became the first mission to land a spacecraft successfully on the surface of another planet and return both imaging and non-imaging data over an extended time period.

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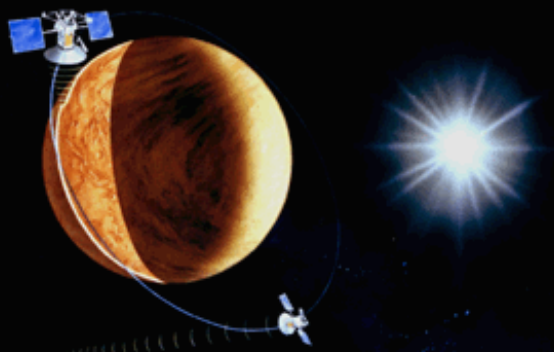
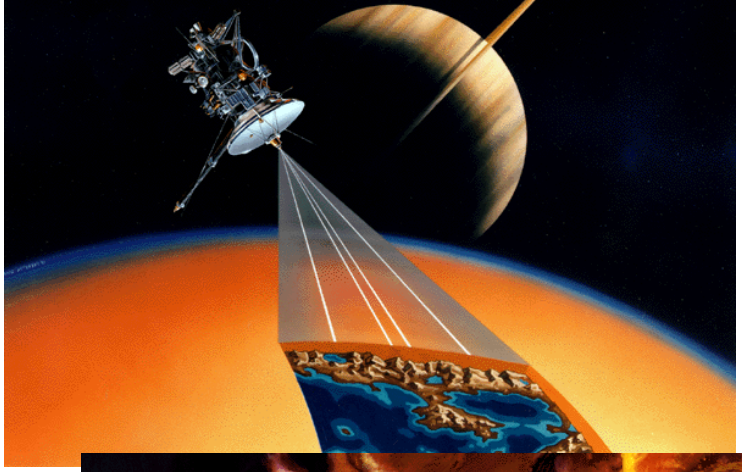
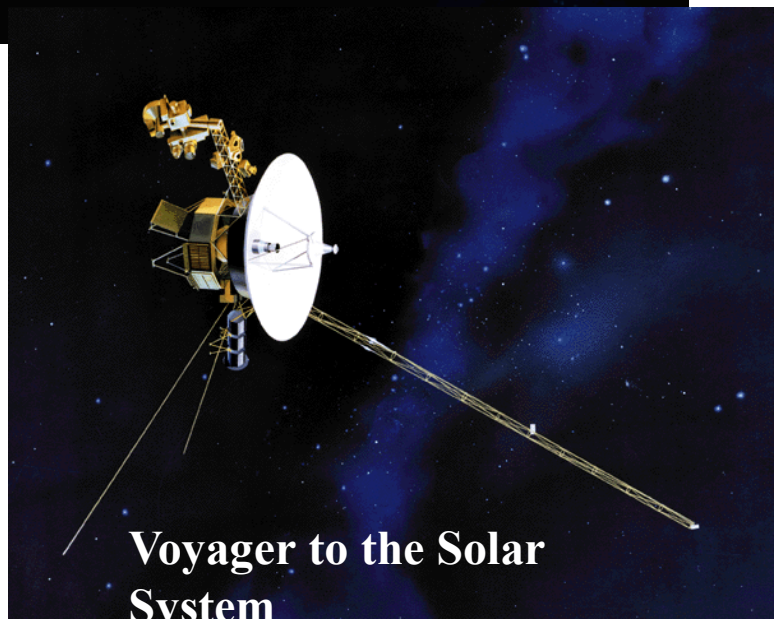
On to other destinations

Magellan to Venus



Cassini to the Saturn System





Voyager to the Solar System

Galileo to the Jupiter System

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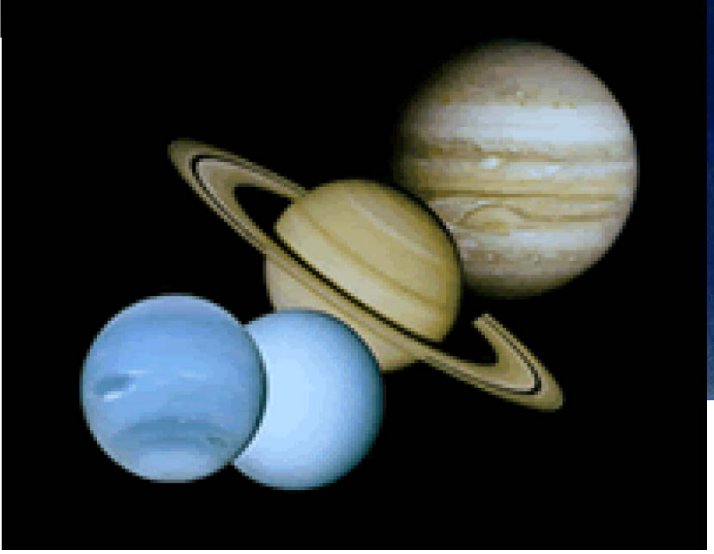
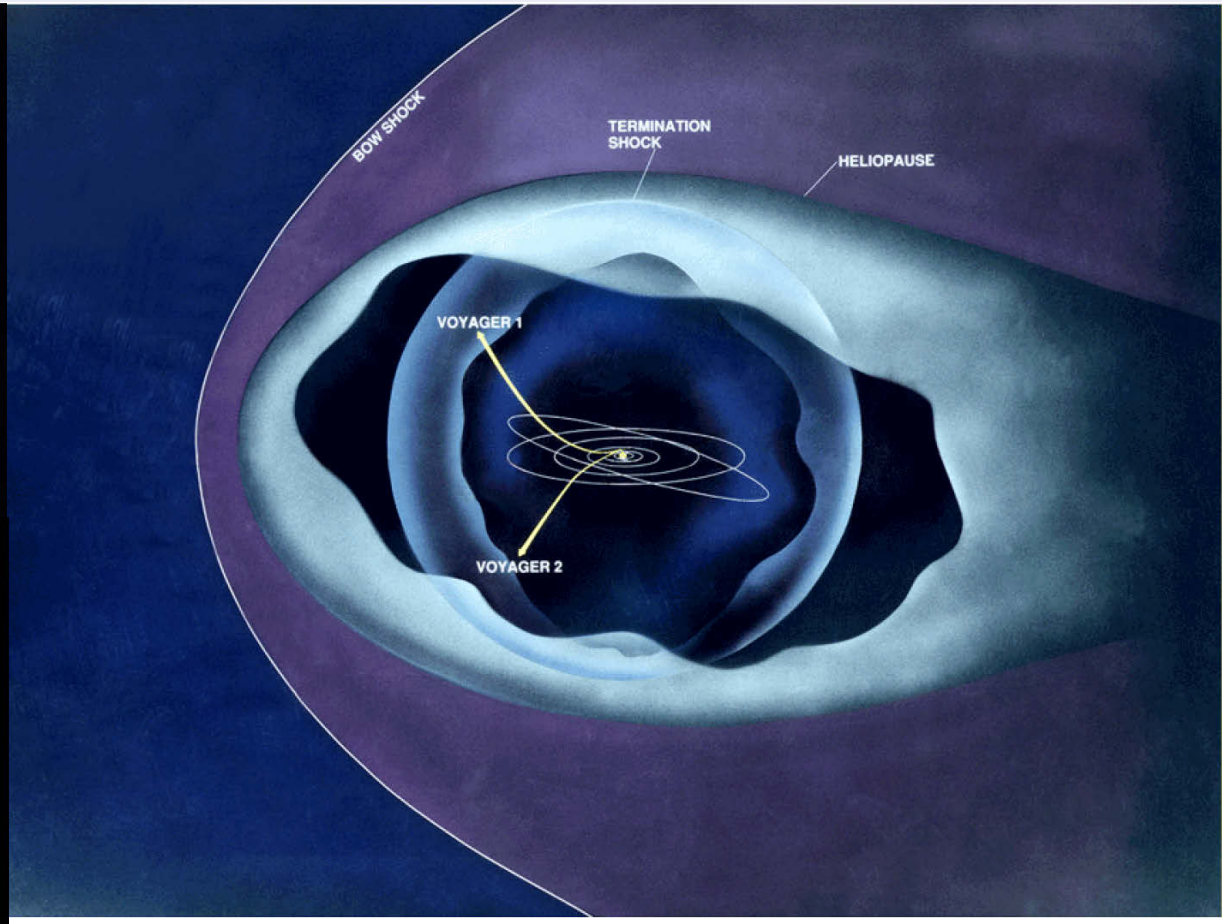
Voyager





Interstellar Mission

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Some of JPL's "firsts"

- History's first scientific satellite: Explorer 1
- First US satellite: Explorer 1
- First interplanetary spacecraft: Mariner 2
- First interplanetary images: Mariner 4
- First lunar impactor: Ranger 7
- First lunar soft lander: Surveyor 1
- First interplanetary orbiter: Mariner 9
- First gravity assist trajectory: Mariner 10
- First 4-planet mission: Voyager 2
- First planetary radar mapper: Magellan
- First Jupiter orbiter: Galileo
- First planetary rover: Mars Pathfinder
- First deep space sample return: Stardust
- First comet impact: Deep Impact
- First interstellar mission: Voyager
- First solar polar orbiter: Ulysses
- First Saturn orbiter: Cassini

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JPL and Robotic Exploration of the Solar System Today: Missions Currently in Operation

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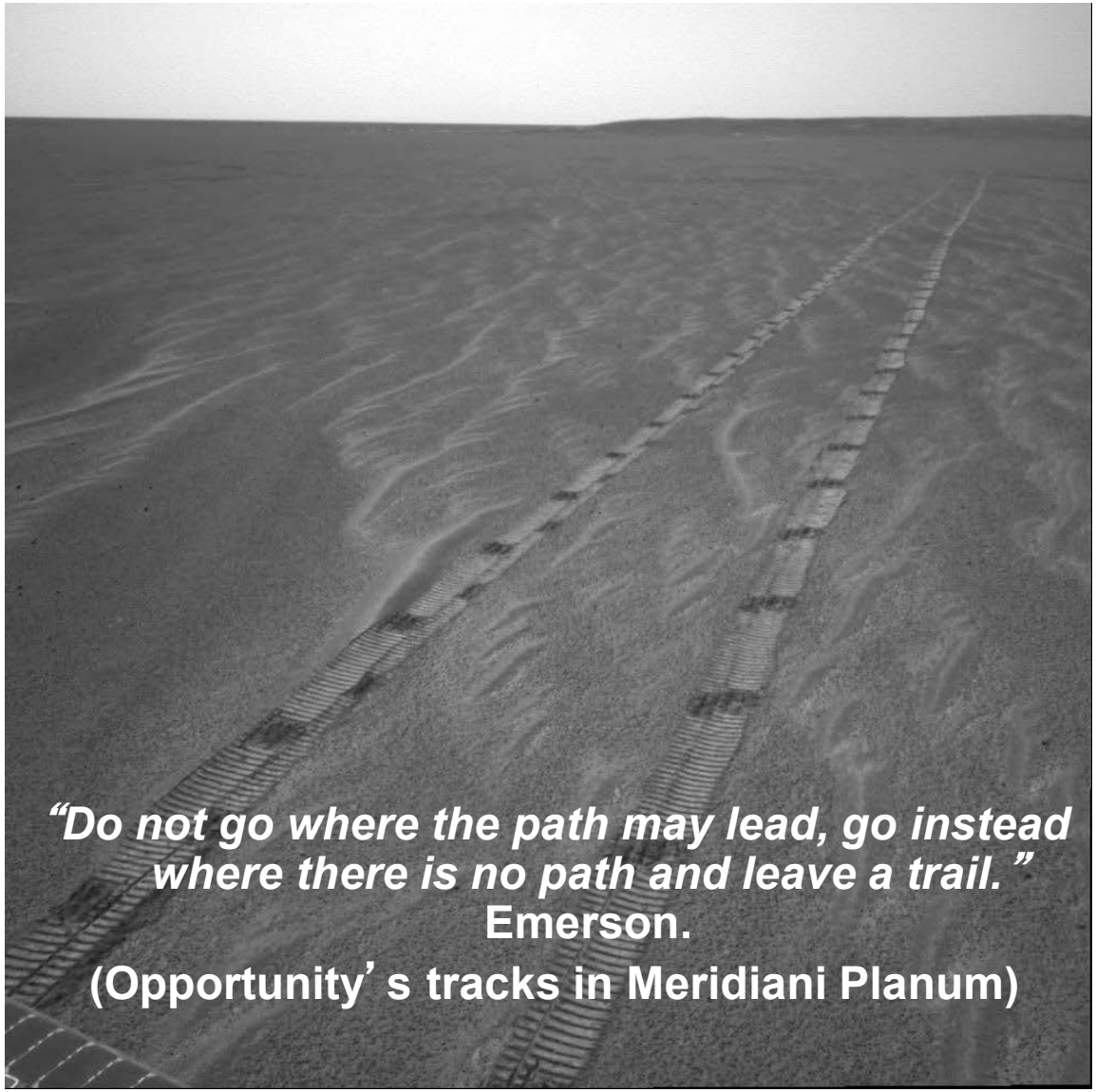
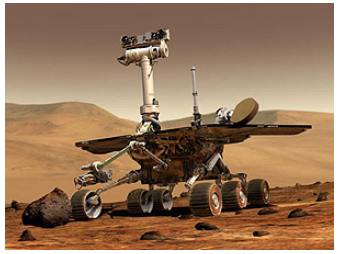
Today: A continuous robotic presence on and in orbit around Mars

2001 Mars Odyssey

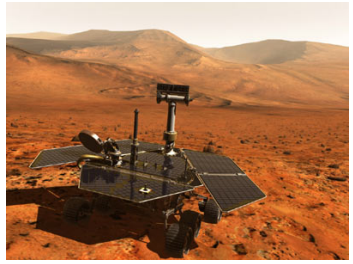
Mars Reconnaissance Orbiter

Mars Express (ESA)





Spirit (silent)



Opportunity

(operating)

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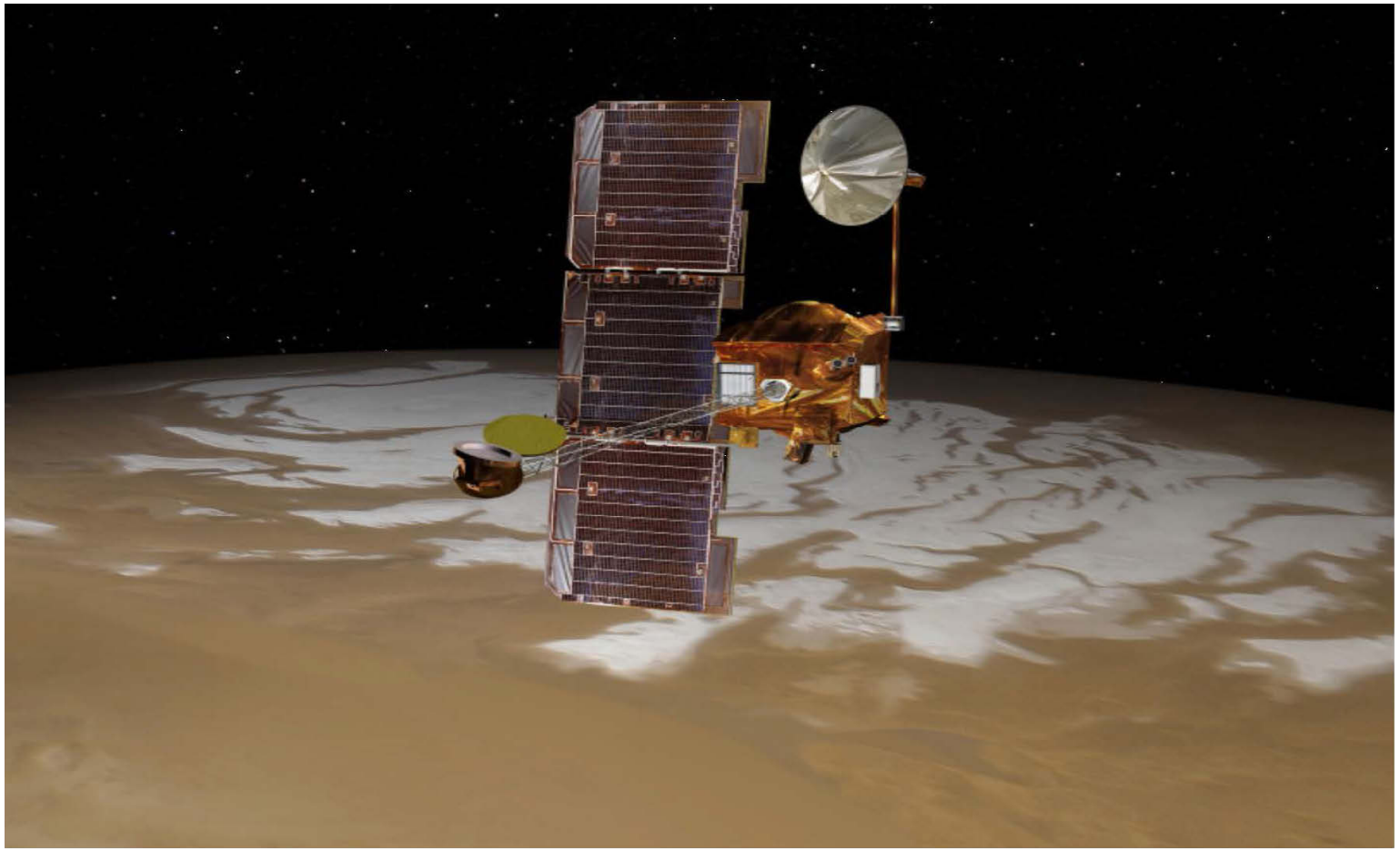
Mars Odyssey



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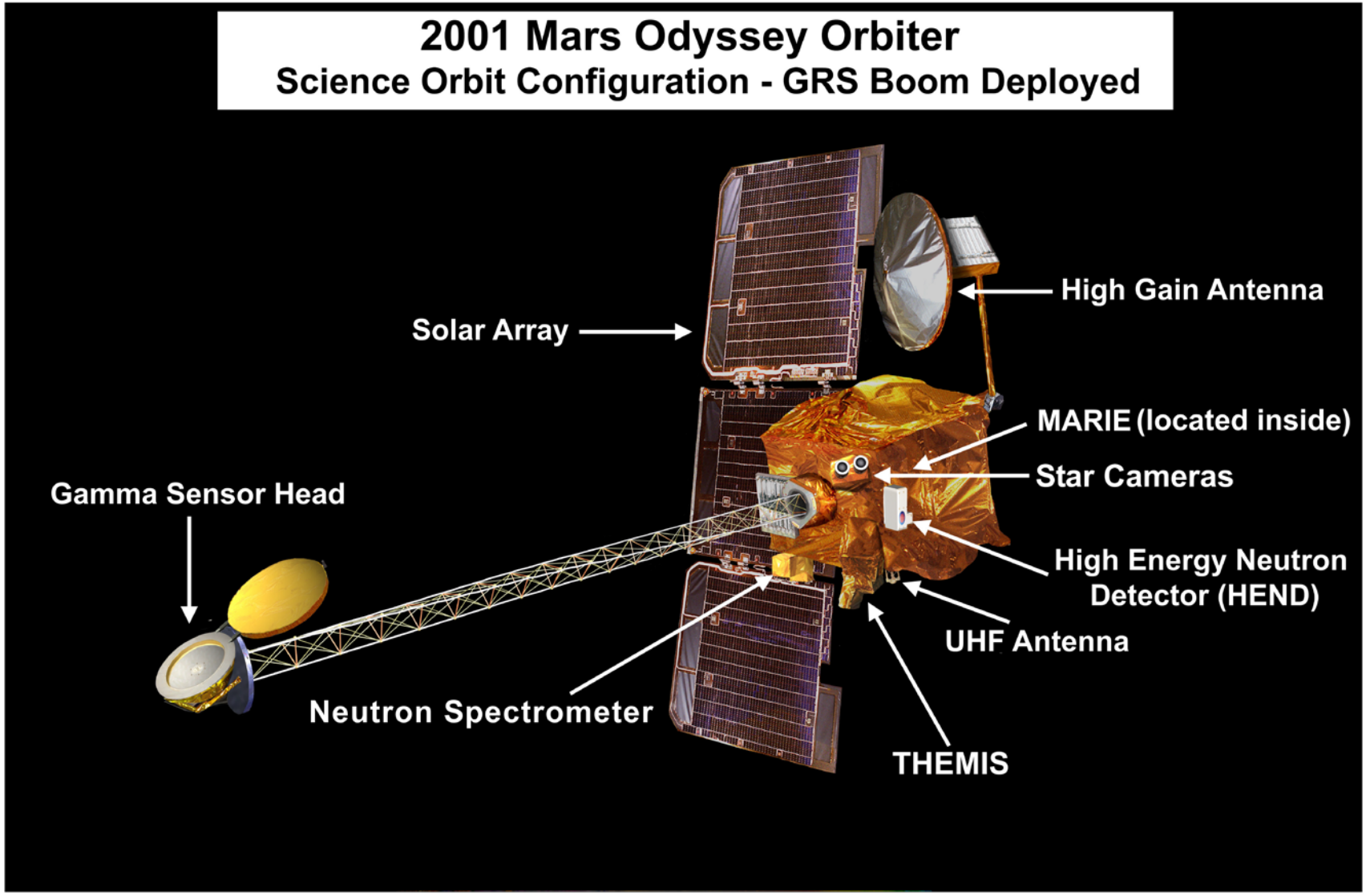
2001 Mars Odyssey Orbiter
Science Orbit Configuration - GRS Boom Deployed



