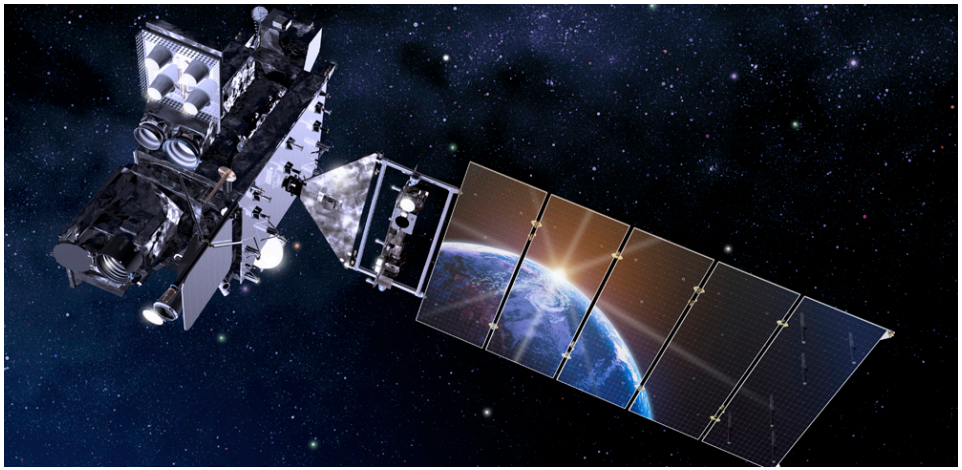
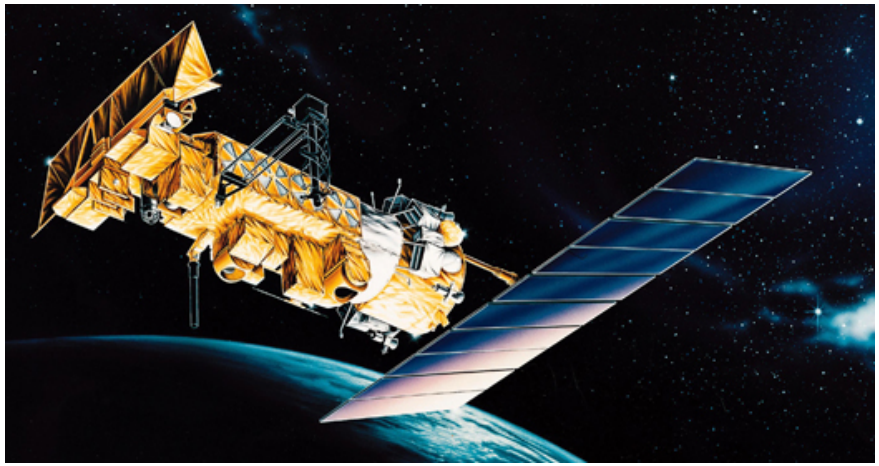
US SEARCH AND RESCUE SATELLITE AIDED TRACKING (SARSAT) Program





SARSAT SPACE SEGMENT OVERVIEW

Mickey Fitzmaurice
NOAA SARSAT Satellite Systems Engineer

SAR Controllers Workshop 2018

Introduction/Presentation plan

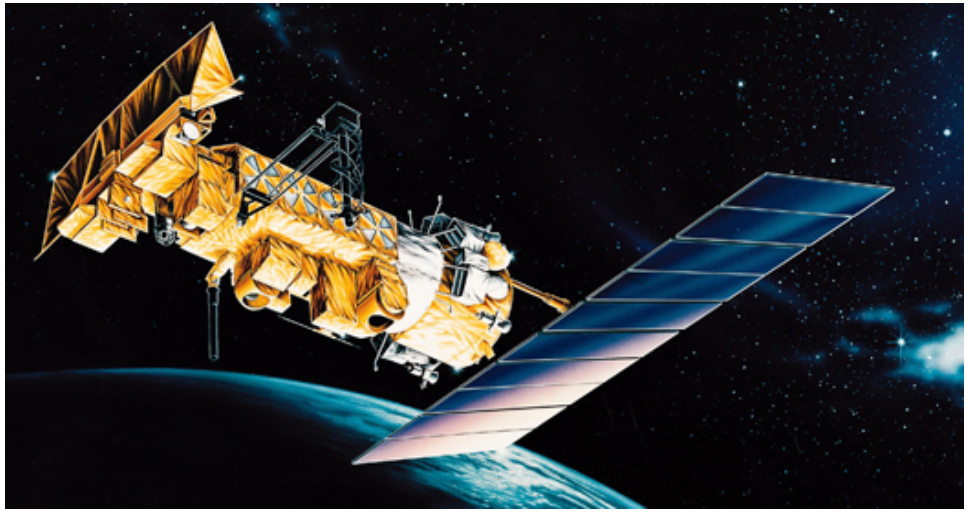
- **Highlight US operated Search and Rescue Satellite Aided Tracking (SARSAT) capable satellites**
- **Explain the SARSAT Space segment and the on-board instruments used for distress detection/relay**
- **Highlight the Advantages of each satellite system**

