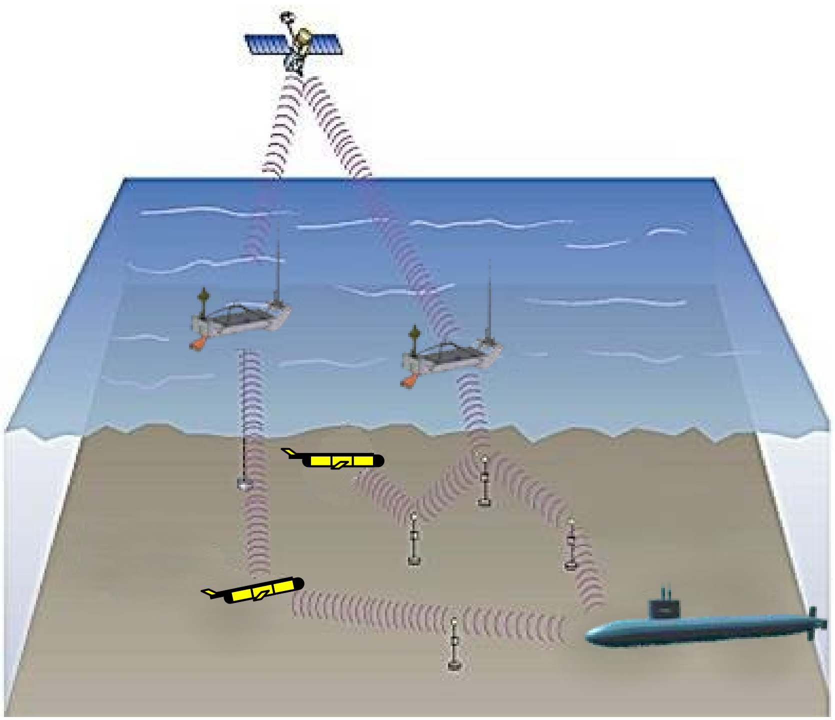
IETF Meeting, DTNRG session
2006 March 24

Seaweb

Seaweb as a DTN pilot application



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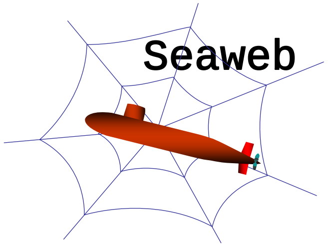
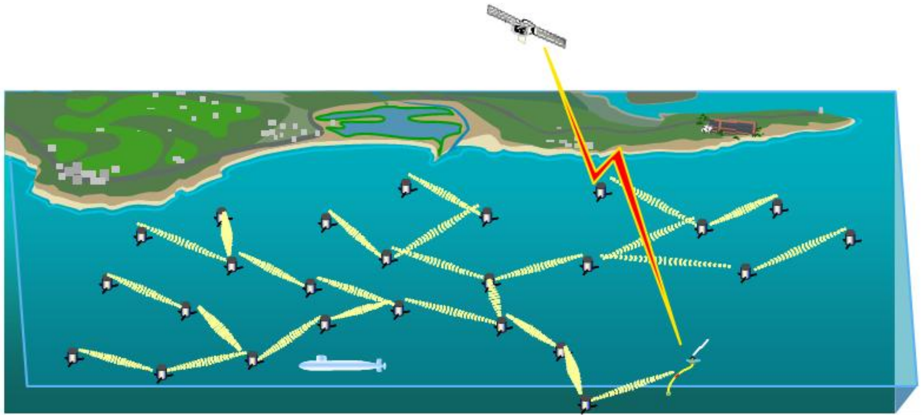
Seaweb is a US Navy developmental technology.

US Navy Seaweb Initiative

Enabling Undersea FORCEnet for cross-system, cross-platform, cross-mission, cross-nation interoperability





Integrated undersea applications

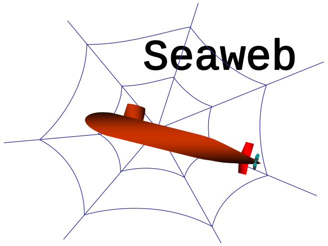
- Littoral ASW sensor telemetry (e.g., DADS)
- METOC sensor telemetry
- Sensor-to-sensor cueing
- Submarine comms @ S&D
- Submersibles (e.g., SDV)
- UUVs (e.g., Gliders, Ematt, etc)
- Sea mines (e.g., Sea Predator)
- Collaborative operations (e.g., Sea Eagle ACTD)
- Command & control
- Deployable ranges
- Sea base defense
- Harbor defense

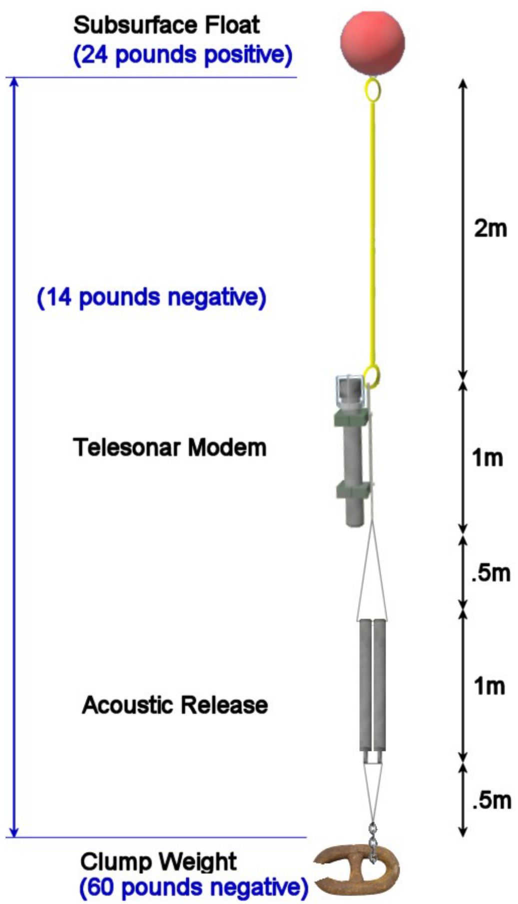
Through-water digital com/nav networks

- Scalable wide-area wireless grid
- Composable architectural flexibility
- Fixed and mobile autonomous nodes
- Gateways to command centers
- Persistent and pervasive
- Low source level, wide band, high freq

J. Rice, "Enabling Undersea FORCEnet with Seaweb Acoustic Networks," *Biennial Review 2003*, SSC San Diego TD 3155, pp. 174-180, December 2003

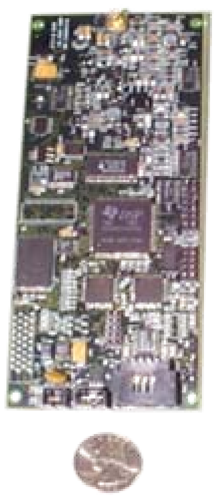
Seaweb repeater node



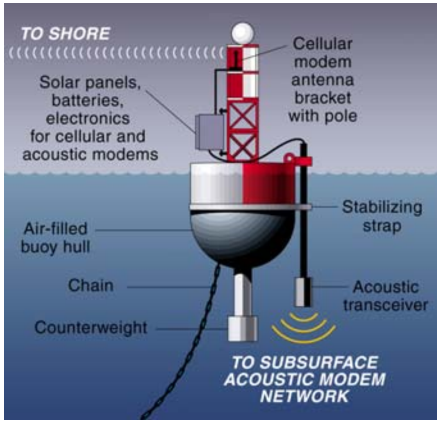


Seaweb telesonar modem, circa 2000-2005

- Benthos, Inc. COTS hardware
- Texas Instruments TMS320C5410 DSP
- US Navy firmware
- Spectral bandwidth = 5 kHz (9-14 kHz)
- SL = 174 dB re 1 μPa @ 1m
- Modulation = MFSK
- 128 tones, 1 of 4 tones keyed
- Forward Error Correction
- Raw bit rate = 2400 bit/s
- Utility packets = 150 b/s
- Data packets = 800 b/s
- DI = 0 dB (omni)
- DI = 0 dB (omni)



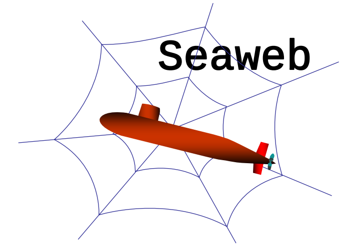
K. Scussel, "Acoustic Modems for Underwater Communications," *Wiley Encyclopedia of Telecommunications*, Vol. 1, pp. 15-22, Wiley-Interscience, 2003

