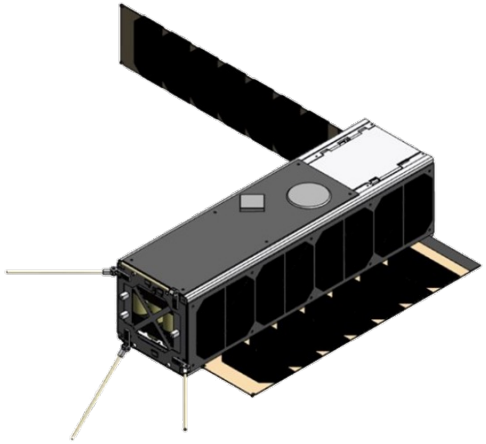


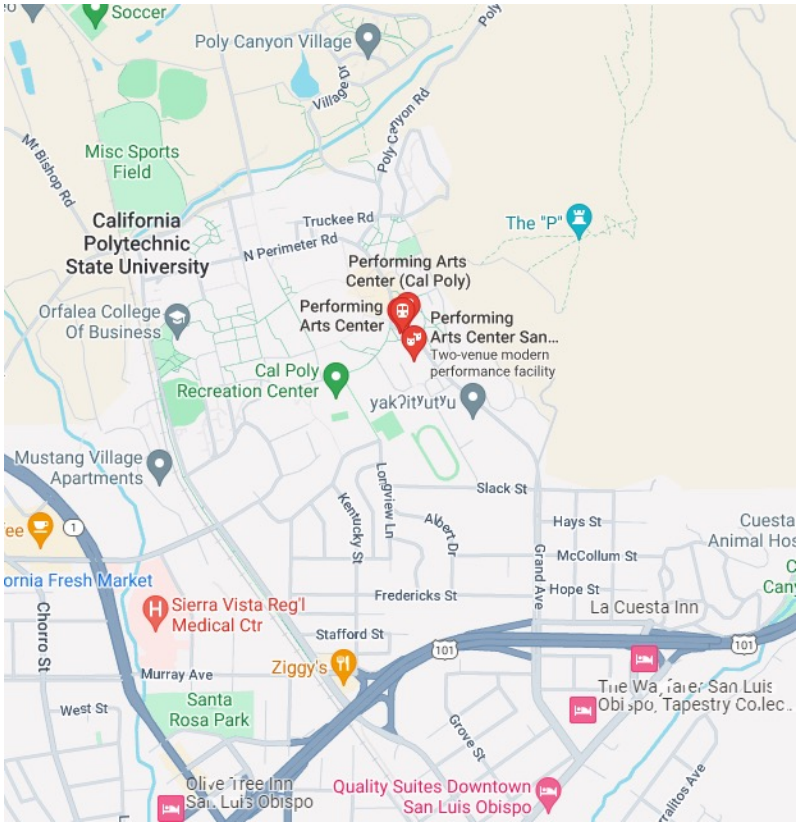
SeaLion Doppler Localization

Prof Richard Freeman, CAPT Royce James, Prof Dan Burbank, Prof Richard Hartnett, LCDR Dahnyoung McGarry, Dr. Chris Mehta - United States Coast Guard Academy

Prof Pete Swaszek - University of Rhode Island

Prof Sharan Asundi, Jeries Abedrabbo, Chris Schappi - Old Dominion University

How Do We Know Where We Are?



https://www.google.com/maps/search/cal+poly+tech+performing+arts+center/@35.2990732,-120.6709303,15z?entry=ttu

