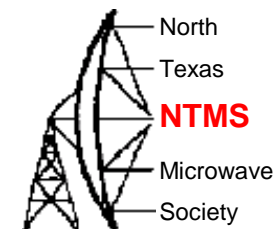


Introduction to HSMM

John Beadles – N5OOM

North Texas Microwave Society

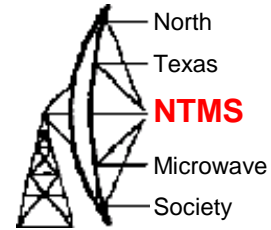
Expectations for this presentation



- This presentation will tell you (briefly) what HSMM is and what you can do with it
- Mostly we will discuss some parts of HSMM that it is important for you to know so you can get started
- We will not go over a lot of examples of HSMM in action
- There is a lot of material here and we may not finish
- If we don't finish, or if you can not make it to other presentations in this series, you can download them from:

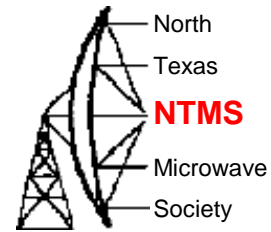
http://www.n5oom.org/2004_hamcom/presentations.htm

Topics



- What is HSMM
- HSMM Applications
- How does it work
 - HSMM vs Packet
 - Part 97 vs Part 15 operation
 - Part 97 operation pros and cons
 - Part 15 operation pros and cons
 - Modes of operation
- HSMM Equipment
 - Ham Equipment
 - Consumer Equipment
 - 802.11b/g Freq Band
 - 802.11a Freq Band
- Client Adapters
- Access Points
- Bridges
- Repeaters
- Gateway Routers
- Antennas
- Power over Ethernet
- Deploying HSMM Stations
 - Propagation Analysis
 - Network Planning
 - Site Survey
 - Radio Survey
- Information resources

What the heck is HSMM?

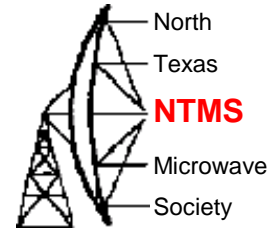


HSMM, or High Speed Multimedia, is the name of an ARRL sponsored technical project to introduce high speed data radio to amateur radio.

HSMM generally uses standard internet protocols, so that regular applications such as web, ftp, email and other applications can run over it without modification.

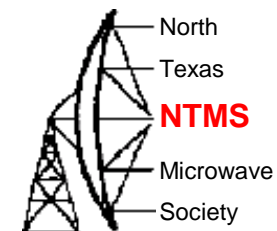
The popular license free 802.11a/b/g services operate on bands that overlap amateur frequency allocations, giving us cheap hardware that can be used in in part 97 operation... when used with care.

HSMM Applications



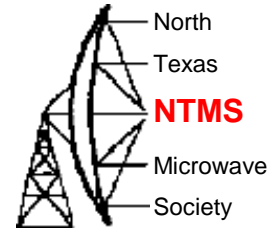
- Hospital / EOC interconnects
- Document Storage & Access
- Document and Printer Sharing
- IRLP Repeater Links
- APRS Internet Feed
- Local Public Service Event Management
- Internet-based Weather Services
- Regular Internet Service
- Web based applications

How does HSMM work



- HSMM, like packet, generally operates by sending packet data
- However, it usually uses spread spectrum modulations and often wide bandwidths (up to 25 MHz) to permit high data rates
- HSMM equipment is generally intended to take the place of a wire that might be used to connect two pieces of equipment together (like an ethernet cable or a serial cable)
- Other equipment, computers for example, are connected to the HSMM gear to use the data connection that the HSMM equipment provides
- To get the wide bandwidths necessary, HSMM equipment often operates in the UHF and above bands.
- Some consumer / commercial equipment can be pressed into service as ham HSMM gear
- QRP operation is typical, with xmit powers from 20mw and higher.

HSMM vs. Packet



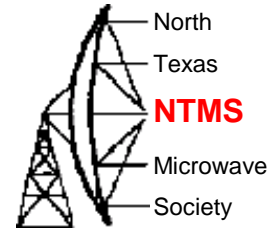
Packet

- 1200 bps to 19200 bps
- Requires special (rare) knowledge to set up, use
- Requires special software to use
- Routing is difficult
- Uses common radios & antennas
- Generally uses UHF down to HF

HSMM

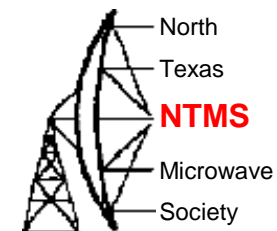
- 60 kbps to 54mbps
- Requires special (common) knowledge to set up, but use is common knowledge
- Software is commonplace
- Routing is simple
- Equipment ranges from common to uncommon
- Runs on 900MHz and higher

Part 97 vs. Part 15 operation



As previously stated, commercially available 802.11(x) equipment intended for part 15 license free use can be operated according to part 97 rules. In some cases, there are valid technical reasons for staying in part 15 rules. Amateur operators should not operate in either just out of knee-jerk reaction, but should consider the technical pros and cons of both.

