

Celebrating a hundred years of Amateur Radio

**Experimenting with High-Speed
Wireless Networking in the 420 MHz Band**

David Bern, W2LNX

Montgomery Amateur Radio Club

Rockville, Maryland

W2LNX@arrl.net

Introduction

- desire to celebrate the centennial of ham radio
- general project requirements
 - systems integration project – little development
 - involves the outdoors and ham radio friends
 - possibly benefit public service and emergency communications
 - non-hams and young hams can relate to project

Introduction

- At the 2011 DCC, Charles, G4GU0 and Ken, W6HHC presented their *DATVexpress* project
 - wondered: would it be easier to build a high-speed data link with commercial off the shelf (COTS) hardware and software?
 - use a video streaming application on laptops
- Chris, KB3CS at MARC suggested to look at Doodle Labs 420 MHz high-speed data radios
- blog page from Steve, KB9MWR, short video from Kyle, N0KEW and documentation page from Joseph, N9ZIA

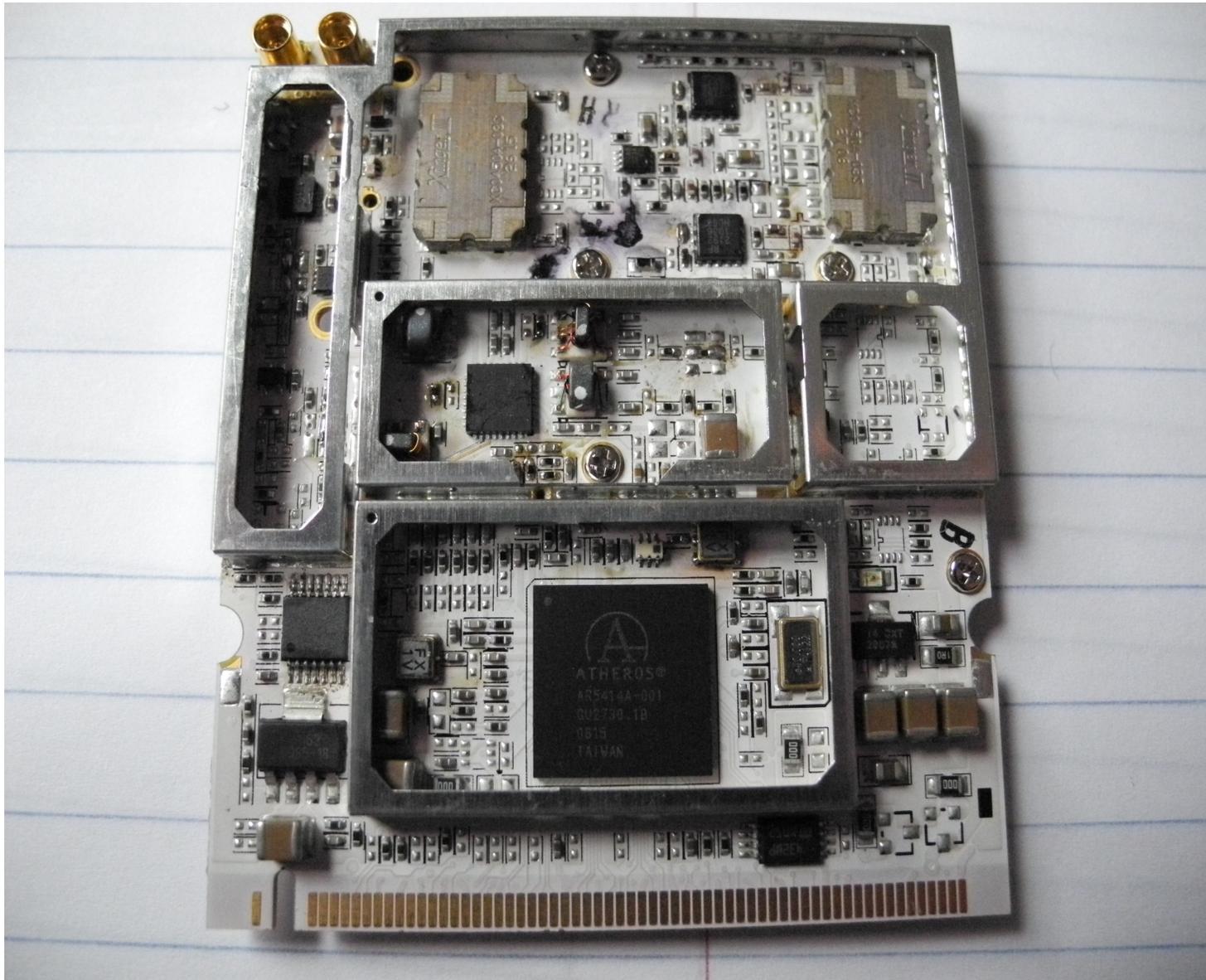
Learning DD-WRT

- purchased
 - Ubiquiti RouterStation Pro router boards
 - three miniPCI card slots
 - Wistron CM9 2.4 GHz Wi-Fi miniPCI cards
 - Doodle Labs and Xagyl cards are drop-in replacements
- ordered
 - Doodle Labs DL435-30 420 MHz miniPCI cards
 - AIR802 MMCX male to N female connector pigtails
 - later, Xagyl Communications 420 MHz XC420M cards

miniPCI 420 MHz data radios

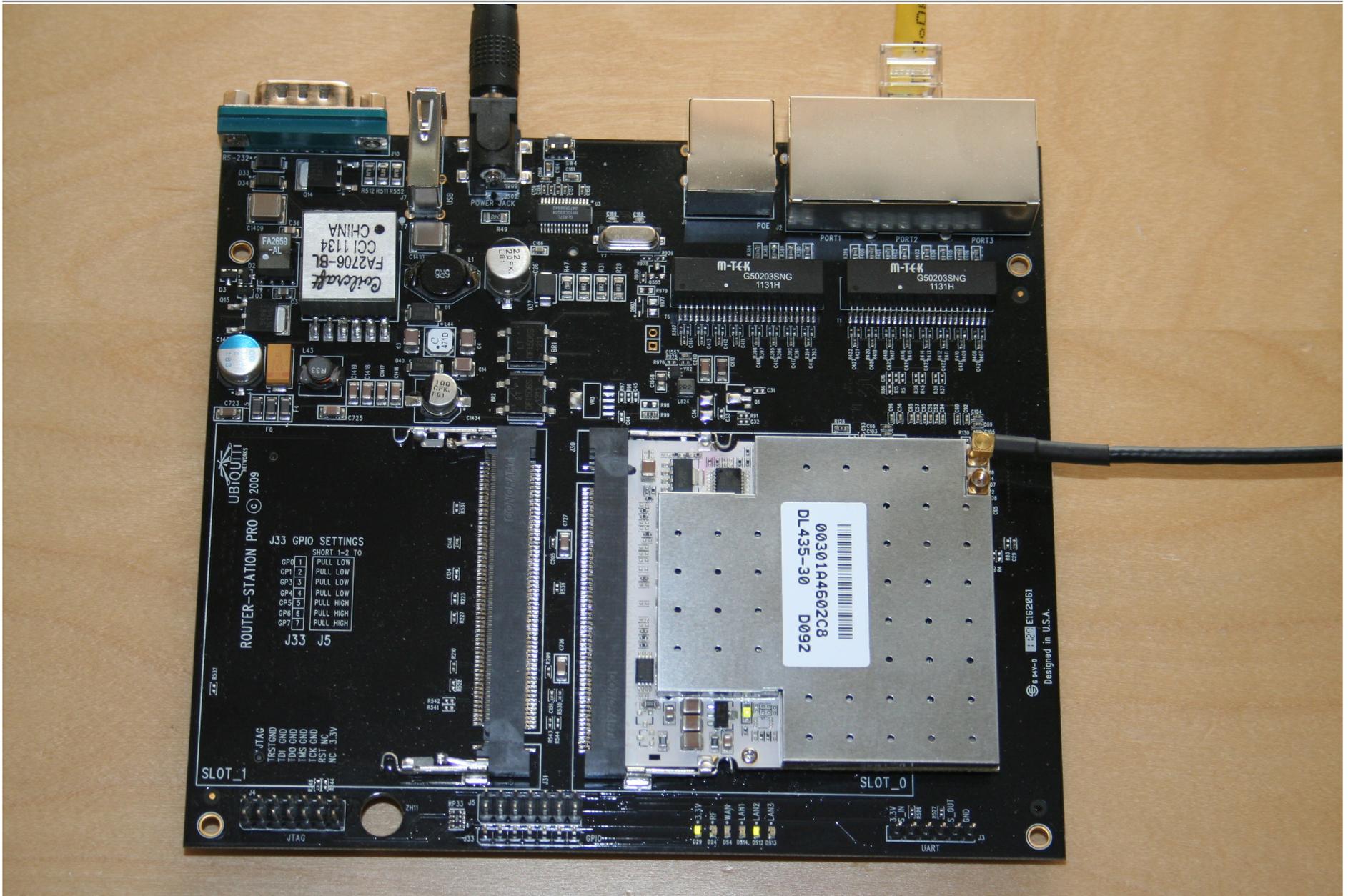
- Doodle Labs DL435-30 and Xagyl Communications XC420M
 - software interface: appears as 802.11b/g Wi-Fi card in the 2.4GHz band
 - Qualcomm Atheros AR5414A chipset at 2.4 GHz
 - RF Micro Devices RF2051 VCO and mixer transverter stage to 420 MHz
 - RF out about 1/2 watt (+28 dBm)
 - RF bandwidth: 5 MHz centered at 422.5 MHz (ATV)
 - DL435-30 – wireless channel 1 – 2412 MHz
 - XC420M – wireless channel 2 – 2417 MHz
 - “1/4 bandwidth”
 - auto fall back: 64QAM, 16QAM, QPSK, BPSK (COFDM)

