INSIGHT: A DISCOVERY MISSION TO EXPLORE THE INTERIOR OF MARS. W. B. Banerdt[1], S. Smrekar[1], K. Hurst[1], P. Lognonné[2], T. Spohn[3], S Asmar[1], D. Banfield[4], L. Boschi[5], U. Christensen[6], V. Dehant[7], W. Folkner[1], D. Giardini[8], W. Goetz[6], M. Golombek[1], M. Grott[3], T. Hudson[1], C. Johnson[9], G. Kargl[10], N. Kobayashi[11], J. Maki[1], D. Mimoun[12], A. Mocquet[13], P. Morgan[14], M. Panning[15], W. T. Pike[16], J. Tromp[17], T. van Zoest[18], R. Weber[19], M. Wieczorek[2] and the InSight Team, [1]Jet Propulsion Laboratory, California Institute of Technology (bruce.banerdt@jpl.nasa.gov), [2]Institut de Physique du Globe, Paris [3]DLR Institute for Planetology, Berlin, [4]Cornell Univ., [5]Univ. Pierre et Marie Curie, Paris, [6]Max Planck Inst. for Solar System Studies, Lindau, [7]Royal Observatory of Belgium, Brussels, [8]ETH, Zurich, [9]Univ. British Columbia, Vancouver, and Space Science Institute, [10]Austrian Academy of Sciences, Vienna, [11]JAXA, Tokyo, [12]ISAE, Toulouse, [13]Univ. Nantes, [14]Northern Arizona Univ., Flagstaff, [15]Univ. Florida, Gainesville, [16]Imperial College, London, [17]Princeton Univ., [18]DLR Institute for Space Systems, Bremen, [19]Marshall Space Flight Center.

Introduction: InSight was recently selected as the twelfth mission of NASA's Discovery Program. It seeks to illuminate the fundamental processes of terrestrial planet formation and evolution by performing the first comprehensive surface-based geophysical investigation of Mars. It will 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 structural 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. These goals will be realized through a specific set of basic scientific objectives:

1. Determine crust thickness and structure.
2. Determine mantle composition and structure.
3. Determine size, composition, and physical state of the core.
4. Determine thermal state of the interior.
5. Measure the rate and distribution of internal seismic activity.
6. Measure the rate of meteorite impacts on the surface.

These objectives have been rigorously and quantitatively tied to mission, instrument and analysis capabilities, ensuring that InSight will provide a major advances in our understanding of planetary formation and evolution.

Instrumentation: InSight will delineate these parameters for Mars with a focused set of investigations centered on seismology and supported by precision tracking and heat flow measurements. It carries two scientific instruments (see Figure 1). SEIS [1] is a six-component (3 Short Period and 3 Very-Broad-Band sensors) seismometer with careful thermal control, shielding from martian wind and temperature variations, and a sensitivity comparable to the best terrestrial instruments across a frequency range of 1 mHz to 50 Hz. HP^3 [2] (Heat Flow and Physical Properties Package) is an instrumented self-hammering mole system that will penetrate as deep as 5 m below the surface, trailing a string of temperature sensors to measure the planetary heat flux through thermal gradient and conductivity measurements.

A key aspect of the mission is the use of a robotic arm and a set of cameras to deploy the seismometer and heat flow instruments to the ground, enabling these instruments of perform their precise geophysical measurements. In addition, InSight carries a set of atmospheric sensors to monitor the ambient air pressure, temperature and wind in order to separate environmental noise from seismic signals.

A third investigations uses the spacecraft X-band communication system. RISE [3] (Rotation and Interior Structure Experiment) will provide precision tracking measurements of the rotation of Mars. Minute variations in the magnitude and direction of the planetary rotation vector can be related to the structure and properties of the core.

Flight System: The InSight flight system is based on a near-copy of the proven Phoenix spacecraft, updated with modern avionics from Juno and GRAIL. 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.

