LGM Overview and EOC

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Introduction

- On 13 December 2016 the Cospas-Sarsat system entered the Early Operational Capability (EOC) for the MEOSAR System

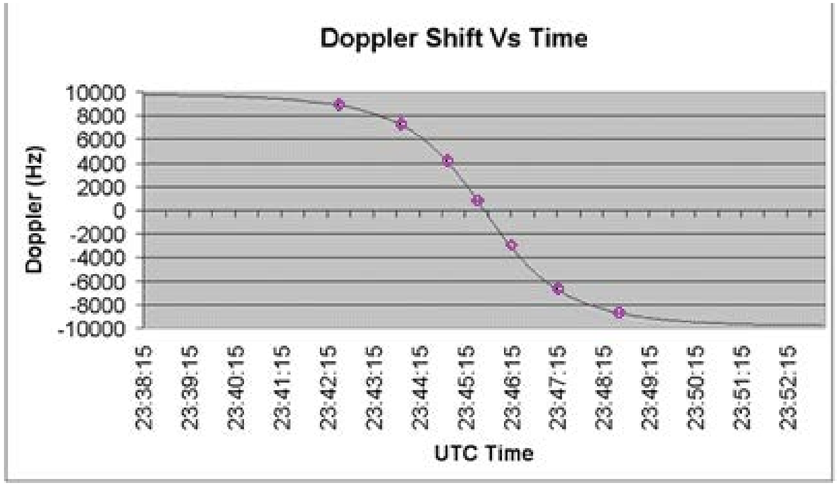
- This means that the USMCC now processes and provides alert data for three types of satellite systems, Low-Earth Orbiting (LEO), Geostationary Orbit (GEO) and Medium-Earth Orbiting and is hence a LEOSAR/GEOSAR/MEOSAR, or LGM MCC

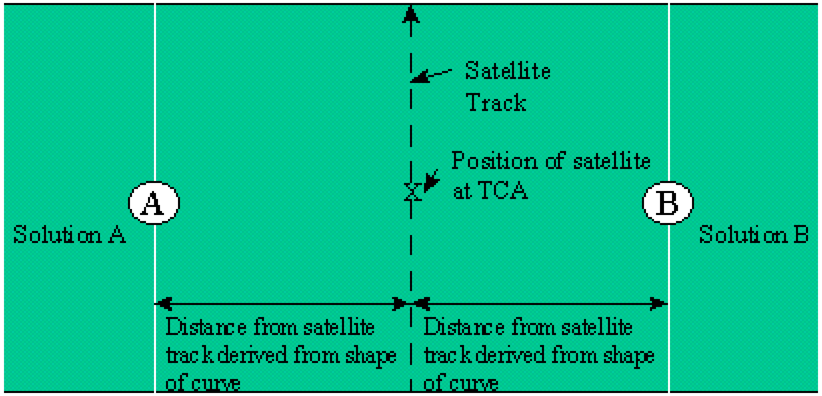
- A quick review is provided on how these different systems function, along with some of their individual advantages and disadvantages, followed by additional detail on MEOSAR

- Then we consider how the introduction of MEOSAR alert data, and the associated move to EOC and its underlying requirements, affects the end products provided to RCCs

