WarRocketing – Network Stumbling 50 sq. miles in < 60 sec.

Presented By: Rick Hill

Project Goals

- 802.11b Network Discovery: Wardriving, WarFlying, why not WarRocketing ???
- Objective: To dramatically increase Network Stumbling coverage by providing LOS to as large a land area as possible. (Wardriving limited by trees, houses, terrain, etc.) Our aerial platform, (the Rocket) does not have these limitations… Essentially, it provides LOS to ALL targets in the antenna pattern!

Project Concept

- Use High Powered Rocket as a boost platform for 802.11b A/P and/or Small Computer
- At Peak Altitude – Parachute Deploys
- Establish WDS link from Rocket A/P -> Launch Site A/P

Concept Cont'd

- Once Communication with Rocket established - Begin Net Stumbling
- Transmit Results to Ground Computer:
  - SSID, Channel, A/P type: b/g, WEP-y/n, Signal Strength
- Other Tests: On-Board IPAQ Computer with Ministumbler captures data independently.

Design Criteria

- Three Systems:
  - Launch Vehicle
  - In-Flight Electronics
  - Antenna System

Launch Vehicle

- Requirements:
  - Capable of Boosting 3 lb. Payload to an Altitude >= 1 mile
  - Large enough to Visually Track & Recover
  - Engine Thrust/Weight Ratio = Min. 5:1
  - Meet Tripoli Rocketry Association Technical & Safety Codes

FOR MORE INFO...

www.tripoli.org

The WiFi Rocket

Nike Smoke 1/3 Scale Model

Yes America – Size does matter ;-)

Nike Smoke History

- US Army Project (1945) to develop a LOS Anti-Aircraft Missile System
- Nike – “Goddess of Victory” Greek Myth.
- Nike Smoke – Used by NASA 1950’s & 60’s for Atmospheric Research.
- Prominent Feature – Dense Smoke Trail

Our Rocket Spec’s

- Design Altitude – 7800 ‘
- Liftoff Weight – 18 lbs.
- Motor – Ellis Mountain L330 Max Thrust = 95 lbs, 8.9 sec Burn Time
- 12” x 5.5” Payload Section

FOR MORE INFO…

www.thrustcurve.org

Electronics

- Requirements:
  - High Power 802.11b A/P or Computer + Card
  - Small & Light Weight: Size < 12”x5.5” Weight < 3 lbs.
  - Low Power Consumption: 12-18 VDC (100 mA)
  - Capable of withstanding 10G’s

Electronics Cont'd

- Possibilities:
  - HP iPaq Handheld: Meets size & weight criteria, but Expensive. $300+ (requires PCMCIA card & external antenna jack.)
  - Dell, Motion Computing Tablet PC: Very Expensive, $2000+ (disk drives & display will not survive 10 G's)
  - Laptops: Forgetaboutit !
  - Various A/P's

The Winning A/P

Deliberant DLB2300 802.11 b/g
High Power A/P

Deliberant 2300 Spec's

- Supports 802.11b/g
- Output Power: 250mW(b) 100mW(g)
- Size & Weight: 5"x7", 12 oz.
- Zinwell Radio: RealTek 8186 Chipset
- Advanced Features: WDS (up to 6 A/Ps), Web Managed User Interface, Site Survey, Link Status, SNMP, Encryption - WPA(TKIP), WPA2(AES)

FOR MORE INFO...

www.deliberant.com

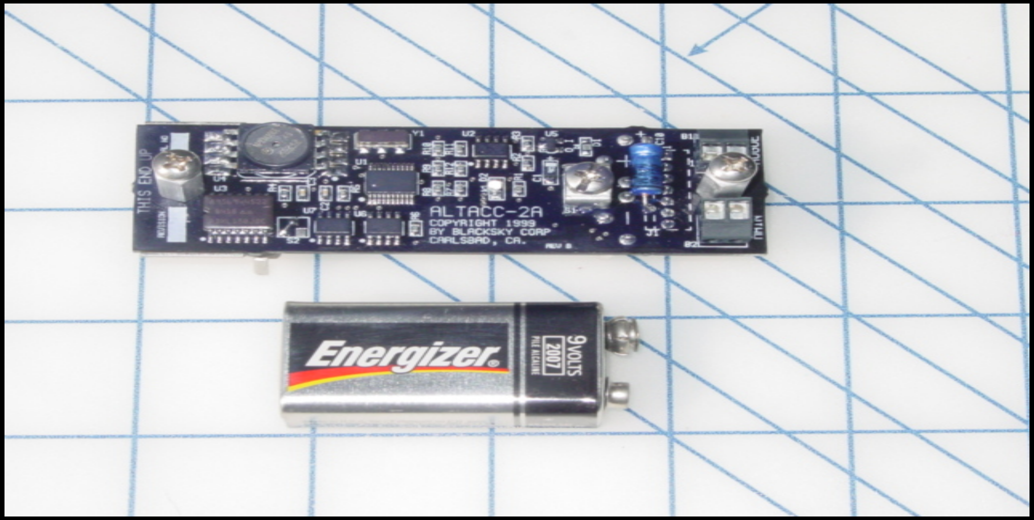
The On-Board Computer

iPAQ 3950 with Orinoco Gold PCMCIA Card

(Blackwave's Stumbling Rig)

ALTACC Accelerometer/ Altimeter

- Nothing to do with 802.11b…
- Saves Max Altitude, Speed, & Acceleration in G’s for post-flight analysis.

