MEOSAR Overview

SAR Controllers Training 2016
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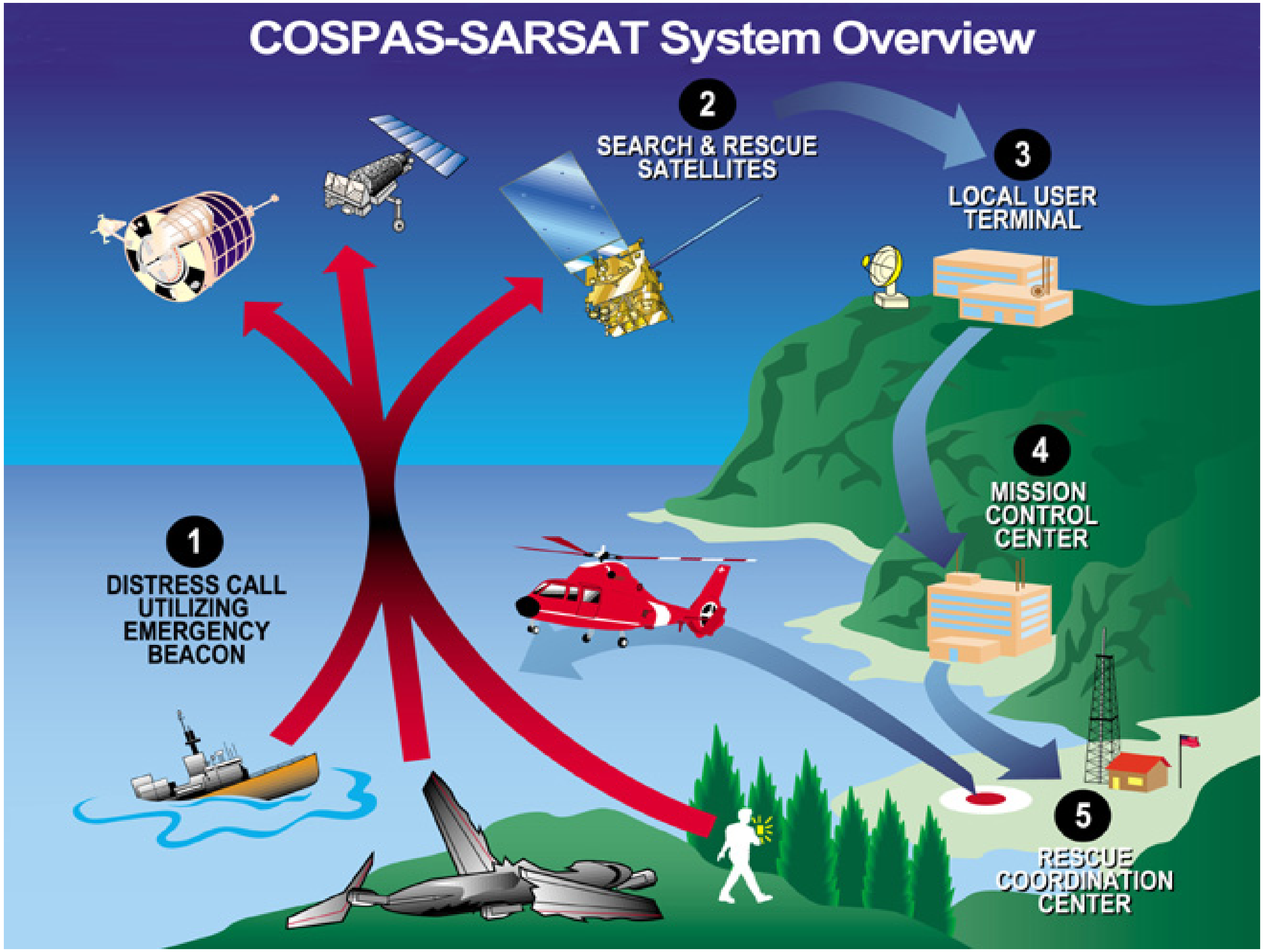
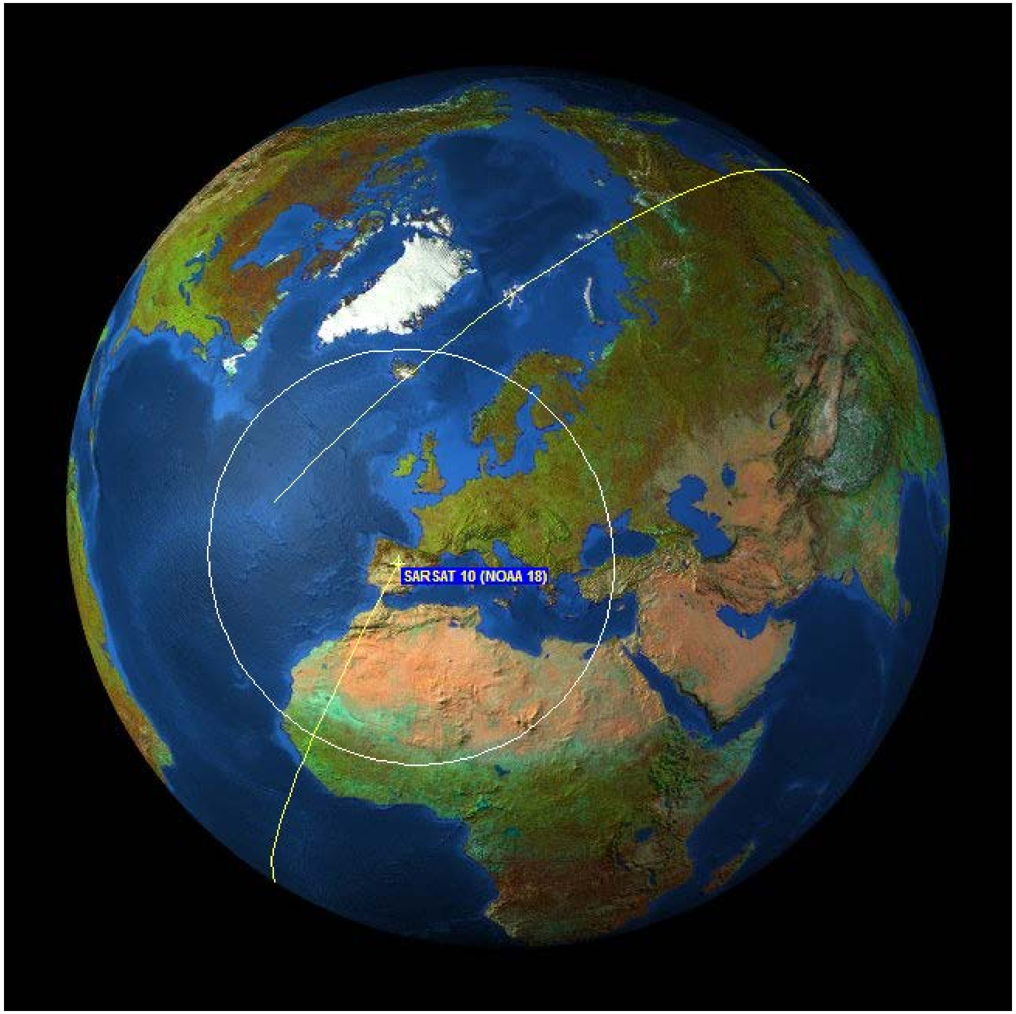
COSPAS-SARSAT SYSTEM