406 MHZ DISTRESS BEACONS AND LEO PROCESSING

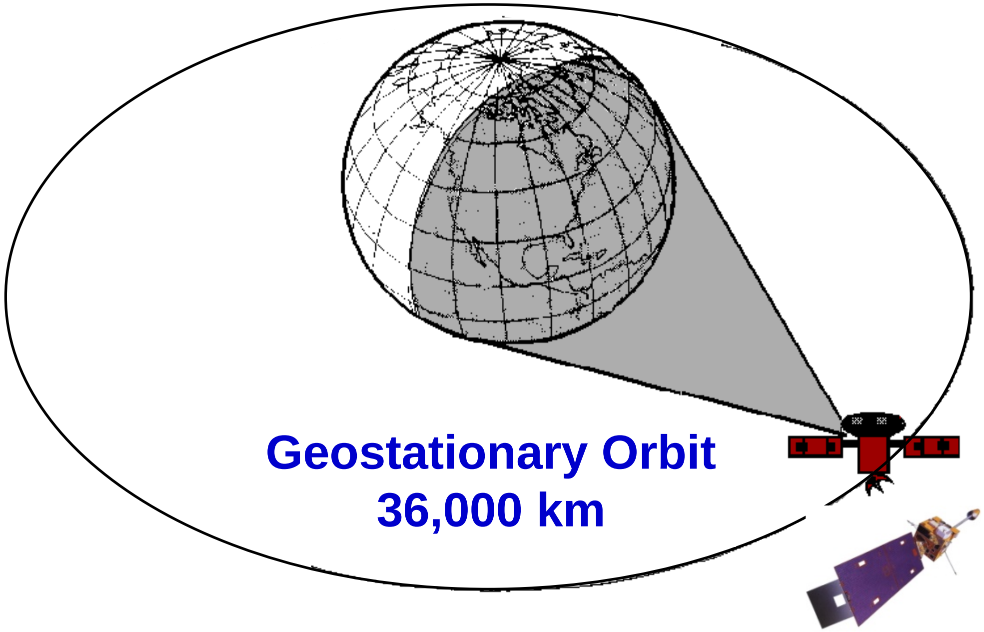
- Transmit signals: ½ second bursts, one burst every 50 seconds
- Each burst contains 120 bits of digital information
- The job of a LEOLUT is to get the burst(s) relayed via satellite, and as possible, "independently" compute a location