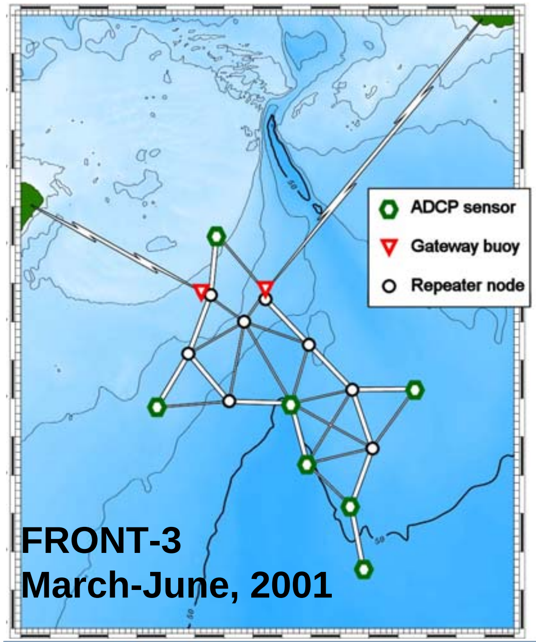


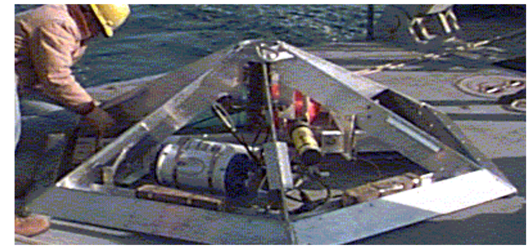
Demonstrated capabilities:

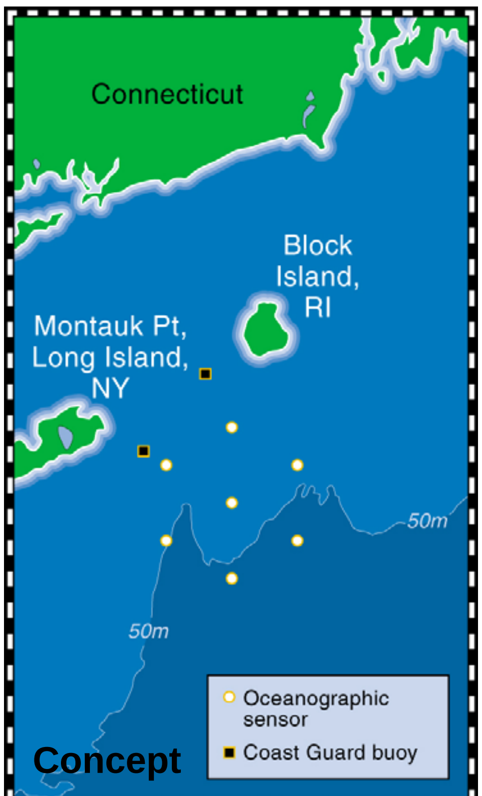
FRONT ocean observatory

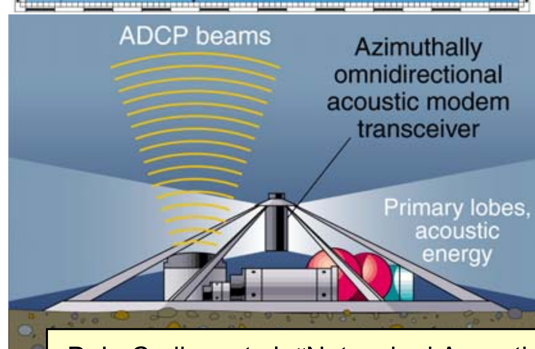
National Oceanographic Partnership Program

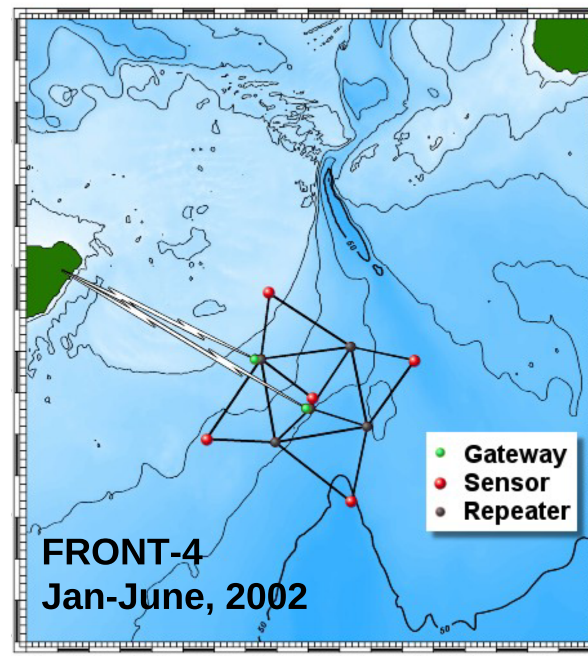








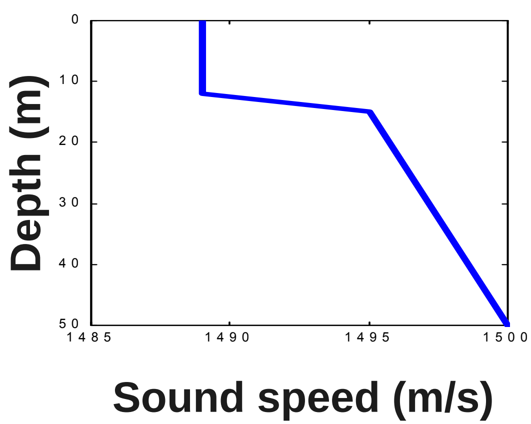


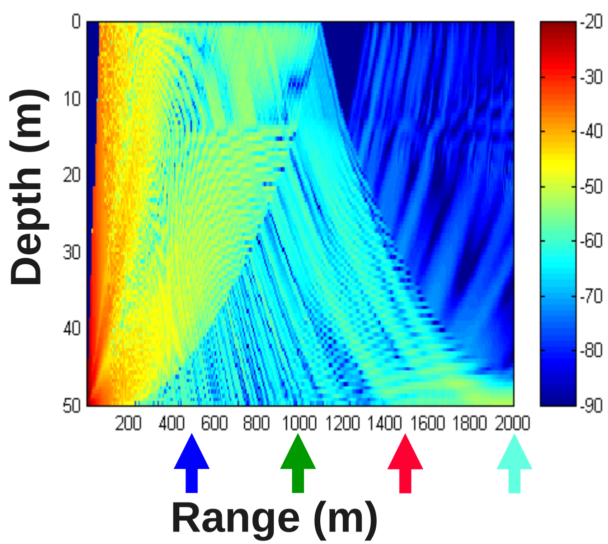


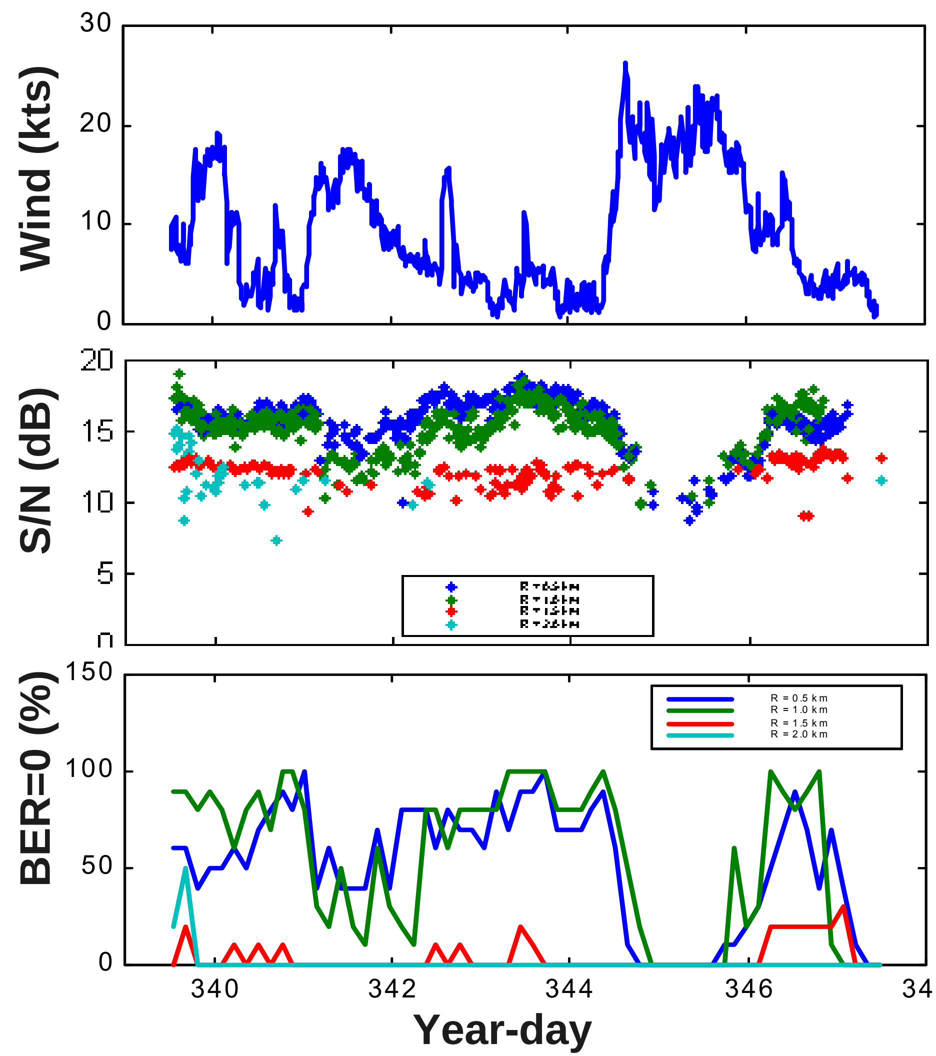
D. L. Codiga, et al, "Networked Acoustic Modems for Real-Time Data Telemetry from Distributed Subsurface Instruments in the Coastal Ocean: Application to Array of Bottom-Mounted ADCPs," *J. Atmospheric & Oceanic Technology*, June 2005