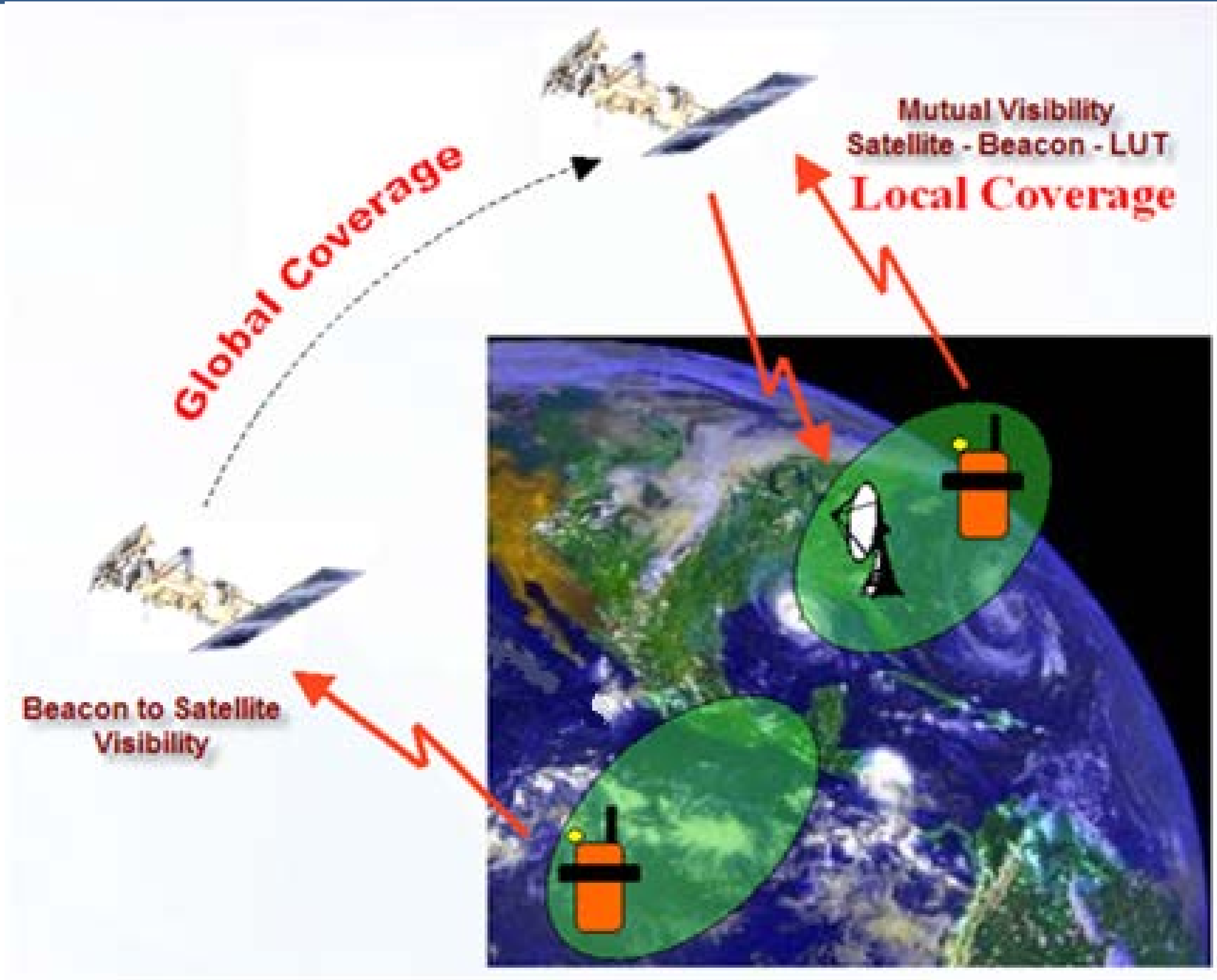


PRESENT LEOSAR SYSTEM

EXAMPLE TRACK/ORBIT

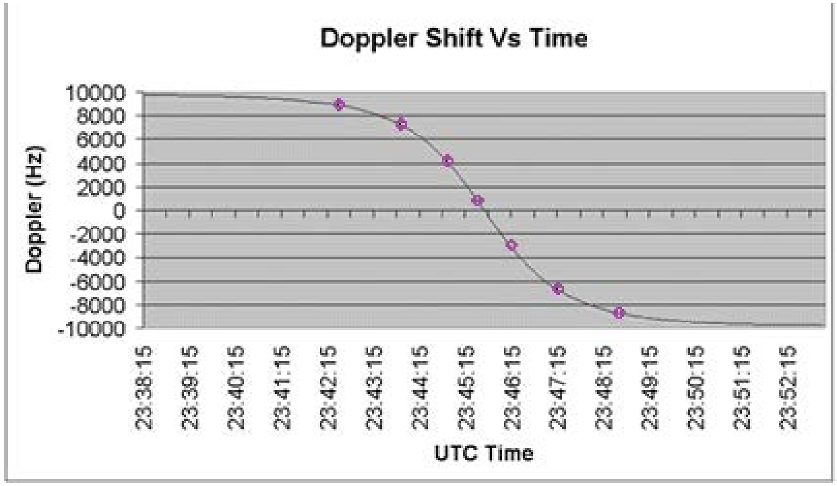


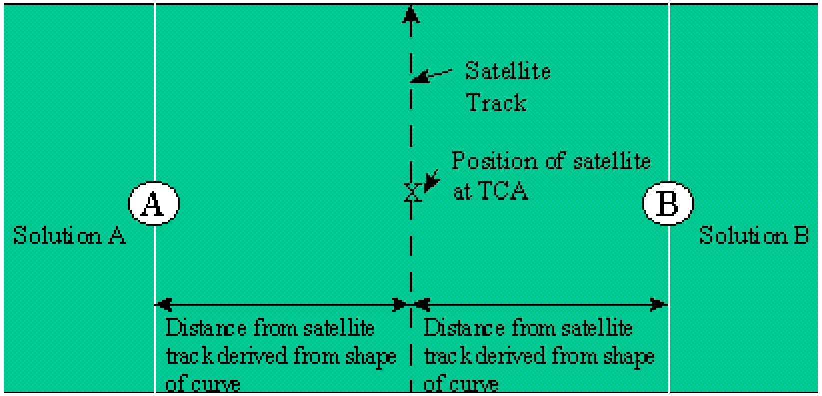
PRESENT LEOSAR SYSTEM
TWO MODES OF OPERATION



406 MHZ DISTRESS BEACONS AND LEO PROCESSING