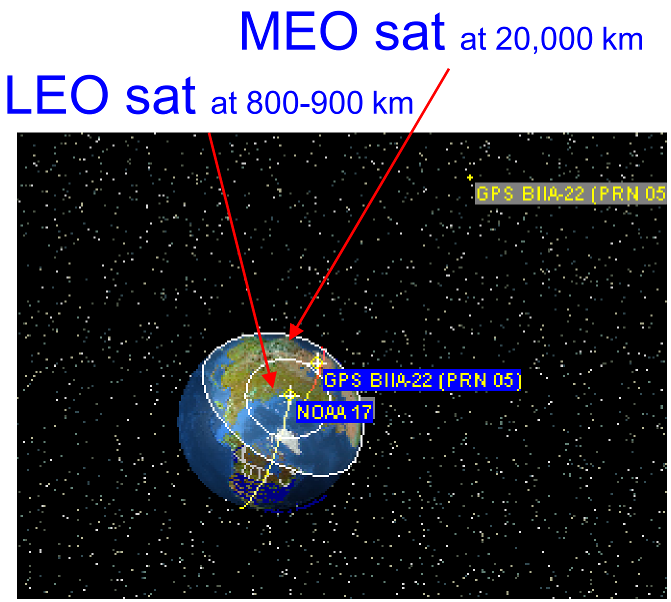


PRESENT GEOSAR SYSTEM

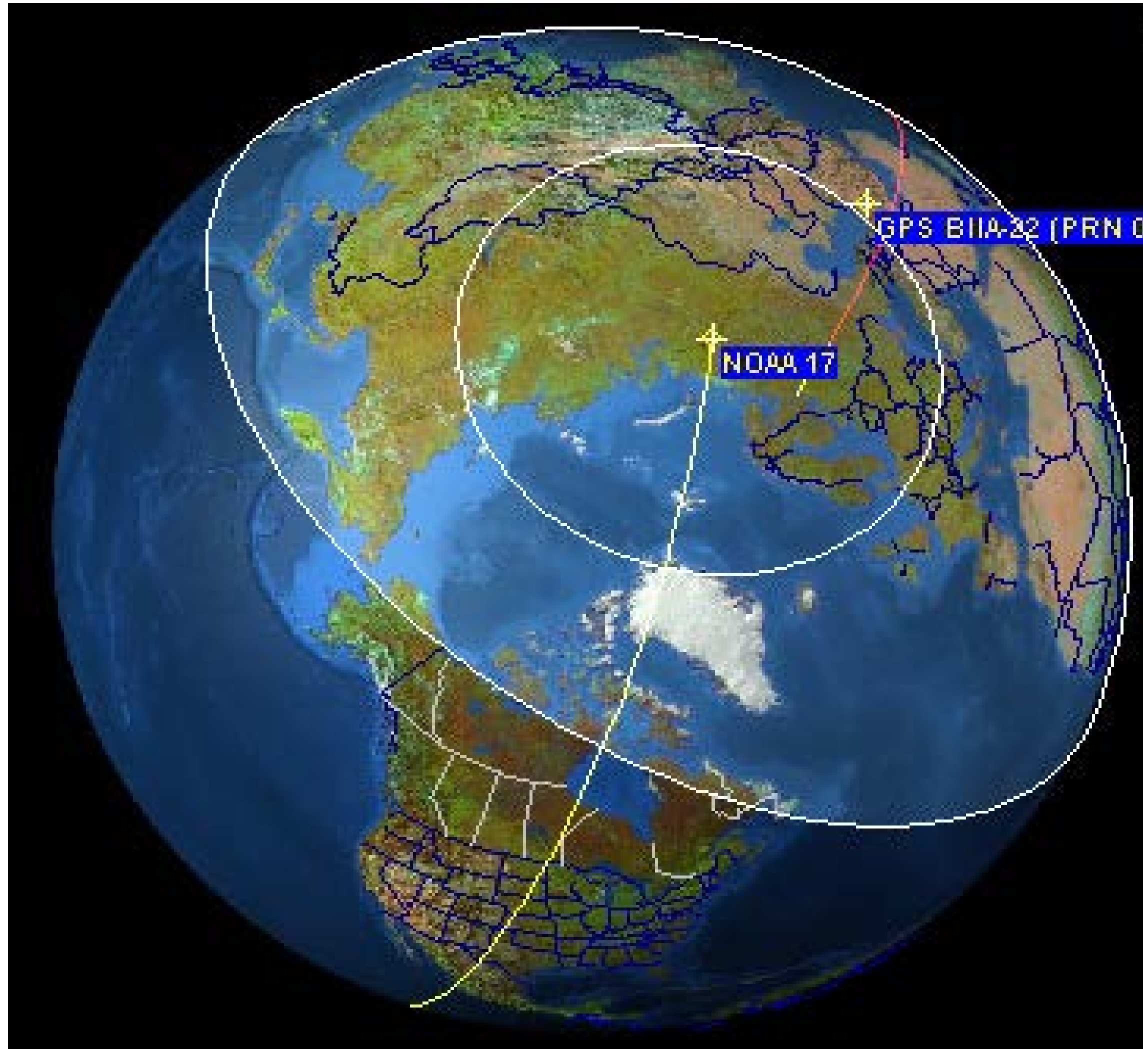
- 36,000 km high: Geostationary satellites relay transmissions from beacons
- GEOLUTs only "detect" alerts and repeat the digital message
- Large, fixed coverage areas (none near poles)
- With no relative motion between beacon and satellite there is no Doppler effect on signal to use for determining location
- Location is available only if beacon has a GNSS receiver chip and encodes the location in the beacon message



MEOSAR: AN IMPROVED SYSTEM CONCEPT



- MEO larger footprint than LEO
- Combines the best attributes of LEO and GEO
- Continuous global coverage (including poles)



LEOSAR vs. GEOSAR vs. MEOSAR

- LEOSAR
  - Small footprint
  - Limited satellites, hence wait times can be significant
  - On-board storage, global coverage is achieved
  - Independent locations via Doppler processing (need 3 or more bursts)

- GEOSAR
  - Large footprint
  - No coverage at the poles
  - Repeater only, geostationary, hence more susceptible to blockages
  - No independent location capability

- MEOSAR
  - Large footprint
  - Coverage at the poles
  - Repeater only, moving, slow orbit (longer sustained coverage)
  - Requires mutual visibility to 3 or more satellites for independent location
  - An independent location can be achieved on a single burst

MEOSAR – INDEPENDENT LOCATION

- Similar to standard GPS receivers, MEOLUTs use multiple satellites to compute the location of a 406 MHz beacon (this location is "independent" of the encoded location produced by the beacon and provided within the beacon message)