Part 97 operation pros and cons



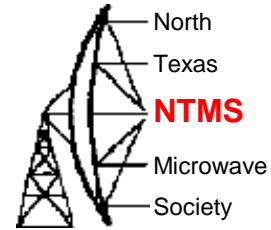
Pros:

- Many antenna choices
- Power amplifiers
- Can modify equipment

Cons:

- No (limited) encryption therefore vulnerable to unlicensed users
- Easy for content to violate FCC rules
- Automatic power control requirements
- 3rd party traffic issues
- Identification

Part 15 operation pros and cons



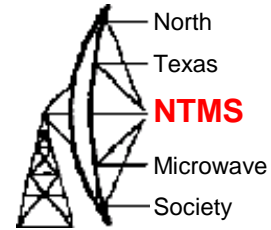
Pros:

- No content restrictions
- No 3rd party issues
- Strong encryption available
- More freqs available
- Don't need to identify

Cons:

- Very limited hardware options
- Lower transmit power
- Shared with many many many other unlicensed users

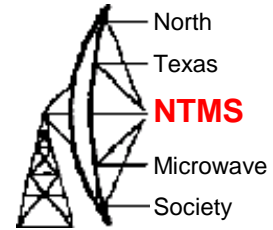
Modes of Operation



Point to Point

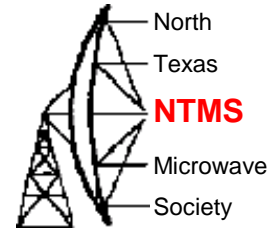
- Used to extend coverage from one fixed location to another
- Use fixed directional antennas
- Often used for bridging
- Point to Multipoint
- Used to provide service to one or more stations in a local coverage area
- Use a wide area coverage antenna at the hub, directional antennas at the outlying points
- Don't expect to cover a wide area like this with 802.11b

HSMM Equipment



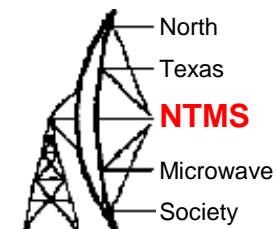
- General configuration
- Ham equipment
- Consumer Equipment

General Configuration



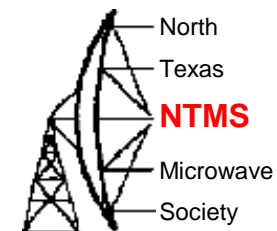
- In general, HSMM equipment is intended to take the place of a cable that you would use to connect one or more computers to a wired network.
- Ethernet connectivity – Much digital equipment is designed around ethernet connectivity and provides a port for plugging in an ethernet cable
- Serial connectivity – Some equipment merely provides a serial data connection. In this case, you might be expected to use the radios to tie two computers together via serial port and transmit data from one to the other. Or, one end might be plugged into a modem, allowing remote dial in to an internet service provider
- Either way, the specifics of data connections is outside the scope of this presentation. Many, many books on basic networking are available, probably in your local bookstore in the computer section.

Ham Equipment



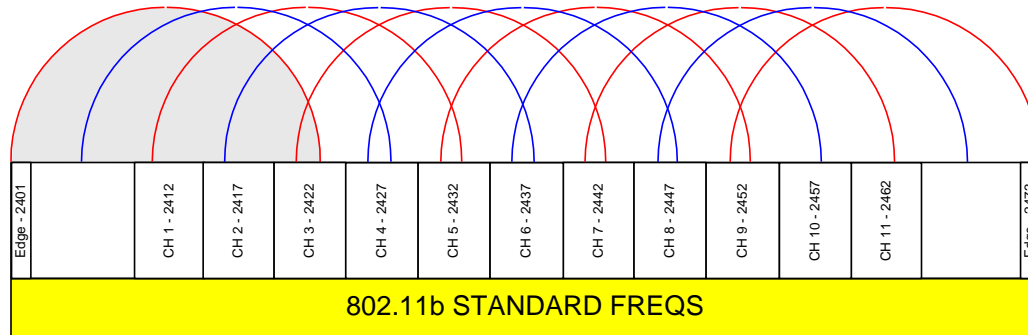
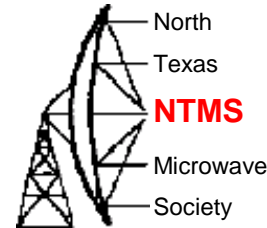
- Icom D-STAR
 - Runs on 1.2 GHz, combines FM voice and 128kb data
 - Requires separate, proprietary analog and digital repeaters
 - System of components including mobile radio, voice and data repeaters and a 10GHz backhaul radio
 - Mobile has ethernet, USB connections
 - Pricey!
 - <http://www.icomamerica.com/amateur/dstar/>
- Icom IC-2200
 - 2m mobile radio
 - Optional modules provides 4.8kb data
 - Data connection type unknown – serial port?
 - Price in the \$200+ range not including digital option