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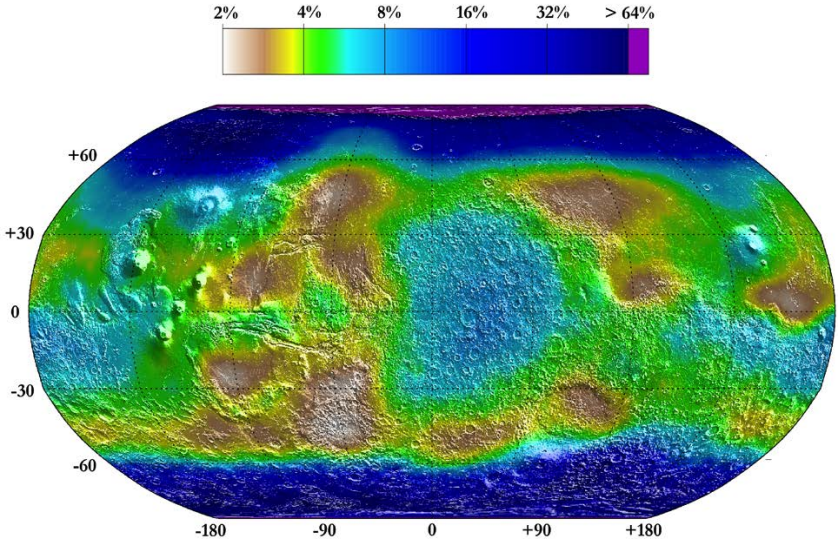
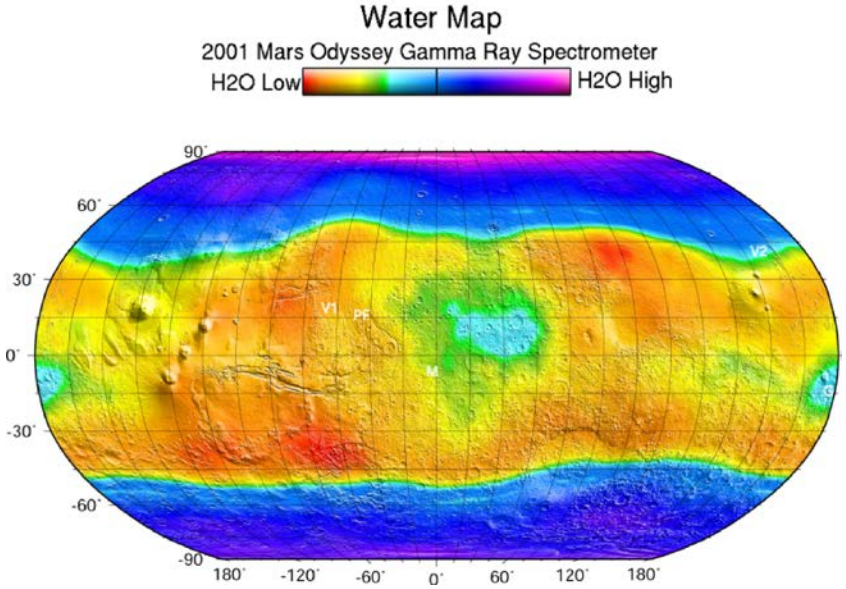
Mars Odyssey
Hydrogen as an indicator of Water Ice



Lower-Limit H_2O Mass Fraction on Mars From Neutron Spectrometer



Gamma Ray Spectrometer measurement of the relative abundance of Hydrogen, an indicator of buried water ice

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Mars Reconnaissance Orbiter

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Mars Reconnaissance Orbiter catches landslides near Mars' north pole

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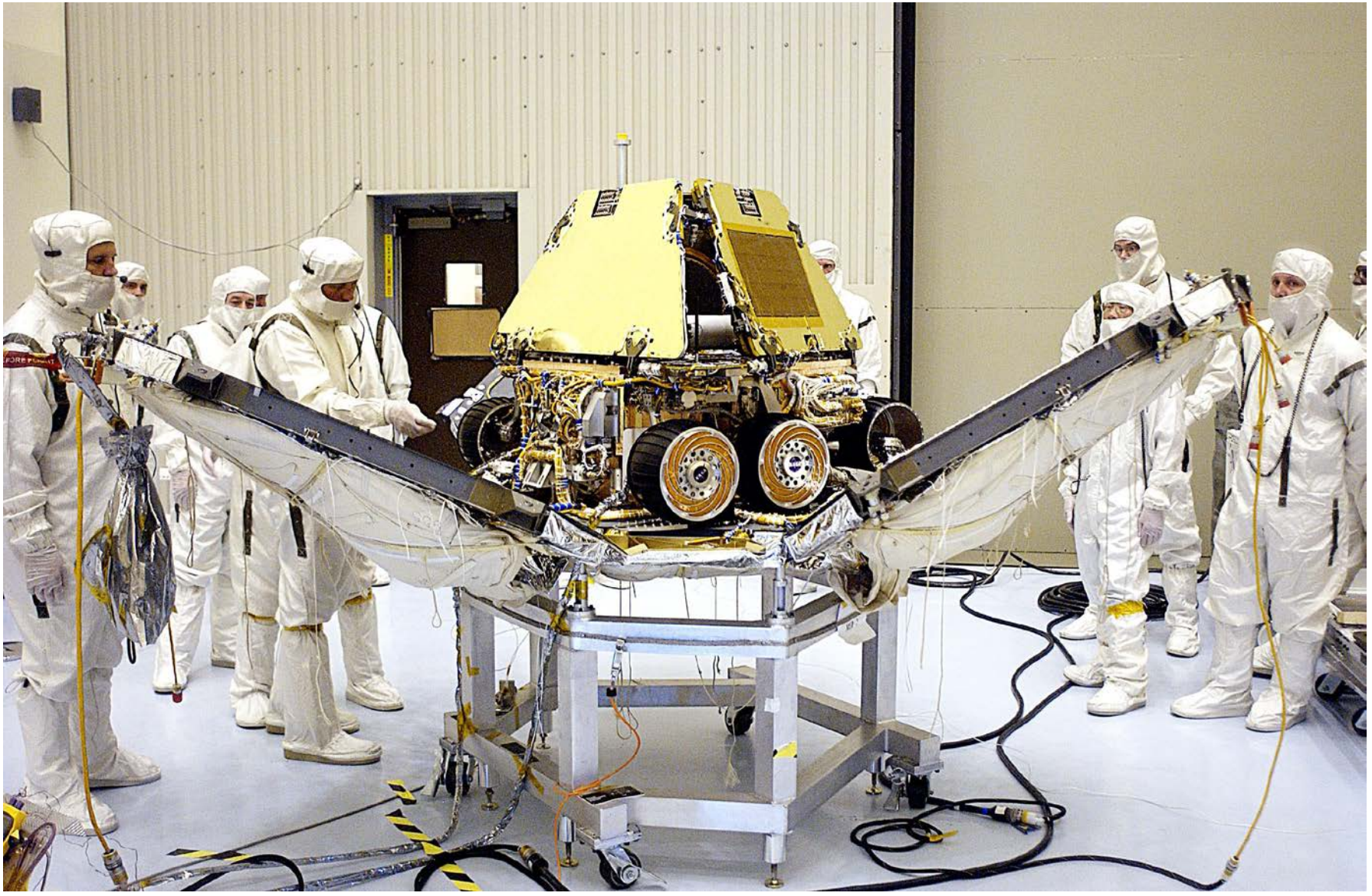
Mars Exploration Rover (MER)
Spirit Before Launch



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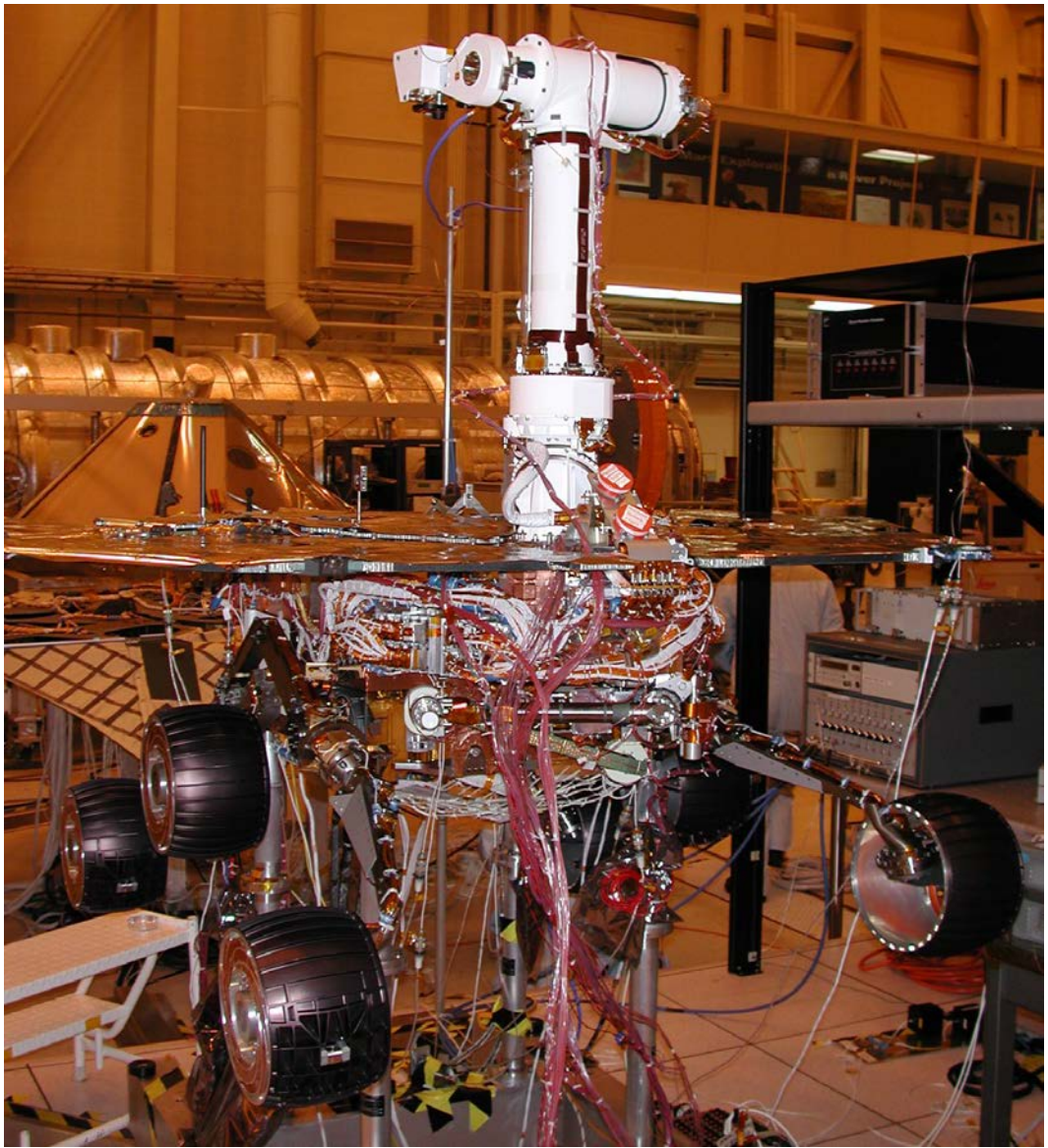
Mars Exploration Rover (MER)
Opportunity Being Built



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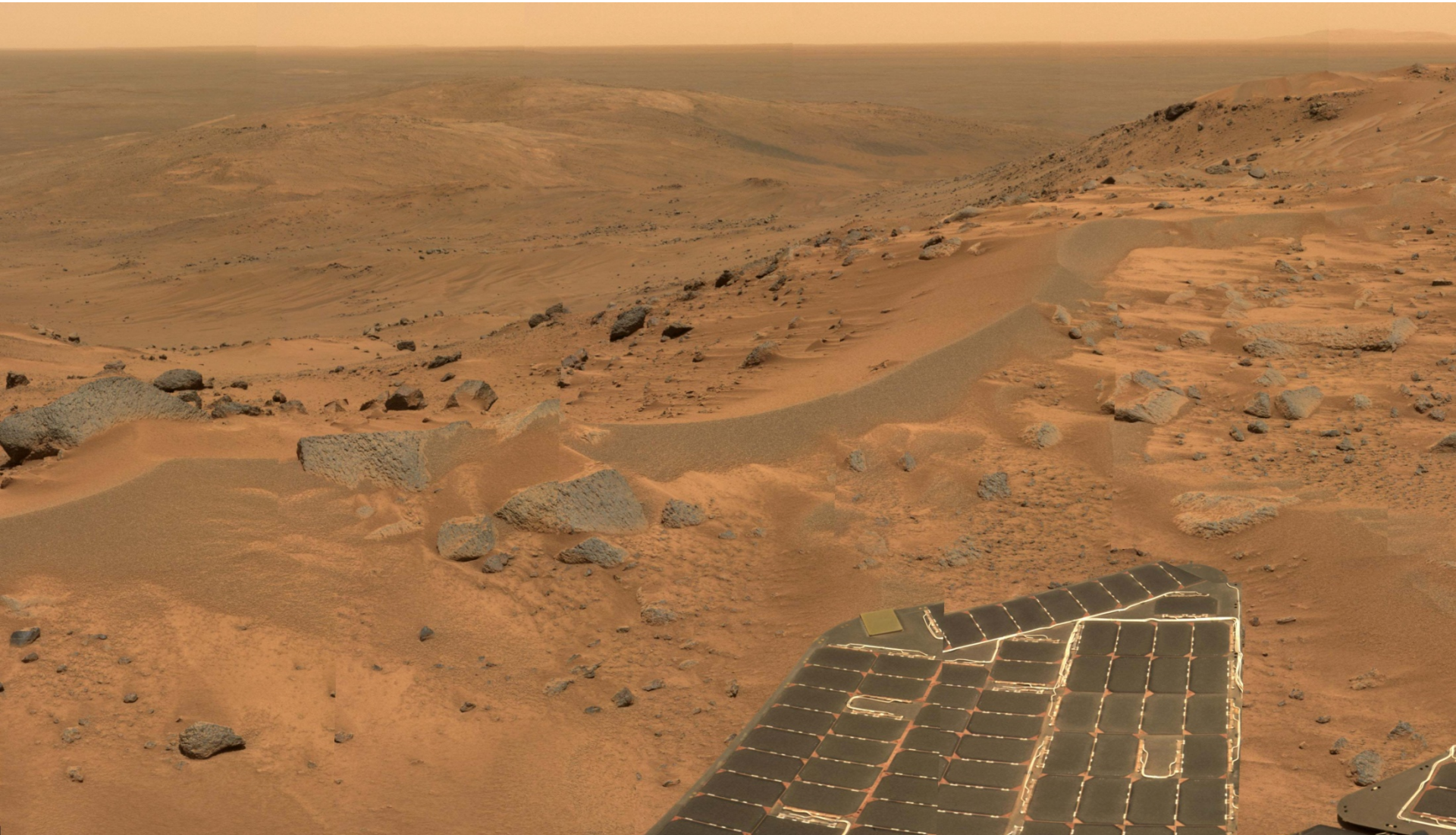
Mars Exploration Rover (MER)
Spirit at the Top of Husband Hill



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Mars Exploration Rover (MER)
Spirit at Home Plate

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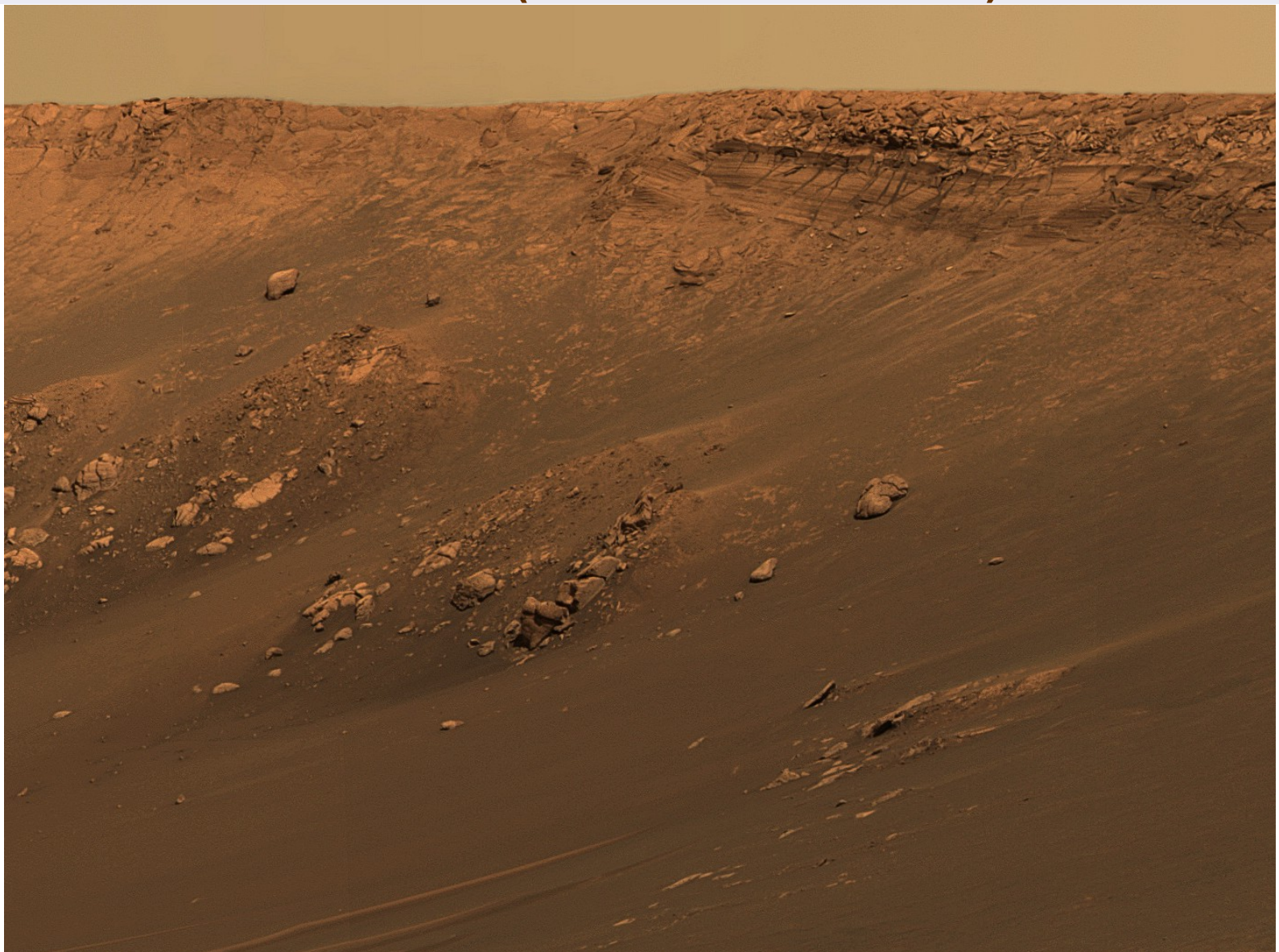
Mars Exploration Rover (MER) Opportunity at Endurance Crater (View of Burns Cliff)



