Celebrating the ARRL Centennial

High-Speed Wireless Networking in the UHF and Microwave Bands

Montgomery Amateur Radio Club

Rockville, Maryland

David Bern, W2LNX and **Keith Elkin, KB3TCB**

W2LNX@arrl.net and mesh@KB3TCB.com

Introduction

- brief history of ham radio wireless networking
- Ubiquiti airMAX wireless networking equipment
- current high-speed wireless digital networks
- building a high-speed wireless digital network
- conclusions

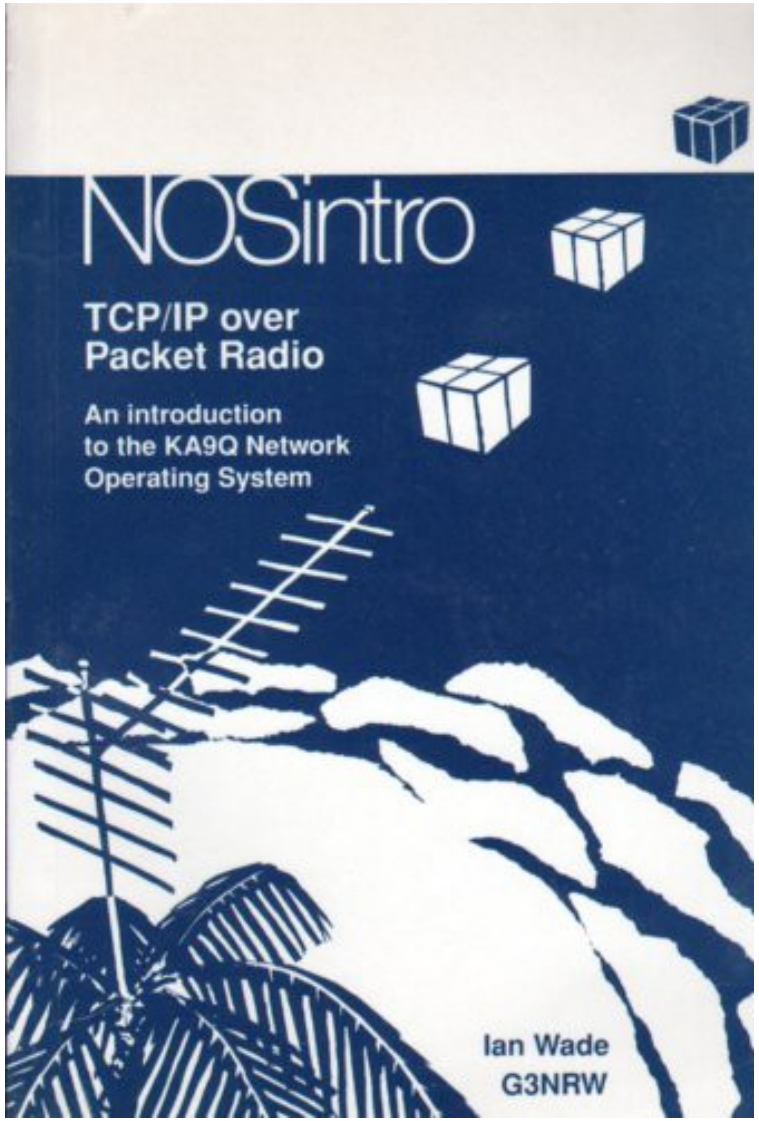
Personal history of wireless networking

- TAPR Terminal Node Controller (TNC) 2 – 1985
- the Phil Karn, KA9Q NOS TCP/IP package – 1991
- Dale Heatherington, WA4DSY 56KB radio modem – 1987
- Automatic Packet Reporting System (APRS) – 1992
- Broadband-Hamnet™ (formerly HSMM-Mesh™) – 2010
- Doodle Labs DL435-30 420 MHz miniPCI cards – 2012
- Ubiquiti airMAX wireless networking products – today

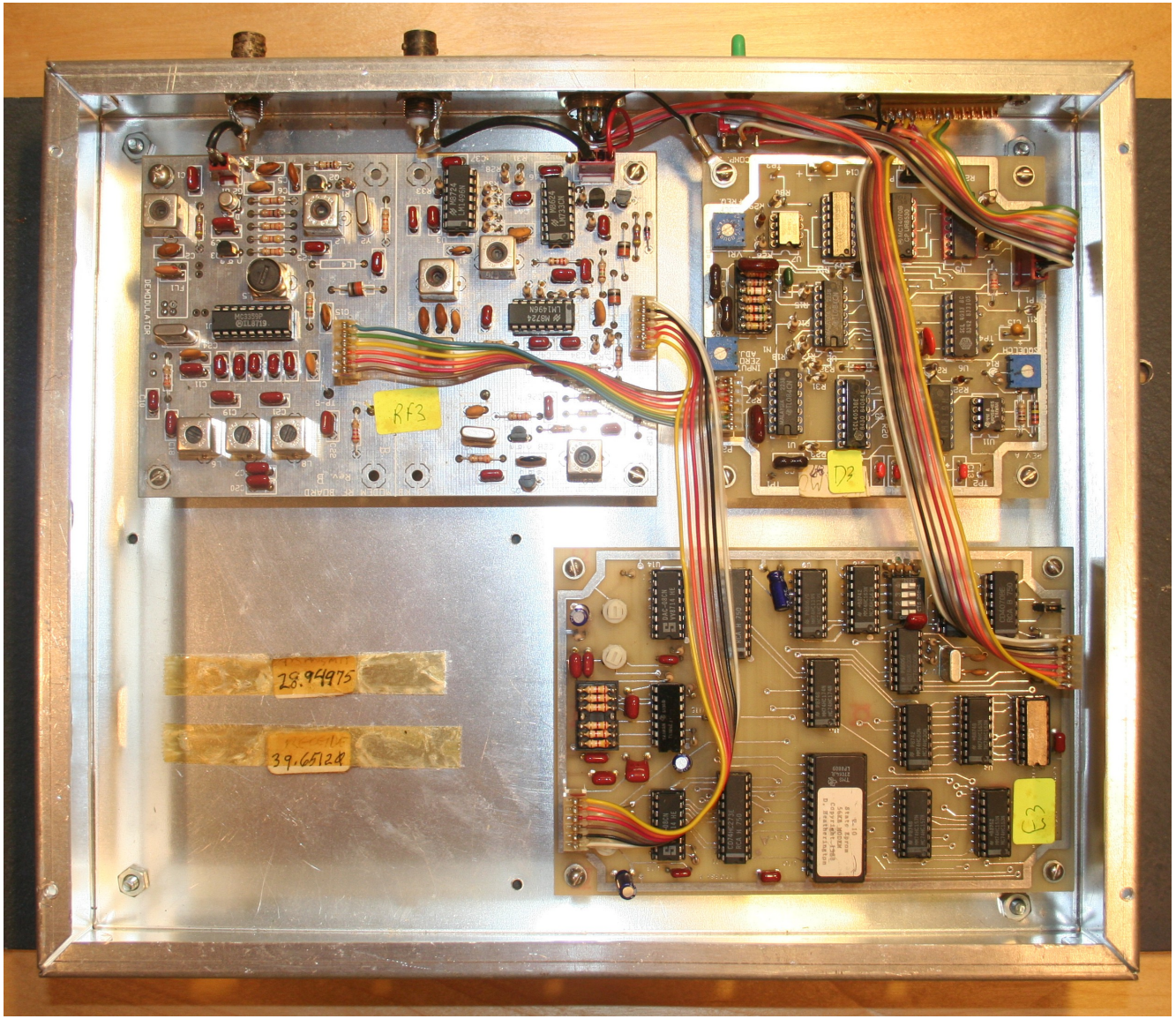
my first TNC – 1985 – used PBBS and later APRS