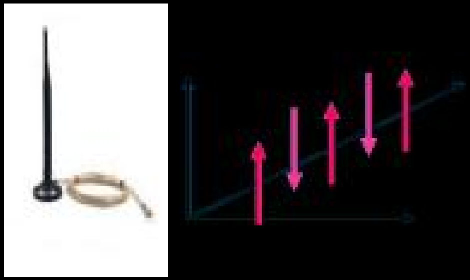


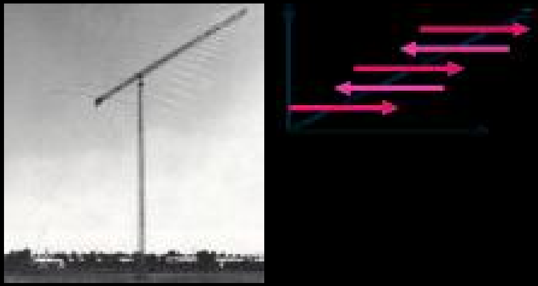
Antenna System

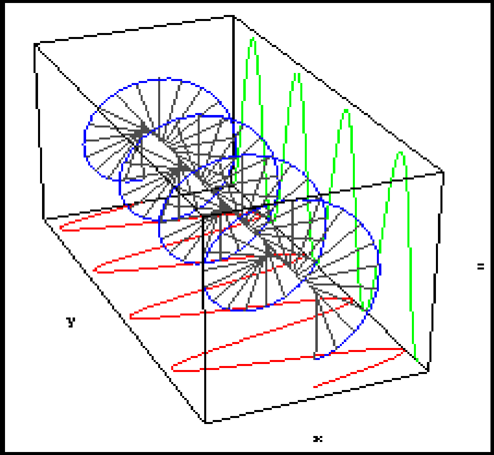
- Requirements:
  - FCC Part 15: Antenna <= 12 dBm PtMP (keeping it legal here -> Just never mind that Rocket flying over your house!)
  - Size < 12”x5.5”   Weight < 1.5 lbs.
  - Radiation Pattern: Crucial for WarRocketing
    - (a) Maximize Land Coverage
    - (b) Minimize Sky Coverage (No A/P’s there)
    - (c) As many dBm consistent with a&b
    - (d) Circular Polarization – Moving Targets

Antenna – Circular Polarization

- A Circularly Polarized antenna will be used for the main Ground -> WDS Rocket Link.


VPOL

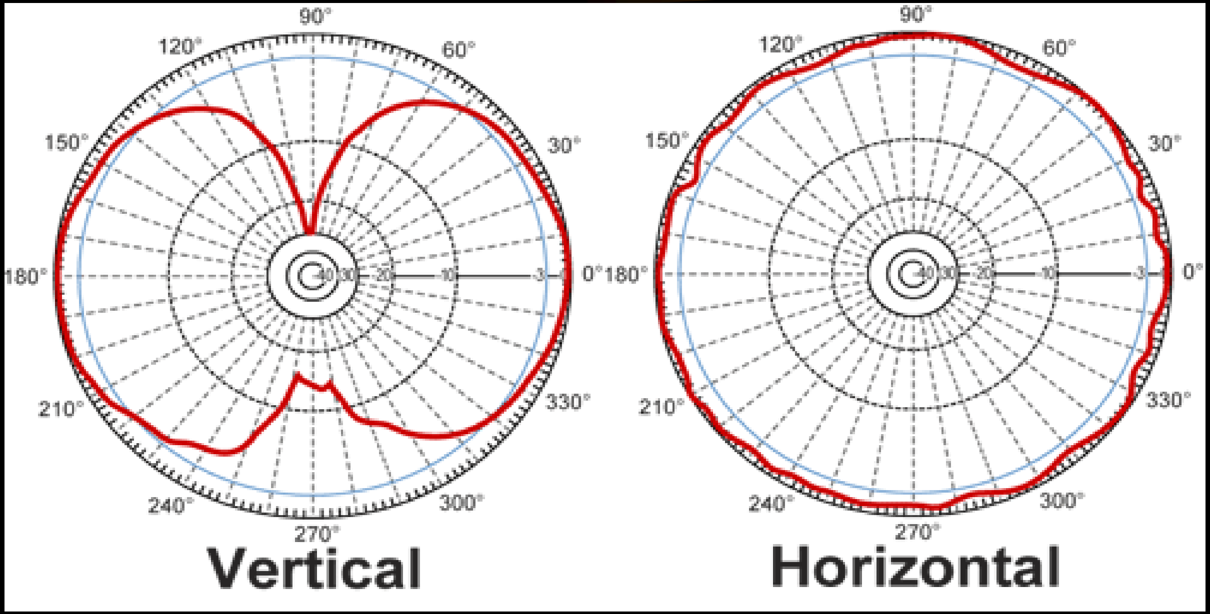

HPOL


CPOL

- CPOL maximizes the signal capture from moving objects (Rocket). Commonly used for Satellite Communications.

Rocket Antenna - iPAQ

HPOL – 3 db

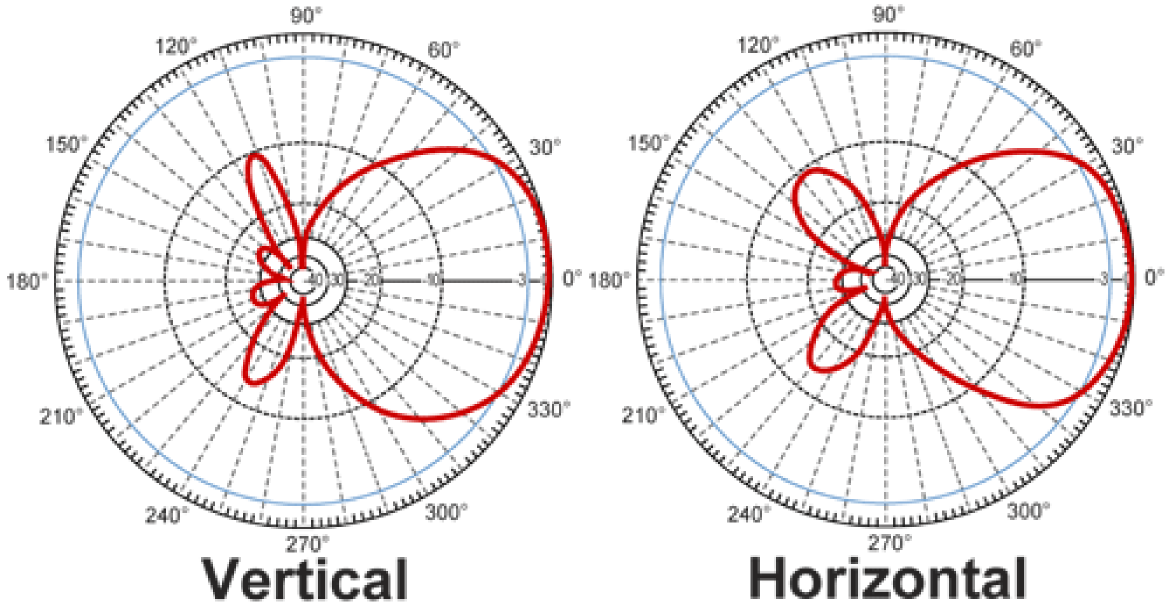


FOR MORE INFO...

