



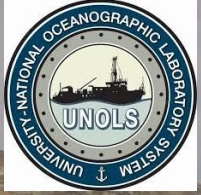
HISEASNET: VISION FOR THE FUTURE

RVTEC plenary session (2024-10-24)

Thomas Lockwood, HiSeasNet Supervisor, UC San Diego



R/V Sally Ride, Anacortes, Washington. Credit: Jeff Dillon.



THANK YOU TO OUR COLLABORATORS AND SPONSORS



Scripps researchers recover a BONGO net off the California coast.



HiSeasNet is a satellite communications network established in 2002 and designed specifically to provide continuous Internet connectivity for oceanographic research.

We support research vessels in the US Academic Research Fleet (ARF) as well the United States Antarctic Program (USAP)



Satellite Terms

LEO

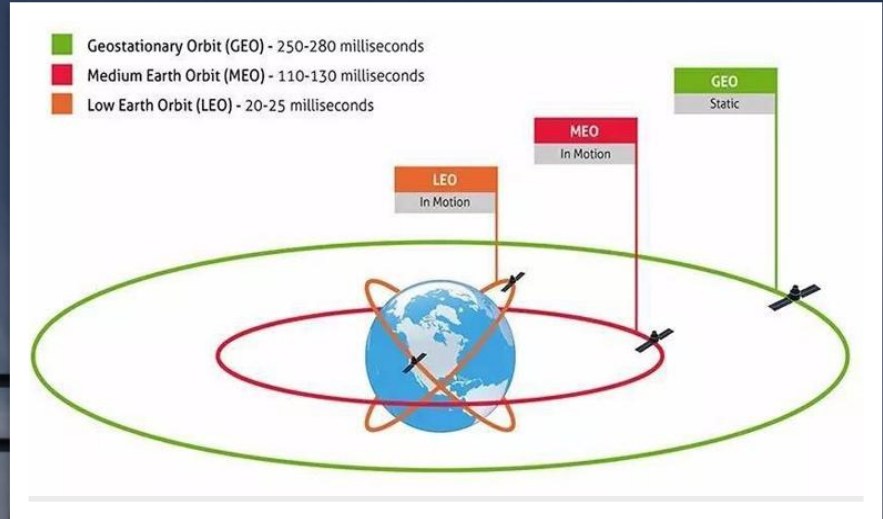
Low Earth Orbit

MEO

Medium Earth Orbit

GEO

Geostationary Orbit



Relevant IEEE Radio frequency/wavelengths

Ka-band

27-40 GHz
1.11–0.75 cm

Ku-band

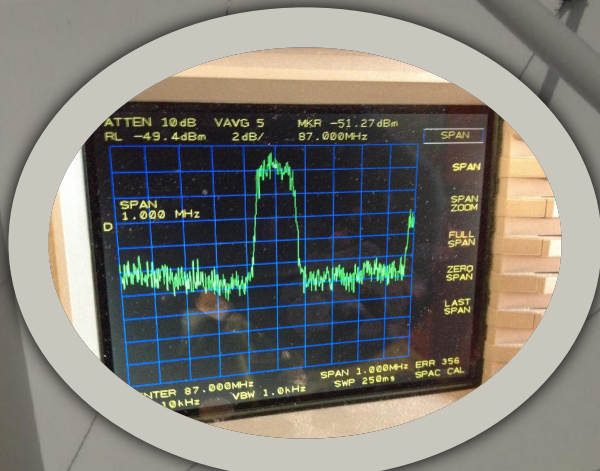
12-18 GHz
2.5–1.67 cm

C-band

4-8 GHz
7.5–3.75 cm

L-band

1-2 GHz
30-15 cm



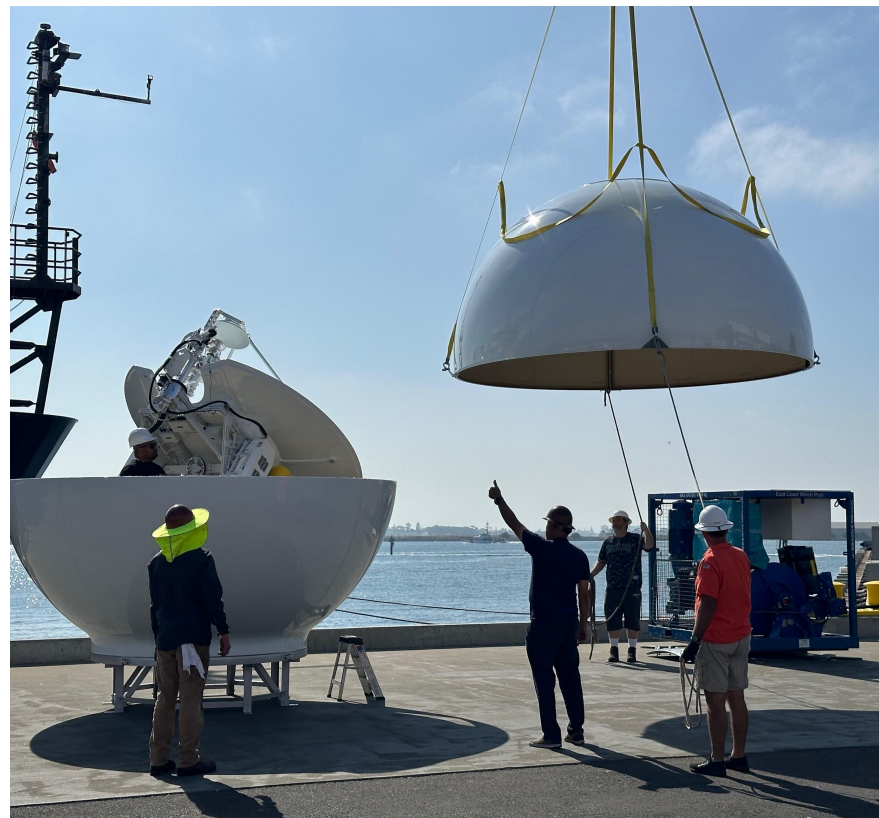


Current systems



Current GEO system: Sealink Plus

- Sealink is currently GEO only; limited capability at the poles
- Internet, phones