- The actual methodology used by MEOLUTs is more complicated (typically a version of linear regression), but it stems from standard triangulation techniques, with 3 unique satellites providing a "2D" location (latitude and longitude), and 4+ providing a "3D" location (includes altitude)

- Rather than just using differences in the time the signal takes to be relayed to the ground (like GPS receivers), MEOLUTs use differences in frequency as well

- The measurements refer to the relayed satellite signal as received at the MEOLUT, and are named Time of Arrival (TOA) and Frequency of Arrival (FOA), and the independent location captures both as Difference of Arrival (DOA)

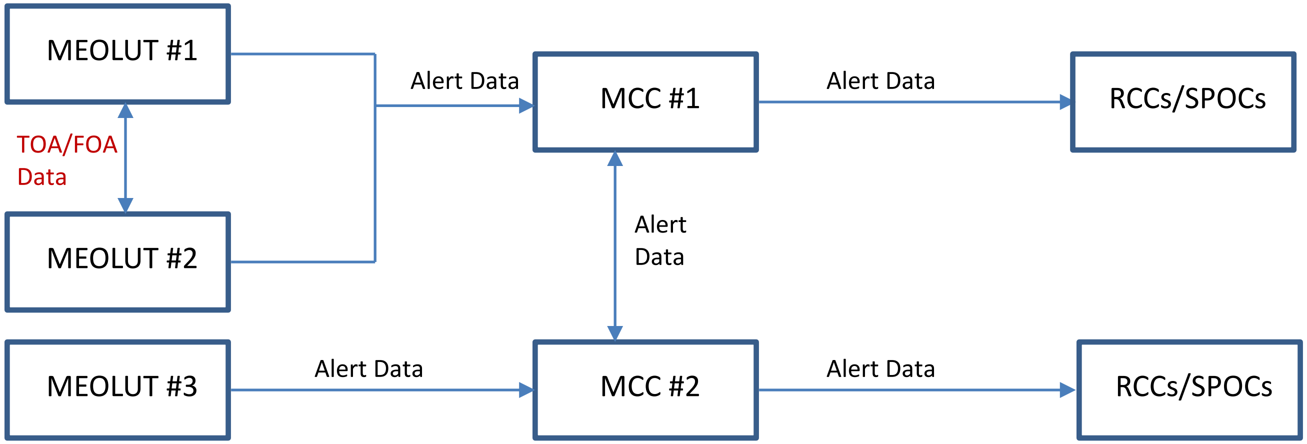
- A major advantage of MEOSAR is that DOA locations can be generated from a <u>single burst</u> from a 406 MHz distress beacon, noting that a MEOLUT will also combine data from multiple bursts, which improves accuracy

MEOSAR – INDEPENDENT LOCATION (cont.)

- The MEOLUT location accuracy requirements for EOC are:
  - Single burst: 70% within 5 km; and 90% within 10 km
  - Multiple burst: 95% < 5 km and 98% < 10 km, within 20 minutes
- And, location accuracy requirements in the future are:
  - Single burst: 90% within 5 km (no 10 km criteria)
  - Multiple burst: 95% < 5 km and 98% < 10 km, within 10 minutes
- Each MEOLUT independent location is provided to the MCC with an expected horizontal error (EHE), which not only helps predict a potential search radius, but more importantly provides a measure of quality for comparing locations and sending additional data when indicated
- For the expected horizontal error, a given DOA position is expected to within that radius with probability of 95% (+- 2%)
- Note: the EHE is not currently provided to US Coast Guard RCCs due to a lack of reliability in this data for slowly moving beacons

MEOLUT NETWORKING

- MEOLUT Networking refers to the exchange of TOA/FOA data "directly" between MEOLUTs
- The purpose of this data exchange is to enhance the performance of the MEOSAR system, specifically by improving location accuracy, as well as helping to compensate for both large distance between the beacon and the MEOLUT and missed detections caused by limited throughput
- This data exchange of "raw" data, is NOT to be confused with the sending of alert data (processed data) that occurs between C/S MCCs using the Nodal "network"
- The standard configuration for the USA ground segment employs MEOLUT Networking between the Hawaii and Florida MEOLUTs, and will include foreign MEOLUTs in the future