miniPCI 420 MHz data radios



Doodle Labs DL435-30 with shield removed (KB9MWR photo)

Ubiquiti RouterStation Pro



Doodle Labs DL435-30 miniPCI card in Ubiquiti RouterStation Pro

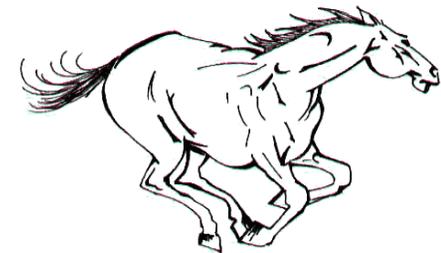
Ubiquiti RouterStation Pro



home brew quarter wave 420 MHz antenna on a large tuna fish can

Ubiquiti RouterStation Pro

- reflashed OpenWRT with DD-WRT
- exercise one: configure a RouterStation Pro router as a 2.4 GHz Wi-Fi client
 - connect to house Wi-Fi access point
- exercise two: configure second RouterStation Pro router as a 2.4 GHz Wi-Fi access point
 - laptop can connect to it
 - SSID: BOARnet – **B**roadband **O**ver **A**mateur **R**adio **n**etwork
- exercise three: connect client router to access point router



Configuring DD-WRT

access point Wireless – Basic Settings

dd-wrt.com ... control panel

Firmware: DD-WRT v24-sp2 (08/07/10) std
Time: 01:46:25 up 1:46, load average: 0.00, 0.03, 0.03
WAN IP: 192.168.2.199

Setup **Wireless** Services Security Access Restrictions NAT / QoS Administration Status

Basic Settings **Wireless Security** MAC Filter WDS

Wireless Physical Interface ath0 Help more...

Physical Interface ath0 - SSID [BOARnet] HWAddr [00:27:1E:30:50:13]

Wireless Mode

Wireless Network Mode

Channel Width

Wireless Channel

Wireless Network Name (SSID)

Wireless SSID Broadcast Enable Disable

Advanced Settings

Card Type

Regulatory Domain

SuperChannel Enable Disable

TX Power dBm

Antenna Gain dBi

Wireless Network Mode:
If you wish to exclude Wireless-G clients, choose *B-Only* mode. If you would like to disable wireless access, choose *Disable*.
Note : when changing wireless mode, some advanced parameters are susceptible to be modified ("Afterburner", "Basic Rate" or "Frame Burst").

Sensitivity Range:
Adjusts the ack timing. 0 disables ack timing completely for broadcom firmwares. On Atheros based firmwares it will turn into auto ack timing mode

setting channel width, channel and TX power to +28 dBm

Configuring DD-WRT

client Wireless – Basic Settings

The screenshot shows the DD-WRT control panel interface. At the top, the logo 'dd-wrt.com' and 'control panel' are visible. The top right corner displays system information: 'Firmware: DD-WRT v24-sp2 (08/07/10) st', 'Time: 02:10:24 up 2:10, load average: 0.00, 0.00, 0.0', and 'WAN IP: 192.168.10.'. A navigation bar contains tabs for 'Setup', 'Wireless', 'Services', 'Security', 'Access Restrictions', 'NAT / QoS', 'Administration', and 'Status'. Below this, a sub-navigation bar highlights 'Basic Settings', 'Wireless Security', 'MAC Filter', and 'WDS'. The main content area is titled 'Wireless Physical Interface ath0' and contains a form with the following settings:

- Wireless Mode: Client
- Wireless Network Mode: Mixed
- Channel Width: Quarter (5 MHz)
- Wireless Network Name (SSID): BOARnet
- Advanced Settings:
- Card Type: Atheros Generic
- Regulatory Domain: UNITED_STATES
- SuperChannel: Enable Disable
- TX Power: 18 dBm
- Antenna Gain: 0 dBi
- Noise Immunity: Auto
- Noise Immunity Level: 4

On the right side, there is a 'Help' section with a 'more...' link. The 'Wireless Network Mode:' section explains that 'Mixed' mode is chosen and provides a note about advanced parameters. The 'Sensitivity Range:' section explains that the current setting of 0 disables ack timing completely for Broadcom firmwares.

setting channel width and TX power to +28 dBm

Configuring DD-WRT

Administration – Management

The screenshot shows the DD-WRT Administration Management interface. At the top, there is a navigation bar with tabs for Management, Keep Alive, Commands, WOL, Factory Defaults, Firmware Upgrade, and Backup. The main content area is divided into three sections: Router Management, Web Access, and Remote Access. The Router Management section contains three password fields: Router Username, Router Password, and Re-enter to confirm, all masked with dots. The Web Access section includes checkboxes for Protocol (HTTP checked, HTTPS unchecked), Auto-Refresh (in seconds) set to 3, Enable Info Site (checked), Info Site Password Protection (unchecked), and Info Site MAC Masking (checked). The Remote Access section includes Web GUI Management (checked), Use HTTPS (unchecked), and Web GUI Port set to 8080. A Help sidebar on the right contains an Auto-Refresh section with a description: 'Adjusts the Web GUI automatic refresh interval. 0 disables this feature completely.'

Management **Keep Alive** **Commands** **WOL** **Factory Defaults** **Firmware Upgrade** **Backup**

Router Management

Router Password

Router Username: [Masked]

Router Password: [Masked]

Re-enter to confirm: [Masked]

Web Access

Protocol: HTTP HTTPS

Auto-Refresh (in seconds): [3]

Enable Info Site: Enable Disable

Info Site Password Protection: Enabled

Info Site MAC Masking: Enable Disable

Remote Access

Web GUI Management: Enable Disable

Use HTTPS:

