

Wireless Networking for Oceanographic Research

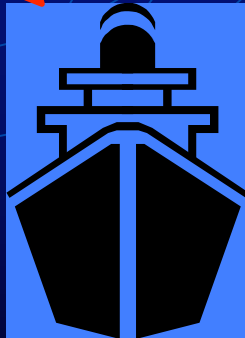
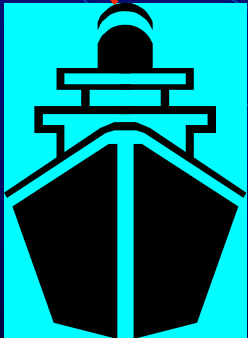
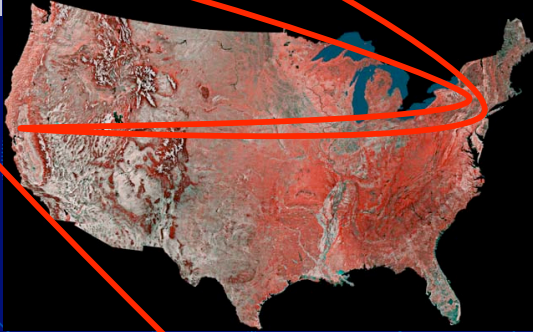
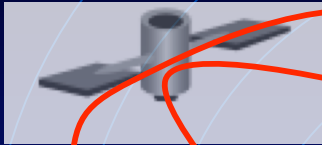
Wireless Mesh Networking in the UNOLS Fleet

Val Schmidt

October 19, 2006

Many Thanks to NSF and UNOLS

Traditional Ship to Ship Data Transfer



- Two satellite hops.
- ~\$35/Megabyte
- \$700 and take 5-6 hours for a 20MB file multibeam file.

Media fishing



Thanks Briana!

Early 802.11 Tests

RVTEC - 2002

<http://pigeon.shipops.orst.edu/swap/rvtec2002/>

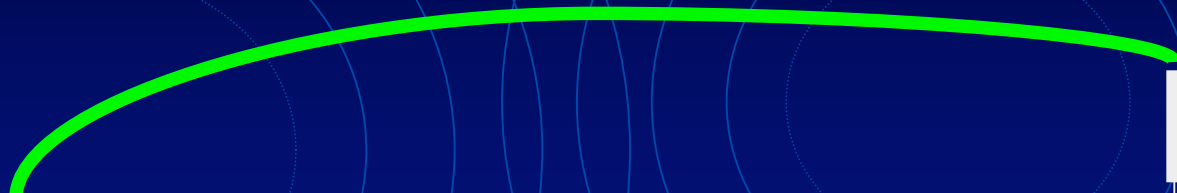
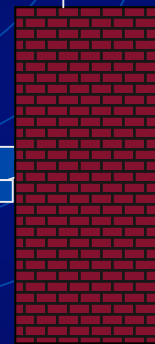
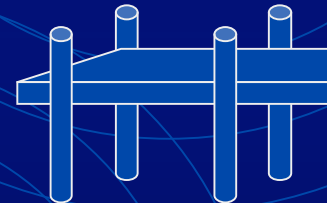
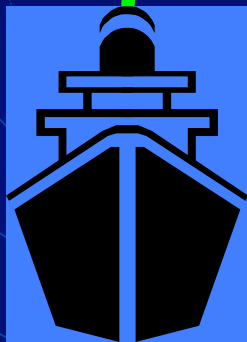


- Toby Martin,
Oregon State University,
R/V Wacoma
- 802.11b point to point
- Lucent “Remote Outdoor Routers”

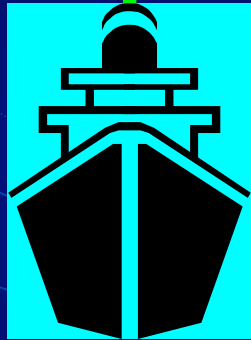
Questions

- Was there a need?
- Commercially available?
- Impact on ship's network?
- Technical skill?
- Range?
- Pitch and Roll?
- Interference?
- Were there other applications?
- Could/should we create a fleet wide system?

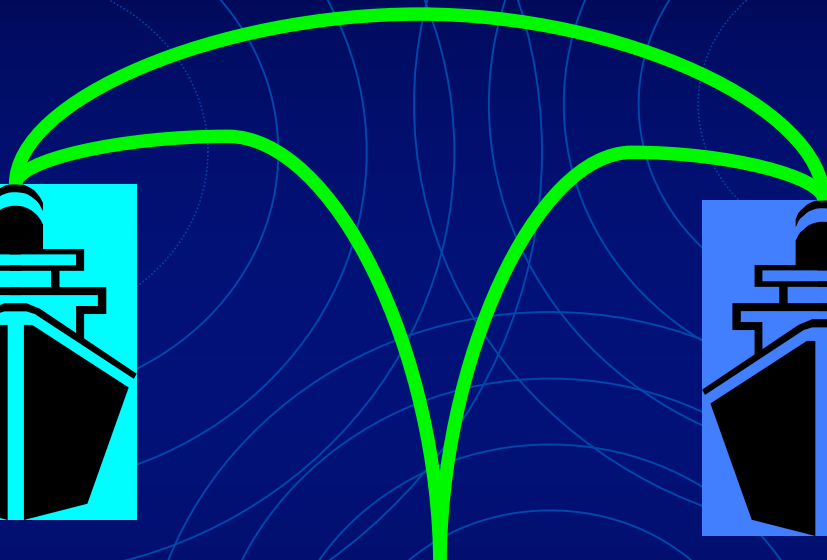
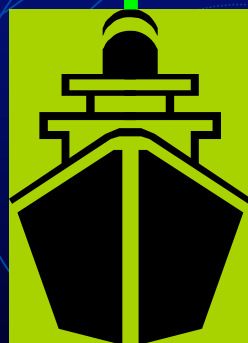
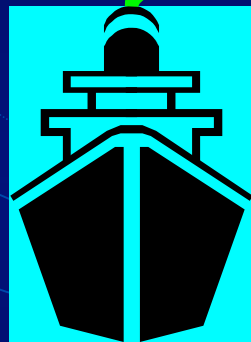
Scenarios



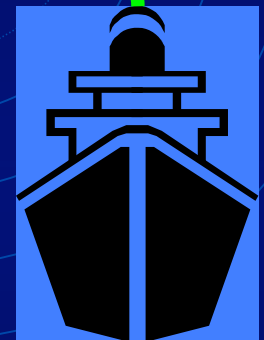
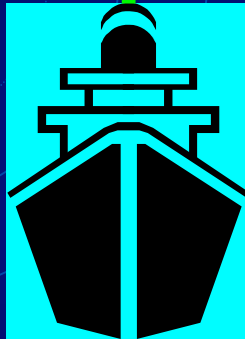
Scenarios



