National Aeronautics and Space Administration

NASA Search and Rescue BMW

Second Generation Beacons Proof of Concept Testing

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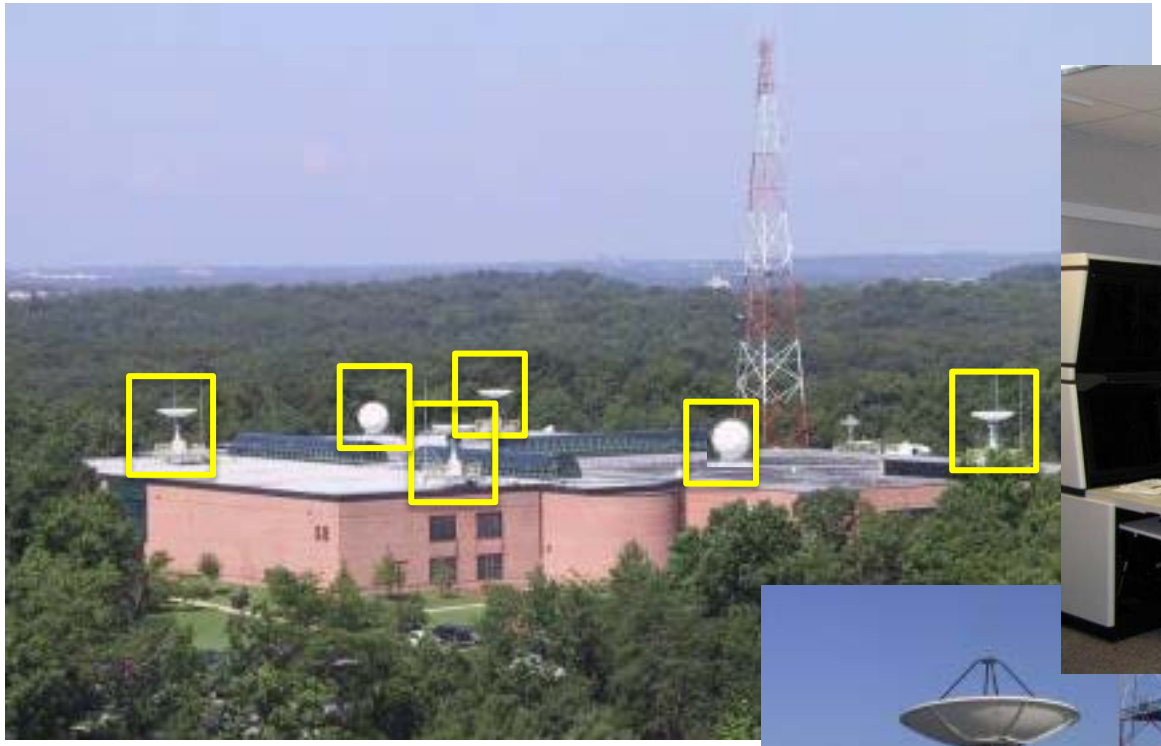
MEOSAR Ground Segment

NASA Ground Segment



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

6-Channel Software Defined Receiver

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

Second Generation Beacons (SGB)

Prototype Beacon

NASA SGB prototype beacon

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.

SGB Proof of Concept Testing & Results

NASA Proof of Concept

- NASA has developed the capability to transmit, receive and process Second Generation Beacon (SGB) signals in its Maryland MEOLUT.
- This capability is being used to perform SGB Proof of Concept (POC) testing in accordance with the SGB POC Test Plan, which is posted to the SGB POC Basecamp Project.