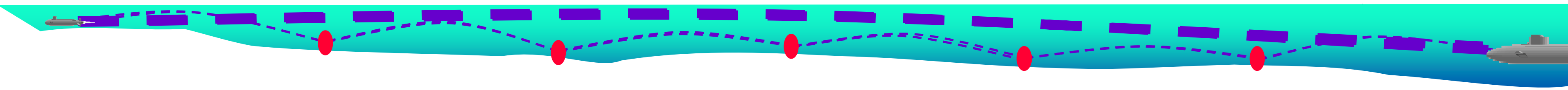
Upward refraction in FRONT-1 caused strong dependence on the sea-surface boundary

Seaweb

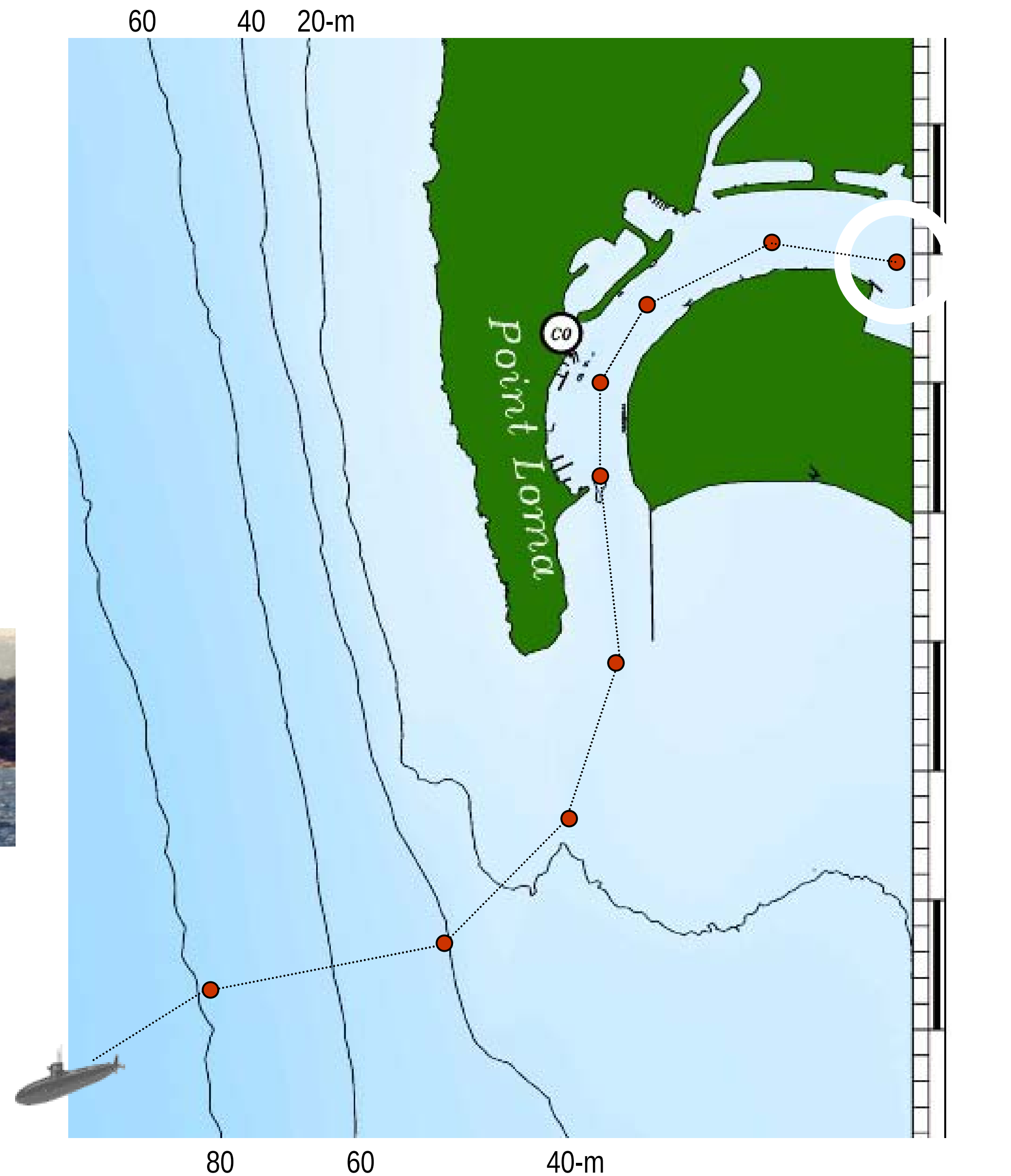








Sea Eagle ACTD is demonstrating connectivity in littoral environments

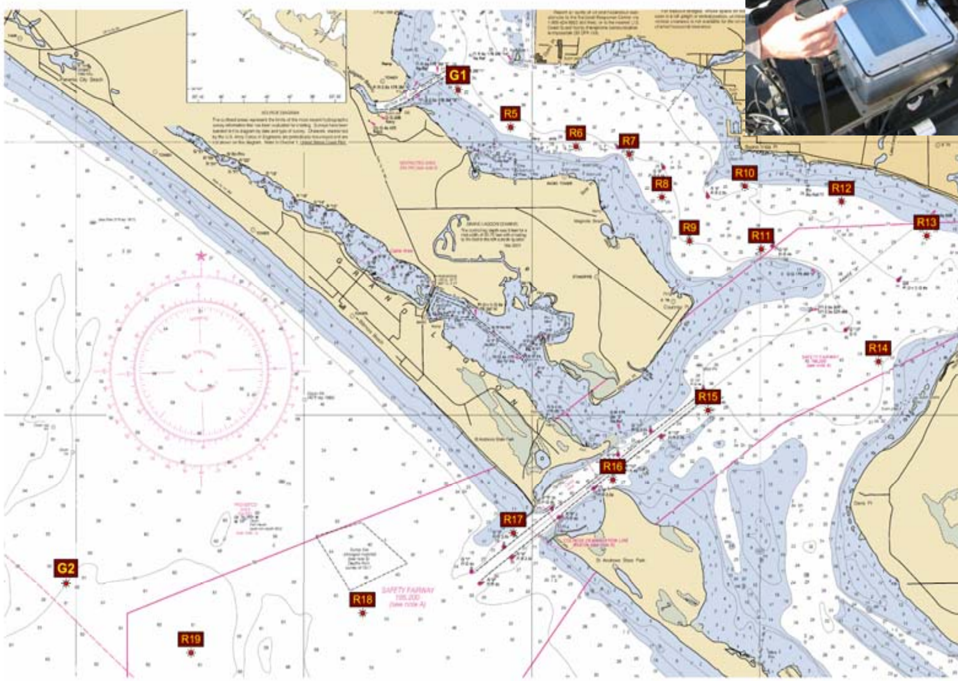


Clandestine undersea connectivity to/from SDV and ASDS during expeditionary ops

Seaweb 2005 NSW Experiment

February 2005, Panama City, FL

Seaweb



- SRQ link-layer mechanism
- NSMA (Neighbor Sense Multiple Access, a cross-layer variation on CSMA)
- Ranging and node localization
- Iridium-equipped Racom buoy
- SDV Periscope Controller
- Compressed image telemetry
- NPS, SSCSD, CSS, Benthos

Engineering sea test for:

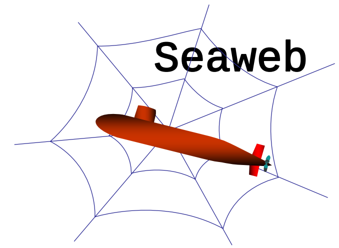
- DADS ASW Barrier
- Sea Eagle ACTD NSW Expeditionary Ops
- Sea Predator (2010 Mine) RECO

