PRELIMINARY EVALUATION OF EARTH-MOON LIBRATION POINT ORBIT NAVIGATION WITH POST-PROCESSED ARTEMIS DATA

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ABSTRACT

The ARTEMIS mission was the first to navigate a spacecraft and perform stationkeeping maneuvers in the Earth-Moon L_1 and L_2 Lagrange points [1,2]. The ARTEMIS operations team successfully navigated the two spacecraft with uncertainties on the order of 0.1 km in position and 0.1 cm/s in velocity [3]. The ARTEMIS team used the Goddard Trajectory Determination System (GTDS) to process range and Doppler measurements from the Deep Space Network (DSN), Berkeley Ground Station (BGS), Merritt Island station (MILA), and the United Space Network (USN). GTDS utilizes a batch least squares estimator with high-fidelity force modeling. The operations team generally estimated the spacecraft's position, velocity, and solar radiation pressure reflectivity coefficient (C_R) [3].

Operationally, orbit determination with GTDS was reinitialized after the execution of every maneuver and no maneuvers were estimated using GTDS. This inherently introduces limitations to the batch least squares method by requiring several days of tracking data before a converged consistent solution can be obtained. Due to the instability of trajectories in the Earth-Moon three-body system, data arcs of approximately ten days are required for optimal orbit determination [3]. Station keeping maneuvers for the ARTEMIS mission were generally performed every 7 days [4]. The ability to estimate maneuvers over a data arc is necessary in order to correctly evaluate the performance of the orbit determination solution.

The work presented in this paper will explore the use of a sequential data processing navigation tool developed at JPL known as MONTE for use in post-processing raw ARTEMIS tracking data. A sequential data processor allows for a more flexible dynamical model when compared to a batch least squares in order to more accurately estimate stationkeeping maneuvers and variations in solar radiation pressure. This work will analyze MONTE's ability to accurately estimate the spacecraft's state, C_R, and stochastic accelerations.

Looking at very specific segments of the ARTEMIS operational orbit data, MONTE will be used

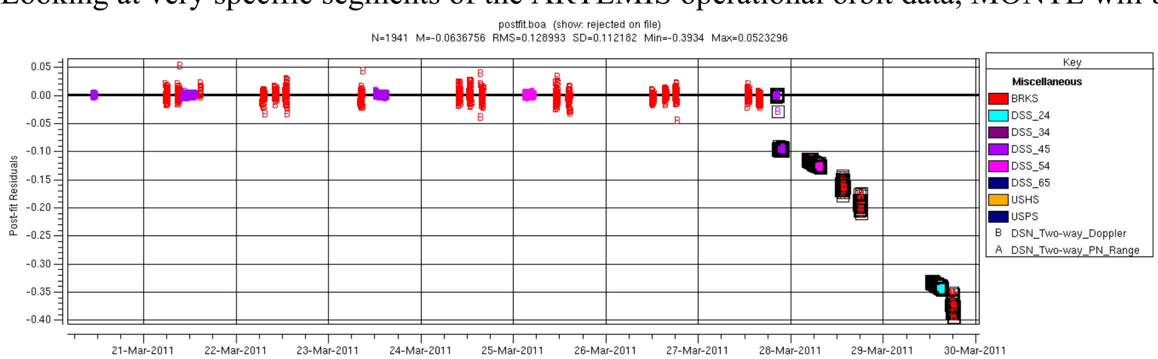

Figure 1. ARTEMIS maneuver passthru

to post-process observations specifically to evaluate the efficacy of tracking geometry using an overlap analysis. This analysis will be conducted over several data arcs to show an improvement in orbit consistency and reduction in uncertainty. This set-up will also enable the estimation of maneuvers and subsequent comparison between estimates and uploaded commands.

Figure 1 shows the post-fit Doppler residuals for a data arc from 20-MAR-2013 to 1-APR-2013. This data arc encompasses the maneuver SKM22. After the maneuver execution on 27-MAR-2013 at about 20:00:00 UTC, a passthru of the Doppler residuals clearly shows the maneuver. Operational navigation was unable to process data over a maneuver and would have needed to reinitialize their orbit determination process just after the maneuver. Using MONTE, one can estimate a finite burn or impulsive delta-v and filter over a maneuver.

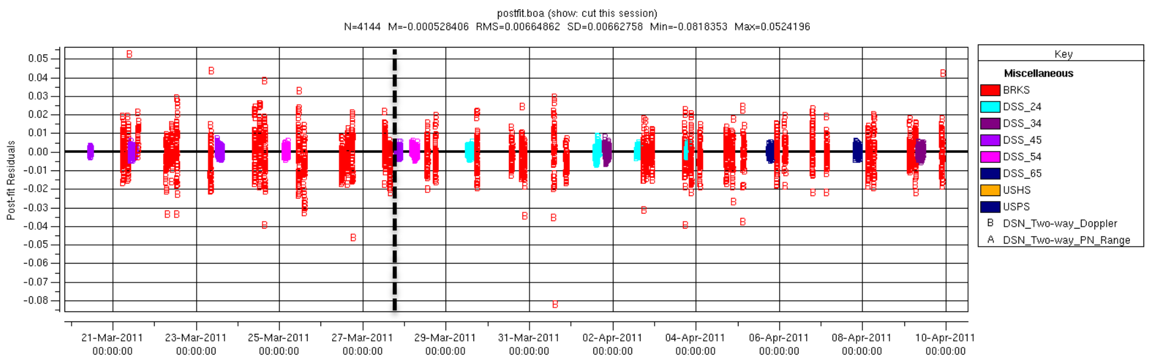

Figure 2. ARTEMIS post-fit residuals while estimating a maneuver.

Figure 2 shows the post-fit Doppler residuals for the same initial epoch while filtering over and estimating an impulsive maneuver for SKM22. Initial results show that MONTE is able to estimate both the magnitude, direction, and time of the maneuver accurately with little or no initial knowledge of the maneuver itself.

The ultimate objectives of this work are to improve the solutions available for Earth-Moon libration point orbits while identifying operational factors to improve future mission utility.

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