SARSAT and Beacon Modernization

Beacon Manufacturer Workshop
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Today's Session

- Cospas-Sarsat evolution (4 slides)
- Comparison of LEOSAR, GEOSAR and MEOSAR systems and their effects on beacon design (14 slides)
- Encoded locations (1 slide)
- Beacon limitations and objectives (2 slides)
- New beacon process and timeline (2 slides)
- **SAR *requirements* for new beacons**

Requirements and Objectives???

- Manufacturers, what do you think…
  - …should be *required* of new beacons operating through MEOSAR to help SAR personnel or beacon users?
  - …should be *specified* for new beacons or the MEOSAR ground system to improve Cospas-Sarsat efficiency or effectiveness?

Cospas-Sarsat Milestones

- 1978-82: Experiment to locate beacons with satellites
- 1979: 1st France-Canada-USSR-USA MOU signed;
  406 MHz set aside by ITU for low-powered distress beacons
- 1982: First 121.5 MHz save
- 1982-85: LEOSAR D&E
- 1984: 1st 406 MHz save (Dec ‘84)
- 1985: LEOSAR declared operational
- 1987: C-S Secretariat established in London

Cospas-Sarsat Milestones (con't)

- 1988: ICSPA was signed to satisfy an IMO GMSS requirement for 'free and continuous availability of the satellite system on a non-discriminatory basis'
- 1993: 406 MHz beacons mandated by IMO
- 1995: 1st GEO satellites operating
- 1998: GEOSAR declared operational
- 1999: ICAO required 406 MHz ELTs
- 2005: Secretariat moved to Montreal
- 2006: IBRD established
- 2009: Satellite processing of 121.5 terminated

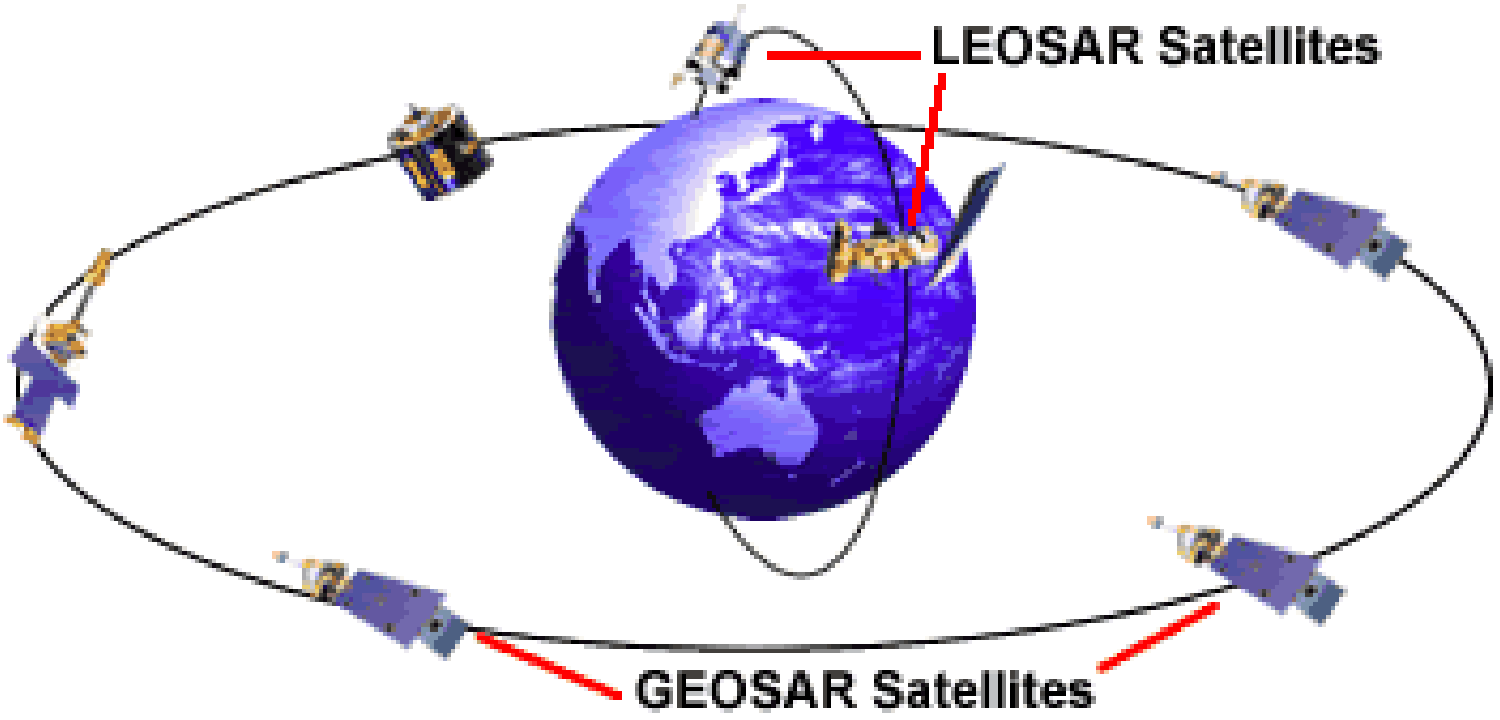
Cospas-Sarsat Milestones (Con't)