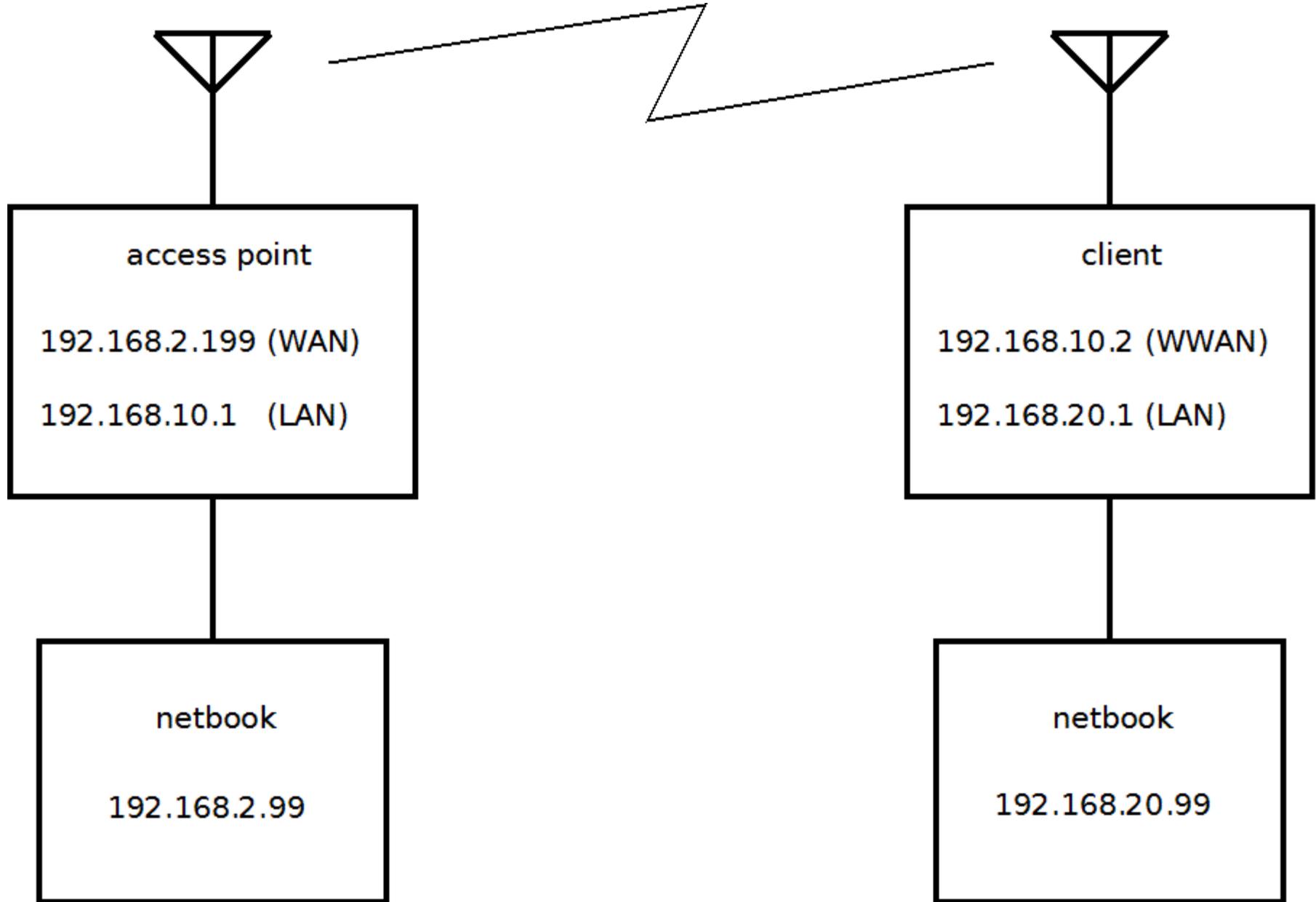
Web GUI Port: [8080] (Default: 8080, Range: 1 - 65535)

Help more...

Auto-Refresh:
Adjusts the Web GUI automatic refresh interval. 0 disables this feature completely.

remote Web access enabled on port 8080

network configuration



Access point router network configuration

- 192.168.10.1 LAN
- 192.168.2.199 WAN

- D257 Aspire one access point netbook
 - 192.168.2.99 netbook
 - Web browser pages
 - 192.168.10.1 access point LAN
 - 192.168.2.199:8080 access point WAN
 - 192.168.2.99:8081 access point *Yawcam*
 - 192.168.2.99 access point *HFS*
 - 192.168.10.2:8080 client WAN
 - 192.168.10.2:8081 client *Yawcam*
 - 192.168.10.2 client *HFS*

Client router network configuration

- 192.168.20.1 LAN
- 192.168.10.2 WAN

- D255E Aspire one client netbook
 - 192.168.20.99 netbook
 - Web browser pages
 - 192.168.20.1 client LAN
 - 192.168.10.2:8080 client WAN
 - 192.168.20.99:8081 client *Yawcam*
 - 192.168.20.99 client *HFS*
 - 192.168.2.199:8080 access point WAN
 - 192.168.2.199:8081 access point *Yawcam*
 - 192.168.2.199 access point *HFS*

Application software

- *Yawcam – Yet Another WebCAM*

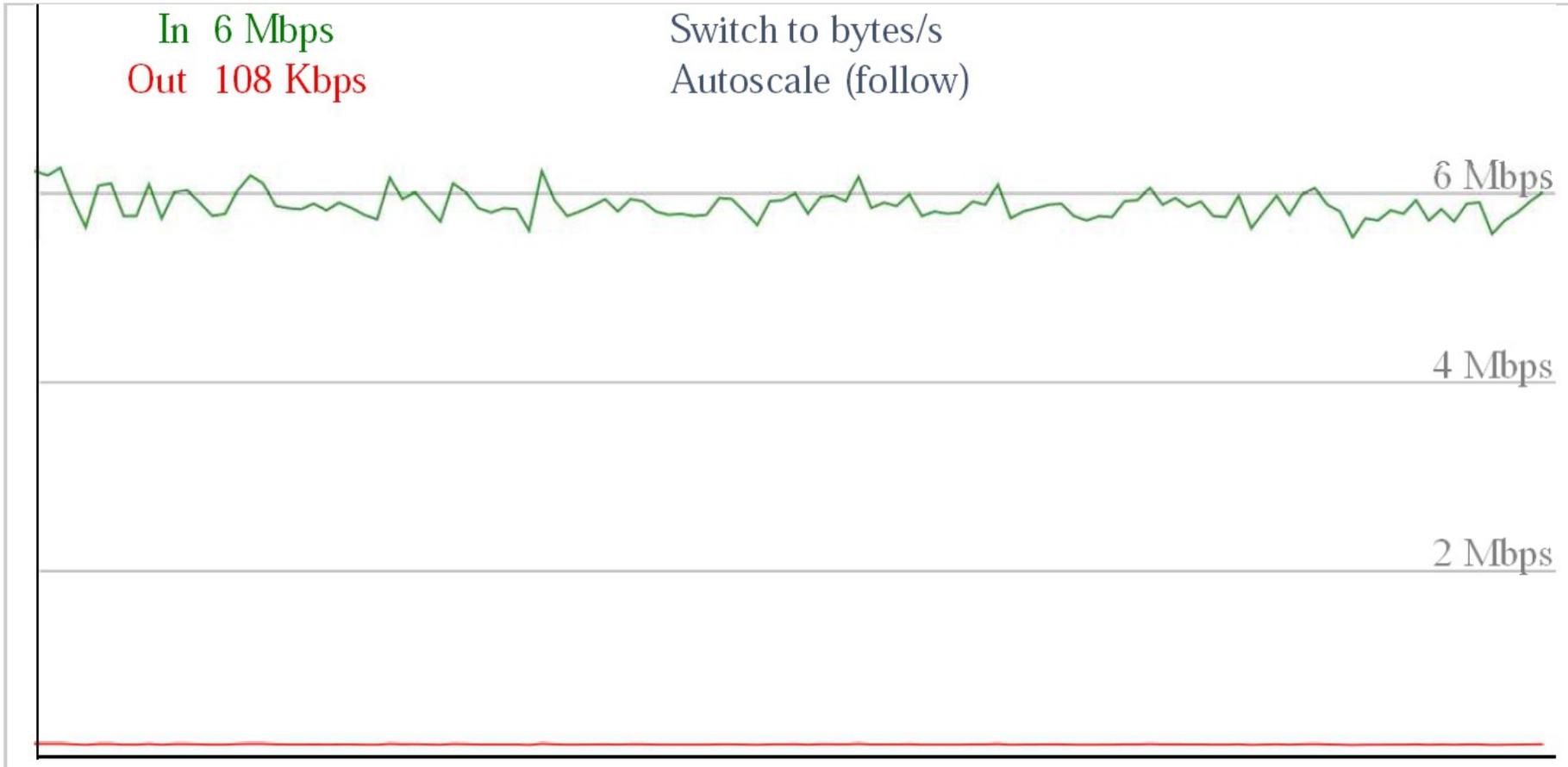
- has built-in video streaming Web server
- client Web browser can select frame rate and quality
- microscope article in *QST* March 2012

- *HFS – HTTP File Server*

- Web server that only serves files
- download rate in *Firefox* Downloads window