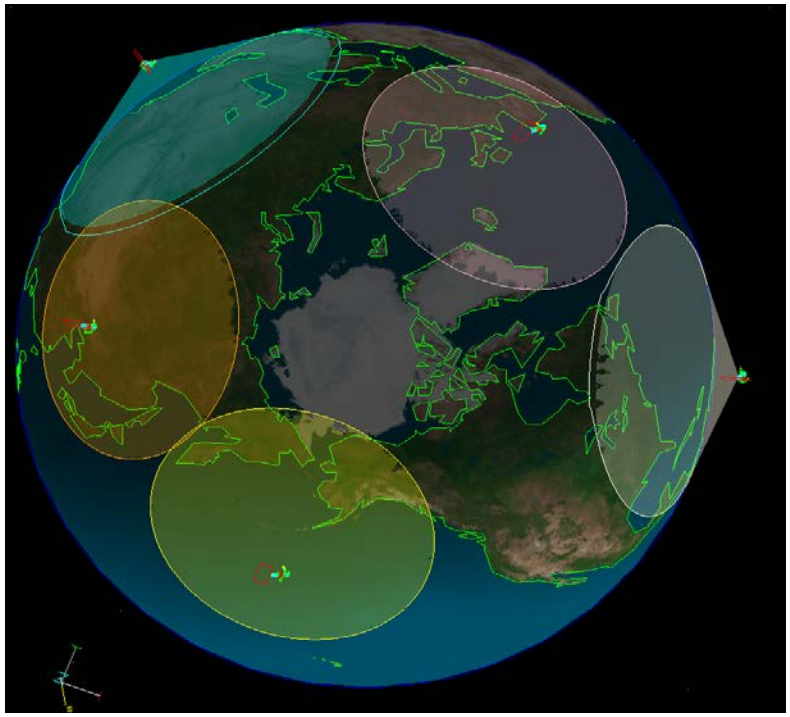
Satellites Types

There are 3 types of operational satellites used by SARSAT:

1. **The US is currently operating 5 Low-Earth orbiting (LEO) satellites**

Each satellite is orbiting at an altitude ~ 850 km has ~ 6% Instantaneous Field of View Coverage on the Earth & completes ~14 orbits/day, covering every location on the earth at least twice.

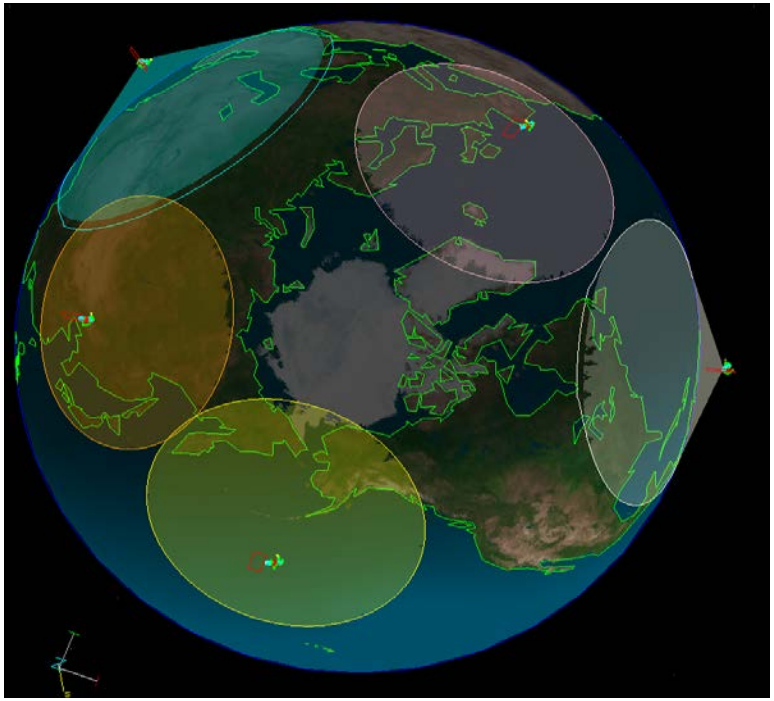




Satellites Types (cont.)

2. The US currently is operating 20 Medium Earth Orbiting (MEO) satellites

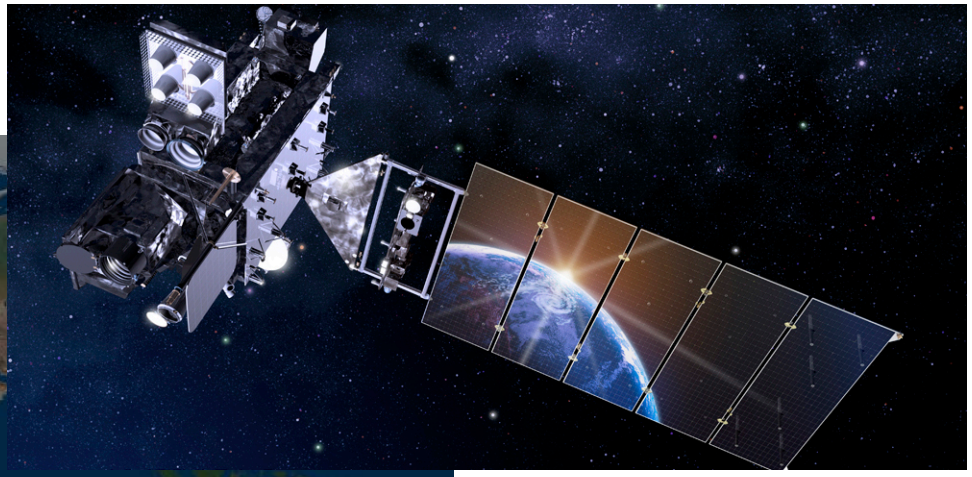
Each satellite is orbiting at an altitude ~ 20000 km & has ~ 33% Instantaneous Field of View Coverage on the Earth & completes ~2 orbits/day. Constellation size ensures that ALL areas of the earth are covered in real-time!

