InSight

(Interior Exploration Using Seismic Investigations, Geodesy and Heat Transport)

An Overview of the Mission and the Entry, Descent and Landing System

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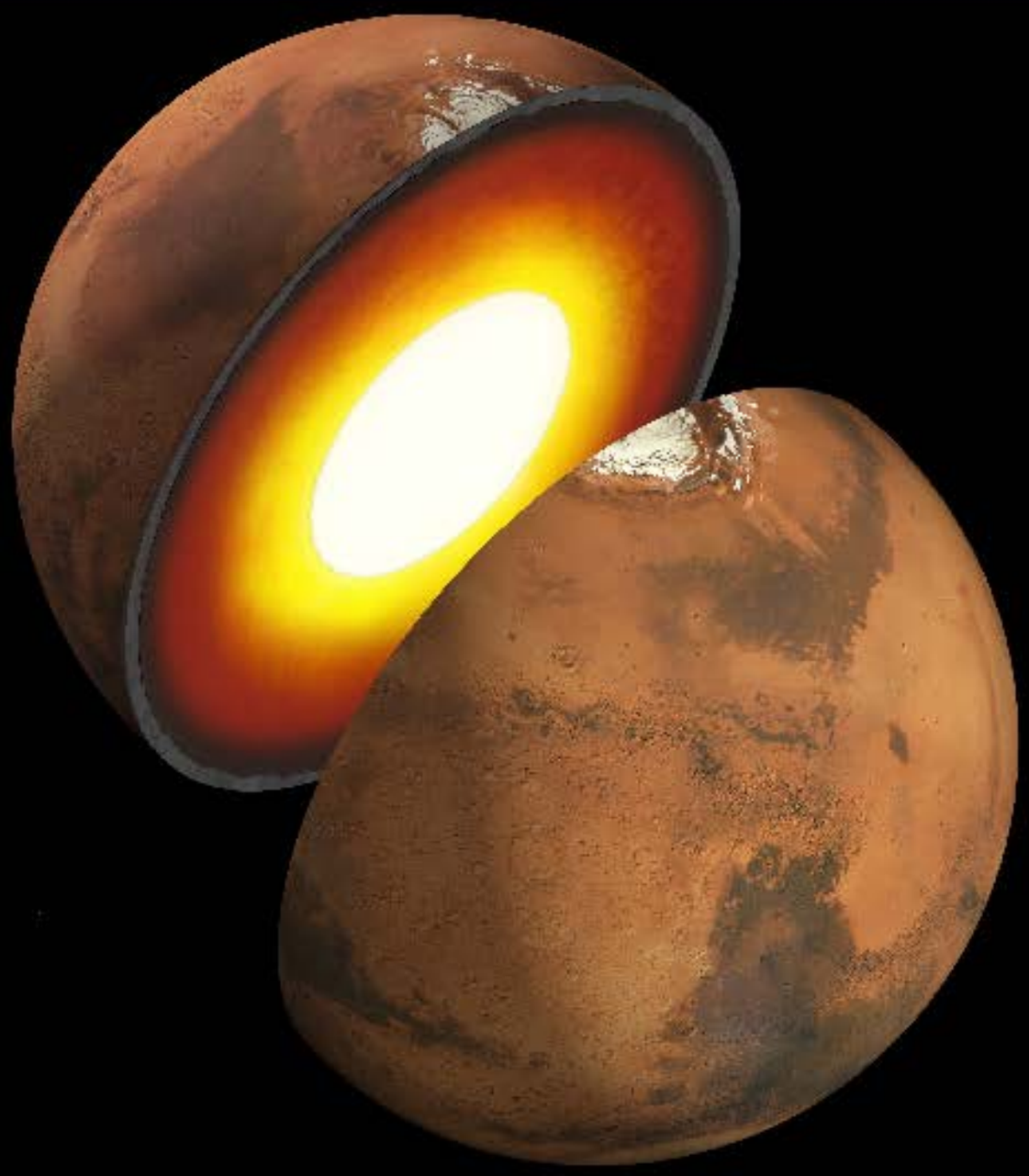
InSight - The Mission

InSight Mission

MRO Launch on Altas V - 2005

- **NASA's next Mars lander (probably)**
- **Originally planned to launch in March 2016**
  - Launch cancelled due to science instrument readiness (or not readiness)
- **NASA is currently considering a launch in May 2018**
  - Decision expected in a month or two
- **A geophysical (areo-physical) mission**
  - Investigation of the interior structure of Mars
- **Would be the first planetary mission launched from California (Vandenberg AFB)**
- **Except for science instruments, the spacecraft is a near copy of the Phoenix spacecraft that successfully landed on Mars in 2008**

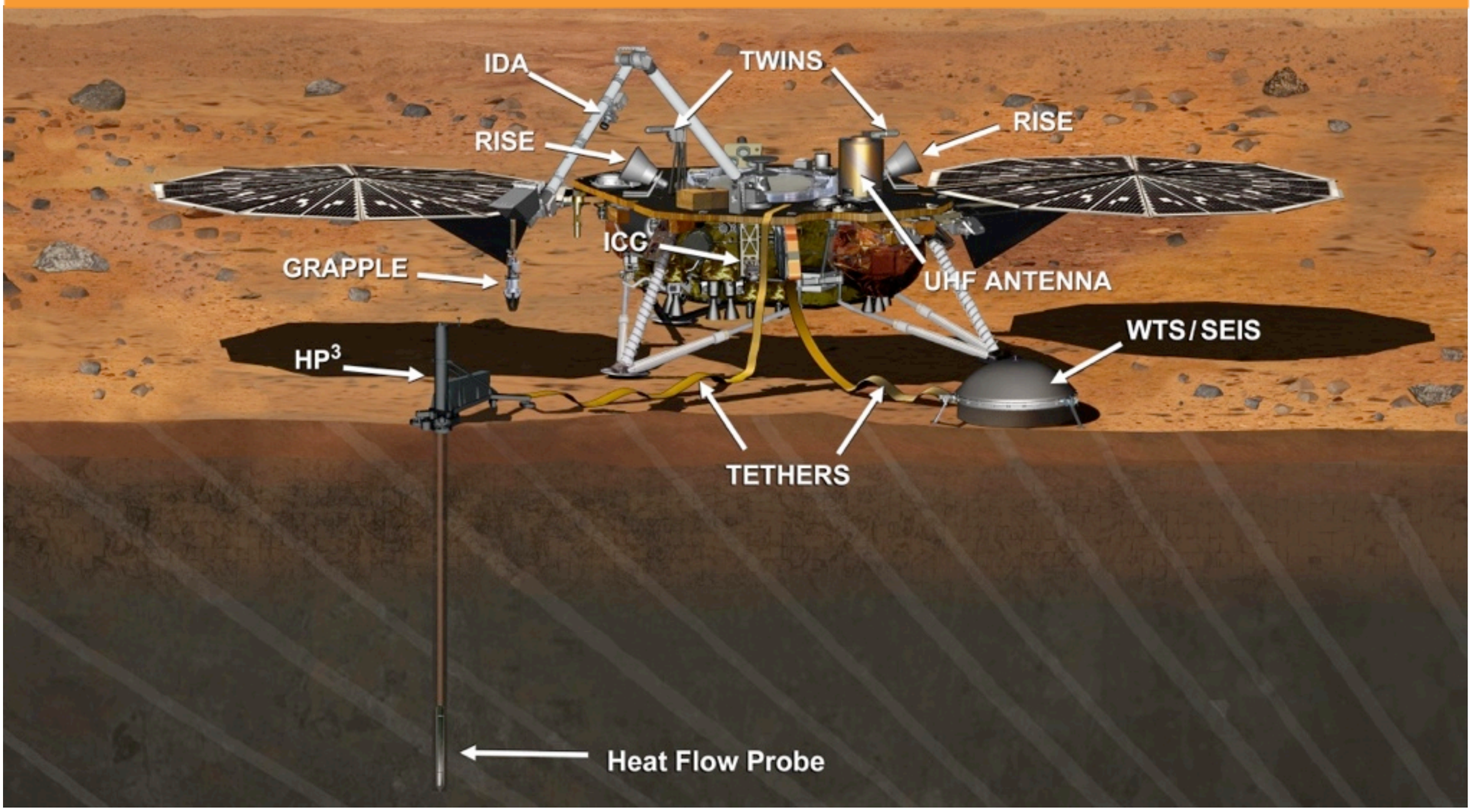
The Insight Mission Goal



- **The overall goal for InSight is to understand the formation and evolution of terrestrial planets through investigation of the interior structure and processes of Mars.**