Cell Phone or GNSS Receiver allows access to GNSS Constellations

Six GNSS Constellations- GPS, GLONASS, BEIDOU, GALILEO, QZSS and IRNSS/NavIC

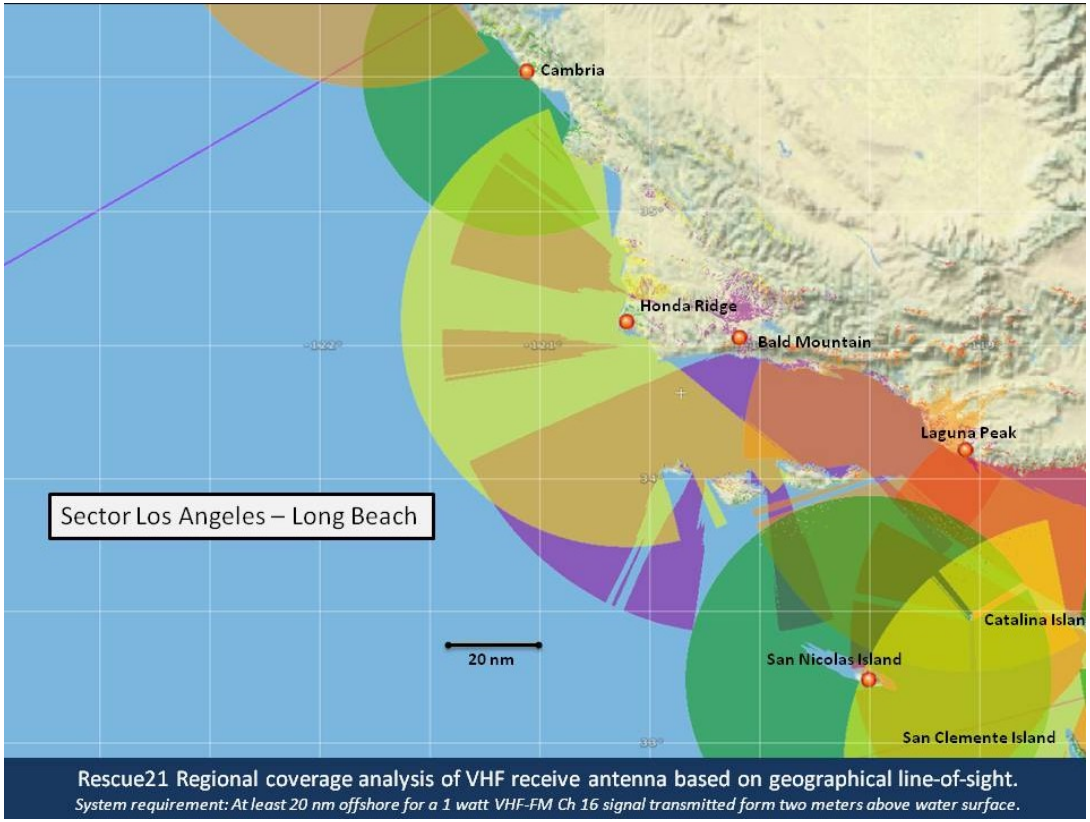
https://www.gps.gov/systems/gnss/

RESCUE 21

US Coast Guard advanced command, control and direction-finding communications system

- Allows persons in distress to call for help
- USCG will triangulate a position for the call
- Dispatch resources to help caller
- Continental US, Hawaii, Alaska, Guam, USVI and major waterways

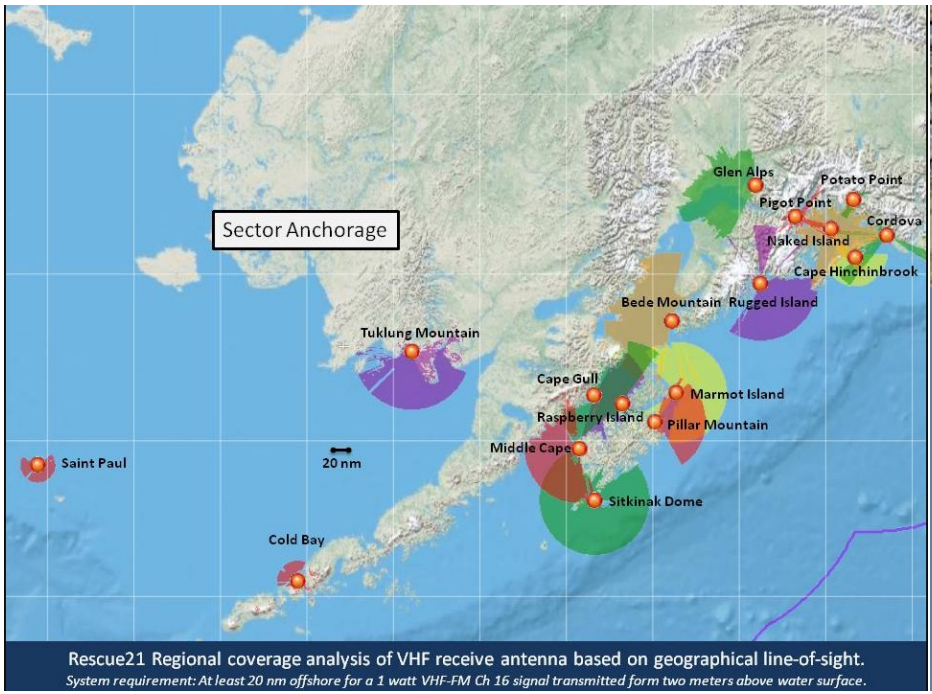
District 11- Sector Los Angeles/Long Beach

