National Aeronautics and Space Administration

NASA Search and Rescue SAR Controllers Training

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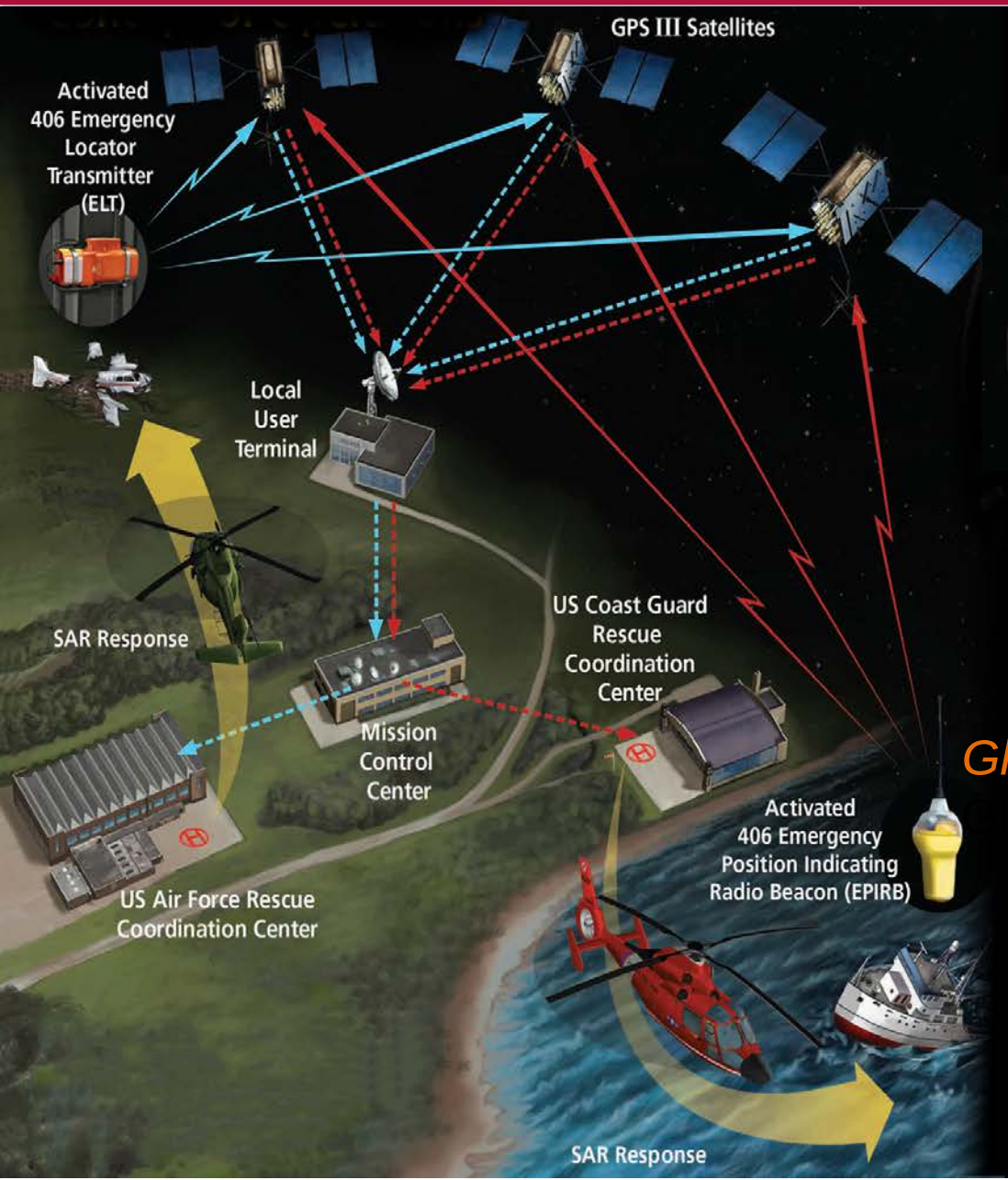
NASA'S ROLE IN SEARCH AND RESCUE

- Innovate and develop new technologies to improve search and rescue hardware for national/international use in emergencies
  - Emergency beacons for use in distress
  - Ground stations that monitor and distribute data to rescue forces
  - Space payloads that detect the emergency signal and relay to Earth
- Technical arm for United States satellite-aided SAR Program (SARSAT)
  - Work with US Coast Guard, Air Force, and National Oceanic and Atmospheric Administration (NOAA)
- Agencies form a delegation and represent USA on international level
  - COSPAS-SARSAT Program
  - 42+ countries work together to obtain full Earth coverage of beacon detections and rescues

