INSIGHT: AN INTEGRATED EXPLORATION OF THE INTERIOR OF MARS.

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Introduction: InSight is one of three missions undergoing Phase A development for possible selection by NASA's Discovery Program [1]. If selected, InSight will illuminate the fundamental processes of terrestrial planet formation and evolution by performing the first comprehensive surface-based geophysical investigation of Mars. It would provide key information on the composition and structure of an Earth-like planet that has gone through most of the evolutionary stages of the Earth up to, but not including, plate tectonics. The traces of this history are still contained in the basic parameters of the planet: the size, state and composition of the core, the composition and layering of the mantle, the thickness and layering of the crust, and the thermal flux from the interior.

Science Goals: The scientific goals of InSight are to understand the formation and evolution of terrestrial planets through investigation of the interior structure and processes of Mars and to determine its present level of tectonic activity and impact flux. A straightforward set of scientific objectives address these goals: determine the size, composition and physical state of the core; determine the thickness and structure of the crust; determine the composition and structure of the mantle; determine the thermal state of the interior; measure the rate and distribution of internal seismic activity; and measure the rate of impacts on the surface.

Historically, our detailed understanding of the interior of the Earth has come from geophysics, geodesy, geochemistry, geomagnetism, and petrology, which revealed its basic internal layering, thermal structure, gross compositional stratification, as well as significant lateral variations in these quantities. The geophysical and geodetic investigations undertaken by InSight would closely complement geochemical investigations of SNC meteorites and future samples from Mars. In addition, the mission would provide important constraints for the astrobiology of Mars by constraining the dynamics of magnetic field generation early in Mars' history (with implications for atmospheric retention), by helping to understand the evolution of the atmosphere through volcanic outgassing, and by illuminating the possibilities of a chemoautrophic biosphere through a measurement of the subsurface thermal gradient.

Instrumentation and Flight System: InSight would delineate these parameters for Mars with a focused set of investigations centered on seismology and supported by precision tracking and heat flow measurements. Rather than relying on a multi-station network to provide this information, InSight would utilize state-of-the-art analysis techniques to derive interior information from a single station on the surface carrying three scientific instruments (see Figure 1): SEIS [2], a six-component (3 Short Period and 3 Very-Broad-Band sensors) seismometer with careful thermal control, shielding from martian winds and temperatures, and a sensitivity comparable to the best terrestrial instruments across a frequency range of 1 mHz to 50 Hz; RISE [3] (Rotation and Interior Structure Experiment), which would use the spacecraft X-band communication system to provide precision tracking for planetary dynamical studies; and HP^3 [4] (Heat Flow and Physical Properties Package), an instrumented self-penetrating mole system that trails a string of temperature sensors to measure the planetary heat flux through thermal gradient and conductivity measurements. A robotic arm and camera would be used to deploy the seismometer and heat flow instruments to the ground, and atmospheric sensors would monitor the ambient air pressure, temperature and wind in order to separate environmental noise from seismic signals.

The InSight flight system would be based on a near-copy of the proven Phoenix spacecraft. All science requirements fit within established Phoenix capabilities, with the exception of a full Mars year of operations. This additional requirement is being addressed with minor changes to the power and thermal subsystems.

Single-Station Approach: There is a widely, but erroneously held belief that multiple landers making simultaneous measurements (a network) are required to address the objectives for understanding terrestrial planet interiors. However comprehensive measurements from a single geophysical station can be effectively used to determine the first-order divisions of a terrestrial planet interior (crust, mantle, core). InSight would utilize sophisticated analysis techniques that are standard in terrestrial seismology, specific to single-station measurements, such as first motion analysis, receiver functions [5], surface wave dispersion [6], multiple surface wavetrain analysis [7], normal modes [8], tidal deformation [9], deconvolution and cross-correlation techniques [10]. These results would be combined with measurements of rotational variations (which are sensitive to deep radial variations in density and strength) and heat flow (which can be related to the state of the core, the viscosity of the mantle, the distribution of radiogenic elements, etc.).