www.hyperlinktech.com

Ground Station & Deliberant Rocket Antenna

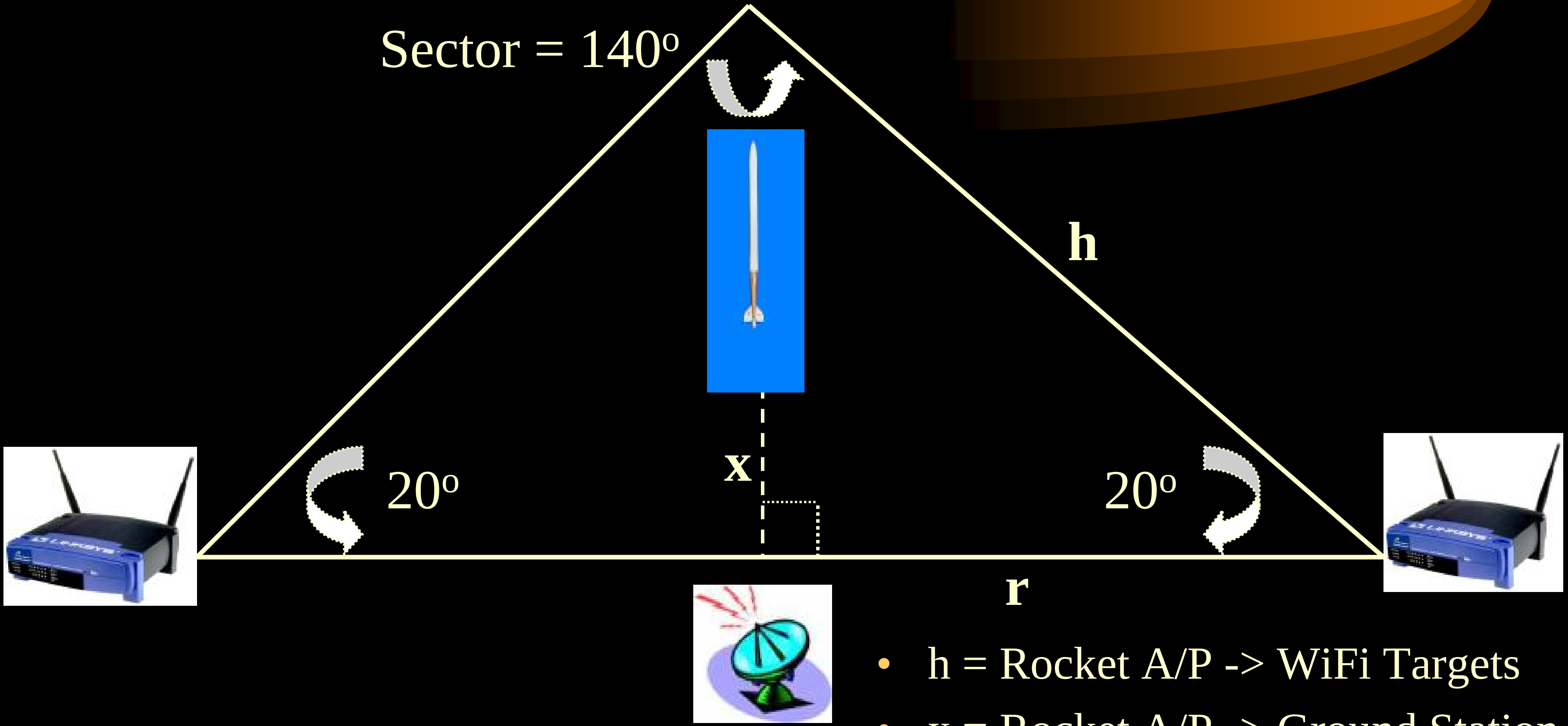
Circular POL – 8 db



FOR MORE INFO...

www.hyperlinktech.com

Antenna Coverage



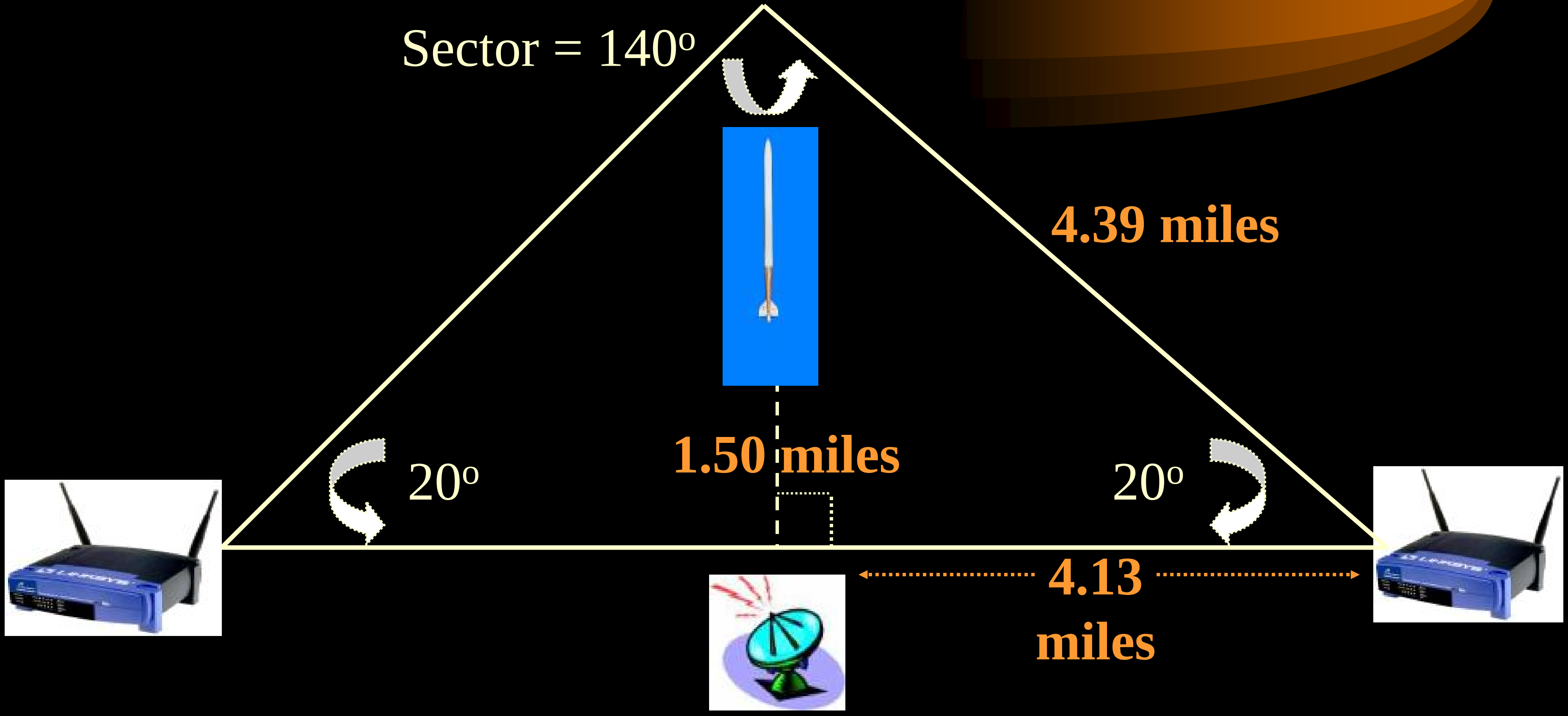
- h = Rocket A/P -> WiFi Targets
- x = Rocket A/P -> Ground Station
- r = Antenna Coverage Radius