- Today: (950,000) 406 MHz beacons; 30 MCCs; 55 LEOLUTs; 21 GEOLUTs; *27,000+ lives saved (6,300+ in the U.S.)*
- Today: U.S. (GPS), Russia (GLONASS) and ESA/EC (Galileo) working to include 406 MHz repeater instruments on future Medium Earth Orbiting (MEO) satellite constellations
  - C-S *MEOSAR Implementation Plan* (R.012) approved
  - Proof-of-concept essentially complete
  - Constellations will be compatible with existing beacons
  - SAR components of constellations will be interoperable
  - MEOSAR D&E phase is about to begin

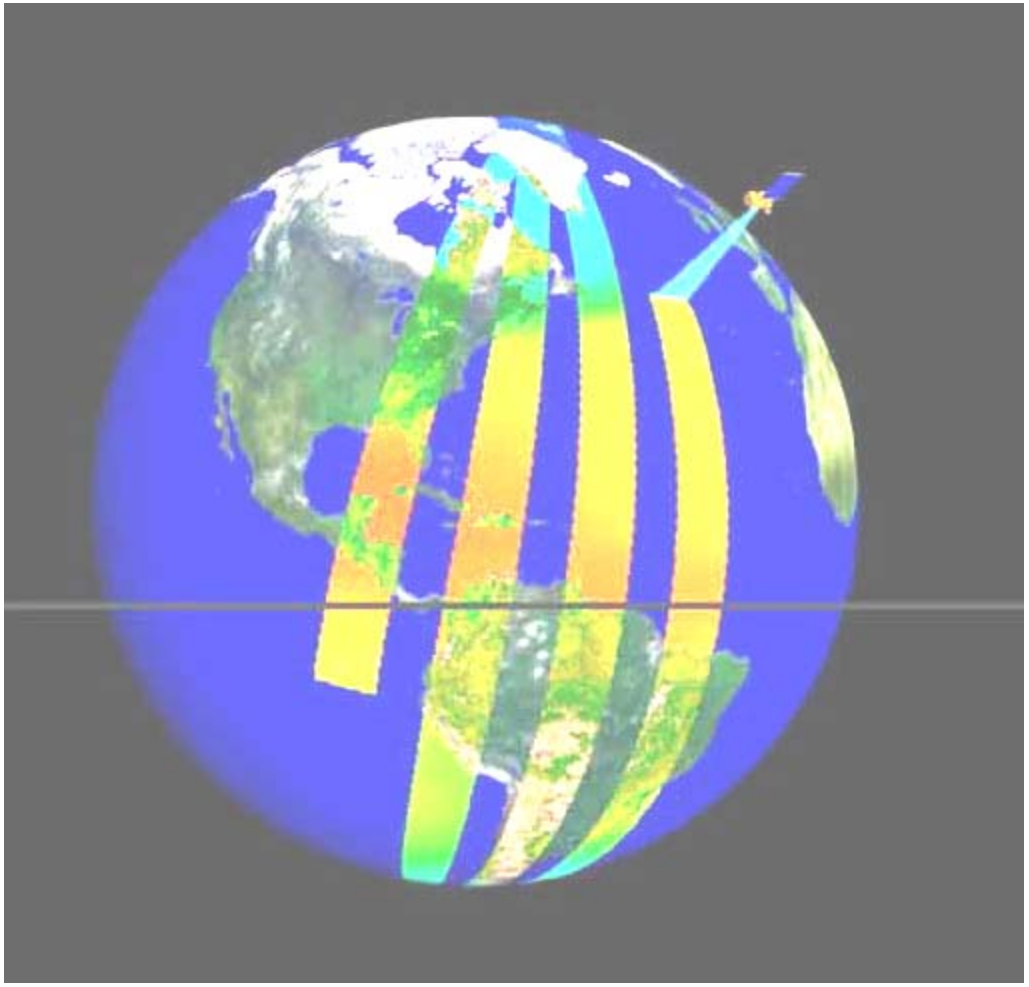
Cospas-Sarsat Milestones (Projected)

- 2010-11: *Requirements* definition for new beacons designed to operate through MEOSAR
- 2011-12: Cospas-Sarsat beacon/MEOLUT *specifications*
- 2012-13: IMO/ICAO/national beacon *standards* updated and beacons developed
- 2014-15: *New beacons* appearing on the market, MEOSAR D&E will be completed, 98% of the Earth will be covered with *MEOLUTs* and 'full constellation' of *satellites* will be operational
- 2018: MEOSAR will be declared '*fully operational*' and beacon population will approach 2.1 million
- 2022: *LEOSAR* might be no longer in operation by this time

