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Abstract:

Accurate lunar navigation and timing knowledge provides for the development of safety-critical services in the cislunar and lunar surface domain. Currently under development, the Goddard Space Flight Center's (GSFC) Search and Rescue Mission Office is investigating and integrating search and rescue (SAR) capability into planned and future lunar communication and navigation interfaces. Lunar Search and Rescue (LunaSAR) development has a stated end-goal for assured, reliable, and timely indication of distress events for a wide variety of lunar surface users, including government-sponsored, commercial, and international users. LunaSAR performance requirements are modelled after the current terrestrial Cospas-Sarsat distress notification system, leveraging an internationally robust global navigation satellite system (GNSS) ecosystem as a core element of survivor locating capability. This presentation will discuss NASA's work to develop user-focused distress messaging capabilities including infusion of example sensor data for triggering of automated distress alerts coupled with location-tagging. Additionally, the presentation will examine overall message structures, rotating fields for use in bi-directional distress messaging, and specific use cases based on NASA's lunar exploration and lunar communication relay architectures.

Modelling and simulation of LunaSAR use by individual lunar explorers will be discussed, based on notional industry and government design reference missions and mission considerations. Results from GSFC-funded Internal Research and Development (IRAD) efforts will be detailed, including successful distress message formulation simulating the ingestion of example legacy space suit telemetry fields. Hardware-in-the-loop testing using high-reliability software defined radio (SDR) modules serve as an example of IRAD successes and the framework for technical requirements. Architectural development and technical evolution from 2020 to 2021 included alignment of LunaSAR distress waveforms with ongoing NASA LunaNet interoperability development, as well as engagement with NASA Lunar Spectrum authorities for allocation of UHF-band distress frequencies on the lunar surface. S-Band and UHF-band transmission characteristics will be detailed, along with band-specific applications of each emission type. Additionally, examples of ingestion and formatting of GNSS signals (using historical terrestrial National Marine Electronics Association-formatted GNSS data) will be detailed, underscoring lunar user needs for a common lunar GNSS receiver output message framework. Maturity and ability to support evolving lunar exploration goals has been demonstrated and will be detailed, with maturity gaps such as position, navigation, and timing (PNT) and lunar reference frames identified within the context of distress message generation.

Provision of LunaSAR services for lunar surface users represents a new era of ensured safety for lunar explorers and builds off of forty years of the Cospas-Sarsat program, underscoring the importance of lunar GNSS for safety-critical applications and growing interest in safe, reliable lunar surface operations. Enabled by new GNSS systems being developed by government and industry partners, NASA will continue to evolve and integrate lunar GNSS types into distress message generation, with a focus on compact and efficient message transmission over various lunar communication links. When fielded, LunaSAR will be the first dedicated search and rescue notification system employed on another celestial body. Robust lunar navigation and timing services form the core of LunaSAR capabilities, allowing for

system syncing with time-dominant sensors, and high-accuracy location of those in distress while engaged in lunar surface activities.