Consumer Equipment

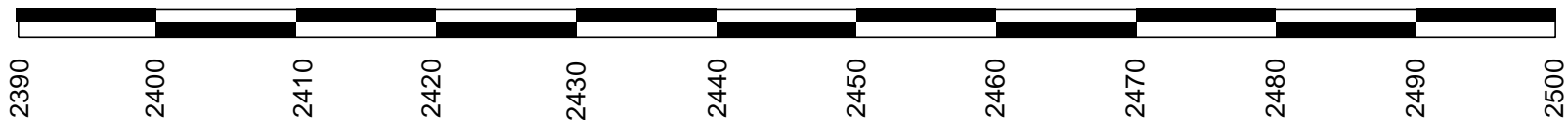
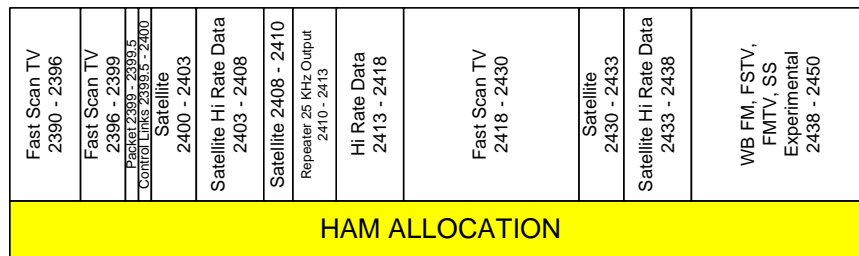


- 802.11 is an IEEE standard for wireless data transmission that operates under FCC part 15 rules.
- Consumer 802.11 equipment runs under FCC part 15 rules for “license free” operation
- 802.11 runs in 2.4 GHz provides up to 2mbps
- 802.11b runs in 2.4 GHz, provides up to 11mbps
- 802.11g runs in 2.4 GHz, provides up to 54mbps
- 802.11a runs in 5 GHz, provides up to 54mbps
- The speed difference is based on modulation
- Most newer 801.11x radios are backward compatible (as long as the equipment works in the same frequency band)

2.4 GHz (802.11b/g)

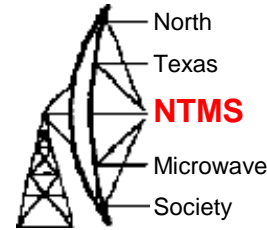


- 11 overlapping 802.11b/g channels
- 11 MHz wide each, 5 MHz spacing

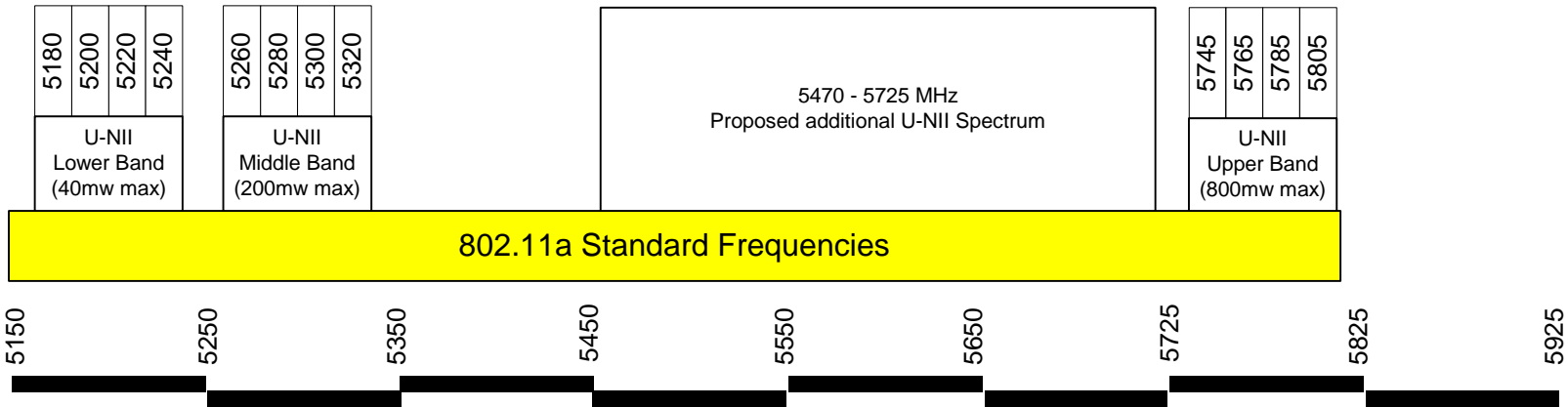
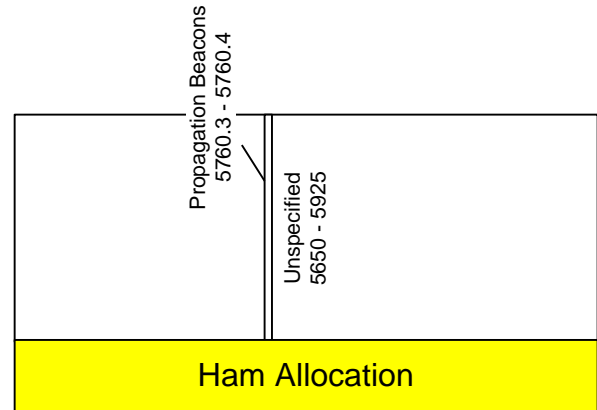