Range test – in the house

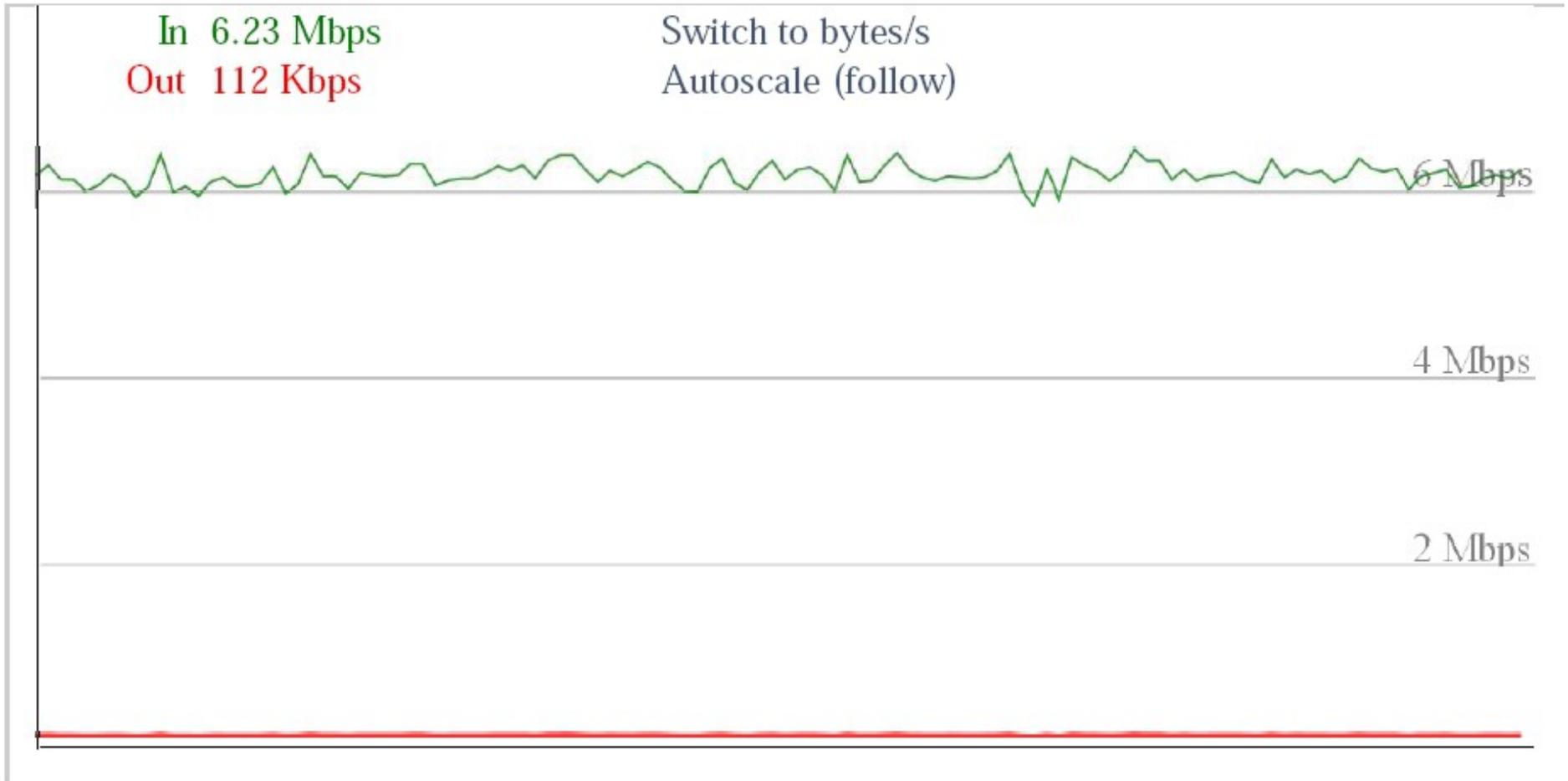
Bandwidth Monitoring - Wireless (ath0)



Doodle Labs DL435-30 file download 20 feet apart

Range test – in the house

Bandwidth Monitoring - Wireless (ath0)



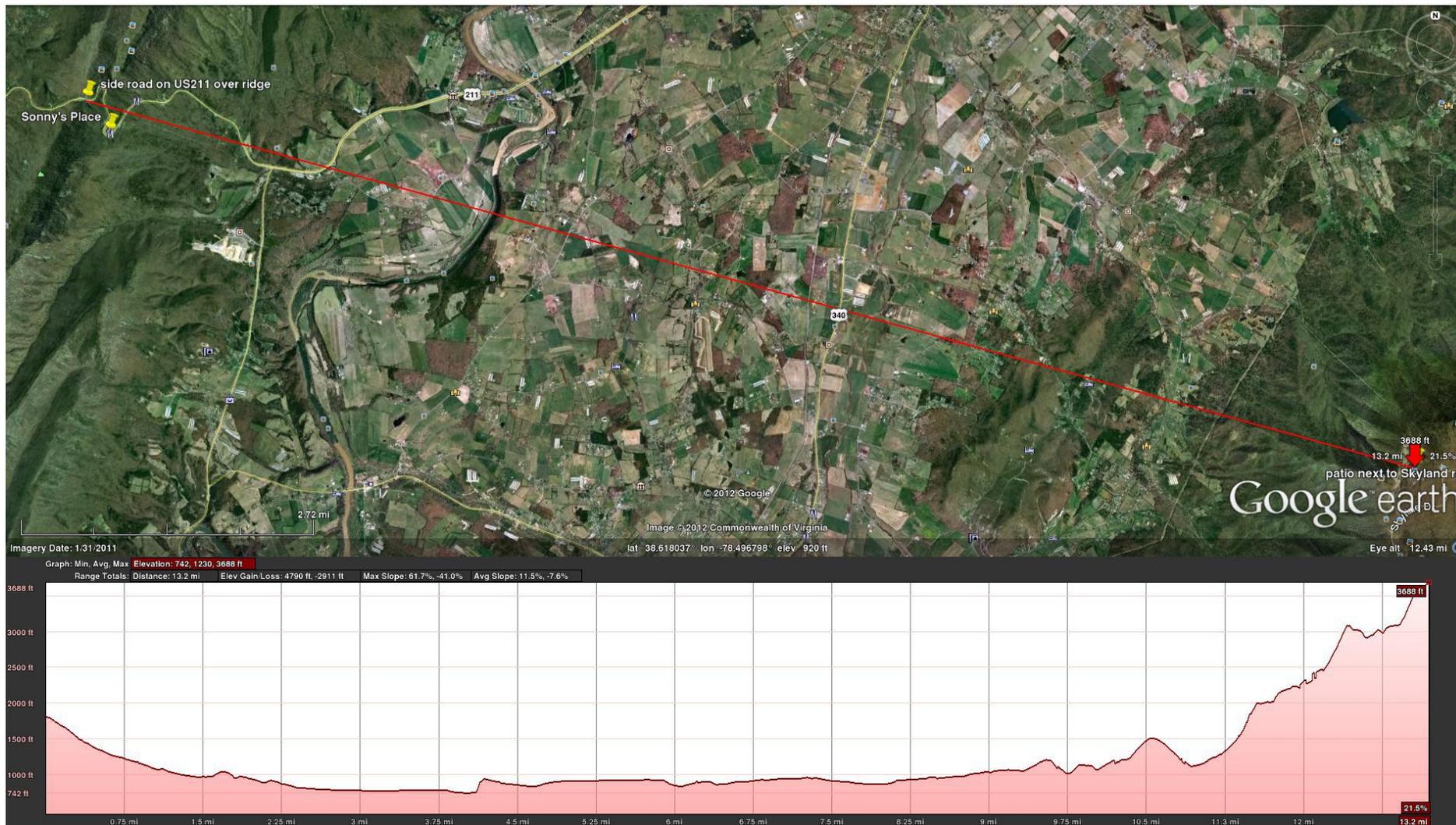
Xagyl Communications XC420M file download 20 feet apart