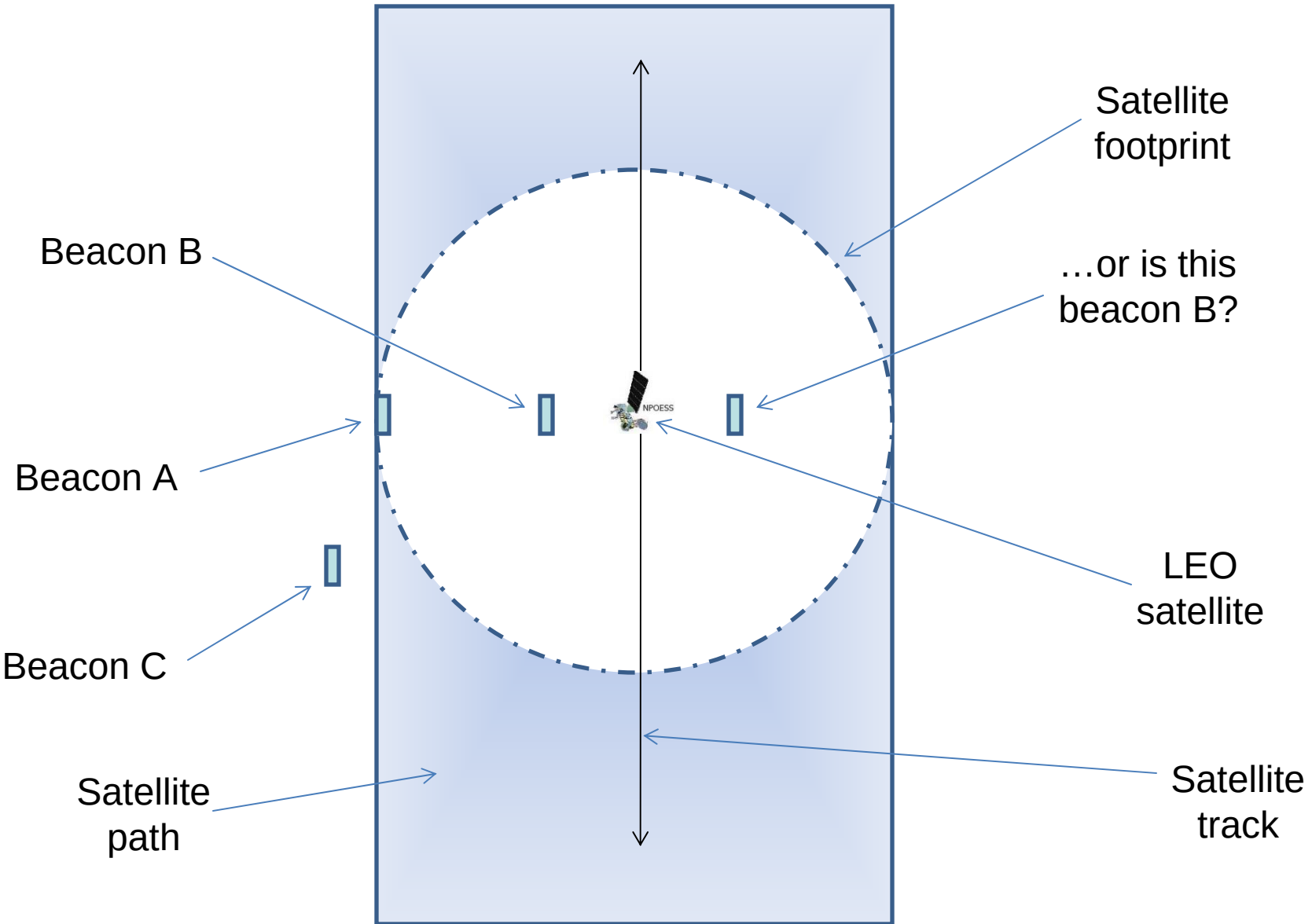
Combined LEOSAR/GEOSAR



LEO satellite ascends and descends between the Earth's Poles while the Earth revolves below