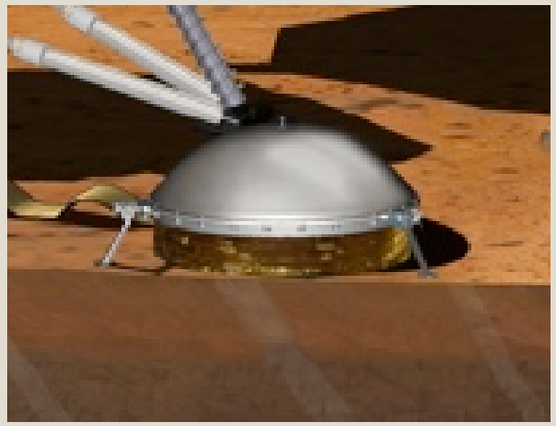
- **This will help us understand the origin and diversity of terrestrial planets, and particularly how the evolution of terrestrial planets enables and limits the origin and evolution of life.**

Instruments



InSight Being Assembled

Focused Set of Measurements



Single-Station Seismology

- Extremely sensitive, broad-band instrument
- Surface installation and effective environmental isolation
- Monitor effects of wind, pressure and magnetic field
- Advanced single-station seismic analysis
- Multiple signal sources

Precision Tracking

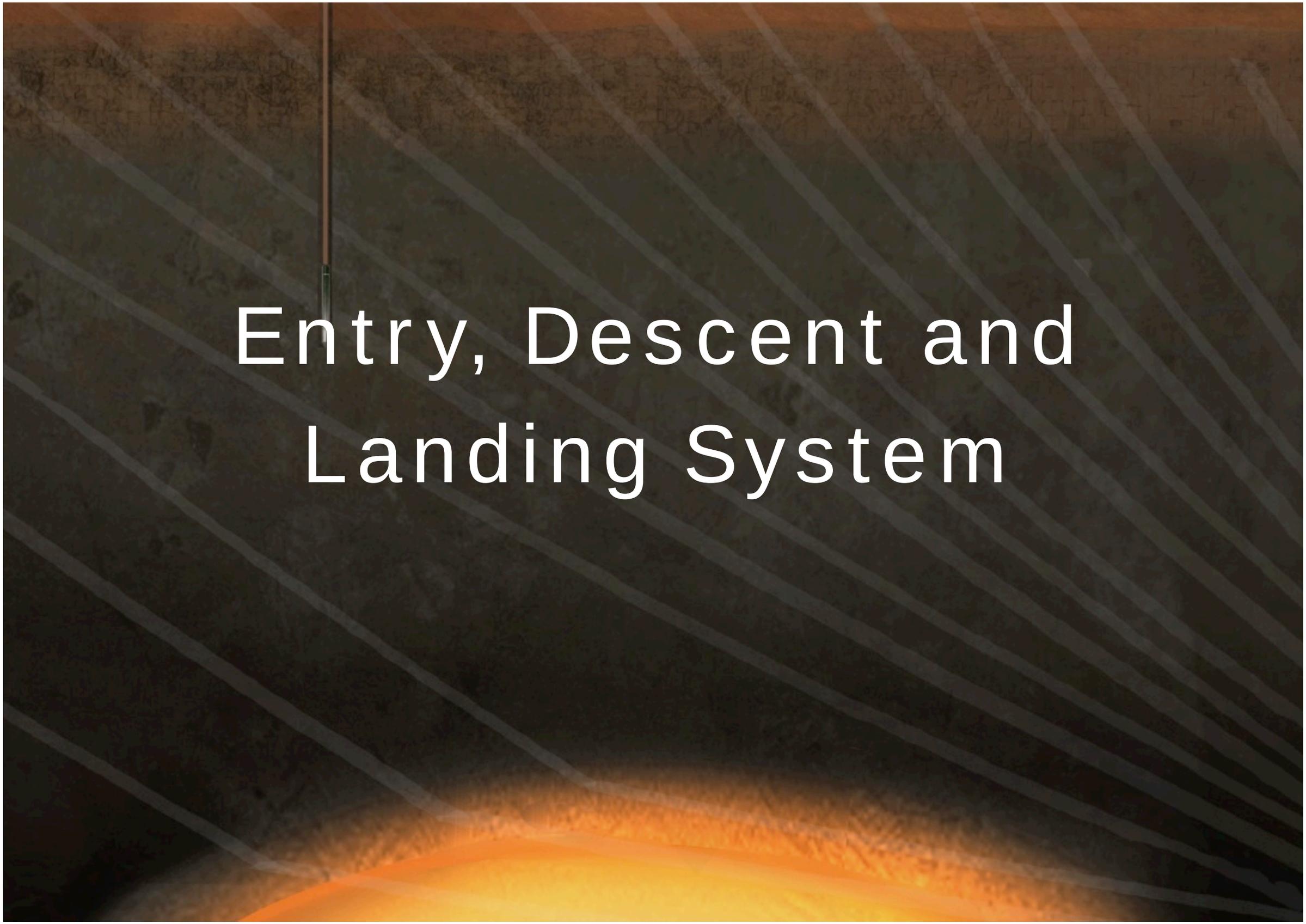
- Sub-decimeter (~2 cm) X-band tracking

Heat Flow

- Innovative, self-penetrating mole penetrates to a depth of 3–5 meters
- Temperature measurements are made along entire length of cable