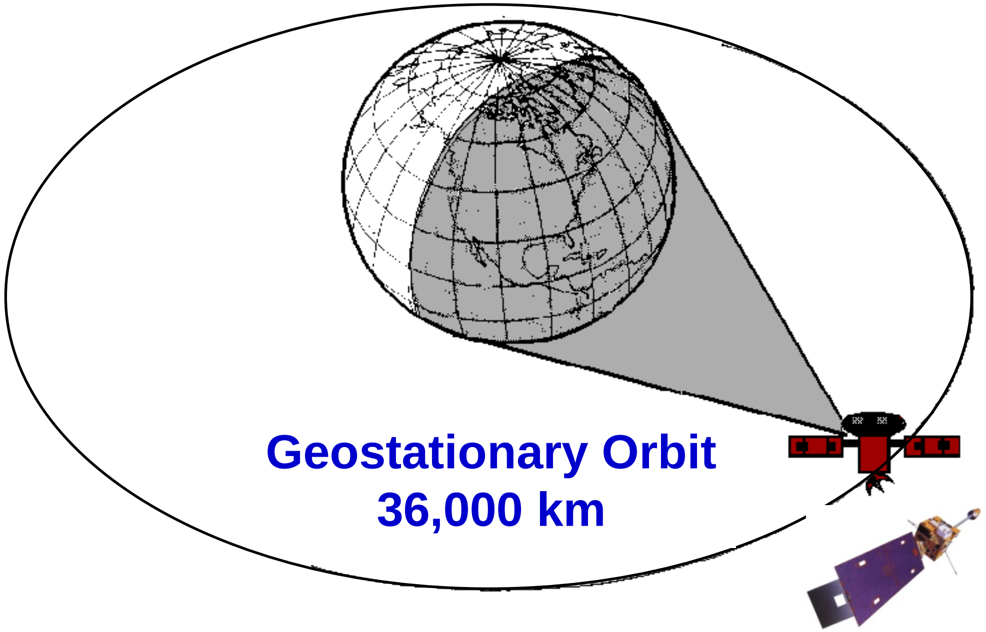
- Transmit signals: ½ second bursts, one burst every 50 seconds
- Each burst contains 120 bits of digital information
- The job of a LUT is to get the burst(s) relayed via satellite, and as possible, "independently" compute a location