MEOSAR Space Segment

MEOSAR CONCEPT OF OPERATIONS



SARSAT — United States Search and Rescue Satellite Aided Tracking

SAR/GPS — Search and Rescue Satellite System

INTERNATIONAL SATELLITE SYSTEM — COSPAS SARSAT — SEARCH AND RESCUE

SAR/GPS

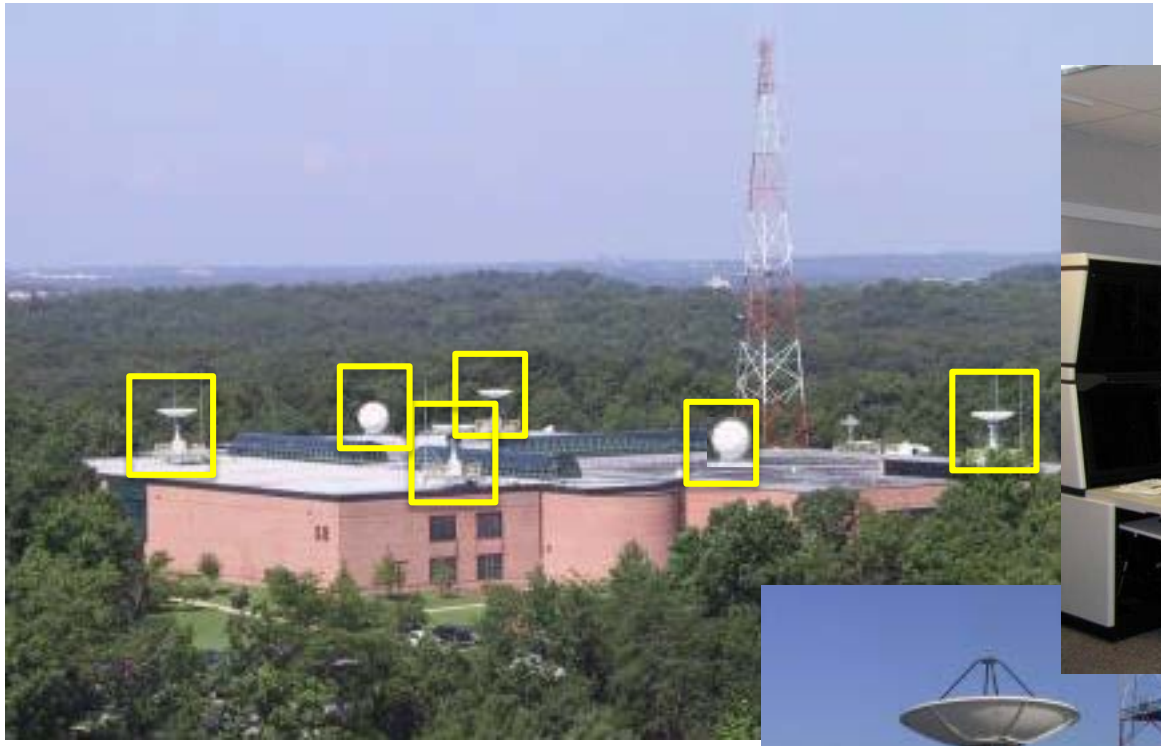
Search and Rescue-
Global Positioning Satellite System

MEOSAR: NEXT GENERATION OF SATELLITE-AIDED SAR

- Based on the use of SAR Repeaters carried on board Global Navigation Satellite System (GNSS) satellites
- Global Navigation constellations consist of 24 (or more) satellites Mid Earth Orbit (GPS, Galileo, GLONASS, China)
- 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