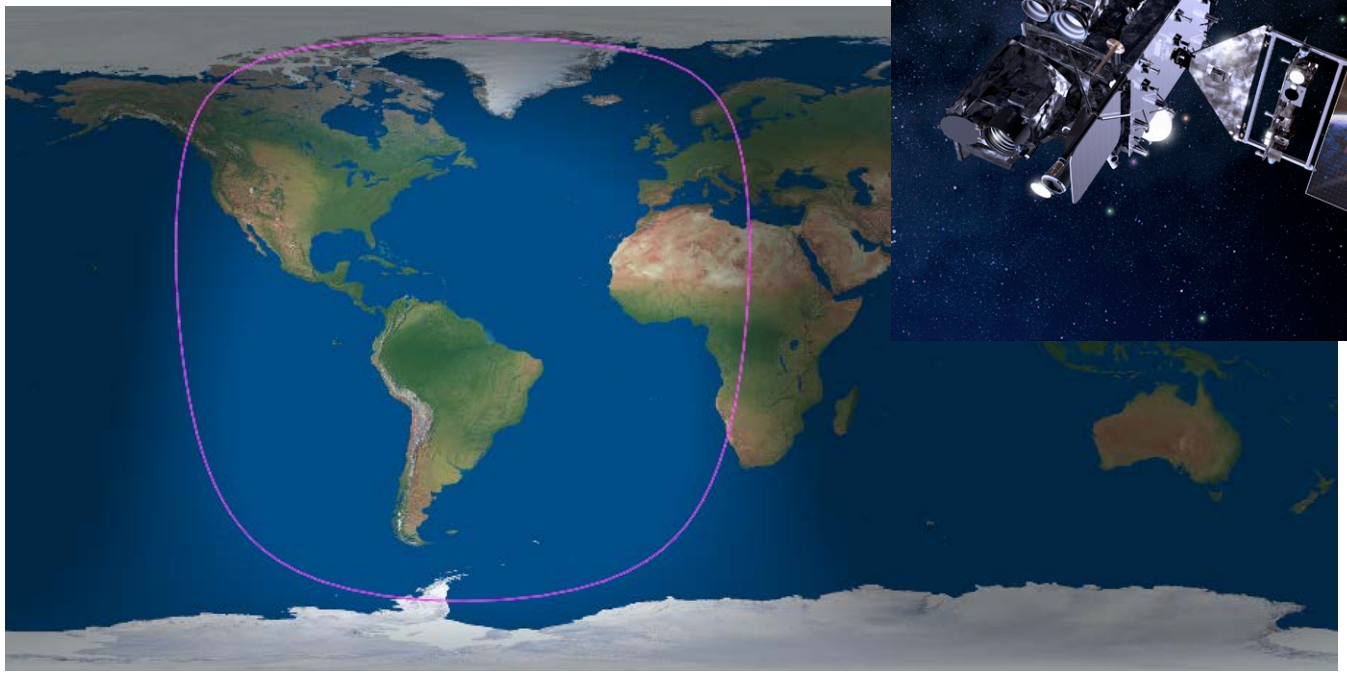


Satellites Types

3. The US currently operates 2 Geosynchronous Earth orbiting (GEO) satellites

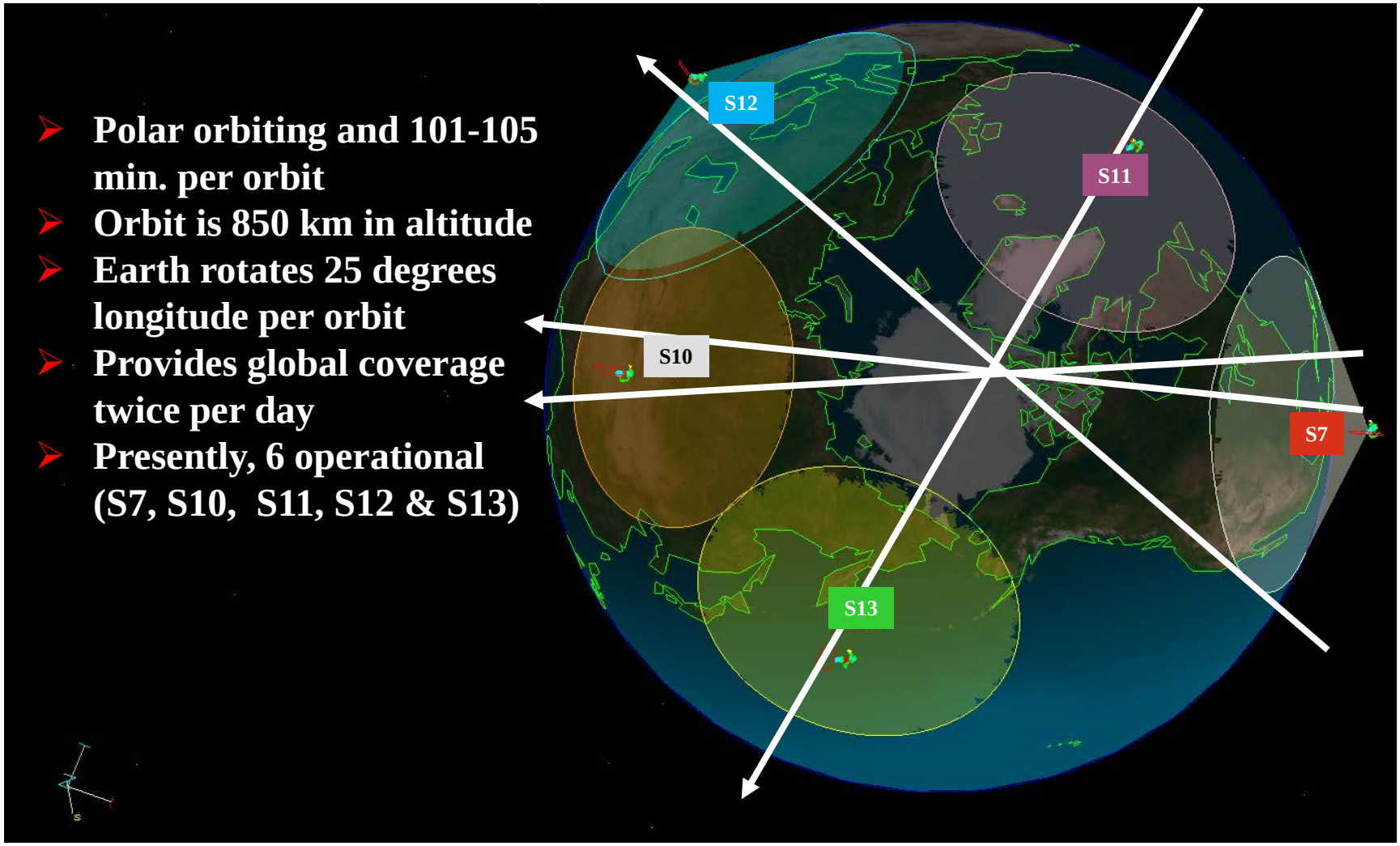
Each satellite is orbiting at an altitude ~ 36000 km
& has ~ 40% Instantaneous Field of View
Coverage on the Earth & completes ~1 orbits/day.