PRESENT GEOSAR SYSTEM

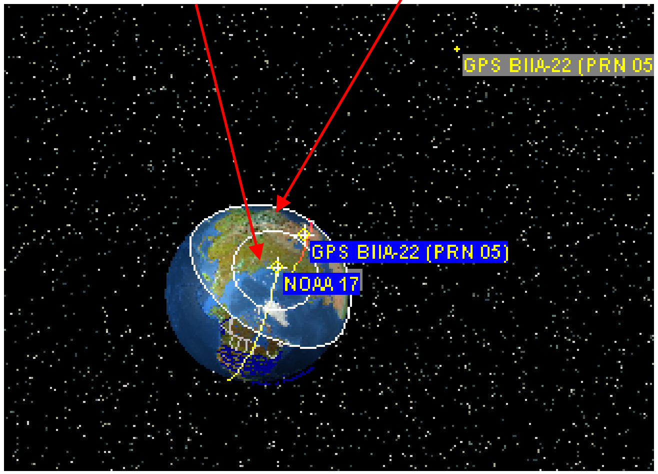
- 36,000 km high: Geostationary satellites relay transmissions from beacons
- GEOLUTs only “detect” alerts and repeat the digital message
- Large, fixed coverage areas
- With no relative motion between beacon and satellite there is no Doppler effect on signal to use for determining location
- Location is available only if beacon has a GNSS receiver chip and encodes the location in the beacon message



