Paper ID: 21217
student

SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Mobile Satellite Communications and Navigation Technology (7)

Author: Mr. liu peng
Nanjing University, China

Mr. zhengtao Zhang
China
Dr. Hou Xiyun
Nanjing University, China
Dr. Jingshi Tang
Nanjing University, China
Prof. lin Liu
Nanjing University, China

EXPLORATION OF MARS USING DELTA DIFFERENTIAL ONE-WAY RANGING BASED ON TRIANGLE LIBRATION POINTS IN THE EARTH-MOON SYSTEM

Abstract

Very Long Baseline Interferometry (VLBI) is a technique that allows determination of angular position for distant radio sources by measuring the geometric time delay between received radio signals at two geographically separated stations. An application of VLBI is spacecraft navigation in space missions where delay measurements of a spacecraft radio signal are compared against similar delay measurements of angularly nearby quasar radio signals. In the case where the spacecraft measurements are obtained from the phases of tones emitted from the spacecraft, first detected separately at each station, and then differenced, this application of VLBI is known as Delta Differential One-Way Ranging (Delta-DOR). Even though data acquisition and processing are not identical for the spacecraft and quasar, they have similar information content and similar sensitivity to sources of error. Consequently, the Delta-DOR can be used in conjunction with Doppler and ranging data to improve spacecraft navigation by more efficiently determining spacecraft angular position in the plane-of-sky.

Over the decades, human exploration of Mars have never been stopped. As we know, Delta-DOR began to serve its purpose for Mars Odyssey spacecraft in 2001. In the following years, Delta-DOR was used from Mars Exploration Rover (MER) in 2003-2004 to Mars Science Laboratory (MSL) in 2011, all with excellent results. At present, human exploration of Mars using Delta-DOR technique mainly depends on the Earth-based ground stations. As we know, the differential time delay between the spacecraft and quasar is given approximately by $\Delta\tau = -\frac{1}{c} B sin\Theta_1(\Delta\Theta_B)$, the accuracy of the determination of angular separation $\Delta\Theta_B$ improves as the measurement error in the observable $\Delta\tau$ decreases. Further, $\Delta\Theta_B$ accuracy improves as the baseline length B increases. Therefore, the introduction of special libration points, i.e. Triangle Libration Points (TLPs) in the Earth-Moon system, can significantly increase B and improve $\Delta\Theta_B$ accuracy. The baseline length B between LL_4 and LL_5 point is about $7 \times 10^5 km$, it is far greater than that between any stations on the Earth. In addition, TLPs are linearly stable in the Circular Restricted Three-Body Problem (CRTBP). Although they are unstable in the real Earth-Moon system due to the Sun's perturbation. The instability is mild and can be compensated by station-keeping. The current conceptual study will focus on some issues about this application.