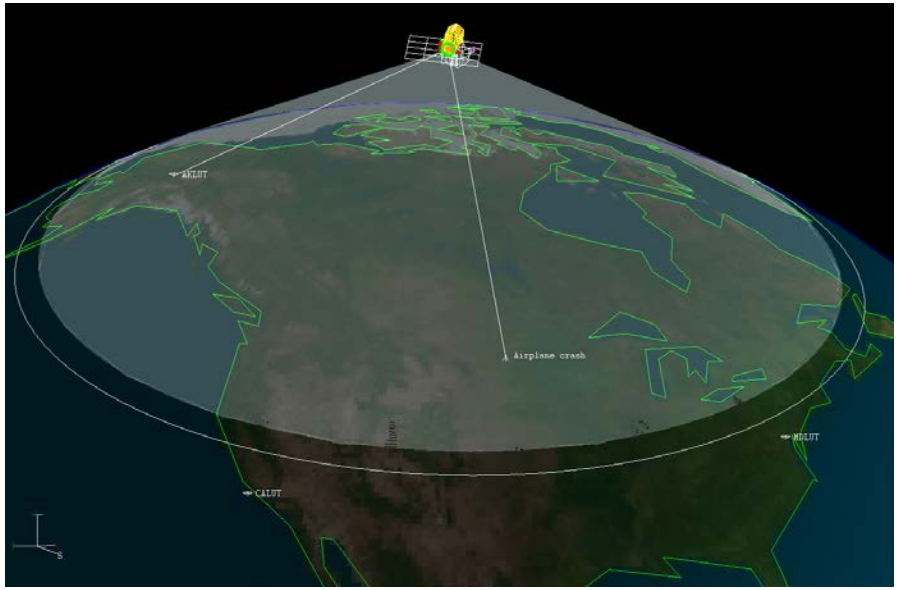
Current LEOSAR Satellites

- Polar orbiting and 101-105 min. per orbit
- Orbit is 850 km in altitude
- Earth rotates 25 degrees longitude per orbit
- Provides global coverage twice per day
- Presently, 6 operational (S7, S10, S11, S12 & S13)