MEOSAR Ground Segment

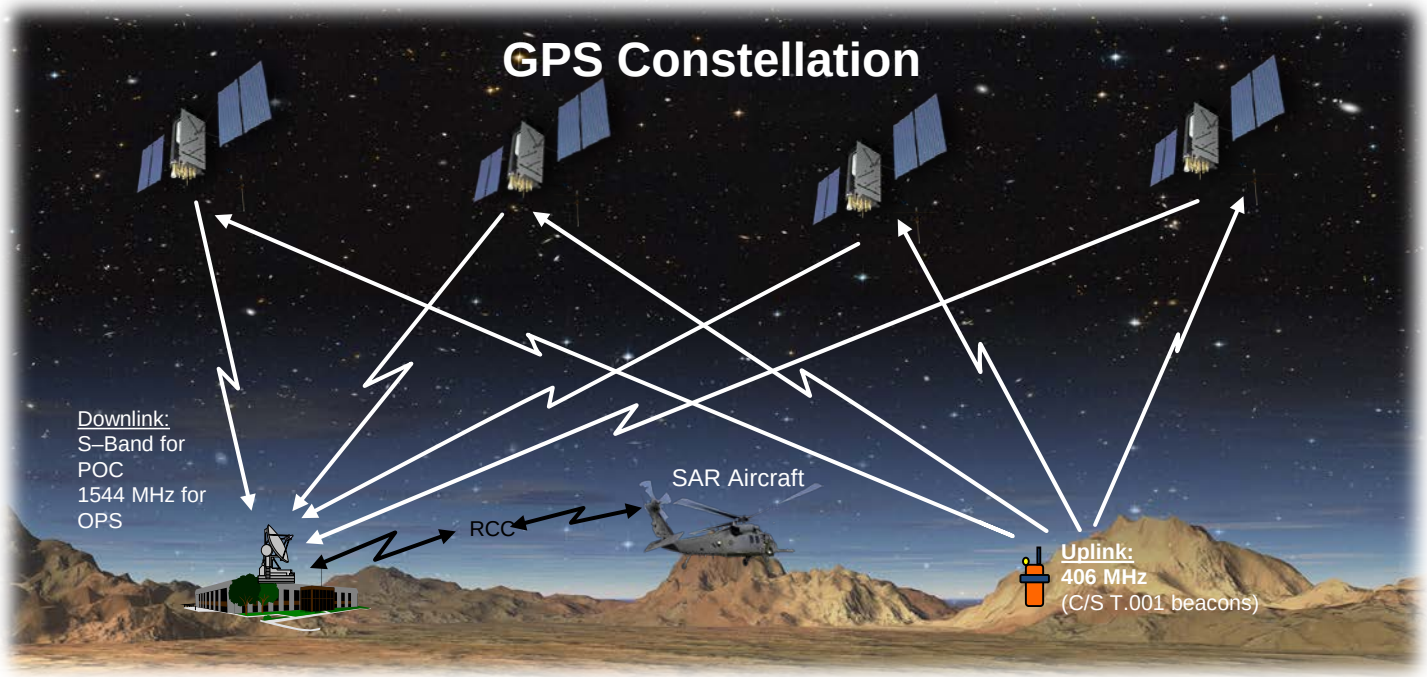
NASA Ground Segment



Six parabolic antennas;
location: NASA Goddard Space Flight Center, MD

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, trilateration using time and frequency measurements of beacon signal through at least 3 different MEOSAR satellites



Second Generation Beacons (SGB)

SECOND GENERATION BEACONS

- Capitalize on MEOSAR space segment and improve system performance to meet or exceed C/S requirements, including:
  - Detection probability, location accuracy and system capacity
  - Relax beacon requirements to reduce cost and complexity
  - Collaborate with manufacturers to obtain the most competitive end product
  - RLS: automatic acknowledgment, where return link message sent automatically when location of alert has been confirmed

Increasingly challenging operational requirements that SAR authorities must consider, which include:

- Cancellation function
- On-scene homing
- Return link service

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

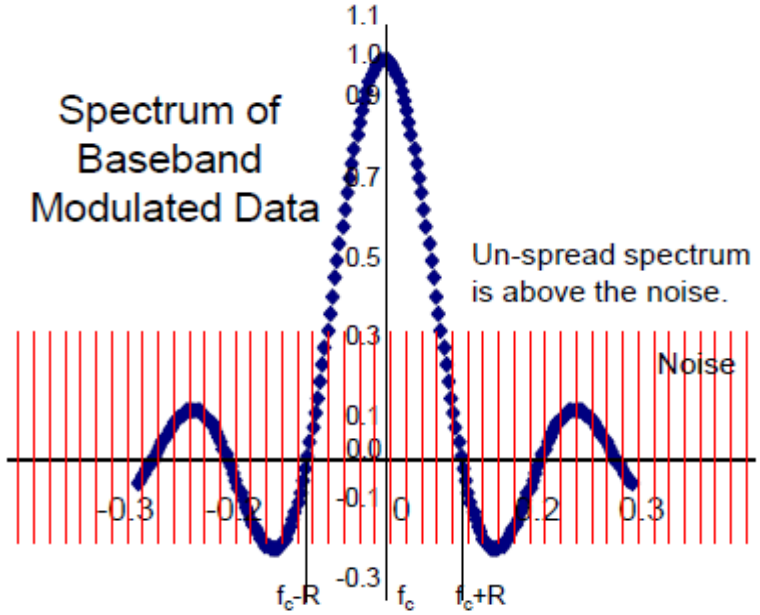
SGB Accuracy Requirement
Determine beacon location within 5 km in first burst 90% of time; 100m after 30 minutes