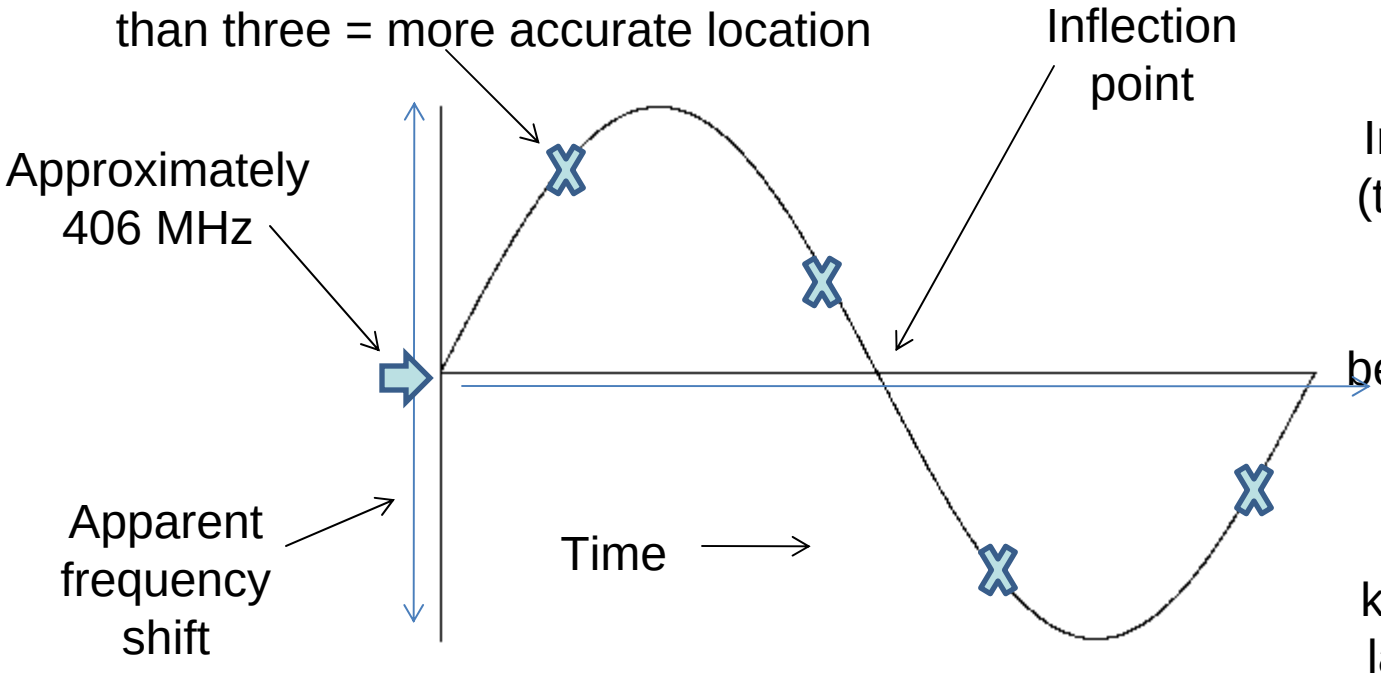


LEO Satellite Pass



Doppler Processing

Beacon burst…need at least three to define curve…less than three = no location…more than three = more accurate location



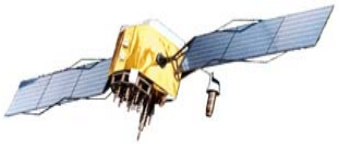
Inflection point (time of closest approach of satellite to beacon) used to determine latitude… same as known satellite latitude at that time

NOTE: this process requires a very stable beacon oscillator…factor in high cost of current beacons.

Shape of curve used to determine longitude by estimating distance from known satellite track…results in a real location and an ‘image’

Unlocated GEO alert if beacon is not near the North or South Poles + LEO delay waiting for a satellite to pass within view

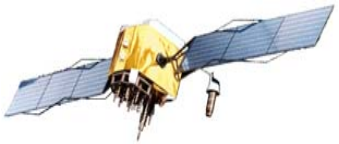
406 MHz Beacons



406 MHz
Beacons

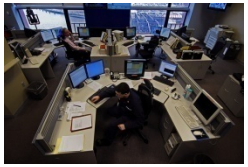
LEO with delay if no ground station in view

LEO with potential unlocated alert or possible delay to determine which of two locations is real



406 MHz Beacons

SAR Resources



RCC

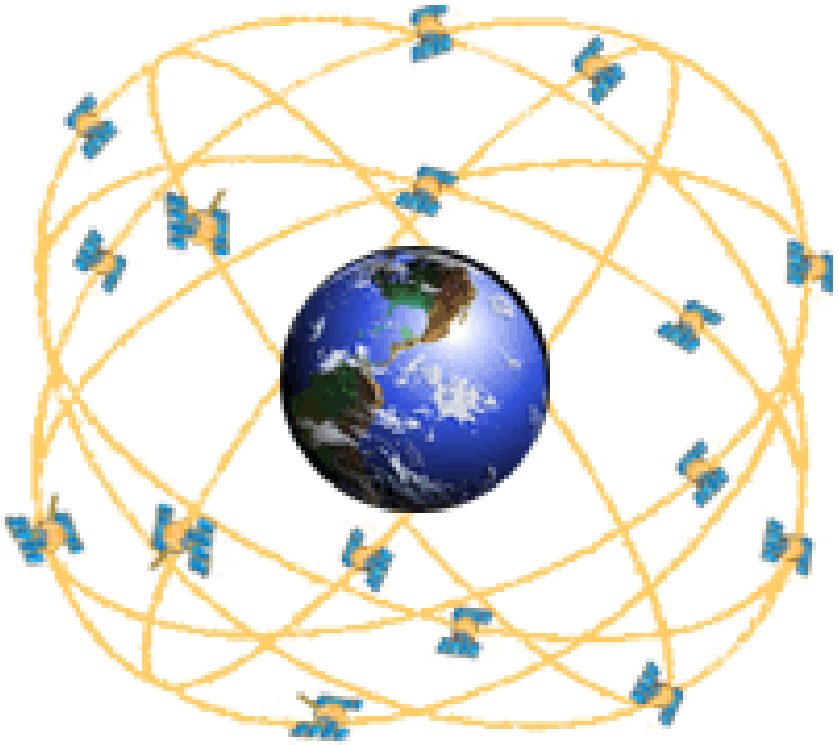
USMCC (NOAA)