Antenna Coverage cont'd

- Now, the higher Math…
  - Sin(20.0) = 1.5 / h — h = 4.39 miles
  - Cos(20.0) = r / 4.39 — r = 4.13 miles
  - x = est. Altitude — x = 1.50 miles

- $A = pi * r^2$ $A = (3.14)(4.13)^2$ A = 53.6 sq.miles

Antenna Coverage cont’d

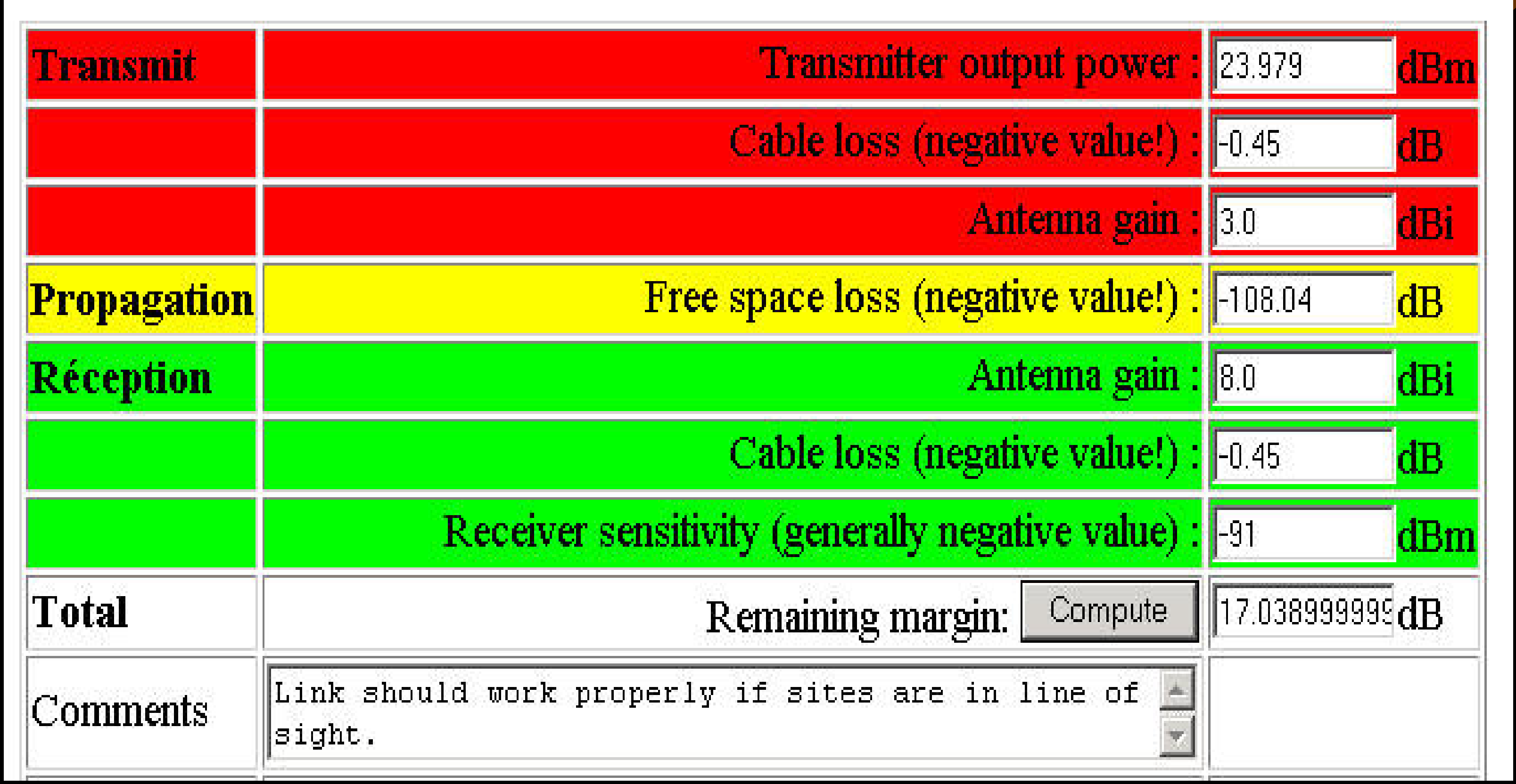


A= 53.6 sq. miles

Link Budget

- Now that we’ve determined the Coverage Area, is the 802.11b link feasible?
- “Link Budget”
  - Calculation where all technical factors associated with the uplink, transponder, & downlink are analyzed to insure communication is feasible. Additionally, a loss margin (dB) is usually built-in to assure a definitive link under adverse conditions, (noise, > distance, rain, etc.)