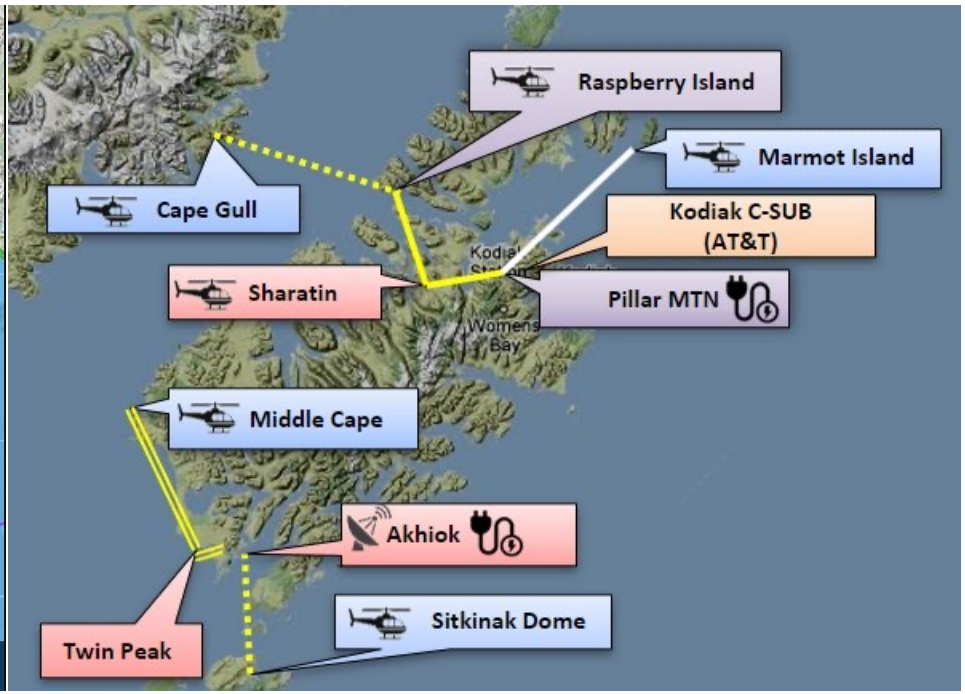


Is this true in the Arctic?

- All GNSS Satellites are closer to the horizon
- Terrestrial and Space Weather and Terrain will affect communications
- Line-of-Sight comms will be limited
- Cell Service is non-existent
- Satellite Service is an option
- EPIRBs/ELTs/PLBs operating on 406MHz may be picked up by Sarsat if activated