2 U.S. Ground Stations

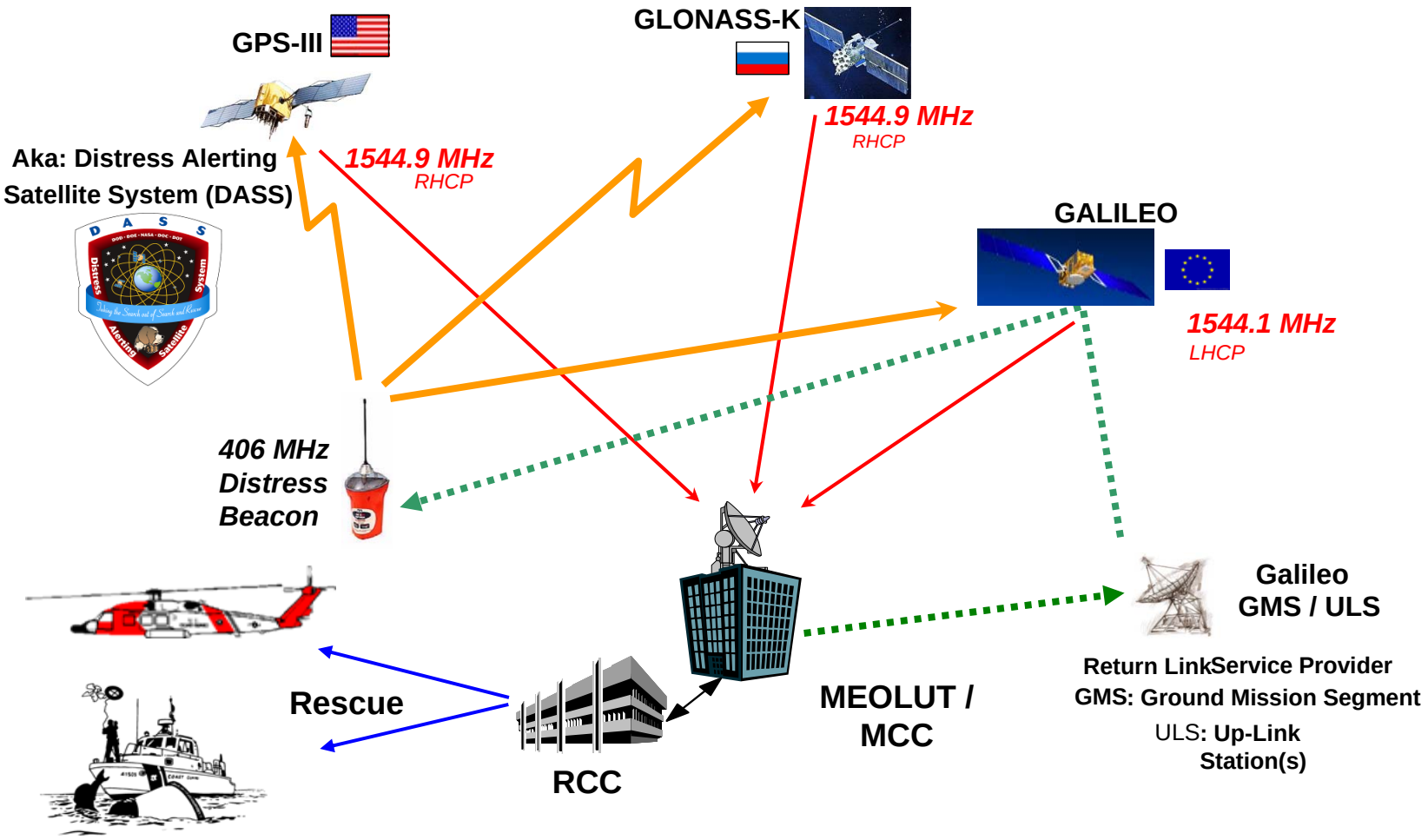
LEO-GEOSAR Limitations/Concerns

- Non-continuous *coverage* for located alerting
- Sub-optimal *probability of detection* of beacons
- Need for *at least three bursts* for a location during what could be a short satellite exposure time
- Frequent dependence on *low elevation* satellites
- Need for very precise beacon *oscillators* to support Doppler locating and ambiguity resolution…one cost driver for beacons
- Long average *time to deliver* located alerts

Generally what the MEOSAR constellation will look like*…except with up to 75 + satellites instead of 16*