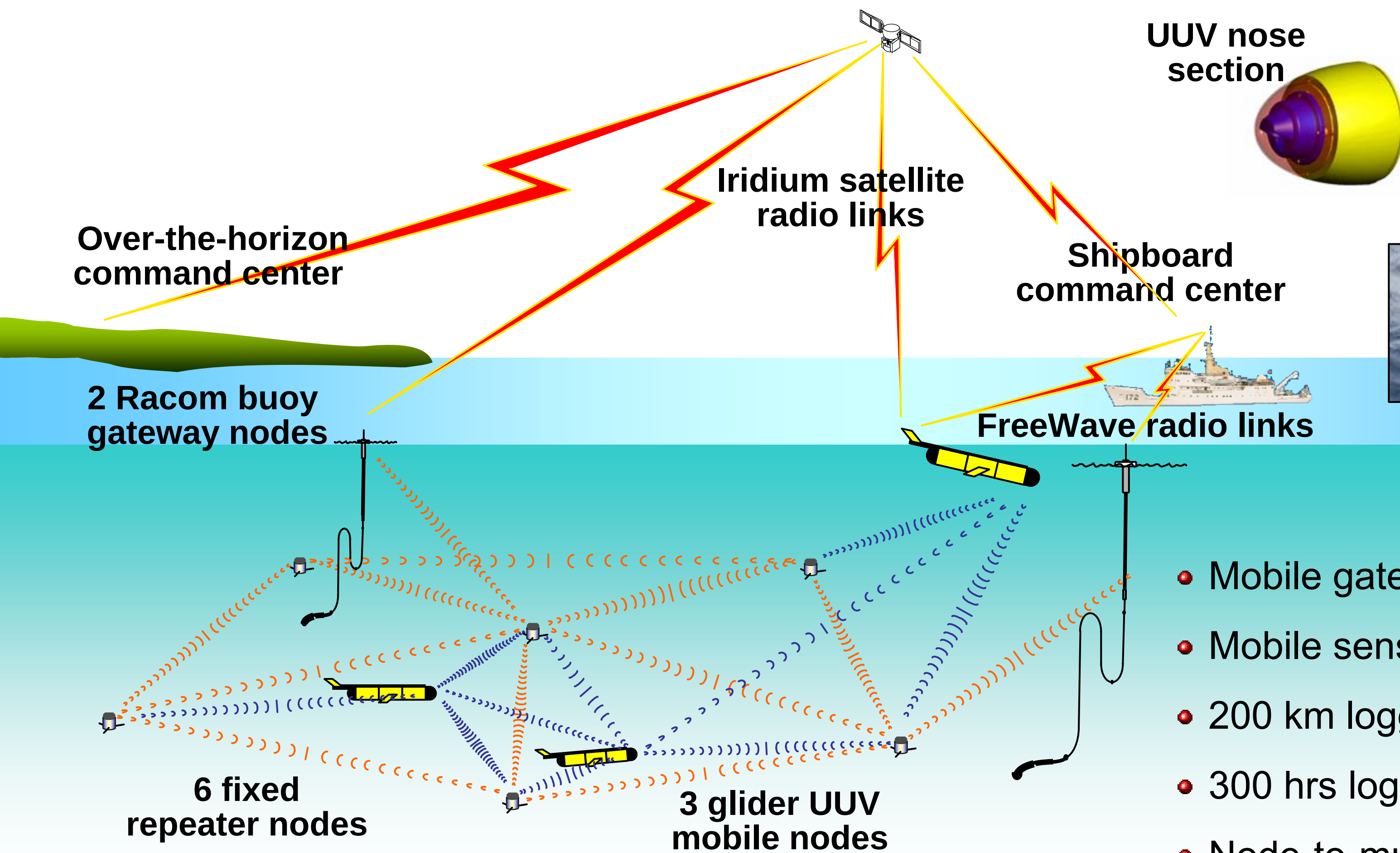
Demonstrated capabilities:

Seaweb network with UUVs

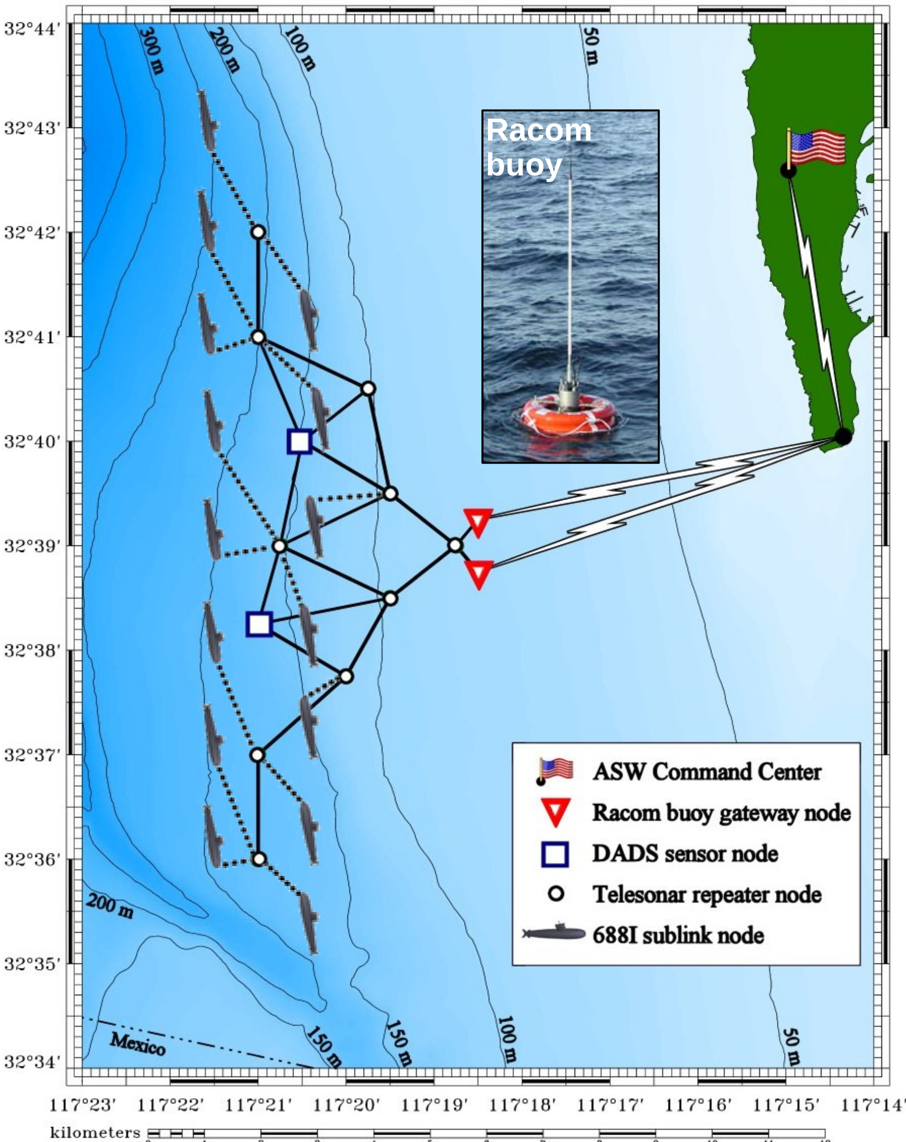
US/Canada collaboration

Gulf of Mexico, Feb 1-8, 2003





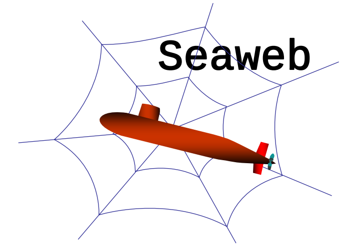
- Mobile gateway nodes
- Mobile sensor nodes
- 200 km logged by UUVs
- 300 hrs logged by UUVs
- Node-to-multinode comm/nav



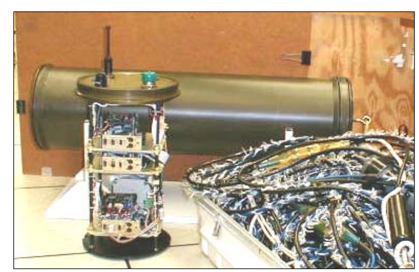
Demonstrated capabilities:

FBE India

June 2001



- SSN with BSY-1 sonar Seaweb TEMPALT
- Ashore ASW command center
- Seaweb server at SSN and ASWCC
- Acoustic chat and GCCS-M links to fleet
- SSN/MPA cooperative ASW against XSSK
- Flawless ops for 4 continuous test days