- 802.11b channels 1-6 overlap amateur allocations
- AMSAT requests not to use ch 1 due to sat interference

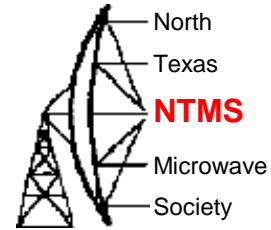
5 GHz (802.11a)



- 12 non-overlapping 802.11a channels
- 20 MHz wide each
- 3 sets of 4 channels
 - 4x40mw ch for indoor
 - 4x200mw ch for indoor, outdoor
 - 4x800mw ch for outdoor
 - Power specified at the IR
- More bandwidth requested



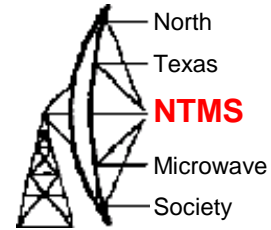
Common Equipment - Client Adapters -



- Device used to connect one computer or device to a wireless network
- Several form factors
 - PCI Card
 - PCMCIA Card
 - Compact Flash
 - USB
- Xmit powers in the 20mw to 200mw range
- Some have connections for external antennas, some don't



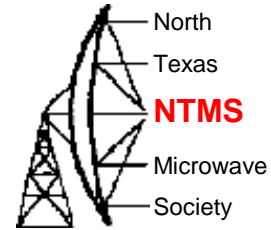
Common Equipment - Access Points -



- Used to connect multiple PC clients to a wired network
- Often 2 antennas to provide coverage in a multipath situation
- Can provide additional filtering to keep out unwanted clients, types of data connections
- Wide range of hardware and prices
- Commercial gear tends to be more flexible, provide more functions
- Consumer gear is very cheap (\$50 - \$100 range), but with fewer functions, buggier software
- Some can provide additional functions such as bridging or repeating, since these are really only software defined
- Becoming harder to find in local stores because of the popularity of residential gateways



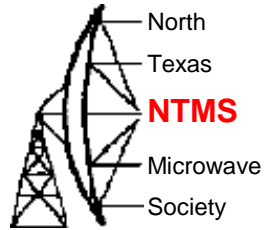
Common Equipment - Bridges -



- Used to connect two wired networks together clients
- Often 1 antenna since neither side is expected to move
- Can be used to connect computers that don't have wireless network client cards



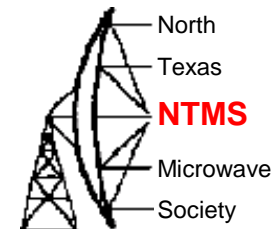
Common Equipment - Repeaters -



- Extends client access into a distant access point
- May be a software feature of an access point product
- Reduces the bandwidth of a system because it has to receive and retransmit in the same spectrum



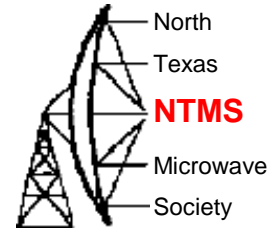
Common Equipment - Residential Gateway -



- Convenience device combining several pieces of equipment
 - Broadband router
 - Ethernet Switch
 - Wireless Access Point
- Often has extra router type capabilities like firewalls, packet filtering
- But fewer features like client bridging
- Best prices because of popularity (\$20 and up)

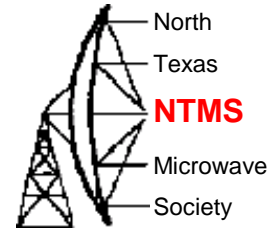


Antennas



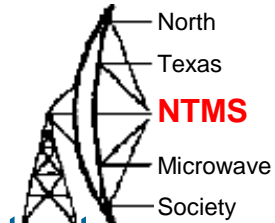
- HSMM equipment needs antennas just like any other radio gear
- But in the higher bands, gain gets smaller and cheaper – up to 24 db gain is common
- Consumer gear can come with fixed antennas or removable
- But Part 15 restrictions force manufacturers to put non-standard connectors on there to keep people from modifying equipment
- eBay is a good source of cheap antennas (search on “WiFi Antenna”)
- Remember, part 15 rules restrict your ability to modify equipment if you intend to use it that way