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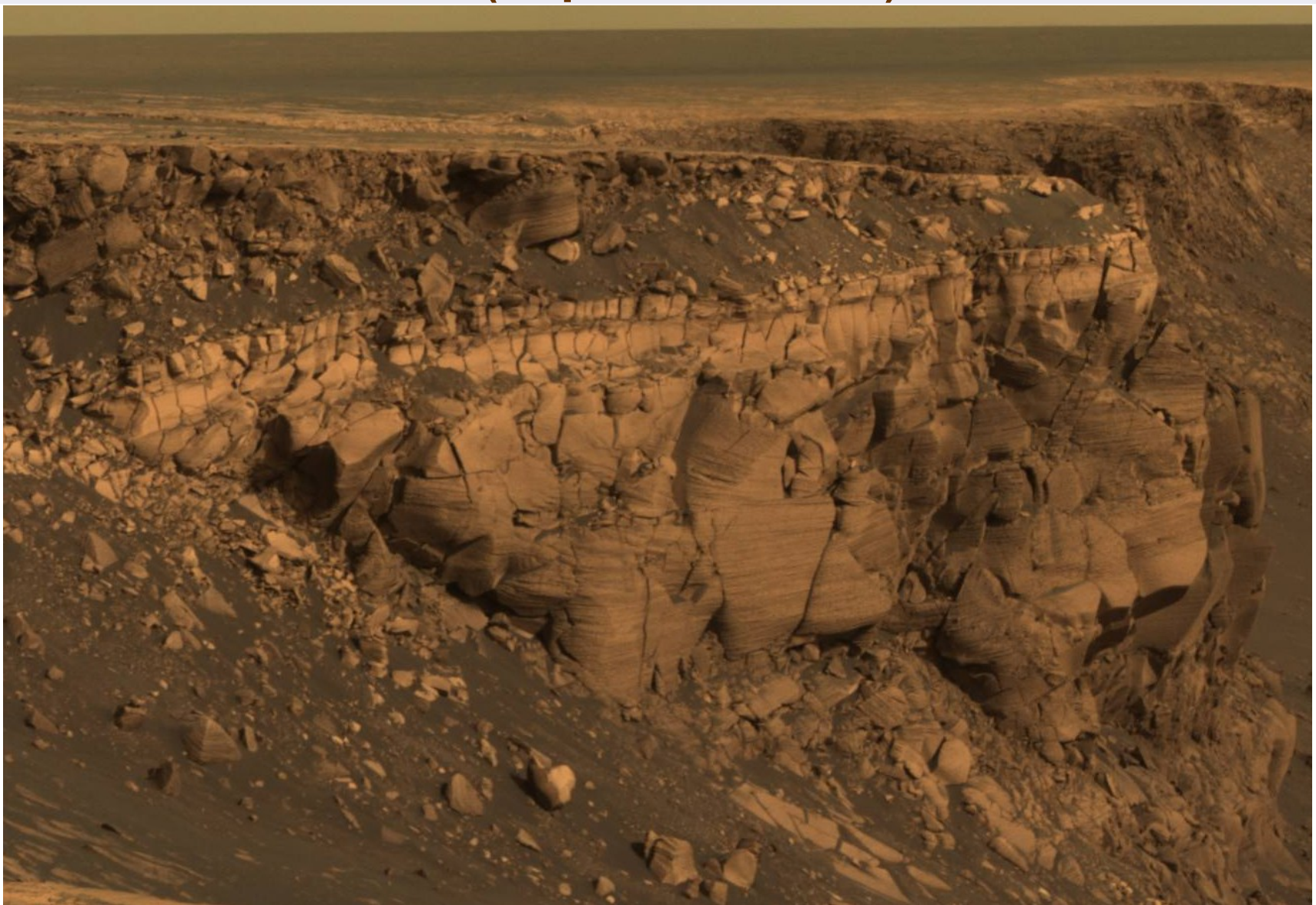
Mars Exploration Rover (MER) Opportunity at Victoria Crater (Cape St. Vincent)



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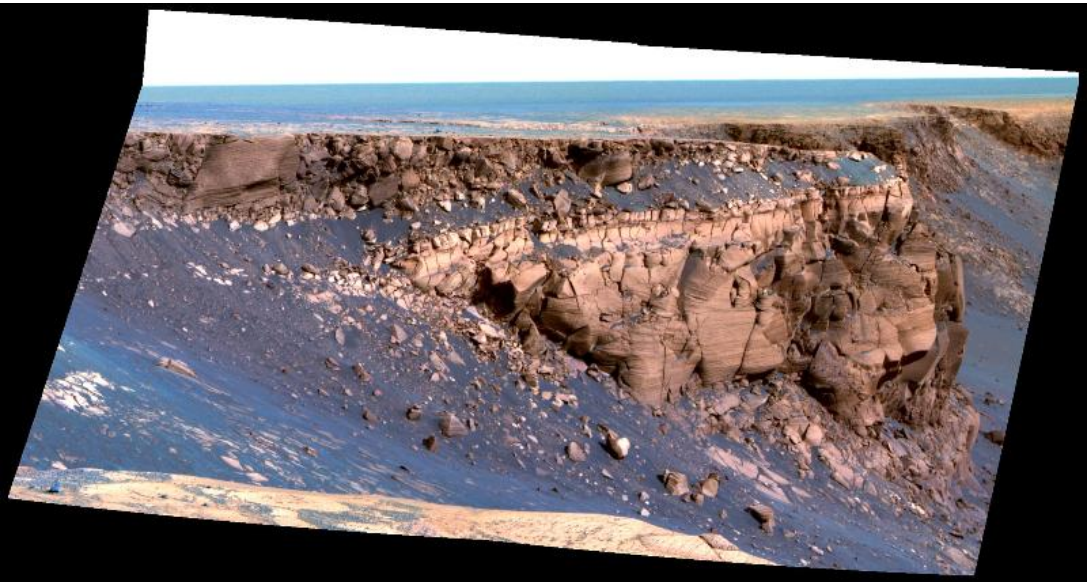
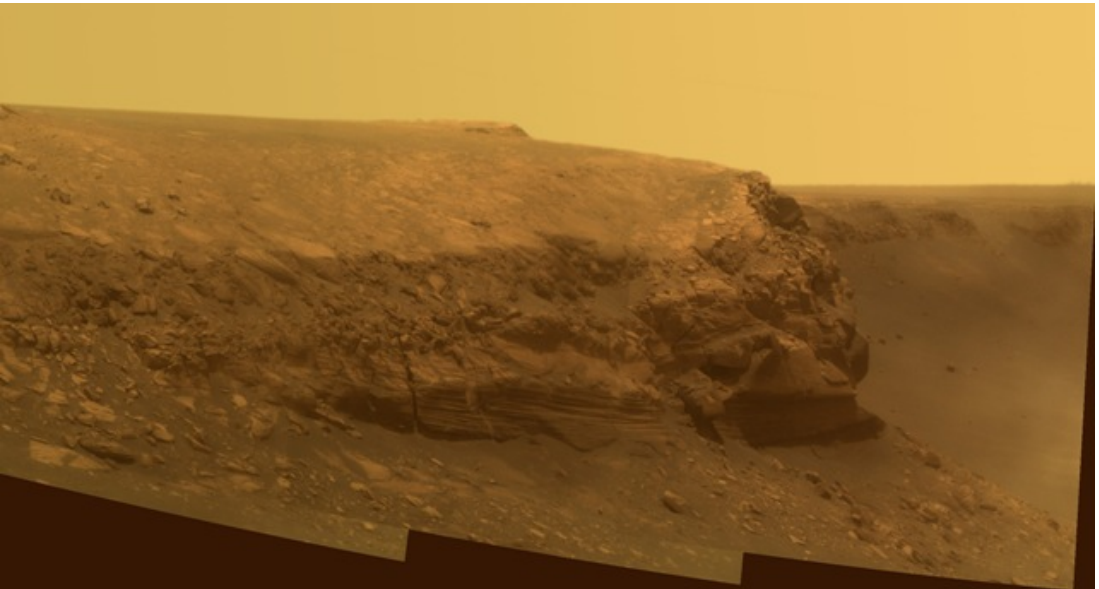
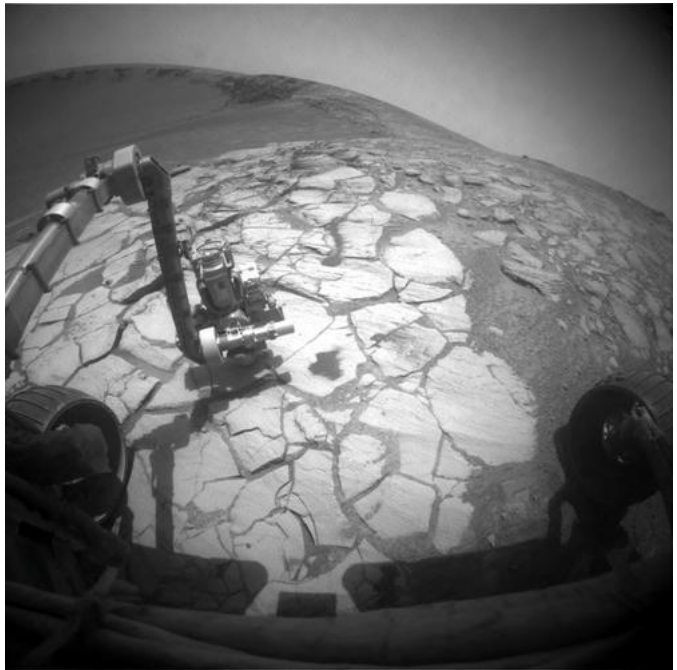
Latest images from Opportunity near and inside Victoria Crater







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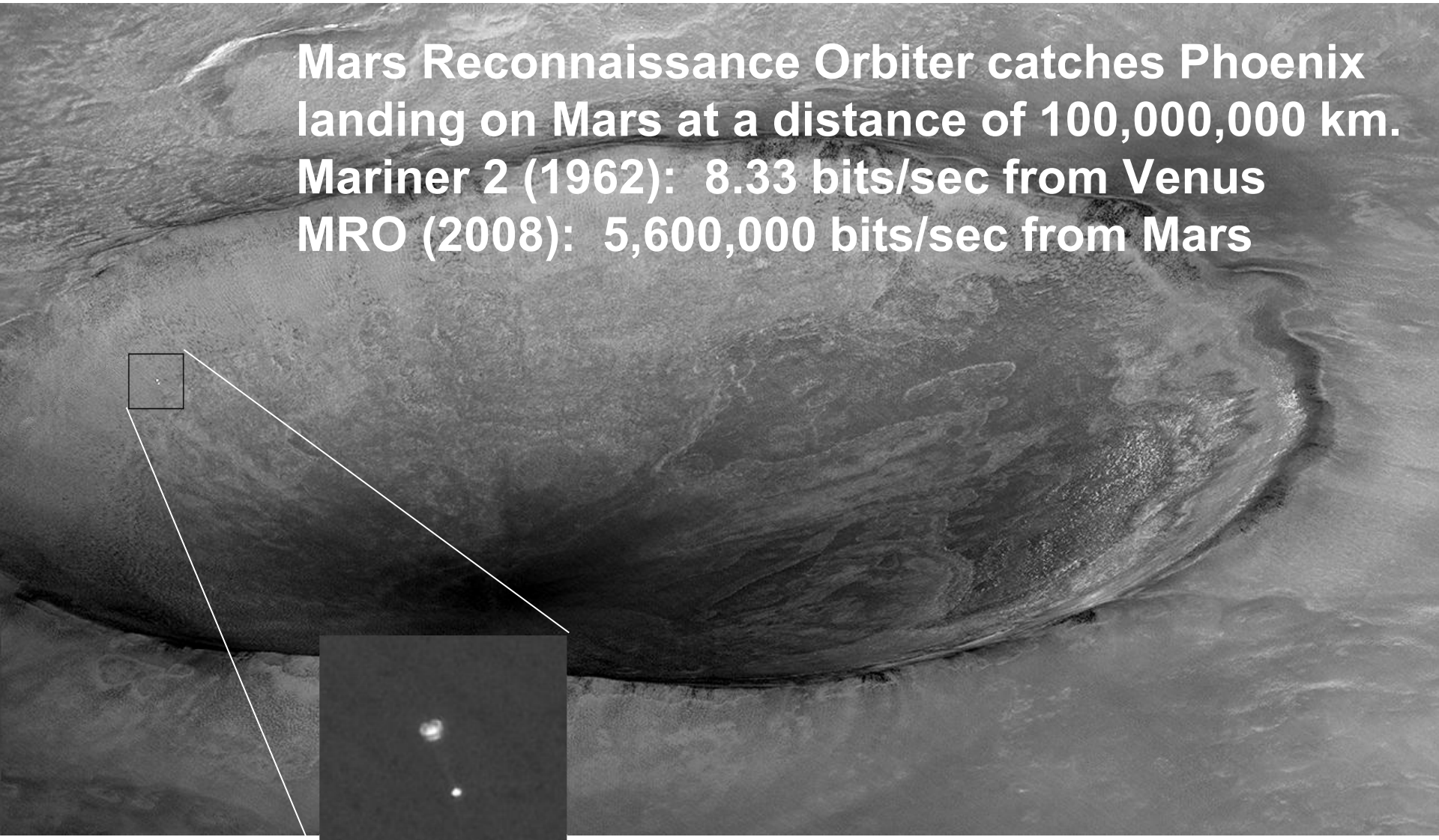
Meanwhile, MRO Supports Other Missions While Doing Incredible Science



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Phoenix landed near Mars' north pole May 25, 2008

- Study history of water.
- Determine arctic soil habitability.
- Study Mars' polar weather.

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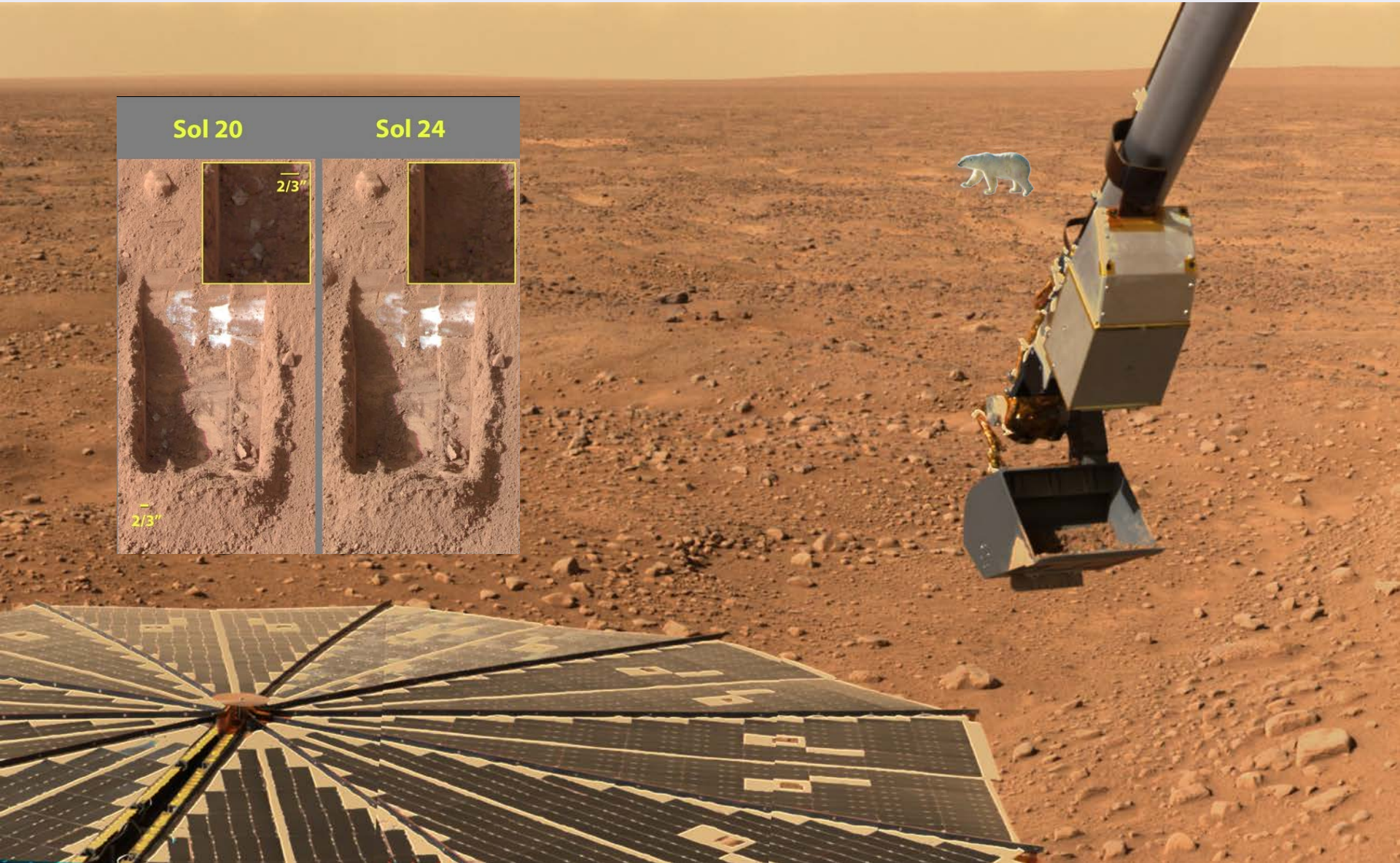
Phoenix makes it official: There is water on Mars

(Clean your glasses if you think Phoenix saw a Mars polar bear)