Range tests – Shenandoah Valley

- acceptance criterion
 - at least one Mbit/s data rate
 - at least 10 mile distance
- Skyland Lodge patio to Massanutten Mountain – 13 miles (21 km)
- Hogback Mountain overlook to Reddish Knob – 57 miles (92 km)
- July 2005 *QST: IEEE 802.11 Experiments in Virginia's Shenandoah Valley* by David Fordham, KD9LA
 - Jason, N4DSL experimenting with long range 2.4 GHz

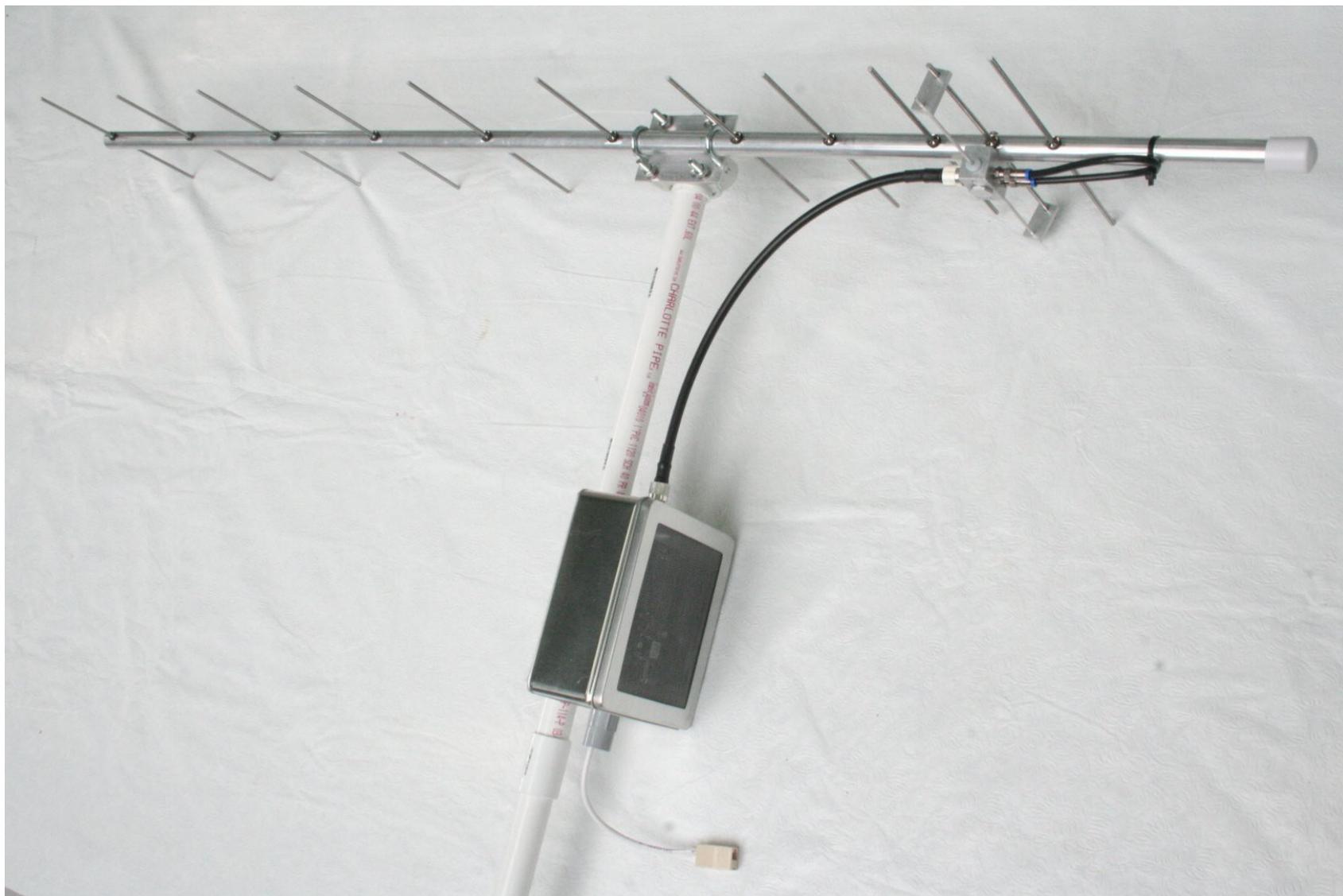
Range tests – Skyland Lodge to Massanutten Mountain

Elevation profile



Skyland Lodge to US 211 on Massanutten Mountain

Range tests – Skyland Lodge to Massanutten Mountain



M2 420 MHz Yagi antenna with router

Range tests – Skyland Lodge to Massanutten Mountain

station power supply



18 aH battery, 75 W power inverter, Ubiquiti 48 V POE adapter

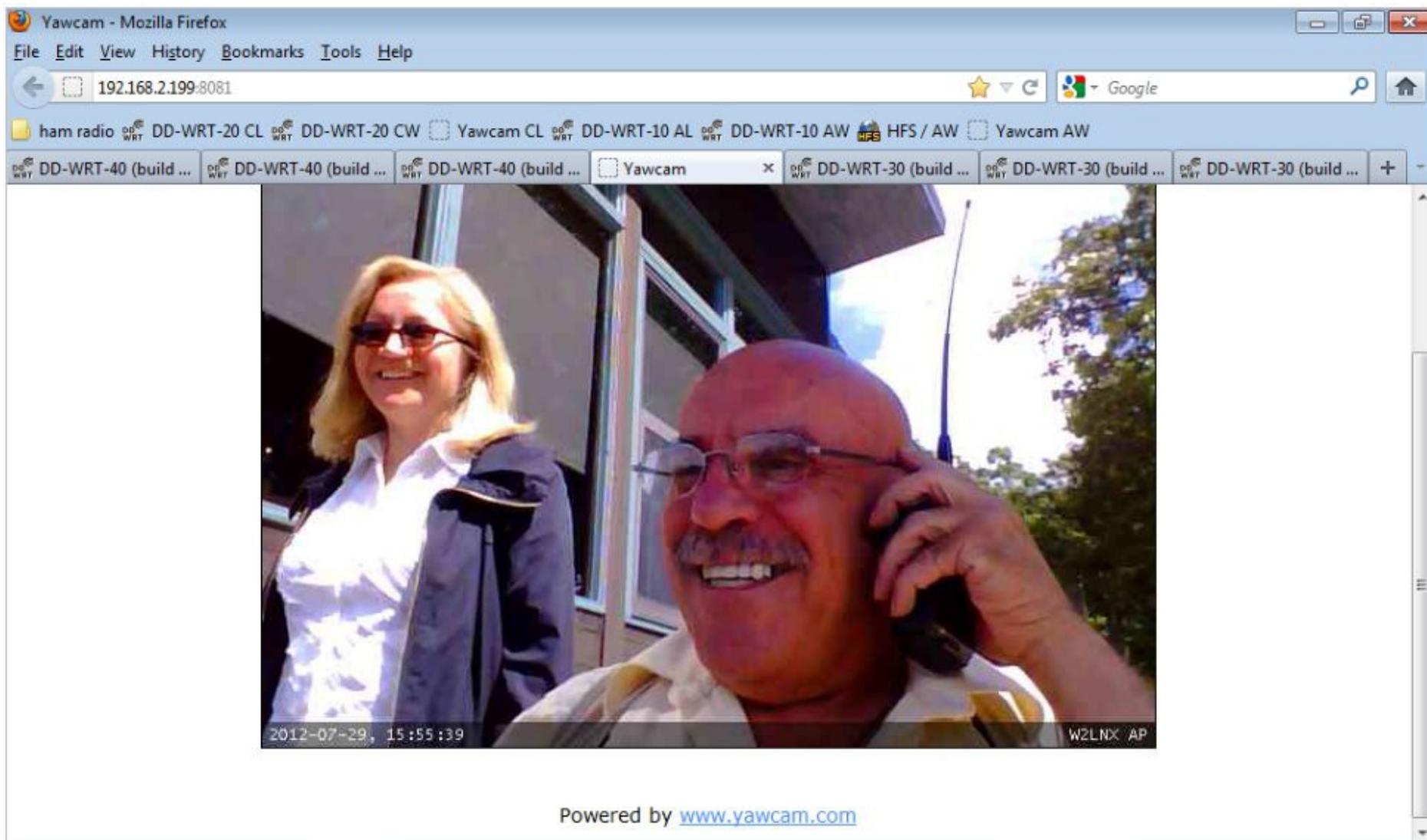
Range tests – Skyland Lodge to Massanutten Mountain