- Mostly capable of ~20Mbps throughput via Ku-band and C-band at global scale
- Intellian v240M-2 antennas, capable of tracking GEO/MEO/LEO
 - Can be purchased/retrofitted with Ka-band, too



Current GEO system: Fleet Xpress

- GEO only; limited capability at the poles
- Internet, phones
- Dual antenna system, consisting of Global Xpress (Ka-band) and FleetBroadband (L-band, 432 kbps)
- Automatic cutover between Global Xpress and FleetBroadband
- Global Xpress can support speed of 2Mbps (always on) and on special occasions, up to 10Mbps

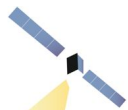
many commercial operations, we are phasing
his service in favor of diverting funds to

Hi Seas Net field



Current LEO system : Iridium Certus

- LEO, with true global coverage
- Internet, phones
- L-band (1-2 GHz) more reliable for extreme weather, but slow (100-700 kbps)
- Used to satisfy Polar Code requirements as standalone, pooled service for phone/emergency Internet since 2022
- Also used in Sealink Plus as an out-of-band path for as needed "dial-in" remote support of Ku-band /C-band equipment.



Hi Seas Net

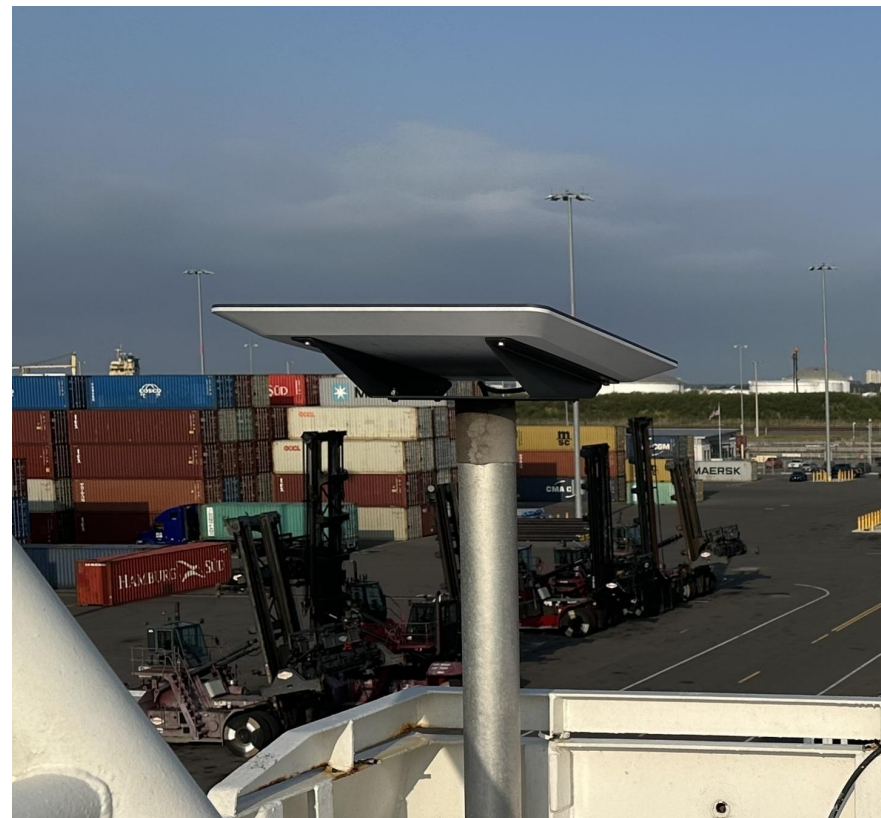
Current near-shore systems: Cellular Modems