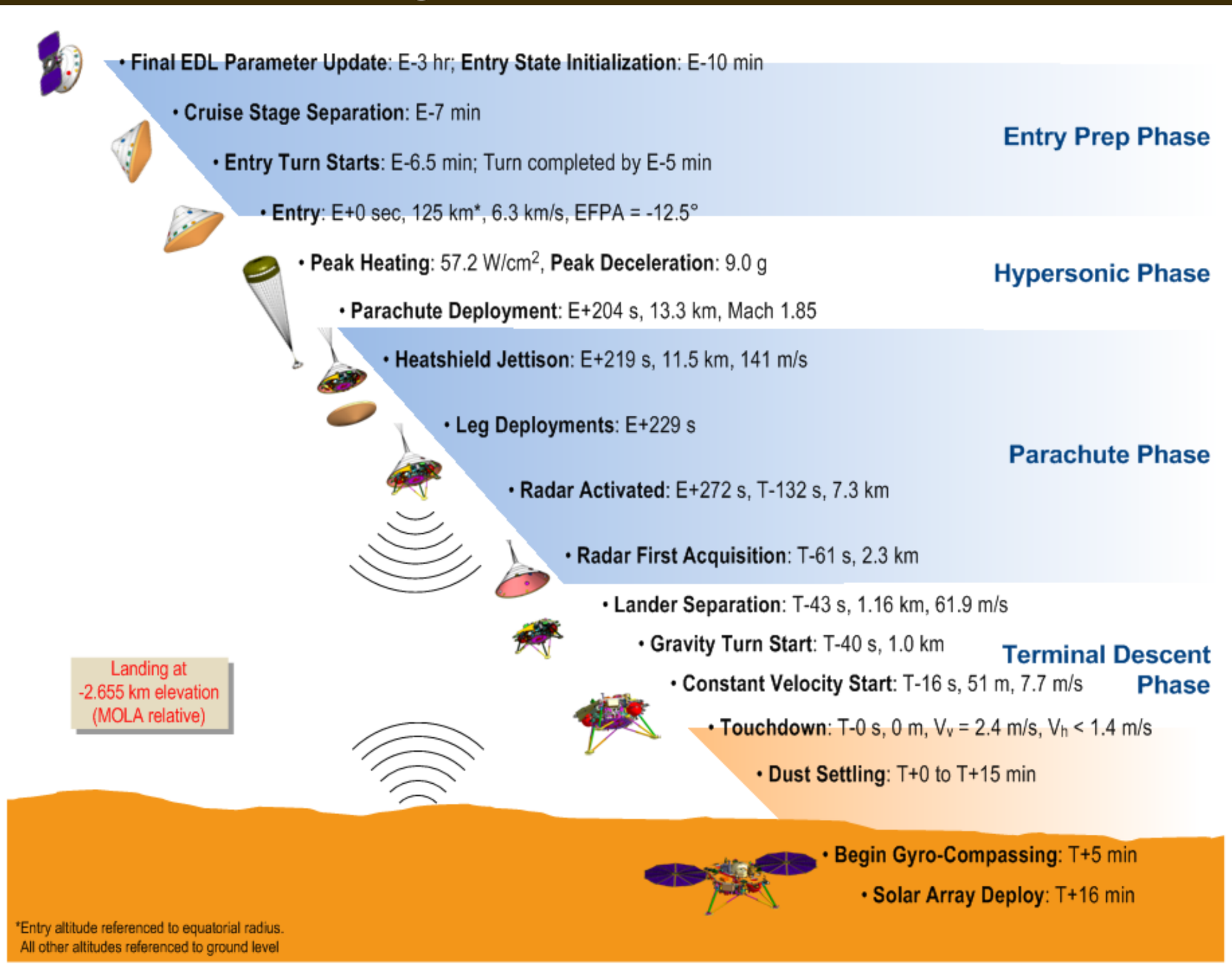
Landing Site Constraints/Criteria

Latitude	**< 2 deg to 5 deg N**	• Sufficient Solar Power Margins
Elevation	**< -2.5 km MOLA**	• Sufficient Atmosphere for EDL
Ellipse Size	**< 150 km x 30 km**	• Capability of lander targeting
Thermal Inertia	**>100-140 J m^{-2} K^{-1} $s^{-1/2}$**	• Avoid surfaces with thick dust that is not load bearing • Prefer ~200 J m^{-2} K^{-1} $s^{-1/2}$ for uncemented or poorly cemented soil • Radar reflective surface
Rock Abundance	**< 10%**	• 99% Safe Landing and Opening Solar Panels
Smooth flat surface	**No large relief features**	• Slopes <15° for Safe Touchdown and Radar Tracking
Hesperian Cratered surface	**Broken regolith > 5 m**	• Penetration of the Mole
No Other Science Requirements	**Just Land Safely**	