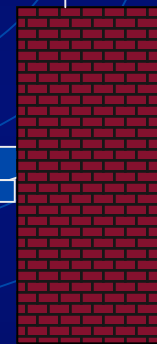
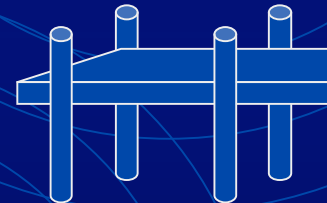
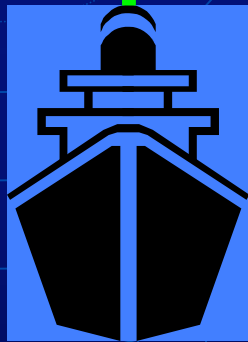
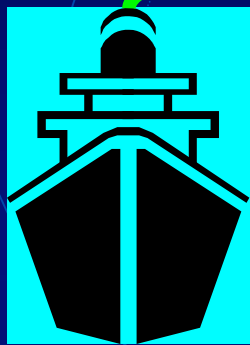
Scenarios



Scenarios



Scenarios



Scenarios

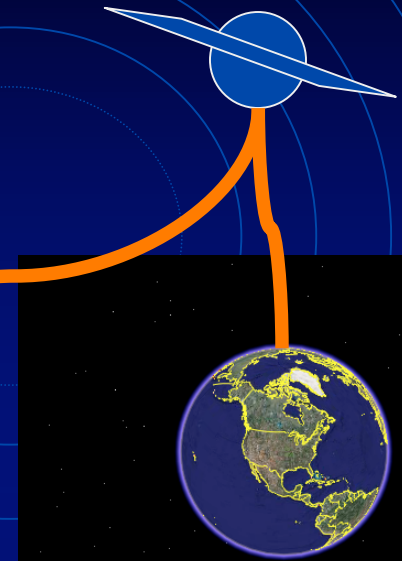
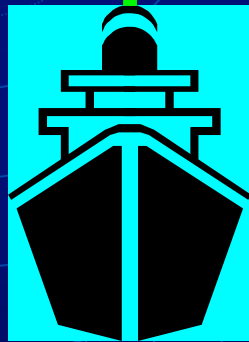
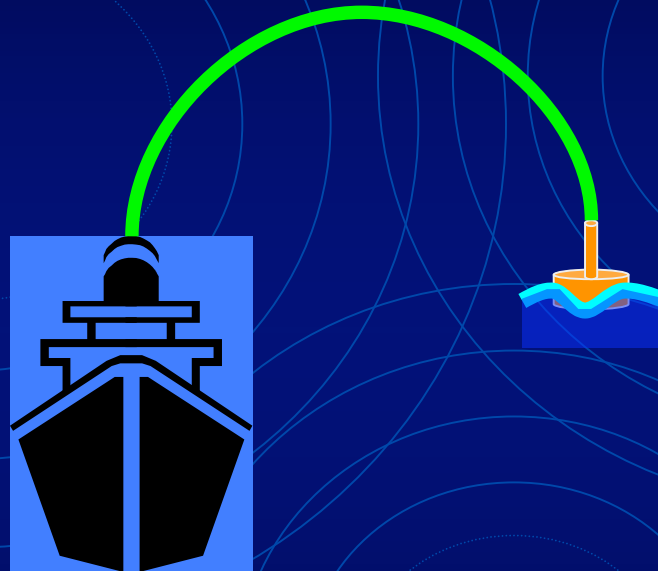
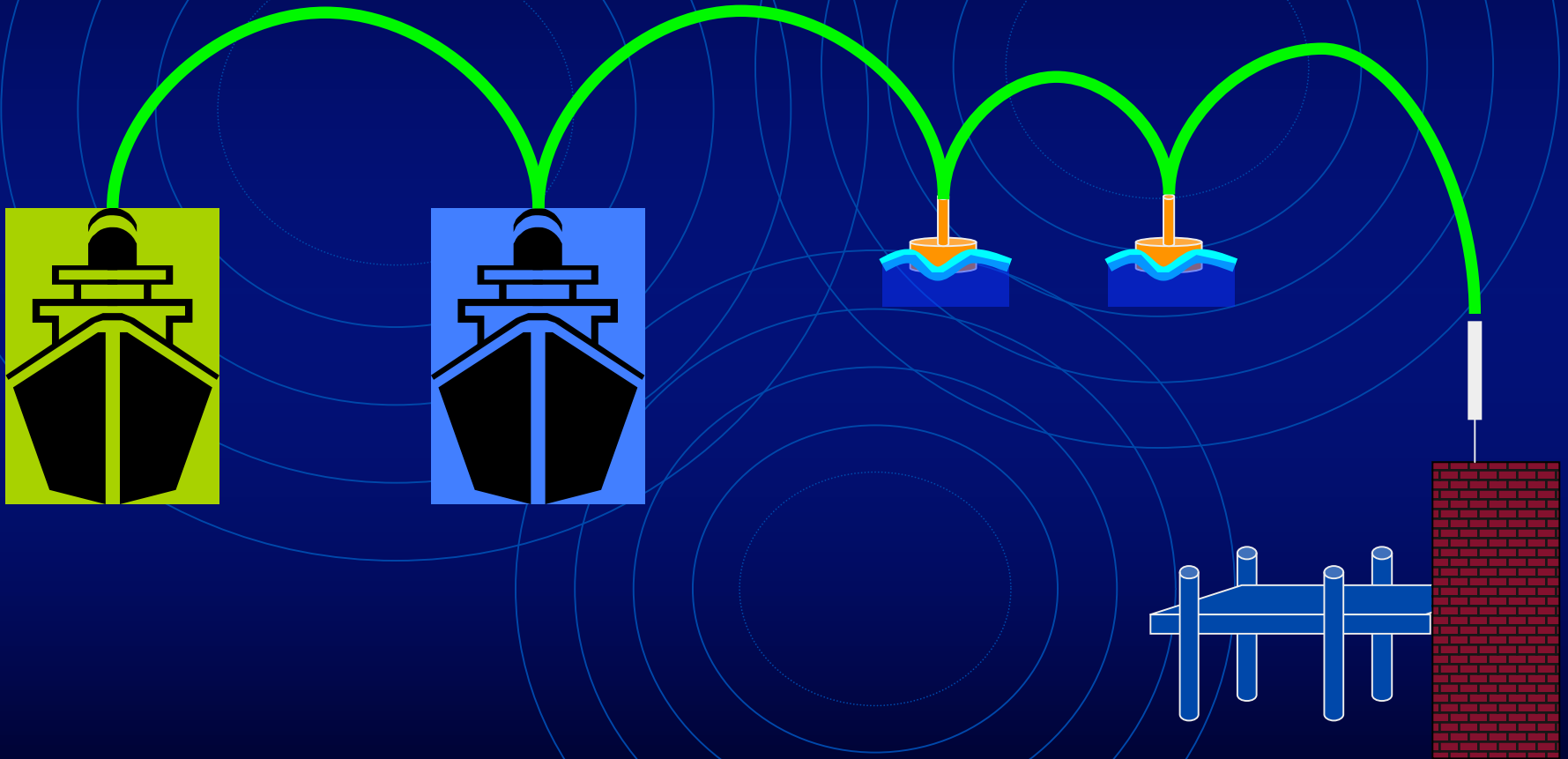


Image Courtesy of Google Earth

Scenarios



Scenarios



Scenarios



Image Courtesy of Google Earth

Practical Requirements

- Automatic.
- Maintenance free.
- Requires little or no increased technical skill on the part of the ship's staff and no additional personnel.
- Relatively secure.
- Doesn't require redesign of ship or shore facility networks.