- Useful as an in-port Internet offload (to avoid in-port use of Starlink/Starshield) when 5G is available
- Most successful test setup so far:
 - T-Mobile for truly unlimited domestic coverage
 - AT&T for \$10/day foreign port coverage
 - Cellular modem that can toggle between SIMs
 - Ignore 4G and lower
- Tests of installing this system inside Sealink domes have gone well. 2.4 Meter antennas already have built in filters for 5G cellular emissions which are close to C-Band frequency spectrum.
- Modem is able to use WiFi-as-WAN, too



Current LEO system : Starshield

- LEO, Ku-band, Internet only
- Starlink Maritime became available in July 2022, Conducted pilot testing on ARF ship in fall of 2022
- Starshield announced by SpaceX December 2022, Deployed fleet-wide May 2023 through August 2024 on ARF & USAP vessels
- Speeds of "350 Mbit/s" (best effort) advertised; Typically seeing closer to 100-250Mbps shore to ship and 6-30Mbps ship to shore.
- 5TB per month or Unlimited plans available; pay per GB for usage over 5TB is option. Usage is typically pushing against 5TB/mo





Future(?) systems



Future LEO systems of interest: Starlink (fully deployed)

- Orbit ~550km Currently deployed: ~6000 satellites; SpaceX has requested licenses for 12,000 (possibly 42,000)
- Speeds of "350 Mbit/s" (best effort)
- Requires purchase of a fixed flat maritime-grade user terminal for seagoing (similar to Starshield)
- Initially, limited intra-satellite comms; Gen 1.5 and Gen 2 launches have allowed for ISL
- As ISL options grow, the speed of the constellation is expected to increase. Number of Starlink ground-stations has also been increasing.
- Areas with limited to no ground stations currently include Africa, Middle-East, India and mainland Asia.
- Constellation coverage over polar regions is currently limited but will improve with full deployment.



Future LEO systems of interest: Starshield (fully deployed)

- Announced December 2022; DOD hand off starts in July 2024.
- Enhanced encryption and other security features
- Unlike Starlink, which is a commercial service, future Starshield satellites would be owned and controlled by the U.S. government
- Currently, Starshield uses encrypted-in-transit data on Starlink's commercial service, but enjoys better speeds and better coverage than the commercial service.
- Plans between 2023-2033 to have the military manage their own constellation of satellites
- Declared a "legitimate military target in the future" by some non-US nations. Satellites include additional imagery and thermal sensors to detect ICBM launches.
- How Starshield's dedicated constellation of satellites interacts with Starlink's commercial service (if at all), in the future, is unclear



Future LEO systems of interest: OneWeb

- Polar orbit ~1200km with 634 OneWeb operational satellites now in orbit, constellation is complete and fully operational down to 35 degrees latitude with Gen1 satellites.
- Expected CIR speeds up to 195Mbps (downlink) and 32 Mbps (uplink)
- In Sep 2023, Intellian and OneWeb introduced an active electronically scanned array (AESA) panel solution for OneWeb (replacing dual stabilized dome solution) as of Sep 2024 these panels have not been commercially released. Current commercially available Intellian solution is dual 70CM domes; Kymeta Peregrine flat panel systems are commercially available along with milspec variants. Original HSN plan was to retrofit dual Intellian GX100NX domes with Ku BUCs once certified for OneWeb use but the new phased array antenna solution would be simpler.
- Deep sea connectivity will be a challenge till intersatellite links are introduced. Gen1 satellites have to be in range of a ground station to provide service. Initial Gen2 test satellites with intrasatellite links but have yet to be deployed at scale.