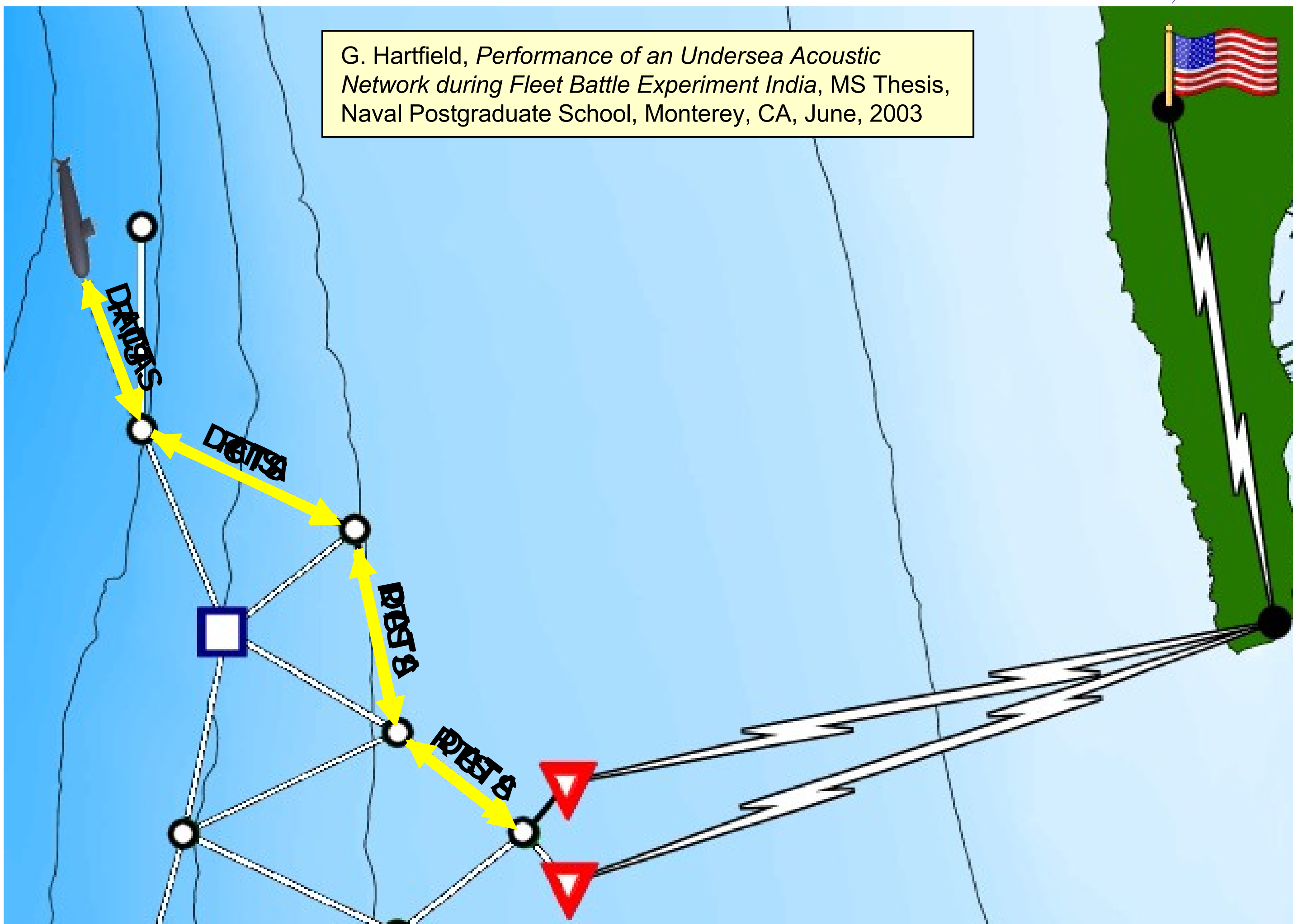


Experimental DADS sensor node

J. Rice, et al, "Networked Undersea Acoustic Communications Involving a Submerged Submarine, Deployable Autonomous Distributed Sensors, and a Radio Gateway Buoy Linked to an Ashore Command Center," *Proc. UDT Hawaii*, October 2001

Seaweb message example:

Multi-Access Collision Avoidance (MACA) Internet Protocol (IP)



Demonstrated capability:

Selective Automatic Repeat Request (SRQ) is a link-layer mechanism for reliable transport of large datafiles even when the physical layer suffers high BERs

Seaweb

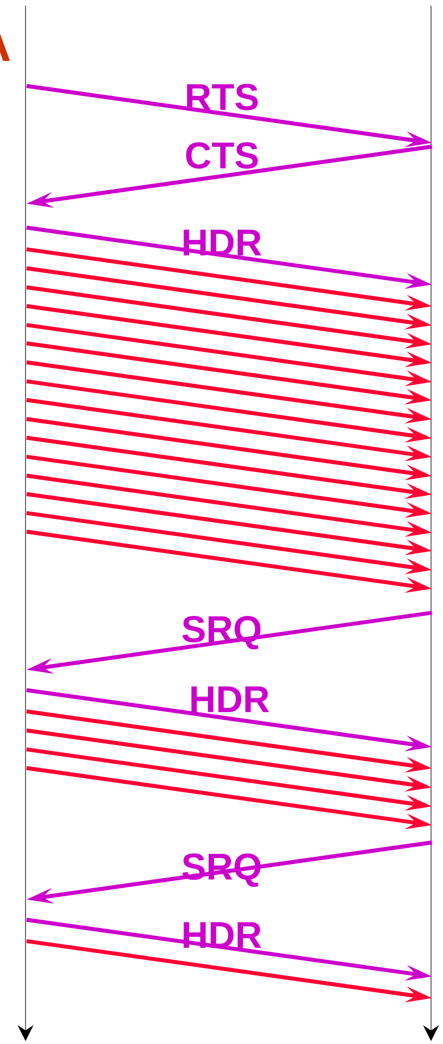
Node A

1. Node A initiates a link-layer dialog with Node B.

3. Node A transmits a 4000-byte Data packet using 16 256-byte subpackets, each with an independent CRC.

6. Node A retransmits the 4 subpackets specified by the SRQ mask.

8. Node A retransmits the 1 subpacket specified by the SRQ.



Node B

2. Node B is prepared to receive a large Data packet as a result of RTS/CTS handshaking.

4. Node B receives 12 subpackets successfully; 4 subpackets contained uncorrectable bit errors.

5. Node B issues an SRQ utility packet, including a 16-bit mask specifying the 4 subpackets to be retransmitted.

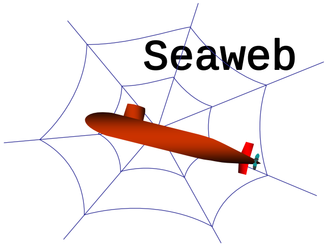
7. Node B receives 3 of the 4 packets successfully (future implementation of cross-layer time-diversity processing will recover 4 of 4). B issues an SRQ for the remaining subpacket.

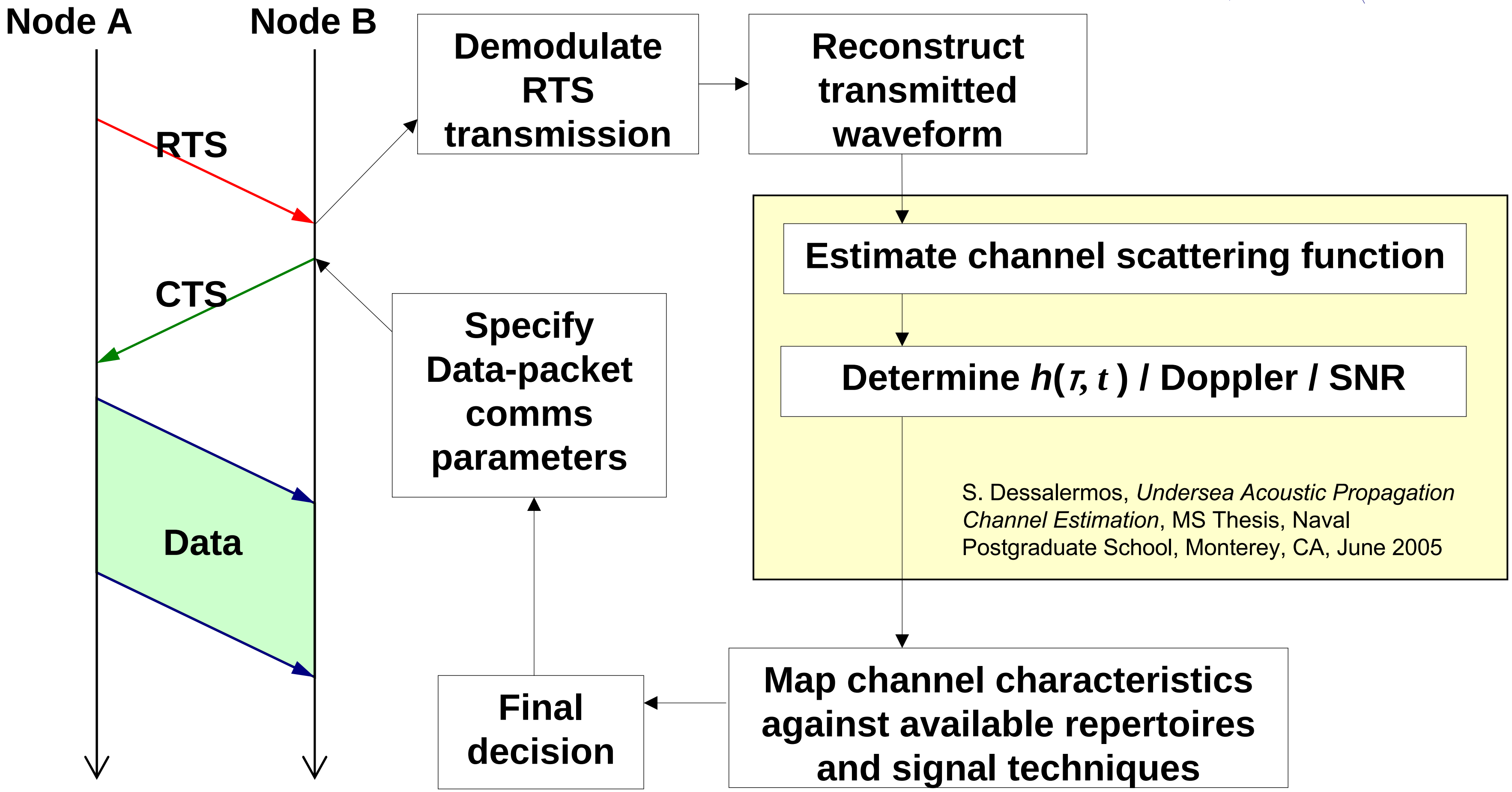
9. Node B successfully receives and processes Data packet.