The Search

No inexpensive commercial implementations met our requirements.

Ability to decentralize routing.



NETGEAR®

LINKSYS®

A Division of Cisco Systems, Inc.

D-Link®
Building Networks for People

Lucent Technologies
Bell Labs Innovations



SWAP

<http://sssg1.whoi.edu/swap>

Untitled Page

[http://sssg1.whoi.edu/swap/](#) SW06

CompSci ▾ Research ▾ Resources ▾ Travel (80) ▾ Val ▾ Vendors ▾ Blackboard Scholar Beanbag

Untitled Page

swap

The Ship to Ship
Ship to Shore
Wireless Access Protocol

- about
- software
- hardware
- construction
- distributions
- install
- faq
- administration
- tools

Project Intro:

SWAP is a collaborative project to provide a working set of hardware, software and networking configurations to facilitate ad-hoc mesh networking between ships, and between ships and shore facilities, within the [UNOLS](#) oceanographic research fleet. SWAP is also being developed to facilitate connections between other kinds of nodes, including instrumented buoys, light houses and cabled observatories.

To better understand our goals read our [Story Scenarios](#) and the [SWAP FAQ](#).

In December 2003, several of us met for a weekend at Scripps Institute of Oceanography and hashed out an initial working topology. Much of that topology exists today and the detailed results of our work can be found in our [Candidate Topology Document](#)

Links

- [whoi swap](#)
- [Seekris Engineering](#)
- [Router Board](#)
- [Mikrotik](#)
- [Mini-ITX](#)
- [Hyperlink](#)
- [Pebble Linux](#)
- [Zebra](#)
- [Quagga](#)
- [Sown](#)
- [Meshing](#)
- [SWAP List](#)
- [Serve](#)

Copyright © 2003-5 swap

Open System Interconnection [OSI] Model

OSI Model

- | |
|-----------------------|
| 7. Application Layer |
| 6. Presentation Layer |
| 5. Session Layer |
| 4. Transport Layer |
| 3. Network Layer |
| 2. Data Link Layer |
| 1. Physical Layer |

“Letter to Larry” Model

- | |
|---------------------------------------|
| 7. “Dear Larry...” |
| 6. Stationary, handwriting, encrypt. |
| 5. Conversation |
| 4. Registered Mail |
| 3. Postal Service. Req’s a Zip Code |
| 2. Shouting distance. Street Address. |
| 1. Roads, City Streets, Highways |

Open System Interconnection [OSI] Model

7. Application Layer

6. Presentation Layer

5. Session Layer

4. Transport Layer

3. Network Layer

2. Data Link Layer

1. Physical Layer

Routing packets BETWEEN Networks

Sending packets to hosts WITHIN Networks



802.11 Standard

Open System Interconnection [OSI] Model

7. Application Layer

6. Presentation Layer

5. Session Layer

4. Transport Layer

3. Network Layer

2. Data Link Layer

1. Physical Layer

3. Router/IP Address

2. Switch / MAC Address

1. Ethernet, wireless link

3. Postman

2. Shouting Distance

1. Asphalt, Concrete

802.11 Wireless Links

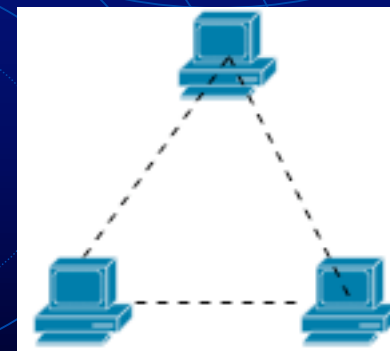
Infrastructure Basic Service Set
(IBSS)

AP/Client Model



Independent Basic Service Set

Ad-hoc Model



Wireless Distribution System - Network Bridging



Connect network segments instead of hosts.

Wireless equivalent of a single switch.

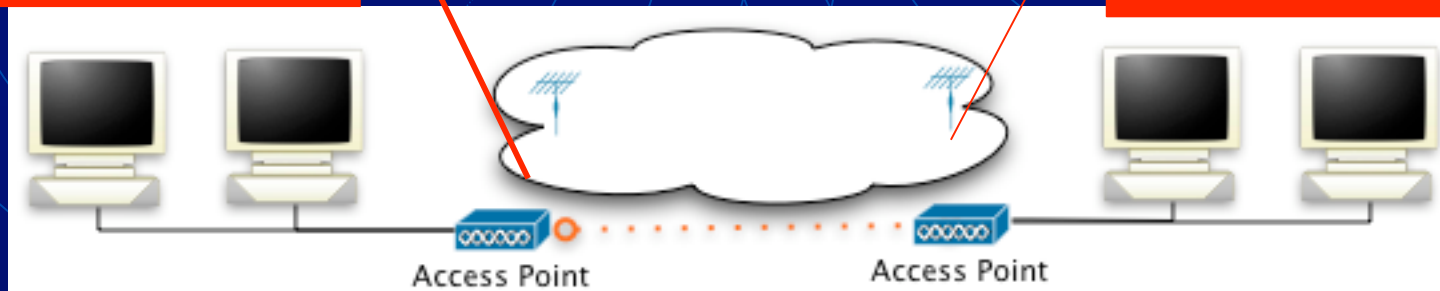
Requires all computers to be on the same
Network.

WDS Links with *aladin*

Aladin gives the new link a “zip code” (an IP subnet).

IP: 10.200.1.33
Net Mask:
255.255.255.252

IP: 10.200.1.34
Net Mask:
255.255.255.252



Connects *networks* instead of *segments*.

Wireless equivalent of two routers
connected by an Ethernet segment.