Future LEO systems of interest: Amazon Kuiper

- Planned to consist of 3,236 satellites
- FCC license requires a 50% deployed, operational constellation by July 2026
- First 2 prototype satellites launched on October 6, 2023
- Plan on "Rolling out commercial service in 2025"
- Phase 1 of deployment will be 578 satellites
- A total of five phases of constellation development are planned
- Operate at 590 km, 610 km, and 630 km orbital altitude
- Ka-band phased-array antenna ~30 cm (12 in) in width
- Expected to support "up to 400 megabits per second"



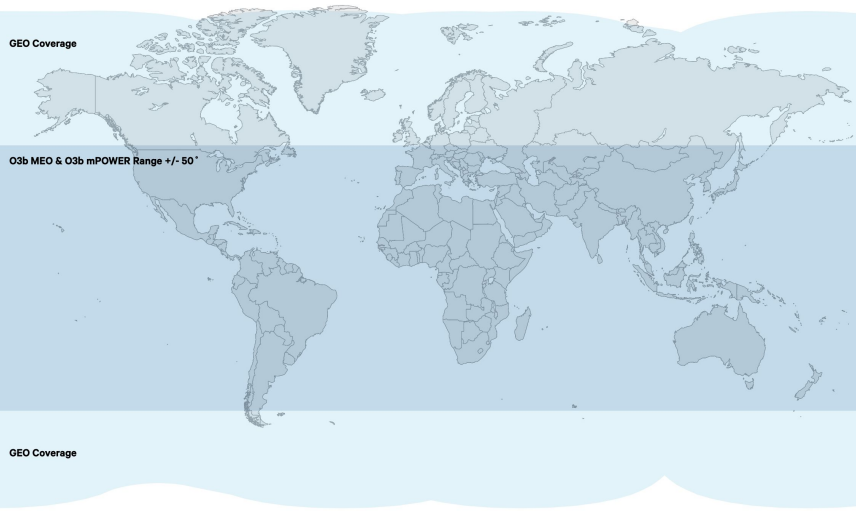
Future MEO systems of interest: O3B mPower

- 8,000 km orbit with 6 Medium Earth Orbit satellites
- MEO, 8000 km orbit
- ~10x more capable than LEO offerings. EG, Gigabit or more to a single ship
- Requires 3 or more pointed 2.4m antennae (radomes)
- Focuses on high-uptime capability, high performance (at a premium) with redundant equipment (ConOps)
- Limited to latitudes 50° N and 50° S (which covers 96% of the global population). They have a polar orbit defined, but no announced plans
- SES Cruise mPOWERED + Starlink service claims to combine the best features of LEO and MEO orbits to provide high-speed, secure connectivity at up to 3 Gbps anywhere in the world