Link Budget: Rocket A/P -> Ground

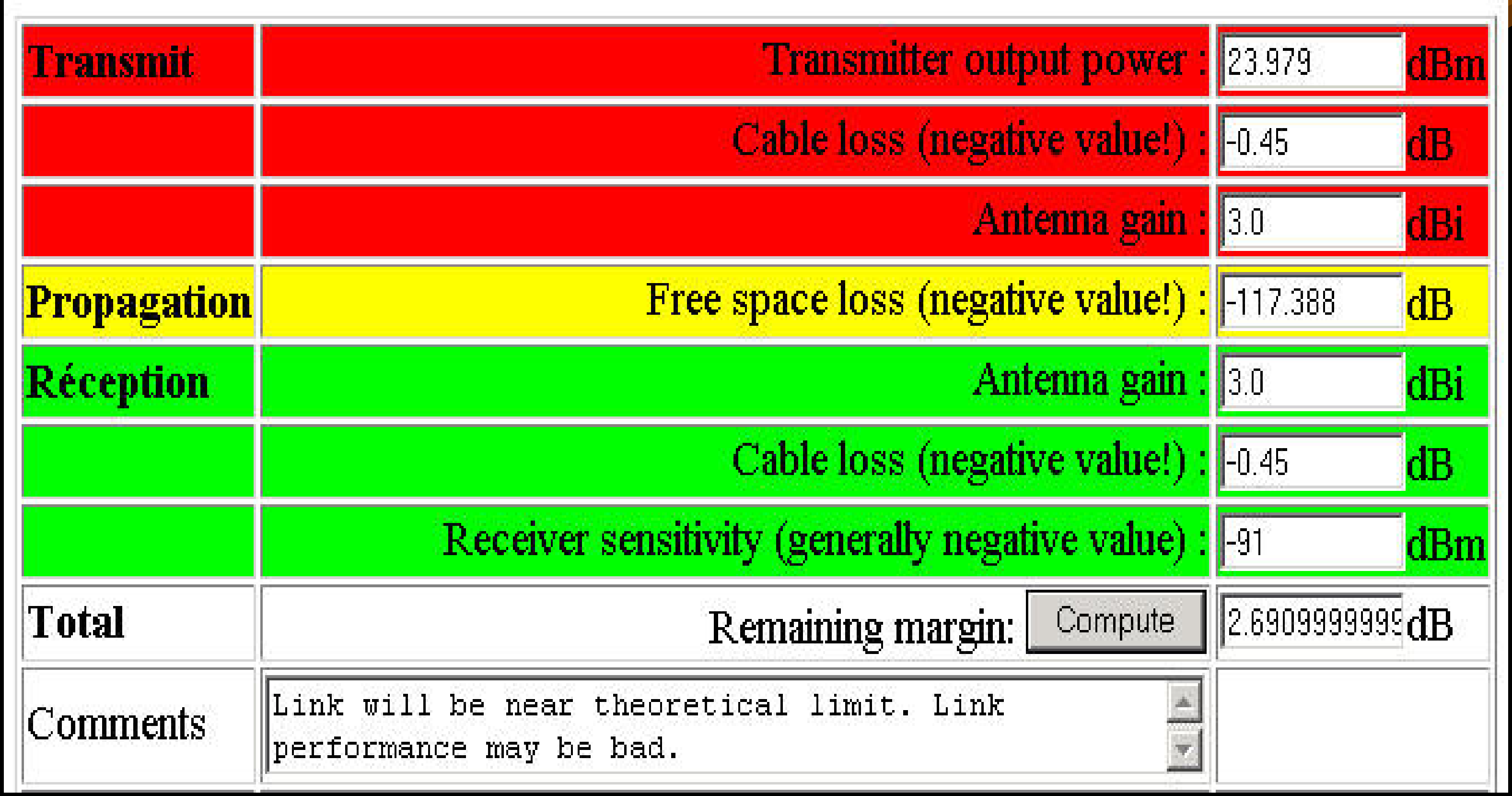


Transmit	Transmitter output power :	23.979	dBm
	Cable loss (negative value!) :	-0.45	dB
	Antenna gain :	3.0	dBi
Propagation	Free space loss (negative value!) :	-108.04	dB
Réception	Antenna gain :	8.0	dBi
	Cable loss (negative value!) :	-0.45	dB
	Receiver sensitivity (generally negative value) :	-91	dBm
Total	Remaining margin: Compute	17.03899999	dB
Comments	Link should work properly if sites are in line of sight.		

www.swisswireless.org

- Note +5 dB is recommended margin.

Budget: Rocket A/P -> WiFi Targets



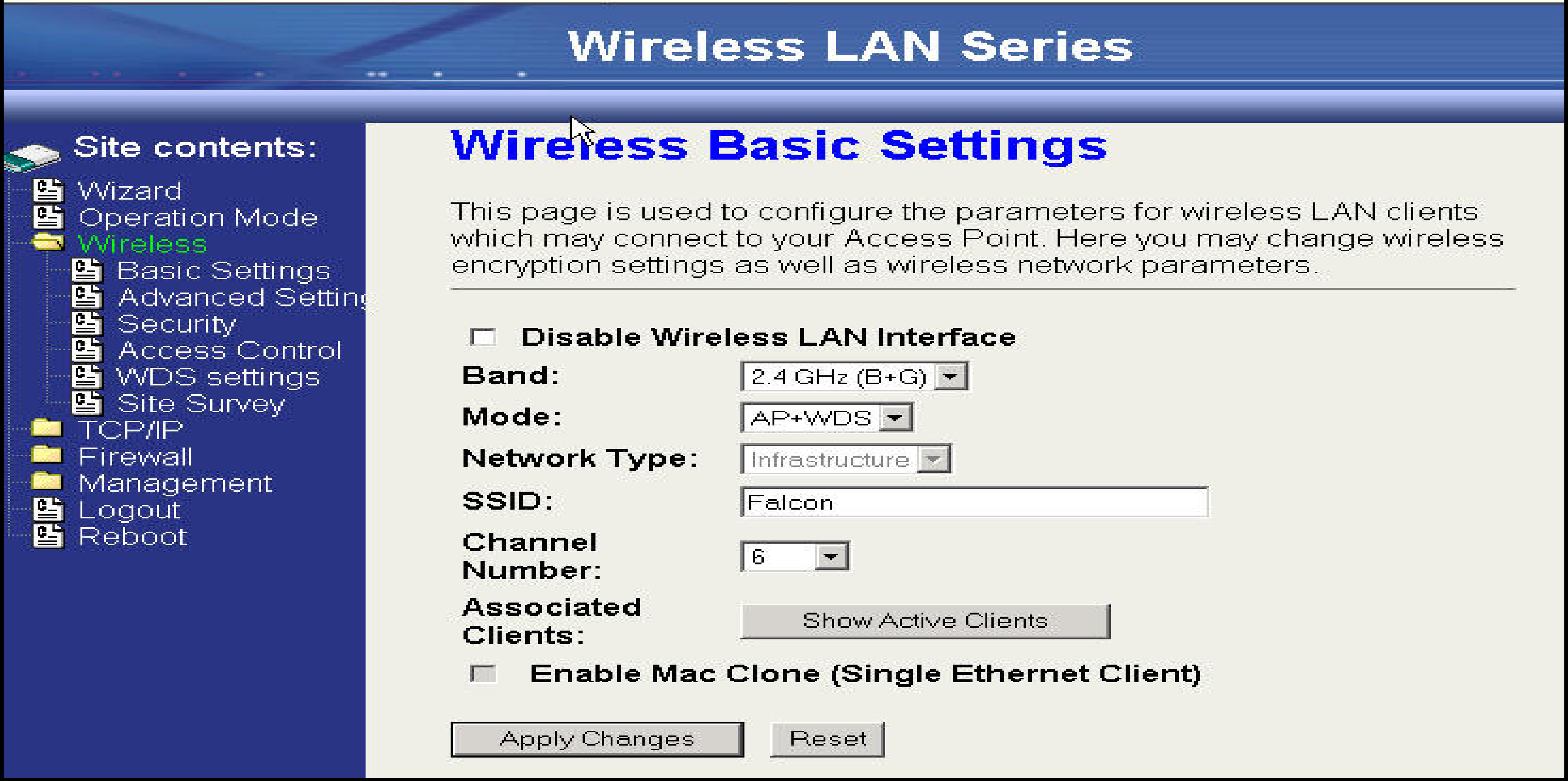
Transmit	Transmitter output power :	23.979	dBm
	Cable loss (negative value!) :	-0.45	dB
	Antenna gain :	3.0	dBi
Propagation	Free space loss (negative value!) :	-117.388	dB
Réception	Antenna gain :	3.0	dBi
	Cable loss (negative value!) :	-0.45	dB
	Receiver sensitivity (generally negative value) :	-91	dBm
Total	Remaining margin: Compute	2.6909999999	dB
Comments	Link will be near theoretical limit. Link performance may be bad.		