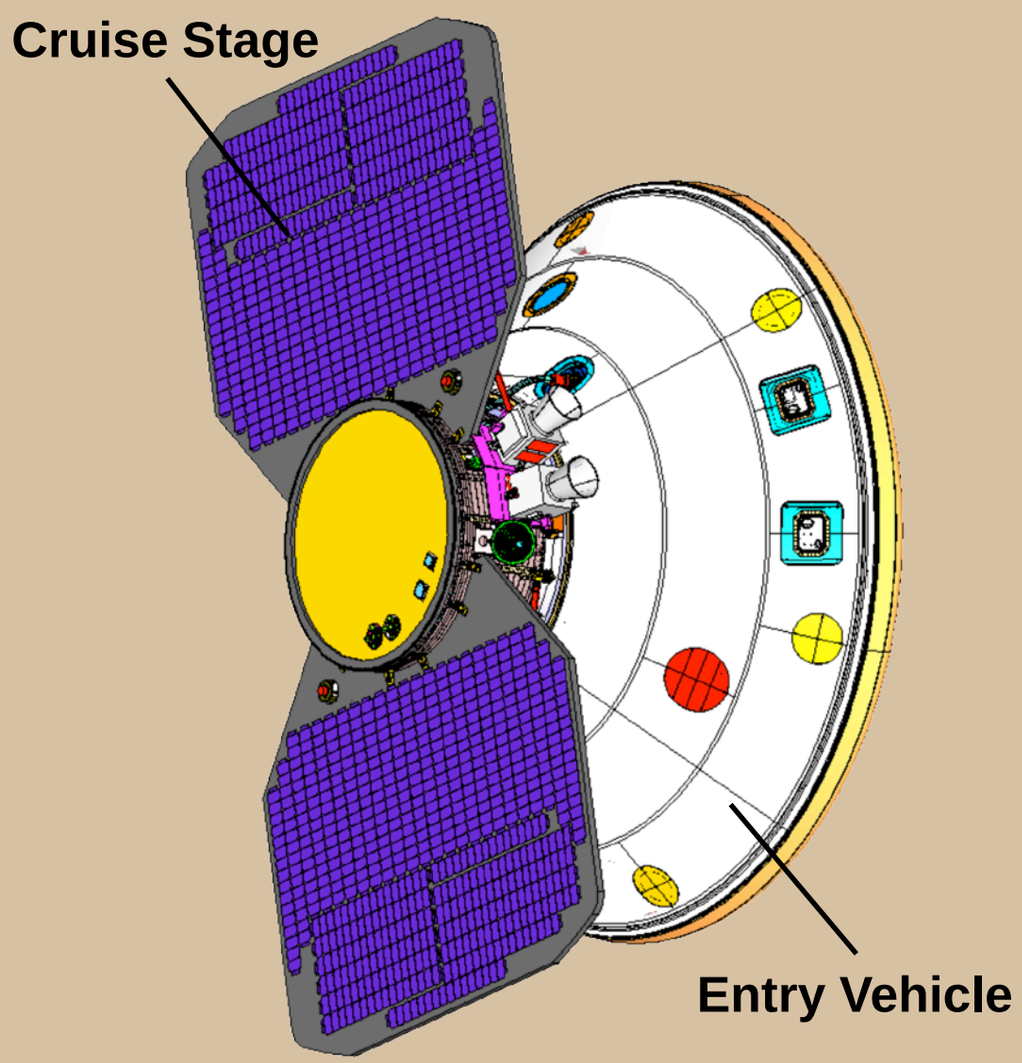
Entry, Descent and Landing System

InSight EDL Architecture



Cruise Configuration

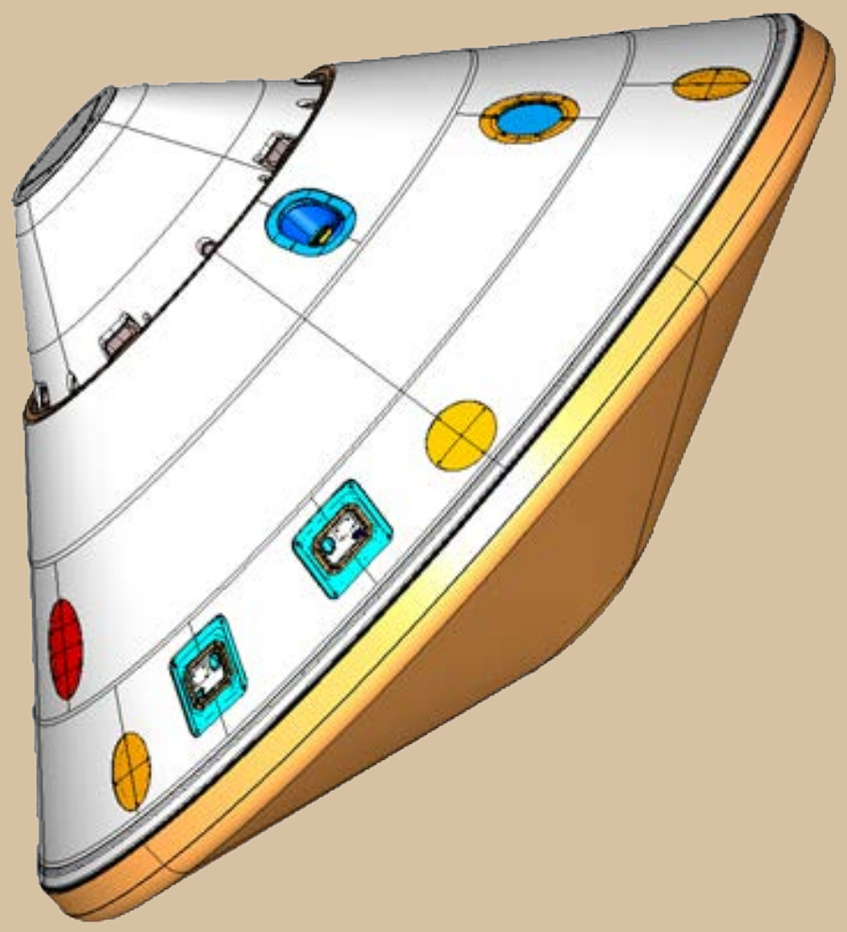
Cruise Stage solar panel design has changed since Phoenix



- Six month cruise to Mars would arrive in Nov. 2018, after a May 2018 launch
- Cruise Stage provides power, navigation sensors and communication
- The Cruise Stage is separated 7 minutes before entry
- Entry Vehicle then slews to the proper entry attitude
- Ordering of events is important!

Entry Configuration

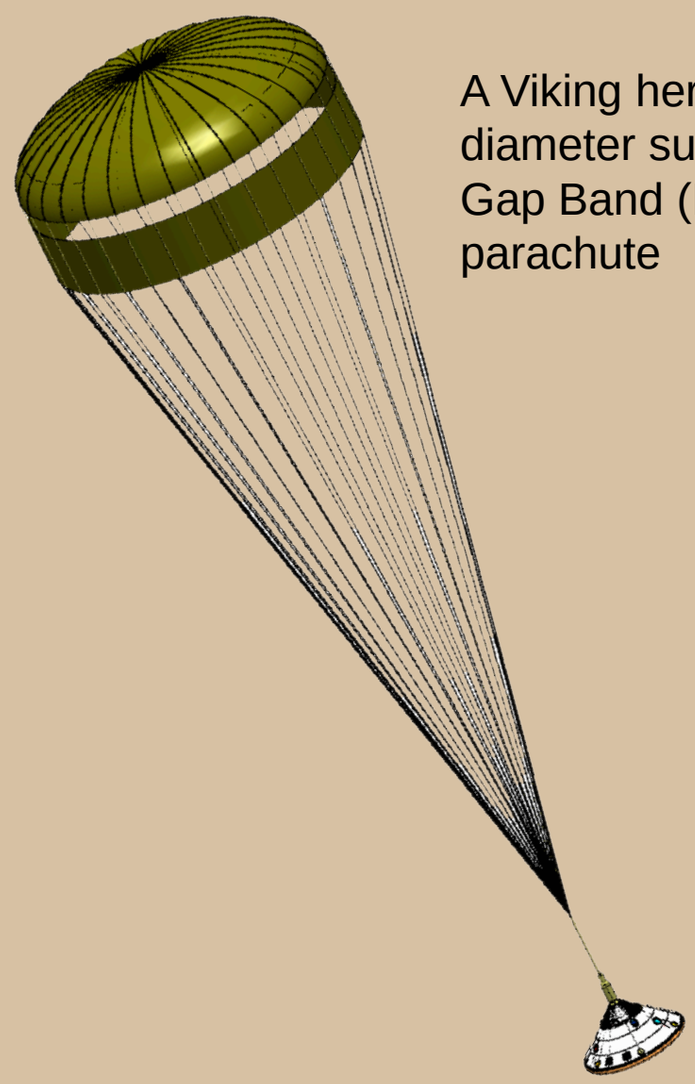
Aeroshell is very similar to Mars Pathfinder, Mars Exploration Rovers and Phoenix



- Entry Vehicle has a 2.65 m diameter heatshield with Viking heritage
- Aeroshell uses SLA thermal protection materials to protect against entry heating
- 1 lb and 5 lb thrusters provide attitude control
- Navigation is accomplished via an IMU
  - Accelerometers and gyros

Parachute Configuration

A scaled design of the supersonic parachute flown on Viking and MSL



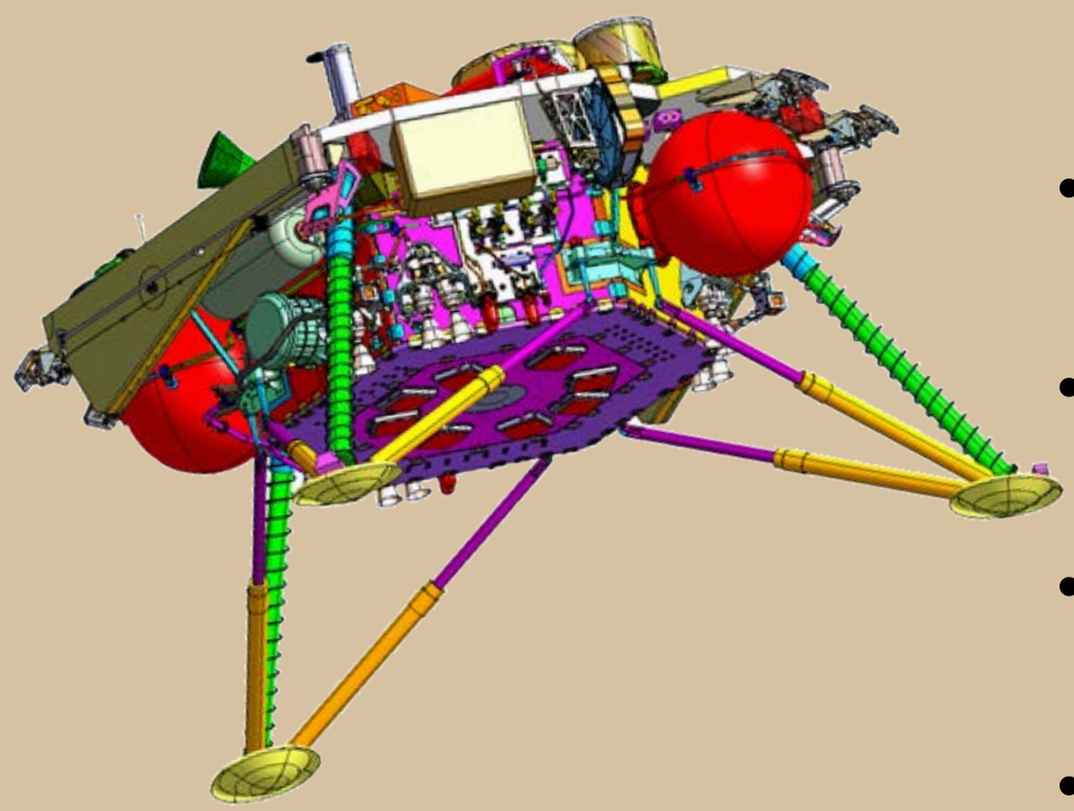
A Viking heritage 11.8 m diameter supersonic Disk Gap Band (DGB) parachute