Antenna connections



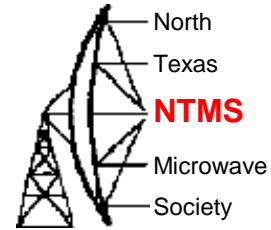
- On base equipment
 - Reverse Polarity N
 - Reverse polarity TNC
- On PCCARDS
 - MMCX, Reverse Polarity MMCX
 - MC
- Others less common
- Generally you will want a short pigtail cable to adapt your non-standard connector to a standard N connector
- FAB-Corp (and others) sell adapters and connectors (<http://www.fab-corp.com/>)

Power over Ethernet



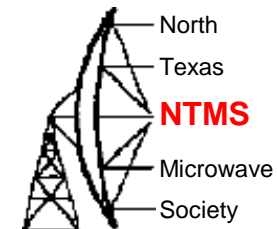
- Because these units are low powered, the way to get the greatest amount of xmit power is to put them up close to the antenna
- But how to get power to them?
- Power over Ethernet (PoE) is one way to do this.
- A typical ethernet cable contains 4 pairs of 26ga wires.
- Only 2 pairs are used to connect a device. The cable provides 4 pairs so you can cable up 2 devices over one cable.
- Depending on the equipment, AC or DC voltage can be run up the unused pair and used to power the equipment
- Some equipment are built to receive power like this but not all (usually commercial eqpt)
- CAUTION! There has not been a specification for this, so vendors have implemented this their own way.
- Consumer equipment doesn't usually have this built in, so you need an external feed and tap.
- See <http://www.nycwireless.net/poe/> for details

Deploying HSMM Stations



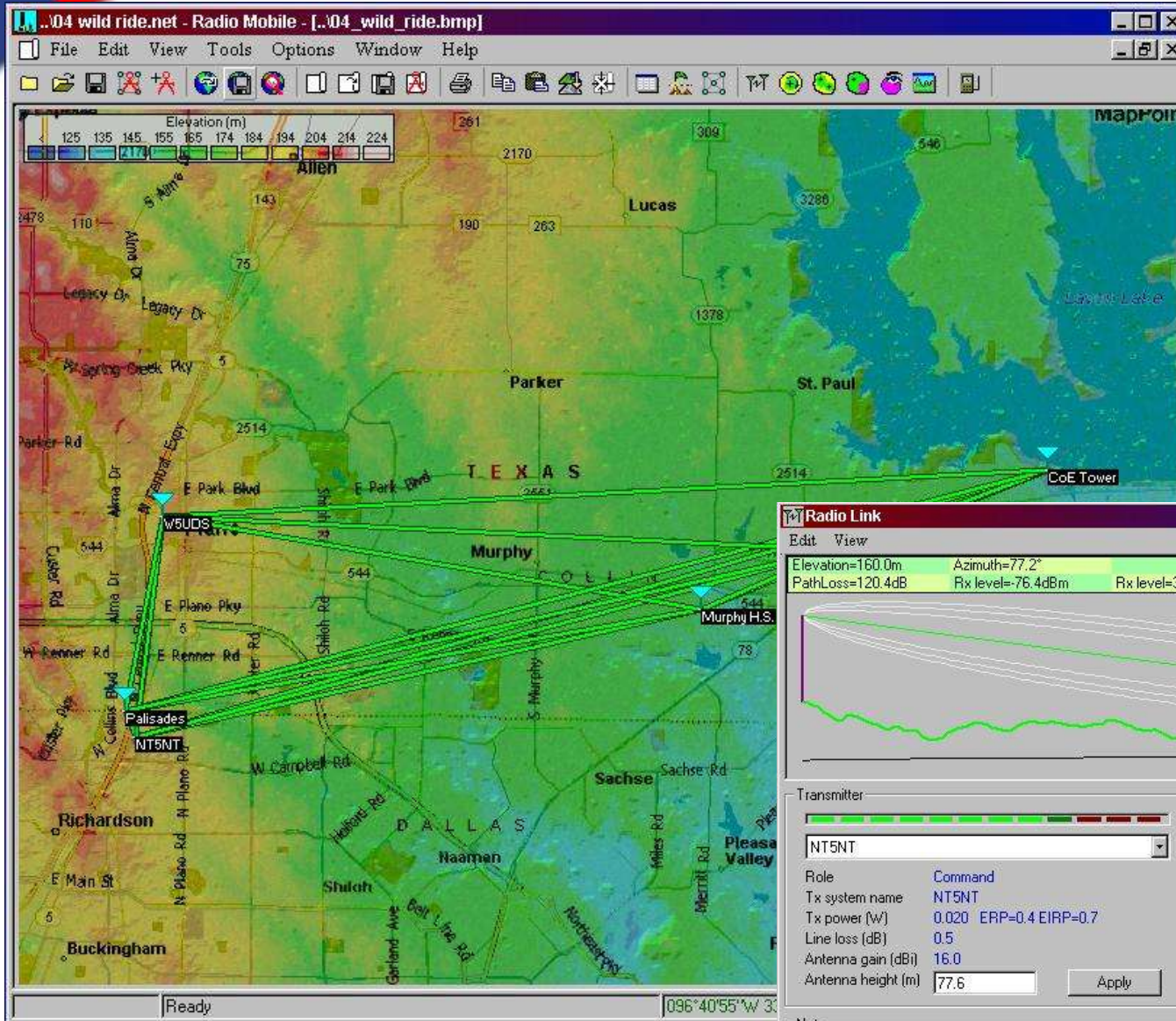
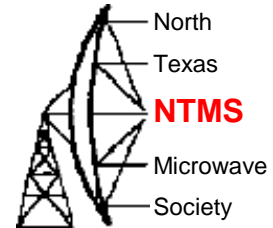
- Develop a general plan
- Propagation Analysis
- Network Planning
- Site Surveys
- Radio Surveys

