

SEARCH AND RESCUE

National Aeronautics and
Space Administration



NASA Search and Rescue SAR Controllers Training Second Generation Beacons

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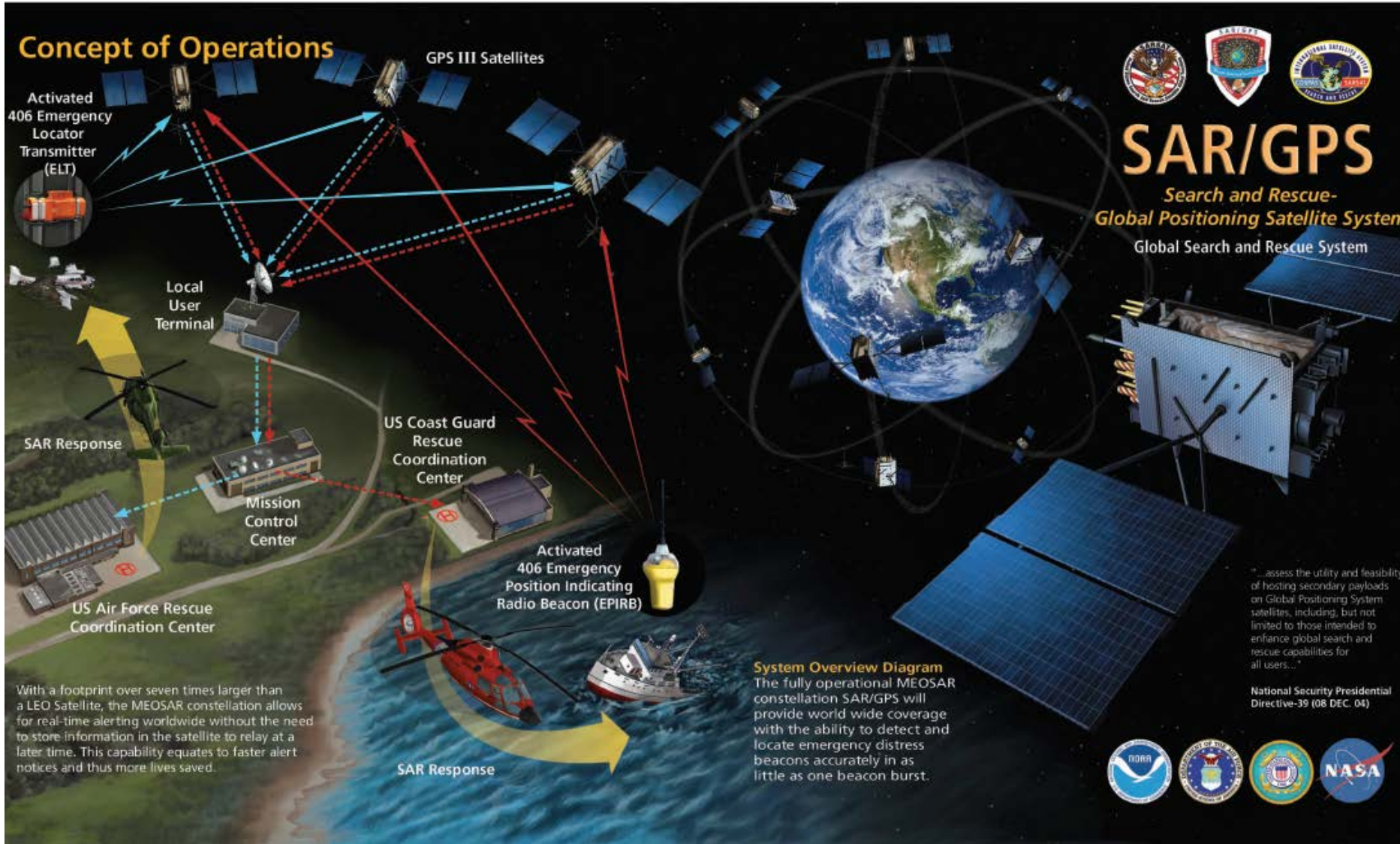
MEOSAR Space Segment

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)
- 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

