NOCTIS LANDING, MARS: CONCEPT VEHICULAR TRAVERSE PATHS FROM A PROPOSED HUMAN LANDING SITE AND EXPLORATION ZONE IN WEST VALLES MARINERIS.

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Summary: Noctis Landing, a proposed landing site and exploration zone for human missions to the surface of Mars, would allow access, via short and long-range vehicular traverses, to an exceptionally wide range possible of Science Regions of Interest.

Introduction: Noctis Landing is one of 47 sites proposed to NASA during the agency's *First Landing Site (LS) / Exploration Zone (EZ) Workshop for Human Missions to the Surface of Mars* held in Houston, TX, in October 2015 [1, 2, 3]. The Noctis Landing site is located at 6° 29' 38.3" S, 92° 27' 12.3" W, in a vast ~200 km-wide regional depression between the western end of Valles Marineris and the eastern end of Noctis Labyrinthus. Although level with the floor of western Valles Marineris, the site straddles the eastern flank of the Tharsis region uplift and is the highest altitude LS/EZ proposed (+2 km) **(Fig. 1)**.

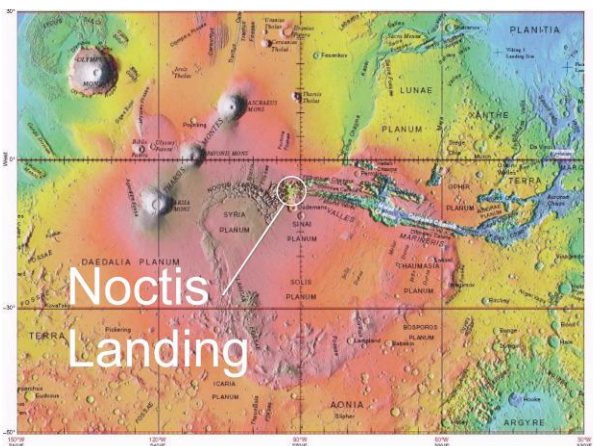

Figure 1. Location of Noctis Landing in relation to major geologic and topographic features on Mars.

In addition to offering a remarkably smooth landing site, year-round daily ~10+hour direct comms visibility with Earth, and local access to potential resources in H_2O expressed as recurring fog [3, 4] and polyhydrated sulfates [e.g., 3, 5], Noctis Landing is located at a strategic crossroads between major Science Regions of Interest (SROIs) on Mars. To the East, the site gives access to Valles Marineris, the most extensive stratigraphic record exposed on Mars, a key opportunity in the search for signs of *past* life on Mars. Towards the West, Noctis Landing gives access to Noctis Labyrinthus, Syria Planum, Tharsis Montes and Olympus Mons, i.e., centers of some of the most recent volcanic – and by likely implication hydrothermal - activity on Mars, and thus to key opportunities to search for signs of *extant* life on Mars.

Pressurized Rover Traverses. Vehicular traverses to SROIs will be a central activity in the exploration of Mars from any Landing Site. Dual or multiple pressurized rovers working in tandem are essential to this activity, for both short-range traverses located well within the primary 100 km-radius EZ and long-range traverses extending well beyond. The actual configuration of an accessible EZ around a LS is in practice more complex than a circular access perimeter, depending in particular on terrain and topography [6]. Also, when planning traverses, *distance* to a SROI is not the only critical factor; *traverse time* is also key. Once a well trodden path has been established, traverses to even the far reaches of an EZ may become relatively rapid. Conversely, over challenging or unknown terrain, even nearby sites might take a long time to reach. The Haughton-Mars Project's Northwest Passage Drive Expedition completed a 500 km vehicular traverse over uncharted, unprepared terrain (sea-ice) in 1 week. Although more data from more analog traverses are needed to better understand pressurized rover traverse planning and implementation, this early experience suggests SROIs at ranges of 500 km, 1000 km, and 2000 km could be visited within 2-week, 4-week, and 8-week roundtrips, resp., which is plausible with adequate caching of supplies along known routes.

Traverse Planning Software Tools: In this study, we planned several concept vehicular traverses from Noctis Landing to various SROIs within the primary EZ and well beyond. Focus was placed on identifying traverse routes avoiding terrain and topography that were too rough or too steep based on available orbital imaging. Other aspects of planning a traverse, such as caching supplies, selecting overnight sites, and planning science ops at SROIs were not considered in detail yet. Two primary software tools were used: *Google Mars* and *Mars Trek*.