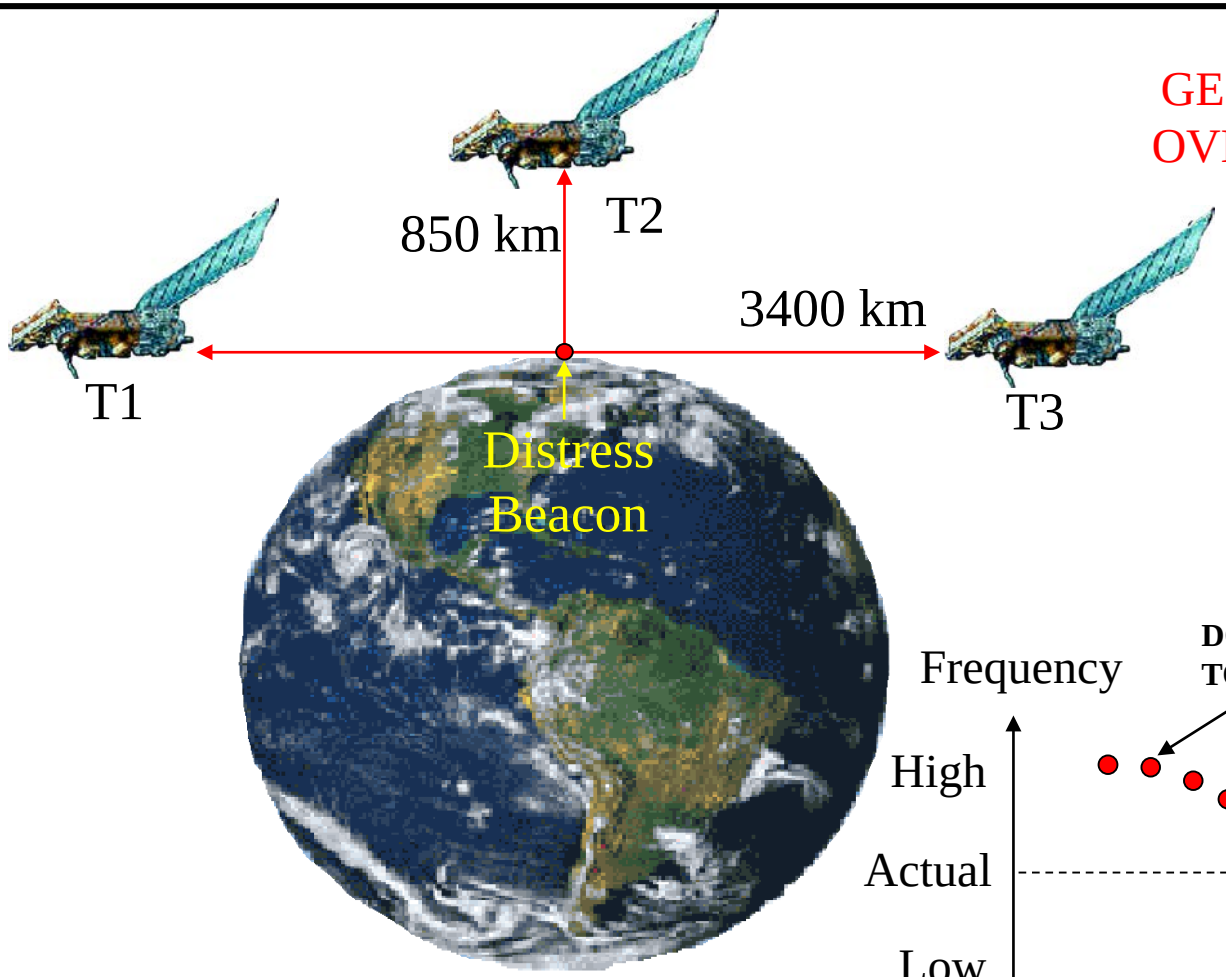
LEOSAR Payloads and concepts

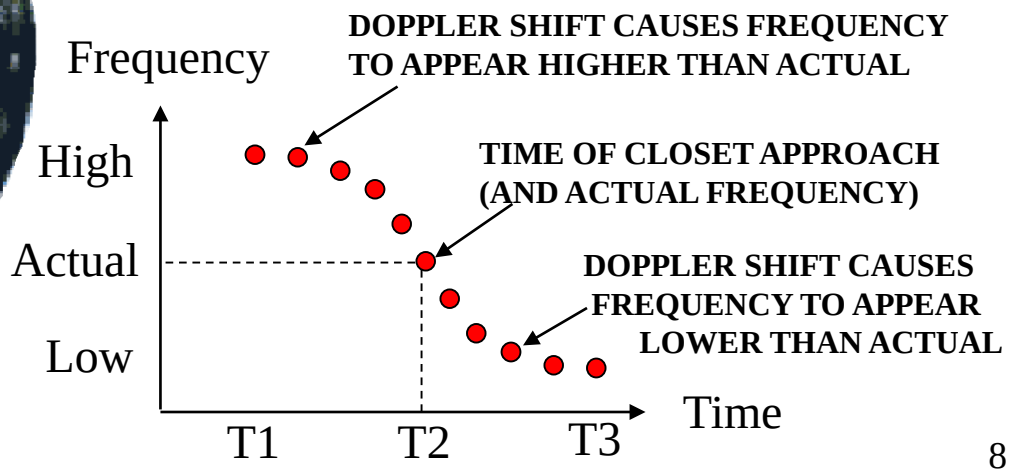
- **Search and Rescue Repeater (SARR)**
  - **Receives 406-406.1 MHz frequency band, then re-transmits band centered at 1544.5 MHz (RHCP).**
  - **No on-board position processing is performed.**
  - **To compute a position, a LEOLUT must be "mutually visible"**



- **Search and Rescue Processor (SARP)**
  - **Digitally extracts the beacon ID, Measures the signal's carrier frequency and time tags the measurement**
  - **Immediately puts the received 406 MHz beacon uplink message into the continuous 2.4 kbps memory data stream downlink transmission (separate from the SARR Tx signal) and memory contents are completely transmitted on a continual basis (about every 3 minutes)**
  - **Once SARP memory is completely filled, oldest data is purged as new is received**

Determining Beacon Locations From LEO Doppler Data





Resolving Ambiguity

Two Pass Solution for a Beacon Located in Brazil

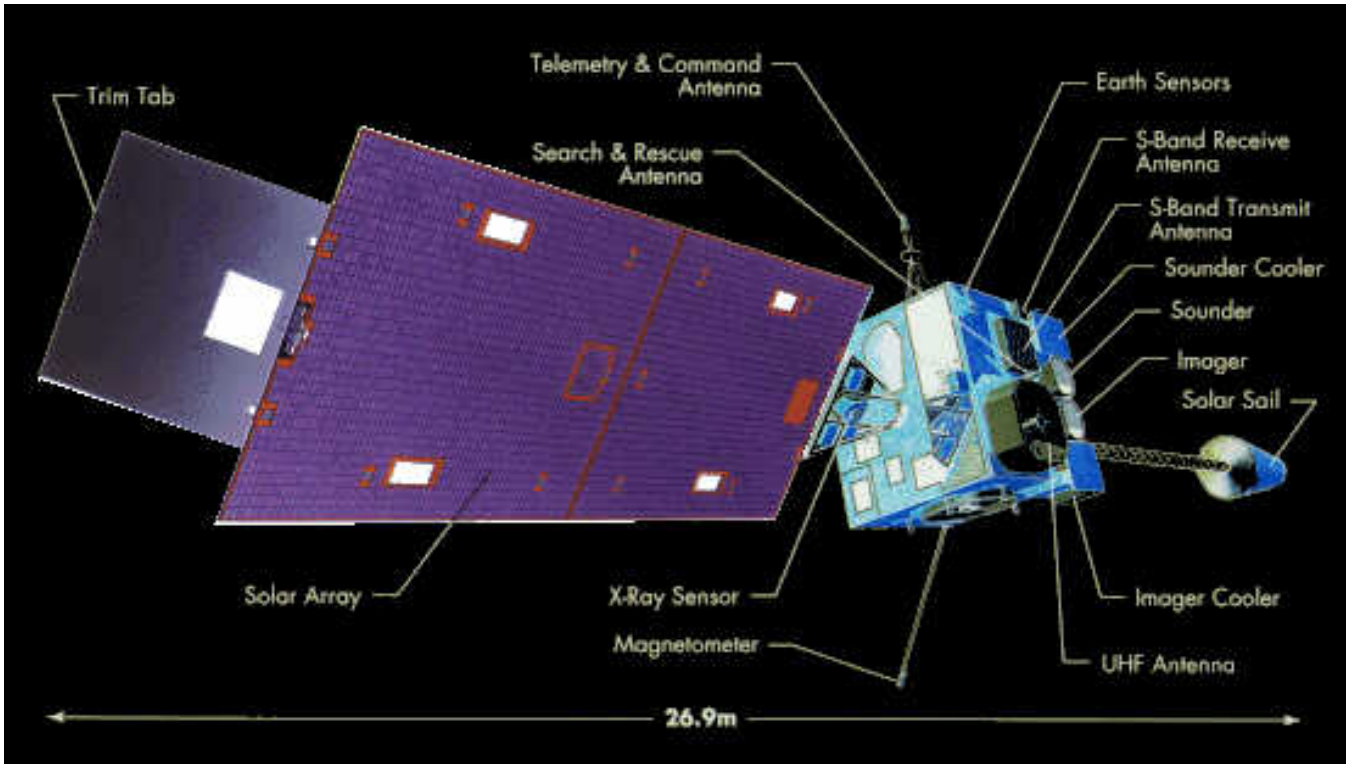
LEGEND: 1 2 ground tracks of successive spacecraft orbits

