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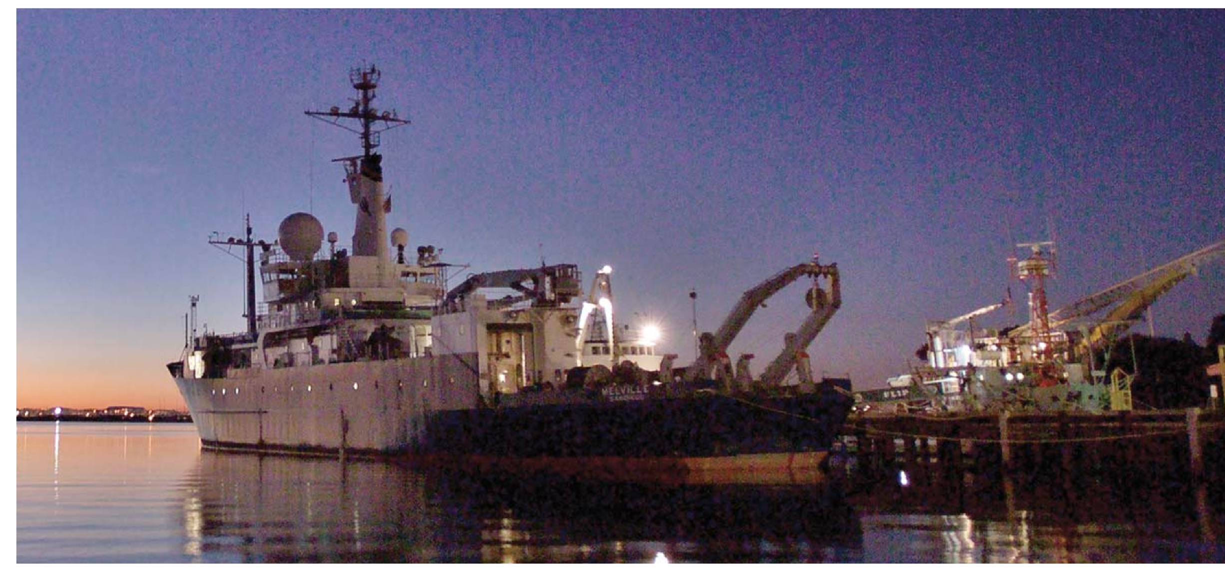
HiSeasNet

Advanced Communications for REMOTE OCEAN PLATFORMS IN THE COMING 15 YEARS



Long-term measurements in the oceans are becoming a scientific and civil imperative that is having a profound impact on oceanography and particularly seagoing oceanography. Ocean observatories such as NSF's Ocean Observatories Initiative (OOI) and NOAA's Integrated Ocean Observing System (IOOS) are providing means for making measurements of change over decadal time scales, a practice of great importance for understanding climate variability and change as well as potential for natural disasters such as tsunamis. At the same time the costs for operating ships at sea are increasing quickly (fuel, personnel, capability) and pressure is mounting for targeted community measurements in which data collected are available openly. Both of these trends drive efforts to enhance communications at sea in coming decades. Ships are now platforms for deployment and testing of new sensors that might be later deployed at fixed observatories and observatories are increasingly common; communications to these remote sites become increasingly important. Streamed real-time data from a ship or observatory allow for rapid response to new data and greater flexibility on how the science facility can be used by the community. Cost effective transfers of large blocks of data with high reliability including surety of data return, coupled with real-time streams, allow data to be analyzed quickly by shore experts and even machine-to-machine interactions, and improve the quality of information derived from science programs. For those scientists working at sea, robust communication with shore will allow for increased contributions to ongoing programs ashore. Satellite bandwidth today is still largely too expensive for personal work by individual investigators, but bandwidth will gradually decrease in price as new spacecraft are launched and more commercial operators offer service at sea. Whether paid by the minute, byte, or month, satellite communications will make increase the quality of research by making data available to a wider audience. We shall review the current use of HiSeasNet for these purposes and present anticipated enhancements of bandwidth by government and industry for the foreseeable future.

