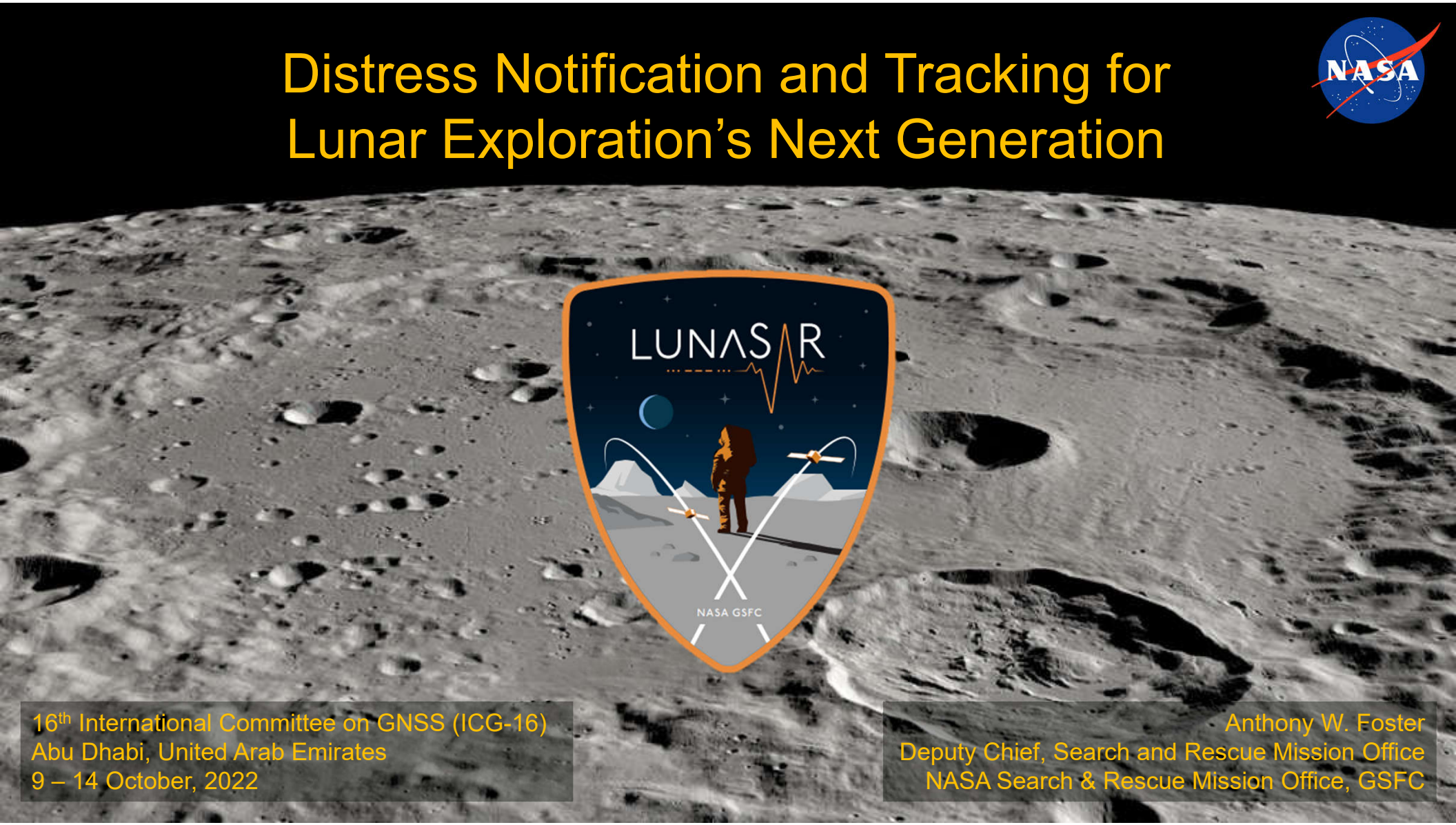
Distress Notification and Tracking for Lunar Exploration's Next Generation



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AN ASTRONAUT'S LUNAR LIFELINE
LUNASAR
Responsive and assured capability for distress tracking and notification serving a growing ecosystem of cislunar users

