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Solar System Missions: InSight

Mars Interior Exploration

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Conclusion

This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

The Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) mission was a robotic lander designed to study the deep interior of the planet Mars. It was manufactured by Lockheed Martin Space, was managed by NASA's Jet Propulsion Laboratory (JPL), and two of its three scientific instruments were built by European agencies. InSight confirmed "marsquakes" on the planet and thus a still active interior.

The mission launched on 5 May 2018 at 11:05:01 UTC aboard an Atlas V-401 launch vehicle and successfully landed at Elysium Planitia on Mars on 26 November 2018 at 19:52:59 UTC. InSight was active on Mars for 1440 sols

(1480 days; 4 years, 19 days).

InSight's objectives were to place a seismometer, called Seismic Experiment for Interior Structure (SEIS), on the surface of Mars to measure seismic activity and provide accurate 3D models of the planet's interior; and measure internal heat transfer using a heat probe called HP3 to study Mars's early geological evolution.

This was intended to provide a new understanding of how the Solar System's terrestrial planets - Mercury, Venus, Earth, Mars - and Earth's Moon formed and evolved.

The lander was originally planned for launch in March 2016. An instrument problem delayed the launch beyond the 2016 launch window. NASA officials rescheduled the InSight launch to May 2018 and during the wait the instrument was repaired. This increased the total cost from US$675 million to US$830 million. InSight successfully landed on Mars on 26 November 2018.

Due to excessive dust on its solar panels preventing it from recharging, NASA put InSight in low-power mode for detecting seismic events in July 2022 and continued monitoring the lander through the operational period ending in December 2022. On 20 December 2022, NASA announced that the InSight lander had lost communications with Earth on 15 December 2022, with the end of the mission being declared on 21 December 2022.

Three major aspects to the InSight spacecraft were the cruise stage, the entry, descent, and landing system, and the lander.

Chapter 1: The Discovery of InSight

InSight was initially known as GEMS (Geophysical Monitoring Station), but its name was changed in early 2012 following a request by NASA. Out of 28 proposals from 2010, it was one of the three Discovery Program finalists receiving $3 million in May 2011 to develop a detailed concept study. In

August 2012, InSight was selected for development and launch.

Run out of NASA's Jet Propulsion Laboratory (JPL) with participation from scientists in several countries, the mission carried a cost cap of US$425 million, not counting launch vehicle funding.

By reusing the landing system designed for the Mars Phoenix lander, which successfully landed on Mars in 2008, mission costs and risks were reduced. Lockheed Martin began construction of the lander on 19 May 2014, with general testing starting on 27 May 2015. A persistent vacuum leak in the CNES-supplied seismometer known as the Seismic Experiment for Interior Structure (SEIS) led NASA to postpone the planned launch in March 2016 to

May 2018.

When InSight was delayed, the rest of the spacecraft was returned to Lockheed Martin's factory in Colorado for storage, and the Atlas V launch vehicle intended to launch the spacecraft was reassigned to the WorldView-4 mission. On 9 March 2016, NASA officials announced that InSight would be delayed until the 2018 launch window at an estimated cost of US$150 million.

The spacecraft was rescheduled to launch on 5 May 2018 for a Mars landing on 26 November 2018 at 20:00 UTC.

The flight plan remained unchanged with launch using an Atlas V launch vehicle from Vandenberg Space Force Base in California. NASA's Jet Propulsion Laboratory was tasked with redesigning and building a new vacuum enclosure for the SEIS instrument, while CNES conducted instrument integration and testing.

On 22 November 2017, InSight completed testing in a thermal vacuum, also known as TVAC testing, where the spacecraft was put in simulated space conditions with reduced pressure and various thermal loads.

On 23 January 2018, after a long storage, its solar panels were once again deployed and tested, and a second silicon chip containing 1.6 million names from the public was added to the lander. The InSight lander, powered by solar panels and batteries, relies on periodic wind gusts called "cleaning events" to

reduce dust accumulation on the panels.

Elysium Planitia, the landing site of InSight, experienced fewer cleaning events than needed to keep science operations powered.

In February 2021, at the start of the Martian winter, InSight's solar cells were producing 27% of capacity due to a thick covering of dust on the panels. At that time, NASA began the process of putting the lander into hibernation mode, shutting down data-gathering instruments on a schedule to conserve enough power to keep the lander electronics warm through the Martian winter.

NASA had hoped that weather conditions would improve and allow InSight to store enough energy to come out of hibernation in July 2021. In May 2021, some generation capacity was restored by using the arm to position sand so it could blow onto the solar panels and scour them clean. NASA determined in May 2022 that there was too much dust on the panels to continue the mission.

InSight was generating only one-tenth of the power from the sunlight than it did upon arrival.

They put the lander in a low-power mode in July 2022 to continue monitoring for seismic events. NASA continued to monitor InSight until the end of 2022, when the spacecraft missed two consecutive communication attempts. Both Viking spacecraft carried seismometers mounted on their landers, and in 1976 vibrations were picked up from various lander operations and from the wind.

However, the Viking 1 lander's seismometer did not deploy properly and did not unlock; the locked seismometer could not operate.

The Viking 2 seismometer unlocked; it operated and returned data to Earth. One problem was accounting for other data. On Sol 80, the Viking 2 seismometer detected an event. No wind data were recorded at the same time, so it was not possible to determine whether the data indicated a seismic event or wind gust. Other lacking data would have been useful to rule out other sources of vibrations.

Two other problems were the location of the lander and that a certain level of wind on Mars caused a loss of sensitivity for the Viking 2 seismometer. To overcome these and other issues, InSight had many other sensors, was placed directly on the surface, and also had a windshield.

Despite the difficulties, the Viking 2 seismometer readings were used to estimate a Martian geological crust thickness between 14 and 18 km (8.7 and 11.2 mi) at the Viking 2 lander site.

The Viking 2 seismometer did detect vibrations from Mars winds

complementing the meteorology results. There was the aforementioned candidate for a possible marsquake, but it was not particularly definitive. The wind data did prove useful in its own right, and despite the limitations of the data, widespread and large marsquakes were not detected.

Seismometers were also left on the Moon, starting with Apollo 11 in 1969, and also by Apollo 12, 14, 15 and 16 missions and provided many insights into lunar seismology, including the discovery of moonquakes. The Apollo seismic network, which was operated until 1977, detected at least 28 moonquakes up to 5.5 on the Richter scale.

One of the aspects of the InSight mission was to compare the Earth, Moon, and Mars seismic data. Well, seismic investigation is really the heart of this mission.

Mass

Total mass during cruise: 694 kg (1,530 lb)

Lander: 358 kg (789 lb)

Aeroshell: 189 kg (417 lb) Aeroshell Diameter (backshell and heat shield) :

2.64 meters (8.67 ft)

Cruise stage: 79 kg (174 lb)

Propellant and pressurant: 67 kg (148 lb)

Relay probes flew separately but they weighed 13.5 kg (30 lb) each (there were 2)

Lander mass: 358 kg (789 lb) including about 50 kg of science payload.

The length of the robotic arm is 1.8 m (5.9 ft)

Tilt of lander at landing on Mars: 4°

Power is generated by two round solar panels, each 2.15 m (7.1 ft) in diameter when unfurled, and consisting of SolAero ZTJ triple-junction solar cells made of InGaP/InGaAs/Ge arranged on Orbital ATK UltraFlex arrays.

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ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.