IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Space-based PNT (Position, Navigation, Timing) Architectures, Applications, and Services (1)

Author: Mr. Floor Thomas Melman
European Space Agency (ESA-ESTEC), The Netherlands, Floor.Melman@ext.esa.int

Mr. Yoann Audet
European Space Agency (ESA-ESTEC), The Netherlands, Yoann.Audet@esa.int
Dr. Serena Molli
European Space Agency (ESA-ESOC), Germany, Serena.Molli@esa.int
Mr. Richard Swinden
ESA, The Netherlands, Richard.Swinden@esa.int
Dr. Claire Parfitt
European Space Agency (ESA-ESTEC), The Netherlands, Claire.Parfitt@esa.int
Mr. David Brandão
European Space Agency (ESA-ESTEC), The Netherlands, David.Brandao@ext.esa.int
Mr. Alex Rosenbaum
European Space Agency (ESA-ESTEC), The Netherlands, Alex.Rosenbaum@ext.esa.int
Mr. Javier Ventura-Traveset
European Space Agency (ESA), France, javier.ventura-traveset@esa.int
Mr. Alvaro Martinez Barrio
European Space Agency (ESA), The Netherlands, Alvaro.Martinez.Barrio@esa.int
Mr. Vicente Lucas Sabola
European Space Agency - ESTEC, The Netherlands, Vicente.LucasSabola@ext.esa.int

MARTIAN NAVIGATION EXPLOITING THE MARCONI NAVIGATION SERVICES

Abstract

With the current European Mars relay orbiters retiring in the next decade, the European Space Agency studied a concept for a future MARs COmmunication and Navigation Infrastructure (MARCONI) service, where the MARCONI payload will be hosted on a network of satellites. Leveraging the current development of the lunar communication and navigation services (i.e., Moonlight), such an infrastructure would provide two-way ranging signals (like the ranging techniques used for deep space navigation) and one-way (Global Navigation Satellite System (GNSS) like) ranging signals. One of the advantages of one-way ranging is that the user does not need to establish a peer-to-peer link with a MARCONI node and as such the system is scalable to any number of simultaneous users and available if the satellites are in visibility. However, such measurements are impacted by the user clock, meaning a set of 4 nodes is normally required to estimate position (3D position and user clock). This service could provide an improvement in positioning performances for the full plethora of Martian users, from surface rovers, landers (transfer, entry, descent, and landing) to orbiters.

Contrary to Earth GNSS, such a system would have a constellation that is much smaller and initially, as little as one node could be orbiting Mars. Therefore, innovative positioning algorithms are required for Martian users using MARCONI.

Within this work, different techniques that are developed are presented including the attainable positioning accuracies. To alleviate the receiver from having to estimate the user clock, a technique was proposed that combines one-way and two-way ranging measurements with respect to the same satellite.

Due to the two-way nature, such measurements are not impacted by the user clock and therefore represent the geometrical two-way range (plus residual hardware biases left after calibration). Therefore, when such measurements are combined, it offers the receiver a way to decorrelate the user clock from the one-way measurements.

A surface user, that would combine this technique with the exploitation of digital elevation models (DEM's) to vertically constrain the altitude, would be able to position itself globally within an accuracy of 15 meters with just 2 satellites. For a lander, sub-100 meter navigation accuracies (noting that the final landing accuracy will be a function of this combined with the guidance system performance) are expected using an accurate inertial measurement unit and an altimeter. For Martian orbiters that employ a reduced dynamical model, accuracies of 80 meters or less could be expected.