Application of one-way laser ranging data to LRO into orbit determination. S. Bauer[1], D. Dirkx[2], H. Hussmann[1], J. Oberst[1,3], D. Mao[4], G.A. Neumann[5], E. Mazarico[6], M.H. Torrence[7], J.F. McGarry[5], D.E. Smith[6], M.T. Zuber[6]. [1]DLR Berlin Germany, sven.bauer@dlr.de, [2]TU Delft, Netherlands,[3]TU Berlin, Germany, [4]Sigma Space Corporation, Lanham, MD USA, [5]NASA Goddard Space Flight Center, Greenbelt, MD USA, [6]MIT, Cambride, MA USA, [7]SGT Inc, Greenbelt, MD USA.

Introduction: The one-way LR (Laser Ranging) experiment provides high-accuracy range measurements over lunar distances between ILRS (International Laser Ranging Service) ground stations and the LOLA (Lunar Orbiter Laser Altimeter) instrument onboard NASA's LRO (Lunar Reconnaissance Orbiter). Unlike ranging experiments to reflectors or transponders, LR to LRO is a one-way measurement (Figure 1). A ground station fires a laser pulse to LRO at a certain time and the received pulse is time stamped by the satellite. An optical receiver is attached to LRO's HGA (High Gain Antenna), which is always pointed towards Earth, and incoming Laser pulses are transmitted into the LOLA laser detector by a fiber optic cable. This permits ranging measurements to LRO simultaneously while LOLA is ranging to the lunar surface [1].

By calculating the light travel time between the ground station and the satellite, a high precision range measurement with a typical RMS of 10 to 30 cm is derived for this experiment [3]. Currently the OD (Orbit Determination) for LRO is based on traditional radio tracking as well as altimetric crossover data. The computed orbits are provided in the form of the LRO SPK's (Spacecraft Positioning Kernels) with an accuracy of ≈ 14 m in total spacecraft positioning [2]. This, as well as the quality of the Lunar remote sensing data products, is expected to improve with a successful incorporation of the LR data to the LRO nominal navigation data [1].

Status: For the application of the LR data into OD we formed Normal Points from the data we previously processed at DLR Berlin [4]. Those Normal Points were used for the estimation of the LRO initial state and clock as well as ground station clock parameters within the software Tudat [5]. Because of the one-way setup of the experiment further information is required when only LR data is used within the estimation. This is taken from the LRO SPK in the form of a priori information on the state vector as well as the LRO clock parameters which we derived from our LRO SPK analysis. As we want to develop an optimal one-way LR data application scheme, we did a variation of our orbit determination setup. Therefore we modified the LRO state and clock arc length, the ground station clock approximation order, the lunar gravity field degree and order as well as the a priori information.

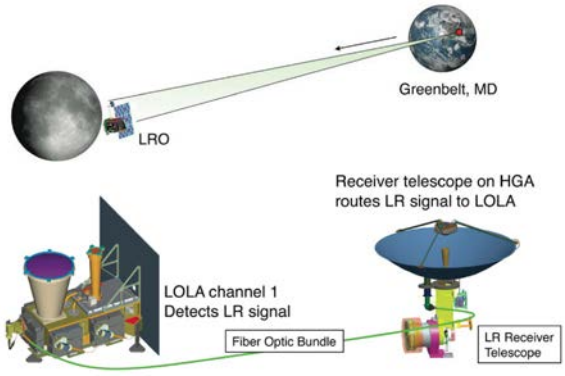

Figure 1: Laser Ranging to LRO - basic principle [1]

The results of the estimation are evaluated by analyzing the trajectory, the measurement RMS, as well as the derived clock parameters and their variation. In addition, the differences to the corresponding results derived from the LRO SPK analysis are used to ascertain the quality of the estimation results.

With the development of an optimal approach for the application of the one-way data, we intend to utilize the precise LR measurements for the LRO positioning improvement.

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