J. Kalscheuer, *A Selective Automatic Repeat Request Protocol for Undersea Acoustic Links*, MS Thesis, Naval Postgraduate School, June 2004

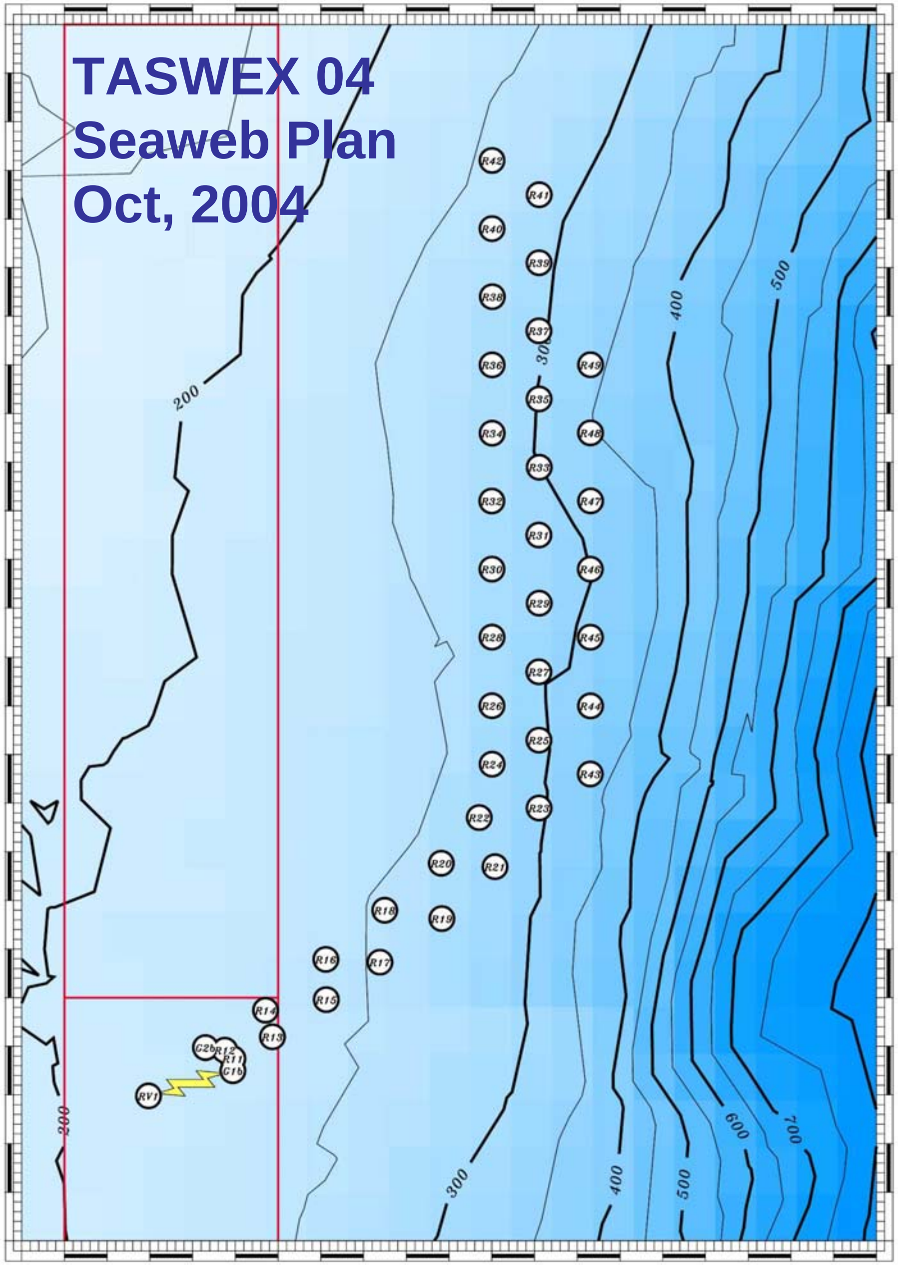
Current research

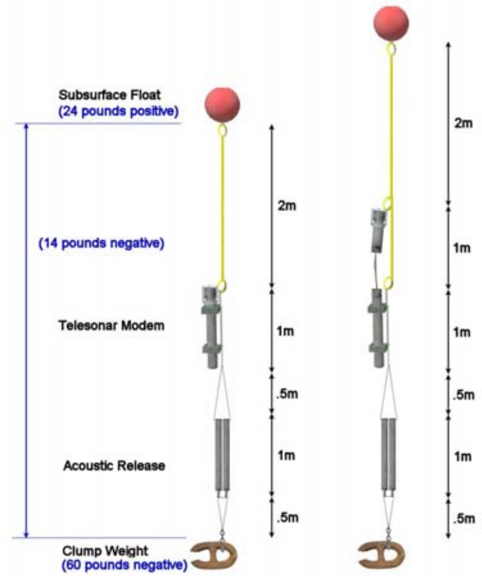
Adaptive modulation

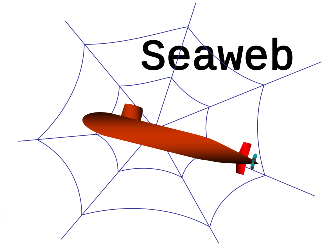




TASWEX 04
Seaweb Plan
Oct, 2004







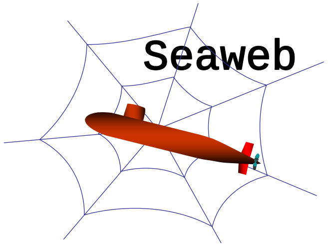
Seaweb repeater nodes

- COTS telesonar modem
- 9-14 kHz
- 180 dB re 1μPa @ 1m
- Alkaline batteries
- 1-man deployable
- Redundant acoustic releases
- Recoverable using RHIB
- $15K/node

