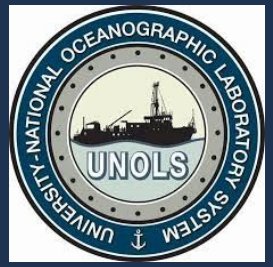


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Telecommunications and change in the US Academic Research Fleet
2020-07-16

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Telecommunications and change in the US Academic Research Fleet

Topics:

1. COVID-19 and telepresence
2. HiSeasNet website updates
3. 2020: a year of major satcoms change for ARF
4. Fleet Xpress
5. Marlink Sealink
6. Future
    - HiSeasNet Ground Station plans
    - Evolving technology
    - 2021 plans at-a-glance

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COVID-19 and telepresence

- The fleet is not 100% ready for reliable telepresence, but that does not mean we should do nothing. The punchline is that conditions to realize success are currently complex. We have a long-term plan to engineer our way out of that, for the fleet, but that will take years
- HiSeasNet generally needs 90 days or more preparation time to change link performance. That said, we are committed to trying our best to make shorter timeframes to overcome COVID-19 challenges
- The UNOLS Tech Services Manager is currently handling COVID-19 requests for us due the slace and timeframe needed
- We are discussing possible changes to ship time requests that can help highlight needs like this, earlier
- Where you go in the world matters for our planning; the sooner that is defined, the better the outcome

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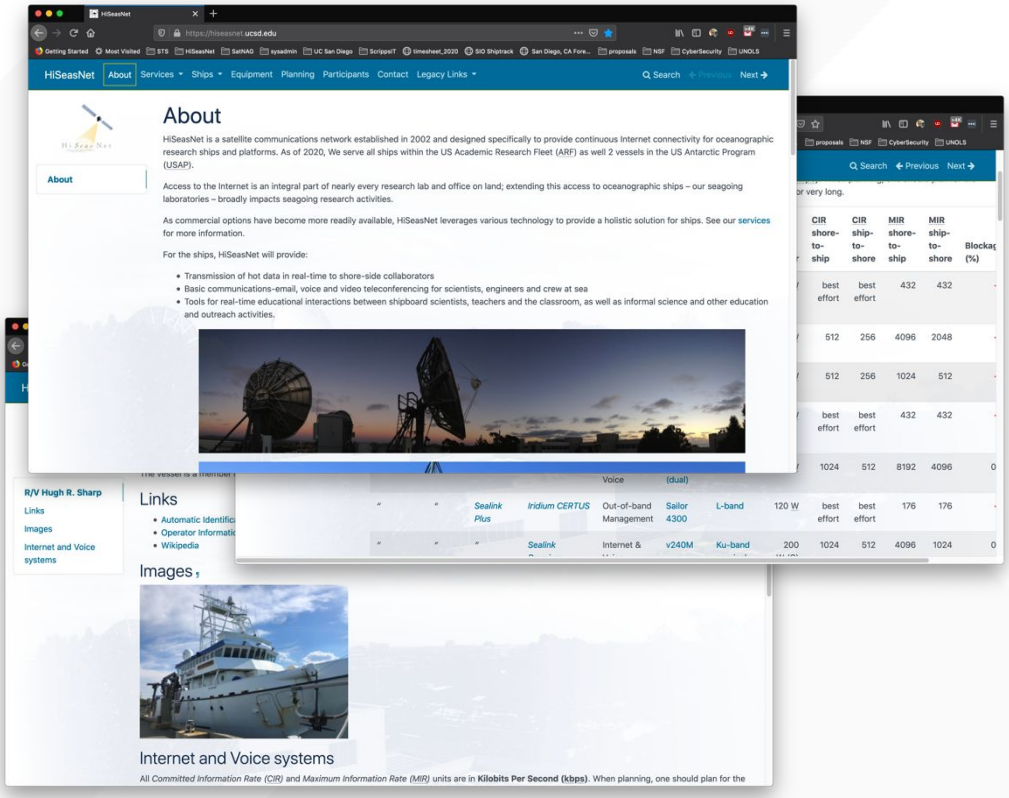
HiSeasNet website updates

