NAVIGATION FOR THE MARS PREMIER NETLANDER DELIVERY

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EXTENDED ABSTRACT

The PREMIER Program initiated by CNES in 1999 aims at sending several vehicles to Mars in the framework of international cooperation with NASA and other agencies, yielding the first Mars Sample Return (MSR) mission within the next decade. The main objectives of this mission are :

- to deliver 4 Netlander probes of about 75 kg each designed for seismology, meteorology and geophysical investigations of Mars to the Martian surface,
- to provide a telecom relay capability to these landers during their lifetime,
- to demonstrate key technological capabilities (remote rendezvous & capture) in preparation for the MSR mission.

From a navigation point of view, the Netlander deployment sequence is a critical phase of the mission. As the Netlanders do not have any deltaV capability, each probe is delivered by the Orbiter directly on its entry trajectory. This means that all the Netlander approach maneuvers (the main targeting maneuvers toward the desired aim points and the trim maneuvers to correct the targeting maneuver errors) are performed by the Orbiter before the Netlander release.

The navigation challenge of this deployment is due to the entry accuracy requirement for each Netlander, which have to target precise sites on Martian surface within a +/- 3° (3σ) entry corridor with only 4 days of tracking available between two successive Netlander releases. Moreover, unlike the Orbiter, whose physical characteristics can be estimated during the cruise phase, the Netlander behavior with respect to solar radiation pressure and non-gravitational accelerations is very difficult to estimate and will lead to great uncertainties.

In order to assess the delivery accuracy of the Netlanders and the Orbiter, a covariance analysis of this deployment sequence has been performed using conservative maneuver execution error assumptions. The baseline for this study considers range and Doppler measurements through DSN facilities. The main objectives of this analysis were:

- to check the feasibility of this phase with only Range and Doppler data, and to evaluate the improvement of navigation performances due to additional doubly-differenced one-way range (DDOR) measurements,
- to estimate the robustness of navigation performance with respect to error sources.

To meet these objectives, some sensitivity analyses have been done jointly by CNES and JPL concerning the impact of DDOR schedule, the influence of ground station tracking coverage, maneuver execution errors, dynamic stochastic accelerations, and other error sources. Results from JPL and CNES covariance analysis tools have been compared and combined to evaluate the robustness of the Netlander delivery navigation performance.

A propulsive maneuver analysis using orbit determination results and Monte-Carlo simulations to compute statistical maneuvers have also been performed to assess navigation performance corresponding to expected maneuver execution errors assumptions.

Conclusions on the robustness of navigation performance and on navigation needs (DDOR, tracking coverage, ...) with respect to the Netlander entry accuracy can be drawn based on this analysis. These results will have to be consolidated using more realistic dynamical models for the Netlander (reflectivity properties, non gravitational acceleration characteristics...). A complete navigation study of the Earth to Mars cruise will also be performed to initiate the approach study with realistic a priori knowledge on the Orbiter position and velocity. Future studies are planned in the framework of a CNES-JPL collaboration on navigation issues in order to refine these results.

CONDENSED ABSTRACT

One challenging phase of the MARS PREMIER mission is the release of four Netlanders to the Martian soil. From a navigation point of view, this deployment requires a high accuracy level for the Netlander trajectory entry, which is difficult to obtain with only radio data. This paper presents covariance and propulsive maneuver analyses performed to determine the impact on navigation performance of parameters such as the addition of DDOR measurements, tracking data schedule, and maneuver execution errors. Conclusions are drawn on navigation needs and an assessment is made of the robustness of navigation performance for the Netlander deployment phase.