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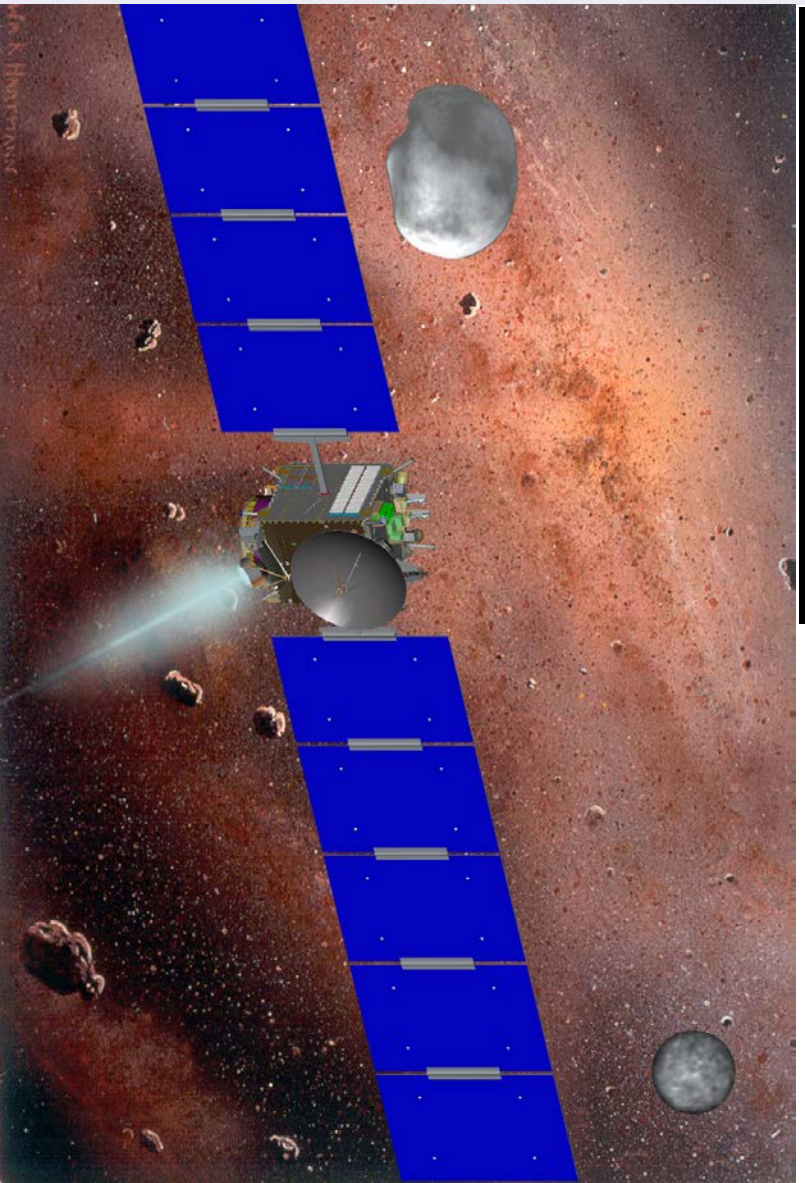
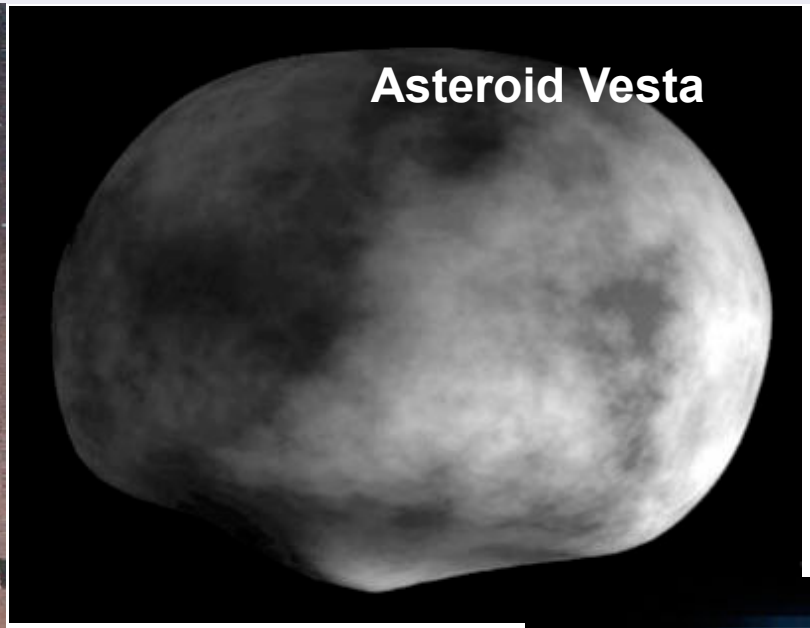
Dawn uses solar electric ion engines to encounter Vesta in 2011 and Ceres in 2015





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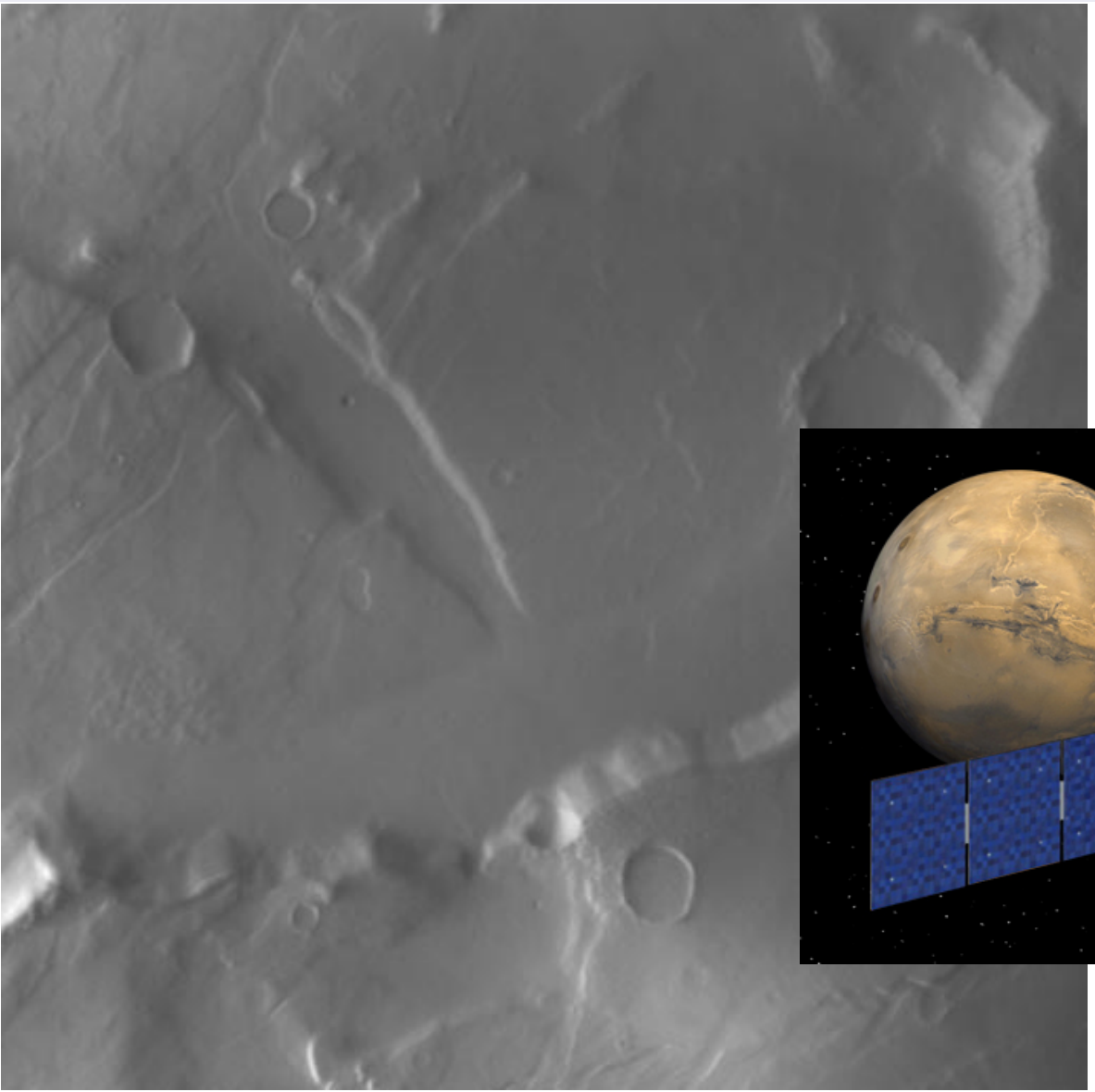
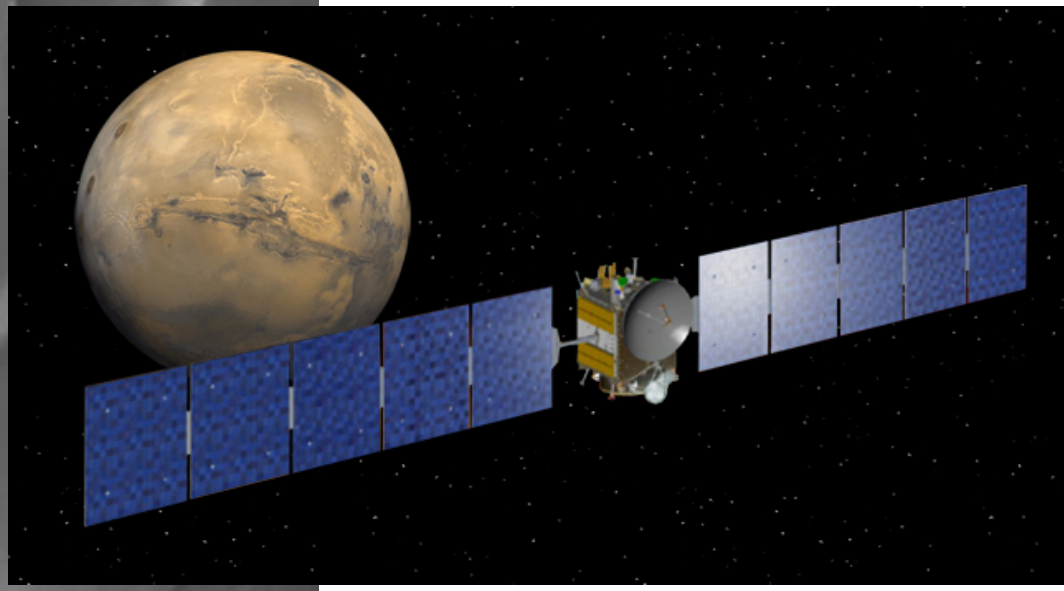
Dawn images Mars on February 17, 2009 on its way to Vesta and Ceres





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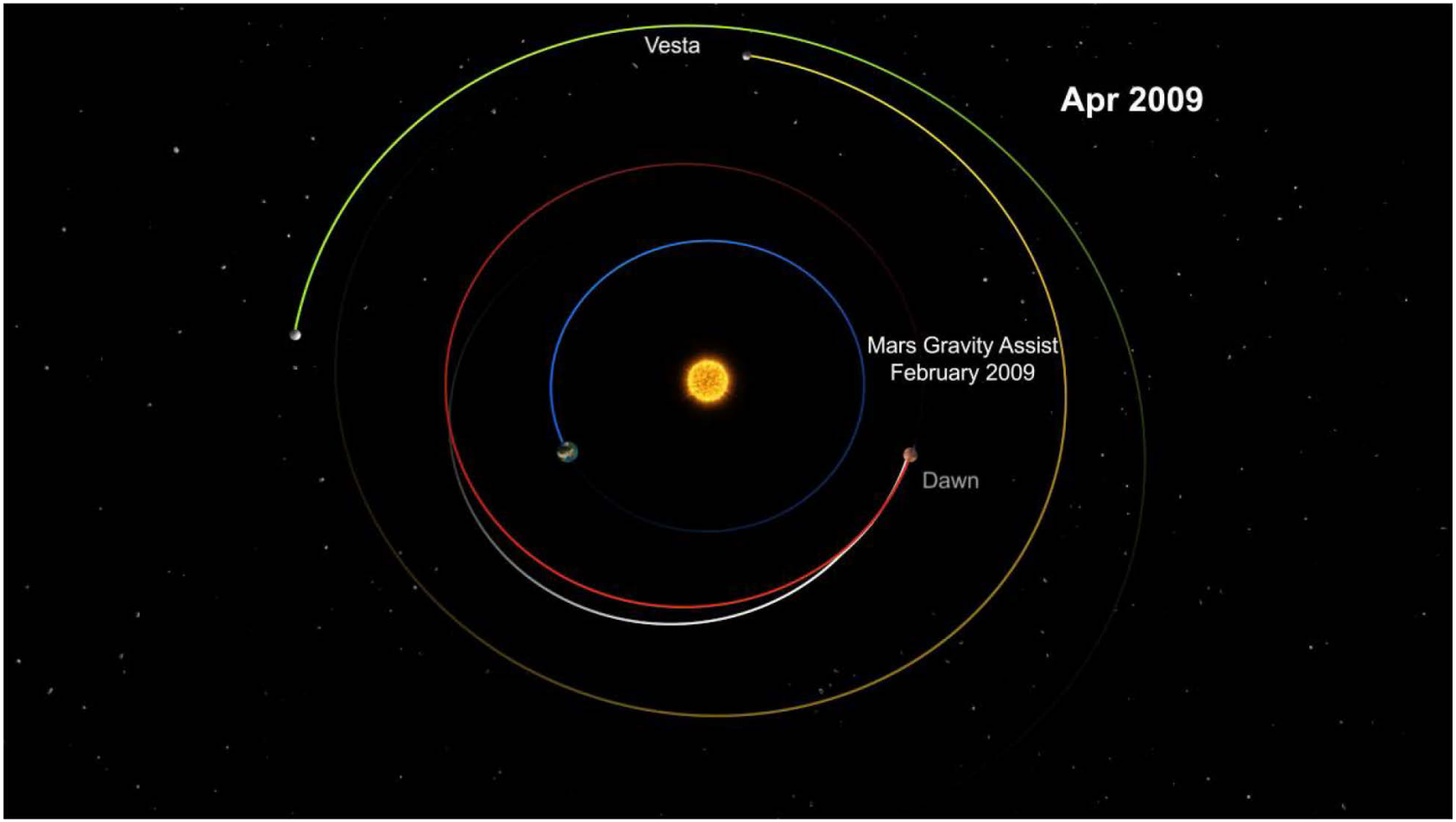
Dawn's Amazing Path to Vesta



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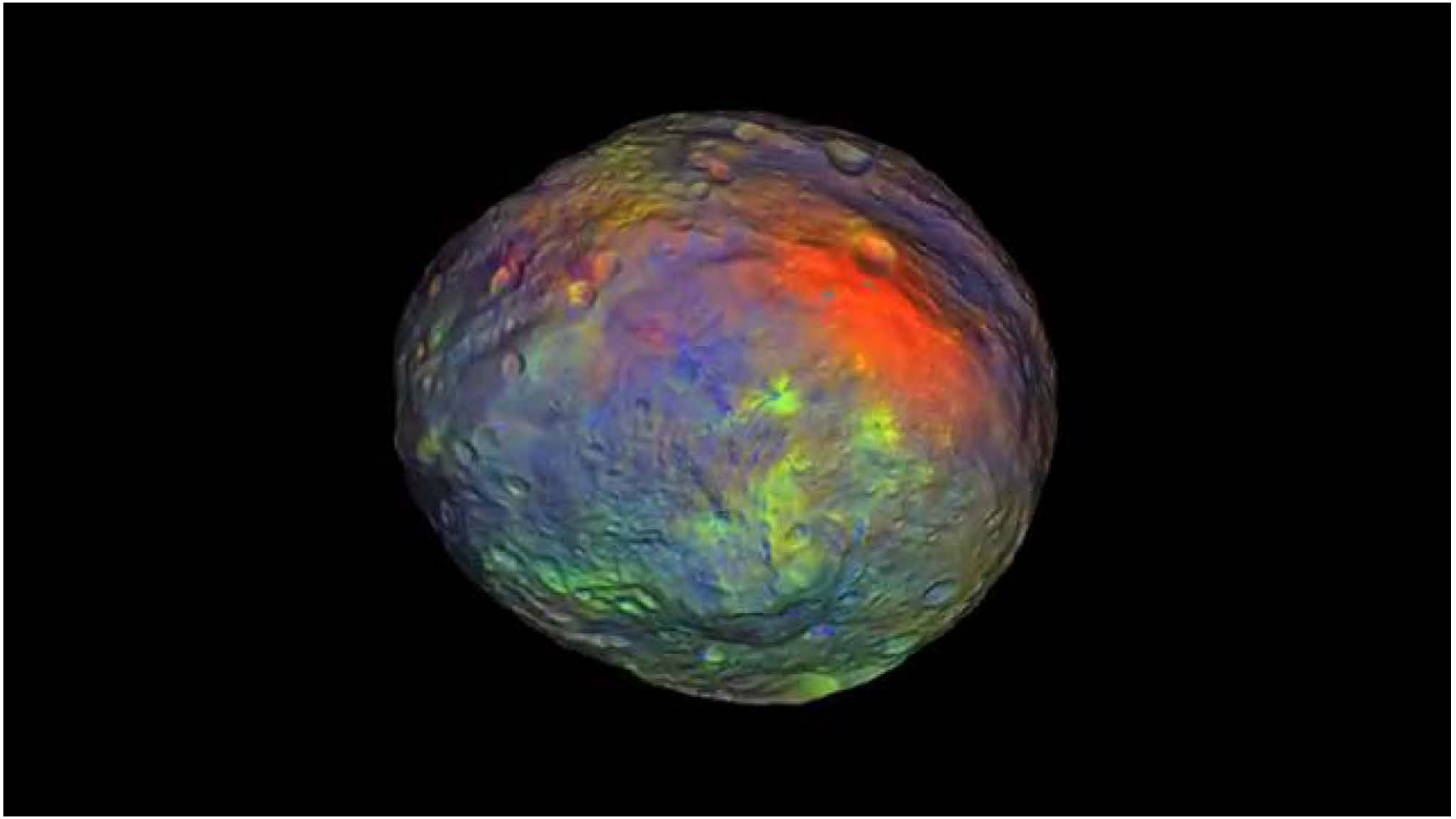
Vesta Revealed from All Angles



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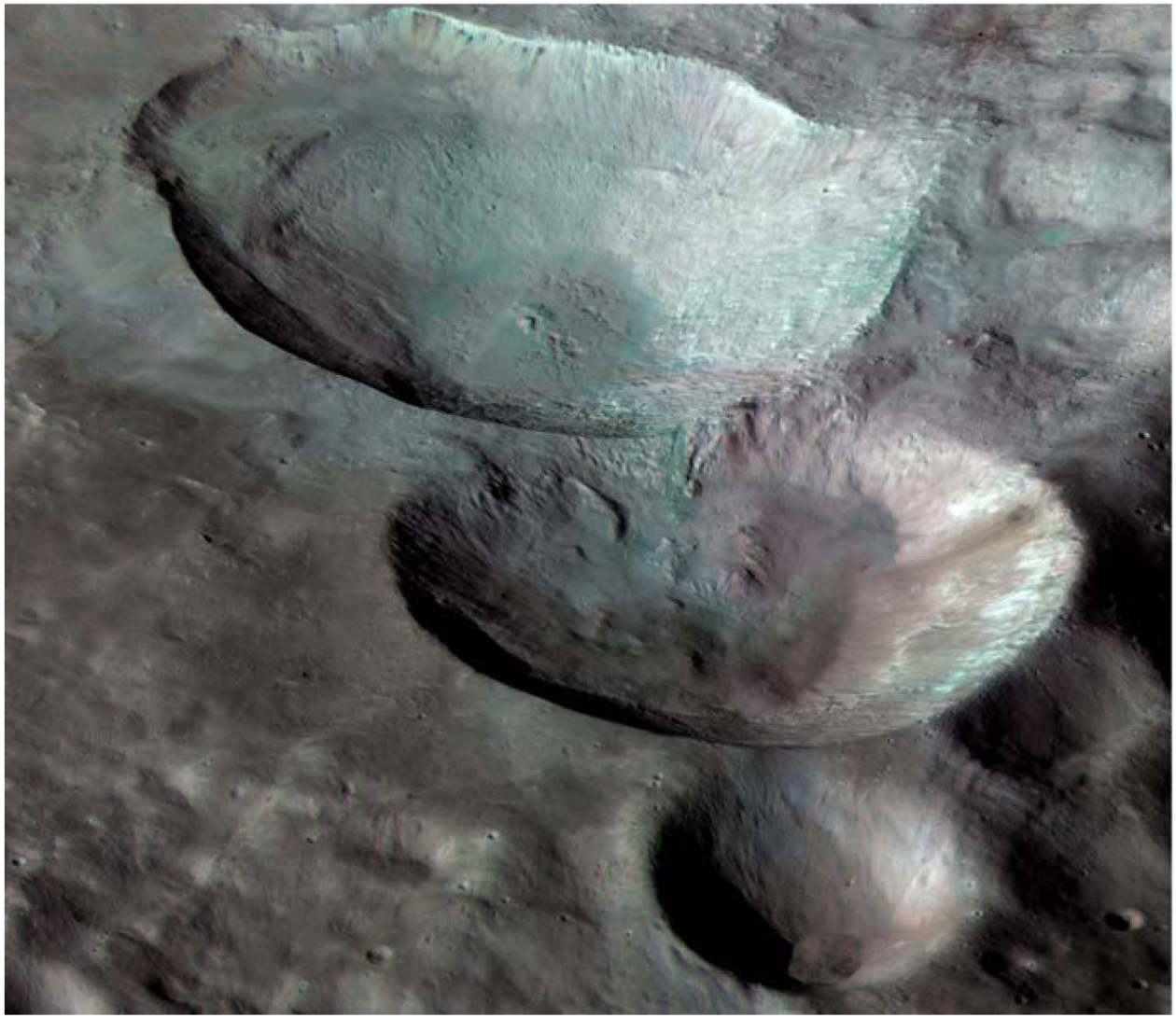
South Polar Region of Vesta