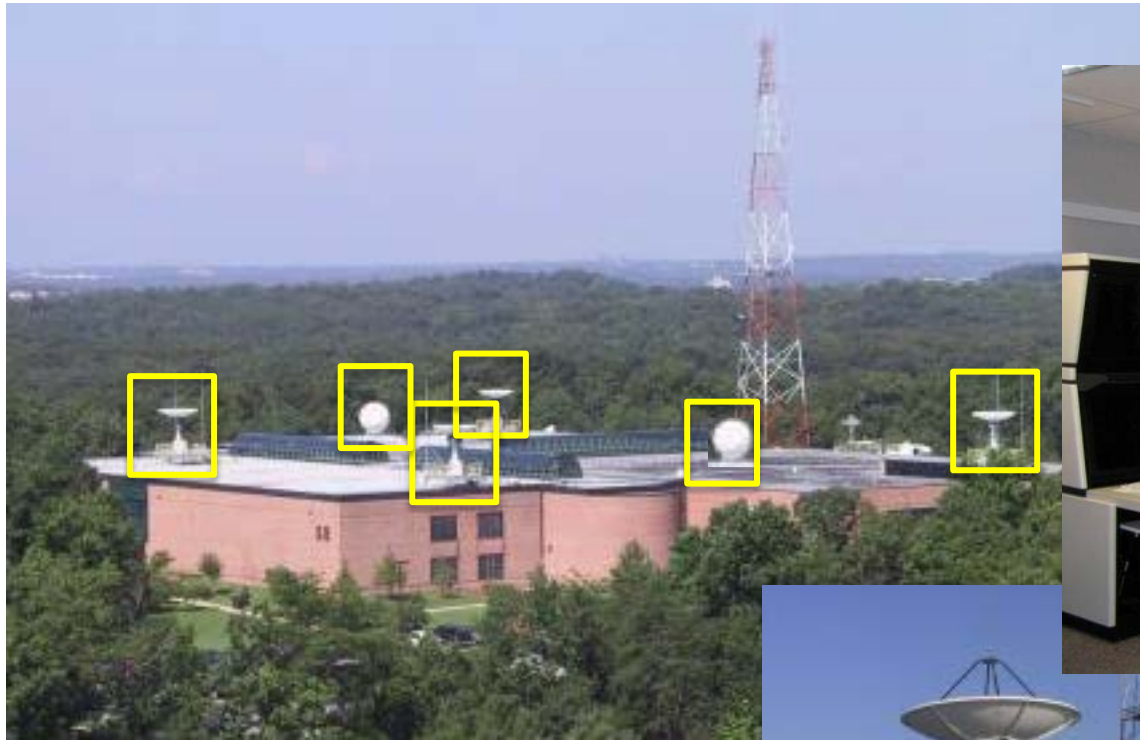


MEOSAR Concept of Operations



With a footprint over seven times larger than a LEO Satellite, the MEOSAR constellation allows for real-time alerting worldwide without the need to store information in the satellite to relay at a later time. This capability equates to faster alert notices and thus more lives saved.

MEOSAR Ground Segment

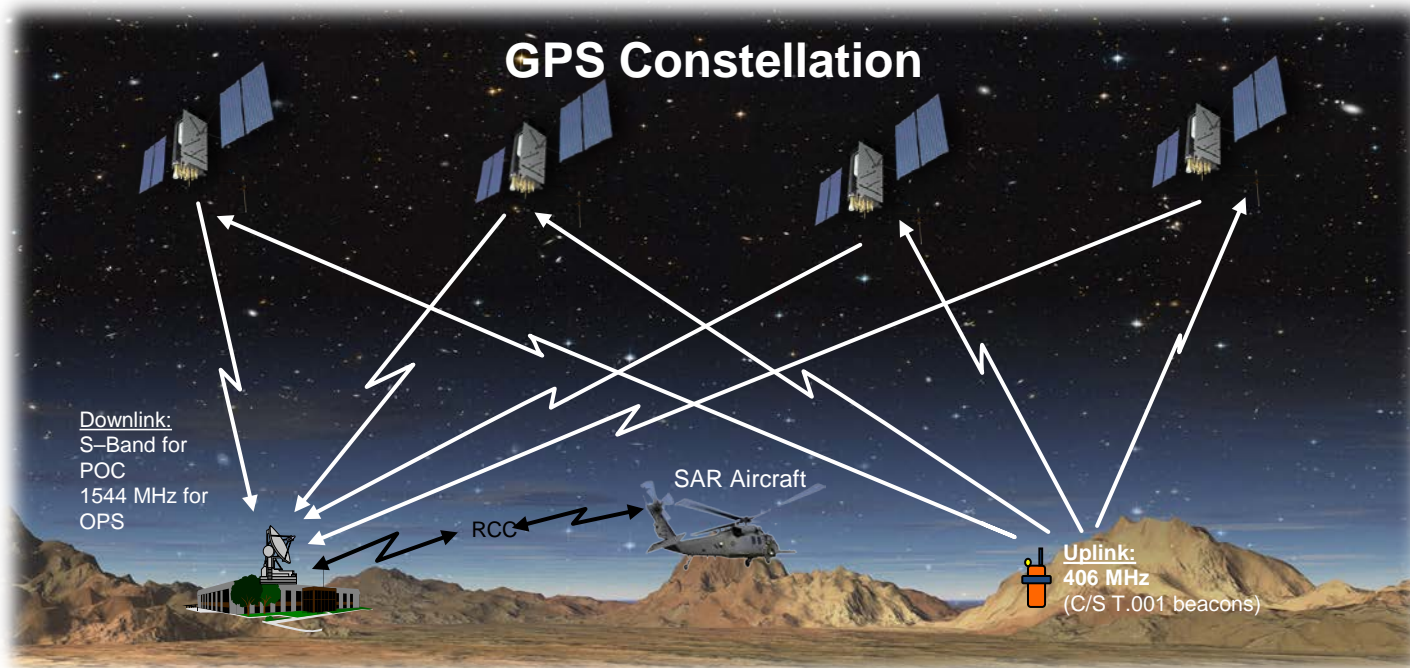


Six parabolic antennas;
location: NASA Goddard Space Flight Center, MD

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)

