Paper ID: 80188
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IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advances in Space-based Navigation Systems, Services, and Applications (7)

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A TRACKING SOLUTION VIA A NETWORK OF BEACONS ON THE SURFACE OF MARS USING THE TUMBLEWEED MOBILE IMPACTORS

Abstract

Tracking solutions for satellites orbiting Mars rely almost entirely on stations located on Earth. This kind of tracking service requires scarce and costly communication resources. Furthermore, the service is subject to significant downtime due to occultations produced by Mars itself or third bodies such as the Sun. The use of powerful antennae on both ends is required, making deep space exploration inaccessible. Moreover, the loss of contact produced by an occultation leads to a loss of service. As a result, a prolonged isolation of spacecraft negatively influences its location estimation and scientific data.

We propose an alternative tracking service for ongoing and future missions on Mars that enables democratized access to deep space exploration. This service, unlike current solutions, would be delivered from Mars itself, relieving the demand for bandwidth from services such as DSN, and providing service during solar conjunction and other events. We show that the tracking functionalities for Mars missions can, at least partially, be transported to the 'red planet', thus achieving a more efficient usage of the scarce resources. The envisioned infrastructure consists of a network of 50 to 100 beacons to provide tracking services to Mars orbiters. These beacons will be distributed on the Martian surface by a swarm of decentralized wind-driven mobile impactors - the Tumbleweed Mission.

In this paper, we show that the proposed system would provide a valid level of accuracy for orbiters around Mars. Simulations are done using open-source orbit estimation software - TU Delft Astrodynamics Toolbox (Tudat). After setting the basic environment, relevant planetary bodies are added as well as a spacecraft to represent the target of our tracking. A trade-off is performed between the number and distribution of beacons, the properties of the instrument (power, frequency, and antenna), and the precision and accuracy obtained, considering the Tumbleweed Science Mission. A comprehensive model for the state-of-the-art tracking methods for Mars orbiters, as well as the proposed network of beacons, are developed and implemented in Tudat. The performance of each beacon can be studied under different circumstances. We validate the methodology by comparing the simulation results with a TU Delft-developed and operated Doppler tracking station, DopTrack. We also study the most desirable influential noise sources for such a tracking network of beacons. This in-house end-to-end experiment allows us to determine the overall usefulness of a Martian tracking system of the future.