LEOSAR/GEOSAR/MEOSAR (LGM) MCC

- The LGM MCC processes and provides outputs to the RCCS for the three LGM data types per national agreements and the rules of the Cospas-Sarsat Data Distribution Plan (DDP), providing initial alert, updated or conflicting information, and as inherent for all MCCs, suppressing redundant data

- With respect to MEOSAR data:
  - When the MEOLUT first computes an independent location (i.e., on a single burst) it will immediately send that location to the MCC
  - Thereafter independent MEOSAR locations will generally include multiple bursts, and will be forwarded to the MCC at a minimum of 5 minutes intervals, and more often if better quality is indicated or new information if available (e.g., encoded location first available or changed)
  - The MCC in turn will forward MEOSAR data to RCCs, SPOCs and other MCCs per rules pertaining to redundancy etc., sending messages more often when new information is indicated, but at a minimum at 5 minute intervals before the position confirmation, and at 15 minute intervals after position confirmation for updated MEOSAR position and 10 minute intervals for position conflicts

LGM MCC (cont.)

- With respect to LEOSAR/GEOSAR data:
  - Before position confirmation, non-redundant LEOSAR and GEOSAR data will be provided by the LGM MCC to RCCs as it becomes available
  - After position confirmation these data types as they become available are forwarded to RCCs using data distribution rules similar to those previously used by the LEO/GEO (L/G) only MCC (per separate presentations on National and International Data Distribution)

- In the big picture, an LGM MCC functions very similar to previous MCCs, as while MEOSAR is a significant technical advance, it essentially just adds a new data type to the processing stream

- Likewise, there is a new data content, and some new associated message types on outputs to RCCs, but overall the formats are very similar and the critical information of locations, as well as supporting information like beacon decode and registration data all remains the same

LGM MCC (cont.)

- Key impacts resulting from the inclusion of MEOSAR alert data are:
  - Independent locations will often be available earlier, often on the very first burst
  - Detect only data will sometimes arrive earlier as well
  - MEOSAR data can now confirm a LEOSAR position, or visa versa
  - In general there is more data overall, especially after position confirmation but before that point also
  - Due to continuous monitoring, there is an increase as well in detect only activations (inappropriate testing etc.); and with many more antennas and sometimes high noise levels in signals there is also a higher potential for system generated anomalies

- Further differences MEOSAR alert data introduces relative to LEOSAR:
  - No inherent ambiguity of its own to resolve
  - MEOSAR to MEOSAR Position confirmation is handled differently (requires a unique set of satellites or significant time separation from one solution relative to another)
  - Extra matching data may be sent while waiting for position confirmation based solely on updated detect time (5 minutes)

Early Operational Capability (EOC)

- EOC provides a transition period for Cospas-Sarsat participants to more efficiently manage the introduction of the significant technical advancement of the MEOSAR System

- Specifically, this transition period:
  - Allows for a reduction in some requirements (most notably MEOLUT location accuracy) as the technology improves
  - The opportunity to learn from experience, and potentially adapt, ensuring the best data distribution procedures in future implementations

- When the Cospas-Sarsat enters the Initial Operational Capability (IOC) for MEOSAR:
  - Standard MEOSAR location accuracy requirements will be met
  - Lessons learned should have solidified data distribution procedures

- Once global MEOSAR coverage is achieved, Cospas-Sarsat reaches Full Operational Capability (FOC) for the MEOSAR system

Summary

- LGM delivers:
  - More timely data in general, in particular shortly after beacon activation
  - Faster times to position confirmation
- LGM brings with it:
  - More data in general
  - New alert data content
- During EOC:
  - MEOSAR location accuracy requirements are reduced
  - There is an opportunity to learn from real world experience and respond (e.g., recent analysis indicates issues with MEOSAR location accuracy for slowly moving beacons, further discussion to follow)
- Beyond EOC:
  - Location accuracy generally expected to be better than LEOSAR
  - Accurate Location for beacon activations in near real time anywhere in the world!