SGB POC Test Plan

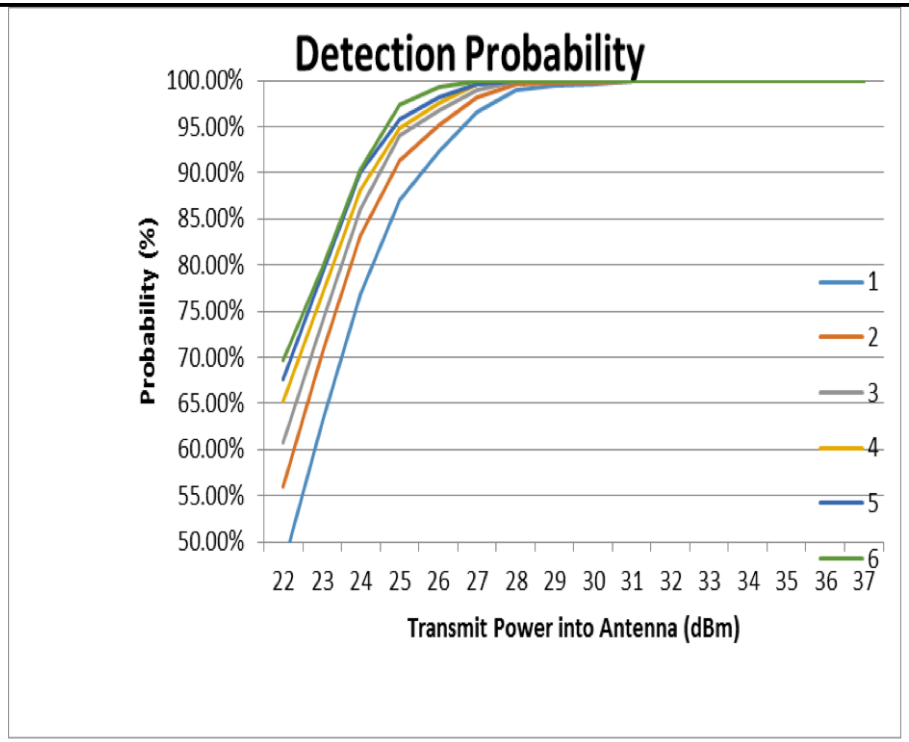
POC Test Case Title	POC Test ID	Definition
Single Burst Throughput	POC-1	Characterize the relationship between the beacon output power and the probability of a MEOLUT producing a valid message for each beacon burst.
Increased performance after the first 30 seconds of beacon transmission	POC-2	Characterize the beacon detection and location performance within the first 30 seconds of beacon transmission.
Independent Location Capability	POC-3	Characterize the independent 2D location performance as a function of the number of bursts since beacon activation.
System Capacity and Compatibility	POC-4	Determine the number of simultaneously active SGBs that can be properly processed. Also determine compatibility with MEO processing of First Generation Beacons (FGBs).
SGB Homing	POC-5	Measure the ability to meet the requirements for on-scene locating and homing.
Field Tests	POC-6	Perform a variety of field tests with prototype SGBs to further characterize MEOSAR system performance.
LEO / GEO Compatibility	POC-7	TBS
Cancellation Function	POC-8	TBS
ELT Activation in Flight	POC-9	TBS

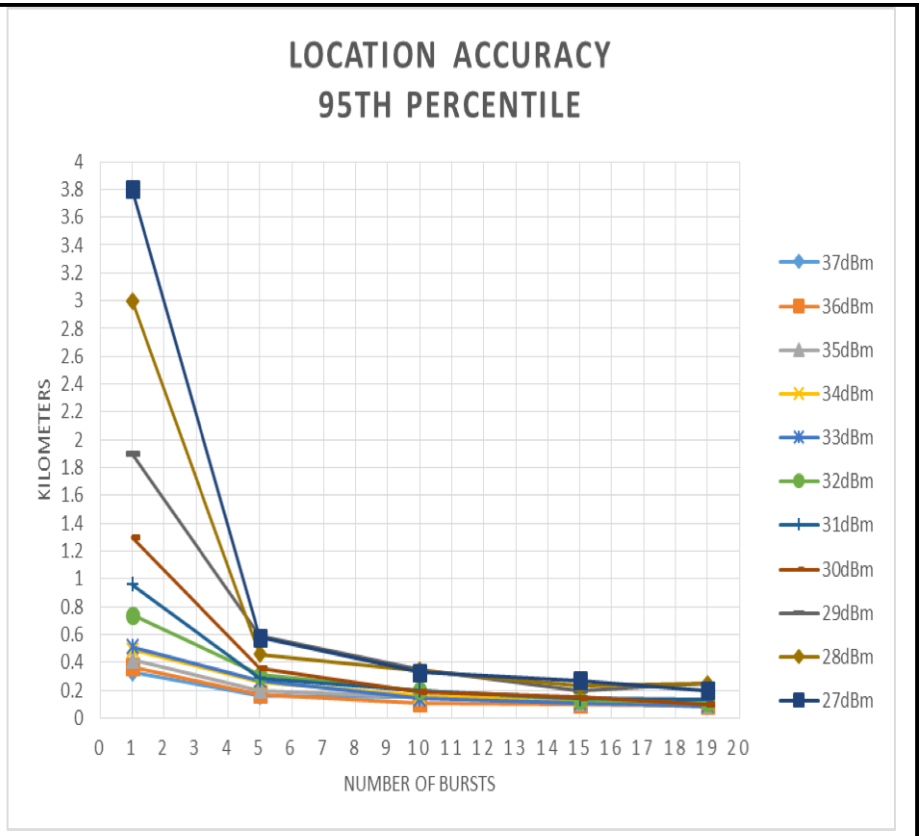
POC 1

Objective: Determine system performance threshold by measuring system performance as a function of beacon transmitter output power

- Multiple beacons are transmitted with a repetition period of 32 seconds, each with one of 16 power levels, which varies from 22 to 37 dBm
- Key performance parameters of detection and location performance were measured in order to compare results from the various power levels tested.

