SELECTION OF THE 2018 INSIGHT LANDING SITE. M. Golombek[1], D. Kipp[1], I. J. Daubar[1], D. Kass[1], M. Mischna[1], W. B. Banerdt[1], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

Introduction: The InSight Discovery Program mission to investigate the internal structure of Mars and the formation and differentiation of the terrestrial planets has been authorized by NASA to proceed towards a launch in May 2018. The originally planned 2016 launch was suspended in late December 2015 due to a leak in the seismometer vacuum sphere that would have significantly affected its ability to achieve the required science. Because the seismometer is the primary instrument on the lander, it was decided that InSight should not launch with this performance degradation.

This abstract describes the changes in launch period from 2016 to 2018 that affected the landing site. Selection of the InSight landing site took place over four years during project development, spacecraft assembly, testing and replanning. The landing site is located in western Elysium Planitia at ~4.5°N, ~135.9°E and meets all the engineering and instrument deployment requirements [1, 2].

Elevation: In January 2016, the project began exploring later launch options. Optimal (minimum energy) launch opportunities from Earth to Mars occur every 26 months, just before opposition, when the distance between the two planets is near a minimum. Because the atmospheric pressure on Mars varies seasonally by 25% due to the tilt of the spin axis and the ellipticity of the orbit, the elevation at which a spacecraft can land (all other factors being equal) is determined by the season and density of the atmosphere at arrival. For the 2016 launch period and a Type 1 trajectory (<180° around the sun), InSight would have arrived at Mars at L_s=231°, which is in southern spring just before the atmospheric pressure maximum near solstice (L_s=270°). In 2018, the Type 1 trajectory that provides both direct-to-Earth and Mars Reconnaissance Orbiter communications during entry, descent and landing (EDL), launches in May 2018 and arrives at Mars in late November 2018. This EDL is during southern summer at L_s=296°, just after the seasonal pressure maximum. Serendipitously, the atmospheric pressure on Mars is almost identical for these two arrival L_s (Table 1). As a result, the landing site elevation requirement is unchanged (<-2.5 km), which is incredibly fortuitous given that there are no lower-elevation options that meet the constraints on ellipse size, latitude, and surface properties..

Latitude and Ellipse Size: The other main factors (besides elevation) that drove the landing site selection to western Elysium Planitia are latitude and ellipse size. The latitude range is determined by solar insolation and thermal management of the lander over a full Mars year. As a result, regardless of when landing occurs, the latitude constraint is unchanged (3°-5°N). The ellipse size is dependent on the entry velocity, which is slower for 2018 and similar to Phoenix, from which the InSight spacecraft is derived (Table 1), resulting in a slightly smaller ellipse for the same entry flight path angle (the angle between the vehicle's velocity vector and horizontal at atmospheric entry). However to gain timeline margin during EDL, the entry flight path angle was shallowed slightly so the ellipse is almost the same size as the 2016 ellipses (and is within the 130 km by 27 km requirement). The azimuth of the ellipse is dependent on the geometry of the transfer trajectory and the landing latitude (the latter of which is unchanged). The azimuthal variation in the ellipse is 11.5° from the opening to closing of the 2018 launch

Table 1. Main differences between InSight in 2016 and 2018 and Phoenix that affect EDL.

	InSight 2018	InSight 2016	Phoenix
Arrival Date	Nov. 26, 2018	Sept. 28, 2016	May 25, 2008
Inertial Entry Velocity (km/s)	5.5-5.6	6.1	5.6
Entry Mass (kg)	<625	< 625	572.2
Landing Site Elevation (km, MOLA)	<-2.5	<-2.5	-4.1
L_s / Season at arrival	296° Northern Winter, Southern Summer, Late Global Dust Storm Season	231° Northern Autumn, Southern Spring, Global Dust Storm Season	76.7° Northern Late Spring
Surface Atmospheric Pressure (mbar) at Landing Site	7.25	7.26	8.5

period (~3 weeks), which is slightly less than for 2016 and is centered at a better azimuth (~93° clockwise from north) with respect to fitting the ellipse away from the large craters around the edge of the preferred landing site (Figure 1). As a result, the previously selected landing ellipse can be accessed in 2018 as well as or better than in 2016 (>99% probability of landing success). This enormously simplified landing site related project activities for 2016-2018. The same landing site could be targeted in 2018, which had already been imaged, selected and certified (Figure 1). This is fortunate because the two-year delay in launch is too short to identify, image, characterize, and select an entirely new landing site from a number of possibilities given the normal (*i.e.,* non emergency) HiRISE imaging cadence used for Mars landing sites. Even if there were time to redo landing site selection, the same factors that drove the selection of western Elysium Planitia in 2016, would drive the selection of the ellipse in 2018 to the same area and ultimately the same ellipse.

The Type 1 trajectory for InSight launching in 2018 was selected by the InSight project in early 2016 and the landing site was unchanged (Figure 1). Only minor additional imaging is required to fill in coverage gaps in the 2018 ellipses. In late 2017 slope and rock maps of all unprocessed HiRISE images will be completed. An updated hazard map will then be produced, enabling new landing site probability simulations for different launch dates, prior to May 2018.