Summary and Conclusions: The GEMS mission would fill a longstanding gap in the scientific exploration of the solar system by performing an in-situ investigation of the interior of an Earth-like planet other than our own. It would provide unique and critical information about the fundamental processes of terrestrial planet formation and evolution.

These goals would be reached with three instruments (see Figure 1): (1) Seismic Experiment for Interior Structure (SEIS), (2) Rotation and Interior Structure Experiment (RISE), (3) Heat Flow and Physical Properties Package (HP^3), as well as a robotic arm and a camera that would be used to deploy these instruments to the surface.

This investigation has been ranked as a high priority in virtually every set of European, US and international high-level planetary science recommendations for the past 30 years, including the recently released Decadal Survey for Planetary Exploration [11,12].

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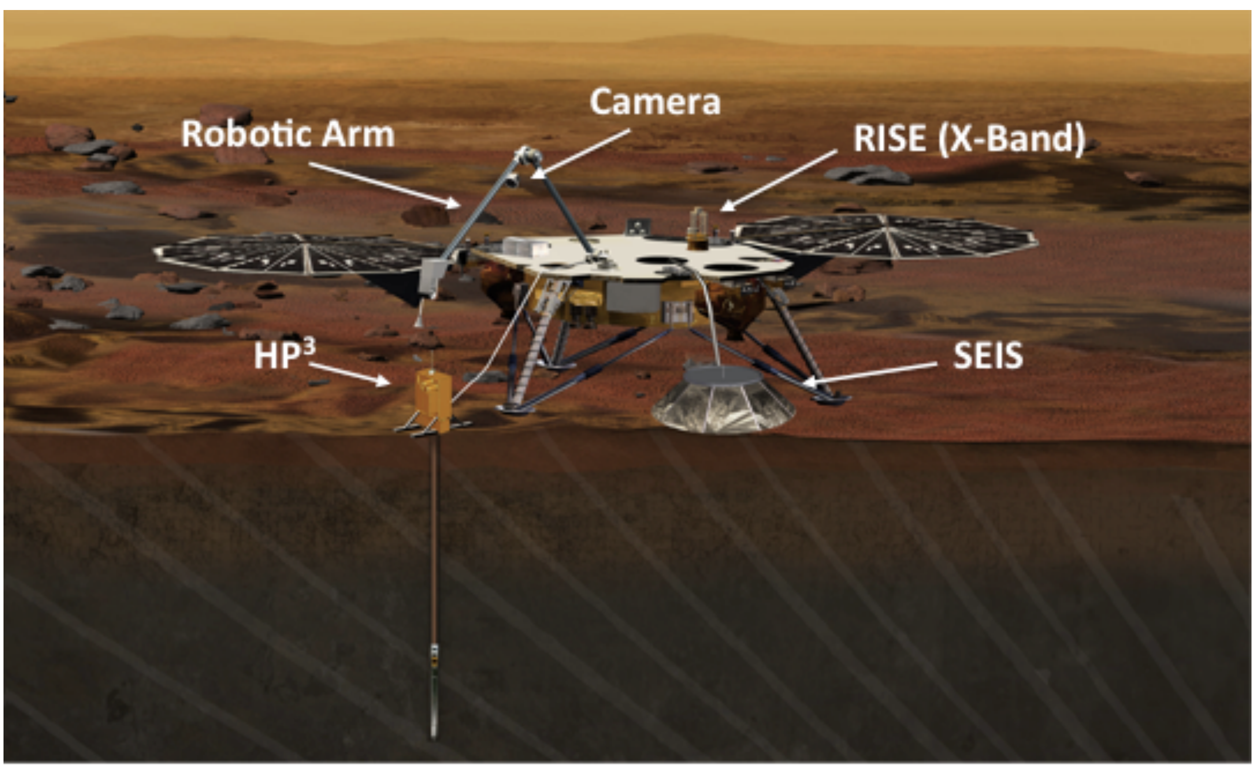

Figure 1. Artists rendition of the InSight lander showing deployed instruments.