POC 1





Excellent system performance was demonstrated at low levels of beacon transmit power that were well below the minimum required transmit power for First Generation Beacons in C/S T.001

POC 2

Objective: Characterize the beacon detection and location performance within the first 30 seconds of beacon transmission

- Beacons that transmit 6 bursts at a repetition period of 5 seconds are activated sequentially for a total of 120 beacons per hour.
- The beacon output power will alternate hourly between the nominal and threshold power levels (30dBm and 35 dBm).

POC 2

- Tables (below) compare measured performance to the requirements. The results show excellent performance even at low power levels.
- The performance exceeds all requirements at both power levels with one exception. The probability of detection at 30 dBm is 98.3%, which falls below the 99.9% requirement.

G.008 section	Probability of Detection Requirement	Beacon transmitter output power (dBm)	Probability (%)
3.5.1	99.9%	35	100
		30	98.3

G.008 section	2D independent location accuracy requirement	Beacon transmitter output power (dBm)	Probability of location (%)	Probability location accuracy meets requirement (%)	Location error 95th percentile (km)
3.5.1	within 5 km, 95% of the time	35	99.3	99.7	0.34
		30	81.9	97.2	2.2

POC 3

Objective: Characterize detection and location performance as a function of time since beacon activation, from the first burst up to 30 minutes after beacon activation.

- Multiple beacons are transmitted with a repetition period of 30 seconds for a limited number of bursts, which varies between 5, 10, 15 or 20 bursts.
- Time since beacon activation is calculated based on the number of beacons bursts that will be transmitted in a given period of time according to the SGB Specification, C/S T.018. Performance is reported for single bursts, after 30 seconds (5 bursts), after 5 minutes (15 bursts), and after 30 minutes (65 bursts).
- The test is performed at three beacon output power levels to cover nominal and minimal power levels.

POC 3

- Table compares measured performance to the requirements which demonstrate significant performance margin

G.008 section	2D independent location accuracy requirement	Beacon transmitter output power (dBm)	Probability of location (%)	Probability location accuracy meets requirement (%)	Location error 95th percentile (km)
3.3.1	Single burst – within 5 km, 90% of the time	35	98.6	99.9	0.39
		32	89.7	99.1	0.60
	30 seconds (5 bursts) after beacon activation - within 5 km , 95% of the time	35	100	100	0.22
		32	100	100	0.34
	5 minutes (15 bursts) after beacon activation – within 1 km , 95% of the time	35	100	100	0.11
		32	100	100	0.16
	30 minutes (20 bursts) after beacon activation – within 0.1 km, 95% of the time	35	100	91.8	0.11
		32	100	80.8	0.17

According to C/S T.018, an SGB will transmit:
6 bursts in 30 seconds,
15 bursts in 5 minutes, and
65 bursts in 30 minutes.

POC 3

- In general, the results show remarkable performance measured in meters rather than kilometers.
- The performance far exceeds almost all requirements at very low levels of beacon transmit power. Single burst detection throughput is nearly 100% and the single burst location probability is above 90% even at low transmit power levels.
- Even the ultimate location accuracy requirement of 100 m after 30 minutes is very nearly met at higher transmit power levels and consistently within 200 m even at lower transmit power levels

POC 4, 5, 6

- Preparations are underway to perform POC test 4 which will determine the number of simultaneously active SGBs that can be properly processed.
- In order to prepare for POC test 5 and 6, the U.S. has been developing a prototype SGB. It has been designed to be small (2.5 x 1 x 2 inches) and lightweight in order to match design constraints that commercial vendors will likely impose upon their products.

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 150m

SGB Commercialization

- Commercialization of SGBs anticipated for early 2019
  - NASA astronauts will be first customer of Cospas-Sarsat SGB
  - USA working with Cospas-Sarsat beacon test facilities to ensure capability to perform SGB type approval