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METRIC TRACKING SERVICES IN THE ERA OF OPTICAL COMMUNICATIONS

Abstract

The Space Communications and Navigation (SCaN) program, at the National Aeronautics and Space Administration (NASA), is developing optical communications technology to facilitate the next generation of space missions in near-Earth, lunar, and planetary space. Optical communication links can operate at data rates 10x – 100x higher than traditional microwave links, but with smaller terminal size, weight, and power requirements. NASA also relies on microwave communication links to deliver radiometric tracking (range and range-rate/Doppler) observations used for orbit determination of spacecraft and for direct science applications. Optical communications technology offers an unheralded opportunity to generate metric tracking accurate to 10s of nanometers, a 5 order of magnitude improvement over microwave based technologies.

Two sources of observation, the data clock and the optical carrier, are readily available on optical communication links to generate optimetic range and range-rate observations. Theoretical performance of optimetric observations and hardware-in-the-loop test results are presented. Simulation of orbit-determination for LEO and GEO spacecraft relying on optimetric tracking will extend raw observation accuracy to realizable orbit-determination performance. Potential science and operational applications are reviewed, along with NASA's strategic reasoning for developing optimetric technology.

Approaches to adapt current Consultative Committee on Space Data Standards (CCSDS) optical signaling standards to generate unambiguous range observations will be discussed. System and modem implementation approaches will be compared to traditional radiometric observation techniques. Maturity of key hardware components necessary to generate optimetric observation, and technology gaps are identified. Delivery of optimetric tracking data to the mission operations center (MOC) or mission flight platform to enable autonomous navigation are discussed.

Recent optimetric development will be highlighted through a review of the optimetric experiment on the Lunar Laser Communications Demonstration (LLCD) and a planned experiment for the Laser Communications Relay Demonstration (LCRD). Current investments in developing optimetric hardware and plans for NASA's future optical communications network define the path for a future operational optimetric capability in the 2020's and beyond.