US Navy racom buoy

radio/acoustic communications gateway node

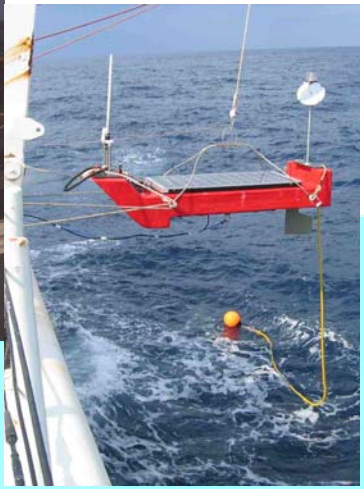
6 units built for TASWEX 04

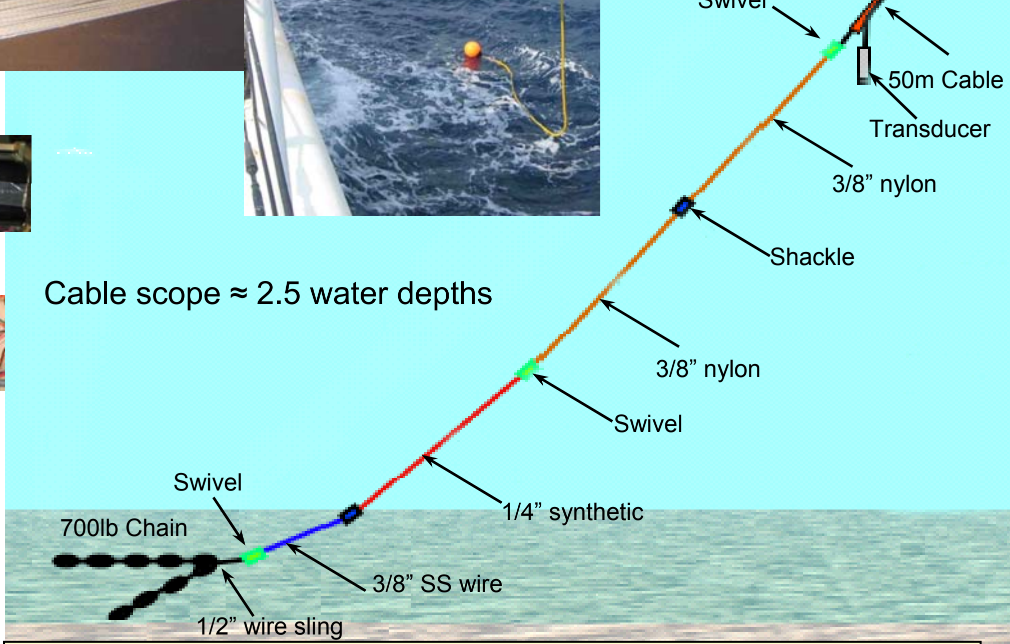


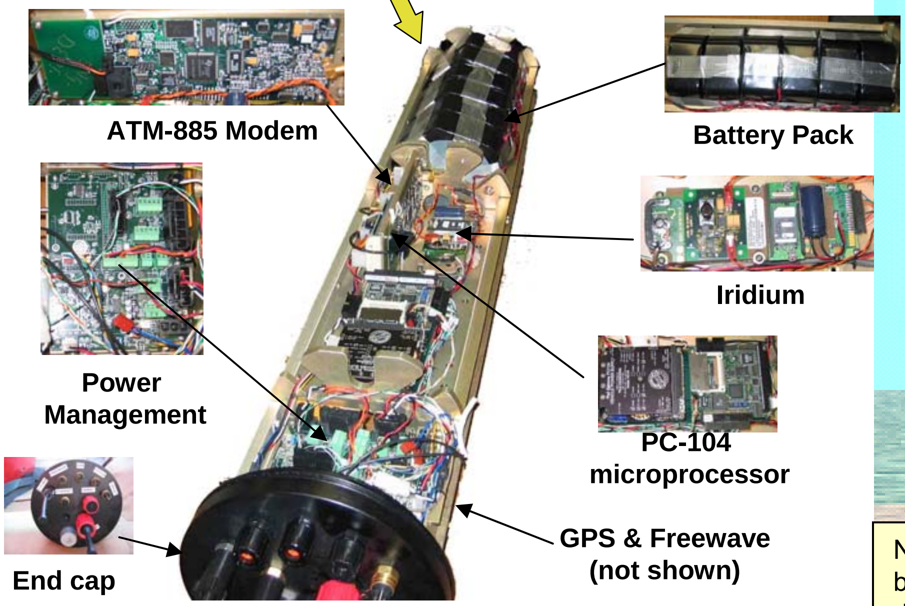
Assembly

Staging

Deployment (6-8 minutes)





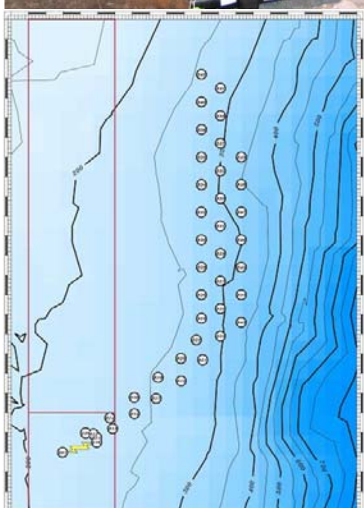


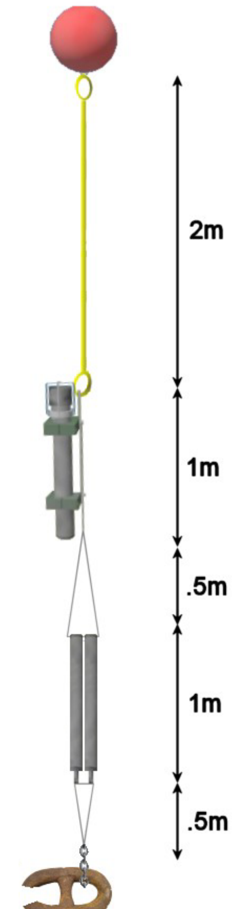
Note: Other racom configurations exist, including pop-up buoys and expendable buoys. Mooringless, energy-harvesting station-keeping USVs are now in development as next-generation racom buoys through SBIR topic N05-077.

Seaweb 2004 Undersea Vehicle Experiment cellular grid deployment

Seaweb

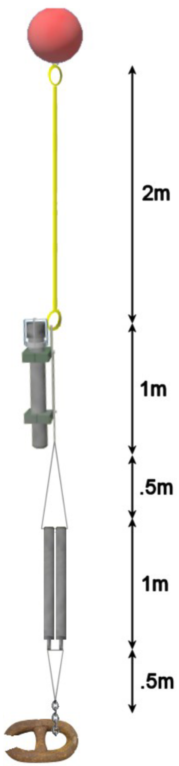
Average speed 6.5 knots
Average 1 repeater every 20 min

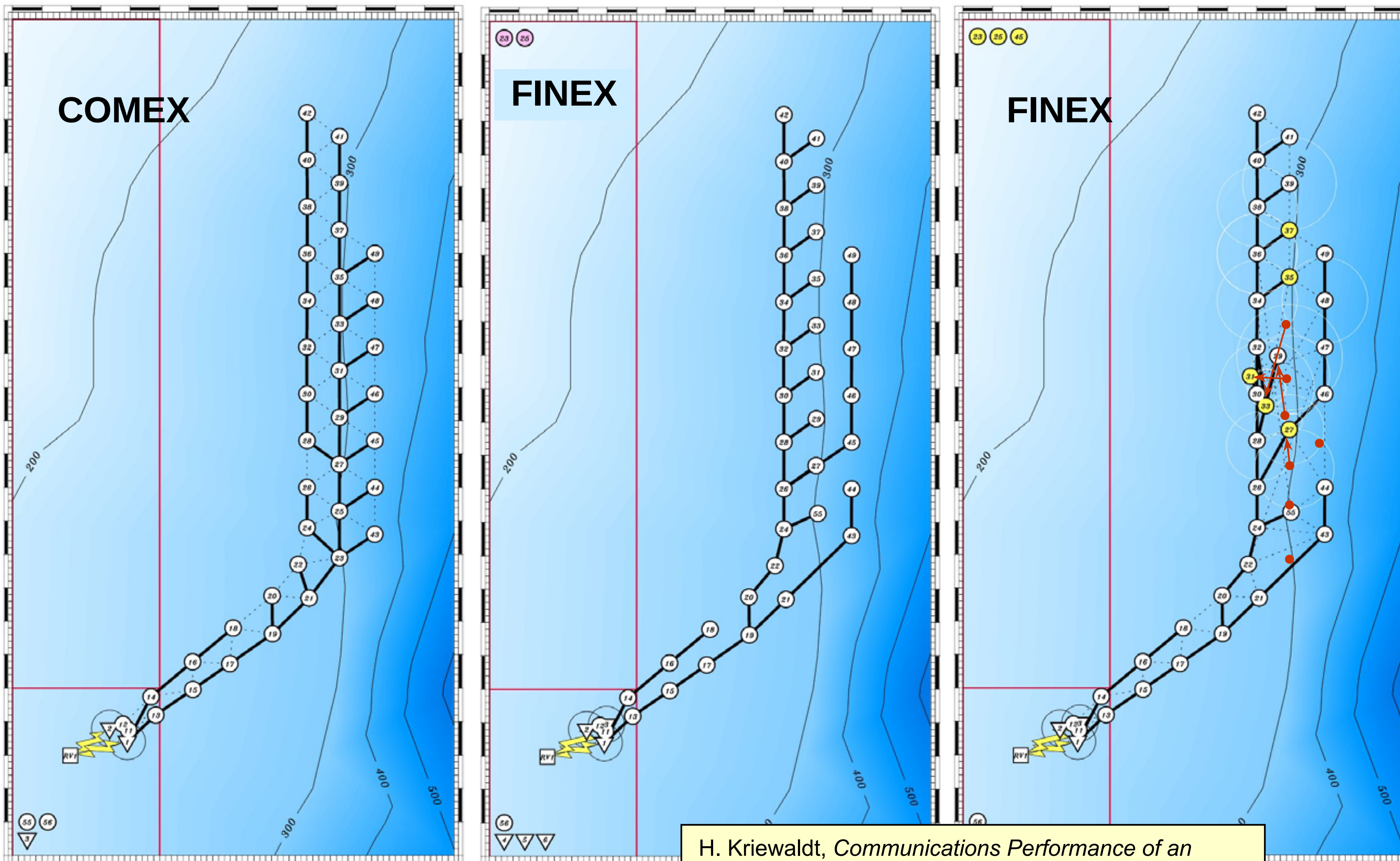




Seaweb 2004 grid post mortem

Impacted by trawling along the 300-m isobath
3 nodes removed, 6 nodes displaced or damaged