MEOSAR System Concept



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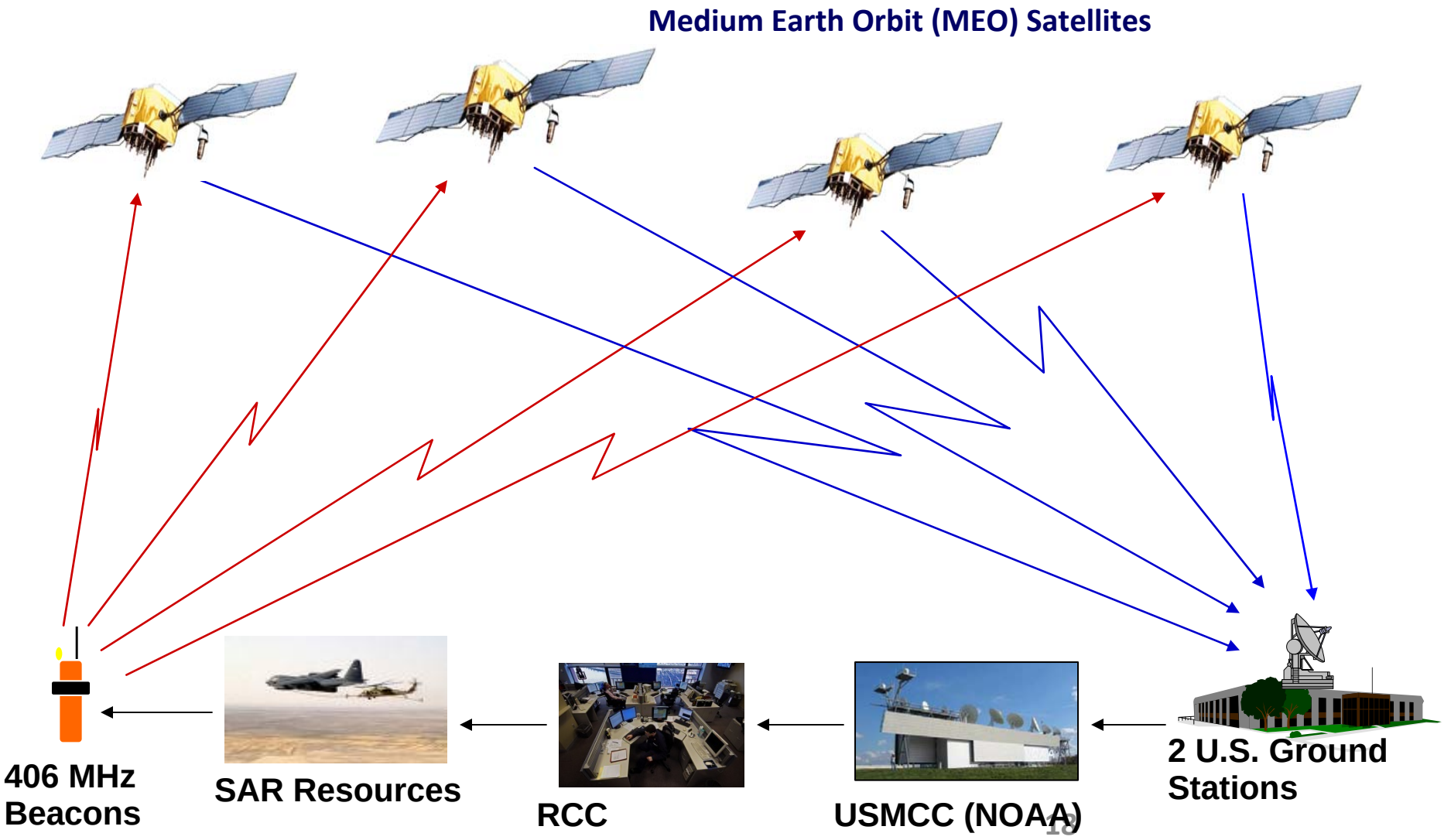
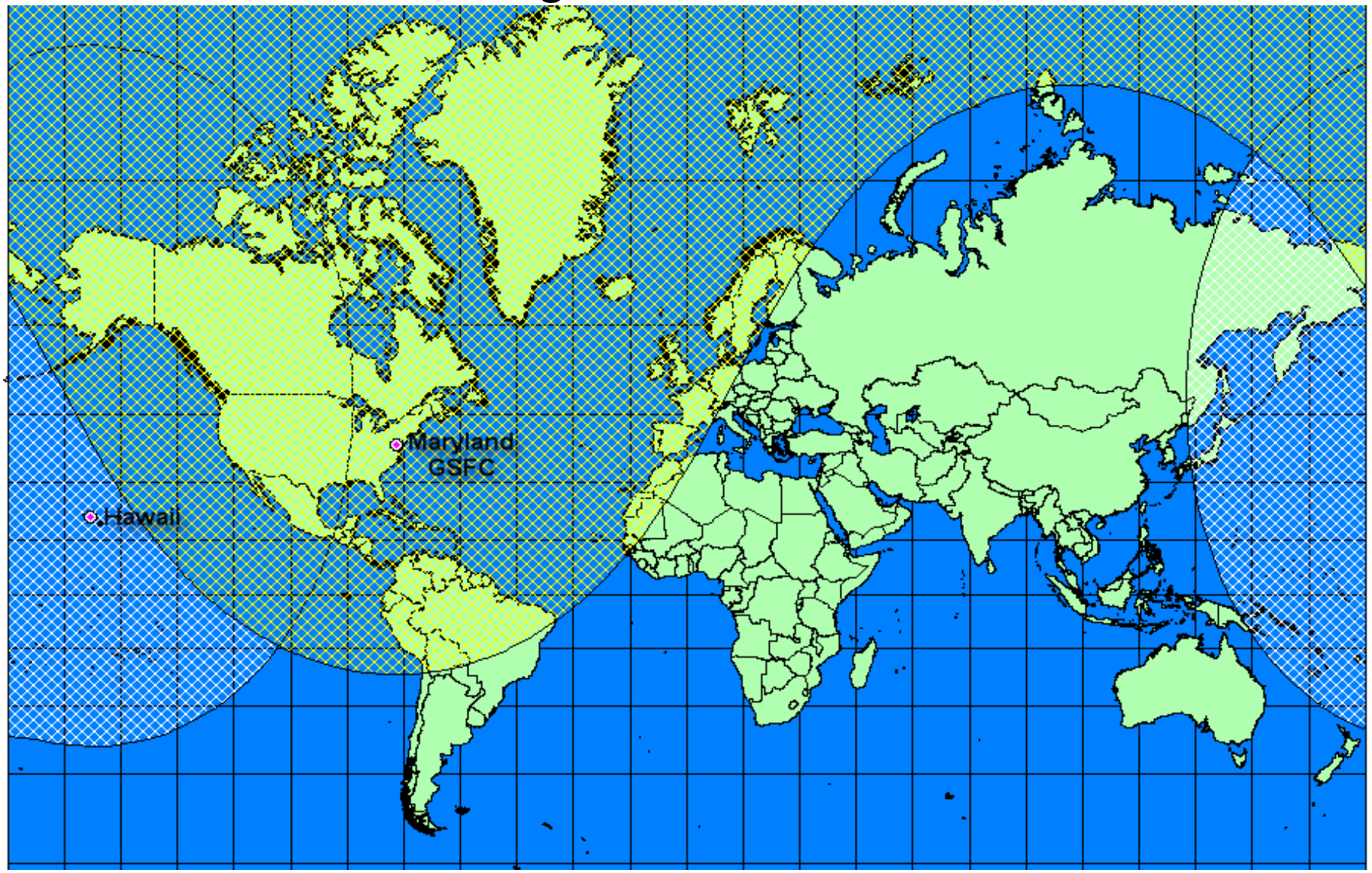