1A, 1B Real and Image solutions from pass 1

2A, 2B Real and Image solutions from pass 2

NOAA GEO Satellite

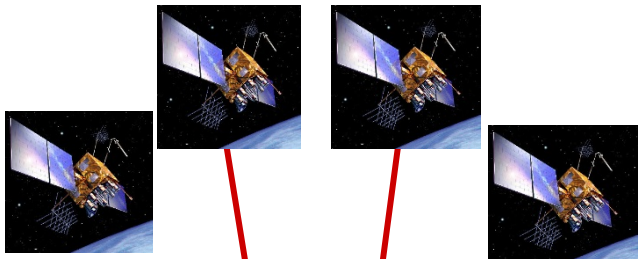
Geostationary Orbiting Environmental Satellite (GOES)



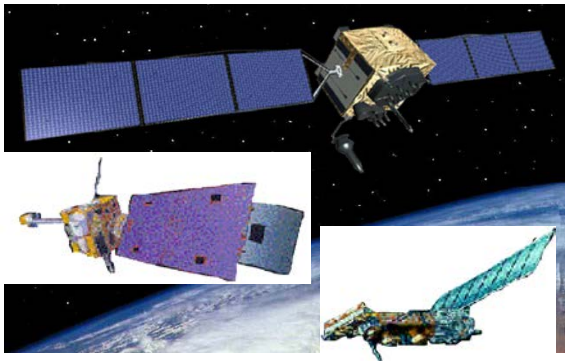
UHF Antenna receives 406-406.1 MHz signals and GOES Search and Rescue Repeater (SARR) retransmits band down via S&R antenna centered at 1544.5 MHz (LHCP)

