# HIRISE CAPTURES THE VIKING AND MARS PATHFINDER LANDING SITES.

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**Introduction:** The HiRISE camera on the Mars Reconnaisance Orbiter has acquired very high resolution images of all the successful lander missions to Mars that are sufficiently detailed as to conclusively place the landers and much of the associated EDL hardware. Locations for the Viking Landers were proposed based initially on a revised location for Viking Lander 1, which was made after the Pathfinder landing in 1997 [1]. These revised locations enabled precise targeting of the landers by the Mars Orbiter Camera (MOC) beginning in 1997, and the HiRISE camera on MRO in the last few months. Accurate locations for the vehicles are essential for enabling scientists to determine the geologic nature of the landing sites. High resolution orbiter images – first MOC at up to 50cm/pixel, then HiRISE at less than 30cm/pixel – will enable us to "bridge the gap" between the much lower, regional coverage provided by the Viking Orbiters (upon which landing site selection and localization was based during these missions), and the ground views from the landers.

**Viking Orbiter coverage:** The Viking 1 landing site has the highest resolution (~7m/p) of the three landers, represented by a single image taken after the landing by Viking Orbiter 2. Mars Pathfinder has the most complete coverage, at ~40m/p and in stereo, as the Ares Vallis site was the primary site chosen for VL-1 based on Mariner 9 images (but deemed too rough based on Viking Orbiter images). Viking 2 had the lowest resolution coverage (and landed in the least dramatic terrain) of all three landers, at nearly 100m/pixel at the actual landing site (an initially favored site west of the actual site was abandoned due to its rough appearance at ~40m/pixel). These images were of insufficient resolution to detect the landers or associated hardware, but they enabled predictions of the lander locations to be made, based on triangulation to horizon features in the ground pans, for subsequent targeting of MOC and HiRISE.

**Mars Global Surveyor Coverage – a retrospective look:** All three landing sites were imaged by MOC a number of times at nominal pixel scales (typically 1.5m/p to a few m/p), and at least once at "super" resolution, by rolling the spacecraft while imaging (up to 0.5m/pixel). With definitive identification of the landers in the HiRISE images, it is interesting to revisit the MOC coverage to see what the images reveal or don't reveal at the three landing sites at >50cm/pixel.

*VL-1.* The lander's actual location matched the predicted location in [1] to within a few meters. In the 50cm/p MOC image R10-02722, the lander is indistinct from the surrounding surface, suggesting that the average of sun glints and shadows over the lander mimics the brightness of the surroundings well. The backshell and possible heatshield are identifiable in the MOC image, but are not recognized.

*VL-2.* Prior to HiRISE, this lander's location was least precisely known of the three. Predictions made by Mike Malin, Phil Stooke, and Tim Parker, based on MOC image R18-01139, all fall within several hundred meters of one another (and the lander). Malin even identified a feature in the image as the lander. Fortuitously, this feature turned out to be the backshell. The lander was south of all three predicted locations. VL-2 is identifiable in the MOC image, as is the possible backshell feature. In the case of the lander, the low sun and long shadow appears to be the primary reason it was deteced and VL-1 was not.

*MPF.* The lander's actual location matched Parker's predicted location during the MPF mission [2], based on Viking Orbiter images, to within a few tens of meters, and Malin's January, 2000 location, based on M11-02414, to within a few meters. In MOC image R05-01414, the lander is detected as a slightly brighter patch against the surrounding surface. The backshell and parachute are identifiable in this image as well as previous images E04-02227 and M11-02414, as a pair of unremarkable bright patches. They're even identifiable (in retrospect) in SP1-25603, acquired less than a year after the landing. In this image, the parachute appears brighter than in subsequent images, suggesting partial obscuration by dust over time. Unfortunately, the backshell/parachute are out of sight from the lander's location, so they weren't scruitinized prior to being resolved by HiRISE. Two other bright patches that were imaged by IMP appear to be EDL debris, most notably a target that was interpreted to be the backshell during the MPF mission [2]. Finally, Sojourner may have been imaged by HiRISE as well, though it is a small object and it's location can't be predicted with certainty since it may have been functioning when contact with the lander was lost. A

feature about the right size has been identified, where there were no sizeable rocks imaged by IMP. This feature is south of the lander and about 6 meters away. If this is Sojourner, it appears to have ceased functioning not long after the lander failed, or it stayed near the lander (as it was programmed to do). No tracks can be identified, which might appear similar to but narrower than the MER tracks, suggesting that Sojourner hasn't moved in a relatively long time.