1. hiseasnet.ucsd.edu has been updated with information mostly about:
   1. The vessels we are supporting
   2. The equipment we use/will use
   3. The service plans we are/will purchase
2. We are in the process of setting up a FAQ section to address some repeated questions we are getting
3. We are in the process of creating a login-required section where reports and private URLs can be shared
4. Feedback welcome via our web form at the site



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2020: a year of change for satcoms

- SIO is now managing both primary and secondary systems as of 2020
- Financial efficiencies are driving rapid adoption of systems not previously used
- The satcoms market is changing and so prices and services are changing, sometimes rapidly
- COVID-19 risk mitigation is highlighting the importance of stable communications at sea – something HiSeasNet is 100% wanting to plan for

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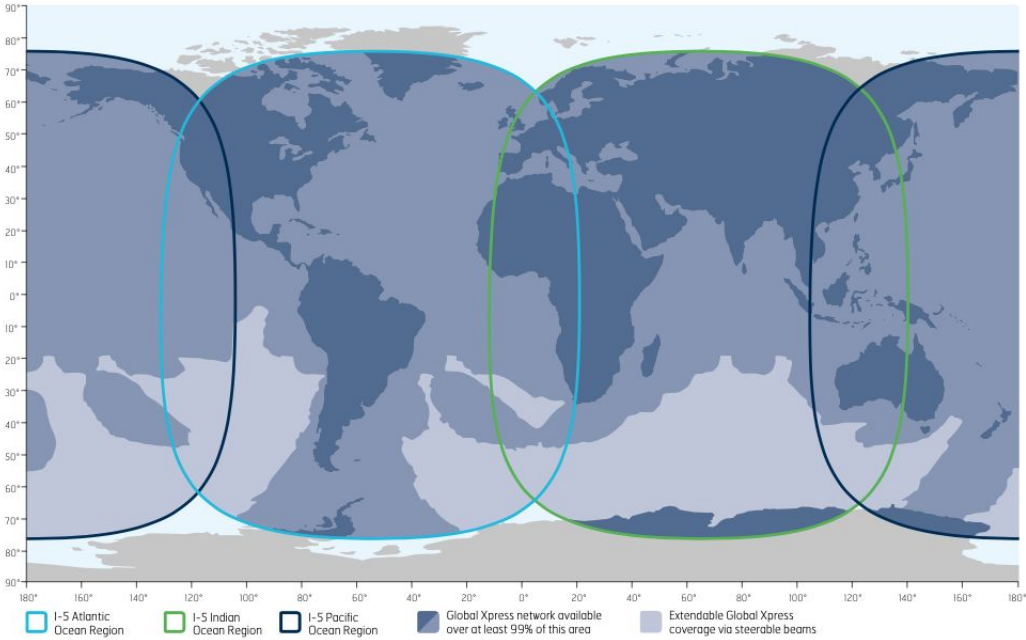
About Fleet Xpress

- *Fleet Xpress* is 2 systems: *Global Xpress* (Ka-band, primary) + *FleetBroadband* (L-band, backup)
- All ARF vessels have or will have Fleet Xpress in 2020
- 1m radomes for Ka-band, 30cm L-band: easier to fit on smaller vessels than Ku-band or C-band options, but Ka-band is more subject to weather
- Performance capability of up to 10Mbps
- Global Xpress Coverage map does **NOT** guarantee service
- Internet and Voice



This map depicts Inmarsat's expectations of coverage, but does not represent a guarantee of service. The availability of service at the edge of coverage areas fluctuates depending on various conditions. The first satellite was successfully launched in 2013, providing coverage over Europe, Middle East, Africa and Asia.