Use of GPS in Location Protocol Beacons

4 GPS Satellites



406 MHz Message with Embedded GPS location



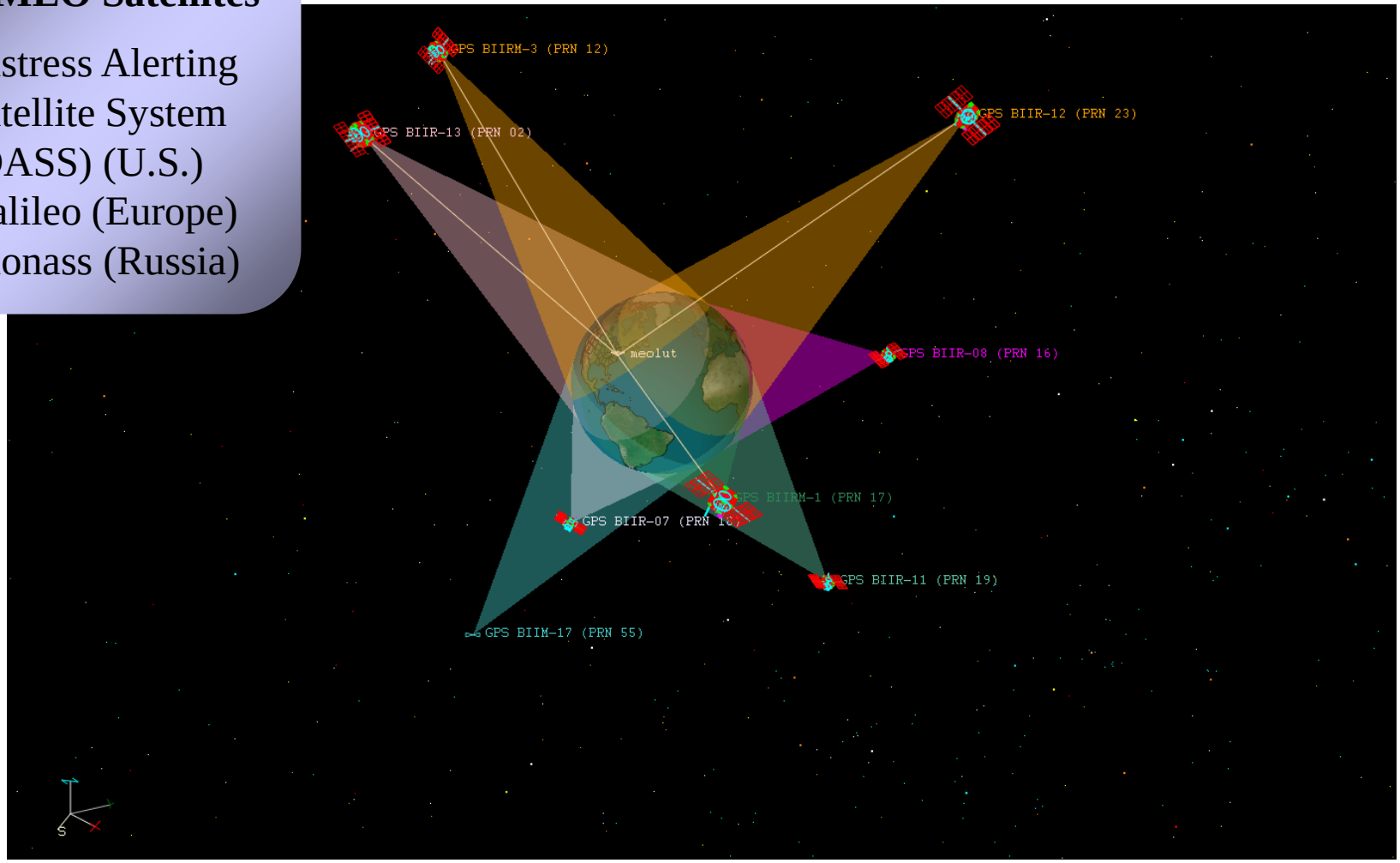
Any C/S Satellites

LUT

MEOSAR

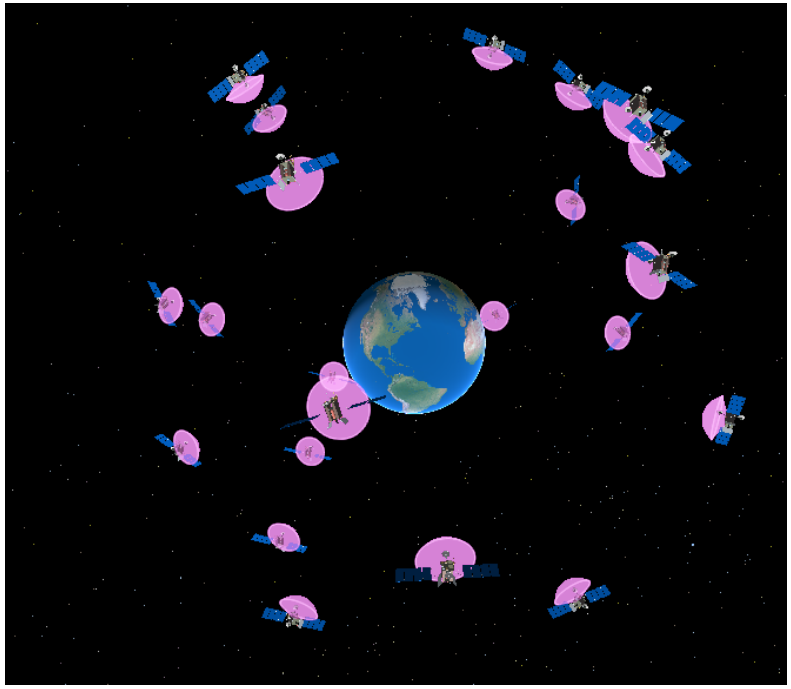
C/S MEO Satellites

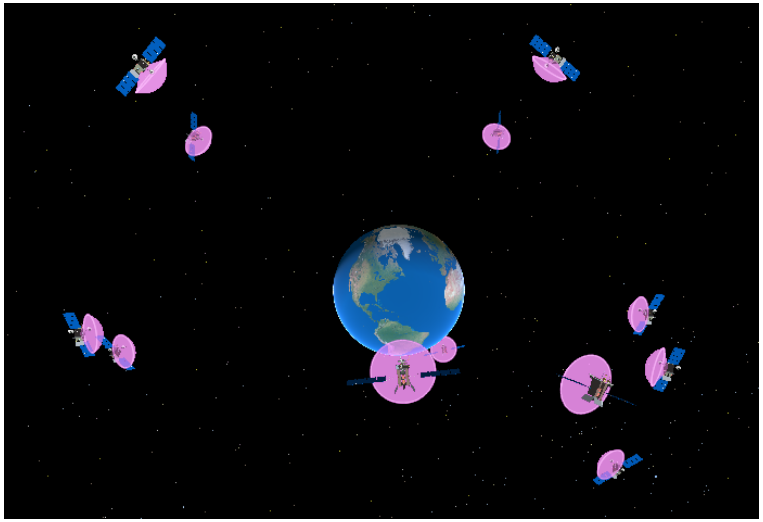
- Distress Alerting Satellite System (DASS) (U.S.)
- Galileo (Europe)
- Glonass (Russia)



Number of MEOSAR satellites

Currently there are 22 GPS w an Experimental DASS payload w a S-band downlink (20 functional)