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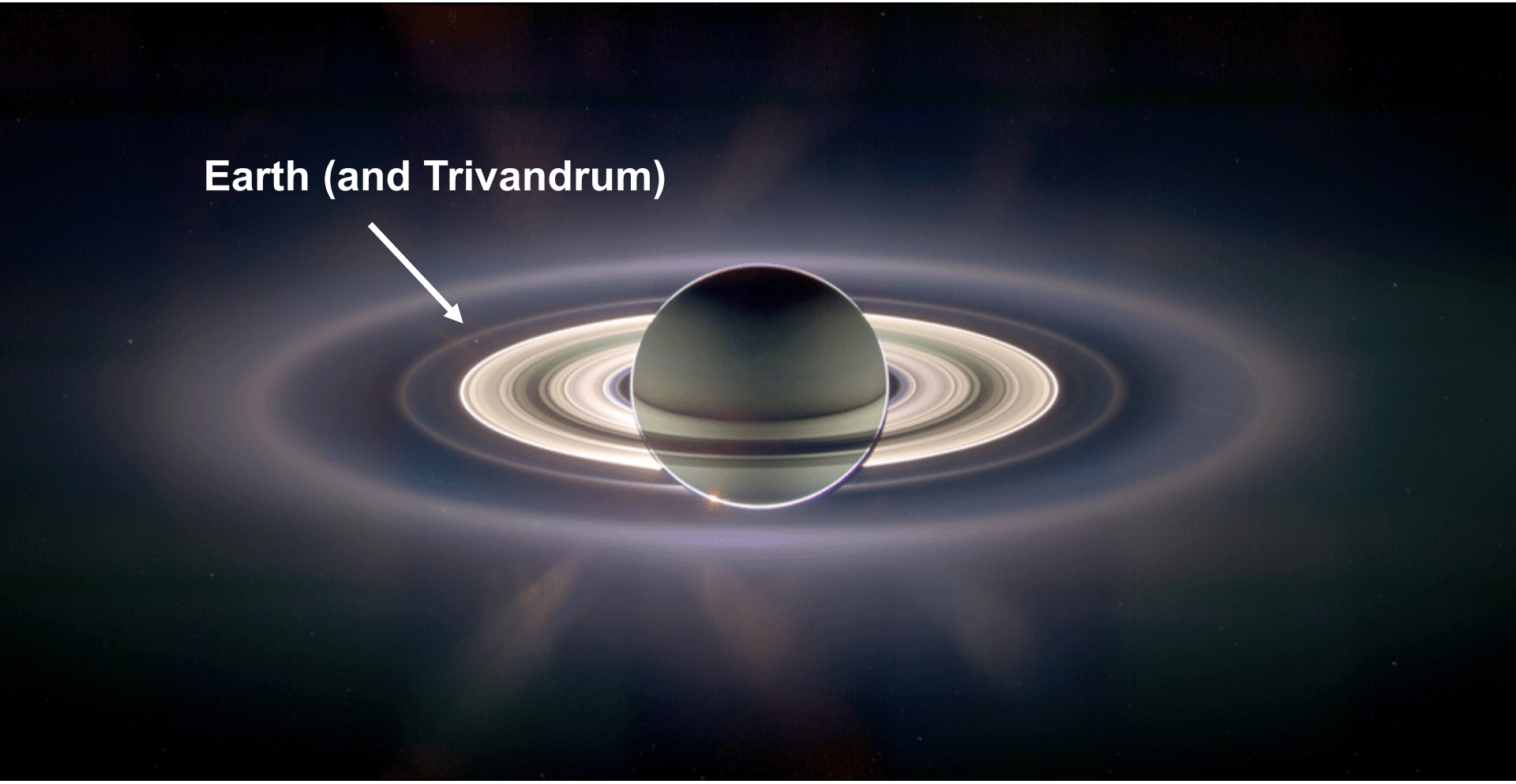
Backlit Saturn from Cassini orbiter



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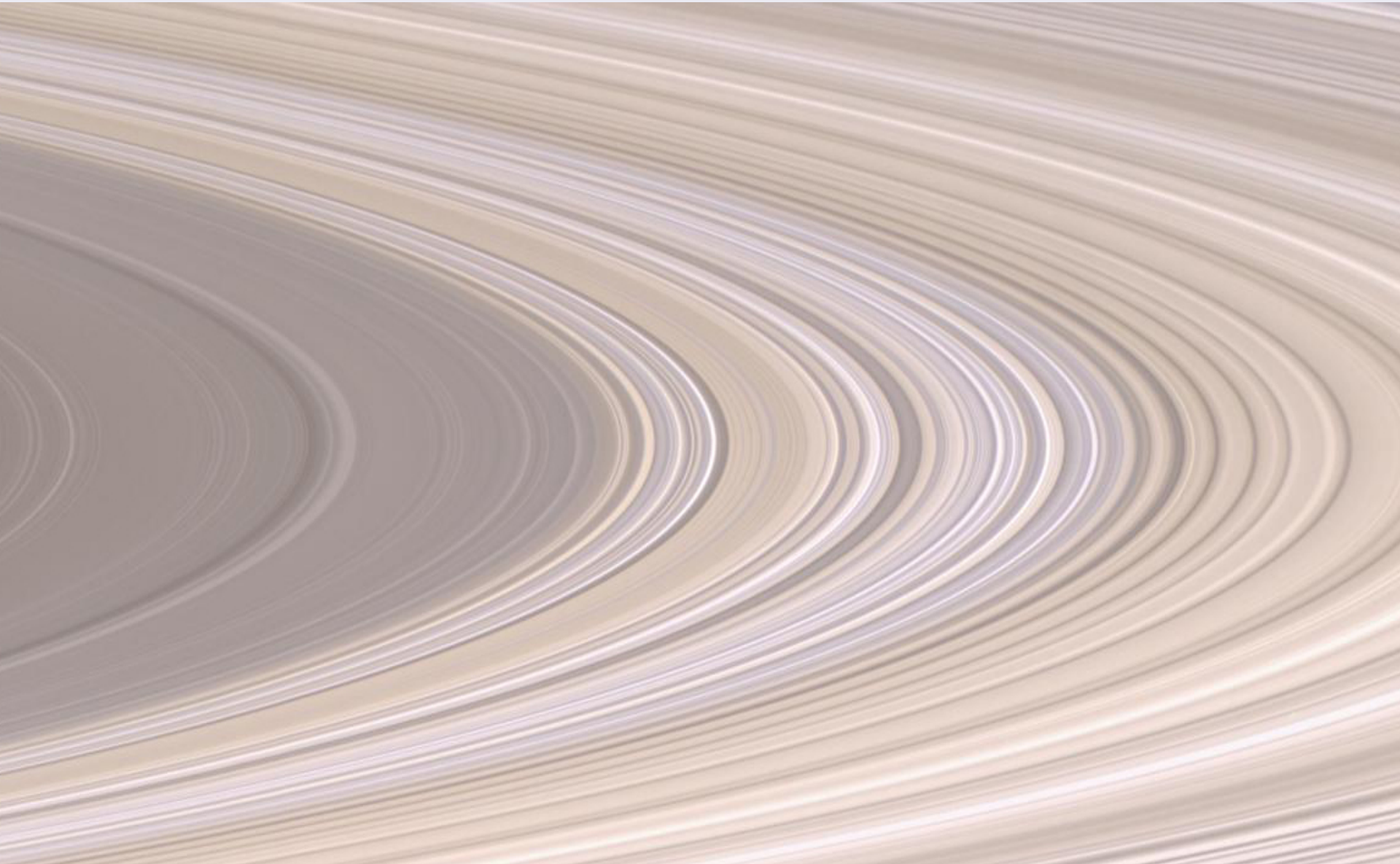
Fine structure in Saturn's rings from Cassini spacecraft



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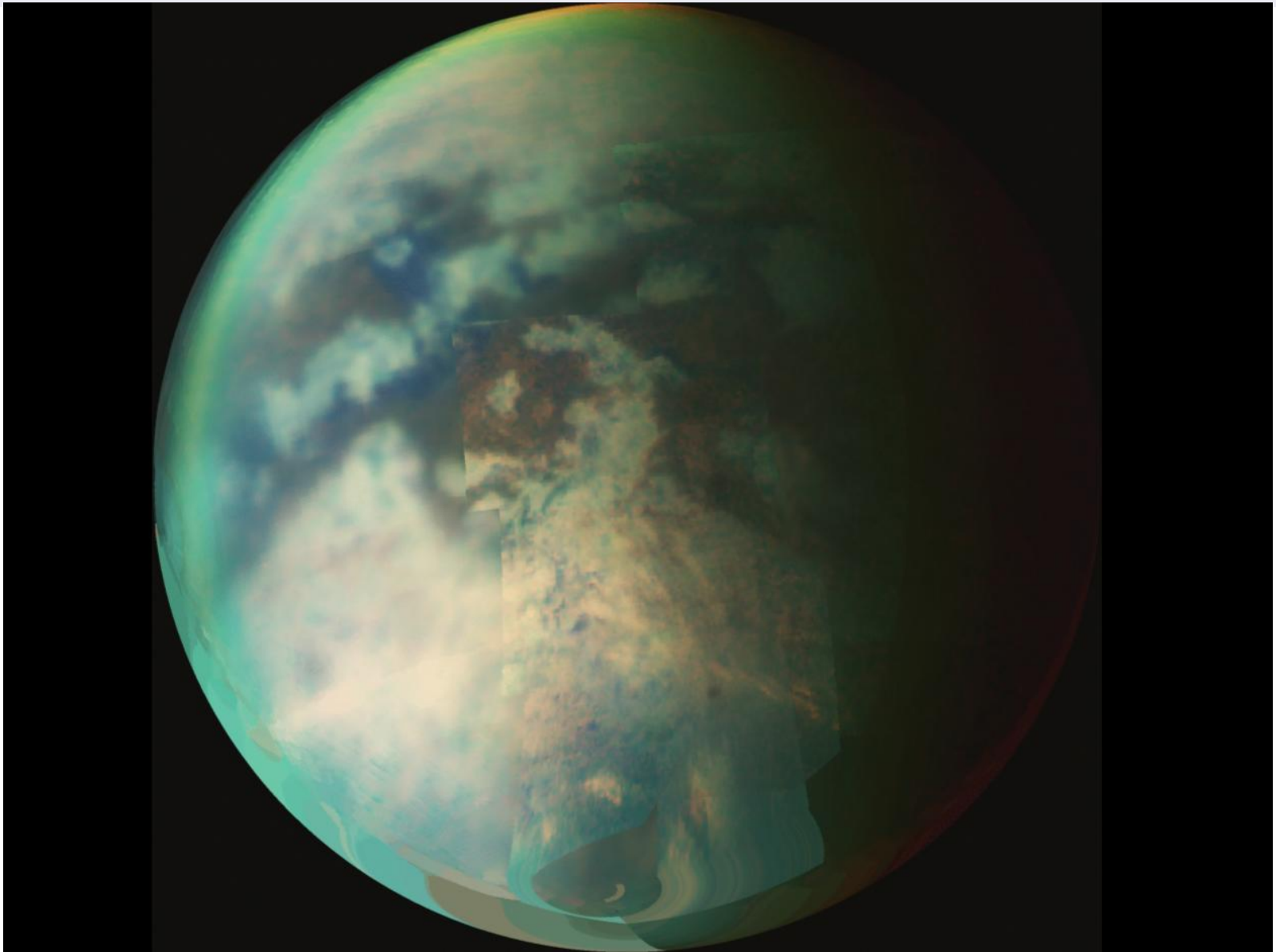
Saturn's moon Titan from Cassini orbiter



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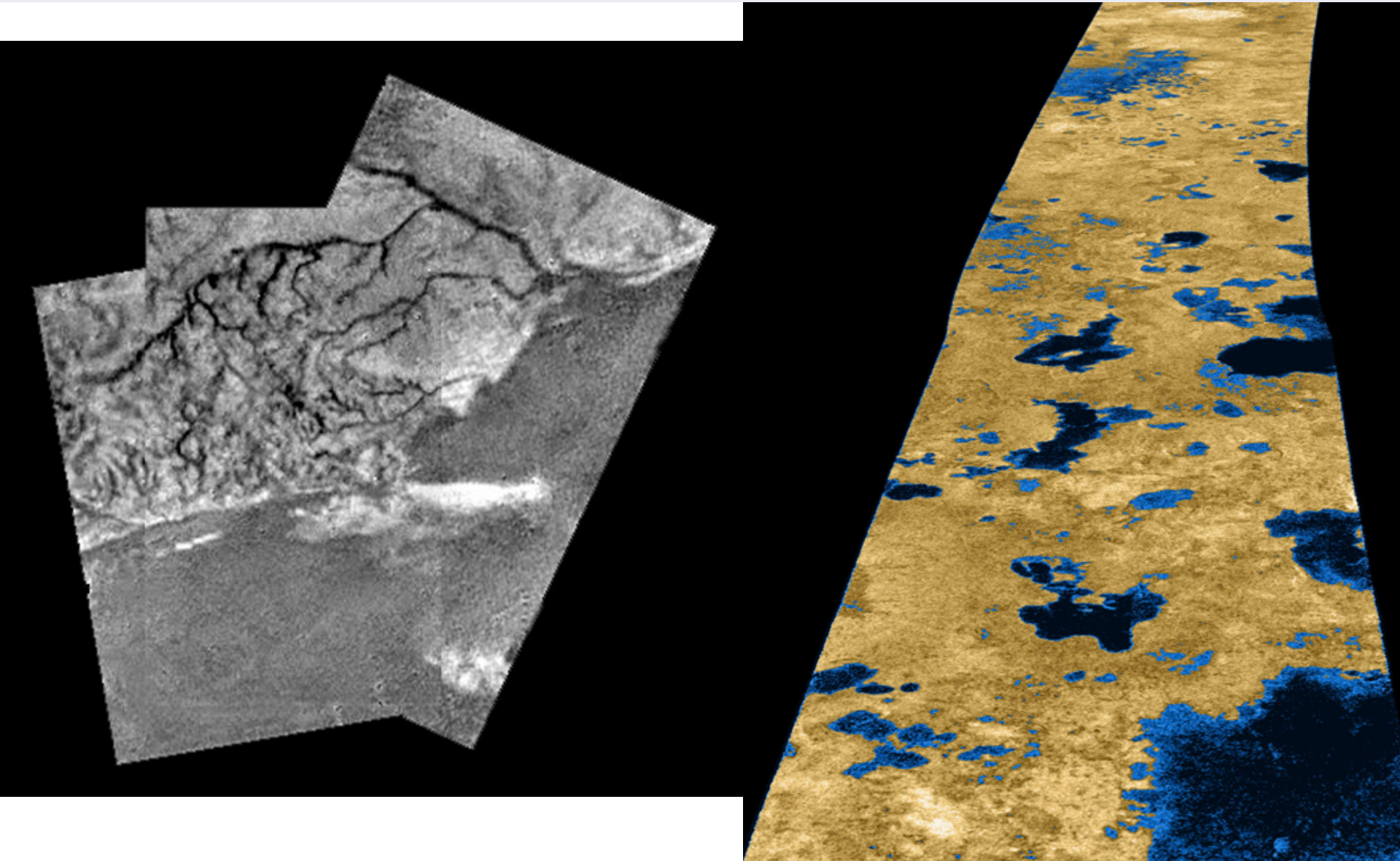
Cassini and Huygens observe Titan's surface and lakes



