SELECTION OF THE INSIGHT LANDING SITE: CONSTRAINTS, PLANS, AND PROGRESS. M. Golombek[1], L. Redmond[1,2], H. Gengl[1], C. Schwartz[1,3], N. Warner[1], B. Banerdt[1] and S. Smrekar[1], [1]Jet Propulsion Laboratory, Caltech, Pasadena, CA 91109, [2]University of Southern Maine, Portland, ME 04104, [3]Mt. Holyoke College, S. Hadley, MA 01075.

Introduction: InSight, the recently selected Discovery Program mission, is designed to determine the interior structure of Mars to better understand terrestrial planet formation and differentiation. The spacecraft is a reflight of the Phoenix lander that will carry a seismometer, heat flow probe, and precision tracking station that will operate on the surface for one Mars year after landing in 9/16 [1]. This abstract discusses the constraints, plans and progress towards selecting a landing site for InSight.

Landing Site Constraints: Although there are no science requirements on the landing site, there are landing safety ("engineering") and instrument deployment requirements. Primary engineering requirements for landing site selection are: MOLA elevation below -2.5 km for sufficient atmosphere to slow the spacecraft during entry, descent and landing; Latitude between 15°S and 5°N for large solar-power margins; Ellipse size 139 km × 27 km for >99% landing accuracy; Smooth, flat, radar-reflective surface; Thermal inertia >100–140 J m^{-2} K^{-1} $s^{-1/2}$ for a load-bearing surface without substantial fine-grained dust; Rock abundance ≤10% for a ~1% probability of impacting a rock that could damage the base of the lander or impede opening the solar panels; Local (1-5 m) and 84 m length slopes <15° for >99% landing safety. These engineering requirements are similar to those used for Phoenix landing site selection.

Instrument deployment requirements involve placing instruments on the surface (from the lander deck) without large rocks or slopes underneath. Both the seismometer and heat flow probe can accommodate up to 3 cm of relief and the windshield that is placed over the seismometer can accommodate 6 cm of relief. All of these could be successfully deployed using the equivalent InSight robotic arm workspace at the Viking Lander 1, 2 and Phoenix sites, even though Viking Lander 2 has 17% rock abundance. The probability of safely deploying the instruments was also evaluated using rock distributions measured from the surface and orbit and sampling statistics [2]. Results indicate >99% probability of safely placing the instruments on the surface within the robotic arm workspace. Finally, the heat flow probe is designed to penetrate up to 5 m beneath the surface, which requires a broken up regolith of at least this thickness with low rock abundance.

Potential Landing Site Areas: The elevation and latitude requirements severely constrain potential areas to land InSight. Three areas on Mars are below -2.5 km elevation and within 5°N and 15°S latitude. Areas inside the Vallis Marineris canyons and outflow troughs meet these constraints, but placing 130 km by 27 km ellipses on smooth, flat surfaces is problematical. The very southern edge of Isidis Planitia also meets these constraints, but rock abundance estimates here and in Vallis Marineris far exceed 10% [3]. In addition, experience searching for low-wind MER ellipses in the equatorial latitudes has shown that both areas are windy (on storm tracks from weather systems generated at high northern latitudes) [4].

The final area that meets the elevation and latitude constraints is in southern Elysium and Amazonis Planitiae. However, all of Amazonis and the eastern portion of Elysium have very low thermal inertia (<140 J m^{-2} K^{-1} $s^{-1/2}$) indicating potentially thick accumulations of fine grained dust that is not load bearing and not suitable for landing a solar powered lander. Western Elysium Planitia, however has higher thermal inertia and broad smooth and flat surfaces at hundreds of meters scale in THEMIS thermal image mosaics.

Elysium Planitia Ellipses: Using available remote sensing data we have identified 16 prospective landing sites in western Elysium Planitia that appear to meet the engineering and instrument deployment requirements (Figure 1). We sited ellipses in smooth, flat regions in THEMIS thermal images (the highest resolution images available at the time) below -2.5 km between 2°S-5°N and 135-145°E. Ellipses were placed so that IRTM and TES rock abundance estimates are dominantly below 10%.

The remote sensing properties of the 16 ellipses are shown in Table 1 (including sources). Center elevations of the ellipses range from -2.5 km to -2.7 km below the MOLA geoid. Thermal inertia varies from around 180 to 280 J m^{-2} K^{-1} $s^{-1/2}$. Albedo at ellipse centers is 0.24-0.26 and dust cover index is 0.93-0.95. Comparison of these properties with those of existing landing sites suggests the InSight landing sites are similar to dusty and low-rock abundance portions of the Gusev cratered plains [5].

The plains surface on which the InSight ellipses are located is mapped as Hesperian-age HBu_2 (Utopia Planitia 2 Unit), interpreted as lava flows or sediments [6]. Ellipses are wedged between highlands to the south and west, a ridge of Medusae Fossae Formation in the center and very young lavas from Athabasca Valles to the east.