Mission Design: InSight will launch within a 20-day window beginning March 8, 2016. After a 6½ month cruise in a Type-1 trajectory, it will land in western Elysium Planitia on September 20, 2016. After a 60-sol deployment phase, during which the seismometer and heat flow probe are placed on the ground, the mole penetrates to its final depth, and all the instruments are commissioned, the lander will settle into a passive, repetitious observation phase lasting 700 sols. The nominal end-of-mission is September 18, 2018.

Data will be relayed to Earth through orbiters (InSight can use any of MRO, Odyssey, Mars Express, or MAVEN). A low-rate X-band DTE channel is available for commanding and data return in case of emergency.

Single-Station Approach: There is a widely held, but erroneous, 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). Rather than relying on a multi-station network to provide this information, InSight utilizes sophisticated analysis techniques that are standard in terrestrial seismology, specific to single-station measurements, such as first motion analysis, receiver functions [4], surface wave dispersion [5], multiple surface wavetrain analysis [6], normal modes [7], tidal deformation [8], and deconvolution and cross-correlation techniques [9]. These results will 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 InSight mission fills a longstanding gap in the scientific exploration of the solar system [10, 11] by performing an in-situ investigation of the interior of an Earth-like planet other than our own. It will provide unique and critical information about the fundamental processes of terrestrial planet formation and evolution.

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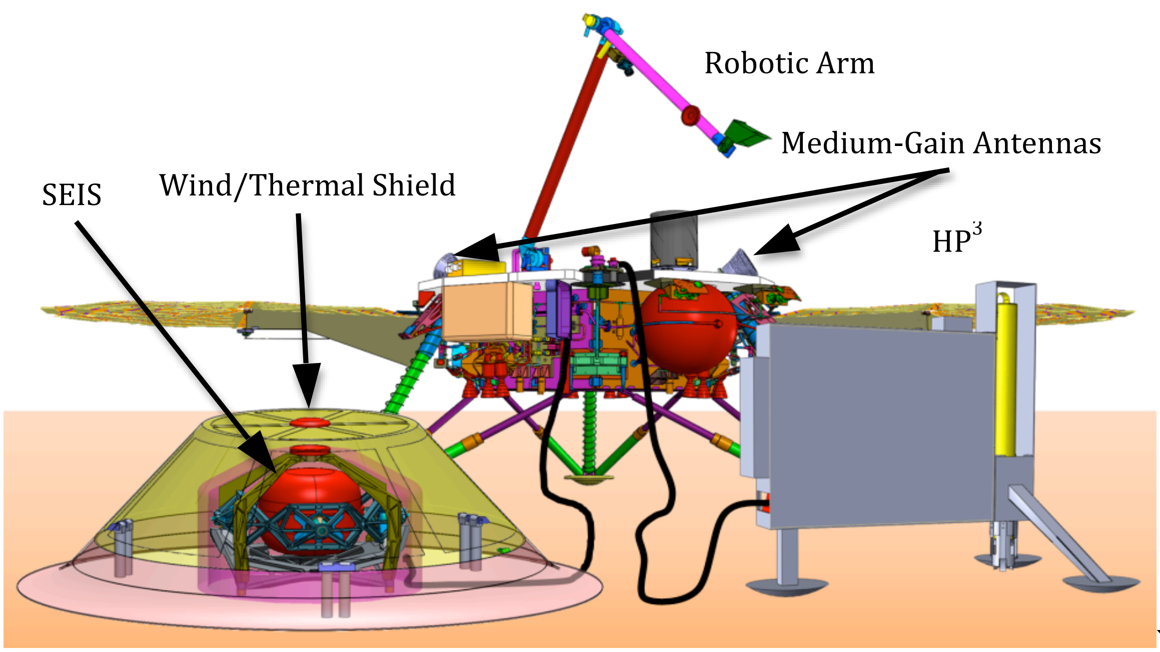

Figure 1. The InSight lander showing deployed instruments.