TAPR TNC 2 and FT-208R

used KA9Q NOS TCP/IP package on IBM PC – late 1980s

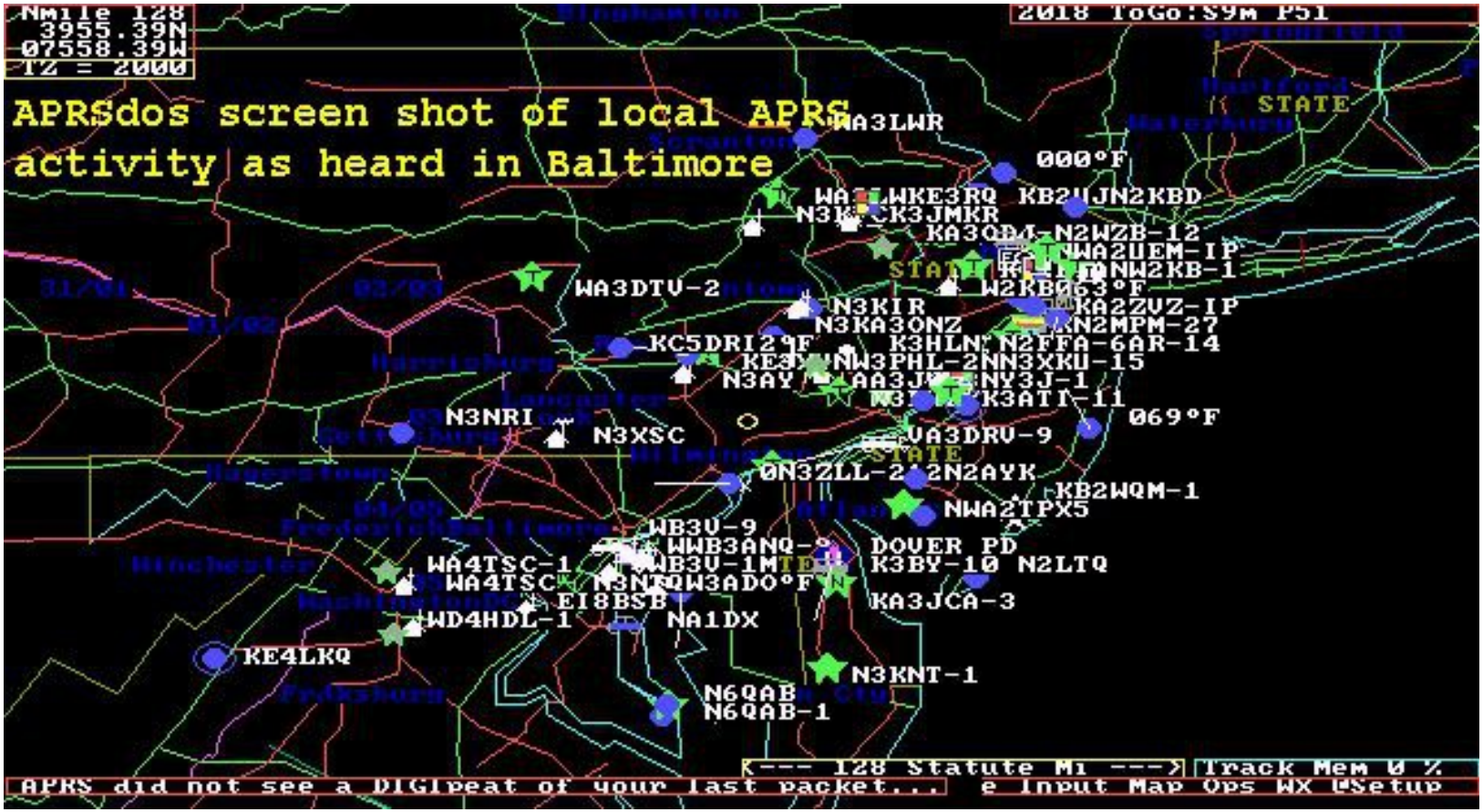


built WA4DSY 56KB modem – experimented in late 1980s



GRAPES WA4DSY 56 KB modem kit

met Bob Bruninga, WB4APR in Washington, DC – about 1995

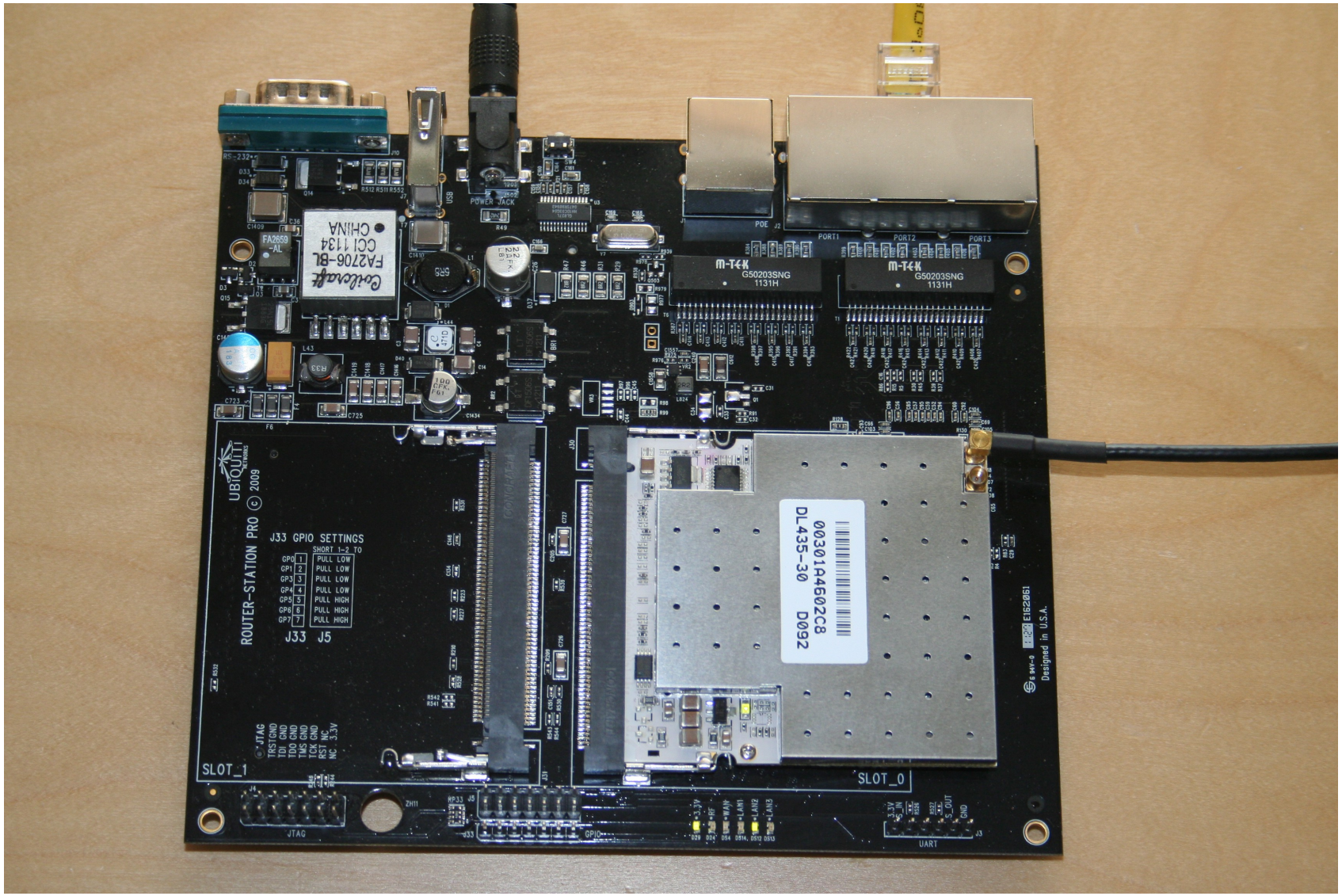


APRSdos

experimented with HSMM-Mesh™ with MARC members – 2012

Linksys WRT54GL wireless router

discovered Doodle Labs 420 MHz miniPCI cards – 2012



Doodle Labs DL435-30 in Ubiquiti RouterStation Pro

This suggested a big idea – 2012

Can we build a high-speed ham radio wireless network using commercial off the shelf (COTS) equipment?

Personal history of wireless networking

K1ZZ and W2LNX at the ARRL Centennial Convention

History of wireless networking

A hundred years ago – ARRL was founded as a network of amateur radio operators to relay messages

Today – wireless networking is

- automatic
- digital
- reliable
- microwave frequencies
- sensitive receivers
- low power transmitters
- less expensive
- COTS

We've come a long way!

Ubiquiti wireless networking products

Based on IEEE 802.11 protocols – uses OFDM and TDMA

airMAX	Ubiquiti	ISM	amateur
M900 900 MHz	902-928	902-928	902-928
M2 2.4 GHz	2402-2462	2400-2500	2390-2450
M3 3 GHz (1)	3370-3730		3300-3500 (3)
M5 5 GHz	5725-5850	5725-5875 (2)	5650-5925

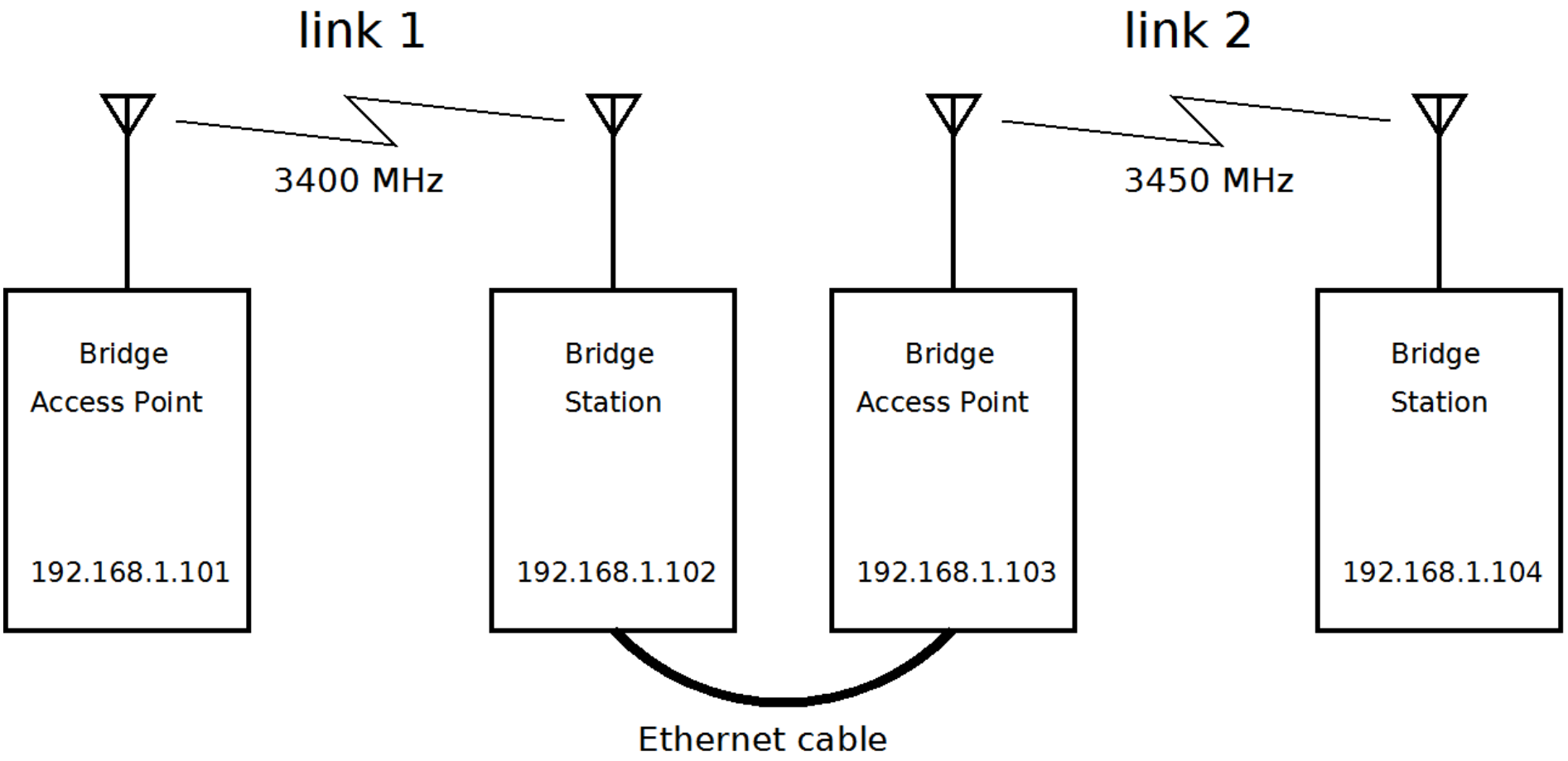
(1) for export from USA – purchased from Streakwave Wireless

