Time-transfer experiments between satellite laser ranging ground stations via one-way laser ranging to the Lunar Reconnaissance Orbiter D. Mao[1], X. Sun[2], D. R. Skillman[2], J. F. McGarry[2], E. D. Hoffman[3,4], G. A. Neumann[2], M. H. Torrence[5], D. E. Smith[6], and M. T. Zuber[6], [1]Sigma Space Corporation, Lanham, Maryland, USA (dandan.mao@nasa.gov), [2]Solar System Exploration Division, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA, [3]GFZ German Research Center for Geoscience, Germany, [4]Honeywell Technology Solutions, Inc. (HTSI), Columbia, Maryland, USA, [5]Stinger Ghaffarian Technologies, Greenbelt, Maryland, USA, [6]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA.

Satellite laser ranging (SLR) has long been used to measure the distance from a ground station to an Earth-orbiting satellite in order to determine the spacecraft position in orbit, and to conduct other geodetic measurements such as plate motions. This technique can also be used to transfer time between the station and satellite, and between remote SLR sites, as recently demonstrated by the Time Transfer by Laser Link (T2L2) project by the Centre National d'Etudes Spatiaes (CNES) and Observatorire de la Cote d'Azur (OCA) [1,2] as well as the Laser Time Transfer (LTT) project by the Shanghai Astronomical Observatory[3], where two-way and one-way measurements were obtained at the same time.

Here we report a new technique to transfer time between distant SLR stations via simultaneous one-way laser ranging (LR) to the Lunar Reconnaissance Orbiter (LRO) spacecraft at lunar distance. The major objectives are to establish accurate ground station times and to improve LRO orbit determination via these measurements. The results of these simultaneous LR measurements are used to compare the SLR station times or transfer time from one to the other using times-of-flight estimated from conventional radio frequency tracking of LRO. The accuracy of the time transfer depends only on the difference of the times-of-flight from each ground station to the spacecraft, and is expected to be at sub-nano second level.

The technique has been validated by both a ground-based experiment and an experiment that utilized LRO. Here we present the results to show that sub-nanosecond precision and accuracy are achievable. Both experiments were carried out between the primary LRO-LR station, The Next Generation Satellite Laser Ranging (NGSLR) station, and its nearby station, Mobile Laser System (MOBLAS-7), both at Greenbelt, Maryland. The laser transmit time from both stations were recorded by the same event timer referenced to a Hydrogen maser. The results have been compared to data from a common All-View GPS, and showed < 1 nanosecond precision and accuracy over 6 months.

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