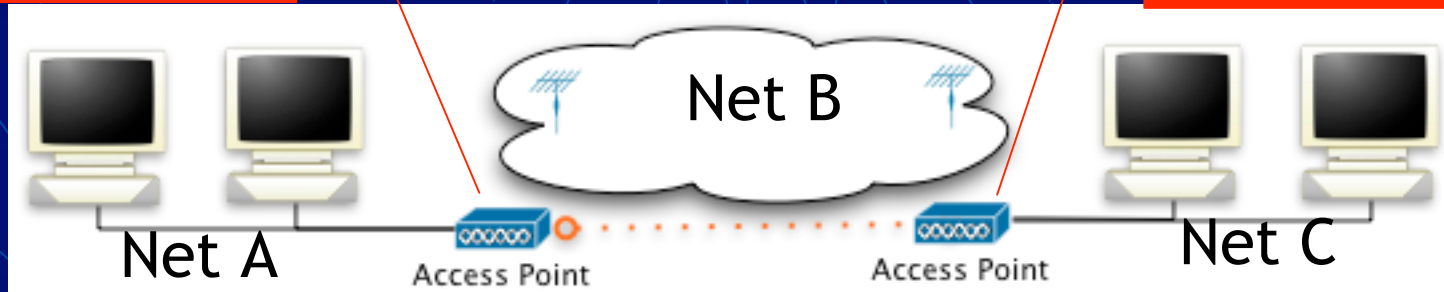
Routing Protocol

“Open Shortest Path First”

Net A --> eth0
Net B --> wlan0wds0
Net C --> via
10.200.1.34

OSPF detects link state changes
and propagates them between
peers to facilitate exchange of
routing tables.

Net C --> eth0
Net B --> wlan0wds0
Net C --> via
10.200.1.33



- Network routing tables are updated automatically.
- Each router independently determines the best route to an endpoint, decentralizing the network.
- Intermediate nodes route traffic to end points that are not locally connected.

MESH NETWORKING!

The Solution

The grass-roots open source wireless community.

OSPF

<http://www.quagga.net>

Aladin



<http://www.sown.org.uk/index.php/HomePage>

HostAP



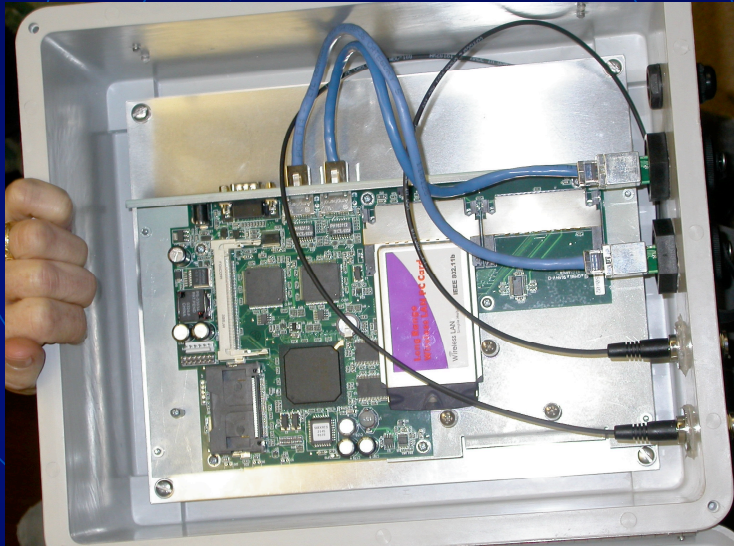
<http://www.seattlewireless.net/>

Pebble Linux



<http://www.nycwireless.net>

SWAP Device Hardware

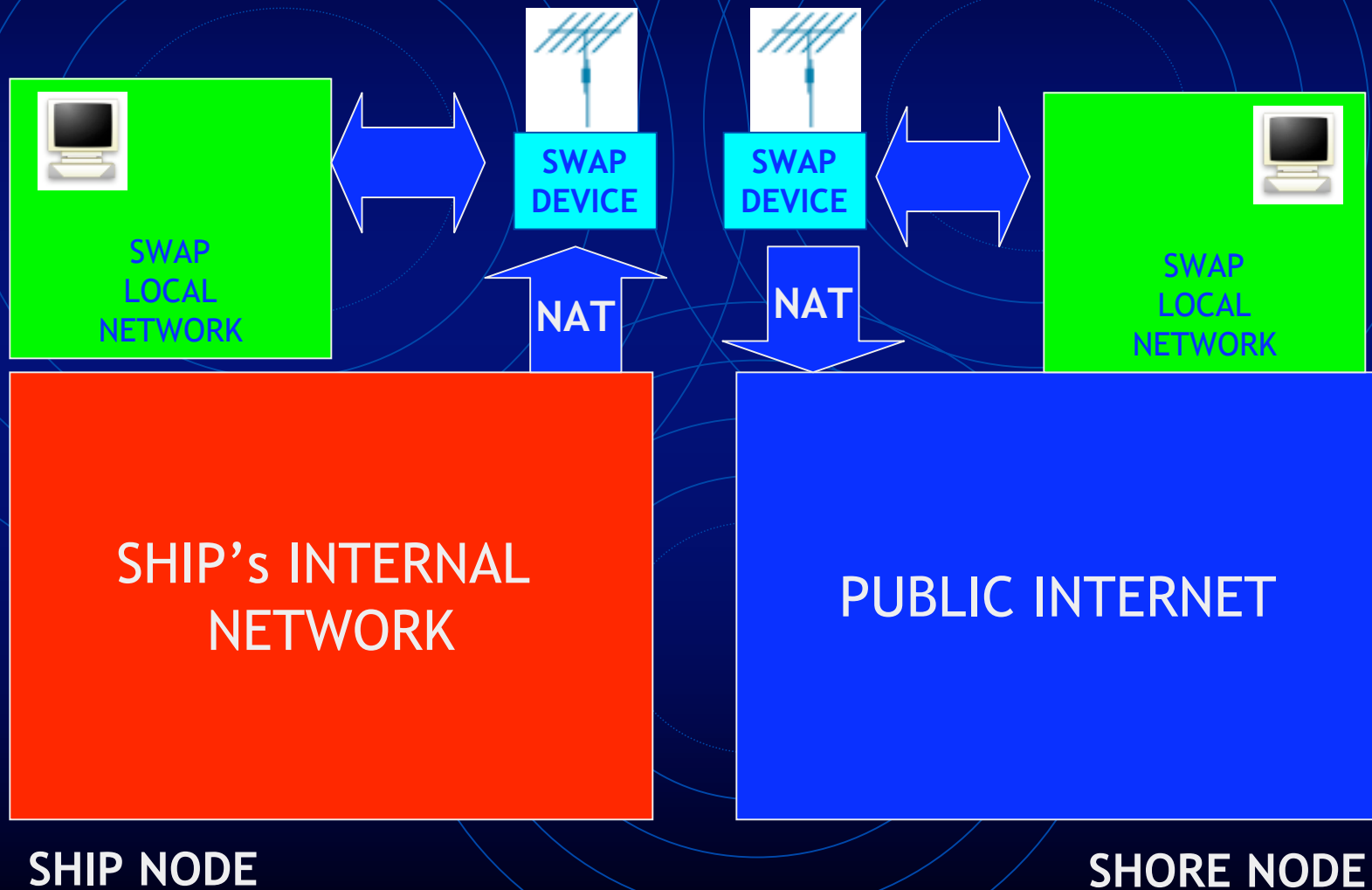


Single Board PC
802.11b PCMCIA Card
Compact Flash Card (OS)

