National Aeronautics and Space Administration

MEOSAR & GPS

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Dr. Lisa Mazzuca, Mission Manager
Search and Rescue Office
Goddard Space Flight Center

Overview

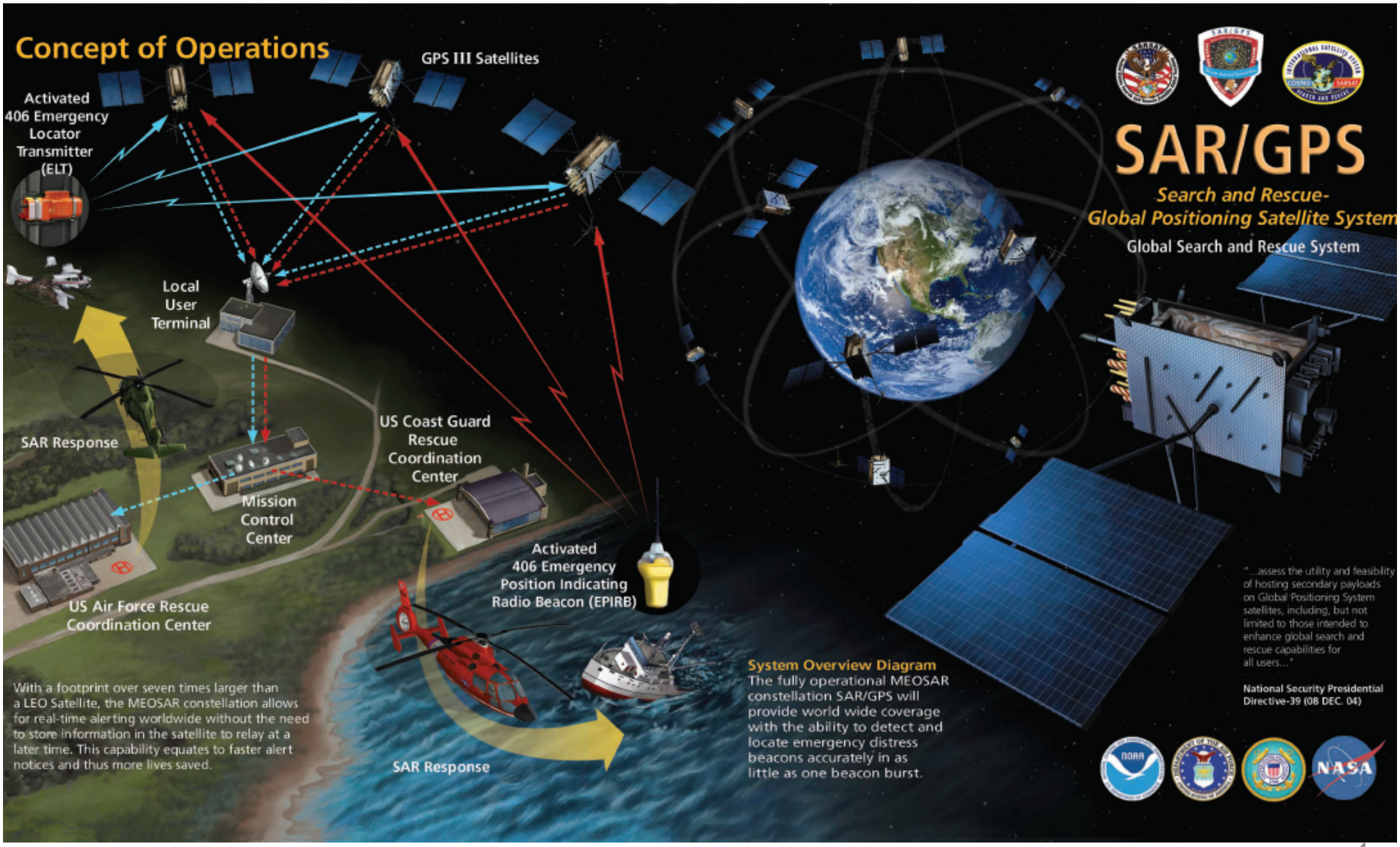
- Cospas-Sarsat System
  - Current operational infrastructure
  - Near-future: GNSS-enabled SAR (MEOSAR)
- MEOSAR implementation timeline
- SAR using
  - GPS
  - Galileo
  - GLONASS
- MEOSAR and Return Link Service (RLS)