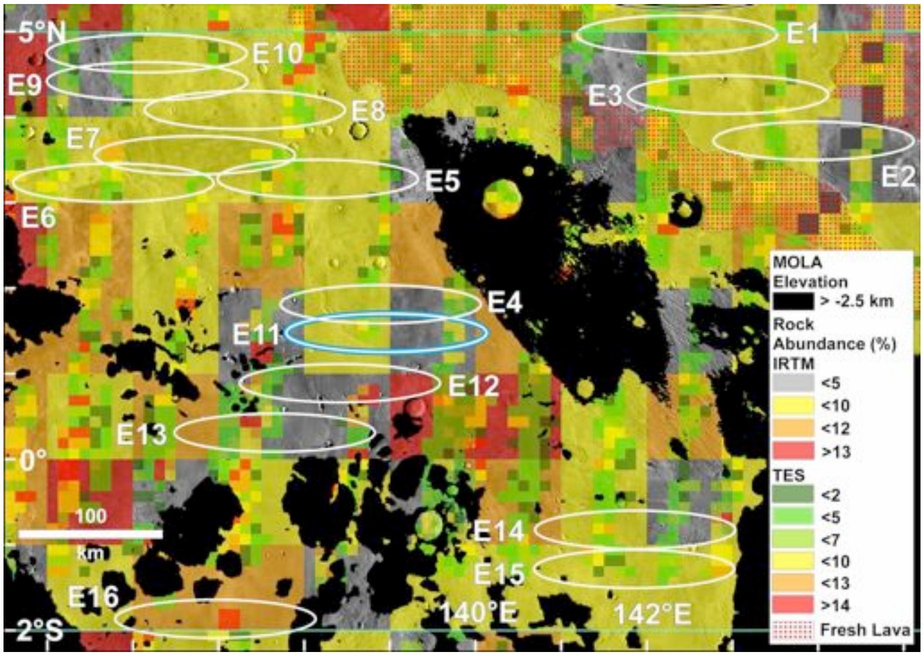

Figure 1. InSight landing site ellipses in Elysium Planitia with elevation limit (black), IRTM and TES rock abundance [3], and young lava from Athabasca Valles.

Recently targeted high-resolution HiRISE and CTX images show the surface is dominated by impact craters in various states of degradation. Fresh craters larger than about 100 m diameter (but not smaller) are surrounded by rocky ejecta, similar to 0.2-2 km diameter craters throughout the northern plains [7]. Because ejecta is sourced from shallow depths (~0.1 times the crater diameter) [8], the rocks are ejected from strong intact rock below 10 m depth, with finer grained and weaker regolith above. We see direct evidence for a fine grained regolith ~10 m thick in a steep exposed portion of Hephaestus Fossae in southern Utopia Planitia [9]. As a result, the onset diameter of rocky ejecta craters indicates a broken up regolith conducive for full penetration of the heat flow probe (5 m).

Landing Site Selection Plans: Because of the lack of science and tight engineering requirements on the landing site, selection will be done within the project, although we are planning for participation of outside scientists with a research interest (contact the first author). With the selection of western Elysium Planitia, the InSight project has already identified the landing region on Mars, which is required one year before launch. Site selection will take 3 years, with downelections at one year intervals. In the 1st year, initial characterization of terrains in ellipses by targeted HiRISE and CTX images will reduce the number of sites to 4-6. The 2nd year will focus image acquisition and analysis on these ellipses, leading to downselection to 2-3 ellipses. In the 3rd year, these final ellipses will be fully characterized allowing certification and selection of one ellipse in late 2015, several months before launch (3/16). A similar level of surface characterization as was done for the MSL landing sites [10] is planned.

Table 1: InSight landing site elipse data.

El-lipse	Latitude, Longitude	Elev.	TES TI	TES RA	IRTM RA	DCI	Al-bedo
E1	4.959, 142.359	-2630	237	5 (1-8)	4,8,8 (6,10)	0.94	0.25
E2	3.72, 143.945	-2636	183	5 (2-10)	3,10 (5,8)	0.94	0.26
E3	4.262, 142.941	-2608	219	5 (2-10)	8,6 (4,6)	0.94	0.25
E4	1.812, 138.89	-2693	278	3 (3-10)	4,7 (1,11,12)	0.95	0.24
E5	3.278, 138.154	-2691	283	5 (1-12)	9,10 (2)	0.94	0.24
E6	3.231, 135.77	-2640	269	6 (1-8)	6,10 (9)	0.94	0.24
E7	3.553, 136.758	-2650	272	6 (2-12)	9,10 (6)	0.94	0.24
E8	4.082, 137.303	-2696	283	6 (3-8)	9,10	0.94	0.24
E9	4.323, 135.663	-2664	259	4 (1-7)	4,9	0.94	0.24
E10	4.744, 136.165	-2677	265	4 (2-7)	4,9 (10)	0.94	0.24
E11	1.477, 138.957	-2699	276	6 (2-10)	4,7 (1,11)	0.94	0.25
E12	0.881, 138.408	-2641	247	11 (2-23)	1,5,14 (7)	0.95	0.25
E13	0.312, 137.652	-2630	240	6 (1-16)	1,5,12	0.93	0.26
E14	-0.833, 141.856	-2687	234	6 (3-11)	2,9 (6,11)	0.94	0.25
E15	-1.281, 141.85	-2700	232	6 (2-12)	8,9 (6,7)	0.94	0.25
E16	-1.864, 136.962	-2561	248	12 (1-19)	11,11 (3,8,10)	0.94	0.26

Latitude and longitude in °, positive north and east, planetocentric; elevation in m wrt MOLA geoid; TES thermal inertia in J m^{-2} K^{-1} $s^{-1/2}$ from [11]; TES and IRTM rock abundance in % from [3], with values in parentheses partially in ellipse; Dust cover index from [12]; Albedo from [13].

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