O3B mPower contrived example

GLOBAL COVERAGE MAP



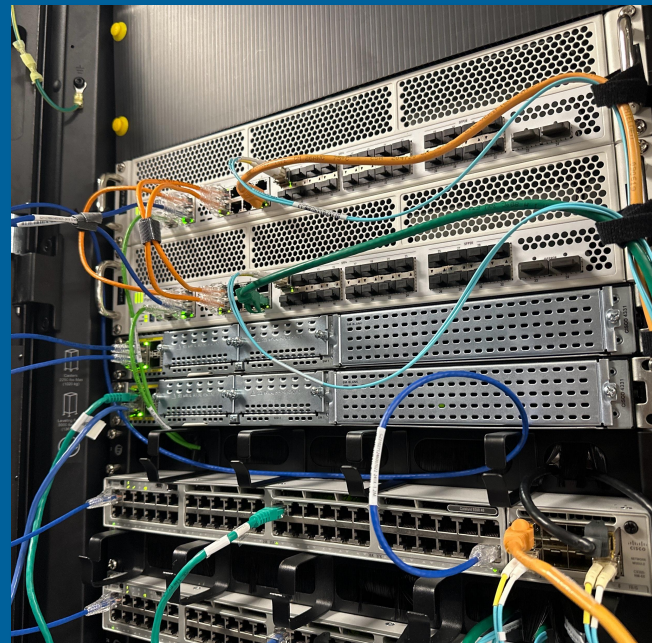


Other Projects



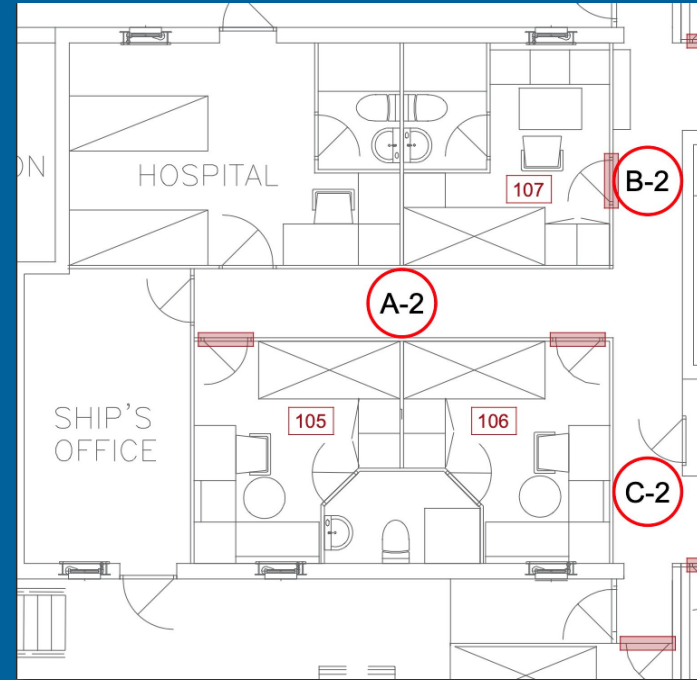
Other Projects: ARF-Firewall-Team

- Working with SatNAG, OmniSOC on fleetwide deployment of Fortigate Firewalls and Analyzers (opt-in)
- Hosting West-Coast hub for:
 - FortiGate routing
 - FortiAnalyzer traffic analysis collection
 - FortiManager device manager
- Purchasing and distribution of equipment
- Will check on state-of-health of equipment during annual satcoms inspections, per-ship
- For questions to all team stakeholders, there is an UNOLS email address specific to this project



Other projects: Safer Seas Act cameras

- Required by law as of Nov 2023
- UNOLS asked USCG about compliance requirements soon after
- Local Coast Guard is the decider; several global ships have been told to comply
- HiSeasNet is managing the group purchase with Digigone and coordinating installations – will be able to advise of bandwidth considerations, too
- Will conduct annual state-of-health checks on the equipment
- UNOLS Office is coordinating other aspects of the Safer Seas Act (EG signage, Title IX office interface, etc)
- OmniSOC is handling cybersecurity review
- For questions to all stakeholders, there is an UNOLS email address specific to this project





Milestones



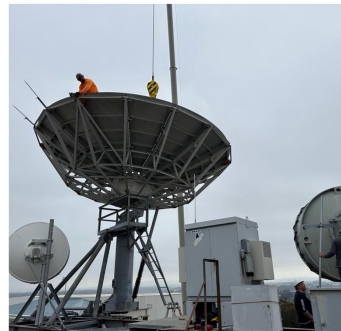
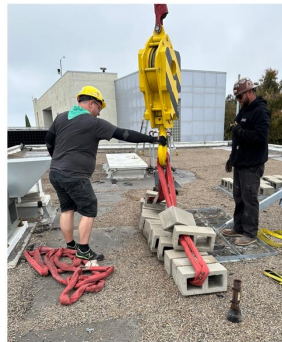
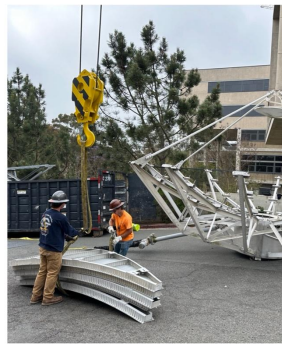
Milestone: Farewell to the HiSeasNet Ground Station

2002 Pacific Ocean Relay

2004 Atlantic Ocean Relay, Ku

2020 All links shut down

2024 All equipment removed





**Milestone: Welcome to the
ARF Firewall West Coast
colocation facility!**

2023 Test install at HSN bunker

San Diego Supercomputer Center

2024 Move down to SDSC Datacenter,
upgrade to 20Gbps

SDSC Central Entrance



2020 Kilo Moana, Revelle

2021 Langseth, Sikuliaq, Atlantis

2022 Atlantic Explorer

2023 Thompson

2024 Armstrong, Ride

Milestone: fleetwide
Intellian v240M/v150NX
conversions for
non-retiring vessels



Thank you!
Questions?
hiseasnet.ucsd.edu/contact/