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PERFORMANCE ANALYSIS OF A MARTIAN POLAR NAVIGATION SYSTEM

Abstract

Deciphering the genesis and evolution of the Martian polar caps can provide critical understanding of the climate system of Mars and allow us to apply the lesson learned about planetary climate change on other terrestrial planets. In this work, we present a novel mission concept that can support autonomous navigation of rovers devoted to scientific investigations of these regions. We propose and analyse a constellation of 5 small satellites with coverage over Mars polar regions, focusing on the positioning performance that can be obtained. Ground support can be heavily reduced by employing an inter-satellite link (ISL) communication architecture. Moreover, this concept may provide excellent range rate accuracies in the ISL via the implementation of radio link architectures able to suppress the adverse effects of on board clock instabilities. The constellation would use 5 satellites deployed on three quasi-circular high-altitude polar orbits. The configuration is composed by a main spacecraft in polar orbit and four spacecraft symmetrically located on the two inclined orbits. The periodical synchronisation of the constellation clocks is granted by the main spacecraft, the only element of the constellation communicating with Earth. We describe the overall architecture of the constellation and report on the results of our numerical simulations in different operative scenarios. We show that excellent orbital accuracies can be obtained for the whole constellation using a batch-sequential filter that can be easily implemented on board, thus enabling a high degree of navigational autonomy. Furthermore, we analyse the effects of non-gravitational accelerations acting on the satellites and their modelling (based on the SmallSats design being developed in Argotec for Mars/Moon constellations), and assess their effects against the on board limited computational resources. Another crucial aspect that has been investigated is the optimal arc length of the batch sequential filter, as a trade-off between the degradation of accuracy in the dispatched ephemerides and the accuracy in the dynamical model. The assessment of the achievable positioning accuracy is also fundamental to evaluate the feasibility of a future positioning system providing a global coverage of the planet.