Image of Phoenix on Parachute

- Parachute is deployed at a target dynamic pressure of 550 Pa
- Spends about 150 s descending on parachute

Lander Configuration

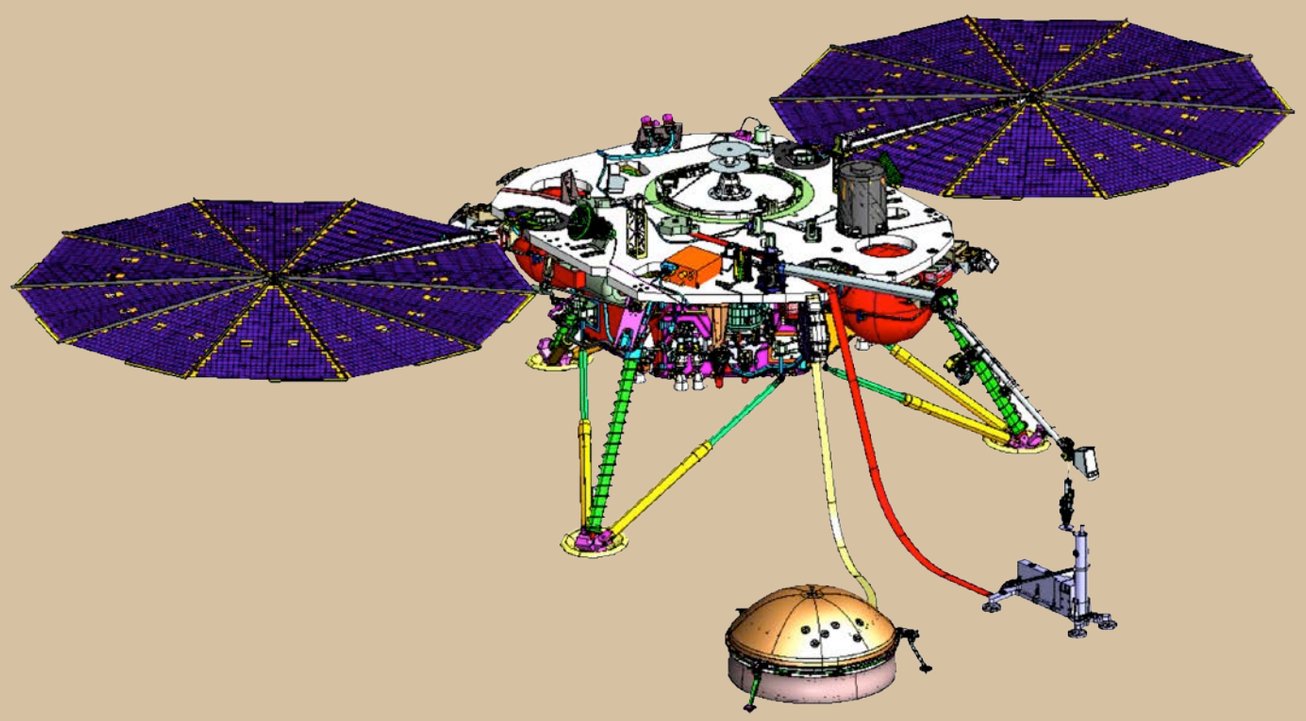
Lander design is a near copy of Phoenix and a close cousin of Mars Polar Lander



- Twelve pulse-width modulated descent engines running at 10 Hz
- Descent engines provide deceleration and attitude control
- Doppler radar provides altitude and velocity measurements
- Hall Effect sensors in lander legs detect touchdown
- Touchdown detection immediately shuts down descent engines
- Target touchdown velocity is 2.4 m/s