Rescue 21 in Alaska





Legacy Radio/RF Systems do not Meet Requirements

System Design

Limited Coastal Coverage

Long Outages

Antiquated Relay Network	Sites Lose Power	Tree Growth

The Result

Missed Distress Calls	Longer Search Times	Failed Missions

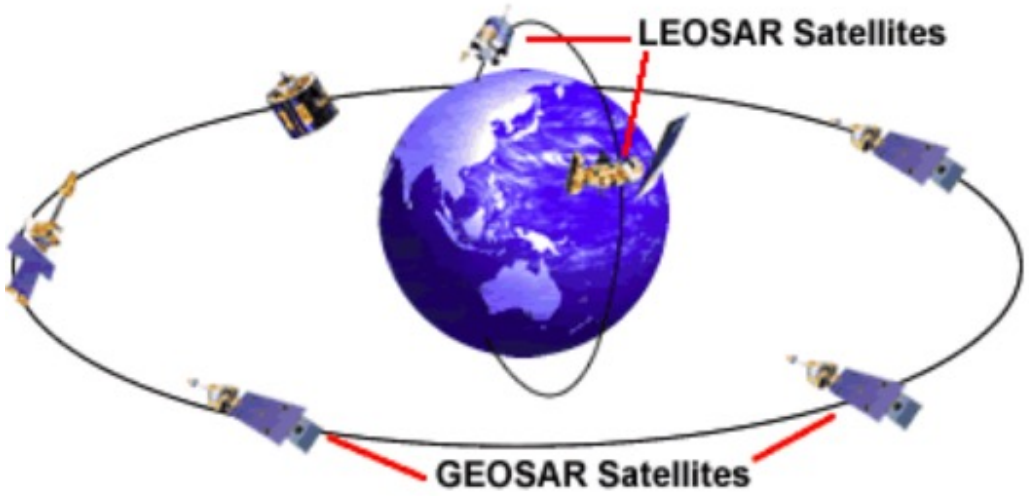
Rescue 21 RFF site in Alaska

Harsh Climates call for different Solutions

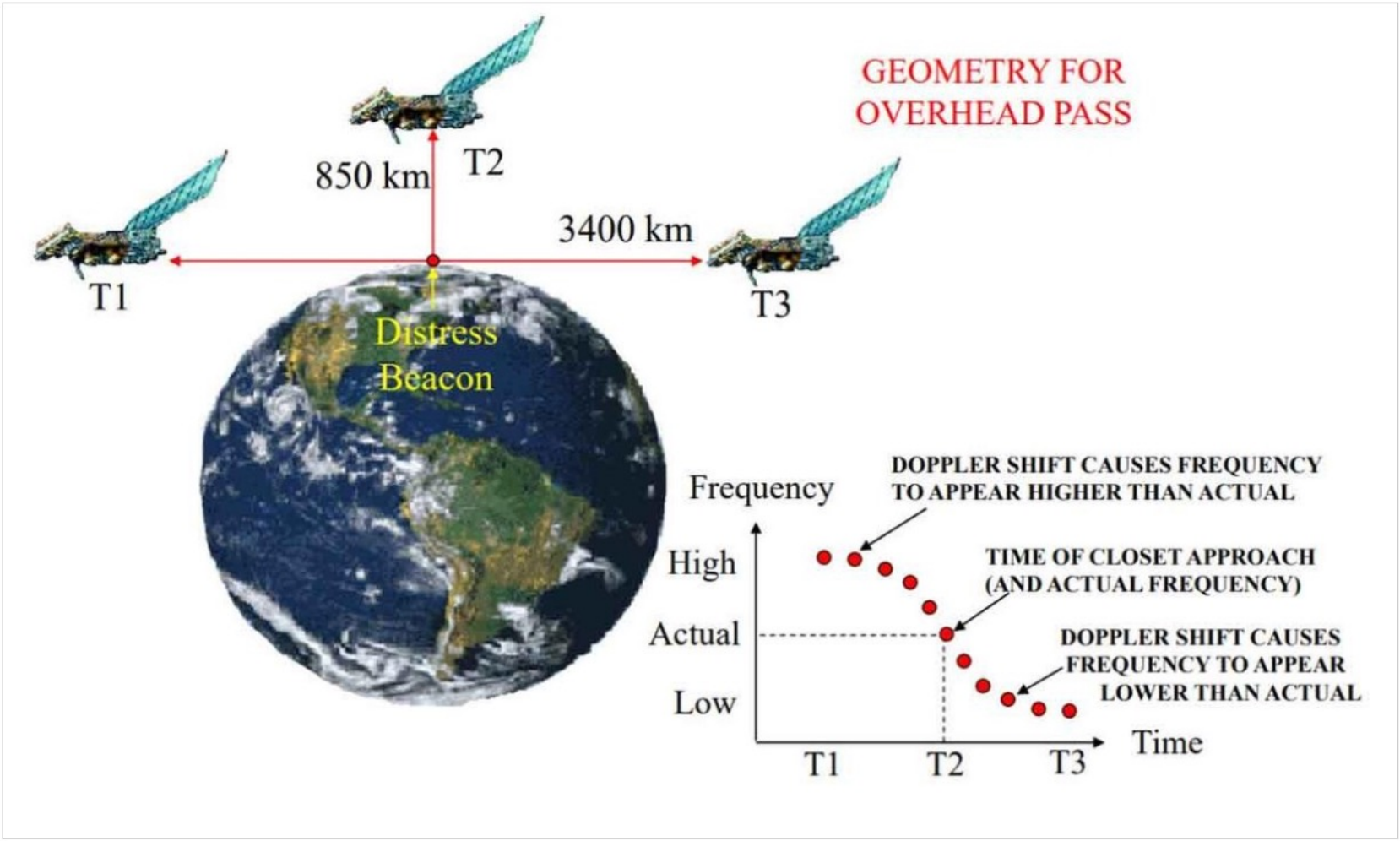
- Given the extreme climate of the Arctic, RESCUE 21 towers can be unavailable for long periods
- Access to towers is limited
- Why not consider a different solution??

Doppler Localization augmentation of RESCUE 21

- Doppler Localization has been published and researched since the early 60s
- Cospas-Sarsat relies on Doppler Localization to locate distress signals from beacons transmitting on 406.0 – 406.1MHz
- Why not develop a constellation of satellites to augment R21 in Alaska and the Arctic?