LunaSAR Basics

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

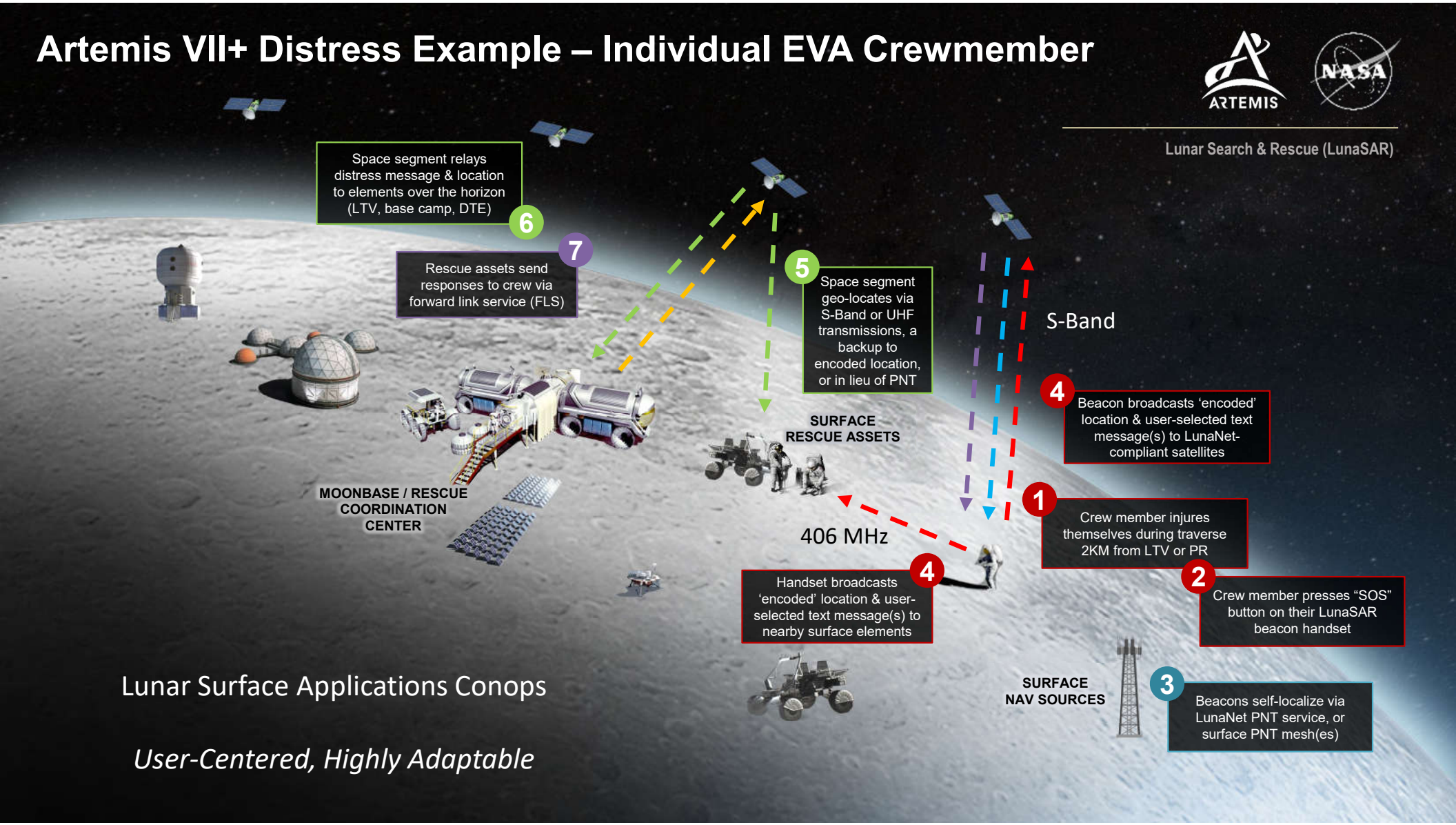
Key element of architecture is use of varied navigation solutions to allow for rebroadcasting of location-tagged distress data and use of nav-service-enabled forward link messaging services (akin to terrestrial return link services)

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

Artemis VII+ Distress Example – Individual EVA Crewmember

Lunar Search & Rescue (LunaSAR)



Lunar Surface Applications Conops

User-Centered, Highly Adaptable

LunaSAR Individual Message Structure

Lunar Search & Rescue (LunaSAR)

LunaSAR Message Format drives message with significant compatibility with existing C/S T.018 test tools and processes

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 coupled with industry best practices to allow for relatively small message size and ease of implementation across varied service providers

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

2021-2022 NASA Effort Progress – Programmatic

- **Space Frequency Coordination Group Agreements**
  - 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)
  - Identifying and studying additional S-band frequency range to support LunaSAR services anywhere on the Moon, between 2200-2290 or 2483.5-2500 MHz
  - Frequency allocations evaluated to allow for both message transmittal and RF geolocation/direction finding on assigned frequency bands
  - **First steps in regulatory framework for non-terrestrial search and rescue services, opening doors for governmental and commercial engagement for service provisioning**

- **Enhanced Operational Capability (EOC) Objectives Matured for LunaSAR**
  - LunaSAR services included in LunaNet Interoperability Spec v4, detailing EOC on-ramping for Artemis-VI+
  - Independent Location accuracies and RF interfaces drafted in Lunar Comm and Nav Services (LCRNS) requirements
  - **Underscores a phased approach to distress notification services aligned with government and commercial lunar exploration plans**

2021-2022 NASA Effort Progress – Technical

- **Distress Message Standardized Header (and Rotating Fields) Drafted & Evaluated**
  - Prototype LunaSAR message header modelled to allow for distress message identification and prioritization
  - Elements of Cospas-Sarsat Second Gen Beacon message features applied to lunar user need cases and optimization for use across proposed lunar communication architectures
  - **Initial steps to standardize distress message contents across varied communication system architectures and open trade space to collaboration with varied ICG partners**