COMMUNICATIONS SATELLITES HISTORICAL HIGHLIGHTS:

- 1964: First commercial communications satellite, COMSAT's EARLY BIRD, launched
- 1976: MARISAT launched for mobile satellite communications at sea
- 1998: Iridium phone service begins
- 2000: Globalstar data service begins
- 2000: 2nd Gen Tracking and Data Relay Satellite System (TDRSS) satellites launched
- 2001: Iridium 2.4kbps data service begins
- 2002: Inmarsat F77 MPDS (by-the-byte) service begins
- 2007: Inmarsat Fleet BroadBand service begins
- 2008: Iridium OpenPort (128bps) service beginsc

USES OF COMMUNICATIONS FOR REMOTE PLATFORMS INCLUDE:

- Real-time data feeds to shore
  - Data quality monitoring
  - Instant event detection and early warning
  - Input to modeling needs
  - Remote control of instruments and autonomous vehicles from shore
- Basic communications between scientists at sea and shore
- Live public outreach from sea
- Leverage shore compute and personnel resources for responding quickly to science observed at sea
- Science program directed by staff and resources on shore

OBSERVATORIES WITH NEEDS FOR NEAR-REAL-TIME DATA RELAY TO SHORE:

- Research vessels
- Ocean Observatories Initiative (OOI)
- Integrated Ocean Observing System (IOOS)
- Global Earth Observation System of Systems (GEOSS)
- Cabled observatories

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Undersea cables allow for large amounts of bandwidth, are great for subsea sensors, but have a limited range from shore.

Cellular/Radio technology allows for cheap and fast communications when cables do not reach...but only when in range of shore-based cellular or radio towers (~30mi) and on the ocean surface.

Satellite technology is required when a platform is out of radio or cable range from shore. Satellite communications may require large directional antennas depending on bandwidth needs.

Coverage area can be very large, bandwidth costs can be a fixed or by-the-byte/minute, and links are optimized for broadcast to many stations.

For bulk, non-real-time data transfers, **TDRSS** uses NASA space tracking satellites with directional antennas to offer 311Mbit bulk transfer on a schedule, making HDTV or 50-100GB transfers possible.

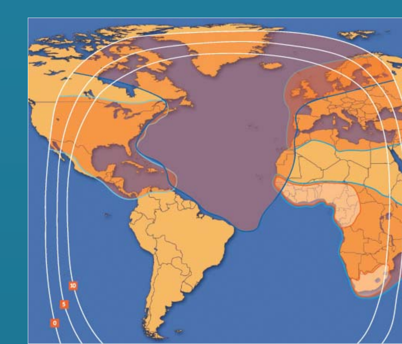
NETWORK ACCELERATION CAN IMPROVE EFFICIENCY OF ANY TYPE OF NETWORK LINK. APPLIANCES CAN PROVIDE:

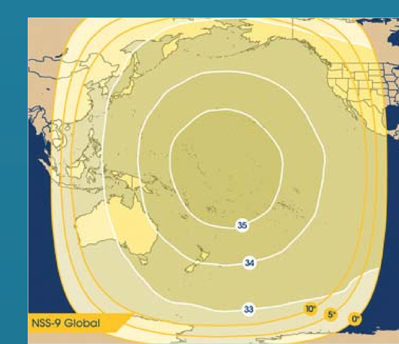
- TCP and UDP transport layer packet caching
- On-the-fly compression
- DNS, HTTP, CIFS application layer caching
- Space Communication Protocol Standards link tuning