Doppler Localization



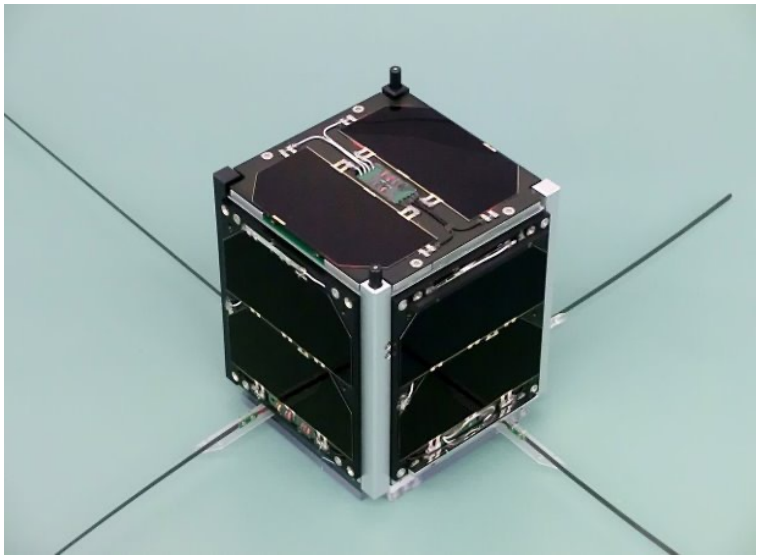
USCGA Doppler Localization Experiment

- Phase 1 (Downlink)
  - Reciprocal problem- known location for radio transmission and using satellites of opportunity
  - More Testing
  - Algorithm Refinement
- Phase 2 (Uplink)
  - Satellite Payload Construction (NET 2025 Launch)
- Phase 3 (Uplink, Multi-Satellite)
  - Coverage Analysis
  - Orbit Selection

Electrical Engineering & Marine Environmental Science Cadets monitor doppler shifts using Phase I method.

Phase 1 Method

- Use a transmitting amateur radio satellite
- Measure doppler curve
- Pinpoint location



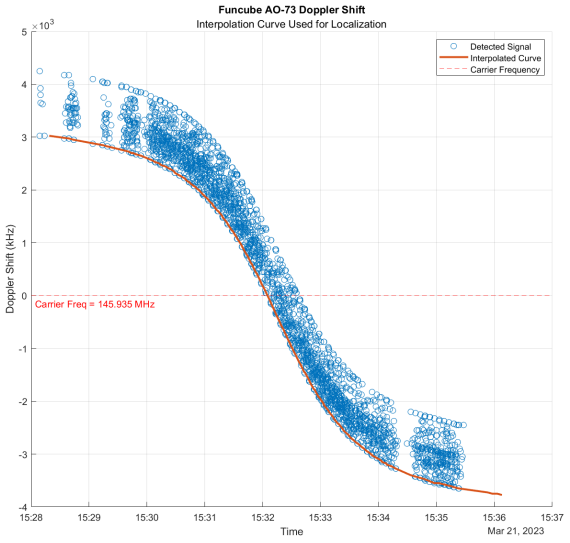
FUNCUBE-1 (AO-73)

Telemetry Beacon: 145.935 MHz BPSK

300mW (During Illumination)

Phase 1 Method

- Use a transmitting amateur radio satellite
- Measure doppler curve
- Pinpoint location



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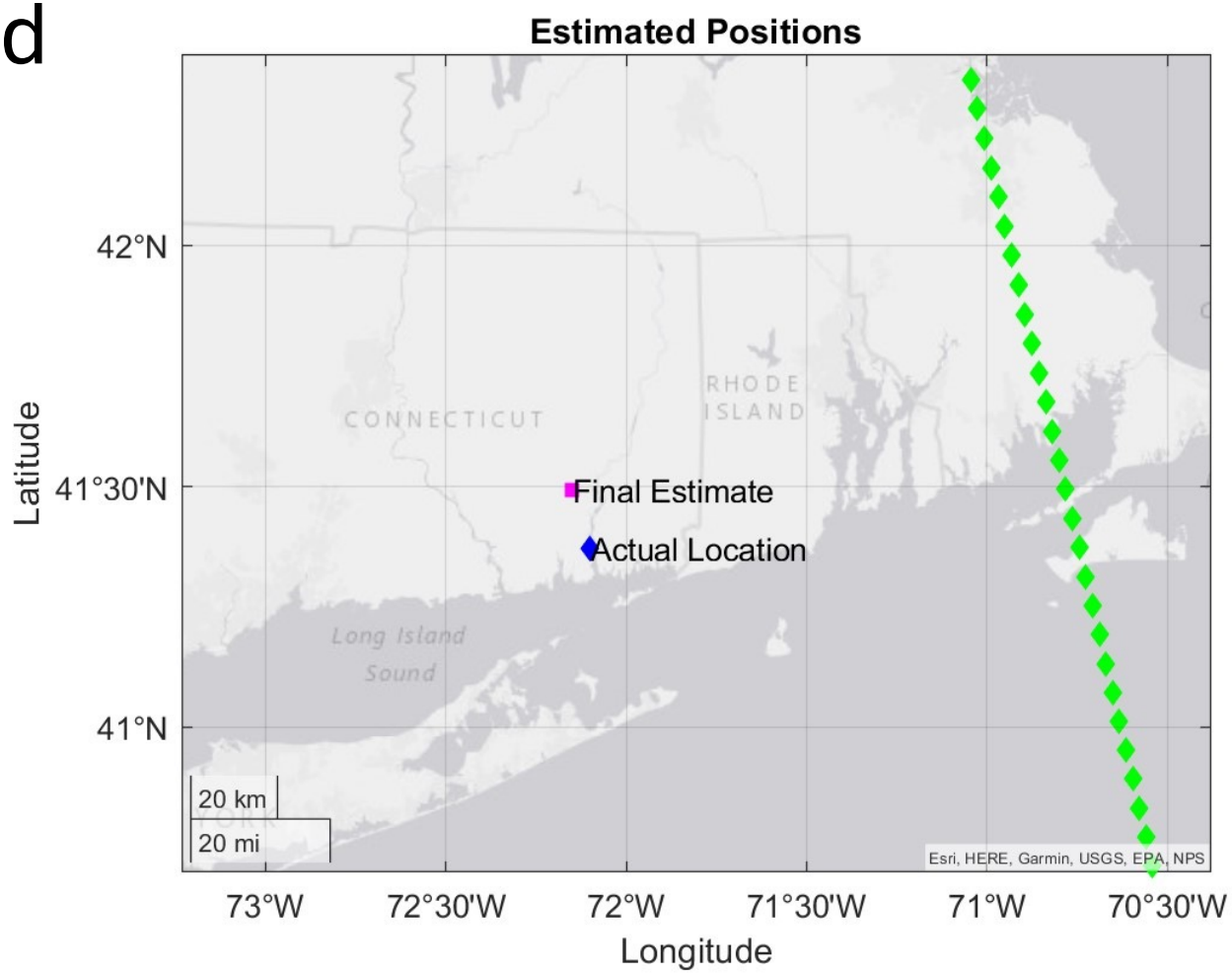