Cospas-Sarsat System Overview

- Cospas-Sarsat (C-S) Program uses dedicated Search and Rescue (SAR) payloads onboard satellites to relay beacons signals to ground stations
- C-S system consists of three segments:
  - User Segment – the emergency beacon transmitters
    - Marine: EPIRB (Emergency Position Indicating Radio Beacon)
    - Aviation: ELT (Emergency Locating Transmitter)
    - Land: PLB (Personal Locating Beacon)
  - Space Segment
    - LEOSAR: Low-Earth Orbit - Provides for beacon location using Doppler processing; uses Store & Forward instrument to provide global coverage
    - GEOSAR: Geosynchronous Orbit Performs instantaneous alerting function; no locating capability unless beacon is equipped with GNSS receiver.
    - MEOSAR*: Mid-Earth Orbit (GNSS)
  - Ground Segment – Local User Terminals (LUTs)

* MEO is not yet operational – early operational capability Dec 2015

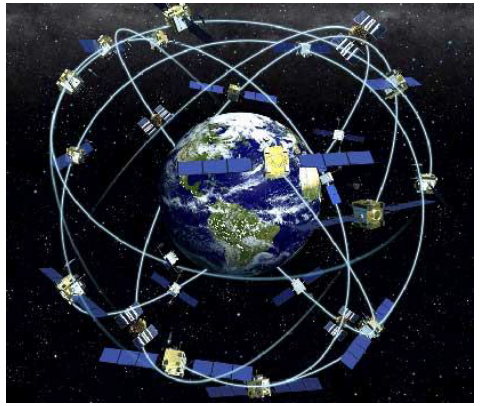
MEOSAR Concept of Operations



MEOSAR

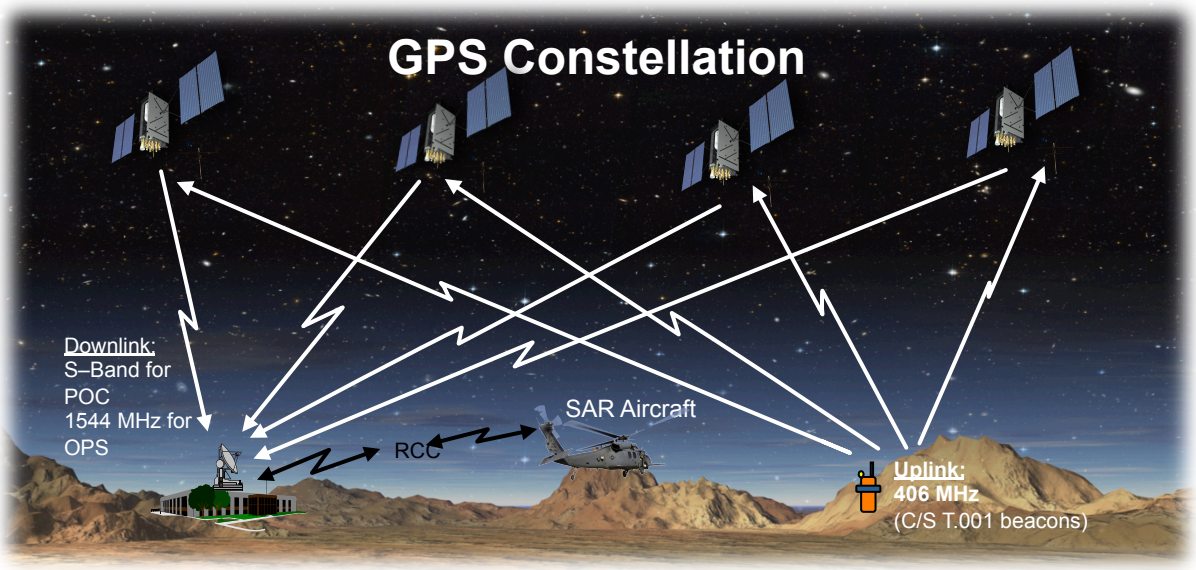
Next generation of satellite-aided SAR

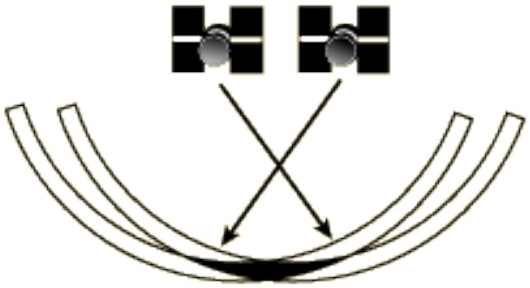