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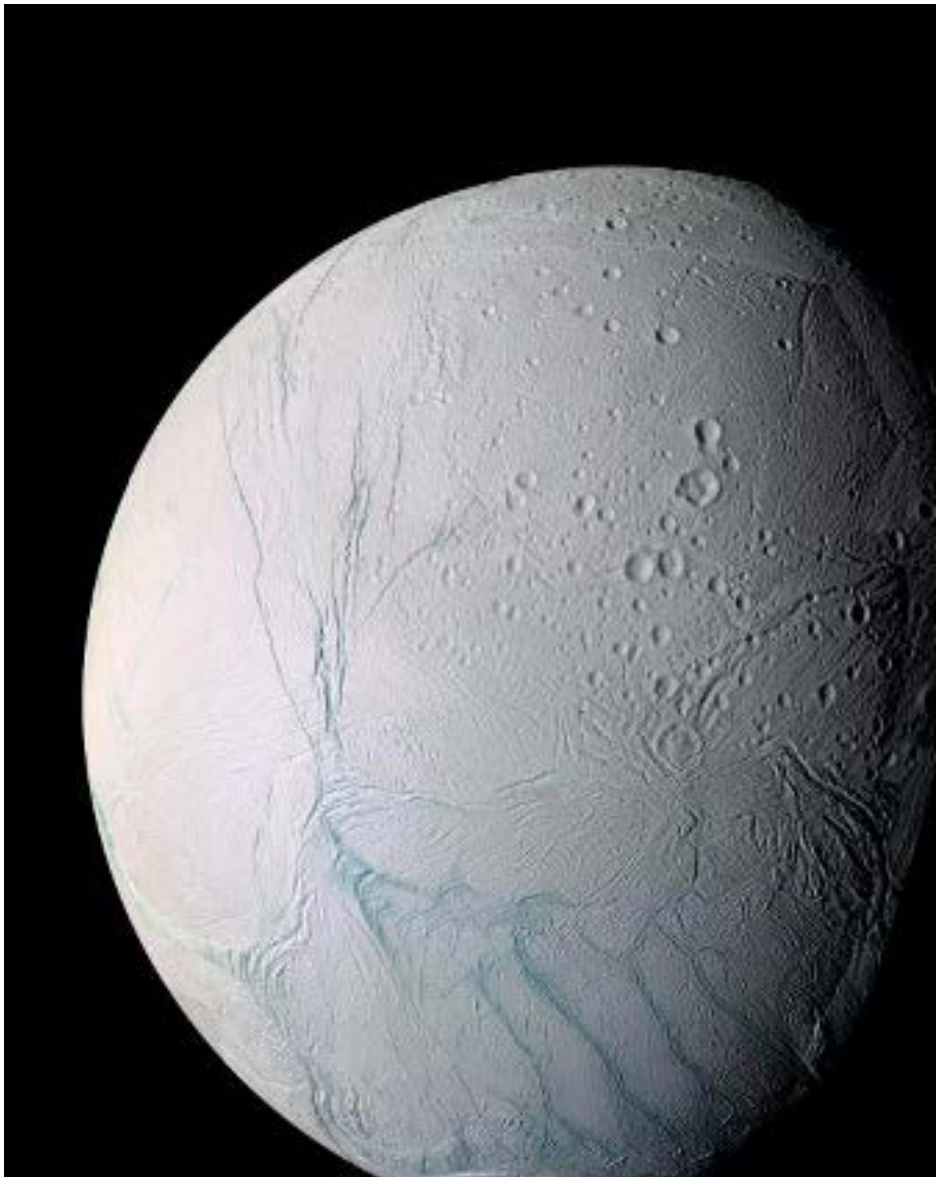
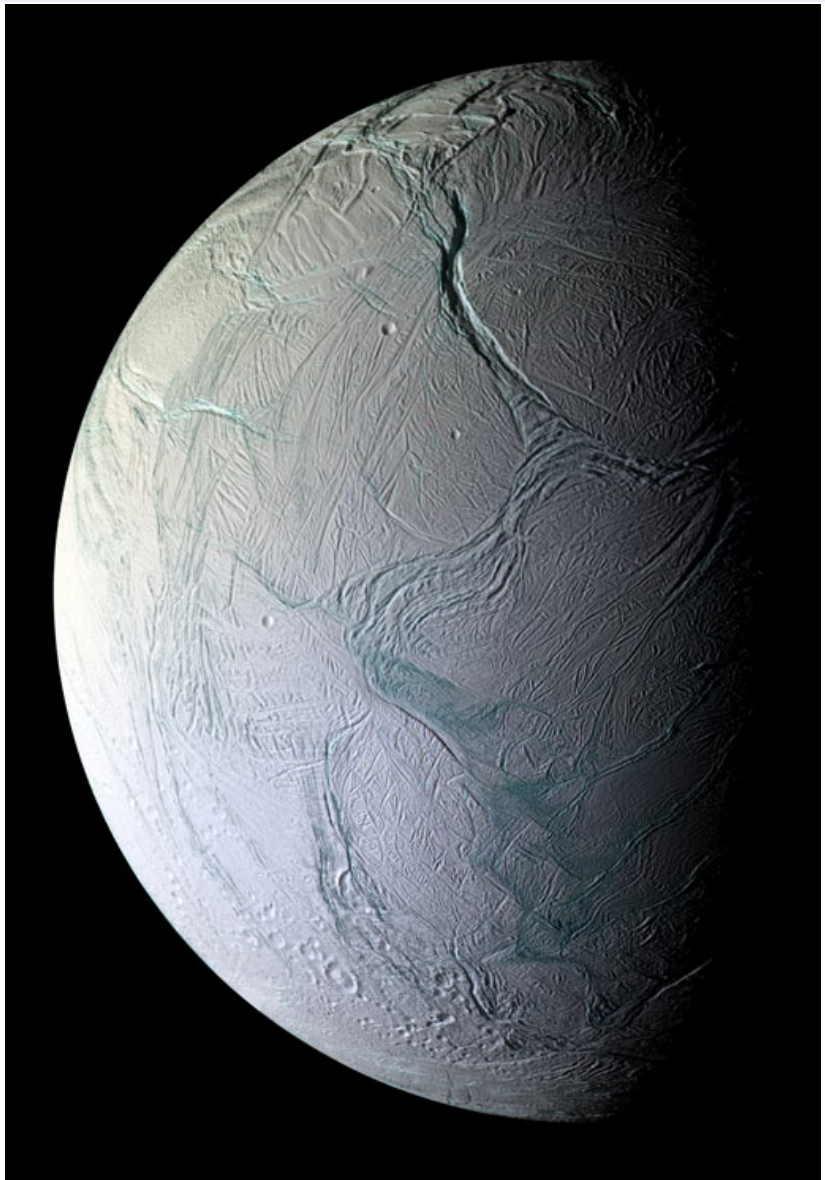
Saturn's moon Enceledus with "tigerstripe" cracks in ice (two views)





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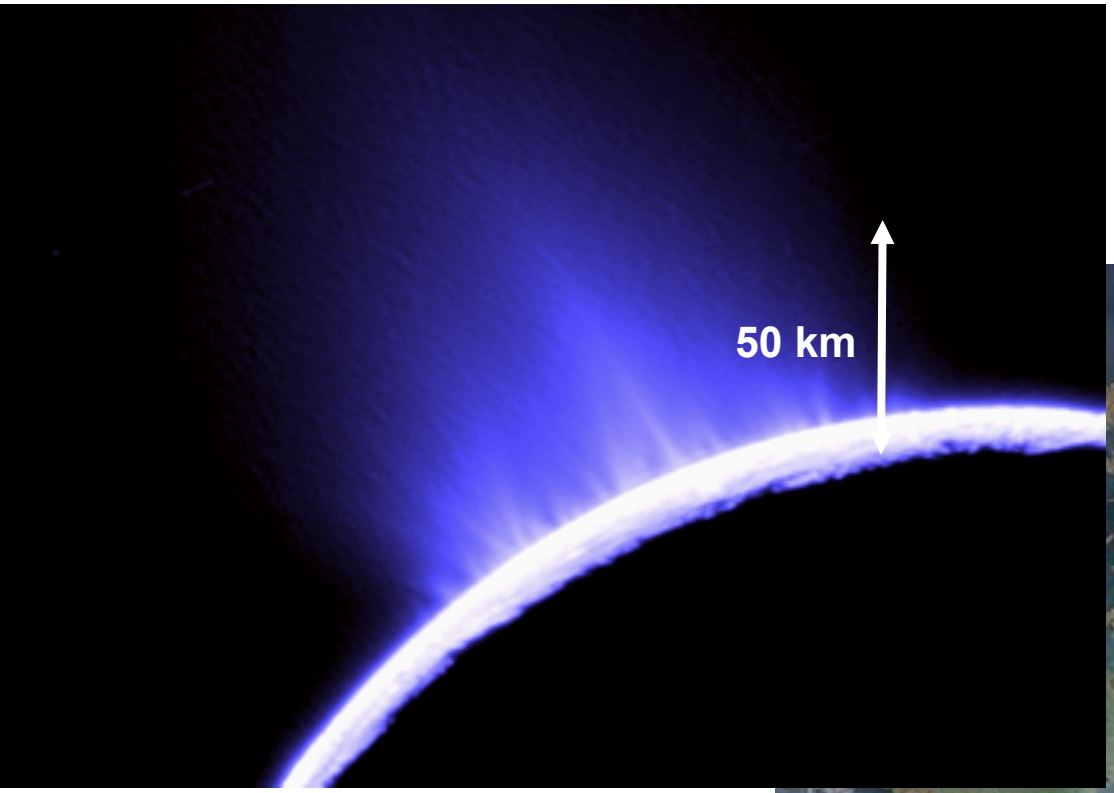
Cassini flew within 50 km of Enceladus on August 11, and *within 25 km* on October 10, 2008



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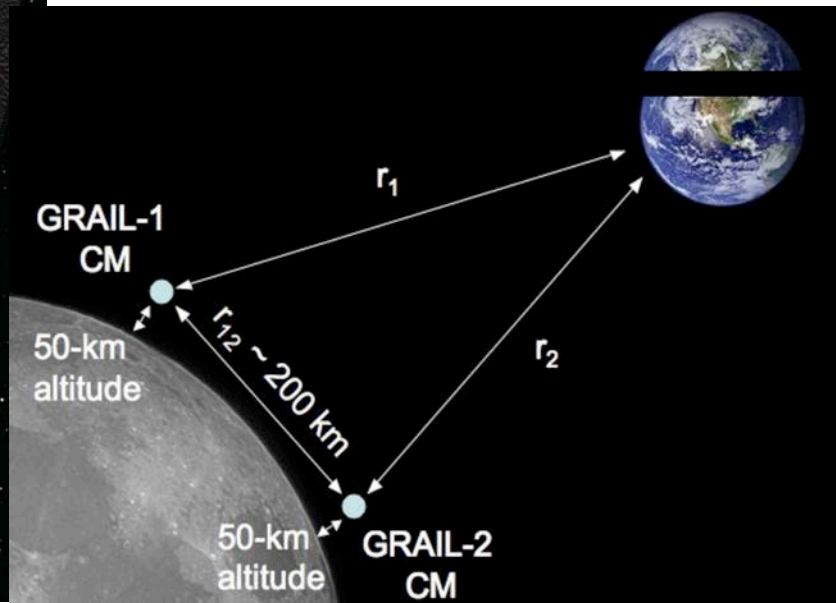
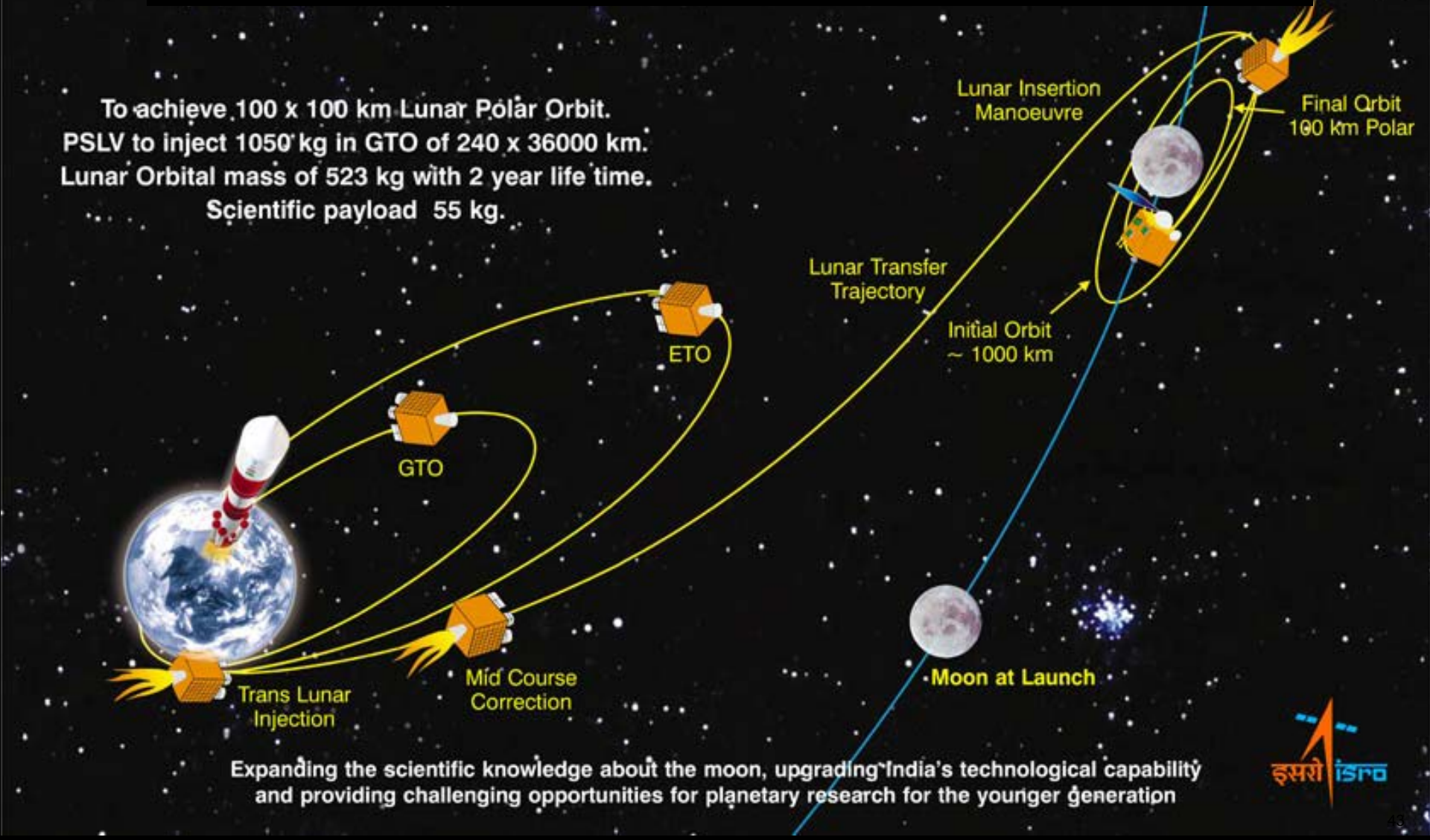
GRAIL: Gravity Recovery and Interior Laboratory

- NASA Discovery Mission
- Maria Zuber (MIT), PI
- Project Management JPL
- Launch in September 2011

- High resolution global lunar gravity map
- Investigation of lunar interior, from crust to core
- Dual spacecraft for high precision



JPL science instruments on other missions: JPL/Brown University M3 on India's Chandrayaan-1



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M3 in Alignment Phase at JPL

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Future Solar System Exploration

Missions in Flight to their Destinations, and Missions in their Early Design Phase

This Decade Mars Exploration

Launch Year

1996	2001	2003	2005	2007	2011
		Mars Express Collaboration 			
Mars Global Surveyor (mission completed)	**Mars Odyssey**		**Mars Reconnaissance Orbiter**		
Mars Pathfinder		**MEP Rovers** *Spirit* *Opportunity*		**Phoenix** *(mission completed)*	**Mars Science Laboratory**

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Looking ahead: Future Mars missions and opportunities in 2012 and beyond

2011 | 2013 | 2016 | 2018 | 2020 | BEYOND 2020

Mars Science Laboratory

MAVEN

Order of future missions to be determined

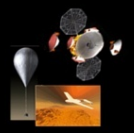
Mars Science Orbiter

* Artist's concept

Mars Mid-Decade Lander

* Artist's concept

Mars Scout Mission

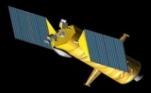


* Artist's concept

Mars Netlander

* Artist's concept

Mars Sample Return - Orbiter



* Artist's concept

Mars Sample Return - Lander

* Artist's concept

Predecisional - For planning and discussion purposes only.

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Next decade: A much larger Mars rover: Mars Science Laboratory to launch in 2011

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Full-scale mockup of MSL back-shell

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Mars Science Laboratory aeroshell entering Mars' atmosphere

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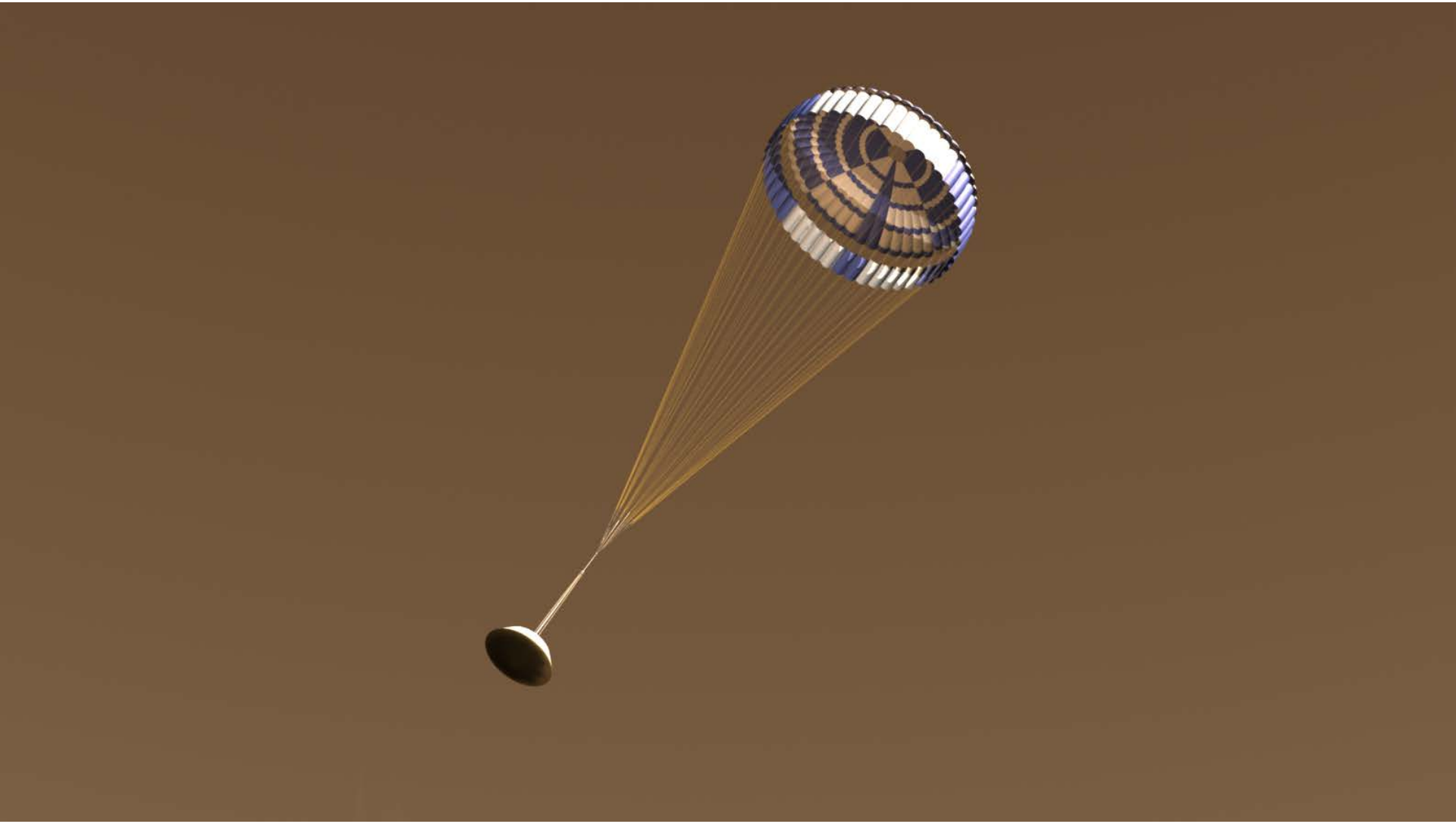
Second phase of descent: Parachute



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MSL drops from its aero-shell

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Sky Crane: A new way to land on Mars

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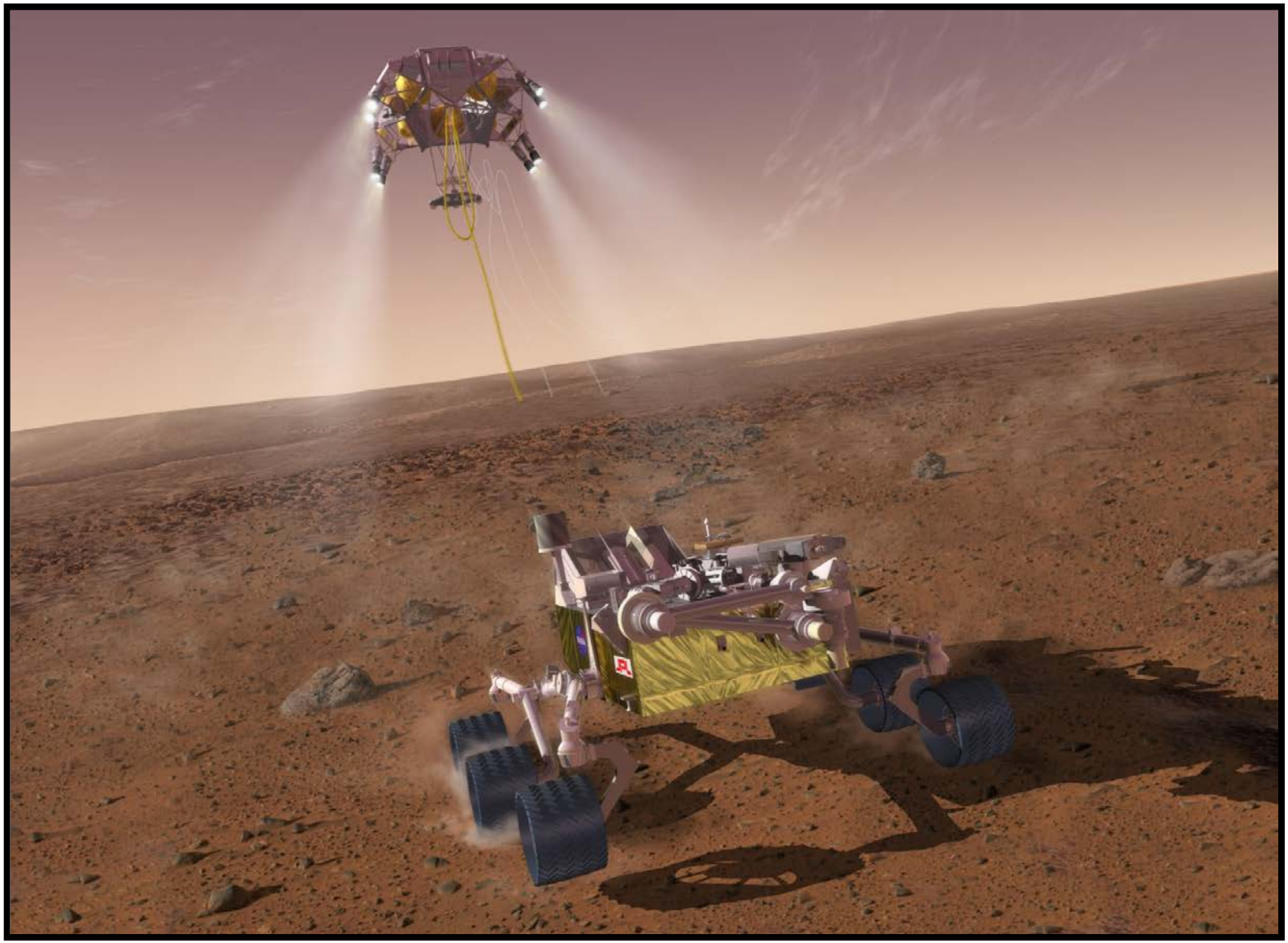
Sky Crane Releases MSL