MEOSAR Coverage with Two Ground Stations



MEOSAR Characteristics

- More than ten times as many satellites as LEOSAR providing continuous global coverage
- Optimum satellite altitudes with larger footprints
- Single beacon burst locating
- Better accuracy
- Single location per beacon signal (no ambiguity)
- Better probability of detection
- System located alerts delivered in less than ten minutes (hopefully < five minutes)

Cospas-Sarsat Satellite Constellations

	LEOSAR[1]	GEOSAR[1]	MEOSAR
Number of satellites:	6	5	about 75
Altitude (km/miles)	1,000 (620)	35,900 (22,300)	19,140 – 23,222 (11,900 – 14,400)
Earth orbit time	90 – 100 minutes	24 hours	676 – 845 minutes
Satellite footprint (% Earth surface)	6%	43%	37 - 39 %
System Locating Technique	Doppler	N/A	TDOA and FDOA[4]
Satellite instruments	Store and forward[2]	'Bent pipe'[3]	'Bent pipe'[3]
Satellite Orbits	Polar orbits	Above the equator	Multiple planes inclined between 55 - 64.8 degrees from the equator

[1] Current Systems

[2] Holds data until the satellite is within view of ground station

[3] Relays data immediately, so coverage is lost if no ground station is within view of the satellite

[4] Time difference of arrival (TDOA) and frequency difference of arrival (FDOA)

Encoded Locations

- Some beacons can acquire and transmit GPS locations; these are called *location protocol beacons*
- GPS locations are much more accurate than locations determined by LEOSAR, but also much less reliable (only 70 % of alerts from LPC beacons include the GPS location)
- When alerts include encoded locations, LEOSAR, GEOSAR and MEOSAR can all relay the data