- Note +5 dB is recommended margin.

WarRocketing Software

- Deliberant 2300 Web Browser Xface, v1.2.4
  - Site Survey, WDS, Connecting to Prey, A/P config.
- HyperSnap 6, v6.03.01
  - Screen Capture
- Netstumbler v0.4.0
  - Stumbling: Ground-based Windows Laptop
- MiniStumbler v0.4.0
  - Stumbling: Rocket-based iPAQ

A/P Setup



Wireless LAN Series

Wireless Basic Settings

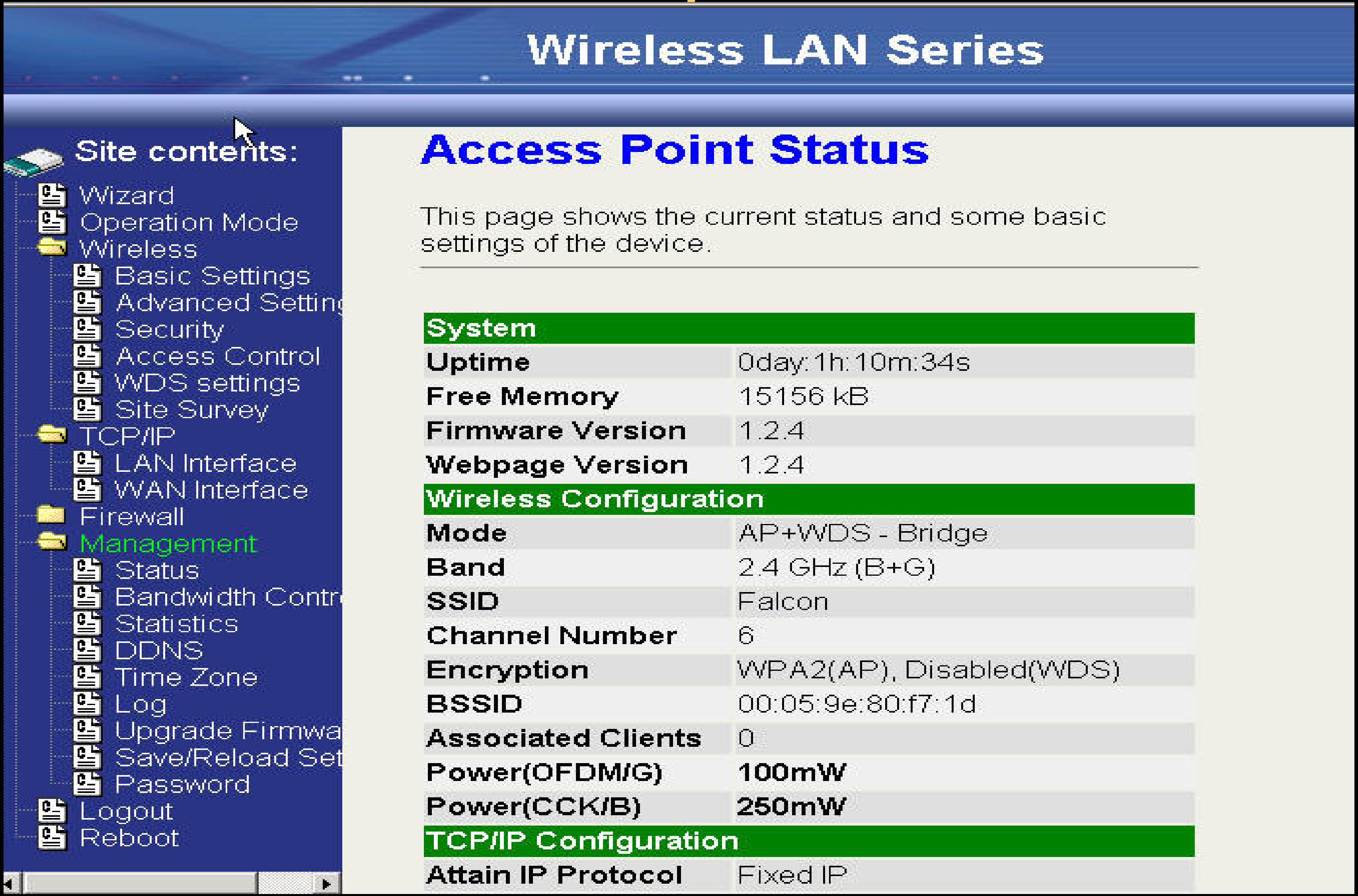
This page is used to configure the parameters for wireless LAN clients which may connect to your Access Point. Here you may change wireless encryption settings as well as wireless network parameters.