Google Mars. Google Mars was used mainly for viewing available spacecraft imaging, data organization, delineating exploration zone boundaries, and drawing traverses. This program allowed the user to set labeled or color coded location pins and paths. The projection and registration of spacecraft imagery onto Mars' global map was sufficiently accurate to make identifying which SROIs or RROIs were located along or close to planned traverses, easy.

Mars Trek. The Mars Trek portal provides web-based interactive visualization and analysis tools. Mars Trek has multiple layers of data for the user to view, such as a MRO CTX Mosaic of Noctis Landing, other proposed landing sites and exploration zones, global dust distribution, and global thermal inertia. Each layer had static data available for pinpointing the locations of potential RSL (Recurring Slope Lineae), icy craters, alluvial fans, aqueous minerals, and many more Mars surface features of scientific interest. This portal also allows calculating distances, generating traverse elevation profiles, selecting sun angles, and creating flyover video clips of traverses **(Fig. 2)**.

Figure 2. Conept Traverse Planning: Concept vehicular traverses within and beyond the Noctis Landing Exploration Zone (EZ) were planned in part using *Mars Trek*, a software tool under development at NASA. Shown here is a "pit" stop on the rim of an elongated pit in the southwestern sector of the EZ.

Concept Traverses from Noctis Landing. Concept vehicular traverses were planned from Noctis Landing into Tithonium Chasma and Ius Chasma to the East, and into Noctis Labyrinthus (Dalu Cavus) to the West. Traverses farther west onto Syria Planum, Tharsis Montes, and Olympus Mons **(Fig. 3)**. Elevation changes along traverse paths were also plotted **(Fig. 4).**

Noctis Landing to Tharsis Montes. Traverses to Ascraeus Mons, Pavonis Mons, and Arsia Mons targeted known or candidate lava tubes, skylights, and pit craters. Traverses paths to Ascraeus Mons and Pavonis Mons circumvent Noctis Fossae.

Noctis Landing to Olympus Mons. Traverses to the base of Olympus Mons would reach a range of 2500 km from Noctis Landing. Exploration of such remote sites might be best approached by establishing a local outpost supported remotely from a main base at Noctis Landing.

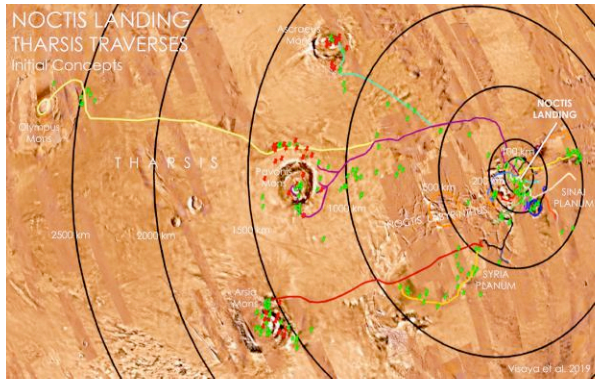

Figure 3. Concept Traverses into Tharsis Region from the Noctis Landing LS/EZ: Traverse paths were mapped in part using the *Google Mars* software tool.

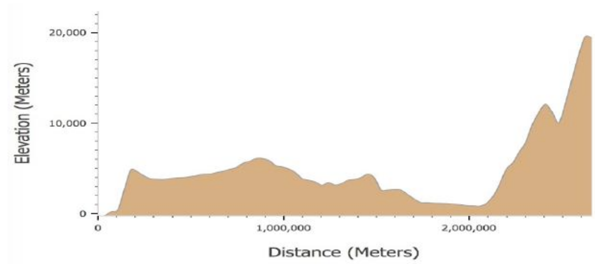

Figure 4. Elevation Profile of a Concept Traverse from Noctis Landing (Left) to Olympus Mons: Vertical scales are exaggerated for visibility. Our preliminary study suggests traverse paths with slopes not exceeding 5^o may be identified.

Future Work: More detailed traverse planning taking into account vehicle autonomy, supplies caching, overnight sites, and science ops at SROIs will be included in next steps.

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