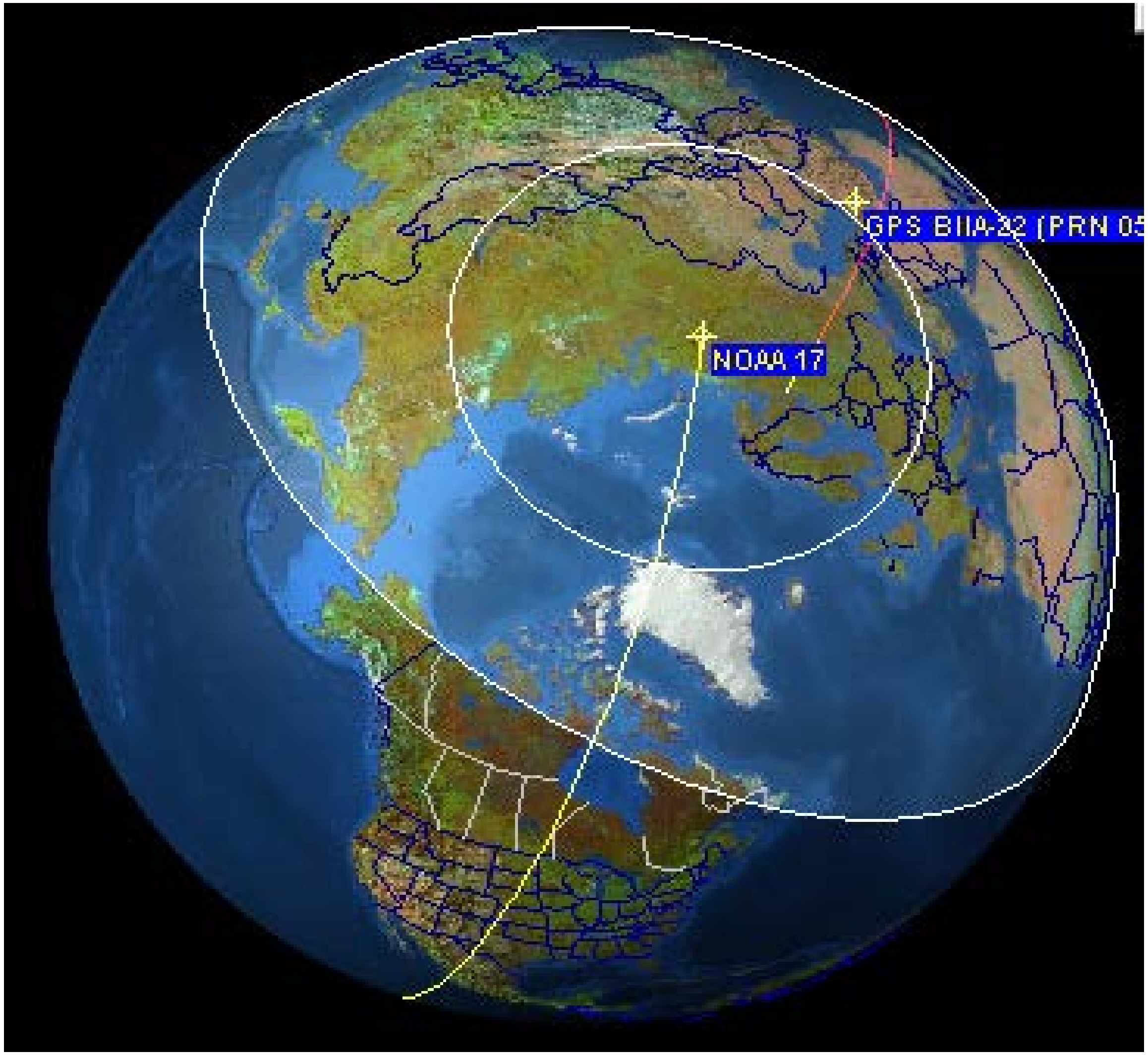
MEOSAR: AN IMPROVED SYSTEM CONCEPT

MEO sat at 20,000 km

LEO sat at 800-900 km



- 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 location produced within the beacon (and encoded within the beacon message)

- The actual methodology used by MEOLUTs is more complicated, 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, which leads to twice as many measurements and a more complex location generation algorithm (e.g., an iterative approach such as linear regression, which refines the location estimate until it converges)

- 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 generated captures both as Difference” of Arrival, or a DOA

MEOSAR – INDEPENDENT LOCATION (cont.)

➢ A major advantage of MEOSAR is that DOA locations can be generated from a single burst from a 406 MHz distress beacon

➢ In addition, a MEOLUT will combine data from multiple bursts, which improves accuracy

➢ 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 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)

➢ Although there is no precise requirement, MEOLUTs will generally reset the processing of multiple bursts at some practical interval (e.g., 10 or 20 minutes), which provides the benefit of improved location accuracy while respecting the potential that beacon could be moving

MEOSAR – INDEPENDENT LOCATION (cont.)

- Each MEOLUT independent location will be provided to the MCC with an expected horizontal error, 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

- The MCC in turn will forward this data to RCCs, SPOCs and other MCCs as per national agreements and the rules of the Cospas-Sarsat Data Distribution Plan (DDP), similarly, 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

- The MEOLUT location accuracy requirements for the near term 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 will be:
  - Single burst: 90% within 5 km (no 10 km criteria)
  - Multiple burst: 95% < 5 km and 98% < 10 km, within 10 minutes

- For the expected horizontal error, a given DOA position is expected to within that

MEOSAR – INDEPENDENT LOCATION (cont.)

