Approach Navigation for the 2009 Large Lander

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Extended Abstract

The current plan for the exploration of Mars envisions the launch of a large lander in the 2009 launch opportunity with a soft landing on Mars in the fall of 2010. This lander will include a rover with a range and lifetime at least twice as great as that planned for the 2003 Mars Exploration Rover and a significantly larger science payload. In addition, this lander will be the first use at Mars of a complete closed-loop guidance navigation and control (GN&C) system, including guided entry and targeting capability, to greatly reduce targeting errors during the entry descent and landing (EDL) phase. The goal is to achieve a landed surface position within $10km$ of the target landing site.

The challenge for approach navigation is clear. Current EDL analysis shows that the largest contributor to the landed position error is uncertainty of the initial conditions. The initial states and errors are supplied by the ground-based navigation process, which determines the spacecraft position and velocity along with the error at a defined Mars entry interface point and supplies that data to the spacecraft before atmospheric entry.

Although the science payload and the desired landing site have not been determined, the project goal is to design an EDL system that can access as much of the Martian surface as possible. The goal is for a system that can be reused for future landers including a possible Mars sample return mission. The scenario used for this study pushes the limits on the accessible locations by choosing a landing site and conditions that are unfavorable to the landing system. The resulting landing location, the "EDL Challenge Site," includes in a single scenario a high-altitude landing site, an atmospheric density at the landing site at a seasonal minimum (which reduces parachute performance), and an entry target that has the most challenging geometry relative to entry flight path angle error. These conditions represent the upper limits of the requirements for the EDL system design.

The focus of this paper is the performance of the approach navigation process. Data are available from several sources. Two-way range and Doppler (range-rate) data are available via the Deep Space network (DSN). Other DSN data includes double-differenced one-way range (ΔDOR) measurements collected along two proposed baselines. Along with these data, an optical navigation camera will be included on the spacecraft, with optical navigation data available for the approach navigation process during the last 15 days of cruise. These data are all processed together on the ground to determine the initial position and velocity for the onboard EDL software.

Approach navigation results for the design of a final course correction maneuver 24 hours before entry will be presented, along with the corresponding knowledge uncertainties used to initialize the onboard systems. Results for several combinations of data types will be included.

Short Abstract

The current Mars exploration plan envisions the launch of a large lander in the 2009 launch opportunity with a soft landing on Mars in the fall of 2010. The goal is to achieve a landed surface position within $10km$ of the target landing site. Current entry descent and landing (EDL) analysis shows that the largest contributor to the landed position error is uncertainty of the initial conditions, which are supplied by the ground-based navigation process. The focus of this paper is the performance of the approach navigation process using combinations of Deep Space Network (DSN) Doppler, ranging and double-differenced one-way range (ΔDOR) measurements along with optical navigation data collected by the spacecraft. Results for several combinations of data types will be included.