- Based on the use of SAR Repeaters carried on board Global Navigation Satellite System (GNSS) satellites
- GNSS constellations consist of 24 (or more) satellites Mid Earth Orbit (GPS, Galileo, GLONASS)
- Provides
  - Multiple satellites in view of the beacon anywhere in the world at all times
  - Advanced location process using time and frequency measurements of beacon signal to triangulate its location
  - Near instantaneous beacon detection and location, globally, at all times
  - Mitigates terrain blockage due to multiple look angles from multiple moving satellites
  - Robust space segment, well maintained and highly redundant
  - Simple space segment repeater allows for development of higher performance beacon signal



MEOSAR Location Processing

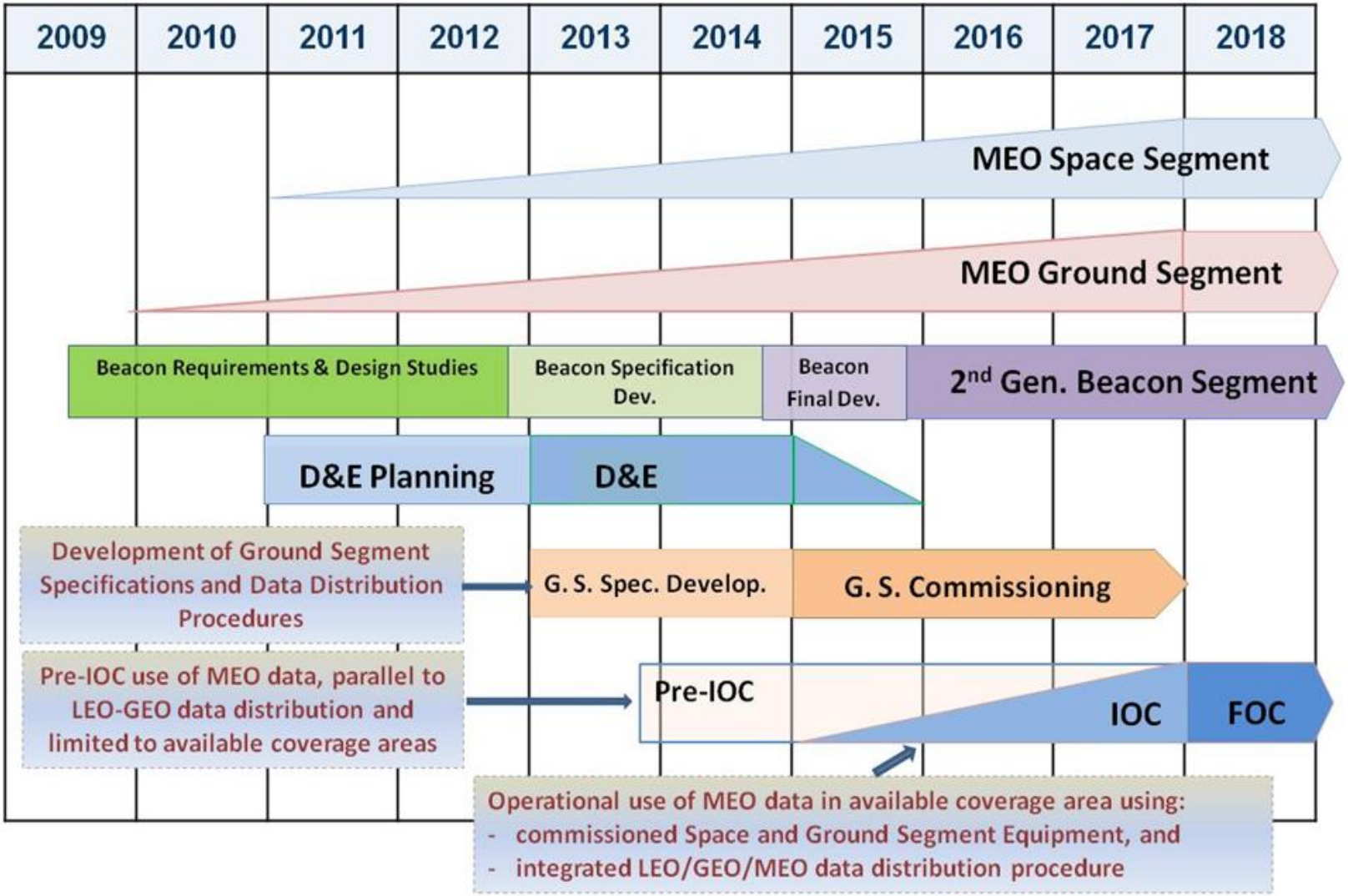
- Like “reverse” GPS
  - Ground Station position is known exactly
  - Positions and velocities of satellites are known (very small error)
- To calculate location of distress beacon, triangulate using time and frequency measurements of beacon signal through at least 3 different MEOSAR satellites