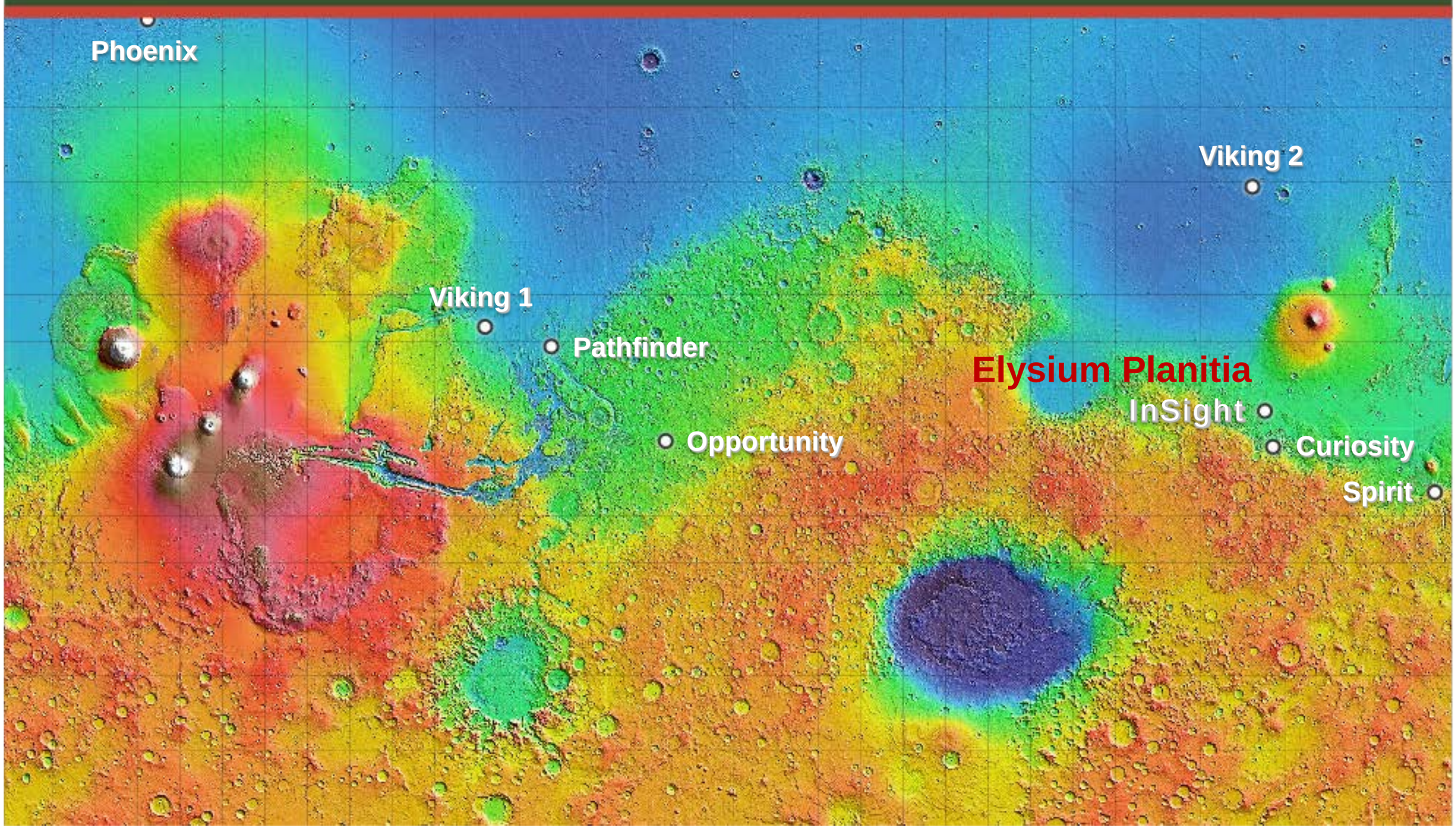
Landed Configuration

At this point in the mission the EDL system has done its job

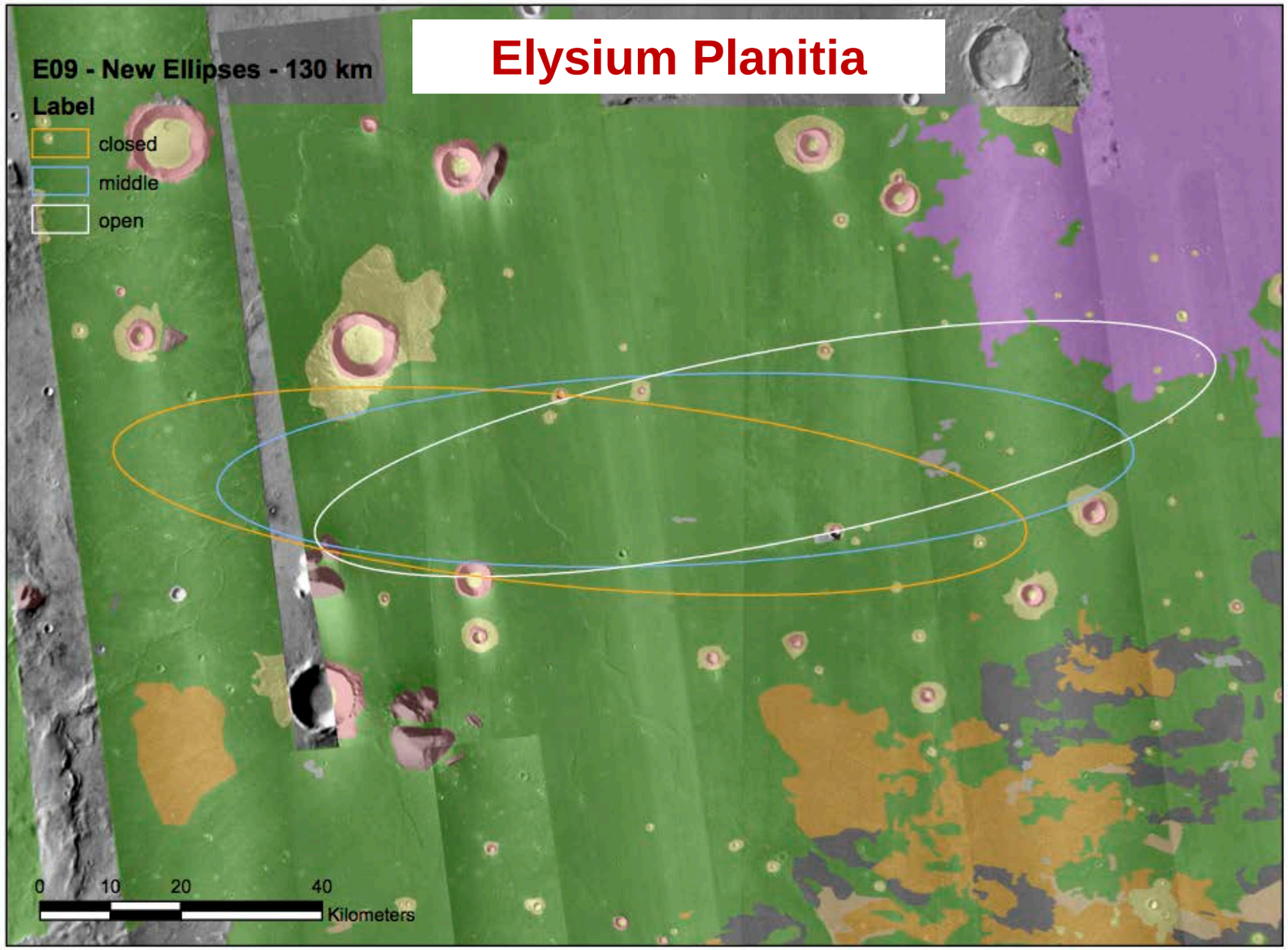


- Solar arrays are fully deployed 22 minutes after touchdown – a priority because lander is on limited battery power during landing
- Science instruments are deployed in the days after landing