(2) U-NII: 5150-5350, 5470-5825 MHz

(3) ARRL band plan

Ubiquiti demonstration network

two link wireless network



- default Network Mode of airMAX router is Bridge
- no latency

wireless network ham radio station

Grandstream GXP1105 IP phone and NanoStation M3

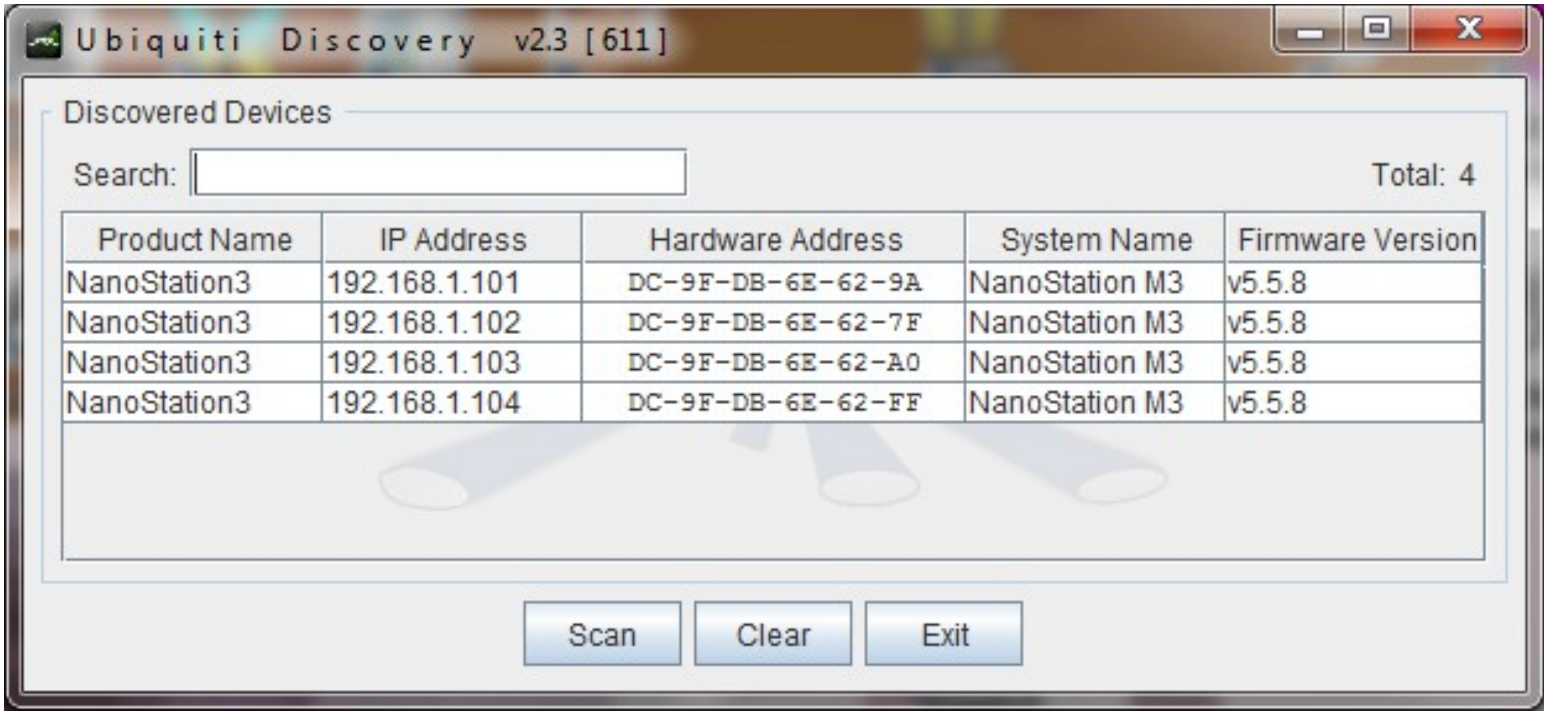
Ubiquiti demonstration network

wireless network relay station

two NanoStation M3 routers

FOSCAM FI8910W IP camera

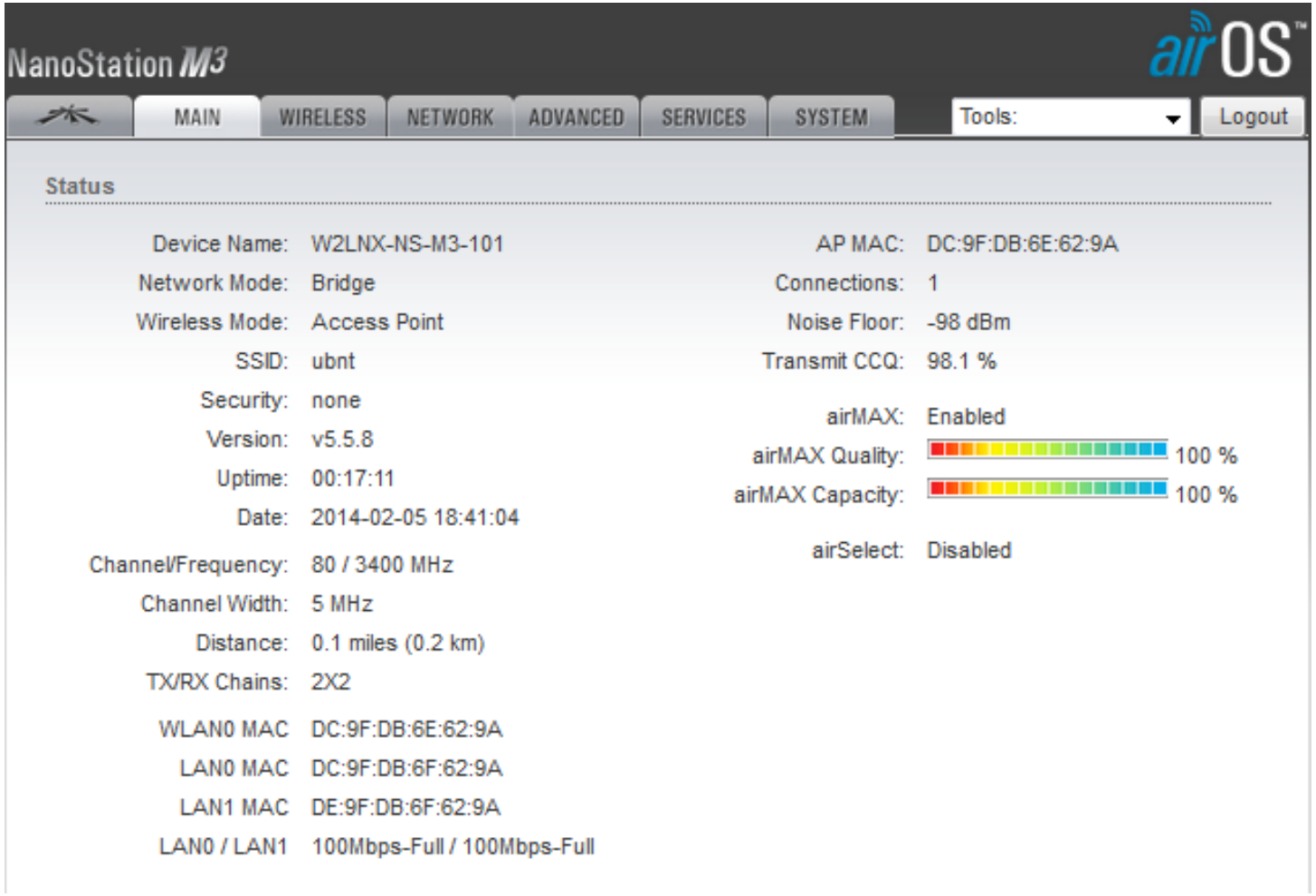
Discovering the network



Ubiquiti Discovery program