Location in 2D

C-S MEOSAR Timeline



GPS and SAR

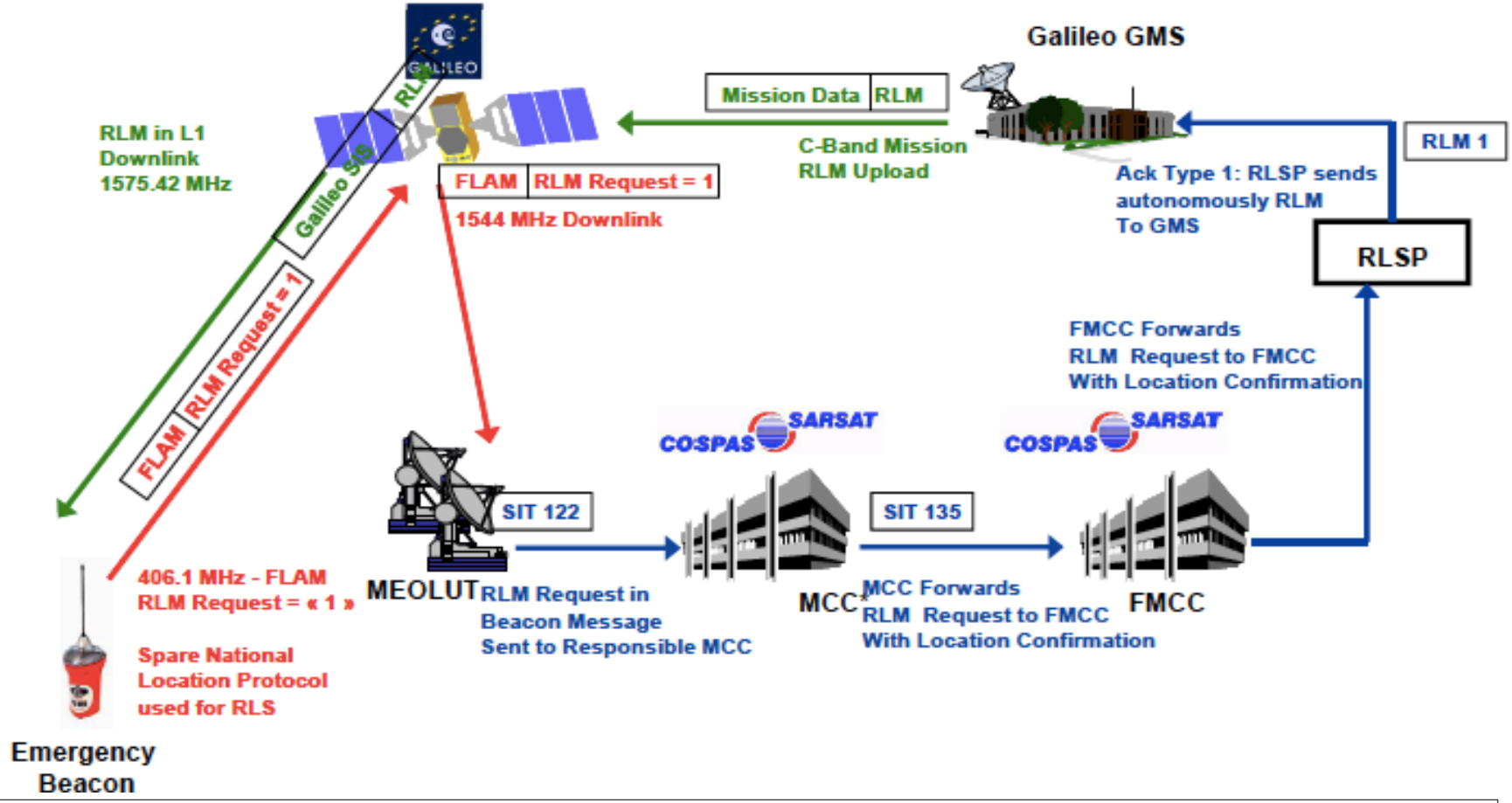
- U.S. SAR Operational Space Segment
  - In 2009 USAF approved request from U.S. civil SAR community to host SAR repeaters on 24 GPS-III satellites
  - Repeater payload will be provided by Canadian government built to C-S specifications including interoperability with Galileo and GLONASS
  - Development underway with first operational payload planned to launch on board GPS III SV-9
    - SAR/GPS PDR – held November 20, 2013

