



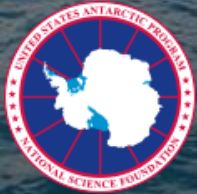
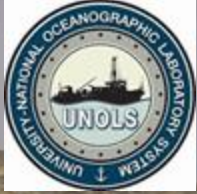
HISEASNET: VISION FOR THE FUTURE

FIC (2024-09-19)

Jon C. Meyer, Presenter



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



THANK YOU TO OUR COLLABORATORS AND SPONSORS





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

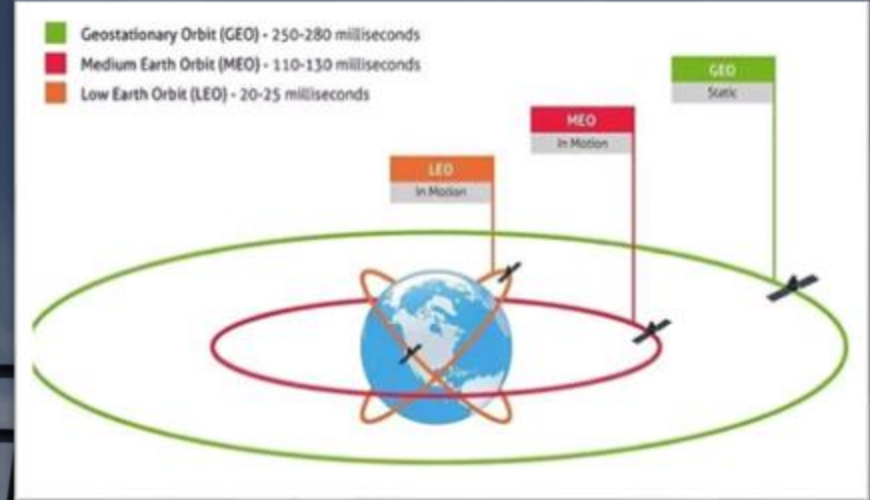
Low Earth Orbit

MEO

Medium Earth Orbit

GEO

Geostationary Orbit



Relevant IEEE Radio frequency/wavelengths

Ka-band

27-40 GHz
1.11–0.75 cm

Ku-band

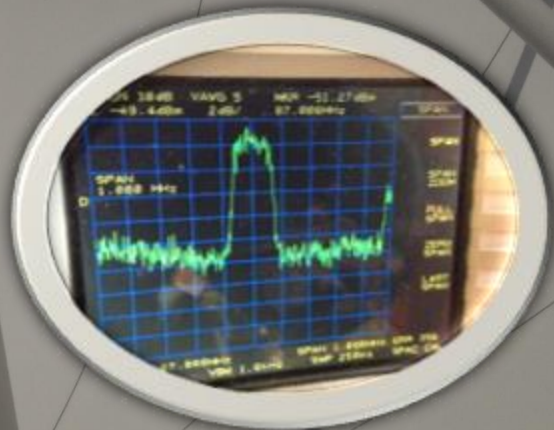
12-18 GHz
2.5–1.67 cm

C-band

4-8 GHz
7.5–3.75 cm