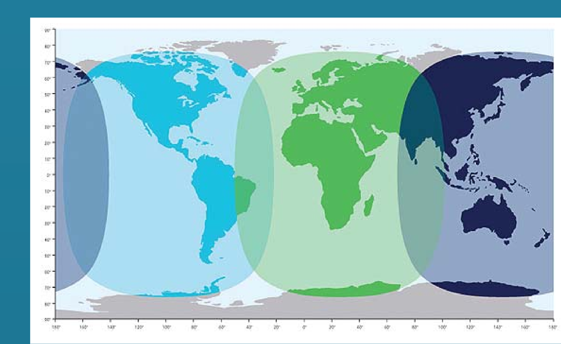
SYSTEM	RANGE	CIRCUIT TYPE	DATA RATE	TARRIF	COST /MB	NOTES
WiFi	~1 km	Always-on	~10 Mbps	User owned	N/A	Very cheap
Point to Point Wireless	Line of Sight	Always-on	Mbps	User owned	N/A	cheap
3G Cell Phone	Line of Sight	Always-on	~1 Mbps	~$100/mo	$0.02	Monthly data limit (~5GB)
Fiber Optic	~100 km	Always-on	Many Gbps	User owned	N/A	High capital cost
Globalstar	100s km	Dial-up	9.6 kbps	$1/min	~$14	Omni antenna
Ku-Band	1000s km	Always-on	As needed	$6K/MHz.mo	$0.02	1.0 m Directional Antenna
Inmarsat Fleet Broadband	Global	Always-on	Up tp 432kbps	$11/MB	$11	Small Directional Antenna
Inmarsat FBB streaming	Global	Dial-up	Up to 256kbps	$42/min	~$22	Small Directional Antenna
C-Band VSAT	Global	Always-on	As needed	$7K/MHz.mo	$0.02	2.4 m Directional Antenna
TDRSS	Global	Scheduled	311 Mbps	~$10/min	$0.004	2.4 m Directional Antenna
KVH	Global	Always-on	Up to 2 Mbps	$5/MB	$5	Small directional antenna
Iridium	Global	Dial-up	2.4 kbps	$0.75/min	~$50	Omni antenna
Iridium OpenPort	Global	Always-on	128 kps	$9/MB	$9	Omni antenna

RECENT SATELLITE MARKET CHANGES INCLUDE:

- Launch of NSS-9: High power C-band service
- Launch of Telstar 11: Ku-band over the Atlantic Ocean
- Fleet Broad Band service: By-the-byte, global, any time data service up to 432kbps, small antennas


Telstar 11 Ku-band service


NSS-9 C-band service


Fleet Broadband coverage area

HiSeasNet (www.hiseasnet.net)

HiSeasNet provides sea-going scientists with real-time access to shore support resources including people, model output, satellite imagery, compute farms, storage clouds, etc. It is also used to stream shipboard data to shore for instant analysis, publication, and quality assurance. Anything based on Internet Protocol (IP) works across HiSeasNet, including: FTP, email, ssh, instant messages, Voice-over-IP, streamed media, videoconferencing, etc.

Started in 2002 with one ship, HiSeasNet now has 15 ships in the US academic fleet (UNOLS) online with one earth station in San Diego, CA handling carriers on 4 C-band and Ku-band satellite beams. Data rates vary from 64-128kbps/ship shore-to-ship and 64-96kbps/ship ship-to-shore. Total program costs are $150 (Ku-band) or $250 (C-band) per ship science day. Increased bandwith can be provided on a temporary basis.

HiSeasNet bandwidth is expected to increase as prices continue to come down. Coverage areas will increase as science happens in more remote locations. In the meantime, network accelerators are improving data flow now.

THE FUTURE OF COMMUNICATIONS WILL SEE:

- More Ku-band ocean satellite coverage for small antennae driven by market for aircraft and vessel fleet communications
- Greater competition in the satellite market
- Greater efficiency in data acceleration
- More high-speed bulk data transfers (ie TDRSS)
- More cabled observatories online
- Cheaper satellite services
- With new generations of satellites out now, capacity will increase, but gradually