Phase 2 Benefits

- Doppler localization is established technique (1978)
- Better estimates of Satellite location mean better estimate of mayday location (GPS from Iridium and satellite TLE)
- Higher-power transmissions from dedicated research satellite
- Expand the bandwidth from UHF to VHF-FM

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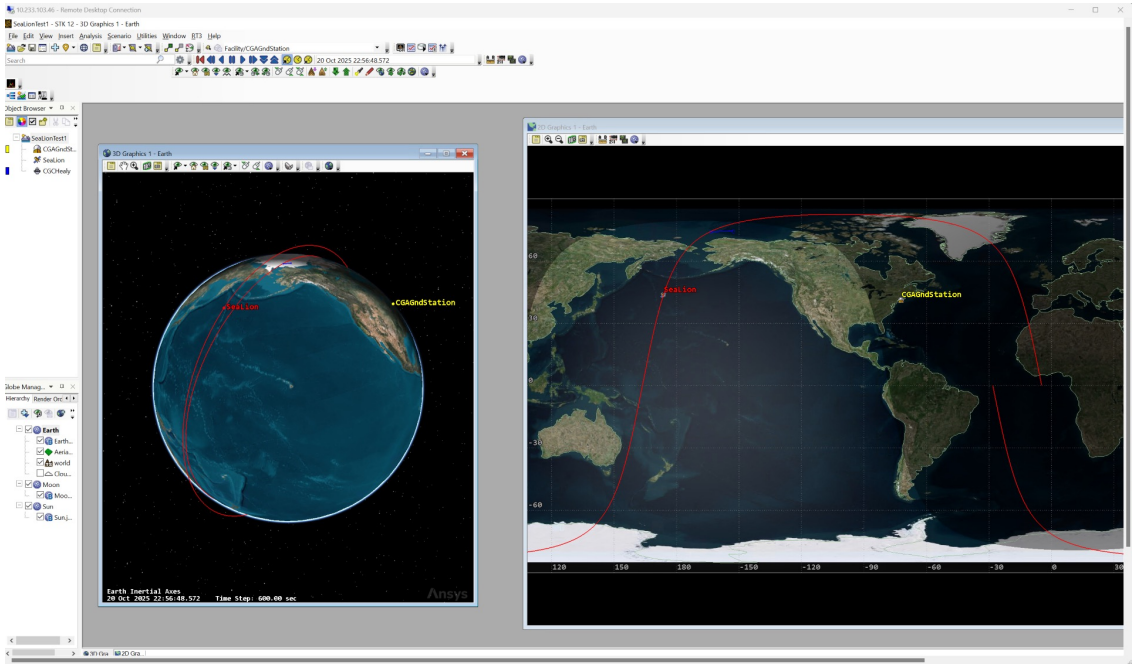
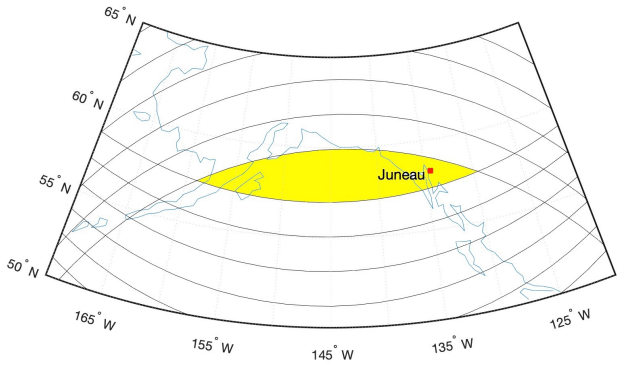