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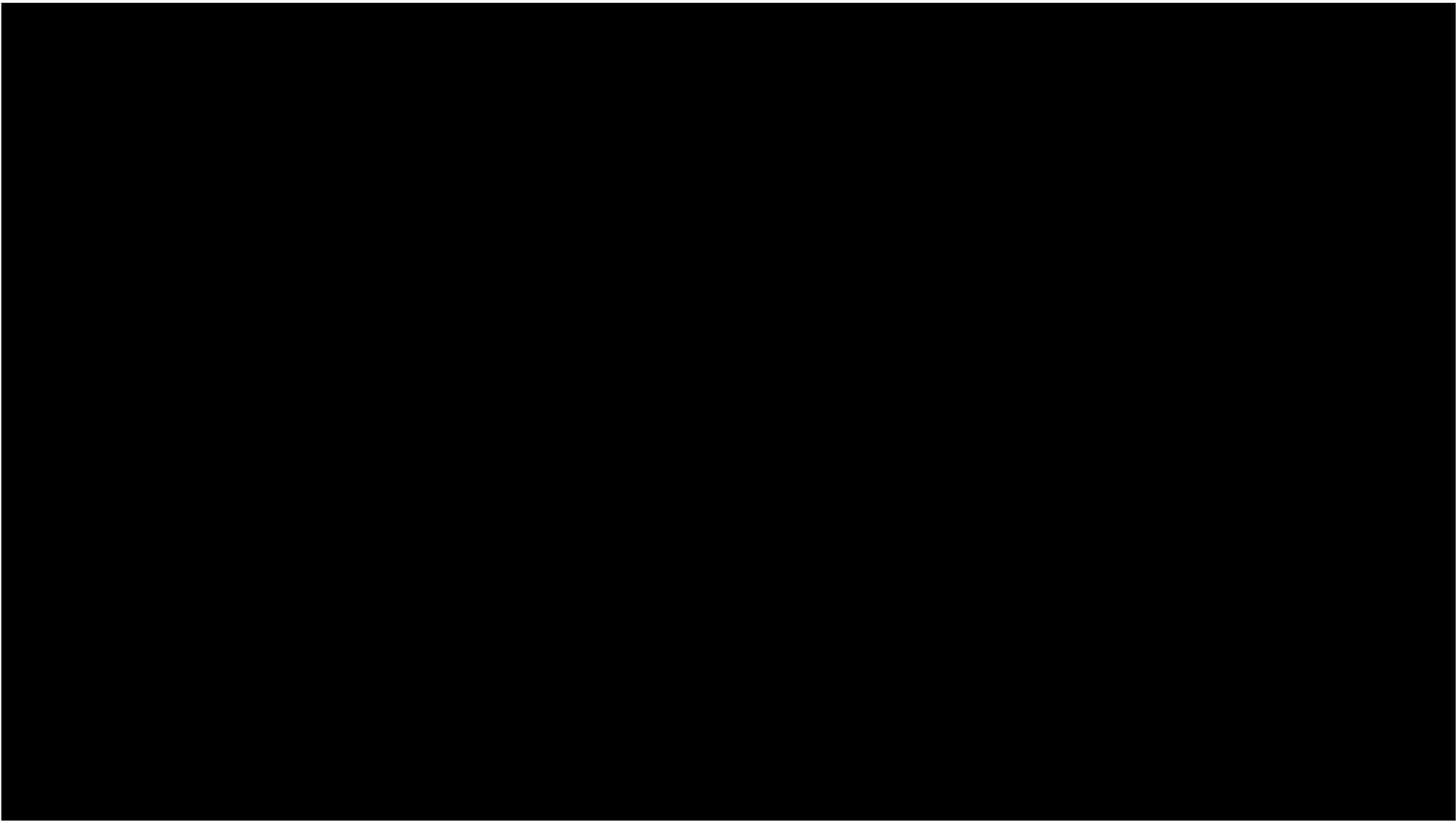
MER Landing Video



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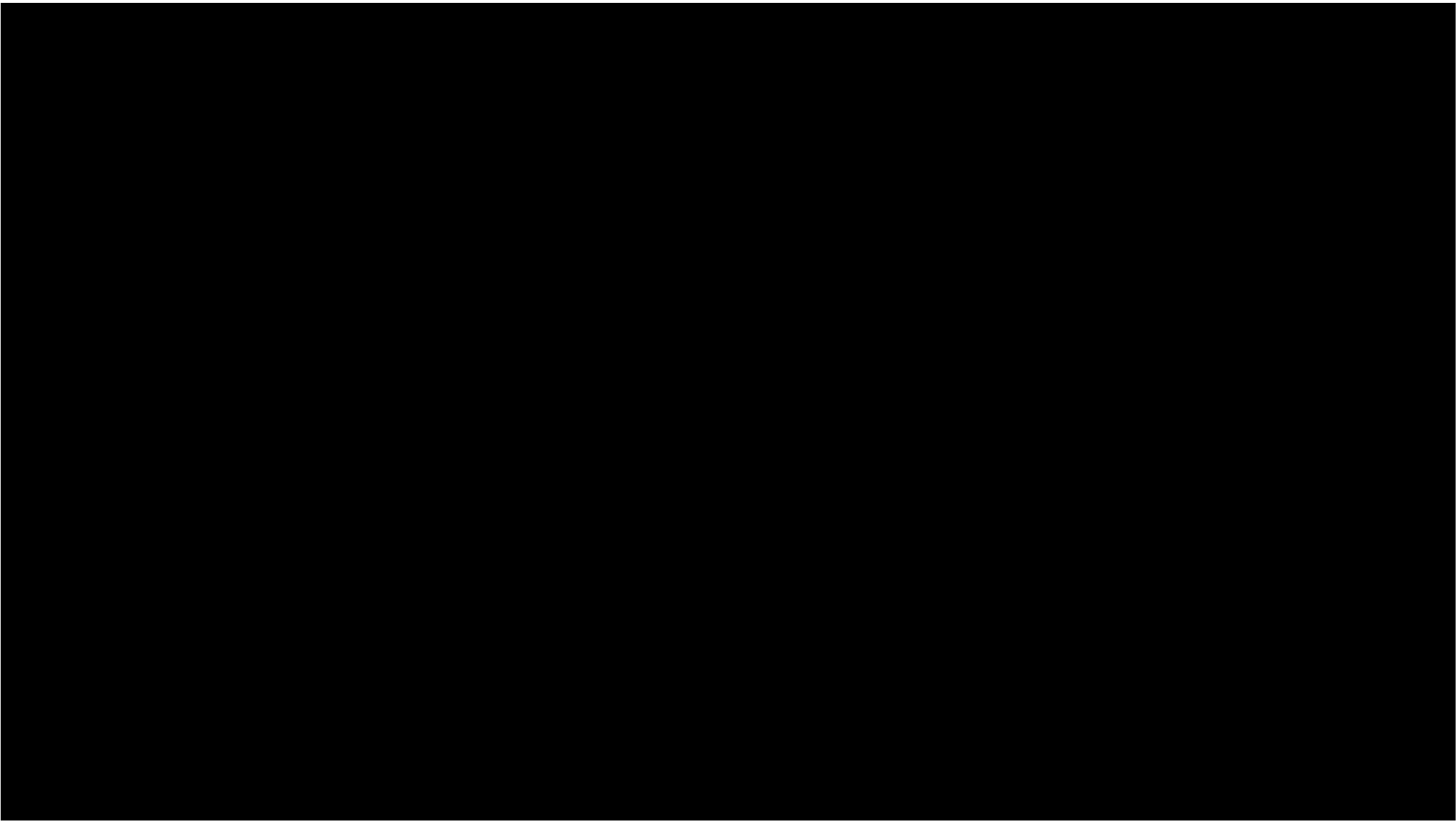
Phoenix Landing Video



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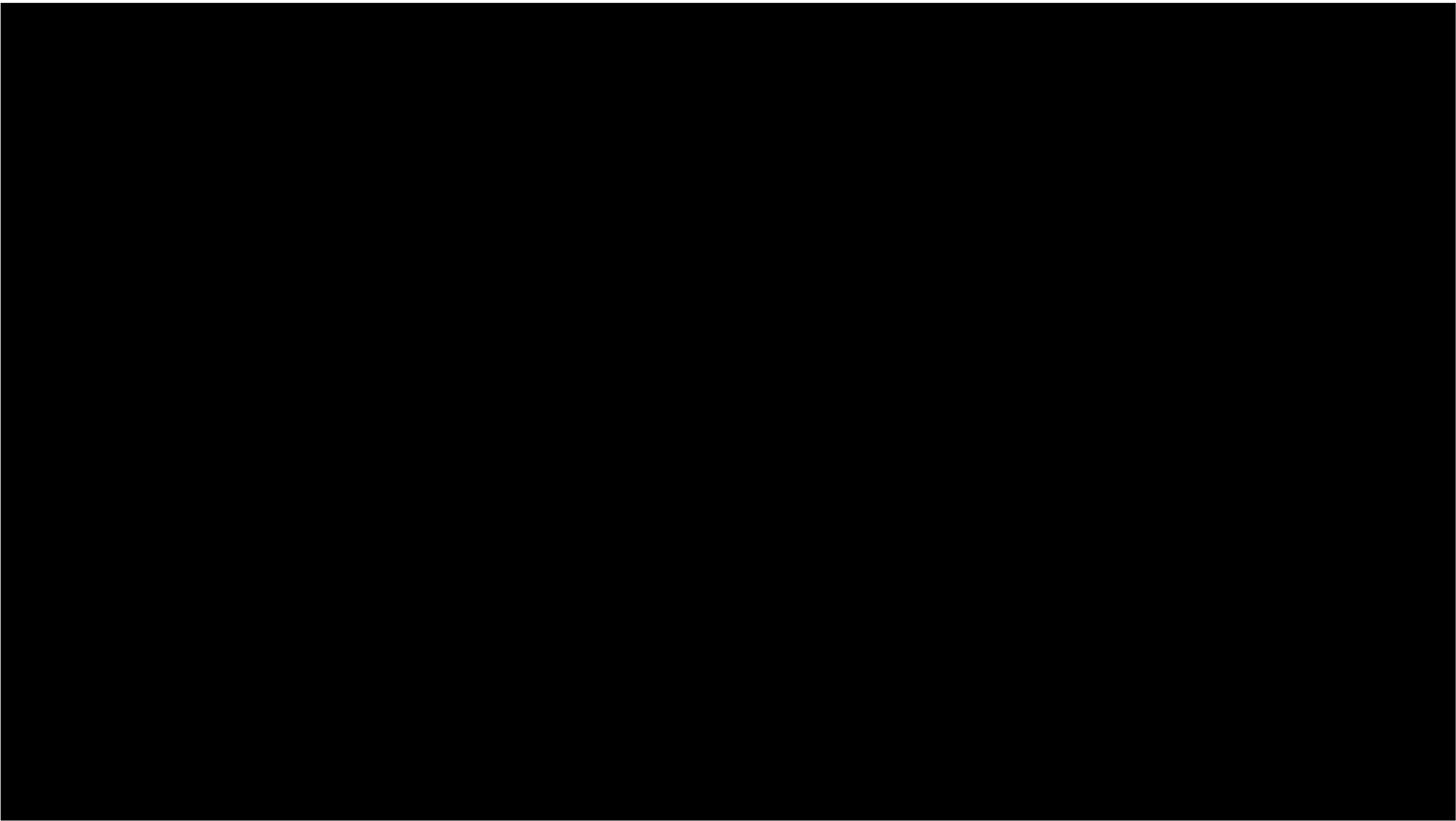
MSL Landing Video



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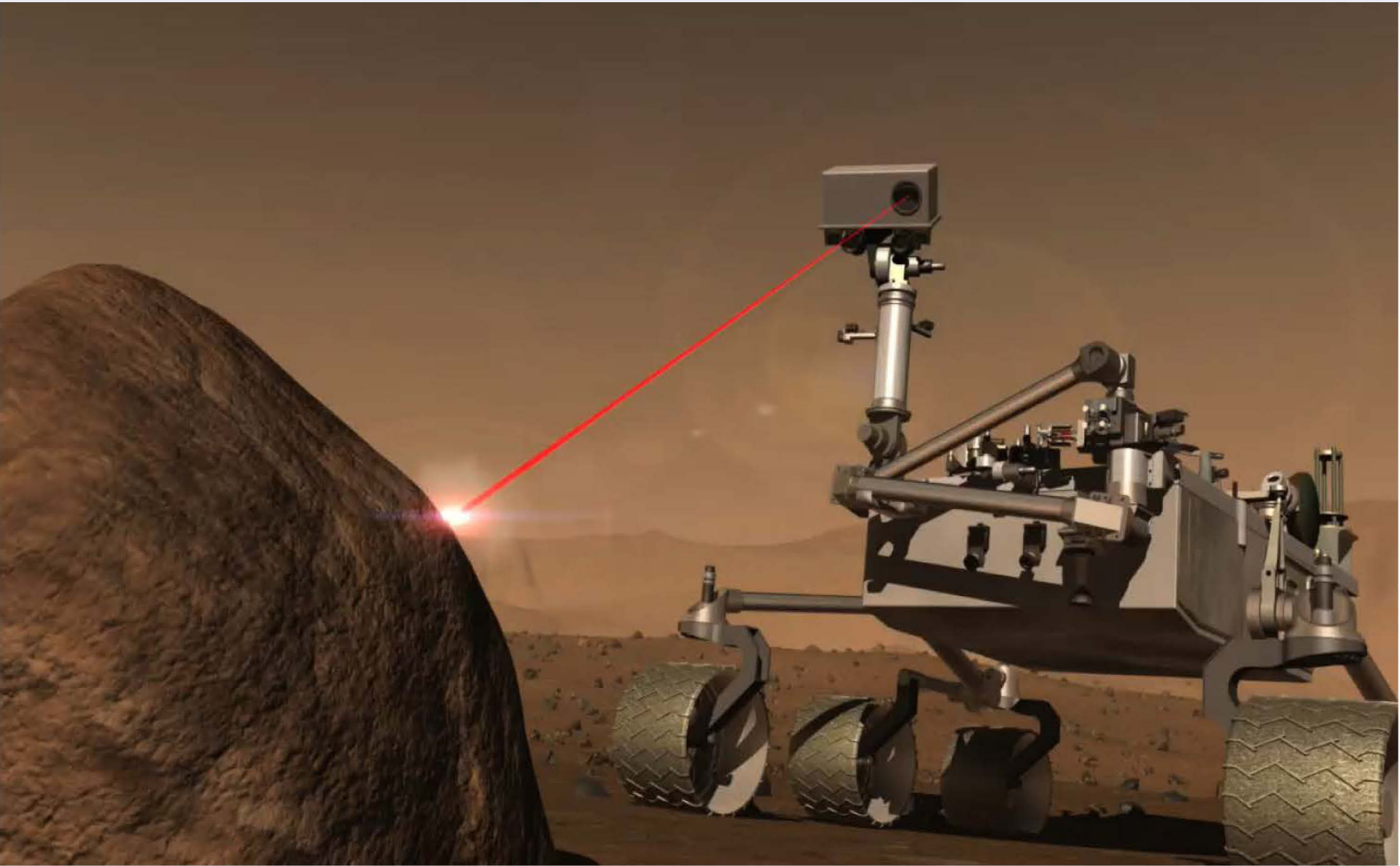
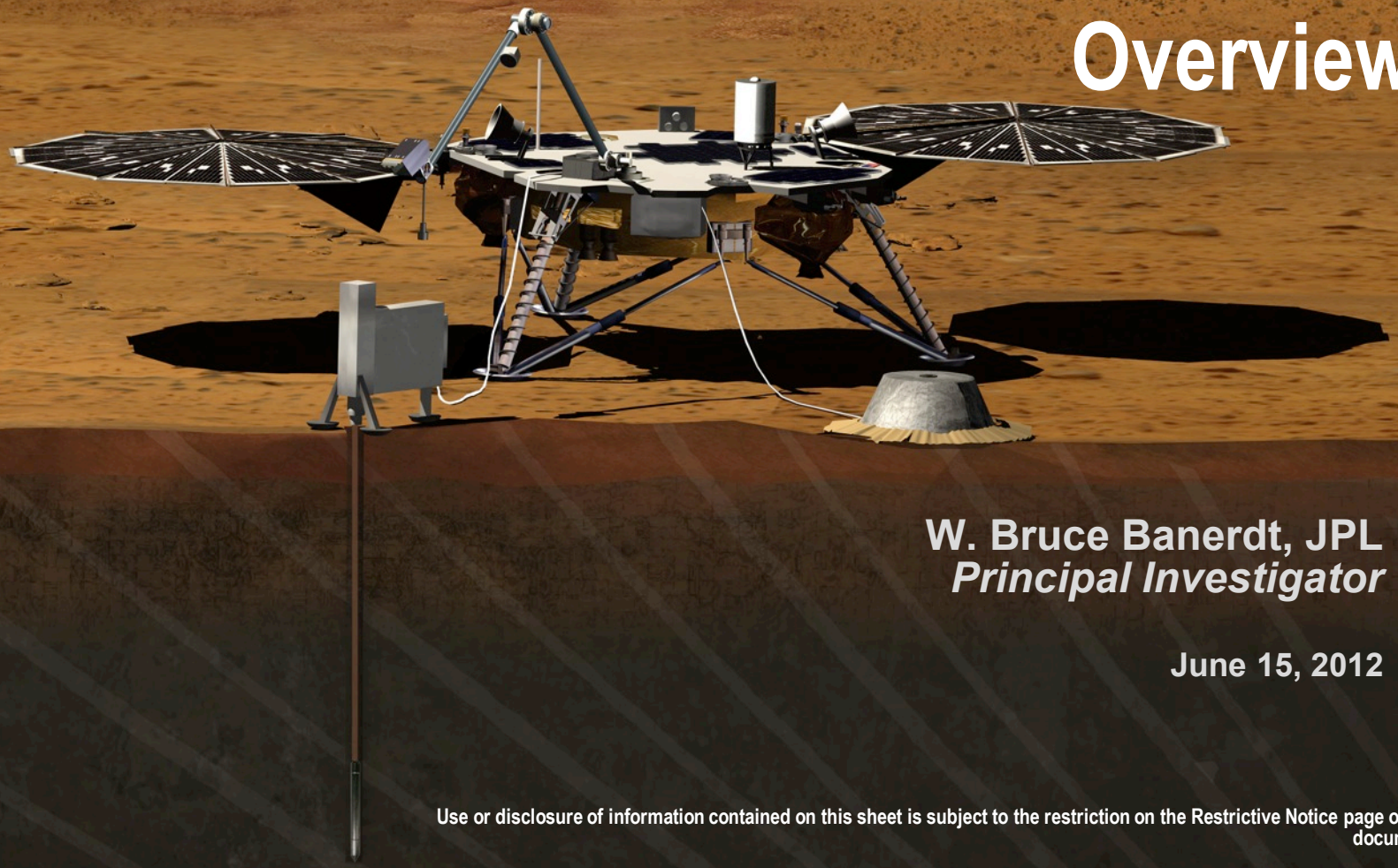
MSL LIBS-Raman Spectrometer
Studies rock composition



