

LUNASAR

LunaSAR: An Astronaut's Evolving Lifeline

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Topics



[1449 1855 32 742]

- **LunaSAR Basics**
- **Recent Developments / Updates**
- **GNSS-Enabled SAR Today**
- **LunaSAR Distress Message Format**
- **Key Interface Areas w/ Lunar PNT Providers**

LunaSAR Basics

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Bottom Line Up Front

GSFC developing Lunar Search and Rescue (LunaSAR) as an internationally-compatible distress notification and tracking system architecture for use with lunar users exploring the Lunar South Pole and cislunar space

LunaSAR goal is to provide persistent, reliable, and accurate distress notification with both Independent Location (non-PNT) and Encoded Location (PNT-enabled) capabilities

Key element of architecture is use of varied navigation solutions to allow for rebroadcasting of location-tagged distress data and use of nav-service-enabled forward link messaging services (akin to terrestrial return link services) – maximum reuse of terrestrial PNT/SAR methodologies

Key areas for partnering and integration include:

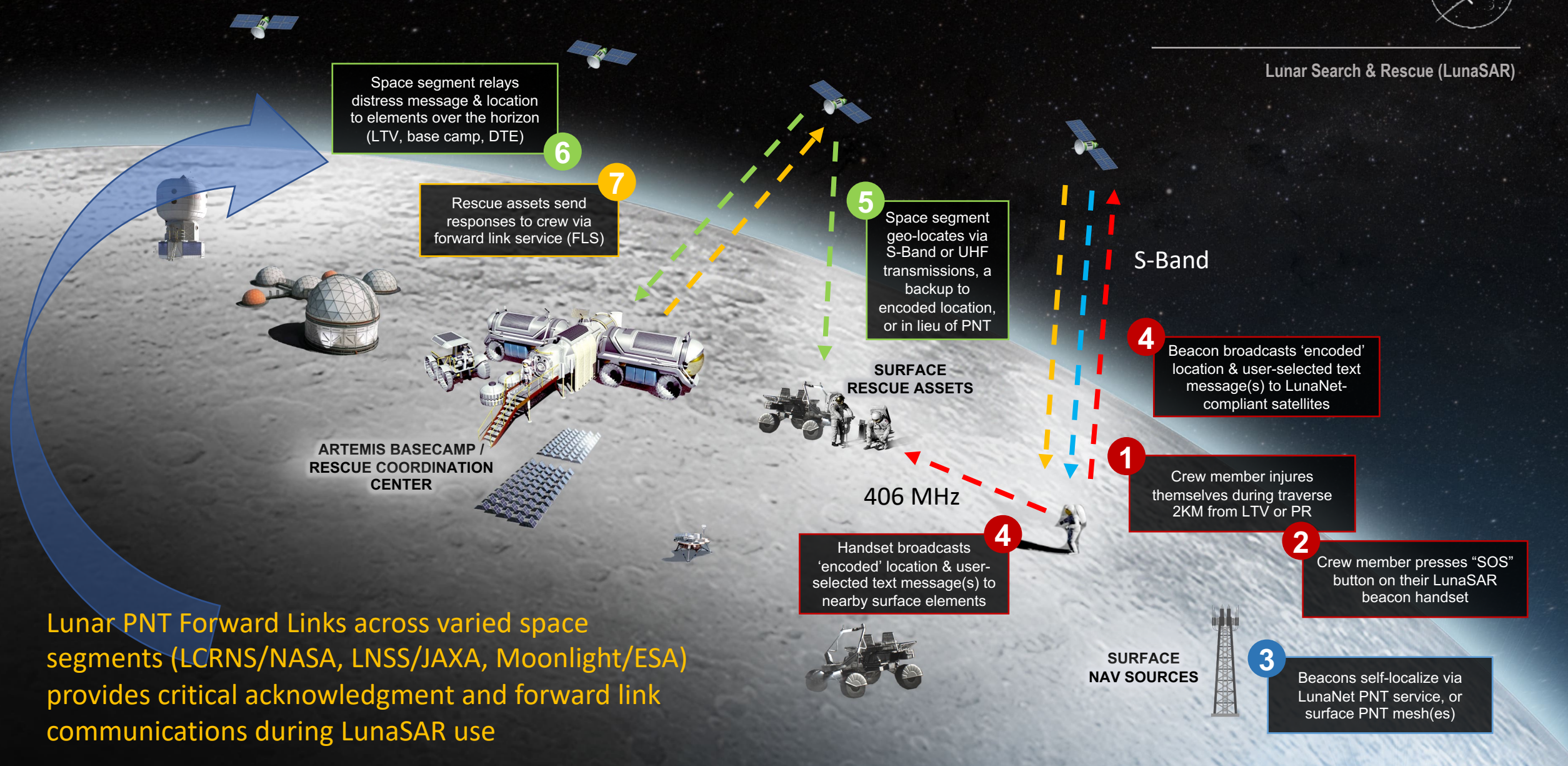
- Distress message contents and standardized preambles
- Nav service forward-link message structures & decoding
- Radiofrequency direction-finding / geolocation of LunaSAR RF signals

