National Aeronautics and Space Administration

Advanced Next-Generation Emergency Locator (ANGEL)
MEOSAR Applications to NASA Human Spaceflight

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COSPAS-SARSAT: satellite SAR

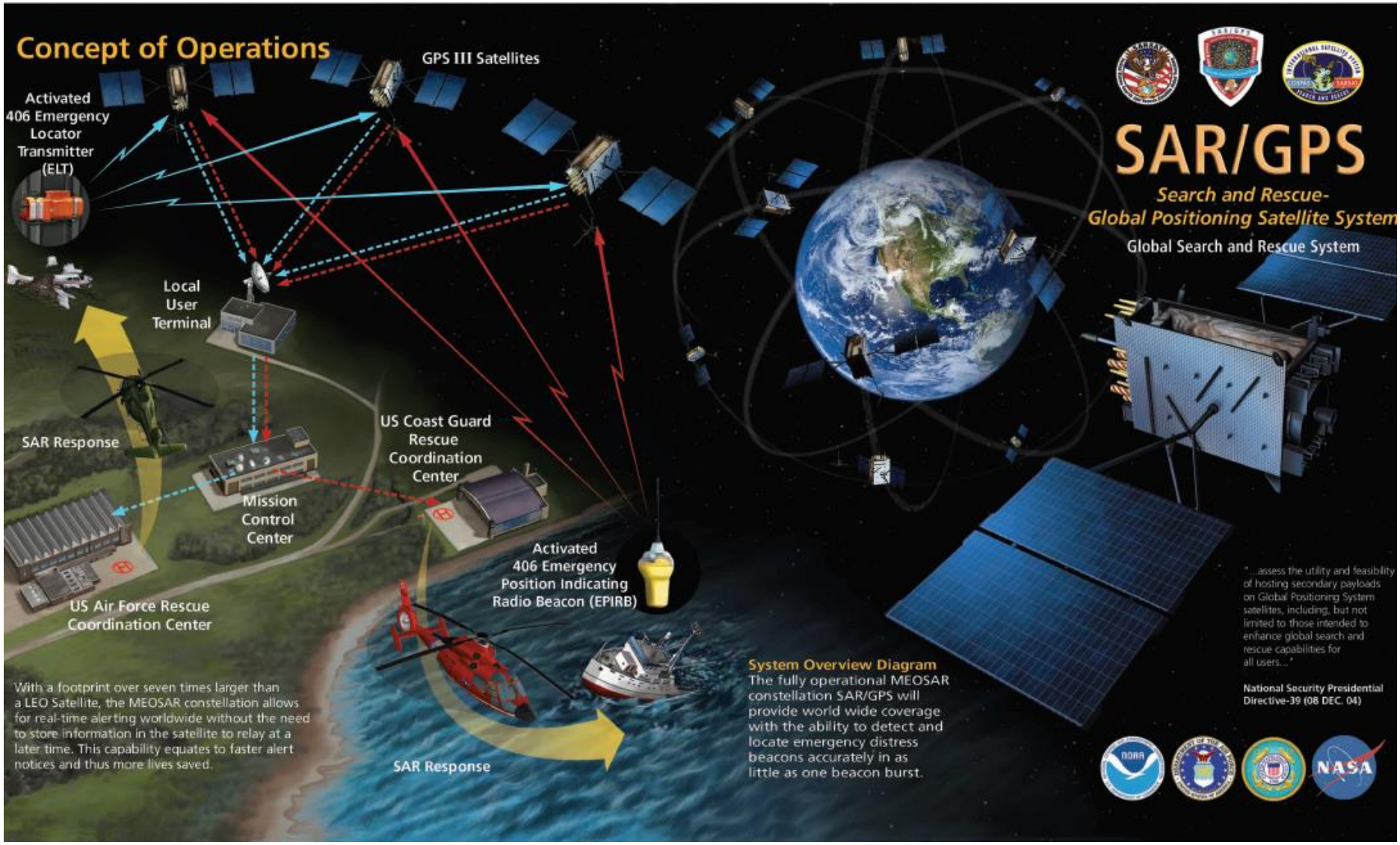
COSPAS-SARSAT System Overview

- International satellite system for SAR; started in 1970s
  - **COSPAS**: **CO**smicheskaya **S**istema **P**oiska **A**variynyh **S**udov (Space System for the Search of Vessels in Distress)
  - **SARSAT**: **S**earch **A**nd **R**escue **S**atellite-**A**ided **T**racking

Quick Facts
Over 40 countries worldwide participate
Monitors distress signals from 406MHz beacons
Over 36,000 lives saved since implementation in 1982
Over 1.4 million emergency beacons are registered