☐ **Disable Wireless LAN Interface**

Band:	2.4 GHz (B+G)
Mode:	AP+WDS
Network Type:	Infrastructure
SSID:	Falcon
Channel Number:	6
Associated Clients:	Show Active Clients

☐ **Enable Mac Clone (Single Ethernet Client)**

A/P Setup cont'd

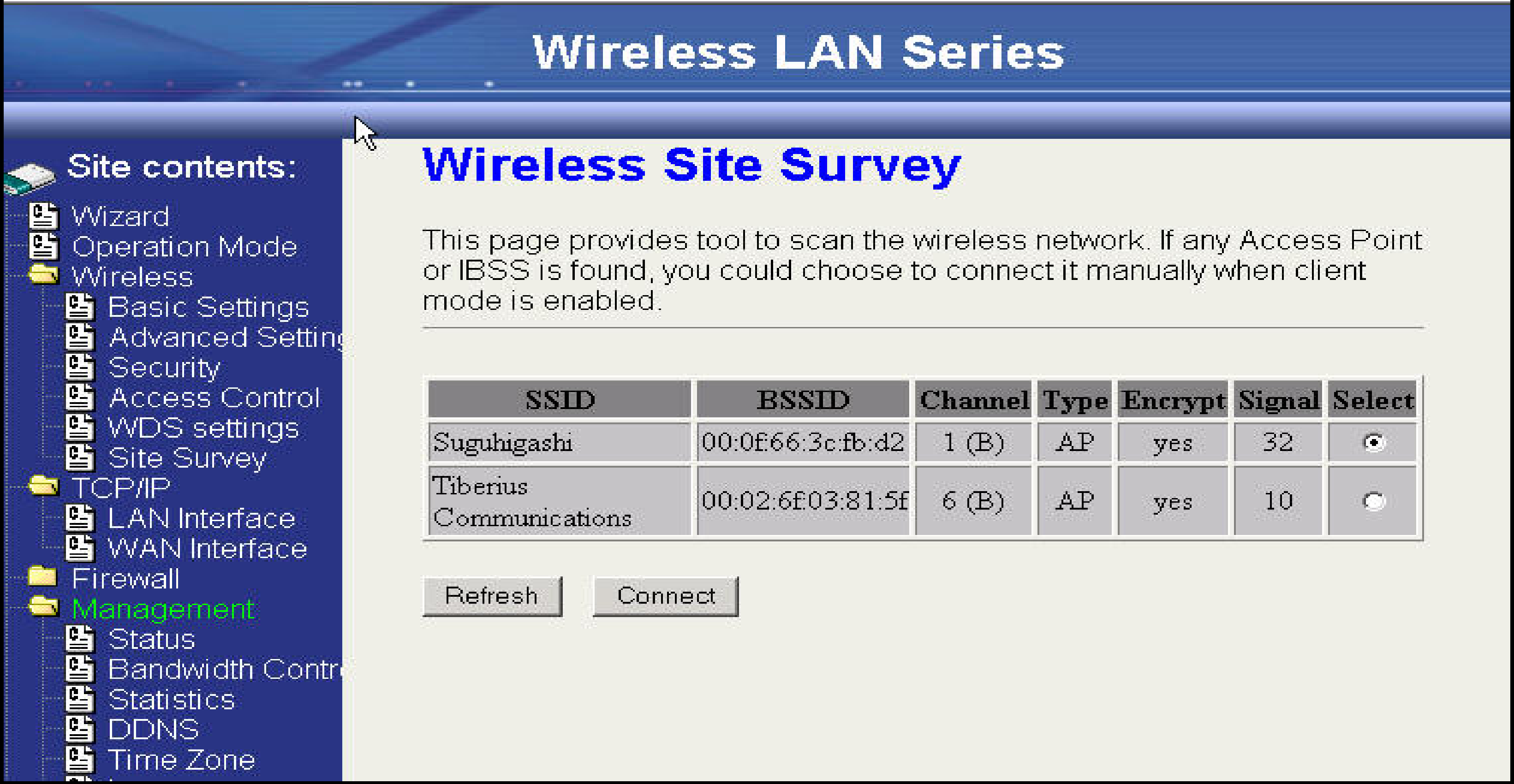


Access Point Status

This page shows the current status and some basic settings of the device.

System	
Uptime	0day:1h:10m:34s
Free Memory	15156 kB
Firmware Version	1.2.4
Webpage Version	1.2.4
Wireless Configuration	
Mode	AP+WDS - Bridge
Band	2.4 GHz (B+G)
SSID	Falcon
Channel Number	6
Encryption	WPA2(AP), Disabled(WDS)
BSSID	00:05:9e:80:f7:1d
Associated Clients	0
Power(OFDM/G)	**100mW**
Power(CCK/B)	**250mW**
TCP/IP Configuration	
Attain IP Protocol	Fixed IP

Network Stumbling



Wireless Site Survey

This page provides tool to scan the wireless network. If any Access Point or IBSS is found, you could choose to connect it manually when client mode is enabled.

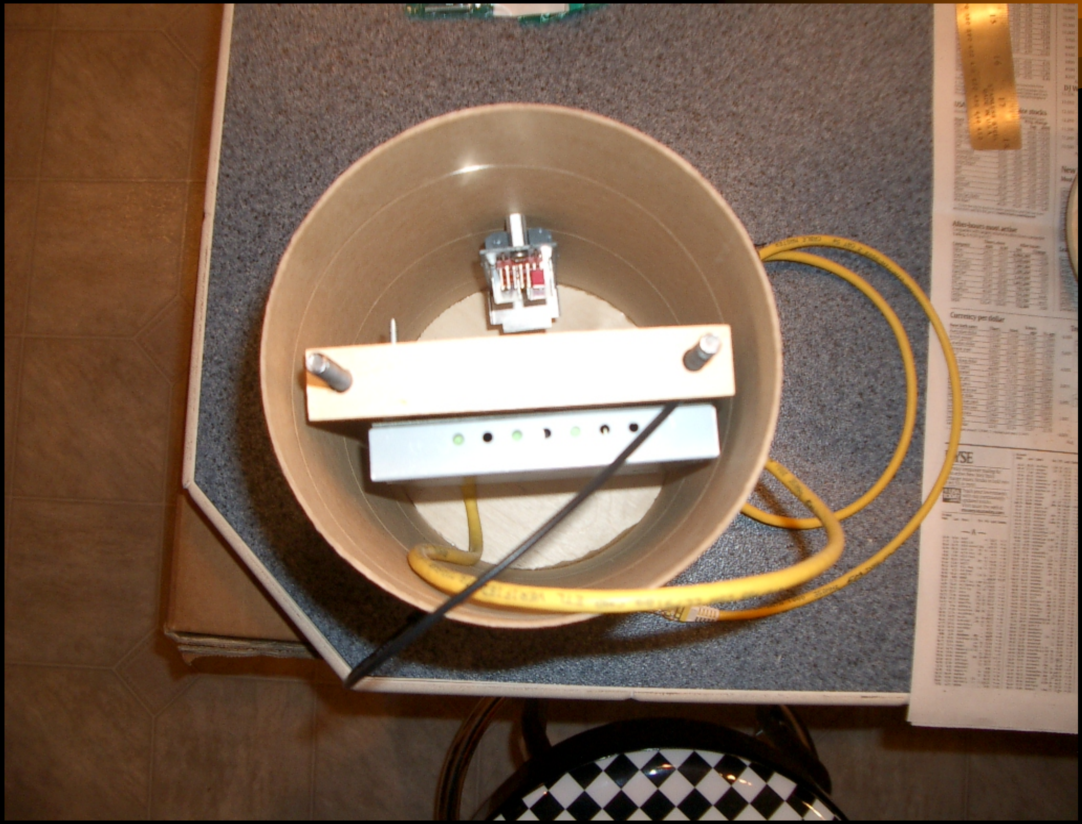
SSID	BSSID	Channel	Type	Encrypt	Signal	Select
Suguhigashi	00:0f:66:3c:fb:d2	1 (B)	AP	yes	32	●
Tiberius Communications	00:02:6f:03:81:5f	6 (B)	AP	yes	10	○