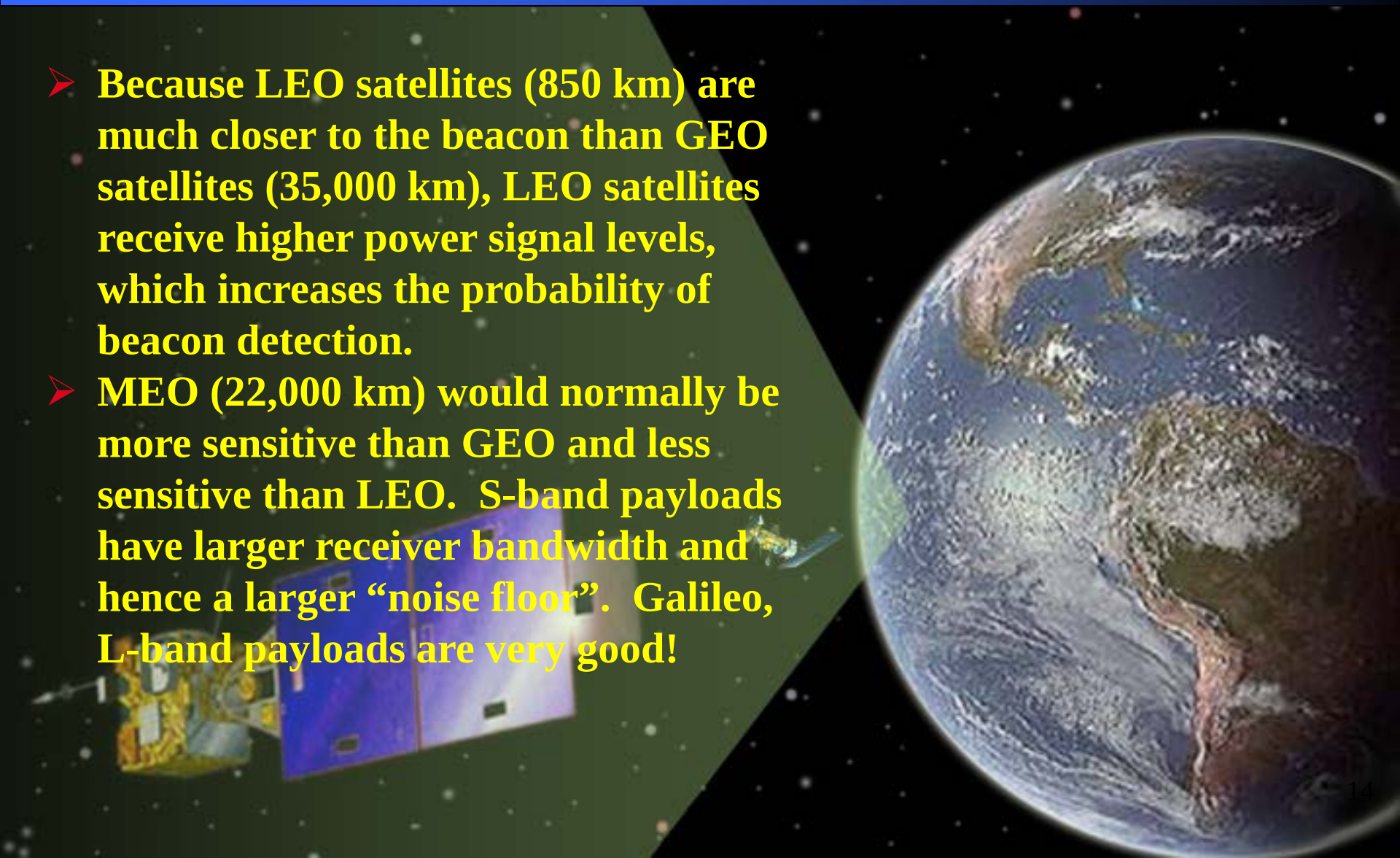




There are now14 Galileo w an L-band SARR payload (10 in use by US)

Beacon Power Levels with Distance

- Because LEO satellites (850 km) are much closer to the beacon than GEO satellites (35,000 km), LEO satellites receive higher power signal levels, which increases the probability of beacon detection.
- MEO (22,000 km) would normally be more sensitive than GEO and less sensitive than LEO. S-band payloads have larger receiver bandwidth and hence a larger “noise floor”. Galileo, L-band payloads are very good!



Advantages of LEOSAR System over the GEOSAR System

- **LEOSAR *independently* computes beacon locations using Doppler shift processing. GEOSAR system does not have Doppler capability only , i.e., locates 406 MHz beacons whereas GEOSAR system only detects and if GPS encoded, but how recent?**
- **LEOSAR provides a global coverage "over time" for 406 MHz. GEOSAR system does *not* cover the polar areas, >70 degrees.**
- **LEOSAR provides improved detection probability for obstructed and moving beacons, e.g., ship housings, waves, etc.**
- **LEOSAR has higher link margin, which increases the probability for low power beacon detection.**

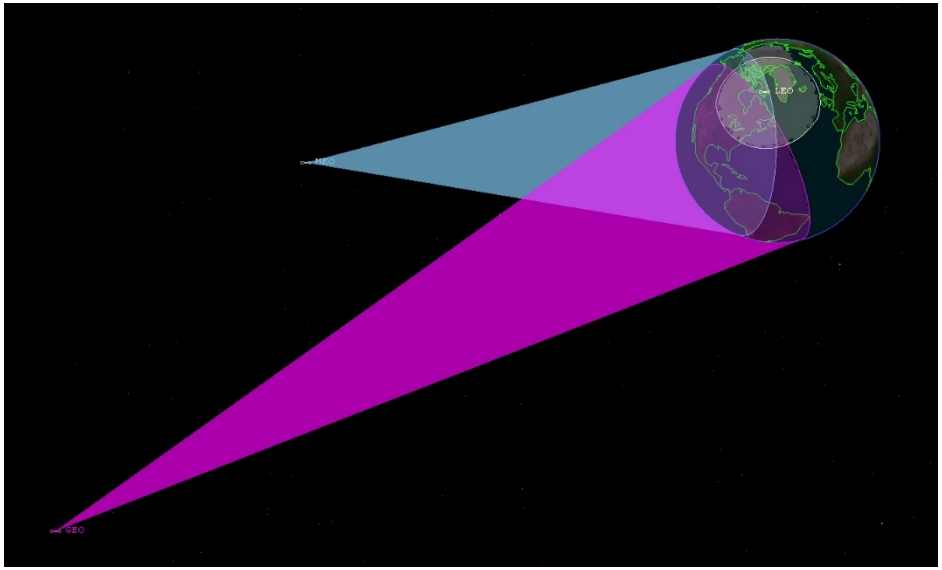
Advantages of GEOSAR System over the LEOSAR System

For 406 MHz beacons only:

- **Near instantaneous detection.**
- **Near instantaneous location determination for beacons with Global Navigation Satellite System capacity (GPS, Galileo)**
- **Continuously monitoring of ~1/3 of Earth's surface**
- **Has a 46 minute mean time 'advantage' for first detection**

Advantages of MEOSAR System over the LEOSAR and GEOSAR Systems

- **The number of satellites almost "guarantees" instantaneous detection AND the ability to locate without GPS encoded info anywhere in the world and with multiple obstructions, i.e., in a canyon, side of an overturned ship, etc.**
- **Near instantaneous location determination for beacons with Global Navigation Satellite System capacity (GPS, Galileo)**
- **Continuously monitoring of 100% of Earth's surface**



Questions?

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