Aleks, W3JAG and Vic, WB2U on Skyland Lodge patio

Range tests – Skyland Lodge to Massanutten Mountain

at Massanutten Mountain:



Aleks, W3JAG and Vic, WB2U on Yawcam at Skyland Lodge

Range tests – Skyland Lodge to Massanutten Mountain

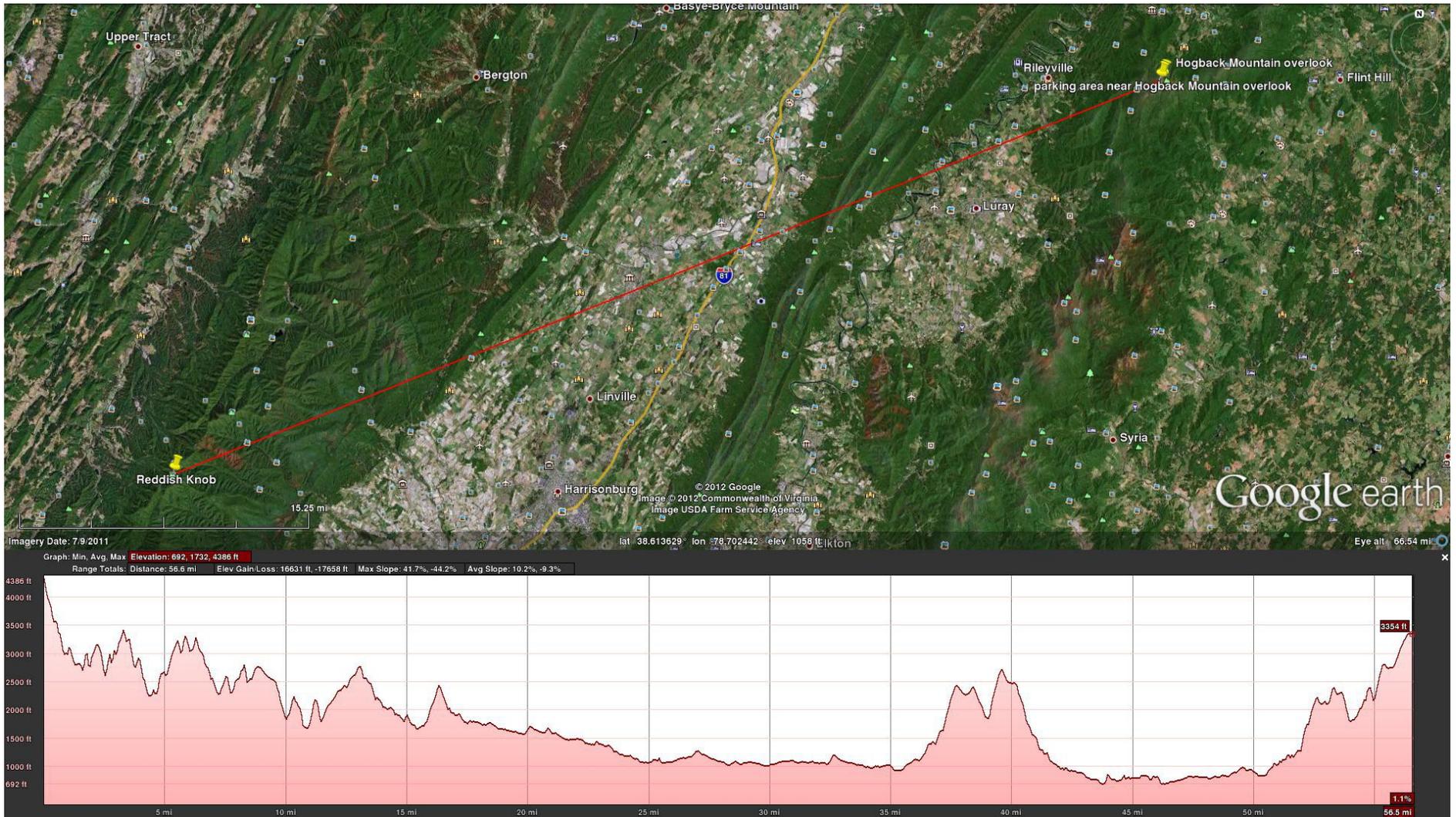
- 2012 July 10
 - Skyland Lodge patio: 3650 feet (1113 m)
 - Massanutten Mountain US 211: 1500 feet (457 m)
 - distance: 12.8 miles (20.6 km)
 - data radio: XC420M
 - antenna: M2 420-50-11 Yagi
 - signal quality: 32 %
 - bandwidth: 2.5 Mbit/s
 - file download: 296 Kbyte/s

Range tests – Skyland Lodge to Massanutten Mountain

- 2012 July 29
 - Skyland Lodge patio: 3650 feet (1113 m)
 - Massanutten Mountain US 211: 1800 feet (549 m)
 - distance: 13.2 miles (21.2 km)
 - data radio: DL435-30
 - antenna: M2 420-50-11 Yagi
 - signal quality: 35 %
 - bandwidth: 4.5 Mbit/s
 - file download: 400 Kbyte/s

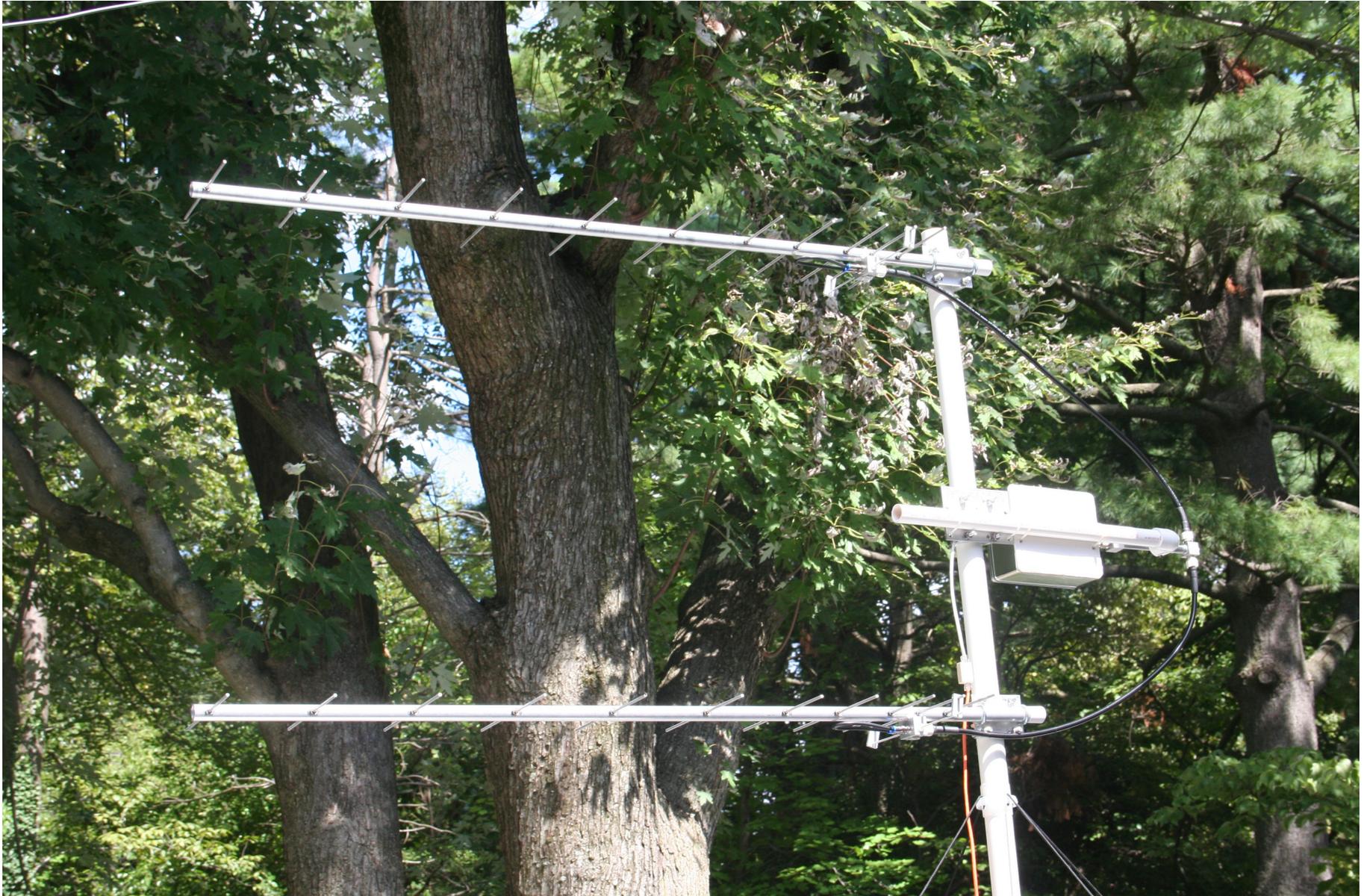
Range tests – Hogback Mountain to Reddish Knob