Current and future planned Lunar PNT Services are a key element of cost-effective Search and Rescue communications

Fully-Enabled Example – Individual EVA Crewmember



Lunar Search & Rescue (LunaSAR)



Lunar PNT Forward Links across varied space segments (LCRNS/NASA, LNSS/JAXA, Moonlight/ESA) provides critical acknowledgment and forward link communications during LunaSAR use

LunaSAR Recent Accomplishments / Updates



- **Space Frequency Coordination Group Agreements**

- Attained agreement with SFCG to use 2299 MHz for Lunar Search and Rescue distress transmissions moon-wide for operations within and outside the SZM
- Attained agreement within the SFCG held July 2022 to use the 406-406.1 MHz frequency band for LunaSAR services outside of the Shielded Zone of the Moon (SZM)
- **Key steps in regulatory framework for non-terrestrial search and rescue services, opening doors for governmental and commercial engagement for service provisioning**



- **Hardware-in-The-Loop Capabilities Under Evaluation**

- Benchtop & board-level work underway for LunaSAR message formulation and S-Band transmittal using lunar-rated hardware components based on biomedical and lunar rover rollover-triggered events
- End-to-end distress alerting and responses to be evaluated in Lunar Orbiting Signal Testbed (LOST) development environment at the Goddard Spaceflight Center
- **Underscores a phased approach to distress notification services aligned with government and commercial lunar exploration plans**



GNSS-Enabled SAR Today – C/S Two-Way Comms

- **GNSS Enabled SAR – SAR/Galileo**

- SAR/Galileo currently implementing “Return Link Messaging / RLM” enabling two-way communications with Cospas-Sarsat beacons
- Users indicate distress / message their status via Cospas-Sarsat uplink (406 Mhz) and receive acknowledgement via PNT signal downlink
- Specific RLM bits allocated in Galileo PNT Signal-In-Space specifications

- **Parallels to Lunar Search and Rescue**

- Lunar PNT systems developed in compliance with LunaNet Interoperability Specification (LNIS) offer ability to on-ramp PNT signal-in-space enabled forward link messaging for LunaSAR purposes
- Lunar beacons will uplink to PNT satellites at 2299 MHz and receive downlinks on assigned PNT forward signal frequencies
- SAR message acknowledgment and SAR coordination response messages under development within Appendix Document 7 (AD7) under LNIS effort