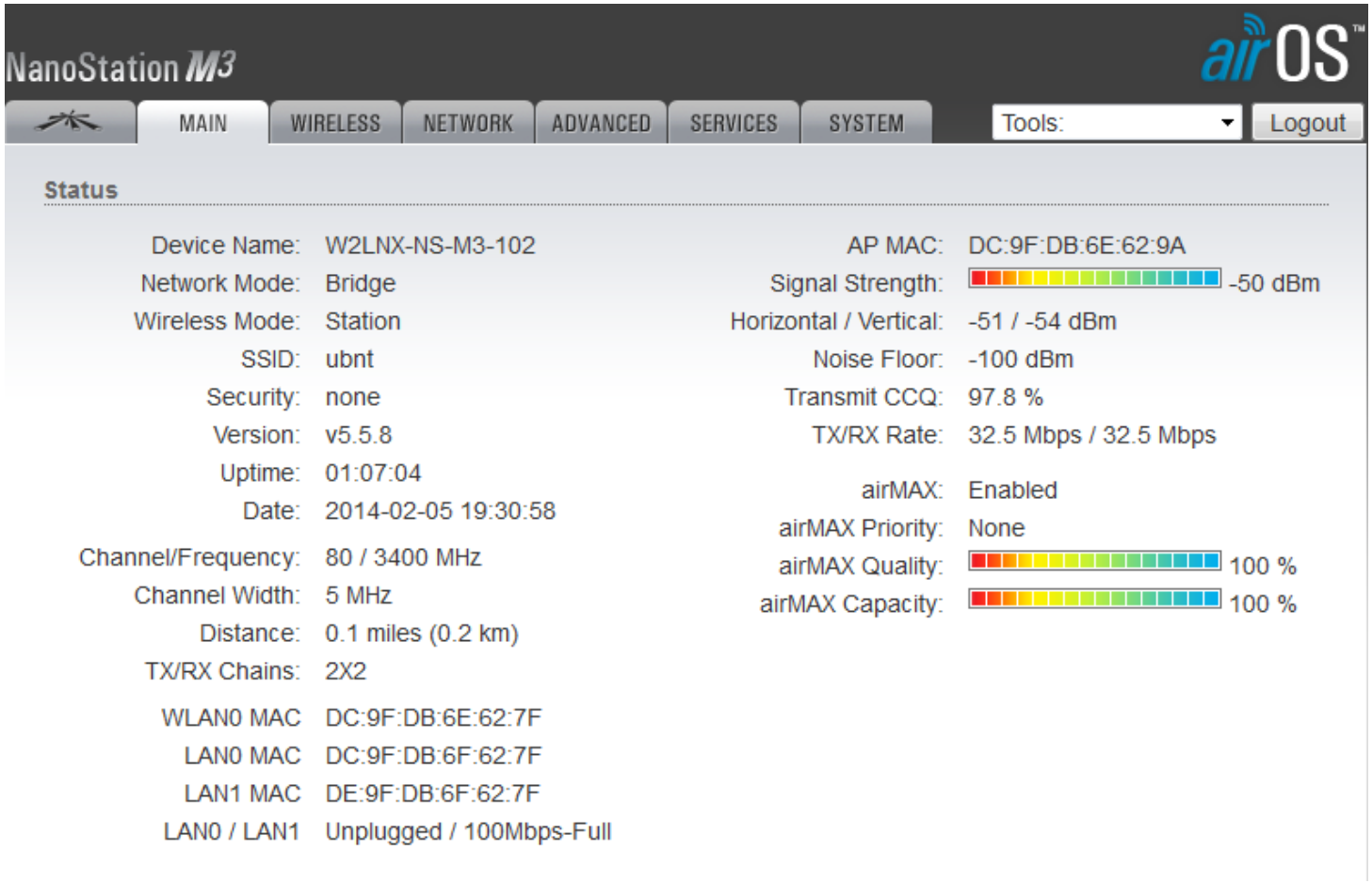
- works on a different subnet

Access point



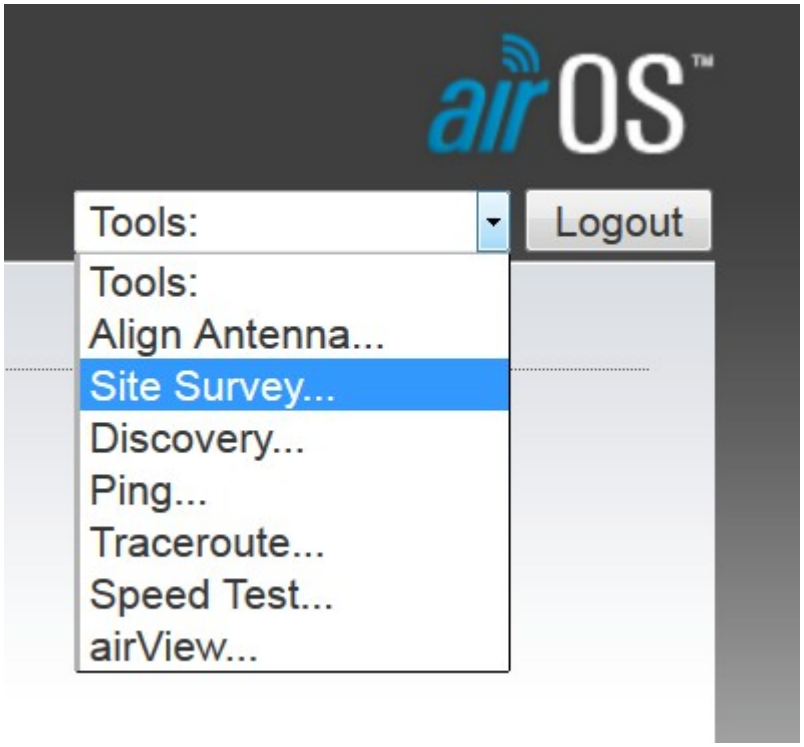
airOS MAIN screen

Station – client



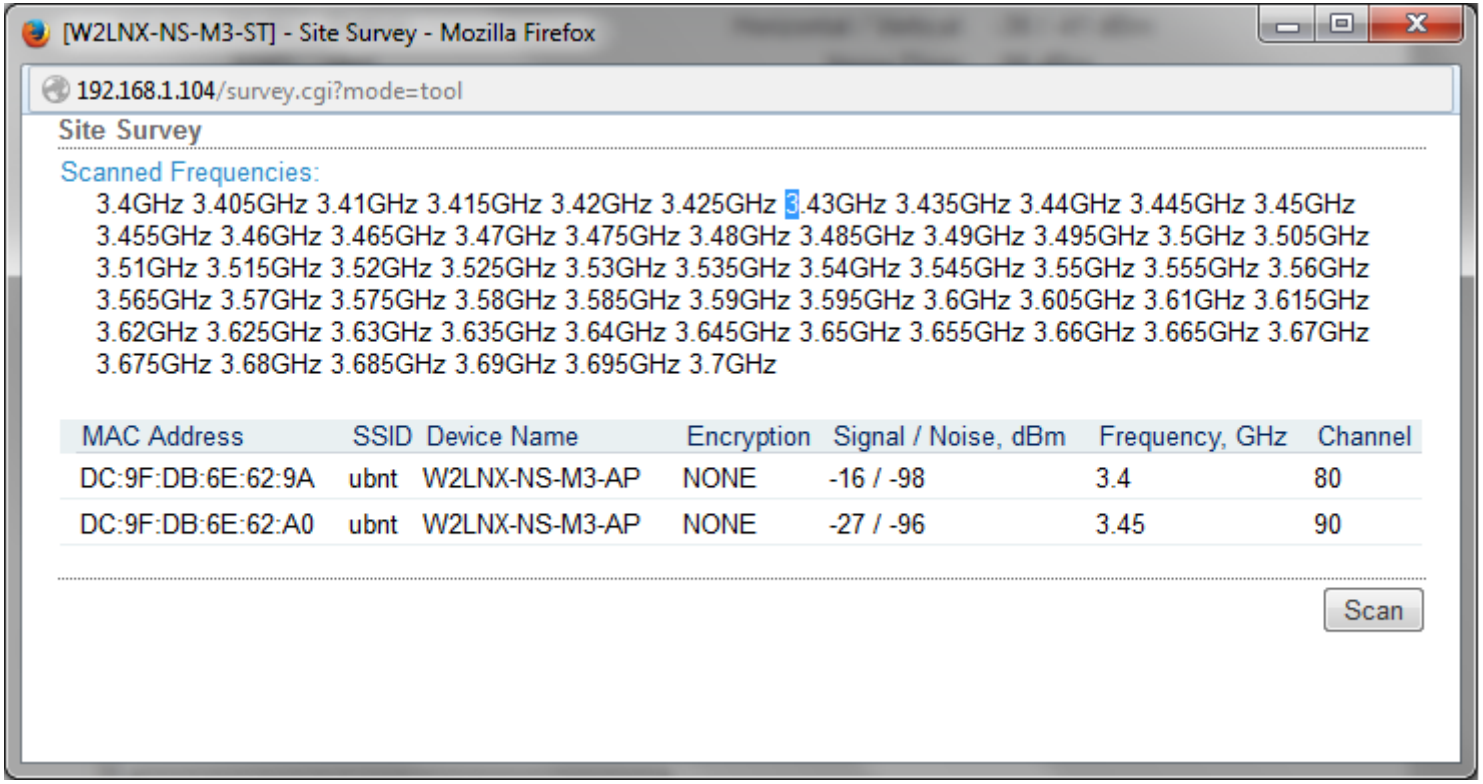
airOS MAIN screen

Discovering the network



airOS Tools

Discovering the network

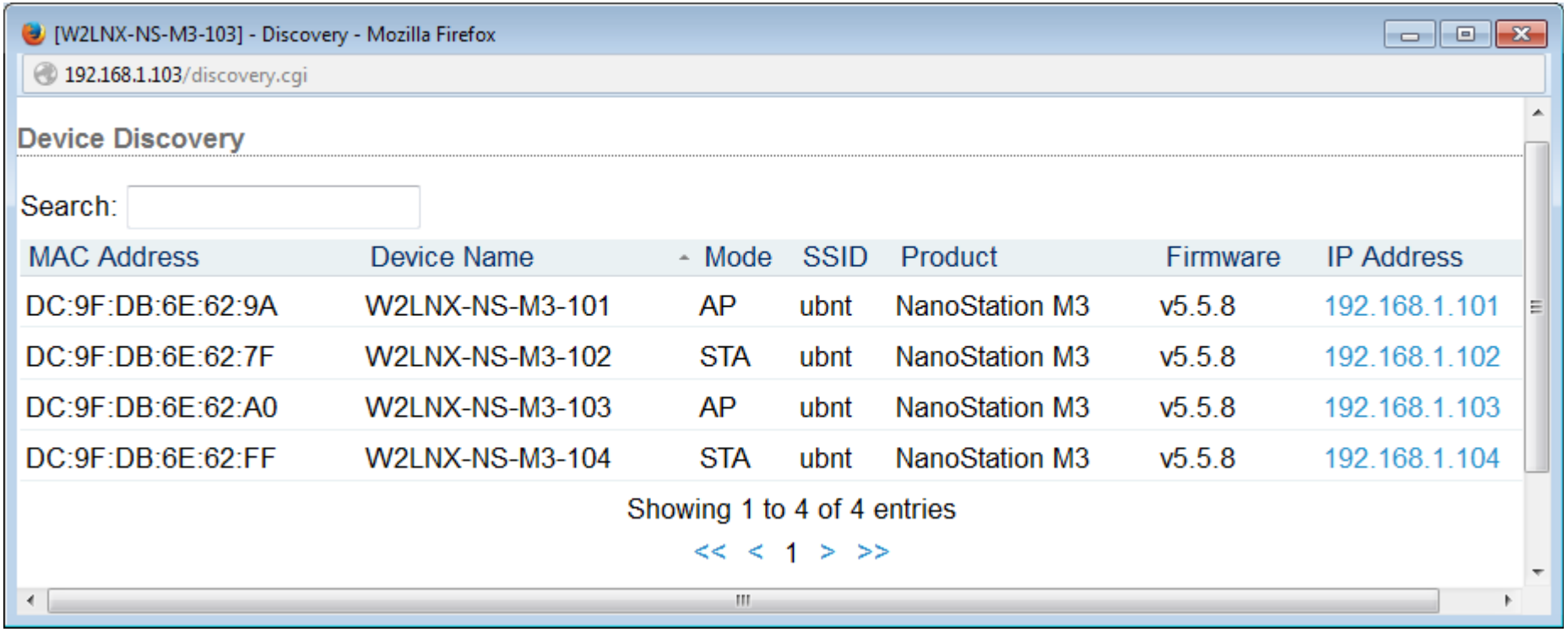


airOS Site Survey tool

discovered:

- access points
- frequencies

Discovering the network



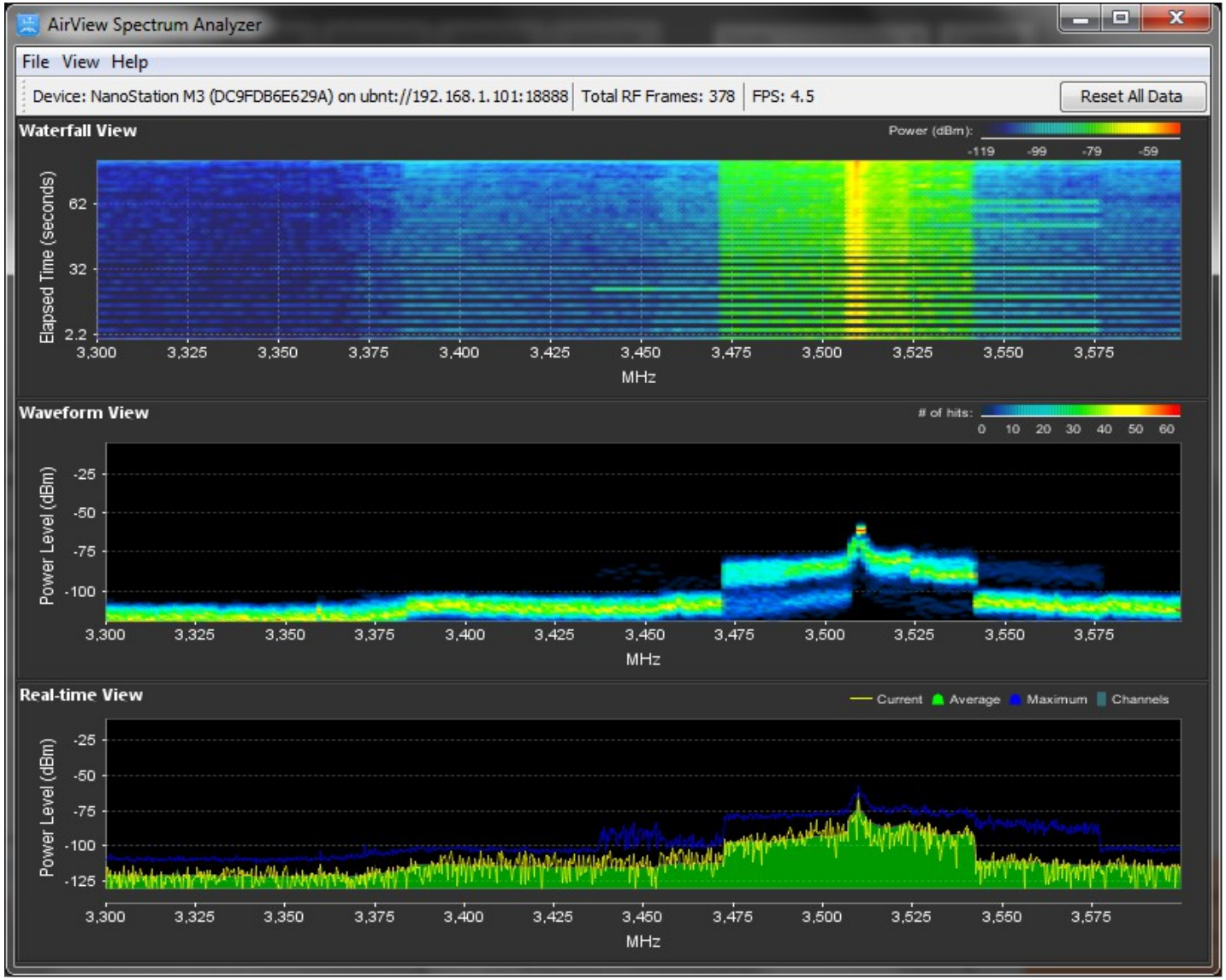
airOS Discovery tool

discovered:

- Device Name – broadcast station identification
- IP Address – broadcast IP address

Ubiquiti demonstration network

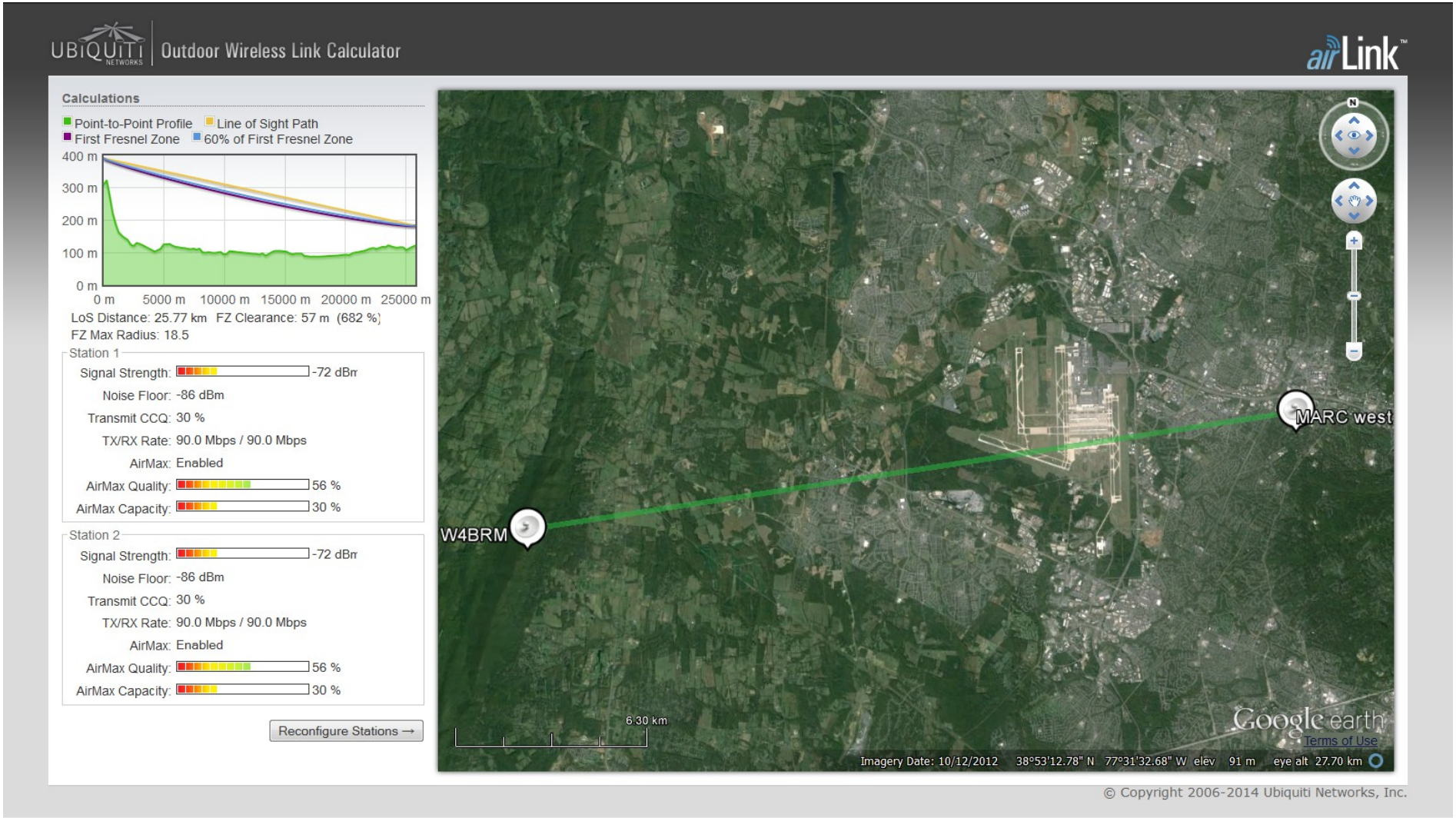
spectrum analyzer



airOS airView tool

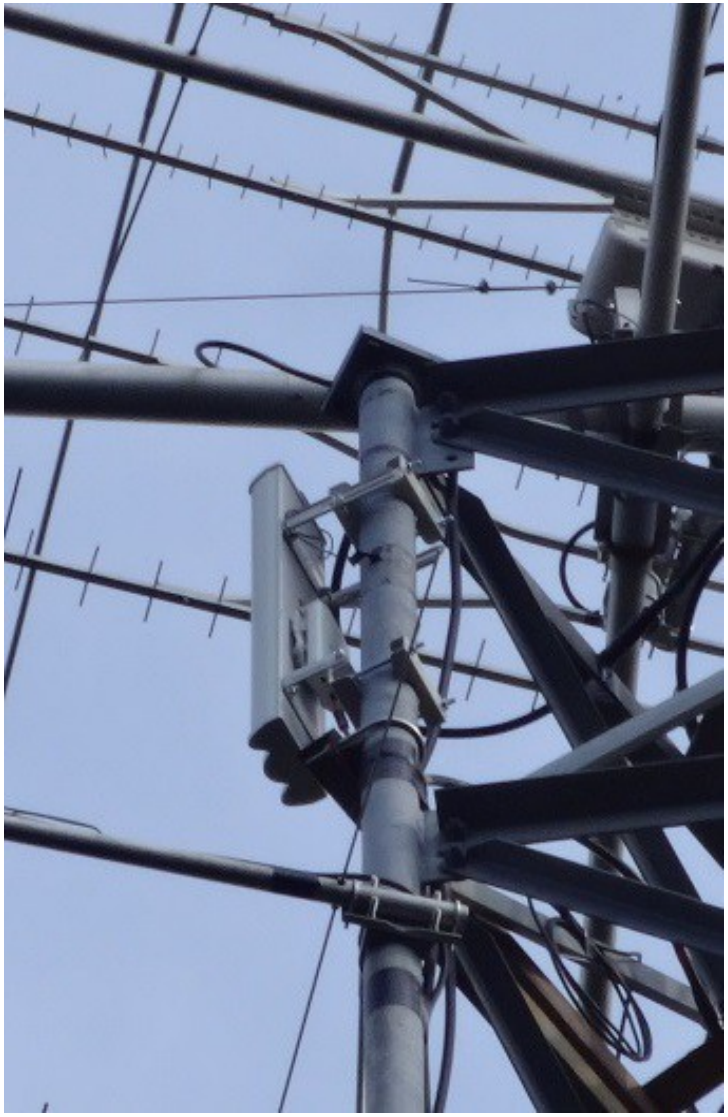
MARC repeater west site to W4BRM test

16 miles on 5 GHz



airLink simulation

access point at W4BRM



Ubiquiti 5 GHz sector antenna

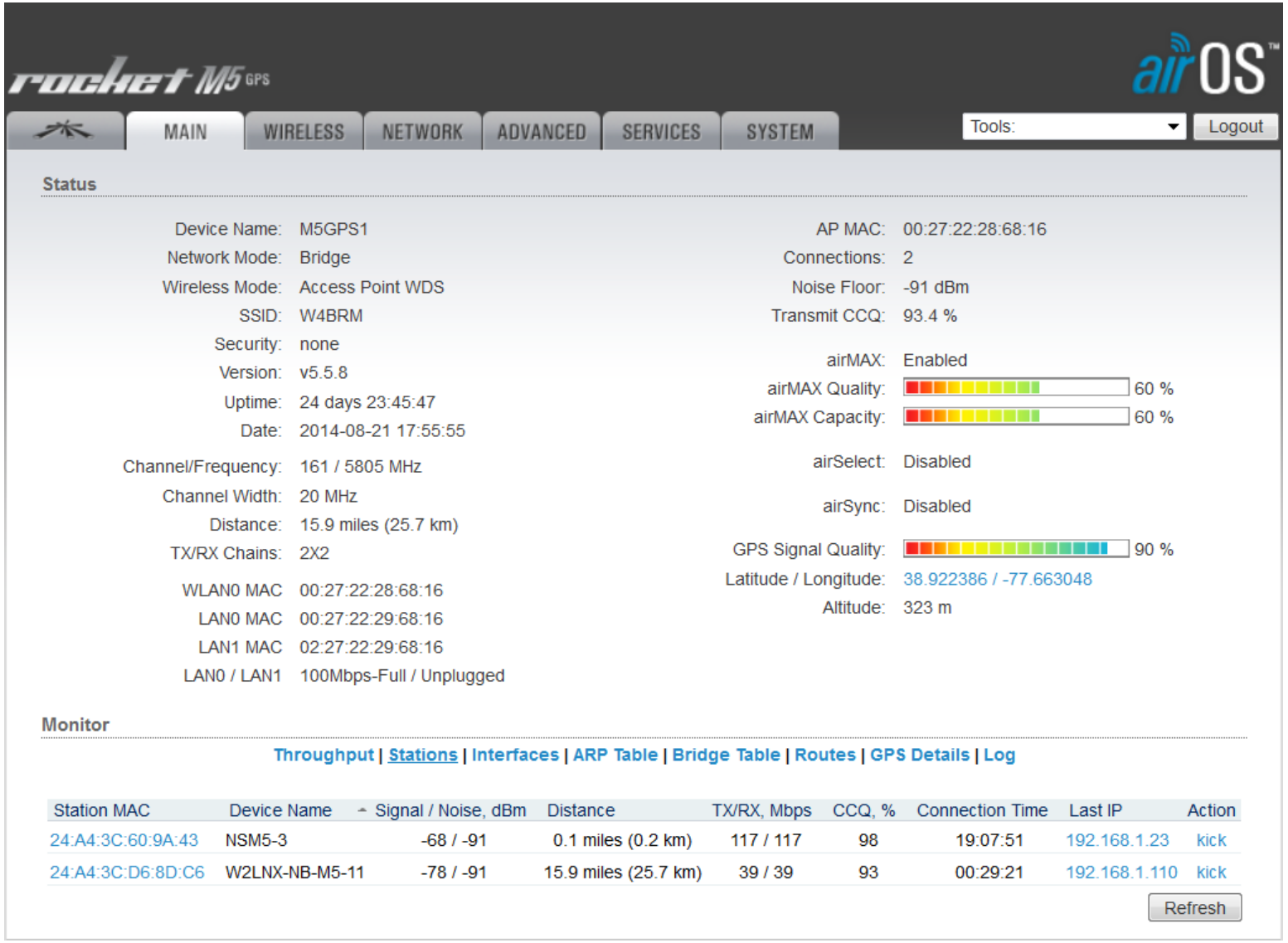
MARC repeater west site to W4BRM test

station at W2LNX

NanoBeam M5 NBE-M5-400

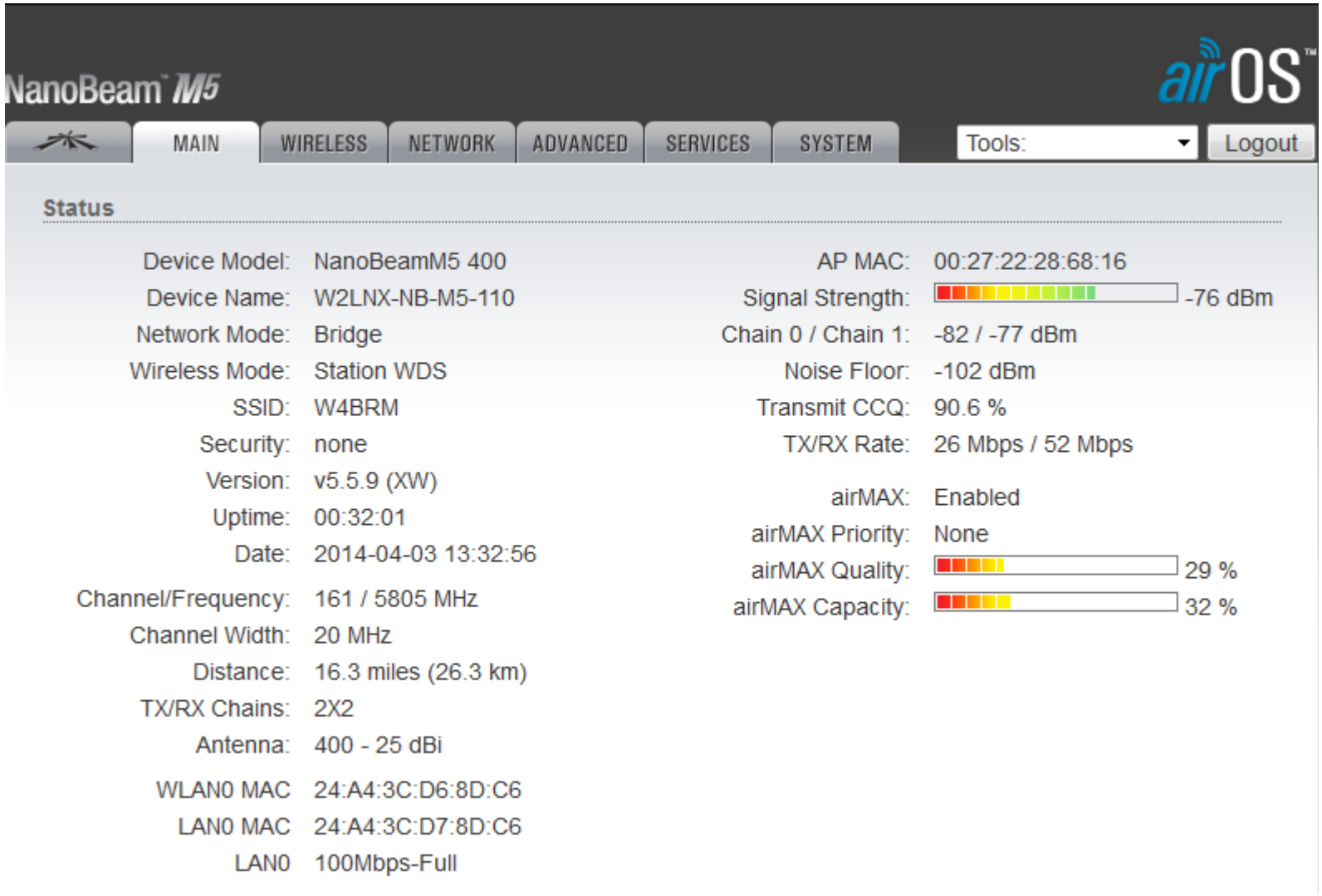
MARC repeater west site to W4BRM test

access point at W4BRM



W4BRM access point main

station at W2LNX



W2LNX station main

MARC repeater west site to W4BRM test

station at W2LNX

Monitor

Throughput | AP Information | Interfaces | ARP Table | Bridge Table | Routes | Log

Access Point	00:27:22:28:68:16		
Device Name:	M5GPS1	Negotiated Rate	Last Signal, dBm
Product:	R5N-GPS	MCS0	N/A
Firmware:	v5.5.8	MCS1	N/A
Connection Time:	00:15:37	MCS2	-76
Signal Strength:	-76 dBm	MCS3	-76
Noise Floor:	-101 dBm	MCS4	-77
Distance:	17.2 miles (27.7 km)	MCS5	N/A
CCQ:	88%	MCS6	N/A
Last IP:	192.168.1.41	MCS7	N/A
TX/RX Rate:	52.0 Mbps / 52.0 Mbps	MCS8	N/A