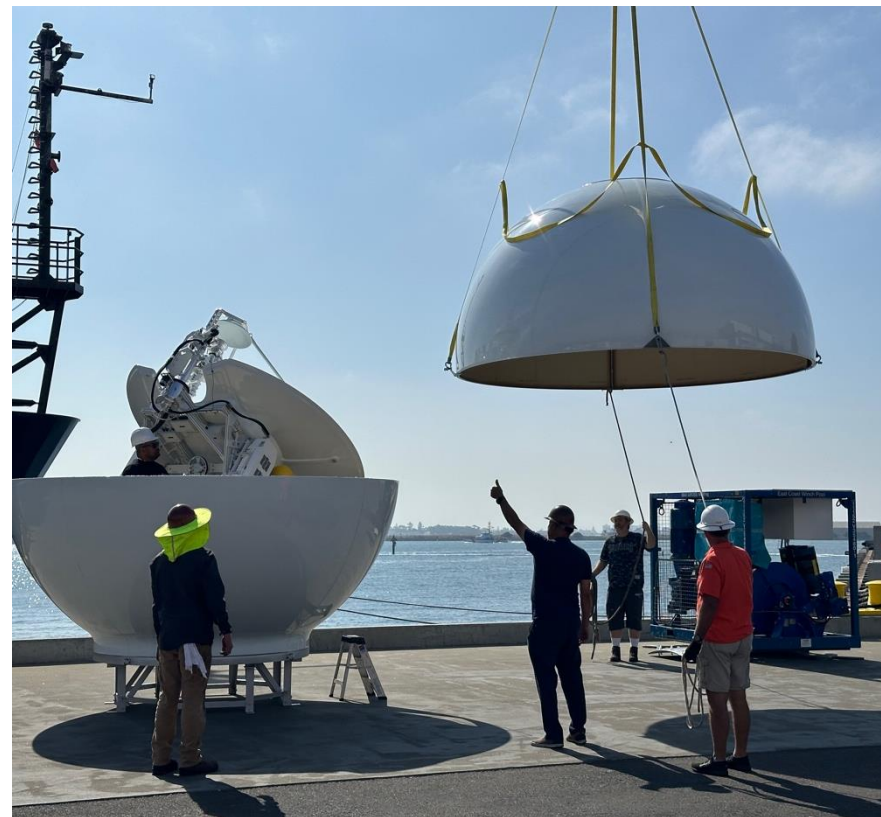
L-band

1-2 GHz
30-15 cm



Current 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
- Uses 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
ield

Hi Seas Net



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.



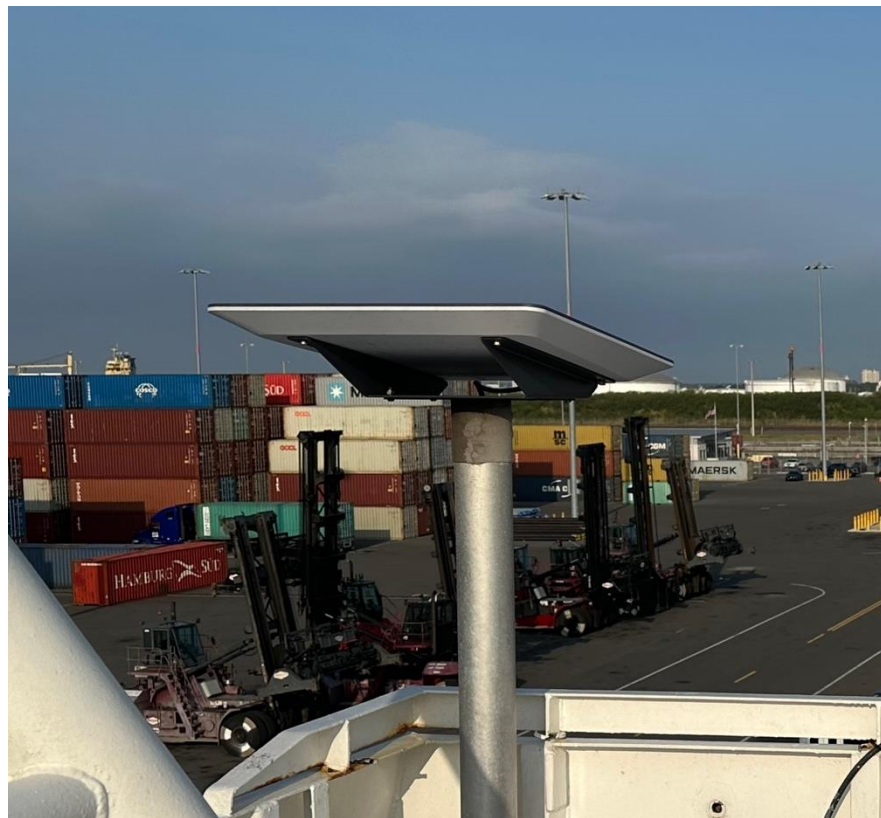
Current near-shore systems: Cellular Modems

- 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 occasionally pushing against 5TB/mo



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 commercial (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 were launched in Mar 2023 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"