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

Spread Spectrum/Code Division Multiple Access

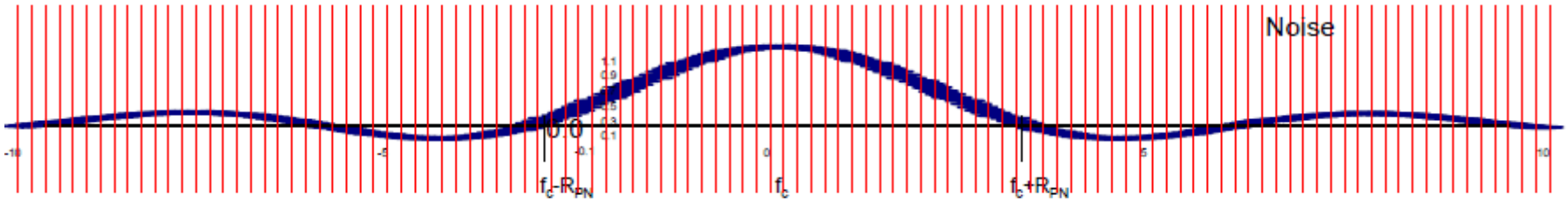
With the same PA output power, area under the Power spectrum curve is the same for spread and un-spread transmission. Since Null to Null spacing is a function of the data rate, for spread data the spectrum is much wider, at least 10 times as wide for this specification.
Amplitude of power spectrum of spread signal is thus less than 1/10th the level of un-spread spectrum and will often be below the noise floor.

f_c = carrier center frequency
R = data rate of original data
R_{PN} = data rate of the PN chips



Spectrum of Spread Modulated Data

Spread spectrum signal shown below the noise.



(Curves shown are linear Voltage spectrum and need to be squared for power spectrum)

6-Channel Software Defined Receiver

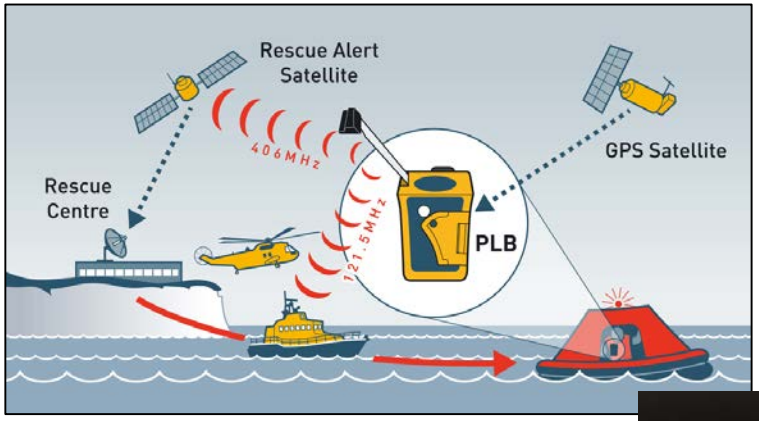
- Processes current and SGB signal relayed by GNSS satellites.
- Measurements made on each beacon burst fed into NASA MEOLUT for location processing.

Real Time Receiver

SGB Applications

Second Generation DF Receiver

ANGEL/Orion Crew Survival



- "Advanced Next Generation Emergency Locator"
- Develop SGB PLB for the NASA Orion crew survival
  - Attached to astronaut Life Preserver Unit (LPU)
  - For operation after splashdown and crew egress from capsule
  - Targeting Exploration Mission 2 (EM-2)
  - 406 MHz signal and 121.5 MHz swept-tone signal

NASA Collaboration on SGB

ANGEL/Orion Crew Survival

- Since mid-2014, NASA Crew Survival Engineering and NASA Search & Rescue Mission Office have collaborated on the development of a miniaturized Second Generation Beacon (SGB) for use in the Orion Crew Survival System (OCCS)

- Blended team of GSFC and JSC engineering staff responsible for operational requirement development and prototype design representing eventual flight unit configuration for use in EM-2 rescue operations

  - GSFC responsible for electronics and mechanical design and coordination with international COSPAS/SARSAT community space & ground segments
  - JSC responsible for requirements development, 406 MHz antenna design, integration with MACES suit, and operational testing and interoperability with SAR forces. JSC will assume full programmatic responsibility for flight certification and flight operations.