TX/RX Bit Rate:	7.45 kbps / 7.83 kbps	MCS9	N/A
TX/RX Packets:	3381 / 4934	MCS10	N/A
TX/RX Packet Rate, pps:	0 / 5	MCS11	-76
Bytes Transmitted:	893847 (872.90 kBytes)	MCS12	N/A
Bytes Received:	938566 (916.57 kBytes)	MCS13	N/A
		MCS14	N/A
		MCS15	N/A

W2LNX station access point information

MARC repeater west site to W4BRM test

station at W2LNX

Site Survey

Scanned Frequencies:

5.765GHz 5.785GHz 5.805GHz 5.825GHz

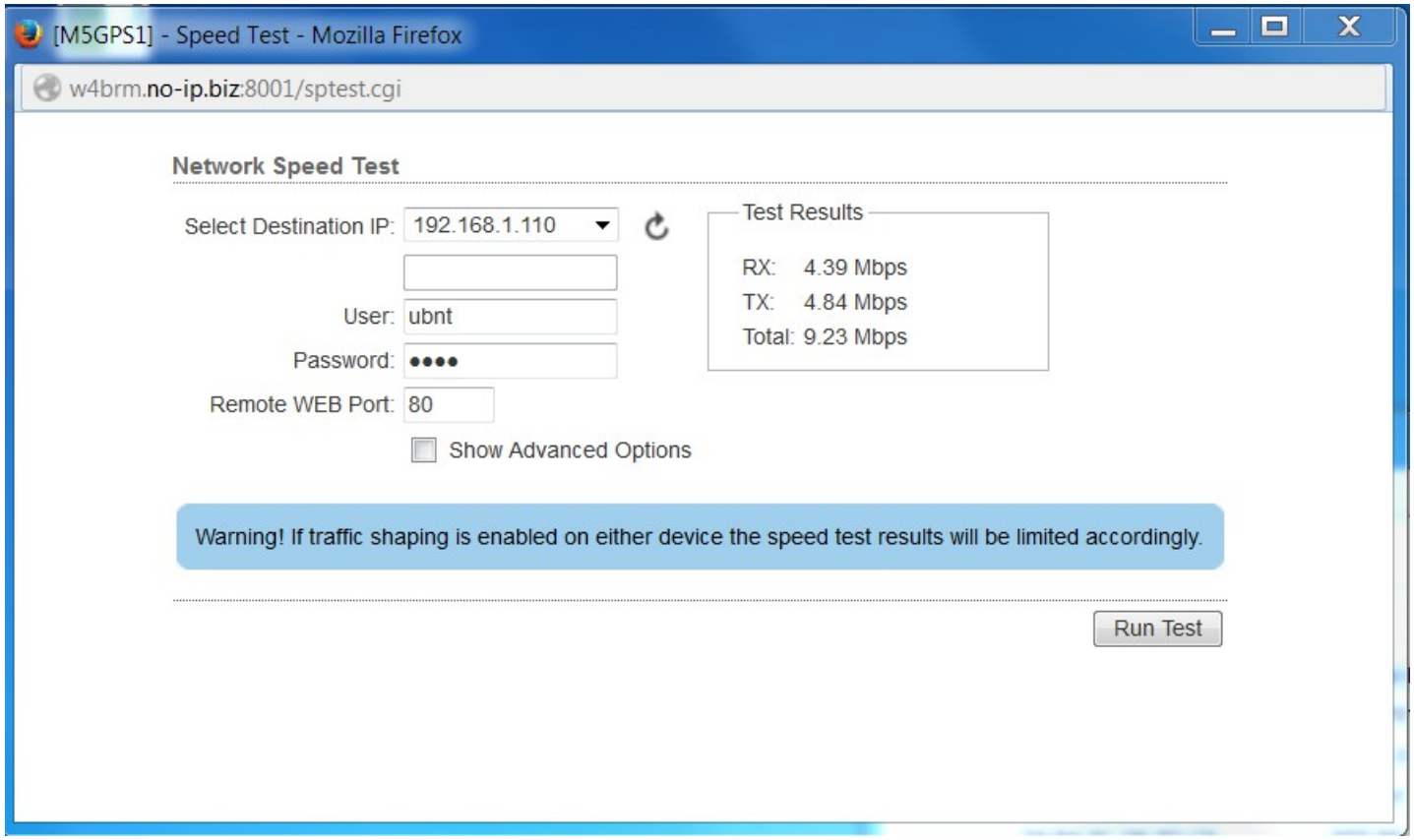
MAC Address	SSID	Device Name	Encryption	Signal / Noise, dBm	Frequency, GHz	Channel
10:0D:7F:D0:51:78	D05178	.$	WPA	-84 / -101	5.785	157
00:24:6C:05:84:0B			WPA2	-87 / -101	5.805	161
00:24:6C:05:84:08	IGSWLAN		WPA2	-89 / -101	5.805	161
34:BD:C8:04:47:6F	CoxWiFi		NONE	-82 / -101	5.765	153
34:BD:C8:04:47:6D	xfinitywifi		NONE	-82 / -101	5.765	153
00:27:22:28:68:16	W4BRM	M5GPS1	NONE	-76 / -101	5.805	161
34:BD:C8:04:47:6E	CableWiFi		NONE	-82 / -101	5.765	153
00:24:6C:05:84:0A	IGSVisitor		NONE	-90 / -101	5.805	161
34:BD:C8:04:8A:CF	CoxWiFi		NONE	-84 / -101	5.825	165
34:BD:C8:04:8A:CD	xfinitywifi		NONE	-83 / -101	5.825	165
34:BD:C8:04:8A:CE	CableWiFi		NONE	-84 / -101	5.825	165
10:BD:18:6B:47:4D	xfinitywifi		NONE	-89 / -101	5.825	165