MEOSAR

MEOSAR Concept of Operations



MEOSAR Concept

- Based on the use of SAR Repeaters carried on board current and future Global Navigation Satellite System (GNSS) satellites
- Provides:
  - Near instantaneous beacon detection and location, globally, at all times
  - Advanced location process using time and frequency measurements of beacon signal to triangulate its location
  - 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

Second Generation Beacons (SGB)

C-S SGBs

- Capitalize on MEOSAR space segment and improve system performance to meet or exceed C-S requirements, including:
  - Detection probability, location accuracy and system capacity
- *Fully realize ability of C-S to provide the gold standard of emergency distress location.*

Current Accuracy Requirement
Determine beacon location within 5km, 95% of time within 10 minutes of beacon activation

SGB Accuracy Requirement
Determine beacon location within 1km in first burst 95% of time; 100m after 30 minutes

SGB Prob. Of Detection Requirement
99.9% probability of detection of at least one valid beacon message within 30 seconds after activation.

Project ANGEL

Project ANGEL Goals

- Develop SGB PLB for the NASA Orion Crew Survival System
  - Attached to astronaut Life Preserver Unit (LPU)
  - For operation after splashdown and crew egress from capsule
  - 406 MHz signal and 121.5 MHz swept-tone signal

- Further US / International development of MEOSAR-based SGBs, ground stations, and airborne interrogation equipment as it applies to NASA human spaceflight operations

Current Work / Progress

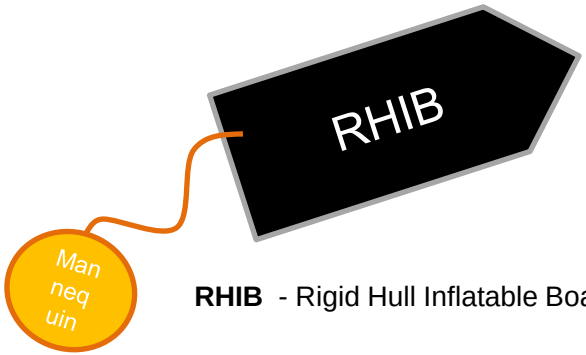
- Antenna measurement / refinement of sea state simulation per NASA post-landing environmental requirements
- RF/electronics board development by GSFC
- RF/electronics hardware testing begins in summer of 2016
- Quantification of signal performance in terms of time of first fix, and location accuracy
- Human-In-The-Loop testing with NASA engineers and astronauts to ensure beacon can be operated as integrated with OCSS system
- End state for FY16 is a flight-like beacon for integrated “over-the-air” demonstration, with iterative demonstrations and analysis during Summer and Fall 2016

Maritime Applications

- NASA's rescue posture and techniques dictate maritime use of the ANGEL beacon in open sea to signal rescue forces
- All of NASA's current human spaceflight missions end in water landings, necessitating solutions to locating astronauts adrift at sea
- ANGEL team is partnering with the US Navy and NASA Ground Systems Development Organization (GSDO) to test prototype ANGEL beacons during joint NASA / Navy Underway Recovery Test (URT) in October 2016
- Rigorous testing in varying sea states from calm to sea state of ~3-4 off coast of San Diego using US Navy assets
- URT testing will serve to evaluate the performance of the ANGEL antenna and waveform in a realistic sea state, enhancing and expanding on testing done during terrestrial / ashore evaluations

Typical URT Test Setup / Execution

Time	Event
T-90 Minutes	**Beacon Team onboard Navy ship verifies location transmission on laptop application and via comm with staff at GSFC MEOLUT** a) ANGEL activated, signal confirmed b) GPS system on & logging c) Environmental Sensors (temp/humidity) on & logging
T-15 Minutes (TBD)	**RHIB deploys with mannequin with ANGEL** a) Mannequin has LPU-10s inflated b) MOBI System Active & Tracking
T-0	**RHIB Crew arrives at test location**
T + 10	**RHIB Crew tethers mannequin (on ~50 ft line) to RHIB and deploys mannequin into water – BEGIN TEST** a) Crew monitors sea state and performs photo-documentation as available
Variable	**Test Underway** a) MEOLUT catalogs / stores ANGEL location data b) Test can be cut short if nominal (BTA, etc) activities take precedence
Variable	**END TEST** a) Retrieve ANGEL & Mannequin b) Turn off ANGEL



RHIB - Rigid Hull Inflatable Boat

Data Collected Each Session

- On-Scene
  - Independent GPS Location
  - Water Temperature
  - Air Temperature / Humidity
  - Survivor Orientation in Wave State
- MEOLUT (GSFC) Collected Data
  - ANGEL Detection / Location Performance
- Maritime Environment
  - Local Wave Height
  - Local Wave Period