Elevation profile



Hogback Mountain overlook to Reddish Knob

Range tests – Hogback Mountain to Reddish Knob



stack Yagi antenna array with router

Range tests – Hogback Mountain to Reddish Knob



Eugene, KB3TZH on Hogback Mountain overlook (W3QX photo)

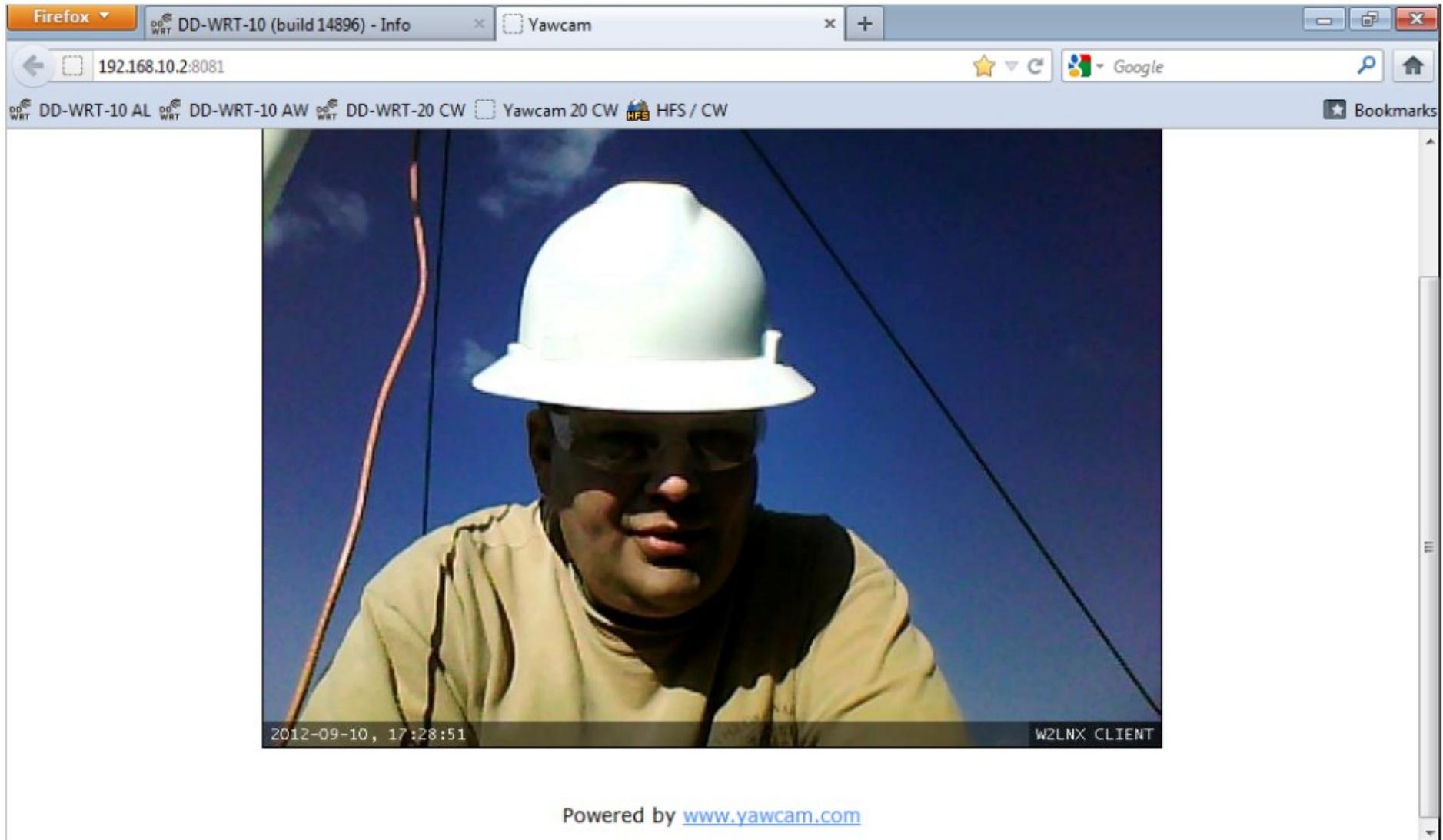
Range tests – Hogback Mountain to Reddish Knob



David, W2LNX on Reddish Knob (KB3CS photo)

Range tests – Hogback Mountain to Reddish Knob

at Reddish Knob:



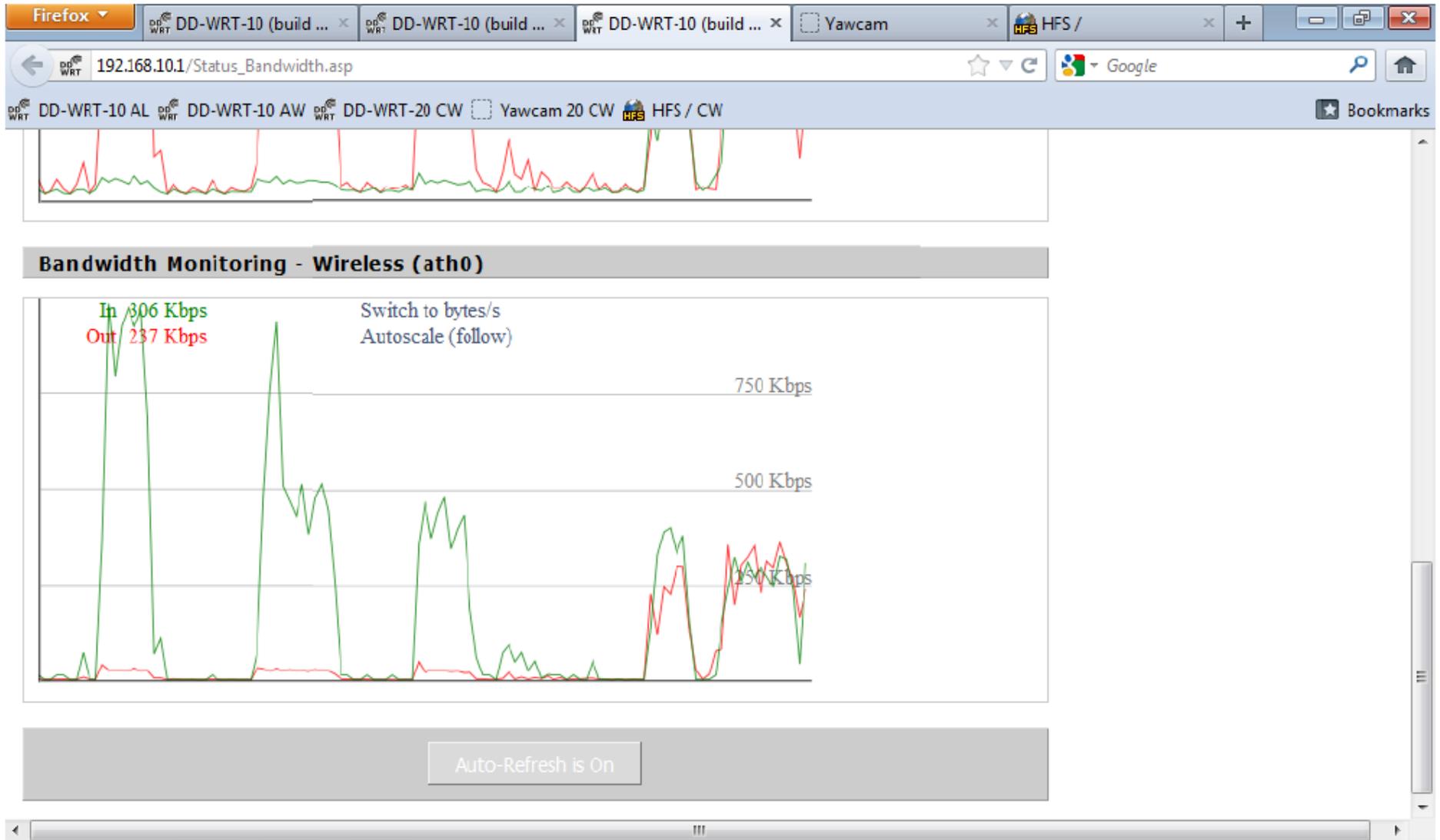
Eugene, KB3TZH on *Yawcam* at Hogback Mountain Overlook