References: [1] M. Golombek et al. (2016) *Space Sci. Rev.* DOI 10.1007/s11214-016-0321-9. [2] M. Golombek et al. (2016) *LPS* 47, Abs. #1572.

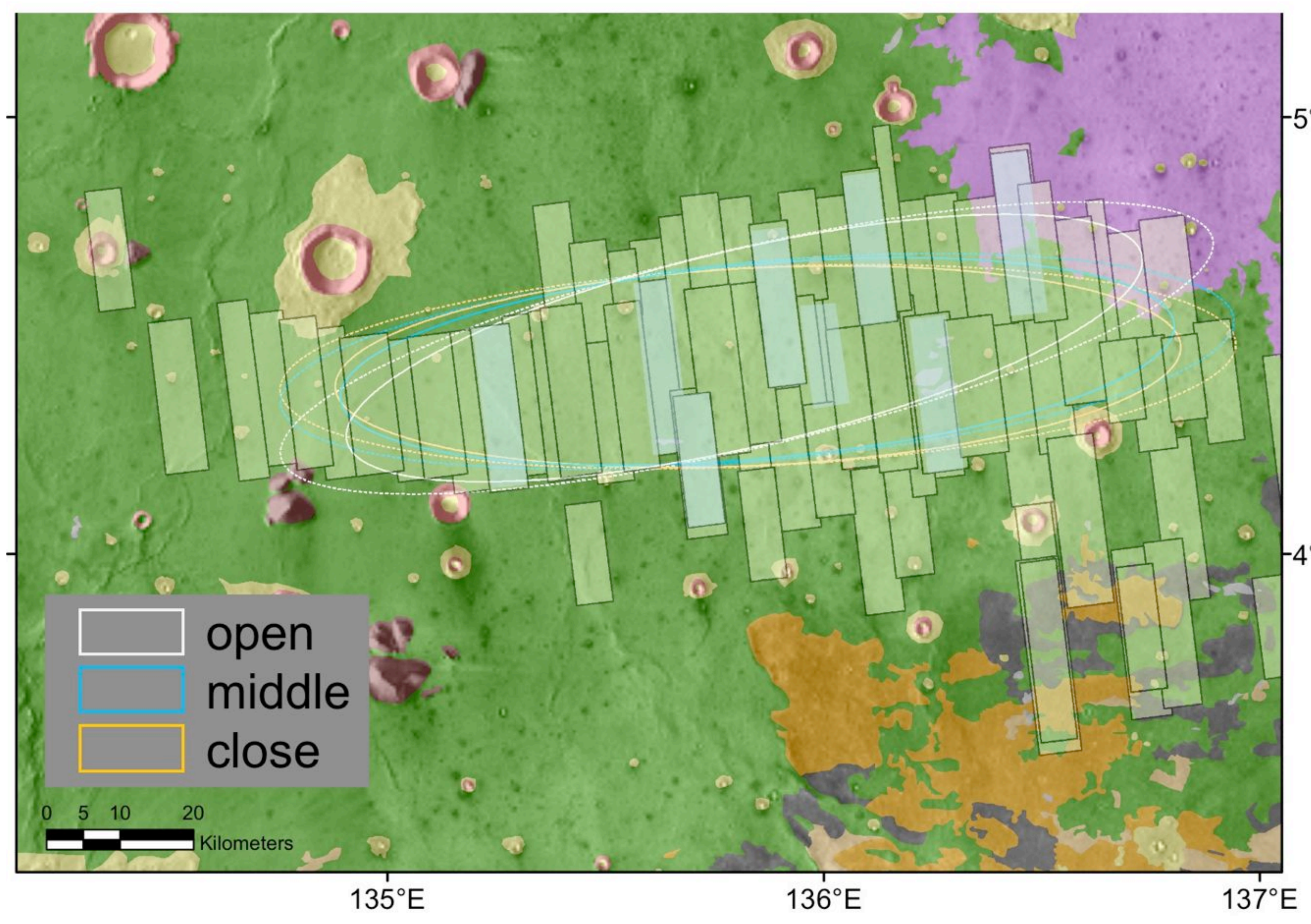

Figure 1. HiRISE image coverage in late 2016 of InSight ellipse for the 2018 launch period. HiRISE mono images are shown in green; those in blue are stereo. Dashed ellipses are 130 km by 27 km and solid ellipses are 100 km by 27 km, possible for some atmospheric conditions, for the open (white), middle (blue) and close (orange) of the launch period. Existing HiRISE images cover >90% of the larger open, middle and close ellipses. Simulations show these ellipses have a ~99% probability of success for landing for the range of ellipse sizes and azimuths. The background is the terrain map over the THEMIS thermal daytime mosaic. Terrains ordered from most benign to most hazardous are: Smooth-green, Ridged-violet, Dark-grey, Etched-orange, Gradational etched-beige, Ejecta-yellow, Highland scarp-red, and Crater rim-pink as defined in [1].