InSight:

a potential Discovery 12 mission

Science and Mission Overview



W. Bruce Banerdt, JPL
Principal Investigator

June 15, 2012

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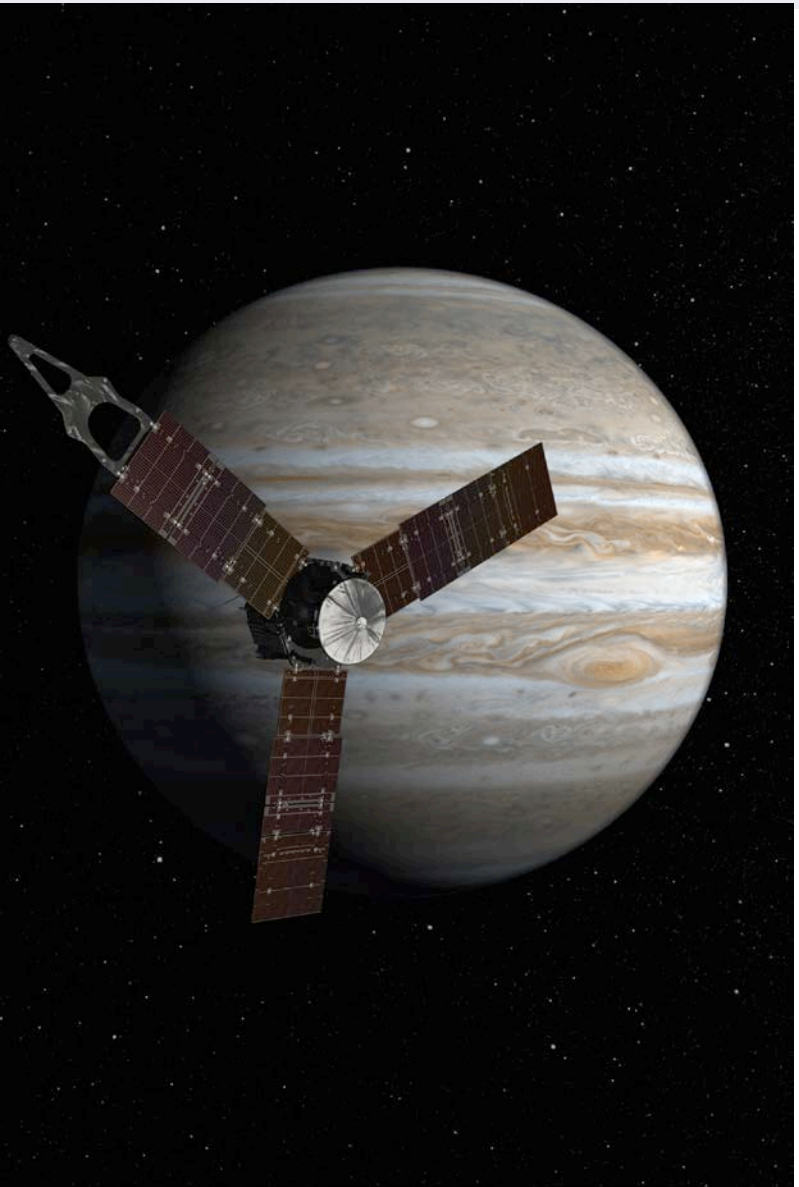
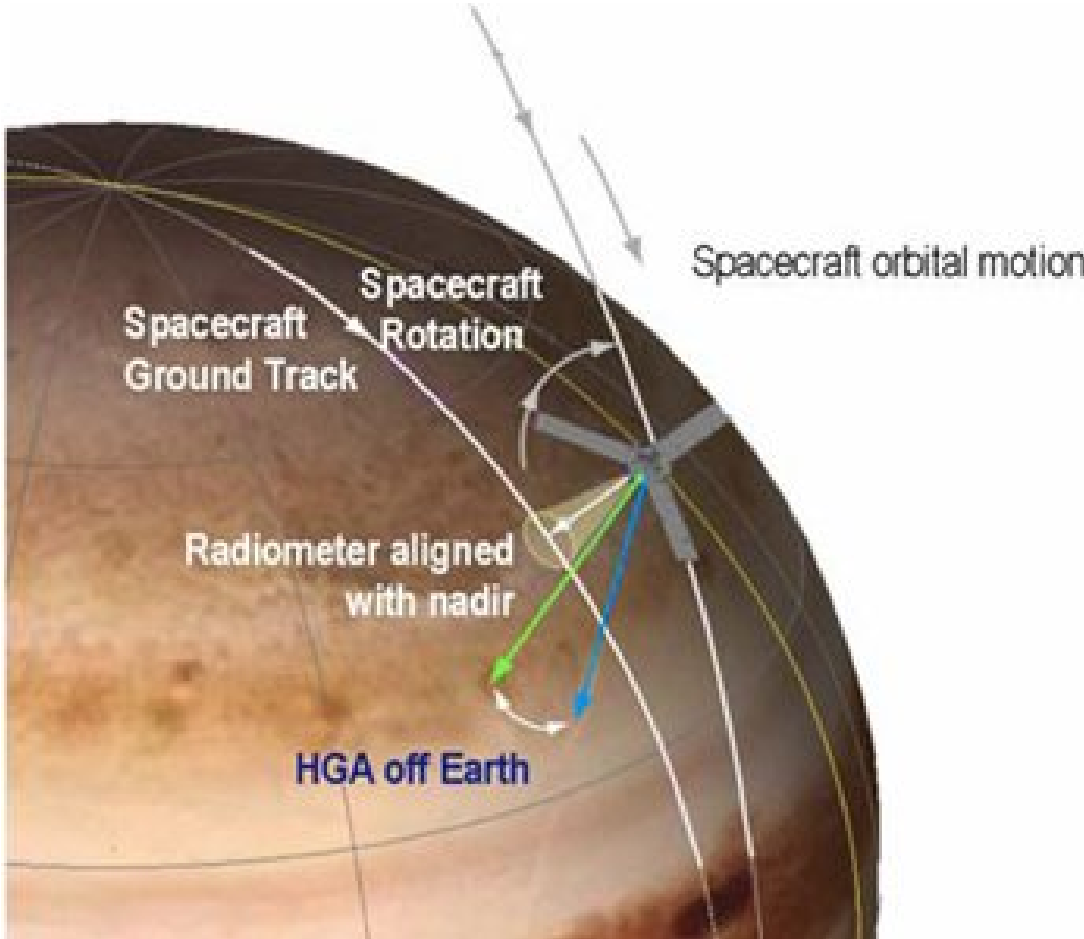
Juno Spacecraft in Orbit over Jupiter

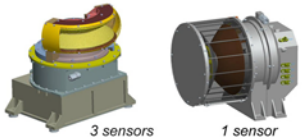


Juno Microwave Radiometer



Juno Payload System Overview

Jovian Auroral Distributions Experient (JADE)



JADE will measure the distribution of electrons and the velocity distribution and composition of ions.

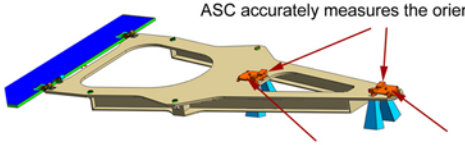
Gravity Science (GS)

The Juno Gravity Science Investigation will probe the mass properties of Jupiter by using the communication subsystem to perform Doppler tracking.

Magnetometer (MAG)

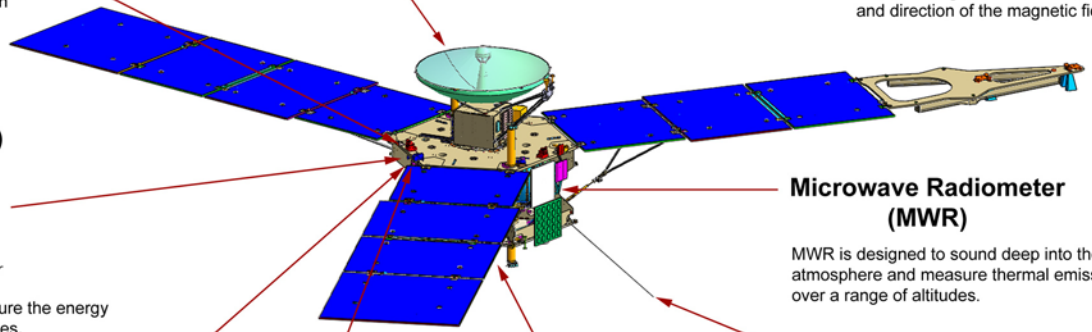
Advanced Stellar Compass (ASC)

ASC accurately measures the orientation of the magnetometers.

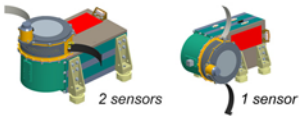


Fluxgate Magnetometer (FGM)

The two fluxgate sensors will measure the magnitude and direction of the magnetic field in Jupiter's environment.



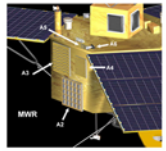
Jupiter Energetic-particle Detector Instrument (JEDI)



JEDI is a suite of detectors that will measure the energy and angular distribution of charged particles.

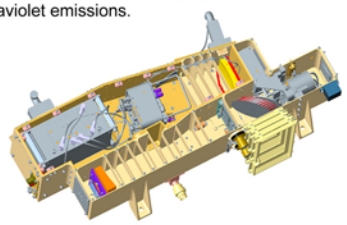
Microwave Radiometer (MWR)

MWR is designed to sound deep into the atmosphere and measure thermal emission over a range of altitudes.

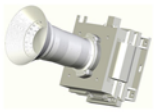


Ultraviolet Spectrograph (UVS)

UVS is an imaging spectrograph that is sensitive to ultraviolet emissions.

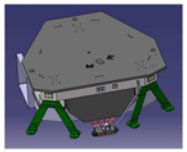


JunoCam



JunoCam will provide visible-color images of the Jovian cloud tops.

Jovian Infrared Auroral Mapper (JIRAM)



JIRAM will acquire infrared images and spectra of Jupiter. JIRAM is located on the aft/bottom deck.

Plasma Waves Instrument (Waves)

Waves will measure plasma waves and radio waves in Jupiter's magnetosphere.

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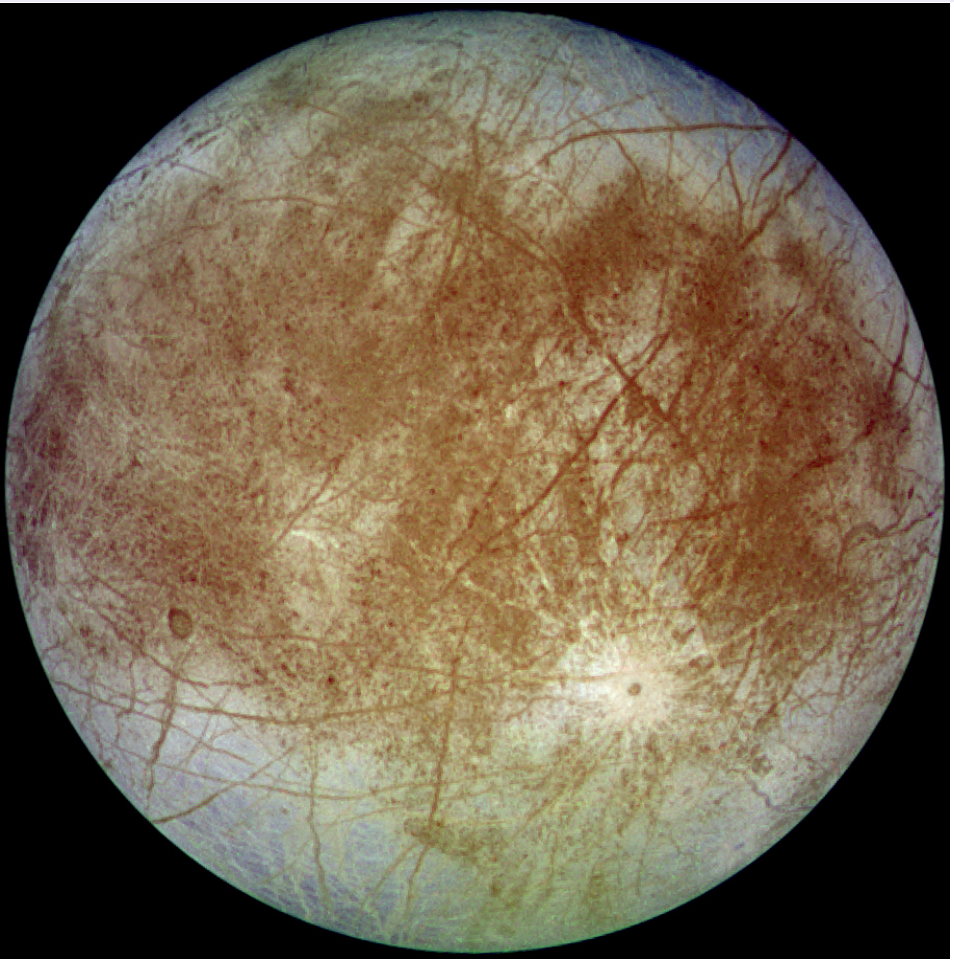
The next frontier: Europa and Ganymede



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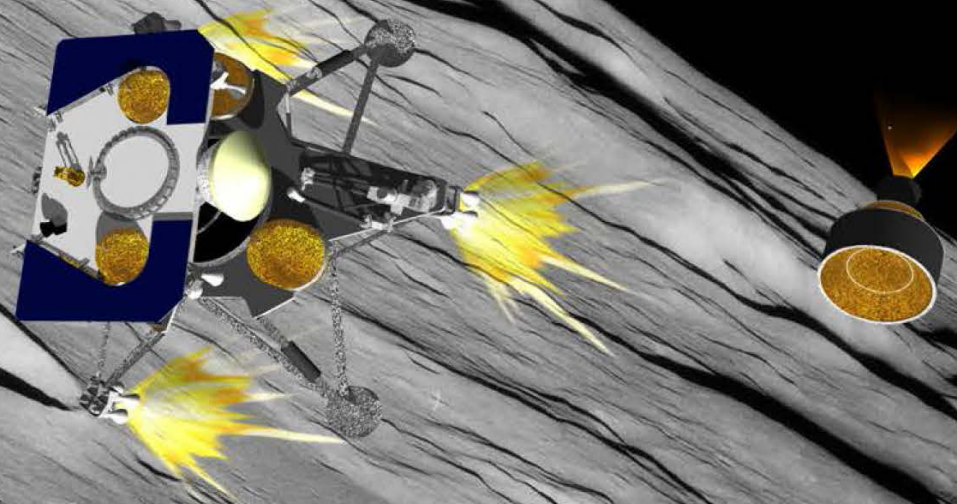
Moonrise: A potential New Frontiers Mission

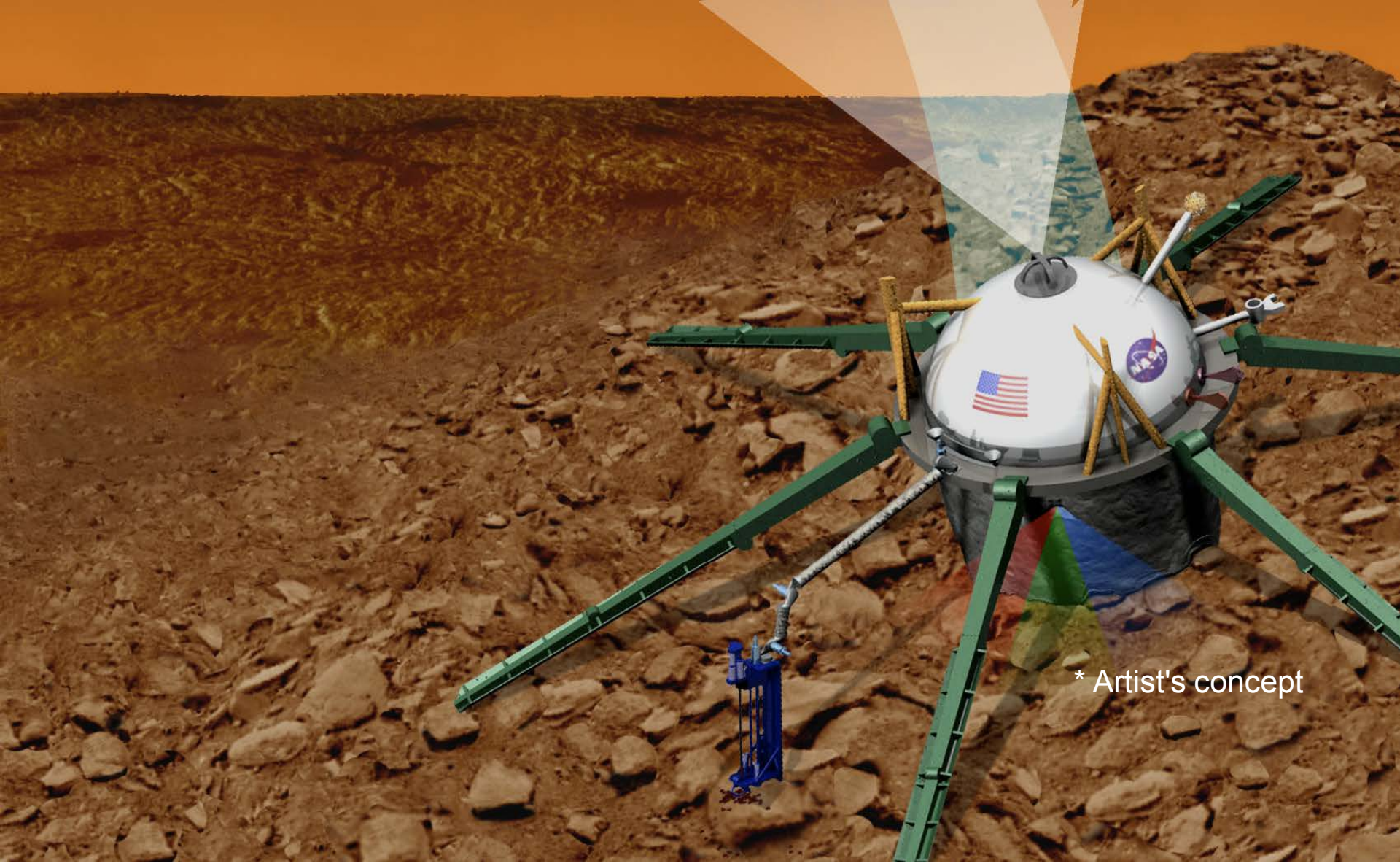
PI: Dr. Brad Jolliff, Washington University

Project Management: JPL

Launch: Late 2016



South Pole-Aiken Basin Lunar Sample Return will reveal the evolution and history of the early solar system



Future New Frontiers Venus Lander would address fundamental unanswered questions of the history and current state of Venus by characterizing the chemical composition of the atmosphere and measuring the surface composition

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Conclusion:

With 50 years of paradigm-shifting discoveries behind us, the next 50 years promise to be even more exciting.