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NASA'S INTEROPERABLE SERVICES TO MITIGATE LUNAR POSITION, NAVIGATION, AND TIMING CHALLENGES

Abstract

Across the Earth, both civilian and government endeavors enjoy a built-in reliance on a position, navigation, and timing (PNT) infrastructure to which they are largely blind. Whether walking, driving, flying, or orbiting, Earth-centric PNT systems that have evolved over decades provide a core functionality to which we have grown accustomed for these pursuits. As NASA joins with other government space agencies and commercial partners to return humans to the moon in a sustained manner within the current decade, expectations for PNT knowledge and timeliness at the moon rival those on Earth. The need exists to develop a viable lunar-centric PNT infrastructure to support the planned human and robotic exploits.

Navigating within the influence of the moon presents its own set of challenges. Identification, understanding, and use of a unified reference frame and time system on which navigation is based becomes a fundamental need at the moon. In addition to the unified foundational elements, measurement liability, dynamic conditions that require Earth-independent autonomous operations, and standards for PNT signals and message-based data exchange each represent distinct challenges to navigation in a burgeoning operational Lunar environment.

The PNT services planned as part of the lunar communications and navigation relay architecture known as LunaNet aid in surmounting the challenges. LunaNet interoperability specifications stipulate standards for signal parameters, messages, and lunar reference systems for PNT services. Within LunaNet's defined interoperability resides the concept of a Reference Signal to provide communication signals specifically structured to enable measurement of pseudorange, Doppler, and time transfer by the recipient. One such signal type, the Augmented Forward Signal (AFS), functions as the mainstay for LunaNet PNT, while also serving the data needs for ubiquitous broadcast of network access and rapid unscheduled dissemination of alerts and messages. The presence of a geometrically distributed network of orbiting nodes transmitting the AFS forms the basis for the Lunar Augmented Navigation System (LANS), that delivers both radio navigation and data to multiple users in the lunar environment simultaneously.

After reviewing the challenges associated with lunar navigation, this paper will describe the concepts and rationale behind the LunaNet PNT services. By borrowing techniques from Earth-centric Global Navigation Satellite Services (GNSS), the Tracking and Data Relay Satellite System (TDRSS), and the Consultative Committee for Space Data Standards (CCSDS), PNT from LunaNet aids to overcome challenges faced for accurate lunar navigation.