- 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

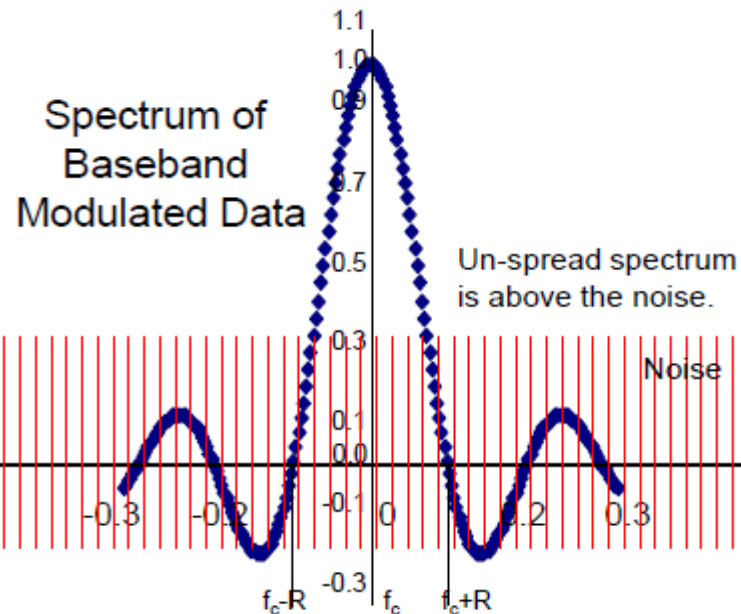
SGB Prob. Of Detection Requirement

99.9% probability of detection of at least one valid beacon message within 30 seconds after activation.

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.

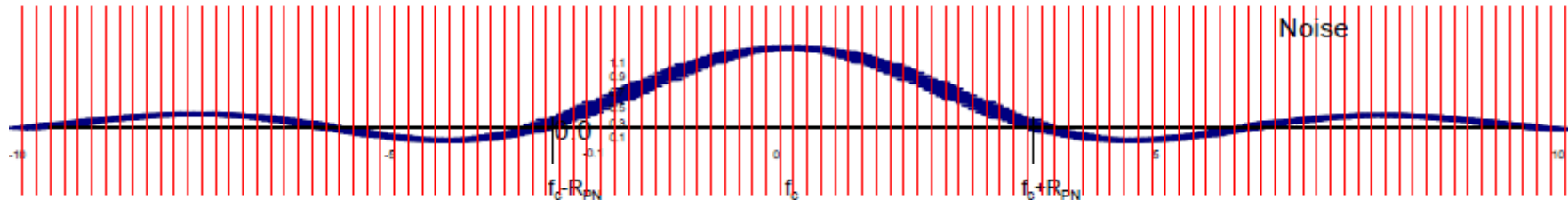
Amplitude of power spectrum of spread signal is thus less than $1/10^{\text{th}}$ the level of un-spread spectrum and will often be below the noise floor.

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)

Prototype Beacon



NASA has developed a proof of concept system, including a 'Second Generation Beacon' and real time receiver capable of implementing the spread spectrum T.018 waveform.



- 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

Prototype Beacon Testing



USS San Diego – Oct 26, 2016



- SGB has shown significant improvement over current first generation beacons.
- Best locations produced were within a distance of 0.15 km



- Several topics are being discussed in the international Cospas-Sarsat community that will impact the final SGB specification:
 - Beacon Cancellation Function (C-S Operational Requirement)
 - Beacon capable of transmitting a message indicating that previous transmissions were a false alert.
 - Unique cancellation message to minimize risk of false cancellation
 - MCC provide further confirmation with set of rules – e.g., has there been an alert with same id
 - 406 MHz Local (terrestrial) Homing transition (< 30 nm)
 - Individual administrations may choose homing frequency (121.5 MHz, 406 MHz)
 - The U.S. is pursuing 406 MHz for SGBs - better homing performance and less battery usage than 121.5 MHz
 - During transition, administrations using 121.5 Homing could consider a reduced duty cycle, which will save battery capacity.
 - Test trials with reduced duty cycle began last year (Australia); US and UK to run tests soon.



- Several topics are being discussed in the international Cospas-Sarsat community that will impact the final SGB specification (continued):
 - Verification of Beacon Registration
 - G.008 requires that the registration status of the beacon be displayed to the beacon user, is valid for 2 years, and that a self-test of the beacon notifies the user if it is not registered.
 - National administrations have a variety of solutions for registration verification.
 - Lack of a common approach makes one specification difficult, and currently no agreement has been reached for SGBs.



- Second Generation Beacon development nearing fruition
 - Proof of concept field testing in progress
 - Initial testing focus on:
 - Single burst throughput
 - Valid message acquisition
 - Independent location capability
 - Results will be presented to Cospas-Sarsat
- Commercialization of SGBs anticipated for 2019