Propagation Analysis



- The first thing to do is see if your system will work
 - Trees, buildings and terrain block severely at these frequencies
 - Radio propagation can vary wildly with atmospheric conditions
 - You have to look at the vertical clearance of the path as well as the horizontal coverage
- You'll need the coordinates (lat and lon) for each station in your system
- Radio Mobile is good, free software to use for doing propagation planning and path analysis
 - By Roger Coude VE2DBE
 - <http://www.cplus.org/rmw/english1.html>
 - Uses free 1 meter SRTM digital elevation data
 - Can also make APRS maps!
- Also look at AQualify by Bill Diaz
 - <http://www.billdiaz.dynip.com/aqualif.htm>
 - Looks neat but I can't figure out how to download it

Radio Mobile



Radio Link

Edit View

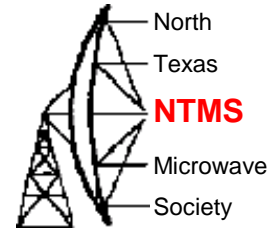
Elevation=160.0m Azimuth=77.2° Distance=13.26km
 PathLoss=120.4dB Rx level=-76.4dBm Rx level=33.76µV Rx Relative=21.0dB S8

Transmitter		Receiver	
NT5NT		Murphy H.S.	
Role	Command	Role	Command
Tx system name	NT5NT	Rx system name	Murphy H.S. to RS1
Tx power [W]	0.020 ERP=0.4 EIRP=0.7	Antenna gain (dBi)	16.0
Line loss (dB)	0.5	Line loss (dB)	0.5
Antenna gain (dBi)	16.0	Rx sensitivity (µV)	3.00 (-97.5 dBm)
Antenna height (m)	77.6 <input type="button" value="Apply"/>	Antenna height (m)	33.0 <input type="button" value="Apply"/>

Net: Start - RS1

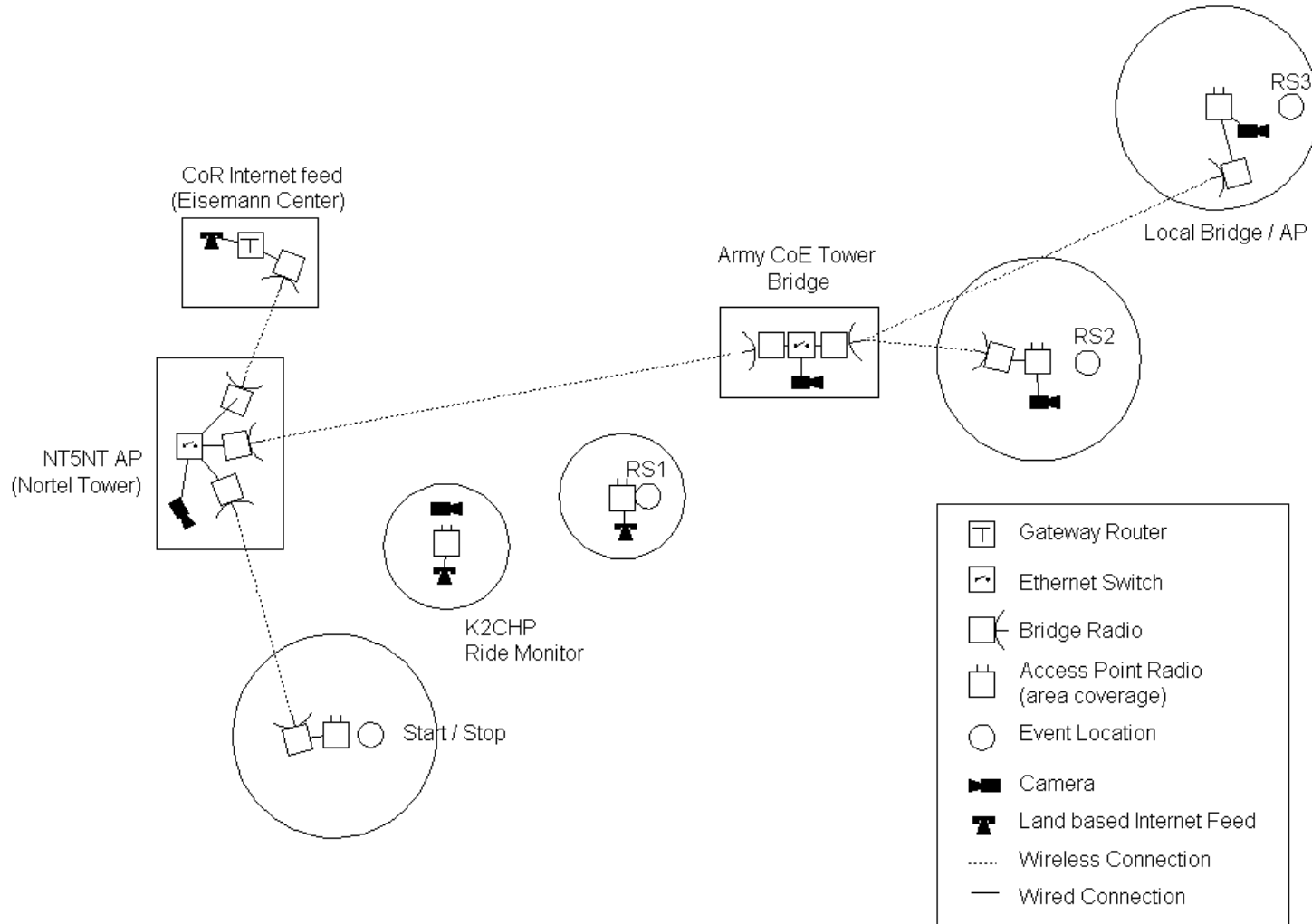
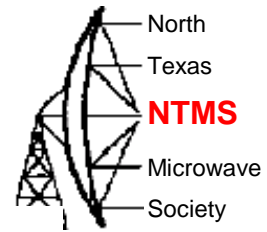
Frequency (MHz):
 Minimum: 2400 Maximum: 2483