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Fleet Xpress Transitions

- World-Link contract was extended beyond Dec 2019 and ended in April 2020. We are ~75% (~15/20 ships) transitioned to Marlink. Marlink is the #1 satcoms provider, worldwide. Most conversions/installs were accomplished in Q1-Q2 2020 and take 2-3 days with Marlink engineers on site
- Pay by-the-byte FleetBroadband plans are gone
- We requisitioned 10 Global Xpress (Ka-band) radomes to the fleet to accomplish this
- We are buying *Intellian* brand radomes for new installs and getting 10W BUCs for more capability
- Ships with more than 40 berths are receiving double the throughput (1Mbps ship->shore, 512 kbps shore -> ship)

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Fleet Xpress Transitions

1. The March 2020 COVID-19 disrupted World-link -> Marlink conversions
2. Solid effort and flexibility the HiSeasNet team, Marlink, Marlink partners, Comm Systems and ARF/USAP ship operators helped us overcome most challenges
3. Fleet Xpress installs left to do:
    1. R/V Blue Heron (scheduled for next week)
    2. R/V Roger Revelle (scheduled for Aug 2020)
    3. R/V F.G. Walton Smith (schedule pending)
    4. R/V Rachel Carson (schedule pending)
    5. R/V Atlantis (2021)

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About Sealink

- Sealink uses a combination of Ku-band and C-band radio frequency. When performance is needed, these are the frequency ranges to use for geostationary orbit satellite
- Marlink (service provider) has field-tested 80Mbps performance on ships. This generally requires a 2.4m radome
- Large radome requirements make it more practicable to consider for Intermediate or bigger vessels
- Commercial version similar to what HiSeasNet has historically done
- Regional plans can be used for cheaper. **We are interested in coordinating with operators on planned work areas to reduce overall costs.**
- Budget constraints currently make commercial services like this a better value for ARF
- Sealink has cheaper regional plans that can be used (and save money)

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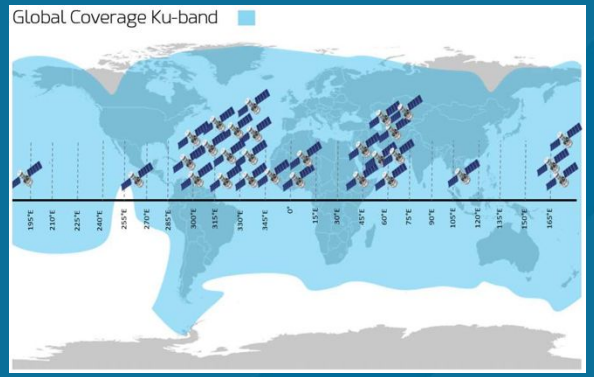
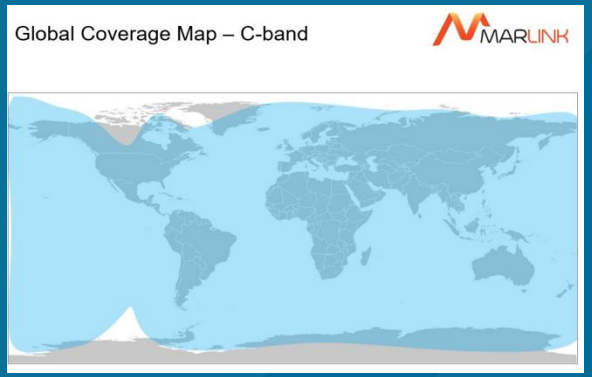
About Sealink: Coverage at a glance





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Intermediate vessels: Transitions to Marlink Sealink

- After trying other solutions that were more expensive, In 2019, *R/V Oceanus* was converted to use Marlink Sealink and this worked well
- *R/V Endeavor* and *R/V Atlantic Explorer* now on Marlink Sealink
- *R/V Walton Smith*, formerly on a Ku-based service, is being converted to Fleet Xpress-only due to work profile
- HiSeasNet Ground Station Ku service remains available for incidental use, but is no longer transmitting 24/7/365
- Adding Sealink Plus capability in the works

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C/Ku Marlink Sealink Plus pilot program