W2LNX station site survey

- 5 GHz band – shared with unlicensed users

MARC repeater west site to W4BRM test

access point at W4BRM



network speed test

High-Speed amateur wireless networks today

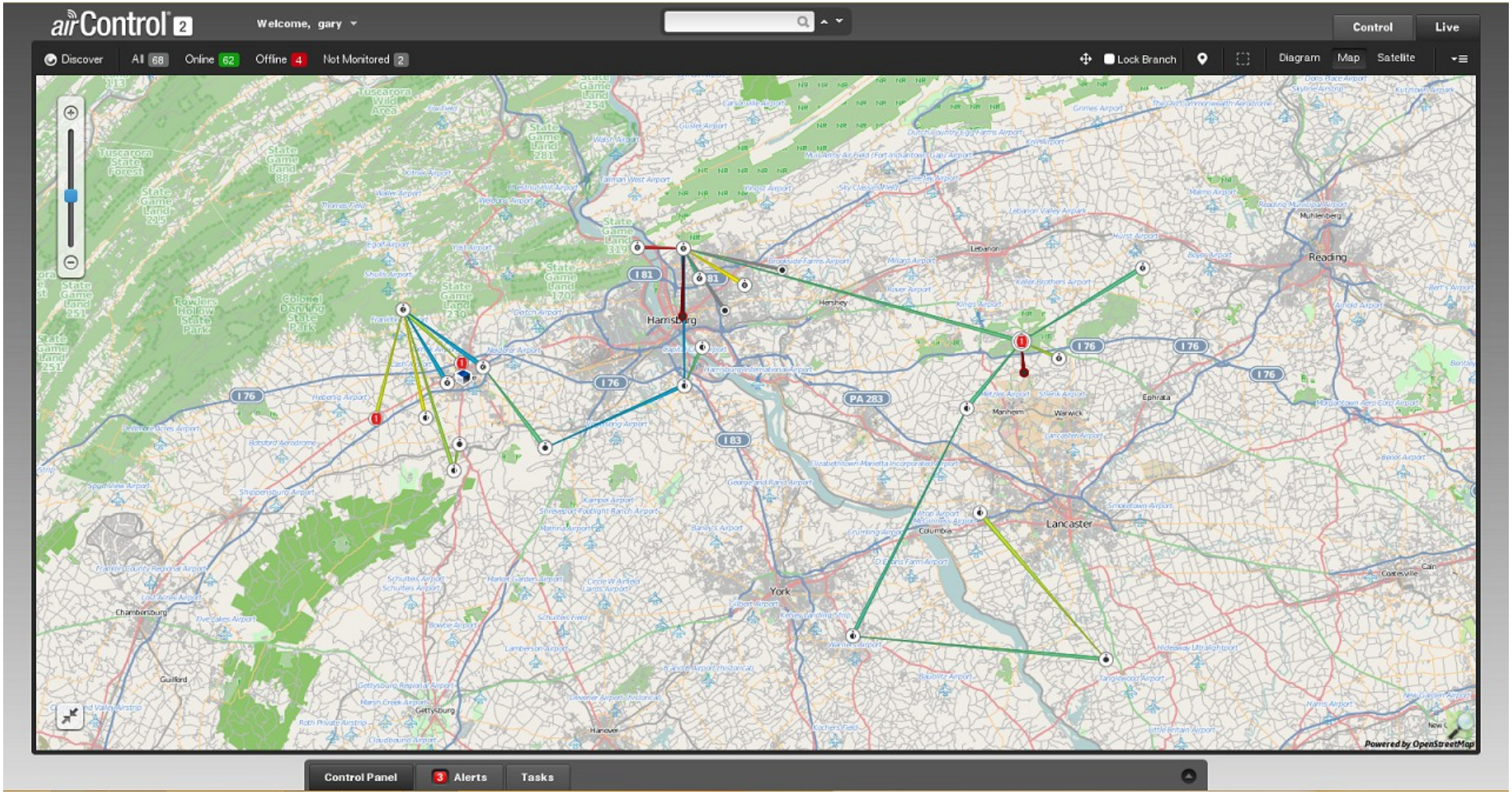
Mid-Atlantic area:

- CPIN – in service
  - extending to Damascus – under construction
- BRATS – in service
- MARC – in planning stages
  - extend to Damascus
- ARCS – in planning stages

other USA:

- Broadband-Hamnet – Austin, TX area – in service
- HamWAN – Seattle, WA area – in service
- BCWARN – British Columbia area – in service
- and more

Central Pennsylvania IP Network (CPIN)



network map

High-Speed amateur wireless networks today

Central Pennsylvania IP Network

- Ubiquiti equipment
- primarily on 5 GHz
- 13 High-profile relay sites
- 157 Miles of network backbone
- 20 IP Cameras
- Asterisk IP telephone system
- and more

Gary Blacksmith, WA3CPO

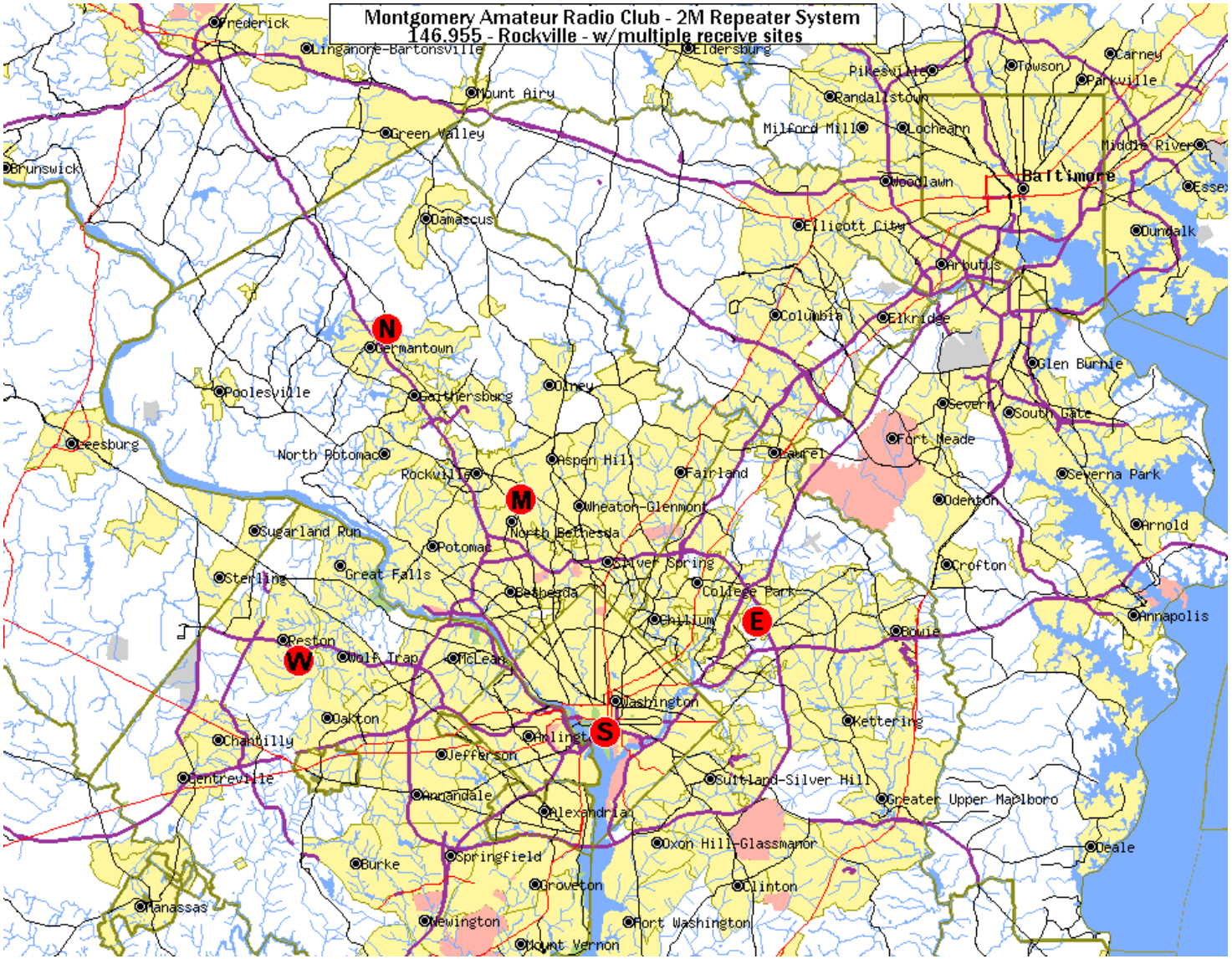
High-Speed amateur wireless networks today

Baltimore Radio Amateur Television Society (BRATS)

- replaces analog repeater links
- 5 sites across 20 miles
- 5 GHz Ubiquiti equipment