- There are a number of factors that can affect the accuracy of a MEOSAR independent location, but the most important are:
  - The number of unique satellites for which burst data is received
    - Satellite in view of beacon and the MEOLUT (mutual visibility);
    - Whether or not the relay actually works (throughput); and
    - The geometrical position of the satellites (dilution of position – DOP)
  - The accuracy of the TOA measurements
  - The accuracy of the FOA measurements

- As a beacon position gets further away from the MEOLUT the number of mutual visibility satellites is reduced

- When satellites are at very low or very high elevation angles to the beacon, throughput is reduced (high angle degradation is due to beacon antenna patterns)

- Interference on the 406 MHz band impacts throughput and measurement accuracy, and stems in part from large satellite ground footprints as well as the characteristics of some MEOSAR repeaters

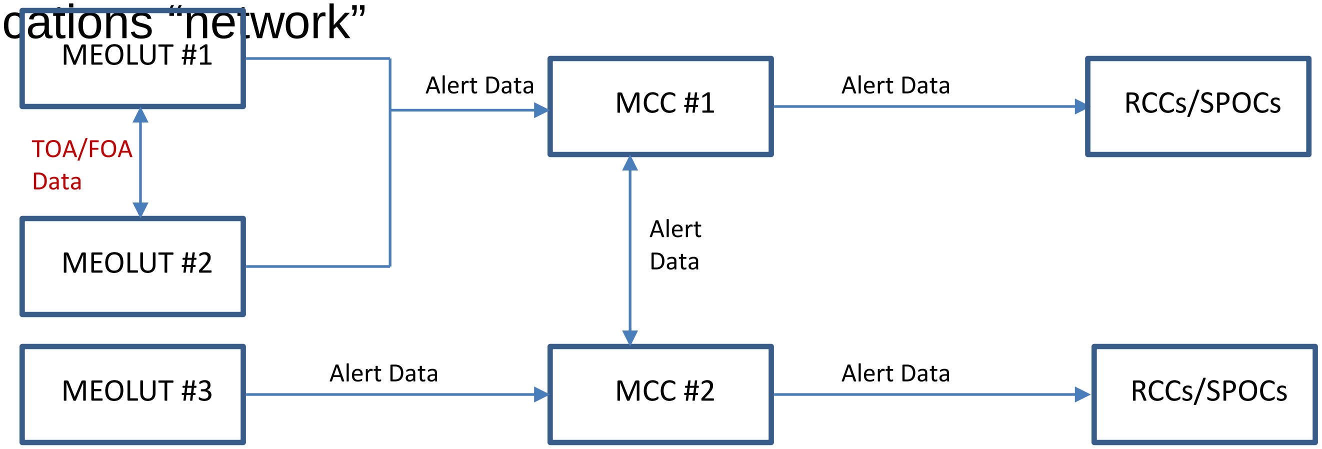
MEOLUT NETWORKING

- MEOLUT Networking refers to the exchange of TOA/FOA data “directly” between MEOLUTs, and is considered an additional capability

- The purpose of this data exchange is to enhance the performance of the MEOSAR system, specifically helping to compensate for:

    - A large distance between the beacon and the MEOLUT
    - Missed data 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 communications “network”



MEOSAR CAPABLE and LGM MCCs

- As always the key function of any MCC is to correlate data and reduce the output to the information deemed truly necessary for SAR to perform effectively and efficiently

- A MEOSAR Capable MCC operates in an experimental capacity, receives data from its National MEOLUTs (e.g., Hawaii, Florida) and other MEOSAR Capable MCCs, and performs functions very similar to a LEOSAR/GEOSAR MCC to distribute MEOSAR data to other MCCs, RCCs and SPOCs

- In the final stages of development and soon to be deployed for acceptance testing in the USA, a LEOSAR/GEOSAR/MEOSAR (LGM) MCC receives data from all three types of LUTs, and again correlates and uses all available information to confirm positions and provide the best possible information to SAR

- A few differences MEOSAR data introduces relative to LEOSAR:
    - No inherent ambiguity to resolve
    - Position confirmation is handled differently
    - Extra data may be sent while waiting for position confirmation

