Laser Communications Relay Demonstration Optimetrics Experiment

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Within this paper, we report on an Optimetrics experiment conducted on the National Aeronautics and Space Administration (NASA) Laser Communication Relay Demonstration (LCRD). The high precision two-way ranging is conducted on the optical communications link between the LCRD space terminal in a geosynchronous orbit and the Optical Ground Station 1 (OGS1) at Table Mountain, California, and is referred to as optimetrics ranging.

The receiver to transmitter clock loopback is implemented in the LCRD space modem. A digital dual mixer time difference phase meter (DDMTD) is implemented in the OGS1 ground modem. The round-trip light time is measured with the DDMTD by counting the frame and data clock ticks between transmitter and receiver frame synchronization markers for coarse range, and the relative phase of the transmit and receive clock for high precision range. This approach provides coverage for all potential ranges with no ranging ambiguity. The flight modem FPGA code was modified for frame and data clock loopback and the OGS1 FPGA code was modified for the DDMTD phase meter implementation.

The experiment team conducted a 36-hour continuous ranging measurement. Preliminary two-way optimetrics ranging data show a noise floor of 3cm (rms). Based on our theoretical noise analysis and on ground tests with spare flight modems, we expected one order of magnitude higher ranging precision. We are conducting the detailed post data processing to identify the differences to further reduce the noise level and are formulating an improved implementation approach for the future missions.

For reference and comparison, the traditional Radio Frequency (RF) ranging between LCRD and OGS1 was conducted at the same time, and indicates a ranging noise floor of 30cm(rms). Other telemetry and relevant environmental parameters, such as weather and atmosphere temperature were also collected for the offline data processing.

The high precision range and range rate measurements from the laser communications data link clock and clock phase are performed simultaneously with the continuous optical communication. No extra hardware was added to the existing system. This high precision optimetrics measurement implementation provides alternative ranging and range rate measurements for orbit determination (OD) and flight dynamics calculations with higher precision. We see a significant OD improvement for navigation upon implementation in future optical communication systems.