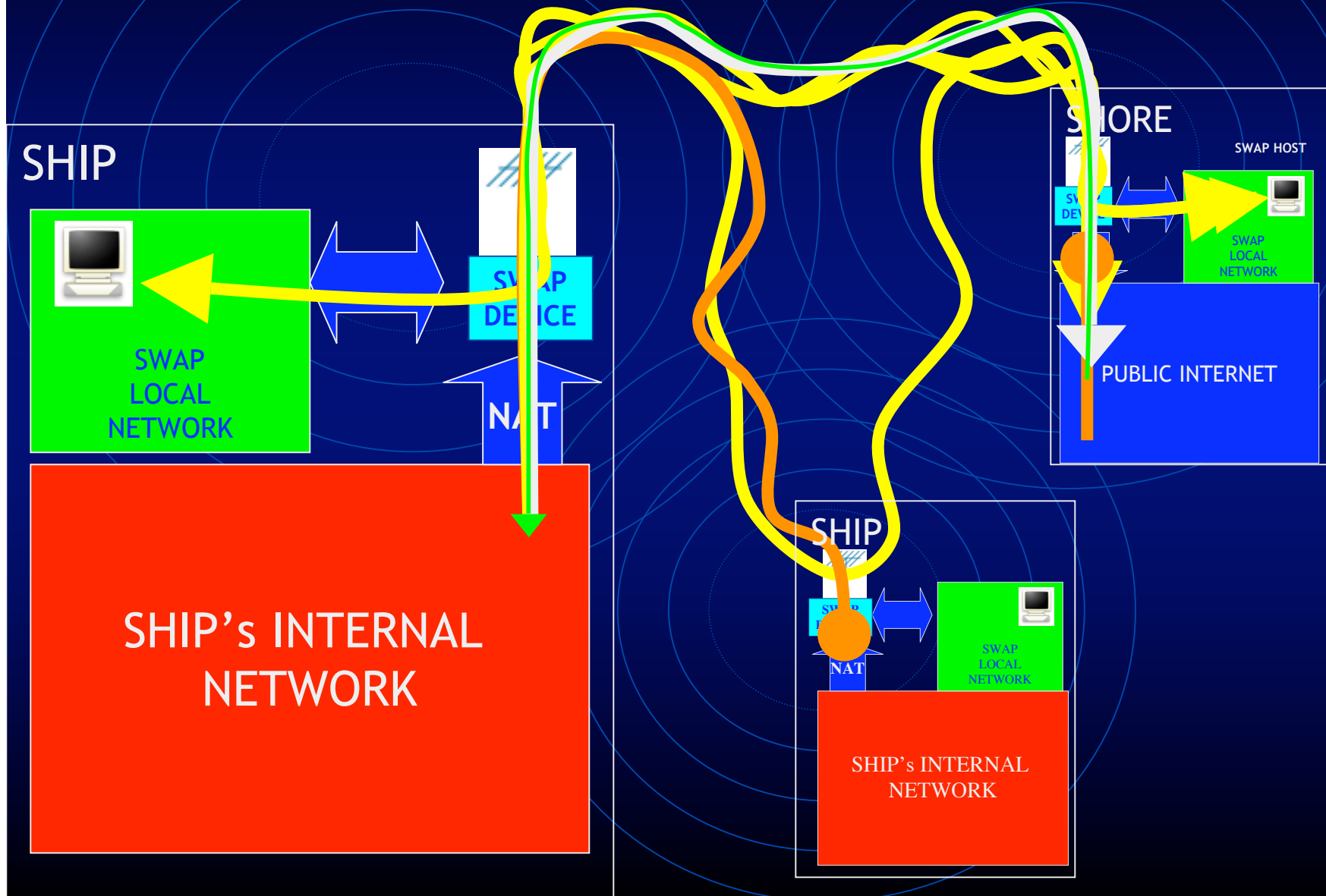


15dB Omni-Directional
Antenna

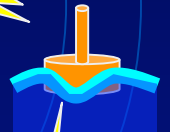
SWAP Networks



SWAP Network



An Example

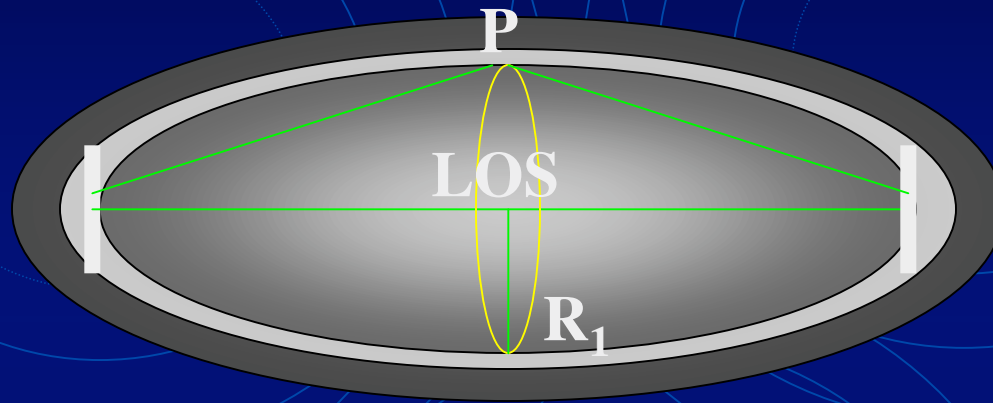


Maximum Connection Range

Can I “see” the antenna?

