Terrain Safety Assessment Approach for the Mars Science Laboratory Mission

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ABSTRACT

In 2012, the Mars Science Laboratory (MSL) mission will pioneer the next generation of robotic Entry, Descent, and Landing (EDL) systems by delivering the largest and most capable rover to date to the surface of Mars. Four finalist sites are currently under consideration in the landing site selection process and are being evaluated on the basis of scientific merit and engineering safety. Site specific safety assessments require a wealth of site-specific datasets describing the dispersed atmospheric profile that will be traversed during guided entry and parachute descent, as well as detailed terrain data describing surface topography, rock distributions, and mechanical properties of the surface over the entire landing ellipse. This paper contains a brief overview of the atmospheric safety assessment process while focusing primarily on the data, analysis tools, and methodologies in use to assess terrain safety at each of the candidate landing sites.

During EDL, the MSL spacecraft interacts with the Martian terrain in three distinct ways. Firstly, successful EDL is dependent on the performance of the on-board radar altimeter/velocimeter over in situ terrain at distances up to several kilometers removed from the ultimate touchdown location. Features with significant vertical relief across this length scale can induce mission failure, even in the case of a perfectly functioning radar, due the variation between the measured "truth" altitude and the altitude at the location where the vehicle finally touches down. Secondly, the success of the touchdown event itself is dependent on the surface geometry and mechanical properties over rover-sized length scales (~3m). The Skycrane touchdown architecture creates a complex touchdown event where the rover mobility acts as the vehicle's "landing gear." Vehicle load margins, stability margins, and clearances, among other risks, must be assessed relative to the joint combination of rocks, slopes, and soil properties that may be encountered. Finally, during Skycrane and Flyaway, high velocity exhaust plumes emanating from the descent stage engines are impinging on the Martian surface in close proximity to the rover. Direct and indirect plume risks must be considered as a function of local surface terrain. Additionally, the viability of the post-touchdown state as an initial condition for the surface mission phase must be assessed, along with the suitability of the mobility to traverse local terrain en route to the primary science targets.

Clearly, an overall landing site safety assessment is a difficult task which must convolve all of these EDL risks to map MSL EDL performance to both regional and highly localized terrain characteristics. The design and implementation of the MSL terrain assessment strategy is discussed in detail.