STATUS OF MEOSAR - INTERNATIONALLY

- The concept began in the late 90's, with a first major study commissioned by NASA in 2002 and started in earnest around 2005 with the C/S MEOSAR Implementation Plan

- A critical first step was the inclusion of a repeater on USA GPS satellites, built for other purposes, but that could be used to relay 406 MHz distress beacon signals (DASS)

- The USA and Canada built the first MEOLUT prototypes, with France and others close behind and by 2008 the "Proof of Concept" (POC) was under way

- In 2010 the MEOSAR Demonstration and Evaluation (D&E) Plan (C/S R.018) was written, and we are now moving toward the last phase of this effort which started February 2013

- There are currently 20 DASS satellites in use; 7 Galileo in orbit (in various stages of use and readiness); 1 GLONASS; about 10 experimental MEOLUTs and 8 MCCs

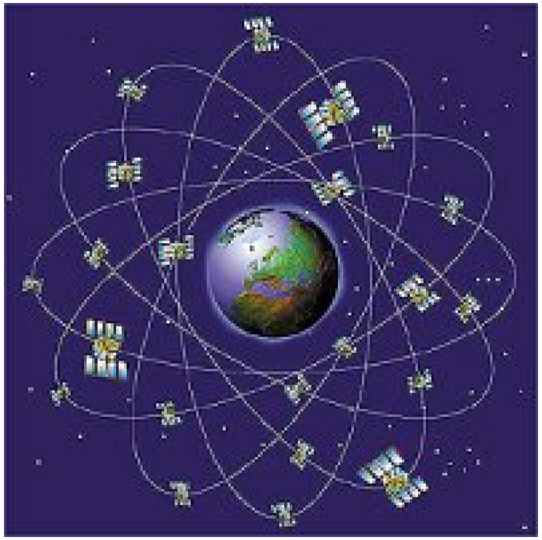
- The majority C/S System documents now account for or include MEOSAR

FUTURE MEOSAR SYSTEM FLEET

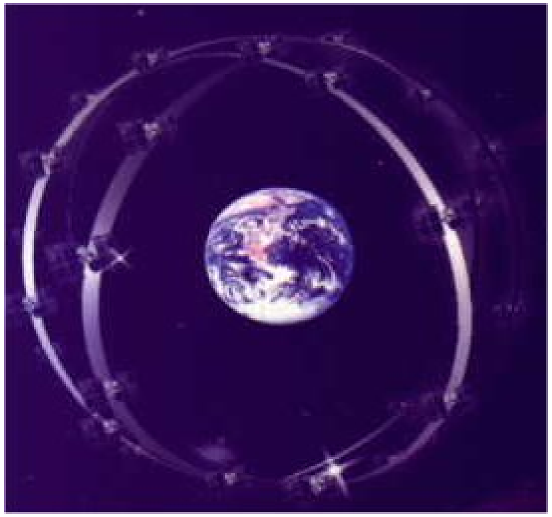
Three Global Navigation Satellite Systems

(each has plans for roughly 24 satellites)

GPS / USA



Glonass / Russia



Galileo / Europe

STATUS OF MEOSAR - USA

- NASA has an experimental MEOLUT, recently upgraded from 4 to 6 antennas
- Installation of the Hawaii MEOLUT (6 antennas) was completed in 2011
- Installation of the Florida MEOLUT (6 antennas) was completed in 2014
- The MEOSAR Capable MCC started operating in 2012
- All four components have and will continue to participate in the MEOSAR D&E
- While there were plans to start distributing MEOSAR alert data to USA RCCs (Pre-EOC/IOC), the transition to EOC is in place and these plans may be overcome by events
- As such, in March/April the USA Operational MEOLUTs, Hawaii and Florida, will be commissioned to EOC standards (less stringent than IOC and beyond)
- And, the new LGM USMCC will be commissioned by August (perhaps sooner), and distribution of LGM data to US RCCs and SPOCs will begin in earnest