InSight Landing Area

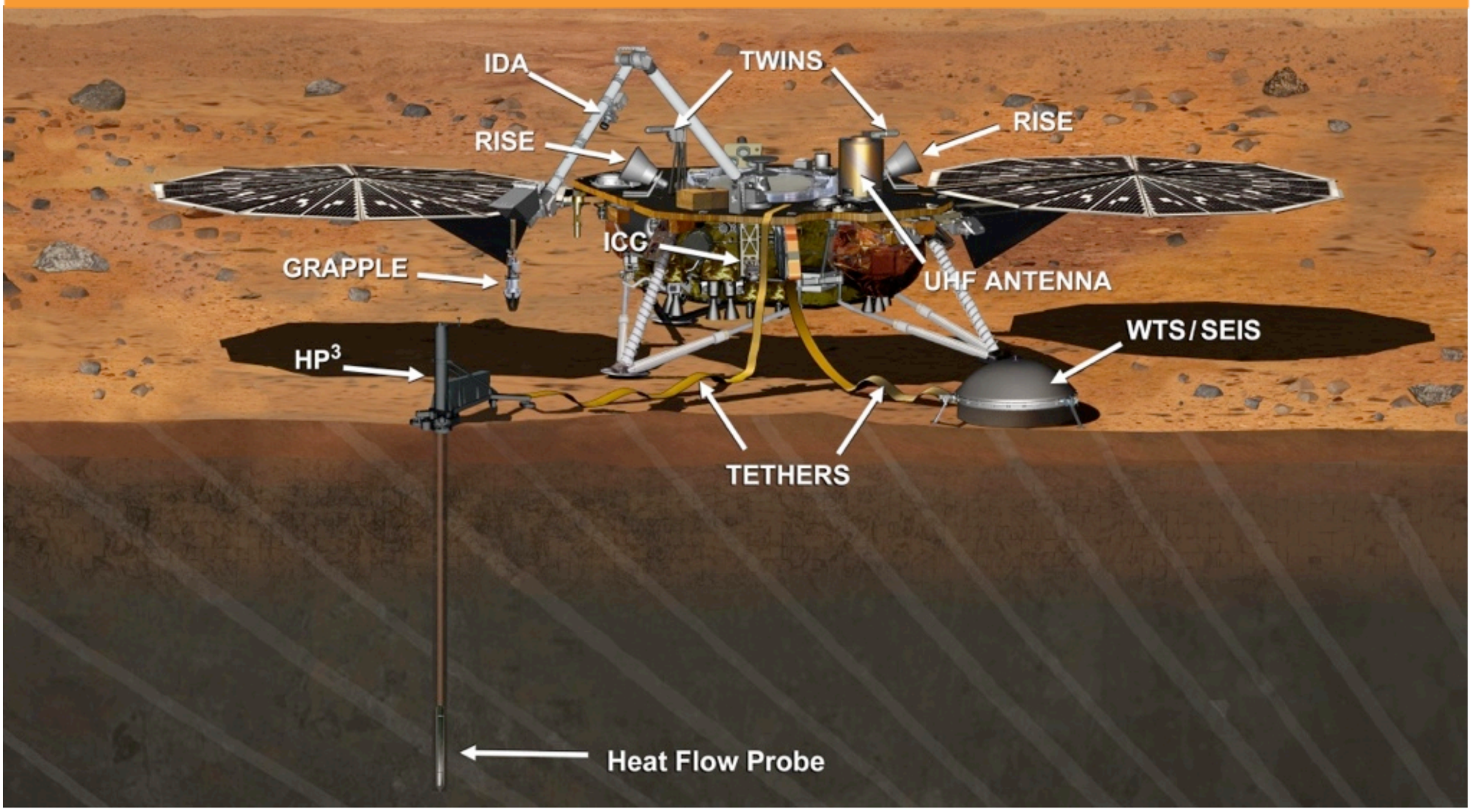


InSight Landing Ellipse – 2016 Arrival



The Instruments

Instruments

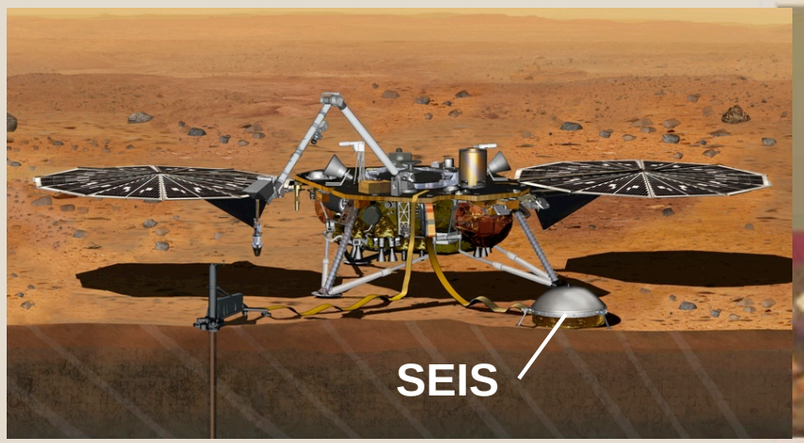


SEIS (Seismic Experiment for Interior Structure)

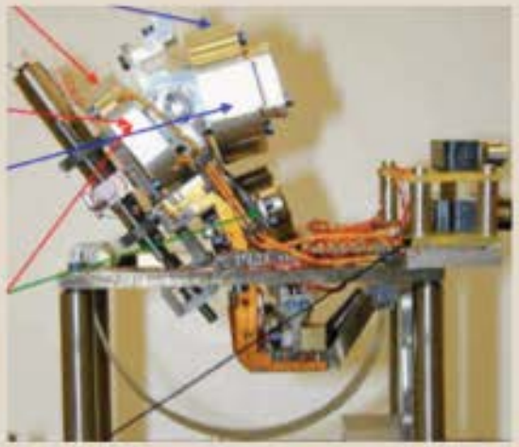
CNES / IPGP – Instrument Lead

- SEIS has a sensitivity and frequency response comparable to the best terrestrial research seismometers.
- Early version flew (briefly) on the Russian Mars '96 mission.
- Previously selected for NetLander, ExoMars and SELENE-2 payloads.

- Managed by CNES, several partners:
  - IPGP (France)
  - ETH (Switzerland)
  - MPS (Germany)
  - Imperial College (UK)
  - JPL (USA)