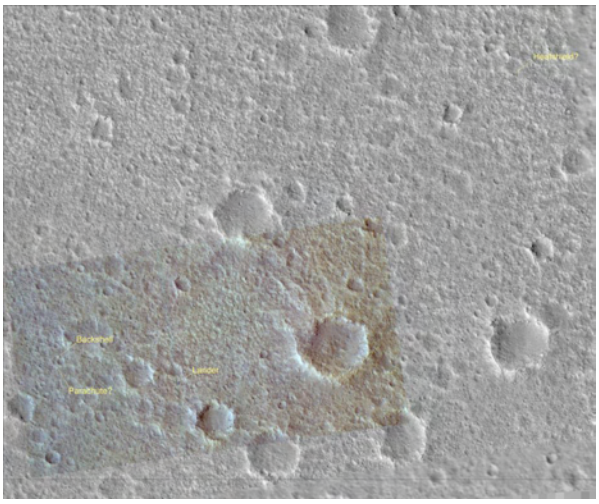
**Implications for locating other landers (Beagle 2, MPL, and the Soviet Mars 2, 3, and 6 landers) without corroborating ground images:** The HiRISE images have shown us that landers, rovers, and EDL hardware can be identified from Mars orbit, particularly when we have ground panoramas from those vehicles. But what about landers that failed to return data from the surface? For these to be captured by HiRISE, we first have to know where on Mars to look, and what to expect at those locations at HiRISE resolution.

Judging from the landing sites imaged to date, we propose that our best chance of identifying one of these landing sites is via the backshell and parachute (if the vehicle had them and they deployed successfully during descent). With the exception of VL-2, all of the successful landers' parachutes are bright objects in the HiRISE images (most of us expected the Viking, and possibly even the MPF parachutes to be obscured by dust after several years).

It is likely, then, that the MPL and Beagle 2 parachutes would also be bright, if they deployed. Perhaps even the Soviet Mars landers might be located by their parachutes, then, if their landing ellipses can be narrowed down based on telemetry. It will be interesting to see what HiRISE reveals at the site proposed by Malin in 2005 to be the MPL landing site (retracted by Malin a few months later). Beagle 2 may be impossible to definitively locate even if the landing site is captured with HiRISE, if the parachute didn't deploy.

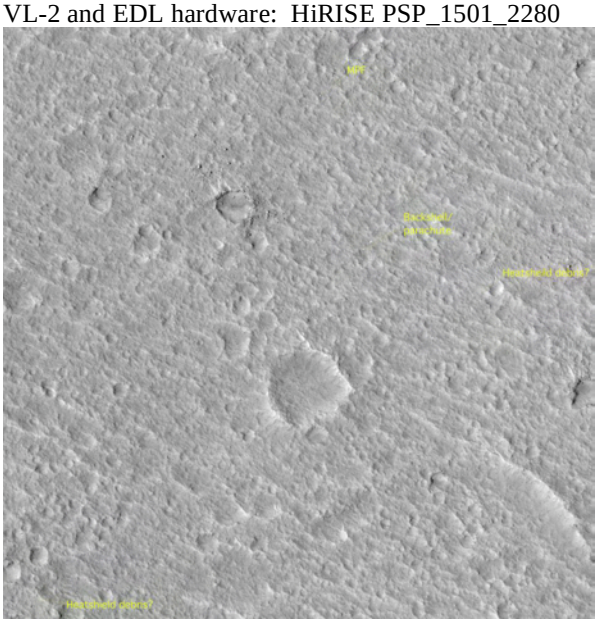
Of the three Soviet Mars landers, Mars 2 is thought to have crashed, and its parachute is thought not to have deployed. Mars 2 and 3 weren't large vehicles – under 400kg - though Mars 6 was over 600kg. Both Mars 3 and Mars 6 are thought to have successfully deployed their parachutes and reached the surface. Unless their locations can be narrowed down, however, the search area for these vehicles is far larger than a HiRISE image frame.

**Reference:** [1] Parker T. J. et al. LPS XXX, Abstract #2040. [2] Golombek M. P. et al. JGR 104, #E4, 8523.




VL-1 and EDL hardware: HiRISE PSP_1521_2025


VL-2 and EDL hardware: HiRISE PSP_1501_2280




MPF and EDL hardware: HiRISE PSP_1890_1995