Edmond Rosen, N3GXH holding a 5 GHz RD-5G30 RocketDish

Montgomery Amateur Radio Club (MARC), Rockville, MD



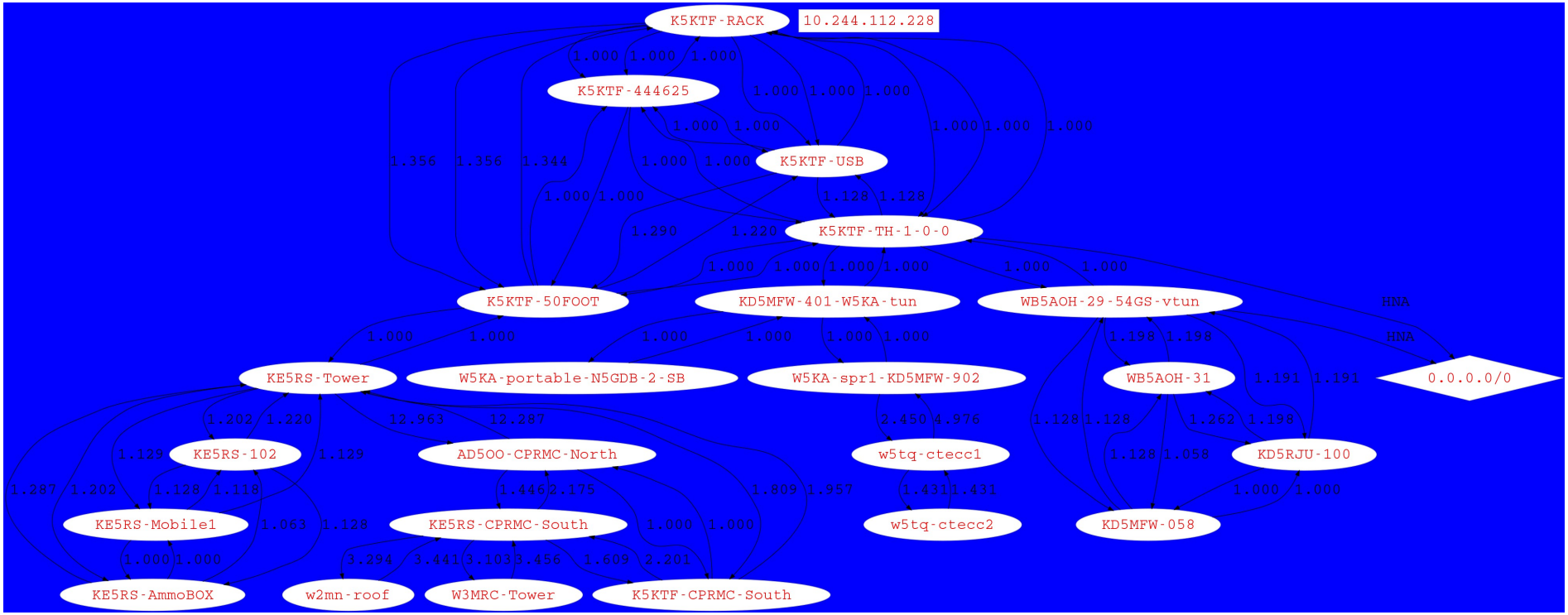
repeater system

Ashton Radio Communications Society (ARCS), Ashton, MD

- repeater system:
  - Ashton, MD
  - Damascus, MD
  - Brookeville, MD
  - Ellicott City, MD
  - NW Washington, DC
  - Jessup, MD
  - Frederick, MD
  - near Mt. Weather, VA

3.4 GHz RocketDish RD-3G26

Broadband-Hamnet Austin, TX mesh network



OLSR topology view of network

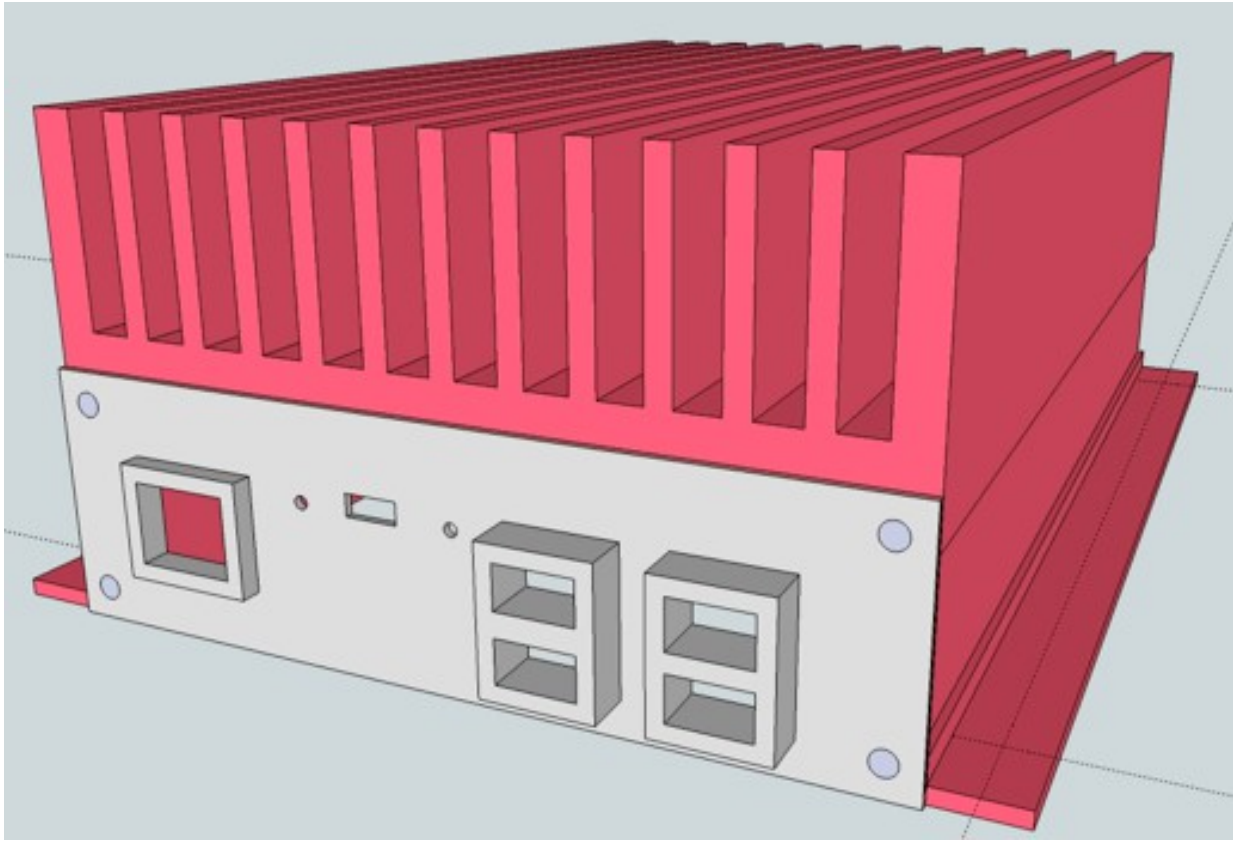
Building local community area networks

Connecting the end-user to the high-speed backbone network

- new radios – products being developed
  - UDRX-440 – NW Digital Radio
  - CS7000 – Connect Systems, Inc.
  - Whitebox radio – Chris Testa, KD2BMH
  - others

Connecting the end-user to the high-speed backbone network

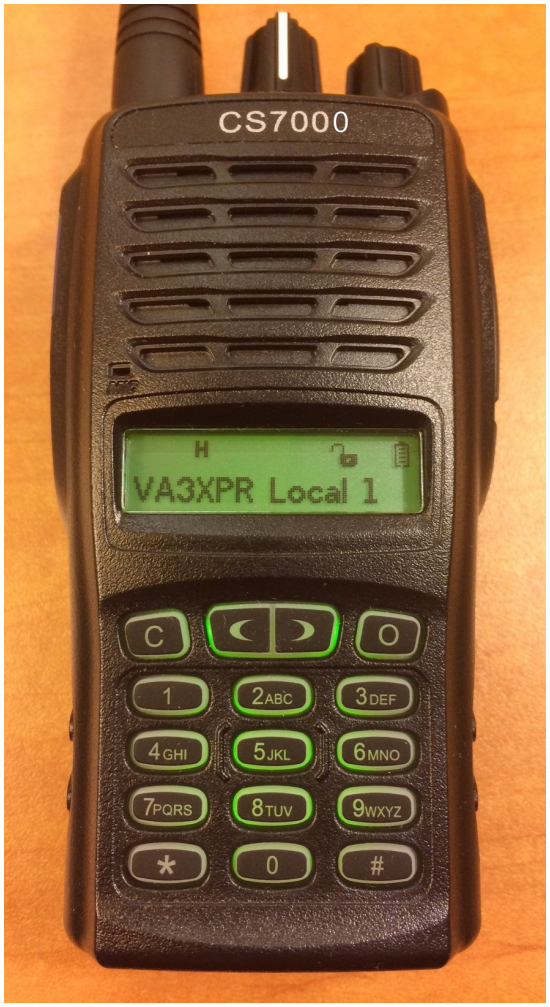
- NW Digital Radio – Bryan Hoyer, K7UDR and John Hays, K7VE



UDRX-440 narrow band data radio with FSK, GMSK modems

Connecting the end-user to the high-speed backbone network

- Connect Systems, Inc. – Jerry Wanger, KK6LFS



mockup of CS7000 narrow band data radio with GMSK, 4FSK modems

Connecting the end-user to the high-speed backbone network

- Chris Testa, KD2BMH

Bravo broadband data radio

Building local community area networks

Connecting the end-user to the high-speed backbone network

- existing radios
  - Doodle Labs – 420 MHz broadband
  - VHF/UHF FM radios with 9600 bps data port
    - audio tap before FM modulator and after the FM demodulator
    - can D-STAR hotspots be used as 4800 bps GMSK modems?
    - **wanted**: inexpensive 9600 bps GMSK modem
  - VHF/UHF FM radios
    - 1200 bps AX.25 TNCs
    - *fldigi* robust modes
  - RTL-SDR USB receiver dongle

Building local community area networks

Connecting the end-user to the high-speed backbone network

- some amateur radio applications – old is new
  - analog and digital repeater linking
  - remote receiver – ham license not required!
  - APRS – extend the network
  - Winlink – extend the network
  - remote HF station operation
  - VOIP – extend the D-STAR, Echolink, IRLP, Allstar networks
  - CW over IP – CWCom program and AD9X serial adapter
  - serial over IP – Lantronix serial to Ethernet adapter

Building local community area networks

Connecting the end-user to the high-speed backbone network

- some Internet applications
  - VOIP – Asterisk
  - Web camera
  - Web and file transfer services
  - email services
  - multicast services
  - Web SDR – remote software defined receivers
    - University of Twente, Enschede, NL

Building an amateur radio wireless network

Issues:

- no single point of failure – distributed servers
- authentication – imperative on shared frequencies
  - is not encryption
  - DCC 2013: Heikki Hannikaninen, OH7LZB, presentation *Authenticated Amateur Radio Services on the Internet*
    - use standard Internet protocols and tools
- network topology and frequencies – what works best
- station ID and IP address
  - are broadcast by Ubiquiti equipment
- **idea**: self assign an IP address
  - created from station latitude and longitude

Conclusions

This is ham radio at its finest!

- additional emergency communication tools from a distressed area
- high speed networks are being built today
  - network is built one link at a time
- attract next generation of hams
  - platform to build and experiment with networking
- take advantage of COTS equipment
- take advantage of proven Internet protocols
- this is fun!

Conclusions

This is...

Together, we can build a national high-speed amateur radio digital communications network.

Please join us!

References and resources

The conference paper and presentation visuals are at

http://tapr.org/pub_dcc33.html

More information is at Keith's Website

http://www.remoteamateur.com

Acknowledgments

- Ron Adams, KB3SYA
- Tony Faiola, K3WX
- Dick Hayman, WN3R
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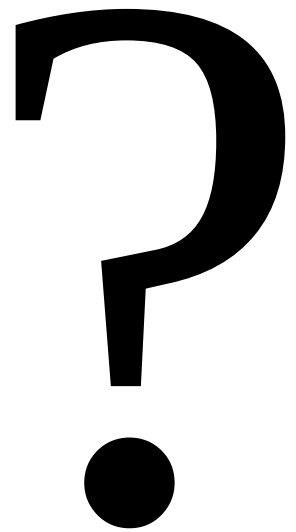
- Phil Karn, KA9Q
- Bill Kisse, W3MSH
- Bruce Perens, K6BP
- Gary Pierce, KN4AQ
- Terry Sharar, W3EDS
- Chris Sylvain, KB3CS

Questions



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