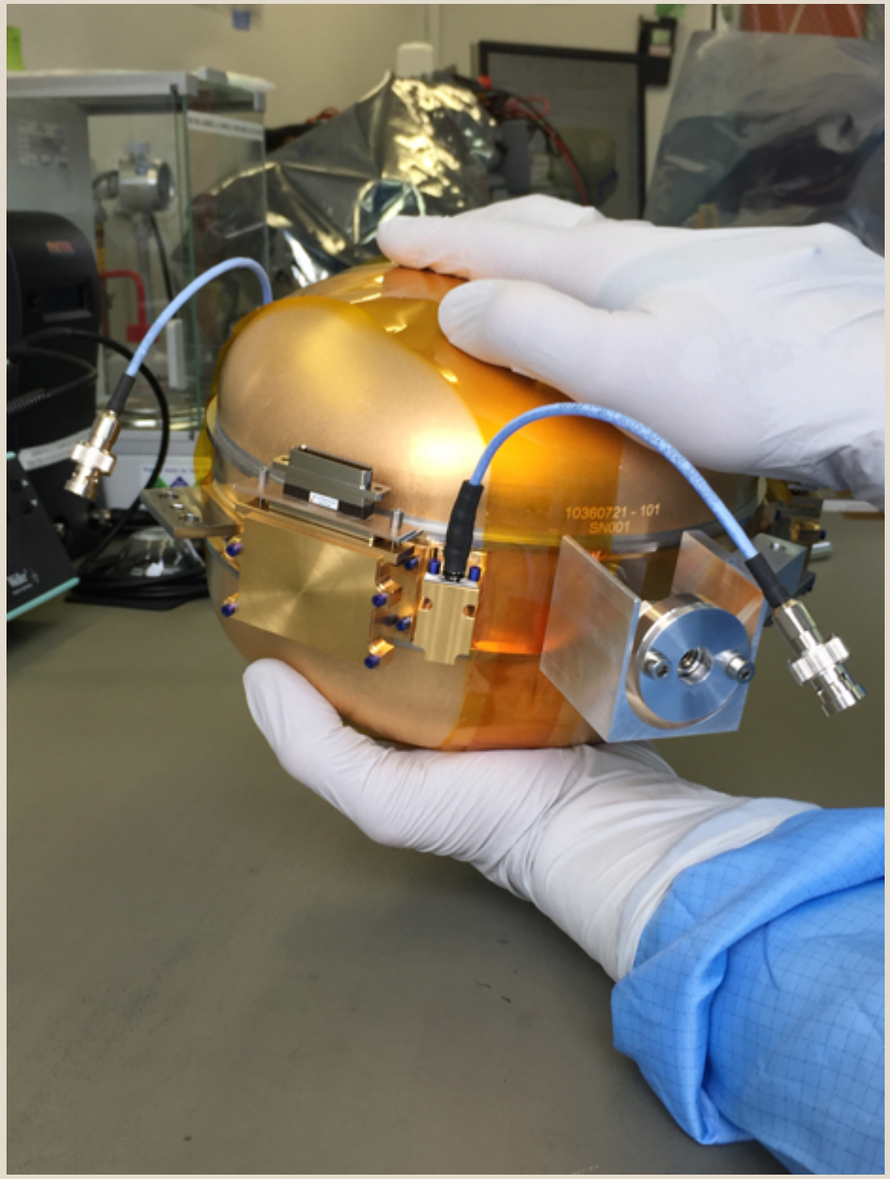
ExoMars Prototype



Long-Period Sensor

Short-Period Sensor

SEIS – Technical Problem



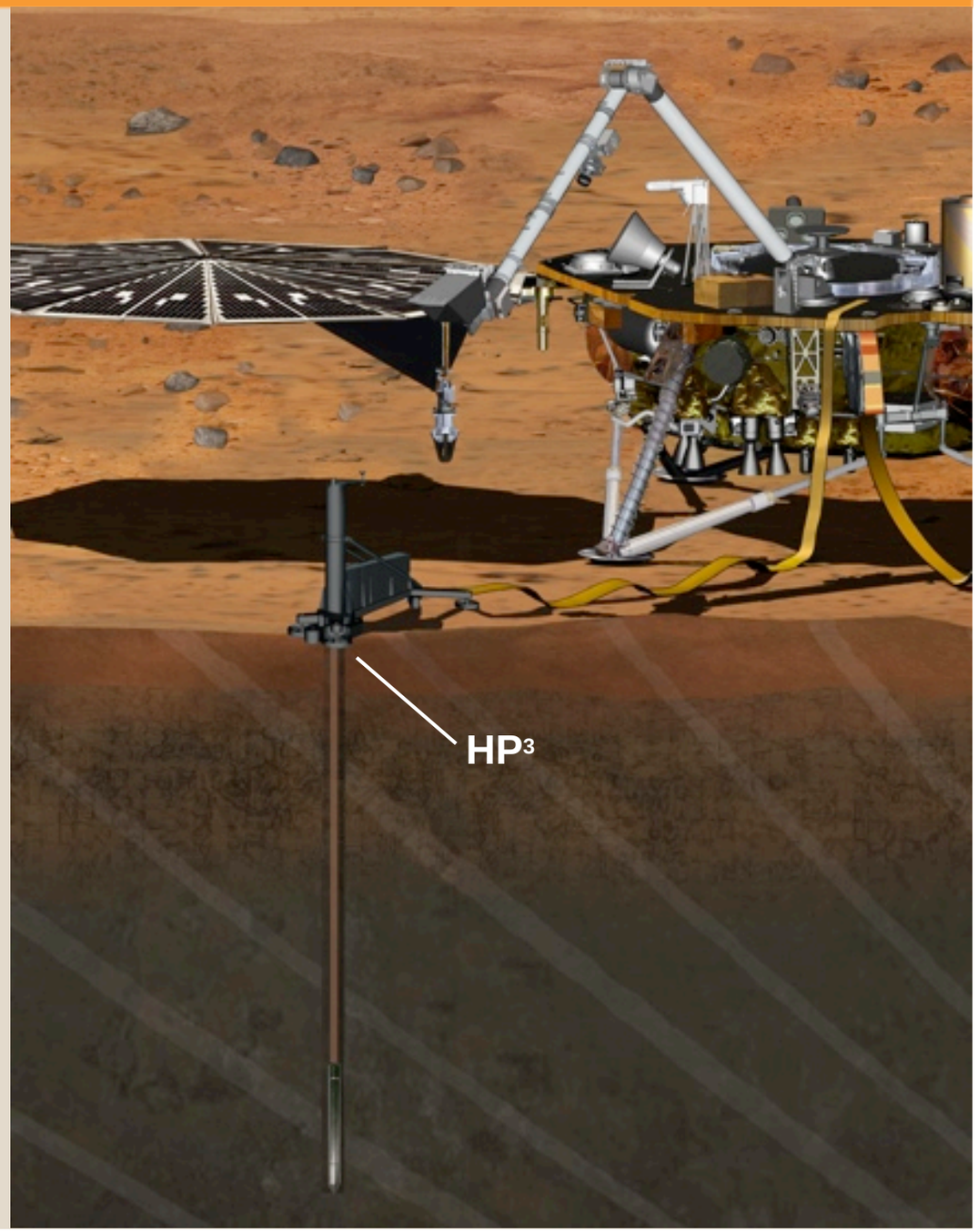
SEIS Pressure Vessel

- SEIS is an extremely sensitive instrument and requires a near vacuum for isolation
- Although repeated fixes were attempted, a small leak remained in the pressure vessel
- The 2016 launch was reluctantly suspended on Dec. 22
- A launch in 2018 is dependent on a reliable and timely fix
- The rest of the spacecraft is essentially ready for flight

HP^3 (Heat Flow and Physical Properties Package)

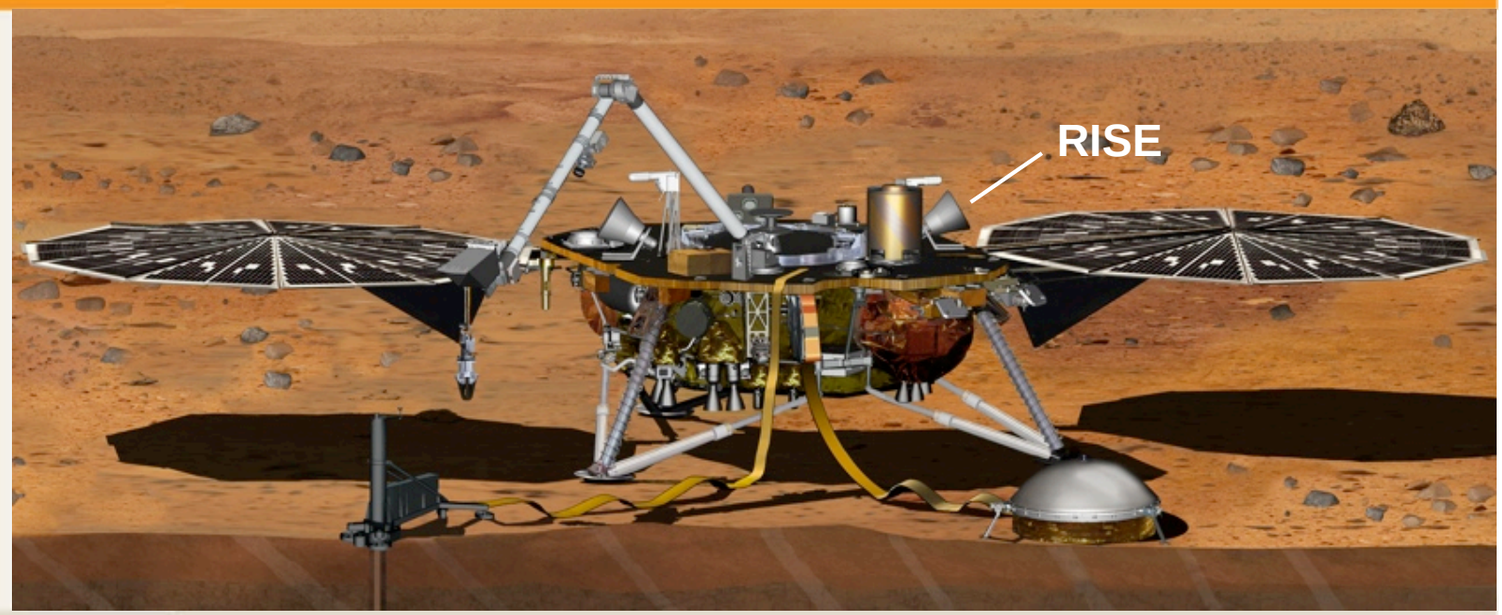
DLR – Instrument Lead

- **HP^3 has a self-penetrating "mole" that burrows down to 5 meters below the surface (flown, but not operated, on Beagle-2)**
- **Previously selected for NetLander, ExoMars and SELENE-2 payloads**
- **It trails a tether containing precise temperature sensors every ~10 cm to measure the temperature profile of the subsurface**
- **Together with measurements of thermal conductivity, this allows a precise determination of the amount of heat escaping from the planet's interior**
- **Contributed by DLR**



RISE (Rotation and Interior Structure Experiment)

X-Band Transponder – SDST
(Small Deep Space Transponder)



- **RISE uses the lander's X-band radio link for Doppler tracking of the lander's location with an accuracy of a handful of cm.**
- **Since the lander is attached to the planet, this allows the measurement of the rotation of Mars, and particularly variations in its rotation axis.**
- **These rotational variations are related primarily to the size and state of the core, through its effect on the moment of inertia and damping of Mars' rotation.**
- **Science team led by JPL.**

InSight leaving Denver, CO for Vandenberg AFB

Spacecraft is currently being prepped for a return trip

Keep an eye out for news on a 2018 launch!

http://insight.jpl.nasa.gov

Jet Propulsion Laboratory
California Institute of Technology