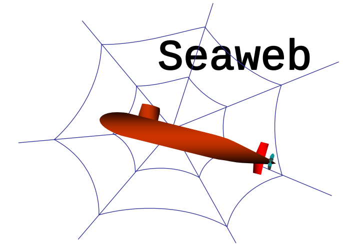




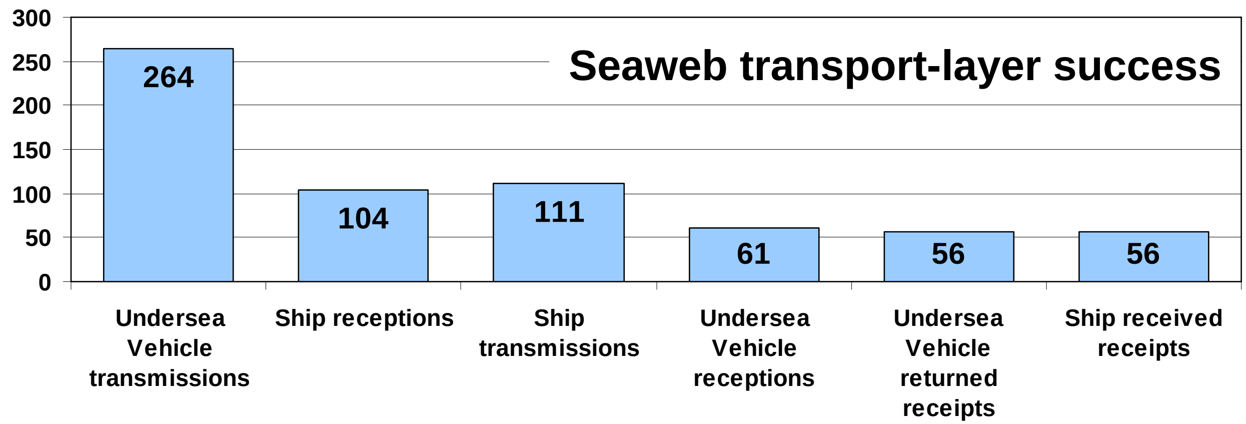
H. Kriewaldt, *Communications Performance of an Undersea Acoustic Wide-Area Network,* MS Thesis, Naval Postgraduate School, December 2005

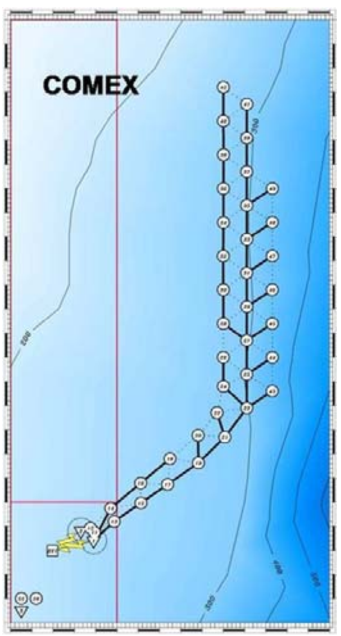
Seaweb 2004 Experiment

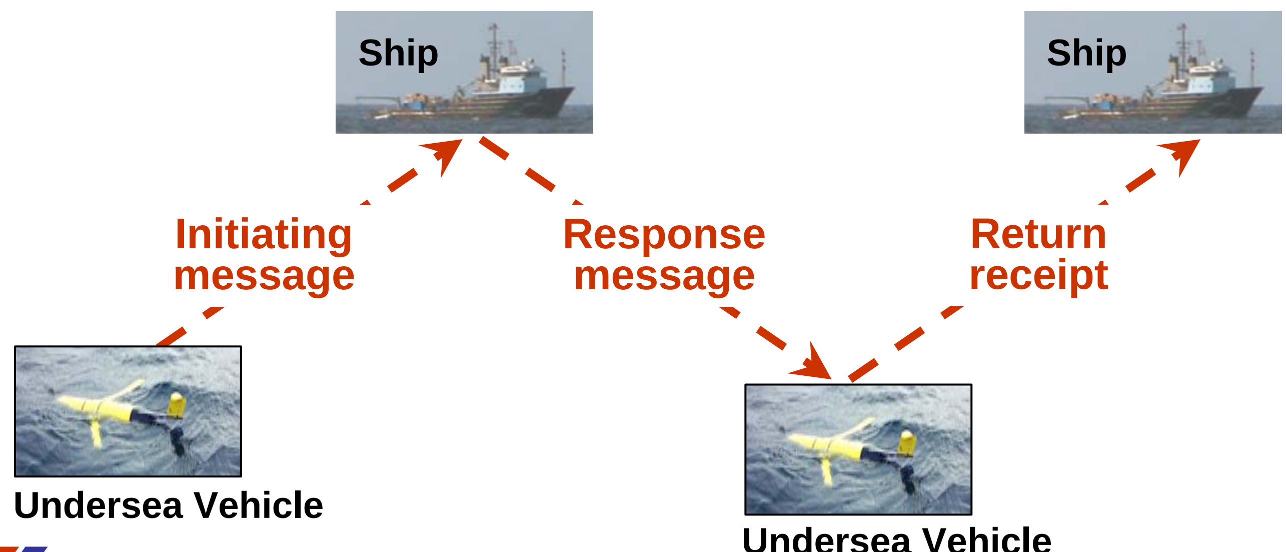
Undersea Vehicle initiates the Seaweb sessions



Seaweb transport-layer statistics show solid performance with dropped messages attributable to UV limited aspect, UV fix-expansion uncertainty, and interference from other UV active sonar

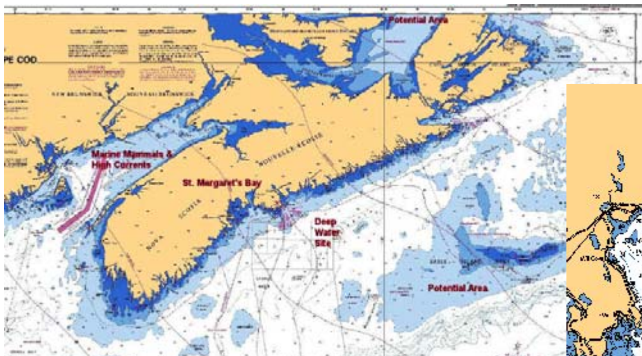


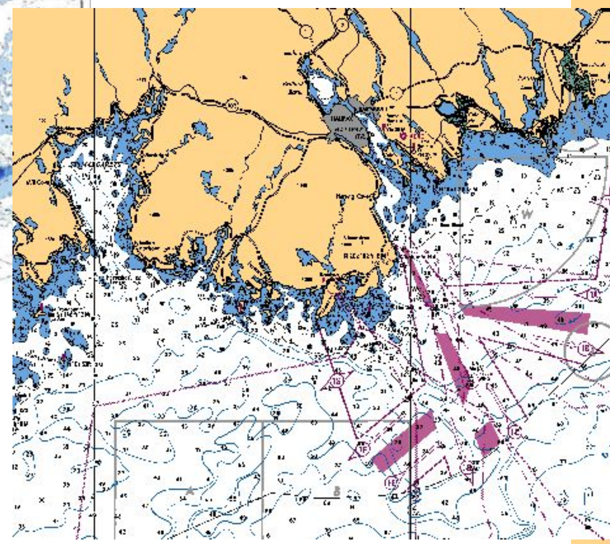


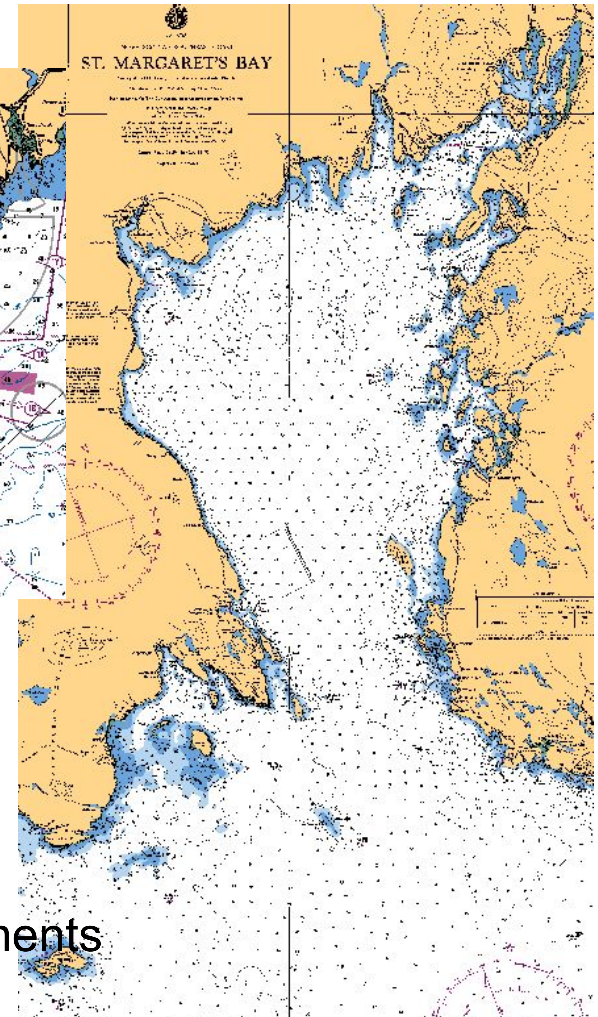


Unet 2006 Sea Trial

May 2006, Nova Scotia







Site selection criteria

- 50-300 m waters
- 20 km x 40 km oparea
- < 3 days from port
- "Benchmark" site useful for follow-on experiments