Network Planning

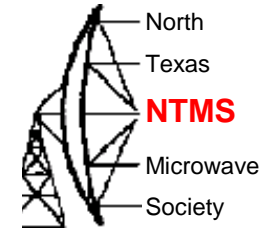


- Presumably you will be using your system to hook computers or equipment together
- Where is your internet service going to come from?
 - Warning: many residential internet providers forbid exporting service outside the local premises
- How are you going to route traffic?
- What are your IP configurations going to be?
- What other non-wireless equipment will you need?
- If you are working with others, be sure to document and publish your network plan

Wireless Connections for the '04 Wild Ride



Network plan for the '04 Wild Ride



04 Wild Ride Equipment Requirements

Default Gateway: 192.168.1.1

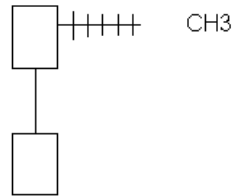
Subnet mask: 255.255.255.0

Clients should set DHCP on

Eisenman Center Internet Feed

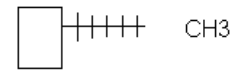
Device: WAP11
 Device Name: NT5NT
 Function: Bridge
 IP: 192.168.1.3
 MAC:

Device: VPN Router
 Function: Internet Gateway
 IP: 192.168.1.1
 MAC:



NT5NT

Device: WAP11 v2.6
 Name: NT5NT
 Function: Bridge Master
 IP: 192.168.1.2
 MAC: 000c416725d0

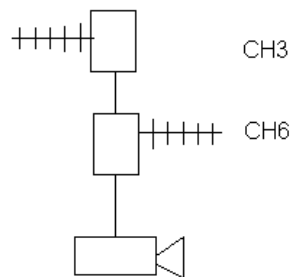


Army CoE Tower Bridge

Device: WAP11v2.8
 Name: NT5NT
 Function: Bridge
 IP: 192.168.1.5
 MAC: 000c416688f5

Device: BEFW11S4
 Name: N5OOM
 Function: Access Point
 IP: 192.168.1.6
 MAC: 000c4166fc80

Device: Camera
 Name: KD5YVL
 IP: 192.168.1.31
 MAC:

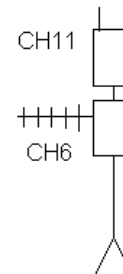
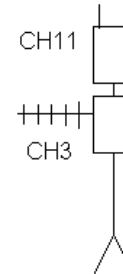


K2CHP / Renner

Device: BEFW11S4
 Name:
 Function: Internet Gateway / Access Point
 IP: Not assigned
 MAC:

Device: BEFW11S4
 Name: KD5OUG
 Function: Internet Gateway / Access Point
 IP: Not assigned
 MAC:

RS1



Start / Stop

Device: WRT54G
 Name: NT5NT
 Function: Access Point
 IP: 192.168.1.8
 MAC:

Device: WET11
 Name: N5OOM
 Function: Bridge
 IP: 192.168.1.7
 MAC:

RS2

Device: BEFW11S4
 Name:
 Function: Access Point
 IP: 192.168.1.10
 MAC:

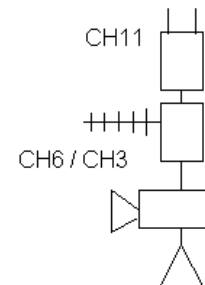
Device: WAP11
 Name: N5OOM
 Function: Bridge
 IP: 192.168.1.9
 MAC:

RS3

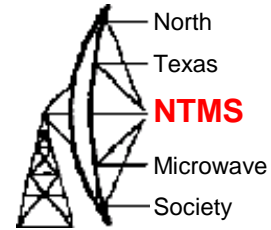
Device: BEFW11S4
 Name: N5PYK
 Function: Access Point
 IP: 192.168.1.12
 MAC:

Device: WAP11
 Name: NT5NT / N5OOM
 Function: Bridge
 IP: 192.168.1.11
 MAC:

Device: Camera
 Name:
 IP: 192.168.1.30
 MAC:

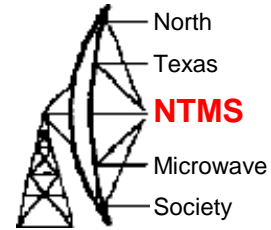


Site Survey (part 1)



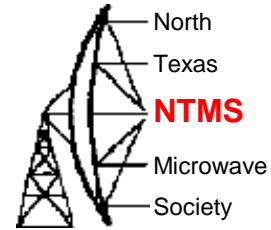
- Because of the low power typical of HSMM, you may install equipment at locations that you don't control
- A Site Survey is performed to capture information about a site so you can minimize the number of times that you have to go to the site
- Equipment to bring
 - A digital camera (take lots of pictures!)
 - A GPS receiver
 - A compass
 - A 100 ft tape measure
 - An inclinometer (used to measure heights)
 - A sketch pad
- Have a map of the site with lines drawn in representing the paths in and out of the site

Site Survey (part 2)



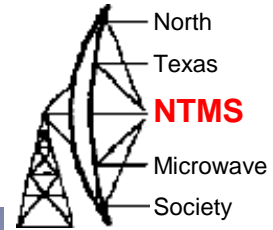
- Information to capture
 - Where to mount the equipment
 - The lat, lon and elevation at the antenna
 - Where to get power and network connections from
 - How to route cables (and distances)
 - Mounting equipment needed
 - Pictures of the paths to the other ends of the paths
 - Pictures of the horizon all the way around (for future use)
 - Pictures of the structure
 - Drawing, photos of the area
 - Notes about any access restrictions

Radio Surveys



- A radio survey is necessary to ensure that your system will work and to identify any environmental interference
- Usually you'll run around with a laptop, wireless card, antenna and maybe a GPS receiver
- Netstumbler lets you see other stations in the nearby environment with certain cards
 - <http://www.netstumbler.com/>
- The Proxim RangeLan2 is an old 802.11 card, but comes with utilities that act like a spectrum analyzer in the 2.4 GHz band
- Most other commercial tools are hideously expensive. If you find anything else that looks good, let me know!!!

Path Testing for the '04 Wild Ride



KD5YVL at Lavonia Park

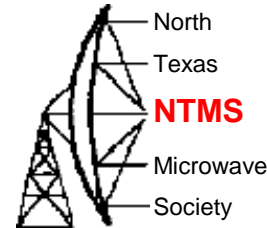


KD5OUG, N5OOM and KD8VL



20mw works at 13.6 miles!!!

Bridge Installation at the Lake Lavon Army Corps of Engineers tower



KD5MNO

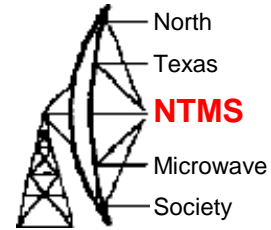


N500M
KD5MNO
KD5YVL
KD5PQA

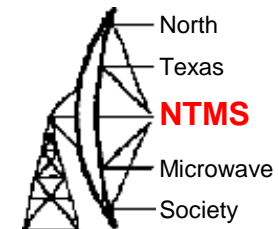


Packaged
Linksys
WAP11

Information Resources



- ARRL HSMM Group
 - The group that started this mess
 - <http://www.arrl.org/hsmm/>
- TAMU Listserv
 - <http://listserv.tamu.edu/archives/arrl-80211b.html>
- Seattle Wireless
 - Very large equipment list
 - <http://www.seattlewireless.net/>
- O'Reilly Books
 - Standard books on 802.11x networking, security
 - <http://www.oreilly.com/>
- eBay
 - Lots of cheap networking gear and antennas (search on WiFi)
 - <http://www.ebay.com>
- Fleeman, Anderson and Bird
 - Ham 802.11x suppliers (state "HSMM" for discount!)
 - <http://www.fab-corp.com/>



More presentations in this series available at:
http://www.n5oom.org/2004_hamcom/presentations.htm

For more information on HSMM, join the ARRL HSMM working group at:
<http://www.arrl.org/hsmm/>