Range tests – Hogback Mountain to Reddish Knob

- 2012 September 10
 - Hogback Mountain overlook: 3383 feet (1031 m)
 - Reddish Knob: 4396 feet (1339.9 m)
 - distance: 56.5 miles (90.9 km)
 - data radio: XC420M
 - antenna: M2 420-50-11 Yagi stacked array
 - signal quality: 28 %
 - bandwidth: 300 to 500 Kbit/s – choppy
 - file download: 50 Kbyte/s

Range tests – Hogback Mountain to Reddish Knob

needed to increase Sensitivity Range (ACK Timing)



access point bandwidth page in Reddish Knob (120 s)

Conclusions and recommendations

- both the Doodle Labs DL435-30 and Xagyl Communications XC420M data radios passed our acceptance test
 - 10 to 20 miles appears to be a practical distance
- DL435-30 is faster but XC420M is cheaper and is available in the U. S. and Canada
- succeeded in assembling system with COTS equipment
- needs line of sight
 - 420 MHz is more forgiving than 2.4 GHz

Continuing work

- continue our range tests
 - comparing DL435-30 and XC420M
- continue learning DD-WRT
 - what are optimum settings? for ACK timing?
- create network of three routers
 - wireless networking bridge
 - one omni-directional antenna or
 - two Yagi antennas in different directions
- internetwork with distant 2.4 GHz wireless LANs
 - HSMM-MESH™

Continuing work

- learn to stream digital video with UDP (no ACK)
 - be more DATV-like
- add VOIP and audio applications
- evaluate other COTS routers that run DD-WRT
 - Gateworks Avila GW2348-4
 - PC Engines alix2d13
 - Intel Atom motherboard with PCI to miniPCI adapter
- evaluate bi-directional linear broadband amplifiers in 420 to 432 MHz ATV sub-band

- improve county public safety backup communications

Optimizing Amateur Radio Resources for Major Disasters

How a single radio operator can provide emergency HF e-mail service to three hospital EOCs at once.

Victor Cid, W3CID, and Andrew Mitz, WA3LTJ

Hams have a long history of technical development for disaster preparedness. The National Library of Medicine (NLM), part of the National Institutes of Health (NIH), has tapped a technically savvy group of hams in the Washington, DC area to develop last resort e-mail communications for three area hospitals. This ambitious project has created a new approach to providing e-mail service to large groups of users during major disasters.

BHEPP — a Unique Partnership

The project began in Bethesda, Maryland where you will find three very different major hospitals across the street from one another. The Bethesda Hospitals' Emergency Preparedness Partnership (BHEPP) was cre-

ated at the National Institutes of Health Clinical Center (NIHCC), a world-famous research hospital, and the Suburban-Johns Hopkins Hospital, an acute care hospital with a regional trauma center. BHEPP is the first military-civilian-federal partnership in the US.¹ The Partnership received funding to conduct a series of research, development and infrastructure projects. The NLM, the world's largest medical library and a leading medical-informatics research facility, joined the partnership in 2008 and leads the implementation of the projects. After recruiting a team of ham and MARS radio experts, the project leaders set out to develop the BHEPP MARS/Winlink2000 Emergency Radio e-mail System (BMERS).

Could It Be Done?

operator with a single Winlink 2000 station provide emergency e-mail service to not just a fully staffed emergency operations center (EOC), but to three large EOCs at once? After many months of research and development, these hams found the answer and have a prototype system to prove it.

EmComm and HICS

As ARRL Emergency Preparedness Manager Mike Corey, W5MPC, will tell you, if you are going to provide emergency communications (EmComm) for an agency, you had better understand how that agency operates. Health facilities such as the BHEPP hospitals use the Hospital Incident Command System (HICS) to manage emergencies.² This system provides an organizational and

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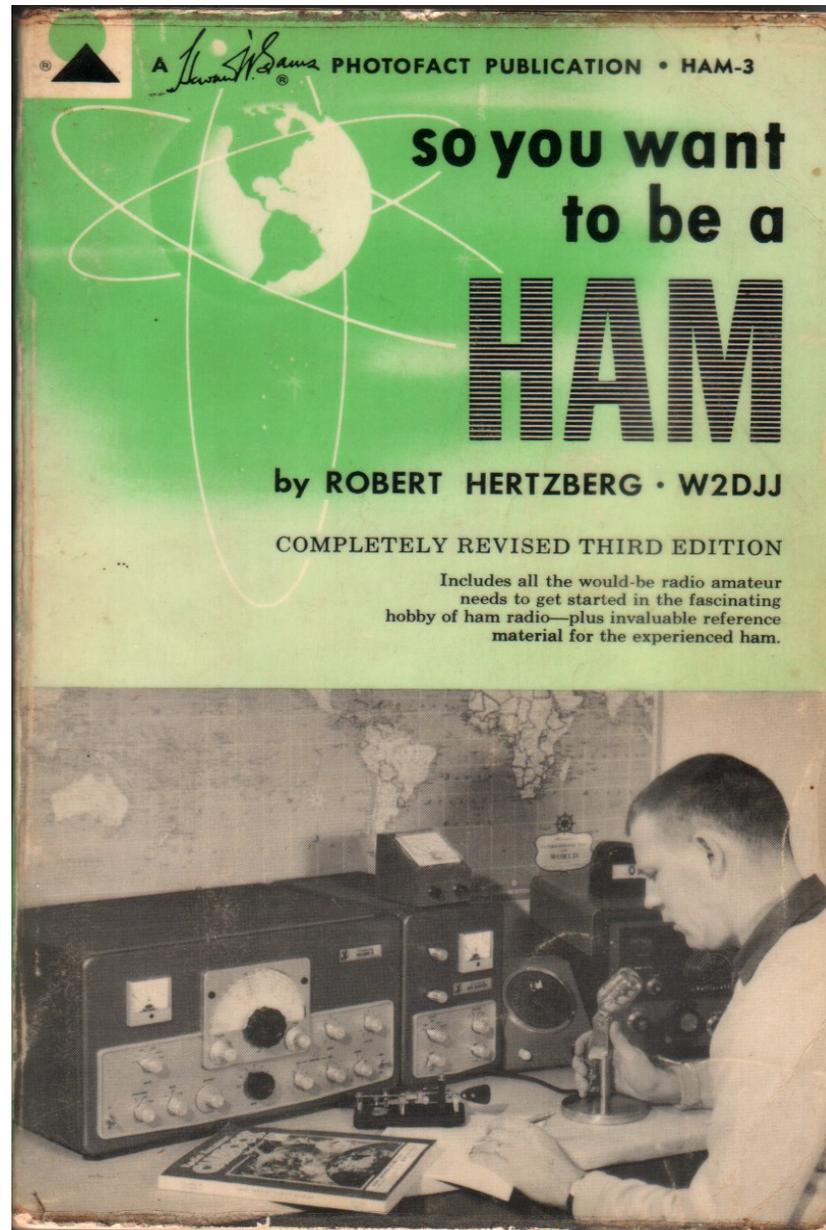
Acknowledgment

- members of Montgomery Amateur Radio Club
 - Aleks, W3JAG
 - Chris, KB3CS
 - Eugene, KB3TZH
 - Vic, WB2U
 - William, W3QX

- Shenandoah Valley
 - Jason, N4DSL

- many others...

Acknowledgment



I received this book when I was a child... Thank you!

Questions



demonstration in the play room