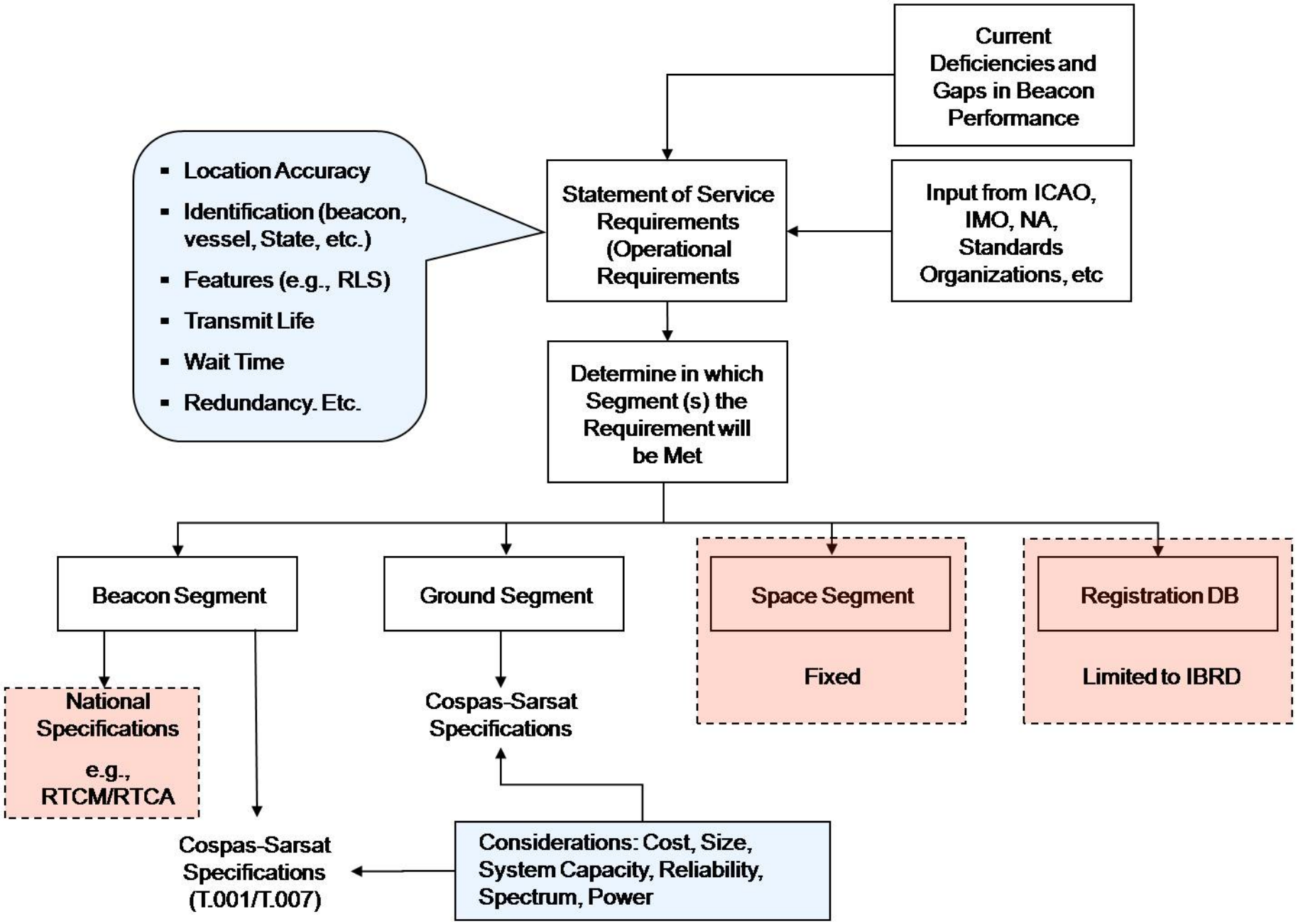
Beacon Limitations/Concerns

- *Beacon cost, size and weight*
- Power hungry…beacon needs a *battery* able to produce 1,728 five watt signals every 24 hours plus support homing signals and other functions
- Mix of complex *coding* protocols
- Sub-optimal *for 406 MHz homing* (e.g., non-continuous signals)
- Many beacons do not acquire and send *encoded locations*
- *Transmissions* of 406 and 121.5 MHz signals are both compromised by sharing an antenna
- Communications are o*ne-way*

Beacon Modernization Objectives

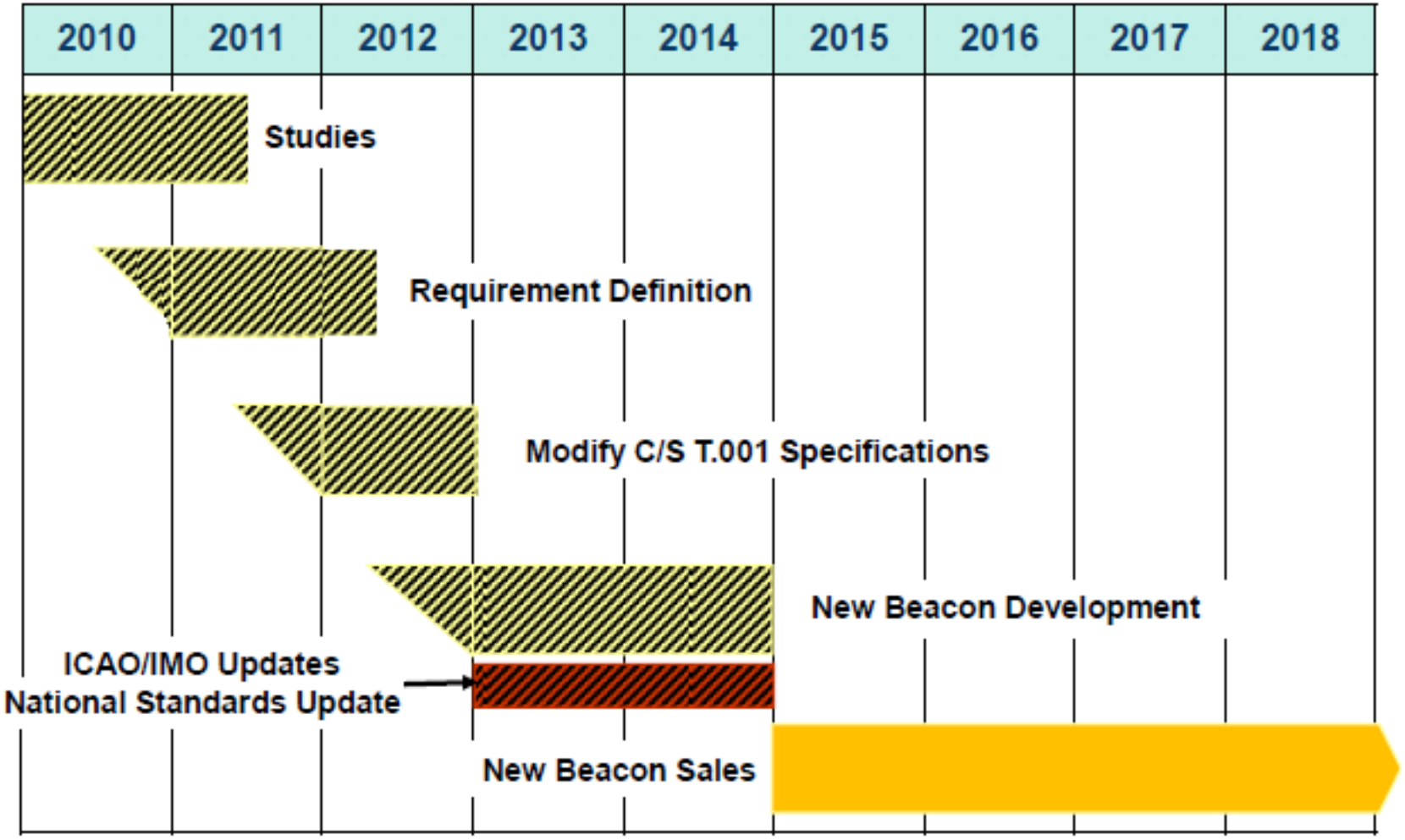
- Overcome *limitations* of current 406 MHz beacons operating through the LEOSAR-GEOSAR system
- Identify operational '*requirements*' of SAR personnel and beacon users…things they need or want…for new beacons operating through MEOSAR
- Develop Cospas-Sarsat and other national and international *standards* for new beacons and for the MEOSAR ground system that match the 'requirements'
- Expand *beacon usage* within communities that should use beacons
- Dramatically improve Cospas-Sarsat *performance and capabilities*

Development of New Cospas-Sarsat Beacons for MEOSAR



Beacon Implementation Timeline

Source: Joint Committee Document JC-24/8/3 (Canada)



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