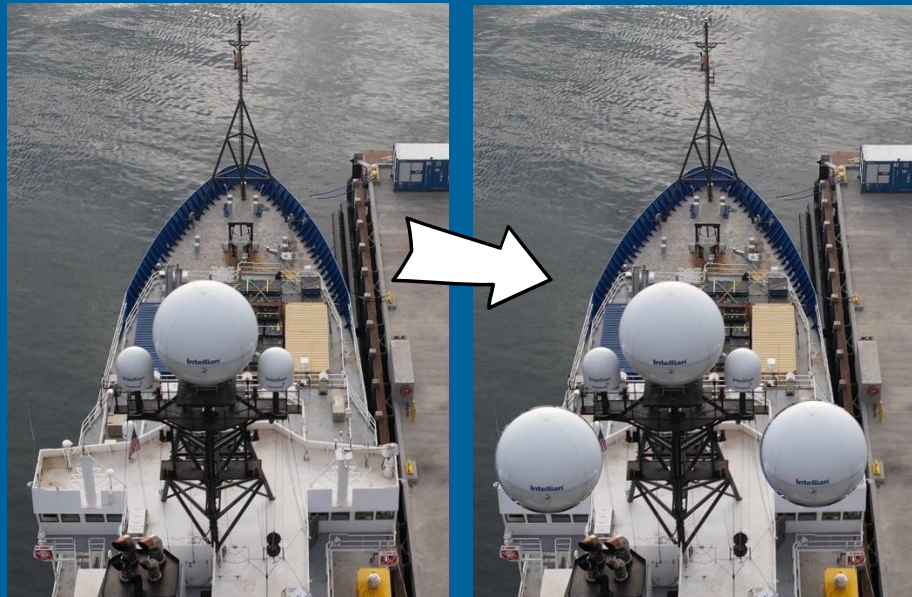
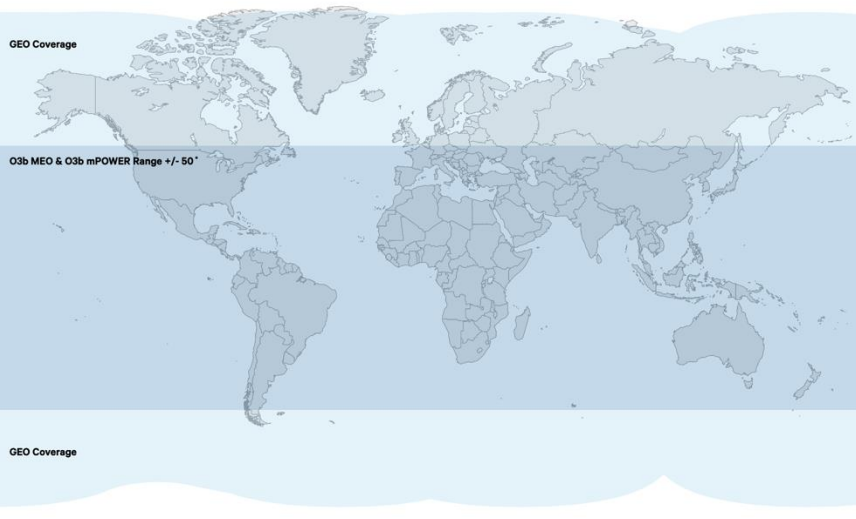
Future MEO systems of interest: O3B mPower

- 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 per ship, to cruise ships anywhere in the world



O3B mPower contrived example

GLOBAL COVERAGE MAP



Recommendations for Global/Ocean Design

- FOYs for ships of these classes are dense, so mobile Internet performance is critical. Plan for 2 performance-capable solutions to avoid an Internet outage delaying a cruise
- Plan for space for a 3-satellite MEO system at 2.4m
- Plan space for MEO ConOps – two, redundant spaces on ship for Below Decks Equipment
- Plan space for 2 performance LEO panels with 1m separation from other systems
- Plan for cellular antenna(s)
- Plan space for 2 out-of-band L-band systems
- Avoid obstruction as much as possible
- Be mindful of radar paths when planning space



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Recommendations for Smaller Ship Design

- FOYs for ships of these classes are not as dense, so mobile Internet performance, while critical, does not need the maximum
- Plan space for 2 performance LEO panels, with 1m separation from other systems
- Plan for cellular antenna(s)
- Plan space for 1-2 out-of-band L-band systems
- Avoid obstruction as much as possible
- Be mindful of radar paths when planning space



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**Thank you!
Questions?**