- Reduces search area using first & last measurements
- Intersection of circular footprints
- Potential for grid search methods



Mission SeaLion's Upgrade to a Multi-Year, Polar Orbit

Generates **New Coast Guard-Relevant Mission Objectives**

Primary Mission Objectives (PMO)

- Validate operation of Impedance Probe as primary payload
- Establish S-band communication link with the MC-3 network
- Transmit spacecraft and payload data to CGA and partner MC-3 ground stations
- Utilize CubeSat Design Standards for spacecraft design and build
- **Demonstrate RF application for Artic SAR localization**

Secondary Mission Objectives (SMO)

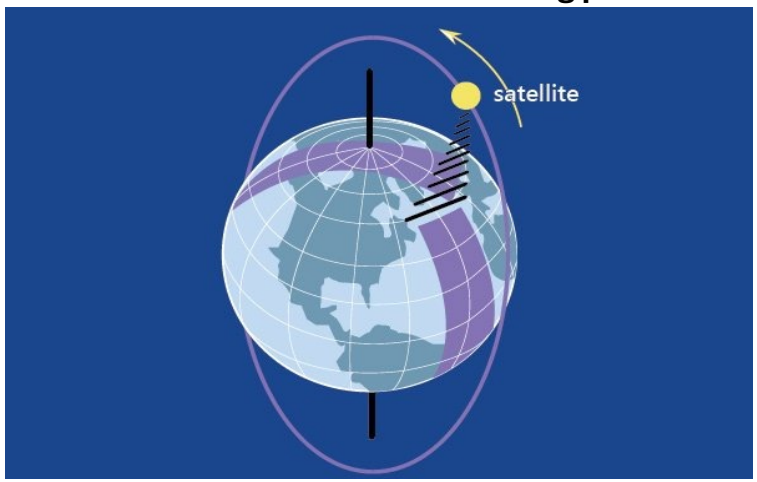
- Validate operation of the Ms.S as a secondary payload
- Validate operation of DeCS experiment as secondary payload

Tertiary Mission Objectives (TMO)

- **Demonstrate Comm Relay for CG Units operating in the Artic**
- Validate on-orbit deployment and functioning of custom developed UHF antenna system
- Gather DeCS experiment in-orbit performance data by capturing structural behavior through accelerometer and temperature sensor

SeaLion CubeSat Meets Arctic AOR Coverage Needs

- Sun-synchronous orbit
- Inclination: 97.6 deg
- Altitude: 550-400 km
- Footprint: 3000 km diameter (6-7 min pass)
- Orbital period: 1 hour 24 min which results in ~15 Artic overflights per day
- Ground tracks range from latitude 82.4S to 82.4N and shift westward 21 deg per orbit