- **LunaSAR Messaging Test Capability Evolved**
  - Successfully matured space-rated software defined radio (SDR) LunaSAR hardware to emulate individual LunaSAR beacons transmitting on SFCG-approved frequencies
  - Successfully emulated basic forward-link messaging* (FLM) concepts based on terrestrial NMEA-0183-like nav message reception and incorporation
  - Successfully matured testing environment for CY23 RF direction-finding / geolocation analysis and testing
  - Identifying technical gaps and message transmit/reception testing needs where ICG partners could contribute
  - **Testing environment evolving to align with NASA and International lunar plans, considering international nature of search and rescue where ICG partners can provide expertise**

* - note, FLM nomenclature is akin to terrestrial “Return Link Messaging”, with differing terminology used in lunar communication documentation compared to Cospas-Sarsat documents

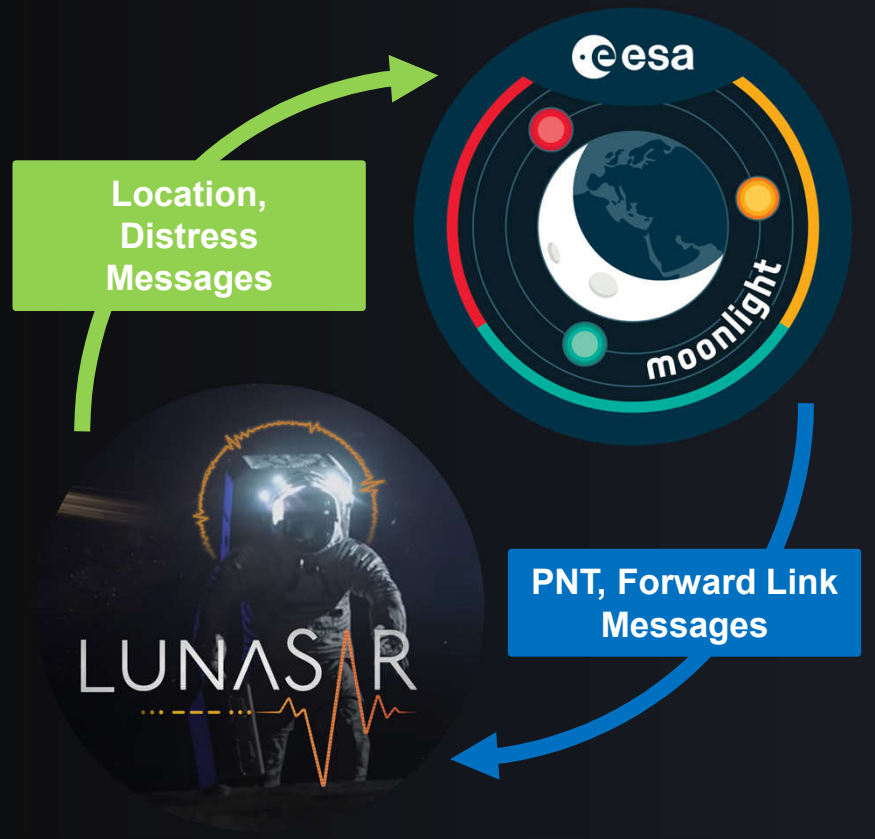
2021-2022 NASA Effort Progress – Programmatic

- **Message Header Collaboration**
  - For LunaSAR to be interoperable and internationally effective, we welcome collaboration in standardization of message header contents and beacon registration management ideas for the 2028 timeframe
  - Want to have commonality of bit allocations and data types for distress message so partner nations can recognize, decode and relay distress messages from any user
  - Expanding, insight and agreement sought on LunaSAR rotating field sizes and bi-directional messaging coordination
- **Nav Receiver Data Specifications for Lunar Applications (with Forward Link Messaging)**
  - While not a SAR-specific need, standardization of lunar nav receiver data formats is a key element of using lunar navigation systems for bi-directional messaging similar to terrestrial Return Link Message (RLM) services
  - Look to coordinate on NMEA-0183 / IEC 61162-1 type documentation as a stepping-stone for industry, governmental and private space collaboration
  - Early efforts to protect for Forward Link Messaging that enables a low-cost assured distress communication path across varied users
- **Radio Frequency Direction-Finding / Geolocation Schema for LunaSAR**
  - Looking to collaborate with ICG partners on Independent Location capability conops and transmit cycles for both surface direction finding (DF) of LunaSAR beacons, and in-orbit geolocation of beacon emitters

International collaboration and cooperation will drive the framework of the AD7 appendix document in the LunaNet Interoperability Specification, and international LunaSAR beacon hardware requirements

Example Opportunities - ESA Moonlight Interoperability Potentials

- LunaSAR architecture and message structure designed from onset to be interoperable with International Partners (i.e. ESA Moonlight, etc)
- LunaSAR development parallels ESA LCNS Capability C3.3 *Search and Rescue* as presented by ESA in Q2 CY21 publications
- LunaSAR interoperability basis detailed in Sept 2022 *LunaNet Interoperability Specification v4*
- Intent is for LunaSAR to be a platform-agnostic approach to distress communications
- **LunaSAR Team highly interested in International Partner developments and interoperability with planned forward link services**



Please Reach Out With Questions & Comments

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