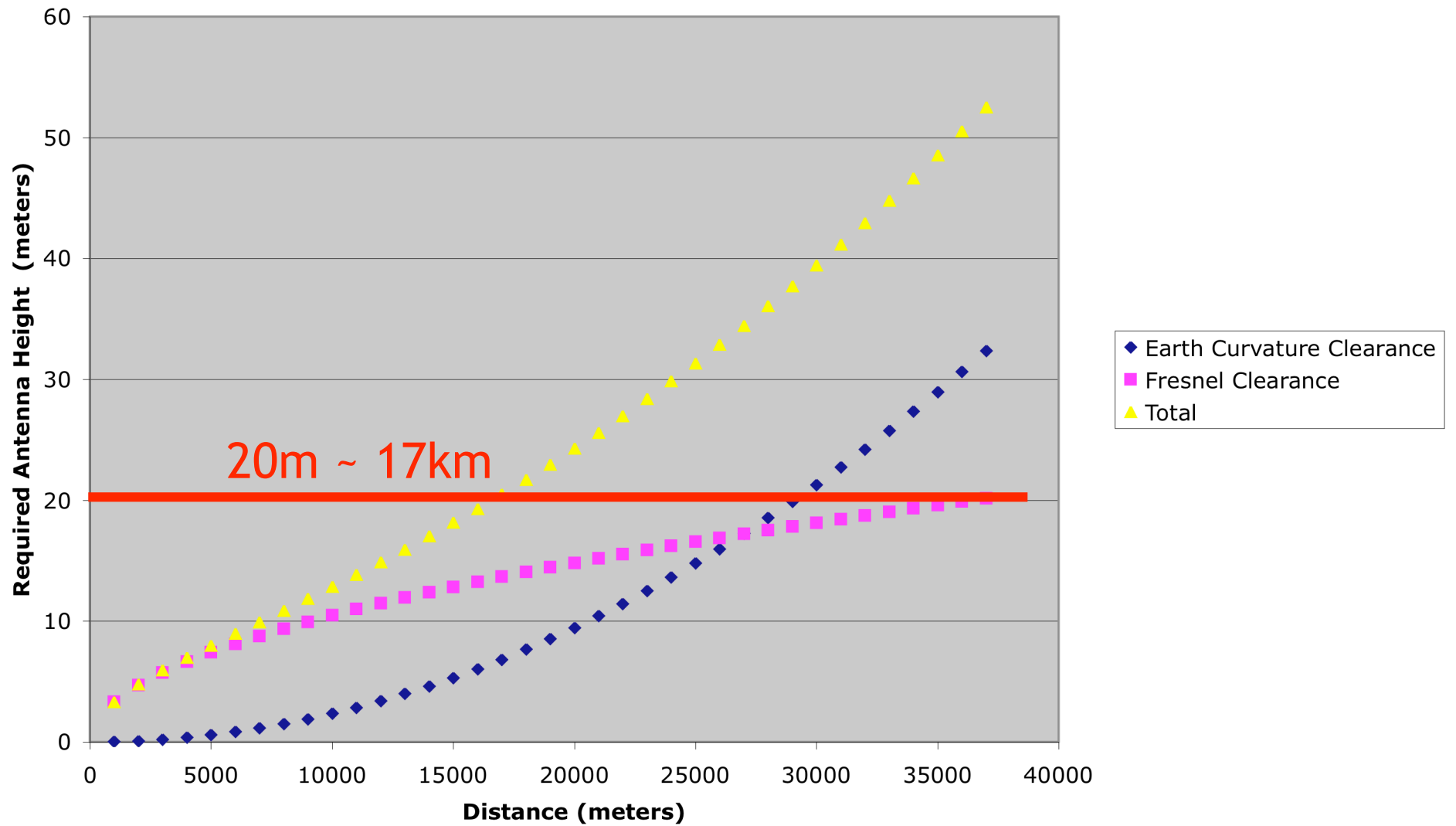
Do I have enough *oomph* to shine/see that far?

Visual LOS vs. Fresnel Zone



$$P - LOS \leq \lambda / 2$$

Required 2.4GHz Antenna Height Due to Fresnel Zone and Earth Curvature Clearance



Fade Margin

- **Transmit Power**
- **Pigtail Loss**
- **Cable Loss**
- **Antenna Gain**
- **Free Space Loss**
- **Antenna Gain**
- **Cable Loss**
- **Pigtail Loss**
- **Receiver Sensitivity**

- **23dB**
- **-.3 dB**
- **-3 dB**
- **15 dB**
- **?**
- **15 dB**
- **-3 dB**
- **-.3 dB**
- **?**

Fade margin

?