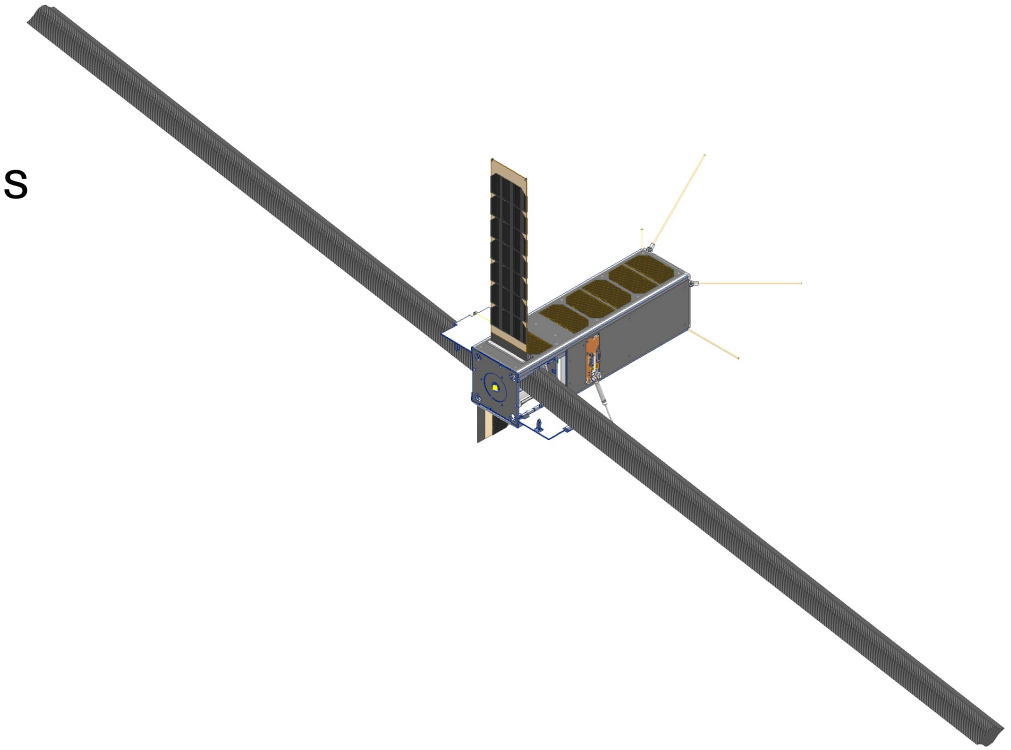


Accelerating Phase 2 Research

- Initial field test
- Simulate distress call on CH 16 (156.8MHz) from USCGC Healy
- Use SeaLion to measure Doppler and compute Healy's location
- Via Software Defined Radio on SeaLion
- Remove doppler suppression- we want to hear the shifted signal

Phase 3 Approach

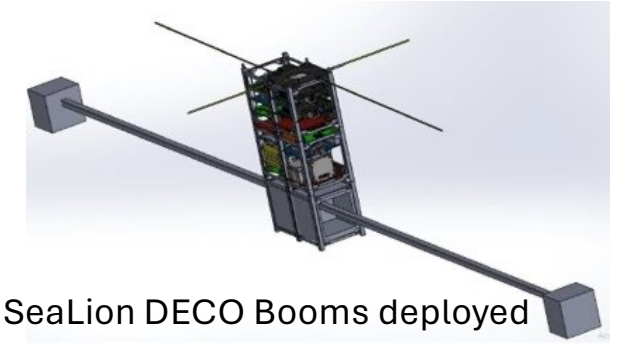
- Multiple Satellites- SeaLion II
- Potentially relay calls via Satellites
- Simulate Distress calls



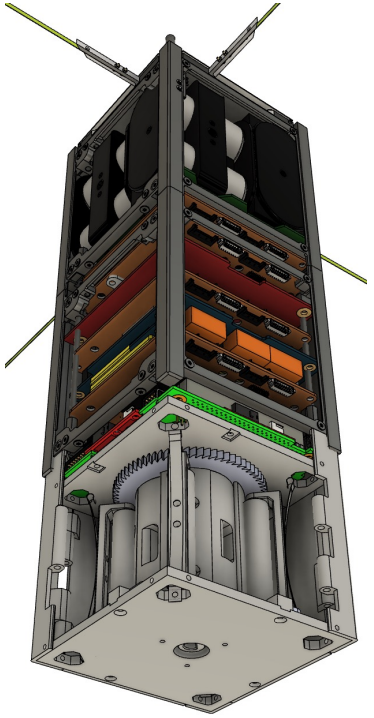
CAD rendering of SeaLion with antenna, solar panels, and boom deployed

Outstanding Design Questions

- Do we use vendor SDR or purpose – built GNU radio SDR?
- Can we implement using current quad monopole antenna or do we need to add a fifth one?
- Can we map Space Weather (Plasma Temperature and Density) over localized radio signals?
- What is the maximum tumble rate Iridium can tolerate?



SeaLion DECO Booms deployed



SeaLion Internal Components

Resources

McGarry D, Hartnett R, Swaszek P, Chan B, Evans B, Kenna A, Potential LEO Satellite Augmentation of Rescue-21 in Alaska, The Institute of Navigation ION-GNSS 23 , Denver, CO, Sept 2023.

https://www.navcen.uscg.gov/sites/default/files/images/marcomms/cgcomms/Rescue21/SECLALB.jpg

https://www.navcen.uscg.gov/sites/default/files/images/marcomms/cgcomms/Rescue21/SecAnchorage.jpg

https://www.cospas-sarsat.int/en/system-overview/detailed-cospas-sarsat-system-description

https://www.sarsat.noaa.gov/search-and-rescue-satellites/

https://media.defense.gov/2023/Aug/11/2003279773/1920/1080/0/230809-G-HT254-1007.JPG