DF Receiver & UAS

- Working with Rockwell Collins to develop an SGB 406MHz Direction Finding (DF) receiver that meets the DF and homing requirements of the next generation SAR beacon signals. The DF receiver will operate in the 406MHz frequency band
- SGB-DFR performance will be field tested on NASA's Sensor Integrated Environmental Remote Research Aircraft (SIERRA) Unmanned Aerial System (UAS)
- The SG-DFR homing capability is scheduled to be field-tested in 2018

SGB Future Concepts

Future Concepts

SIGNaL: SAR Integrated Generation Nano Locator

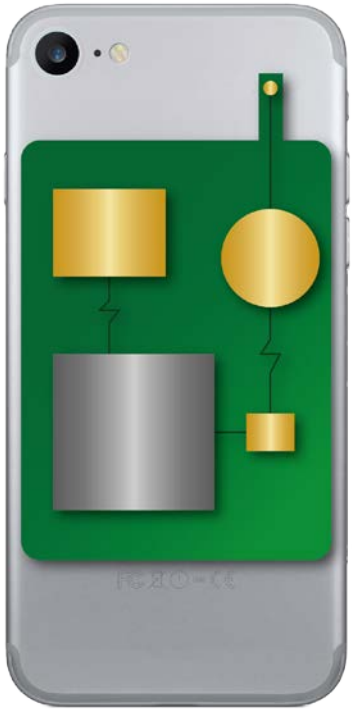
Option 1 – Smartphone C-S Beacon

Smartphone Front

- Downloadable Cospas-SARSat App:
  - If in cellular-starved area (no 911), trigger transmission
  - If RLS-equipped – receive message of acknowledgement from SAR forces

Smartphone Back

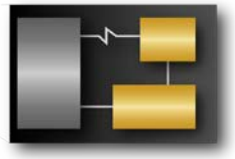
- External bump approximately ¼” thick consisting of:
  - Electronic boards
  - Rechargeable lithium ion battery
  - Antenna
  - Utilizes GPS chip already in smartphone



Future Concepts

SIGNaL: SAR Integrated Generation Nano Locator

Option 2 – PLB Embedded in Clothing



- 6”X6” patch antenna, integrated into the fabric of the jacket
- Push button activation
- Removable, rechargeable battery pack
- PLB
  - 406MHz with GPS chip

Future Concepts

Local Homer

Vehicle edition

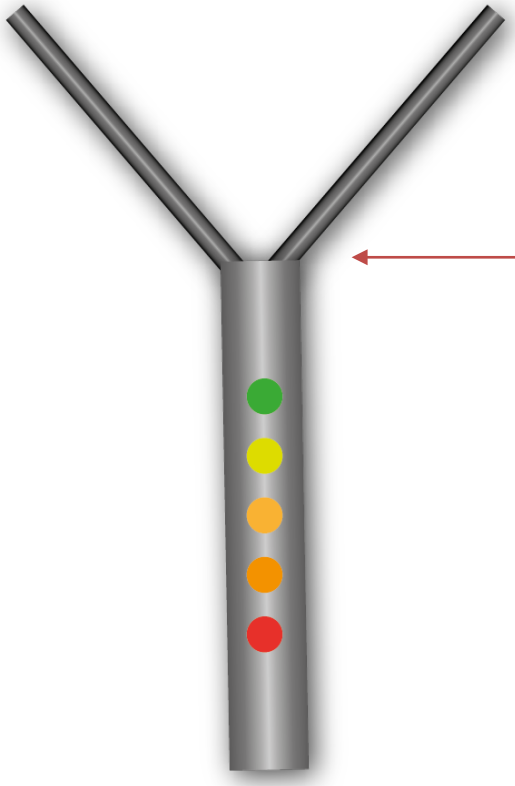
406Mhz SGB receiver and external antenna

- Antenna secured to vehicle roof
  - ~1-foot in diameter
  - Wired from antenna to receiver
- Receiver equipment stored in trunk of vehicle

Future Concepts

Local Homer

Handheld



Handheld 406 MHz SGB homing device

- ~10-inches in diameter
- Lights on device indicate direction and distance to person in distress to assist rescue personnel