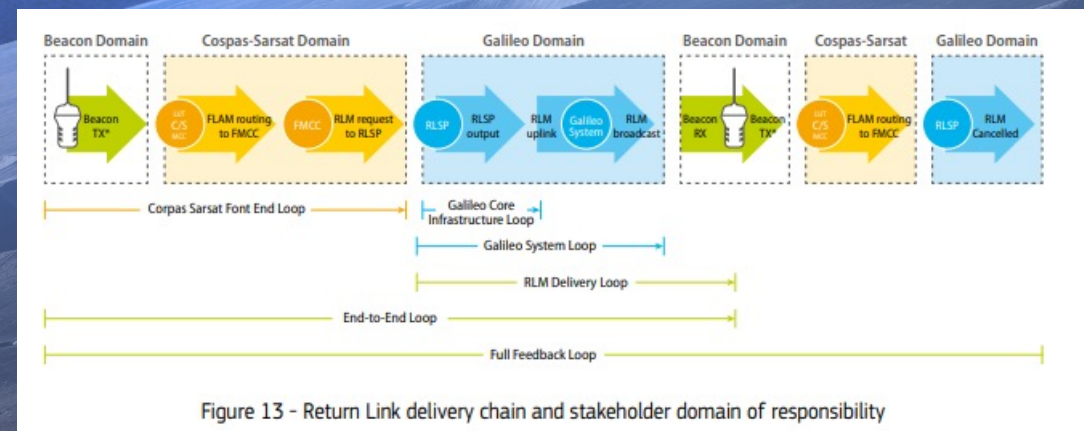
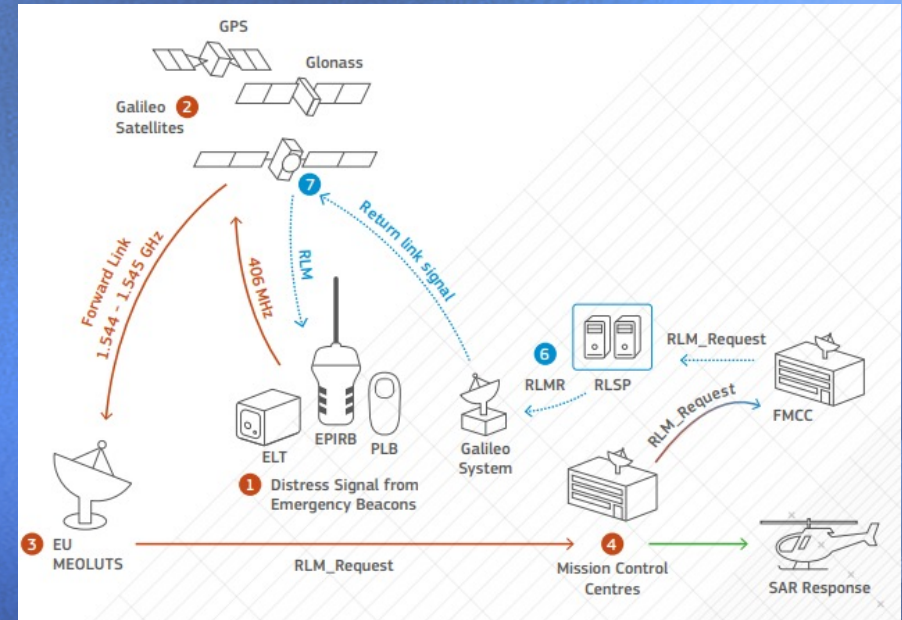


Figure 13 - Return Link delivery chain and stakeholder domain of responsibility

Note: Images from SAR/Galileo Service Definition Document

LunaSAR Distress Message Format

1449 1855 32 742

LunaSAR message format totals approximately ~350 bits including provision for encoding PNT-provided time and location data as well as Rotating Fields

Common Distress Message format allows for international interoperability and partnering

Preamble

Fixed Header
w/ Location, Time, PNT Source, etc

Rotating Field(s)

- Text Messaging
- Telemetry Triggered Msg
- Biomedical Triggered Msg
- Etc....

LunaSAR Message Format modelled after terrestrial Cospas-Sarsat beacon message structures and industry best practices to allow for small message size and ease of implementation across varied service providers

Currently assuming PNT services formatted in NMEA format like current terrestrial GNSS receivers

Key Interface Areas w/ Lunar PNT Providers



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- **Uniform Allocation of Distress Forward Link Bits Among Interoperable PNT Providers**
 - For cross-provider interoperability, standardization of Forward Link Message Content for LunaSAR needs baselining and agreement
 - Current benchtop evaluations assume a NMEA-0183-like message from a Lunar PNT receiver for simplicity
 - LNIS AD7 document details distress message, but Acknowledgement and Forward Link responses currently not-yet defined
 - **Key element for cross-provider services specifically for search and rescue comms**
- **Standardized Distress Message Alert / Response Message Set**
 - Based on Cospas-Sarsat Two Way Communications (TWC) formulation, standardized alert message and response catalog needed for effective distress communications
 - Standardized messages allow for cross-provider integration in a sparse satellite environment and fielding of user terminals compliant across varied PNT space segments akin to current Cospas-Sarsat TWC plans
 - **Message content / mapping is a first step for operationally-relevant LunaSAR capabilities enabled with lunar PNT services**

Return Link Service	Beacon ID		Message Code				Short-RLM Parameters Field																
	60		4				16																
	bit 1	To	Bit 60	Bit 61	Bit 62	Bit 63	Bit 64	Bit 65	Bit 66	Bit 67	Bit 68	Bit 69	Bit 70	Bit 71	Bit 72	Bit 73	Bit 74	Bit 75	Bit 76	Bit 77	Bit 78	Bit 79	Bit 80
Acknowledgment Service Type-1	15 HEX ID		0	0	0	1	1	0	Spares														Parity
Test Service	15 HEX ID		1	1	1	1	Spares														Parity		

Figure 5 - Return Link Message Content