- We were approved to conduct a Pilot Program for the ARF wherein we lease satellite equipment
- Leasing spreads out costs over ~5 years -- essentially 20%/year
- Leasing enforces lifecycle maintenance due to length of the lease -- something we have been asking for in order to increase reliable operations
- When done through Marlink, leased equipment must contain an airtime plan (Marlink's *Sealink Plus*)
- We started off with the plan to do this solely aboard *R/V Roger Revelle*, coming out of midlife
- Reported equipment failures aboard ships with aging installs (*R/V Kilo Moana* and *R/V Marcus G. Langseth*) forced us to add these ships
- Kilo Moana was first converted; they report being very pleased
- In April, *R/V Neil Armstrong* was to be the only C-band ship in the Atlantic for some time. That disrupted the affordability of leaving HiSeasNet's C-band transmission to IS-23 (Atlantic). As a result, we have also converted Armstrong to a blended C/Ku Marlink Sealink Plus plan
- Marlink's primary satellite provider partner for Sealink is *Intelsat* – the same provider we have generally been using for HiSeasNet. As a result, ships now on Sealink are most often point toward the same spot in the sky as before

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Future: HiSeasNet Ground Station

- Based on initial positive results, we anticipate converting *R/V Sally Ride*, *R/V Sikuliaq* and *R/V Thompson* to *Marlink Sealink Plus* in Q4 2020-Q1 2021
- This will see us shut off 24/7/365 transmission of our third and final satellite dish at the HiSeasNet Ground Station
- HiSeasNet plans to have the ground station remain available for expansion work and/or future plans
- If high-performance throughput is needed consistently, 24/7/365 operations will likely need to resume
- More downtime means upkeep can happen – a growing need
- A point of presence at our ground station allows us to consider a conversion to a Low Earth Orbit ground station in the foreseeable future

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Future: Evolving Technology

1. Deeper discussion at hiseasnet.ucsd.edu/services/
2. *Low Earth Orbit (LEO)* is an evolving technology that works with 100% global coverage using a numerous array of satellites at ~2000km orbit.
3. Geostationary orbit is ~35,786 km. The difference in distance can help make realized LEO performance an order of magnitude more favorable. This can result in smaller antennae or higher performance capability
4. Electronic beam steering can be used, which means less moving parts … but less broad coverage at many elevations. Transmission power can be a limiter too
5. Satellite providers are considering hybrid approaches where 2-3 1.5 m traditional radomes can blend electronic beam steering logic with the performance advantages of classic radomes. HiSeasNet has been installing radomes that can support this where feasible to provide as many options as practical, going forward
6. LEO satellite constellations such as Iridium CERTUS have been available for widespread use since 2018; performance is limited to 1.2 Mbps and cost is similar to FleetBroadband

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Future: Evolving Technology (cont'd)

7. High-performance LEO options are coming… but the engineering challenges of multiple systems in the same orbit has created controversy with safety experts and bankruptcy for many companies trying to be the first to market
8. It will be some time before stable and complete high-performance systems are available for 100% global use, at-scale
9. We are pursuing strategic partnerships to leverage solutions in this realm as quickly as feasible
10. Punchline: LEO is of strong interest to seagoing research, but the technology has yet to truly catch up with the desire. While we wait, location-specific and/or usage-specific options with predictable throughput can be considered

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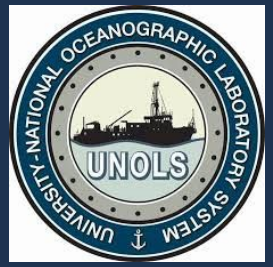
Future: 2021 Plans at-a-glance

1. We are working with our funding agencies on a Day Rate for ARF in 2021. To date, HiSeasNet-as-a-service has had a day rate, but Fleet Xpress and/or FleetBroadband has **not**.
2. Work with our agencies to agree upon a lifecycle plan that is within bounds of our finances. **Target:** radome replacement every ~5 years for reliability reasons, but this timeframe can vary depending on how ships work
3. Dual Global Xpress radomes to overcome blockages (Atlantis: planned)
4. Lifecycle replacement of aging FleetBroadband radomes
5. Lifecycle replacement of aging C-band/Ku-band radomes
6. Target replacing 5W Global Xpress radomes to 10W versions for better telepresence options
7. Should something like stimulus funds become available, we have a plan for leverage LEO for specific uses



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Thanks!