Galileo and SAR

- Galileo – launch of full constellation of a minimum of 24 satellites has begun
  - SAR payloads on Satellites 419 and 420 launched in October 2012 are fully compliant to the C-S technical specifications and commissioned.
  - Two more satellites launched in 2014 but in unintentional eccentric orbit
    - Small (not quantified) performance impact to SAR but fully functional
- Planning to use Return Link Service (RLS)
  - Protocol is now defined as a specific protocol within the C-S Program (use at national level); inclusion of a RLS Functionality on maritime beacons has been accepted by IMO
  - Type-1, called also automatic acknowledgment, where return link message sent automatically when location of alert has been confirmed
- Routing mechanism for RLS implementation also defined
  - Return Link Message to the beacon is carried on the L1 navigation signal.
  - Planned to be tested during the Demonstration & Evaluation Phase

Galileo RLS Protocol

Return Link Acknowledgment Service End-to-End Loop (RLM Type-1)



Message sent by the distress beacon (specific RLS protocol on the 406 MHz uplink signal) to the RLS Provider (RLSP) to indicate it has a Return Link capability

GLONASS and SAR

- One Glonass-KI satellite, launched on 26 February 2011, was successfully tested and is now available for MEOSAR D&E testing.
- Russia plans to launch 5 more Glonass-K1 satellites between 2015 and 2018.
- Planning to implement RLS after 2018

RLS and the USA

- GPS has the capability to implement RLS but not currently in the concept of operations (i.e., SAR/GPS not fully interoperable with other GNSS)
- A US registered beacon must use the Galileo space and ground control segments to take advantage of the capability
- Upon detection of an RLS enabled beacon, the US Mission Control Center (USMCC) must forward beacon message to French MCC
  - Bit embedded in beacon message indicating RLS beacon
  - Impacts interoperability and response time to SAR incident
- US Coast Guard endorses RLS for use in SAR cases
- GPS Modifications
  - Need authority to use bits (estimate 80 bits for Type-1 message and beacon ID);
  - SAR downlink needs to go from USMCC to GPS control center, which then sends command to GPS to insert the message into the PNT downlink

Summary

- SAR payloads onboard GNSS (i.e., MEOSAR) will significantly increase SAR capabilities and interoperability
- Provides single burst location identification and enhanced second generation beacons
- Allows for use of RLS
  - Type-1 protocol adopted by C-S and will be implemented
  - Further use of RLS being considered by ESA for Aviation remote in-flight beacon activation
    - Requires further investigation on reliability