Free Space Loss for Microwave Links

$$FSL = 92.4 + 20\log_{10}(D) + 20\log_{10}(f)$$

- D = distance in km.
- f = frequency in GHz

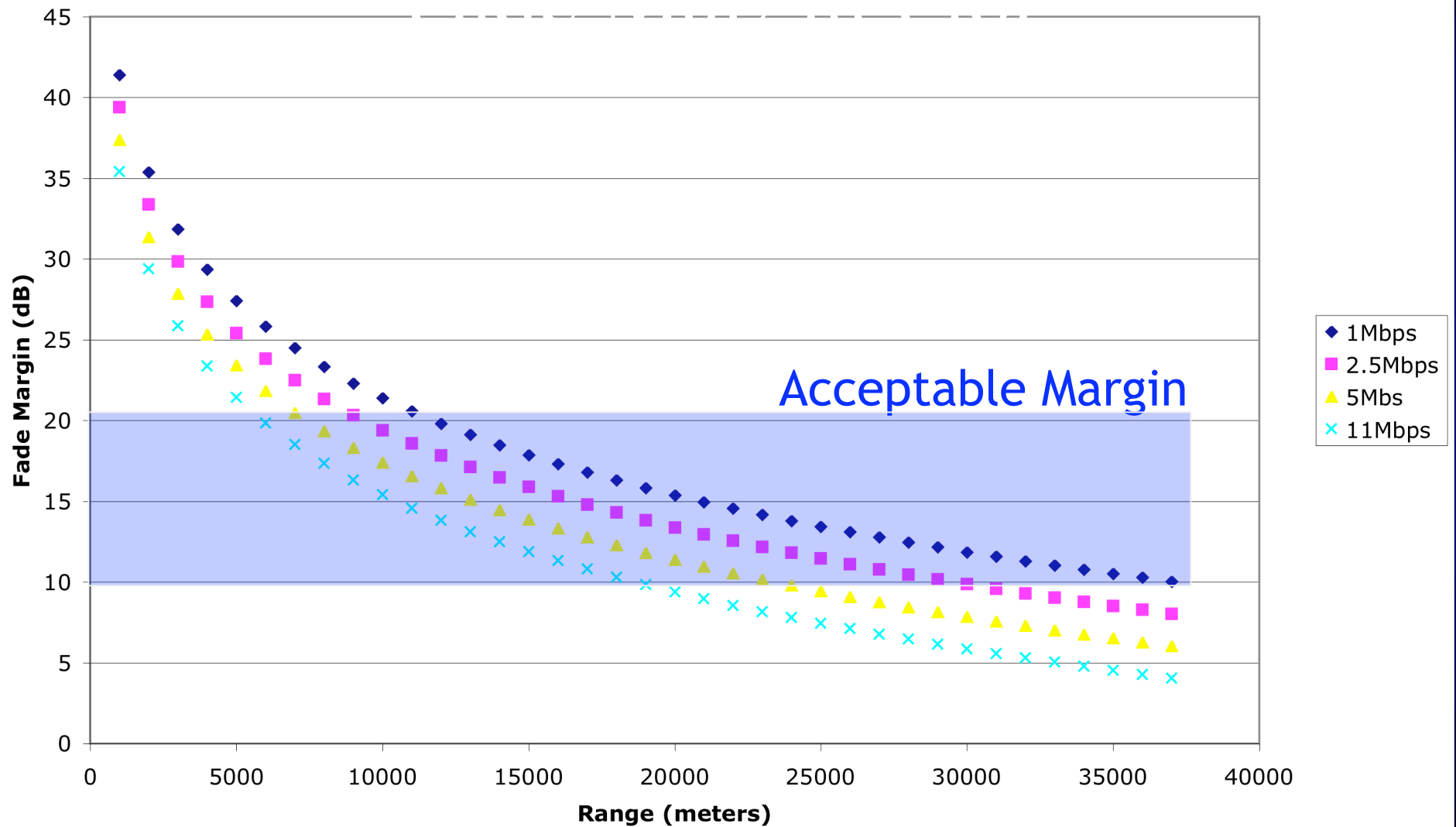
Receiver Sensitivity

- Seneo/Engenius -- NL/SL2511CD PLUS EXT2

Rate (Mbps)	1	2.5	5	11
Sensitivity (dB)	95	93	91	89

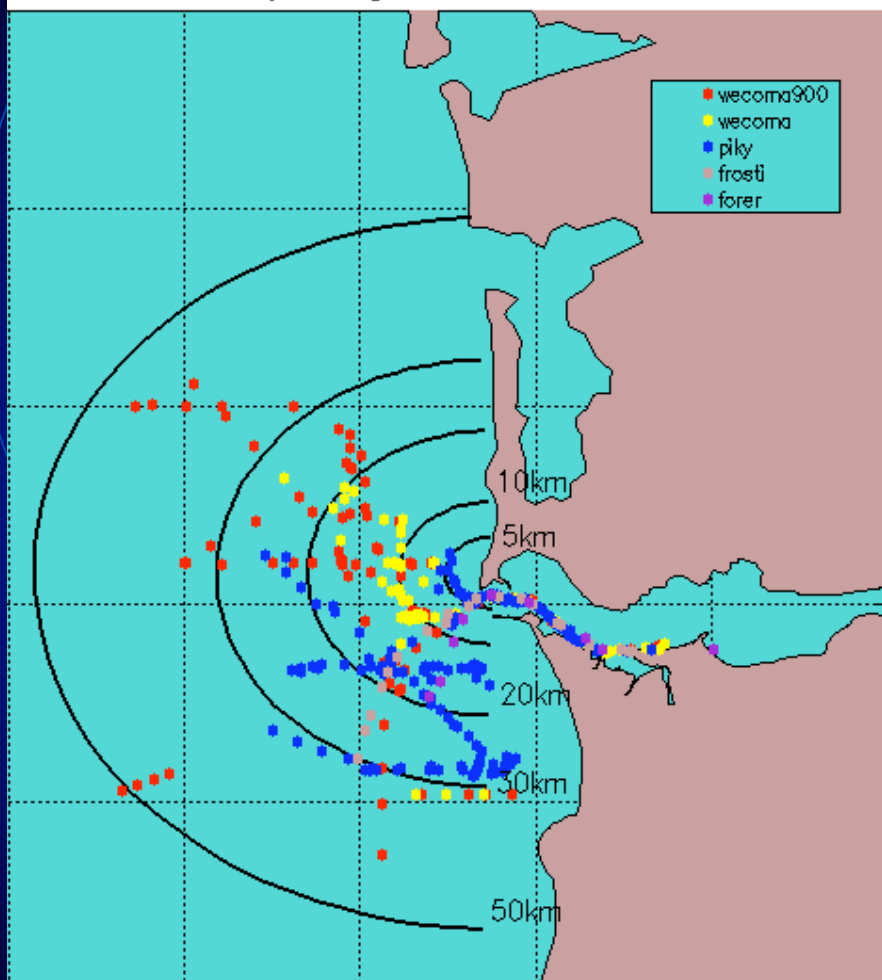
<http://www.freenetworks.org/moin/index.cgi/ReceiveSensitivity>

Fade Margin vs. Range for Various 802.11b Transmission Rates (10dB Acceptable)



Columbia River

network connectivity through 2006-10-09 09:00:04 PST

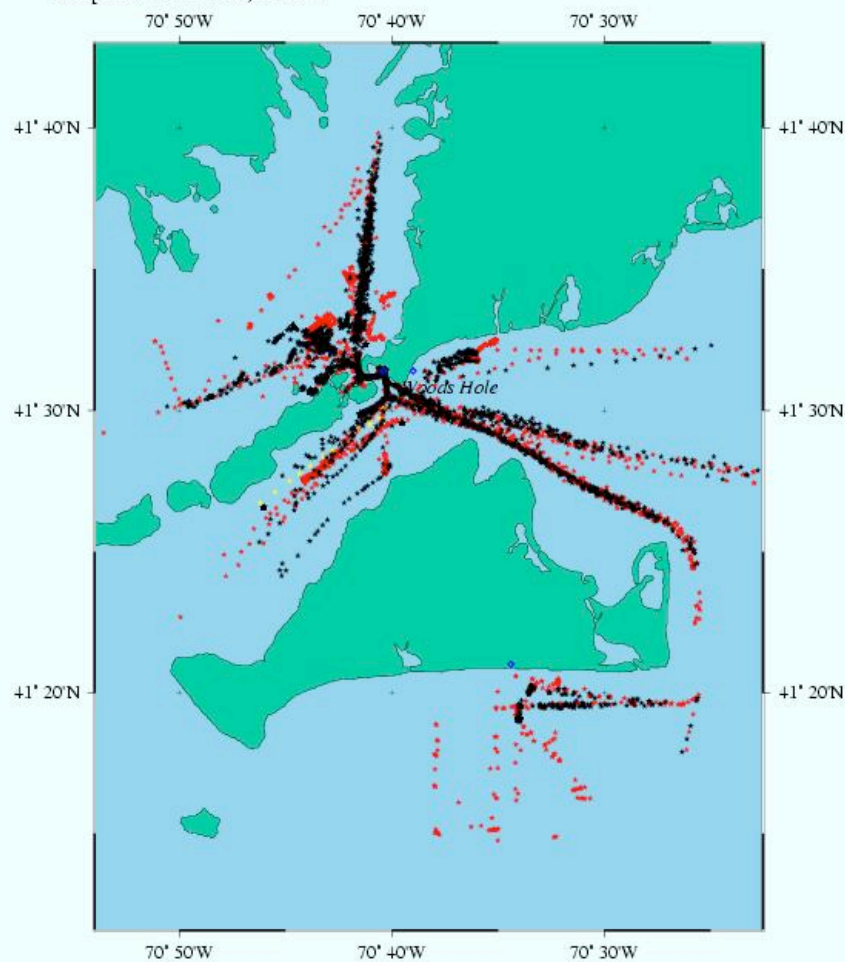


<http://www.ccalmr.ogi.edu/CORIE/cruises/sigiso.html>

Woods Hole

cruise ti_2006_09_14

Last position: 41.52 N, 70.67 W



http://sssg1.whoi.edu/whoi_swap/

SWAP Applications

Ship's
Web Page



Shared
Directories



Incoming



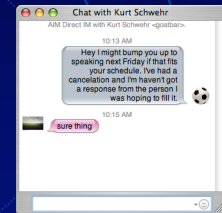
Outgoing

E-Mail



E-Mail

Science
Party Chat
Sessions

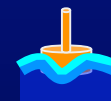
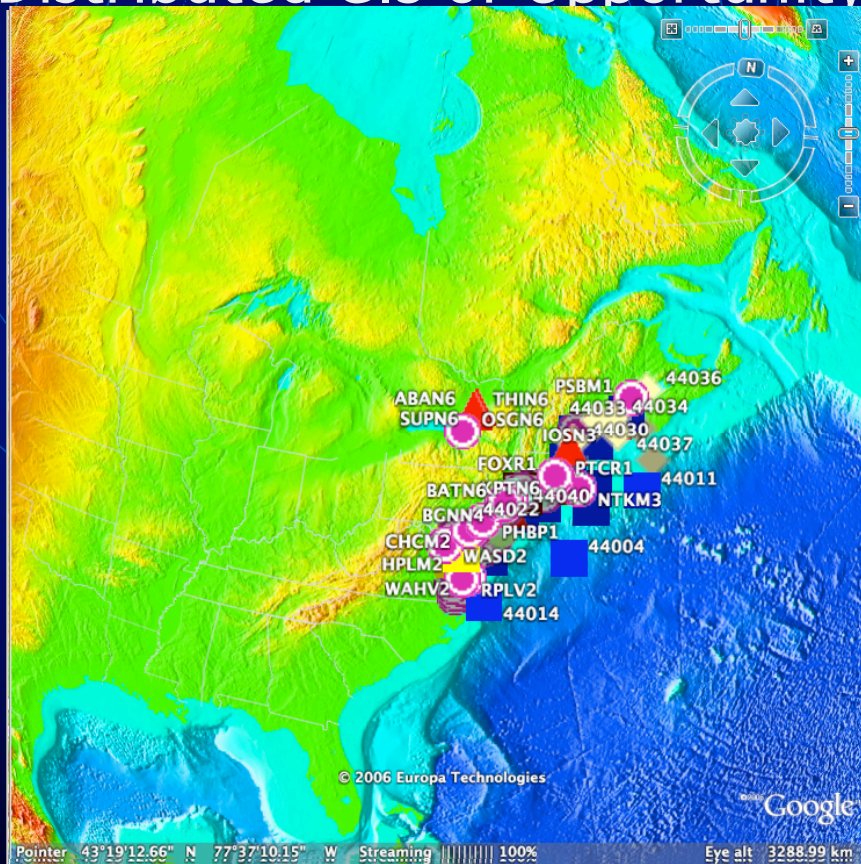


Science
Party
VoIP
Lines



SWAP Applications

Distributed GIS of Opportunity



Installations

University of
Washington

Oregon State
University/
Columbia River

MBARI

WHOI

University of
Delaware

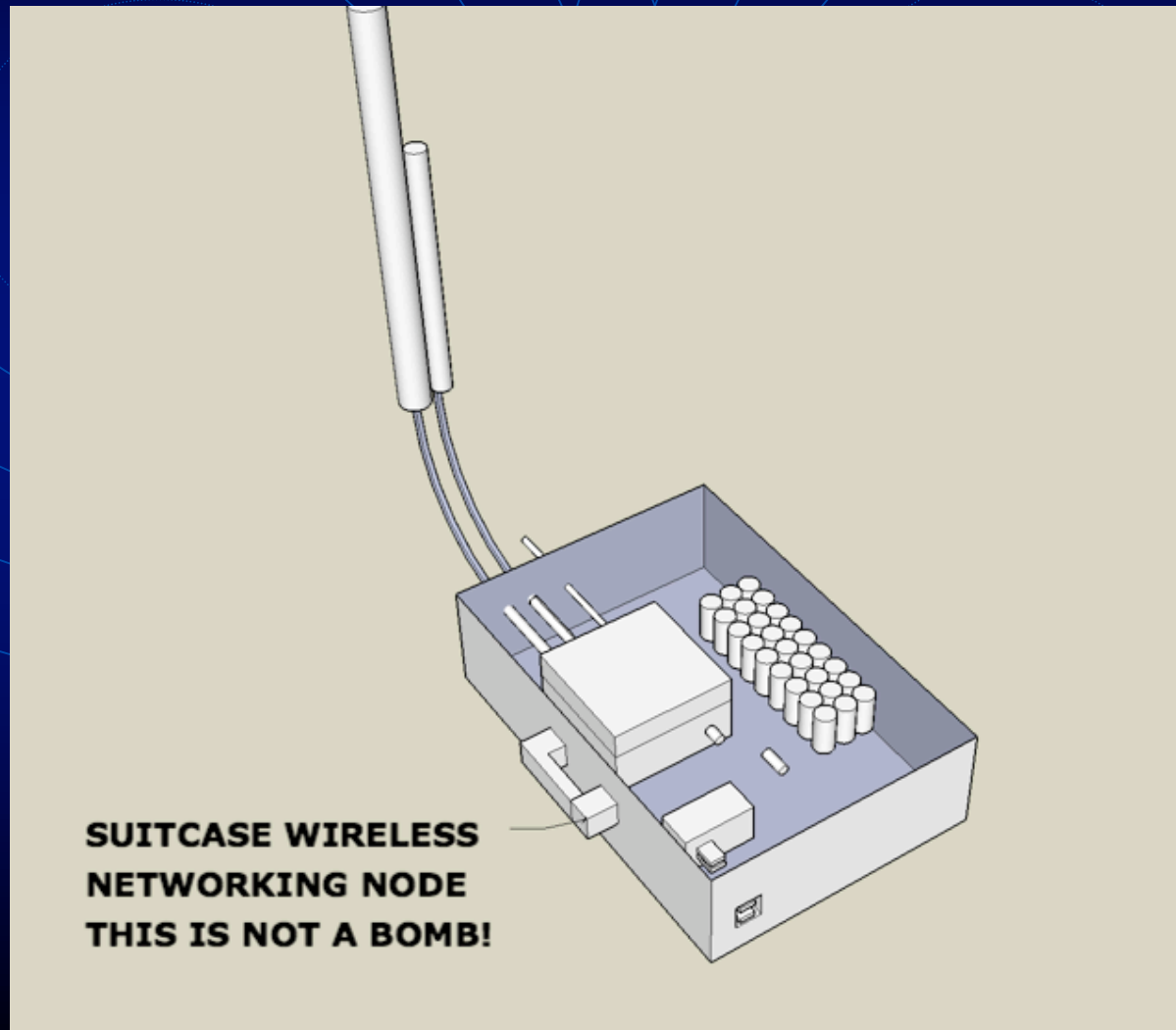
Duke - Cape
Hatteras
Marine Lab

U of Hawaii -
Snug Harbor

Scripps



Suitcase node



Remaining Issues

- A more scalable routing engine. [OLSR?]
- Graceful handling of poor quality links.
- User Friendly Interface.
- Security
- “Telecom Reality Check”

The background is a solid dark blue. Overlaid on this are three sets of concentric circles, each consisting of four thin, light blue lines. The circles are arranged in a triangular pattern: one set in the top left, one in the top right, and one centered at the bottom. The word "Thanks." is written in a bright green, sans-serif font, centered horizontally between the two top sets of circles.

Thanks.