Stumbling Plan

- @ Max Altitude (APOGEE) – the Rocket Parachute deploys, Antennas are now in the proper spatial position in the hanging Nose Cone, (pointing down.)
- Descent Rate = 20 ft./sec
- Assuming Altitude of 7800 ft: 7800/20 = 360 sec. gives us 6.5 minutes of Stumbling Time
- # of Targets Decrease with Decreasing Altitude !

Rocket Construction

- Electronics:

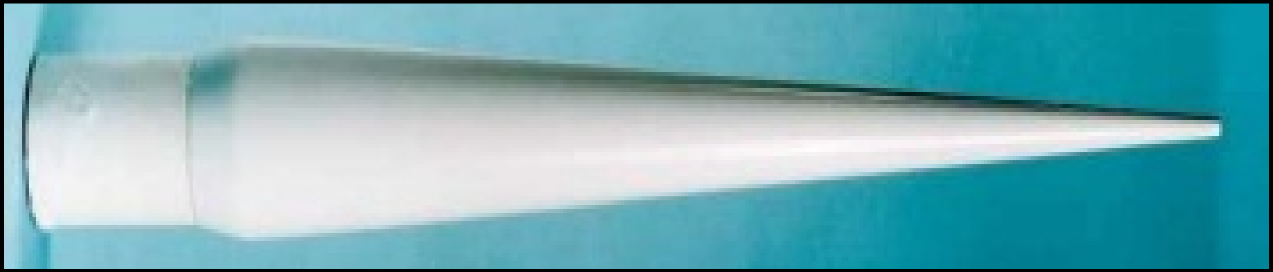


Rocket Construction cont'd

Engine Mount

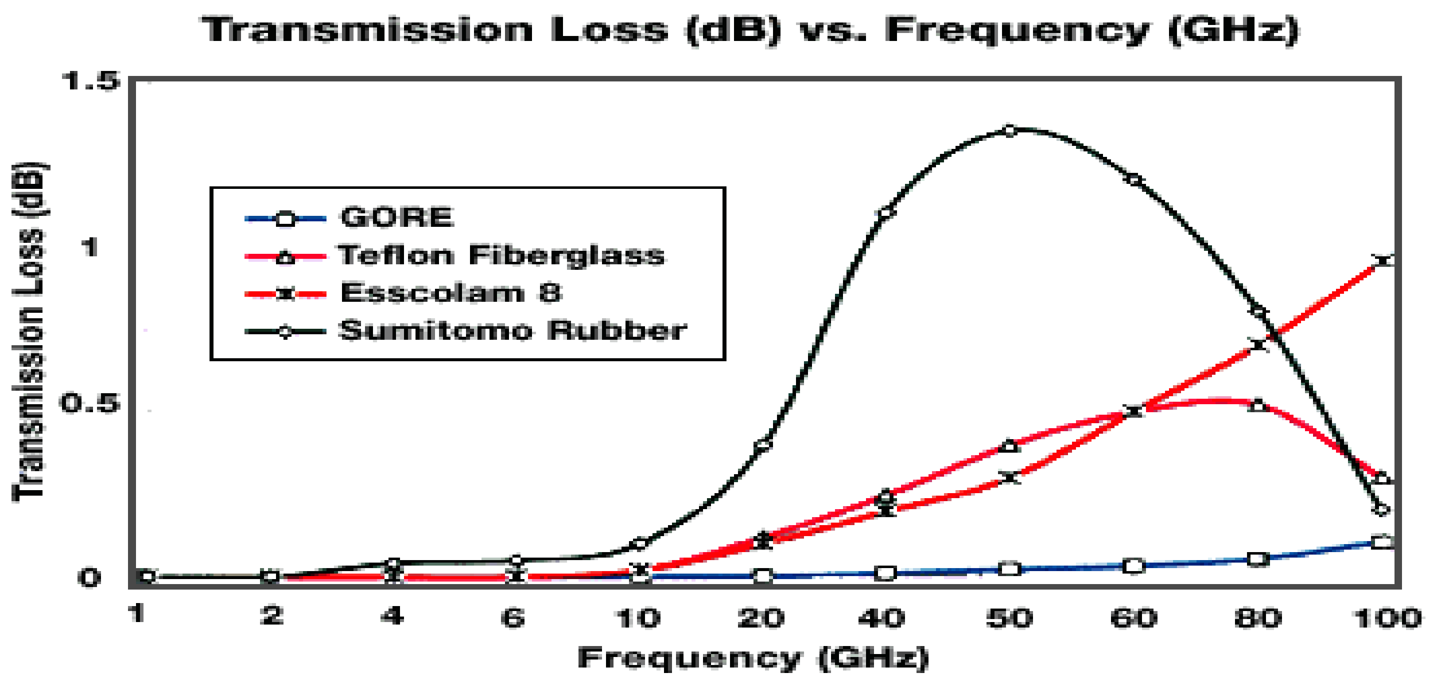
Rocket Construction cont'd

- Nose Cone functions as Antenna Radome:



Rocket Construction cont'd

- Nose Cone Transmission Loss:



FOR MORE INFO…

www.gore.com

Rocket Construction cont'd

- Finished Nike Smoke:

Stumbling Rocket #2

- After purchase of the iPAQ, it was decided to also add a 2nd smaller Backup Rocket to our arsenal for WarRocketing Use – PML Patriot (previously built.)
- Advantages:
  - Patriot capable of lofting the iPAQ to 2000 ft.
  - Can be launched in much smaller fields &
  - More Densely Populated Areas
- Enabled 3 Launch Sites: Culpeper, VA – Centerville, MD & Charlottesville, VA

Rocket #2 “Patriot”

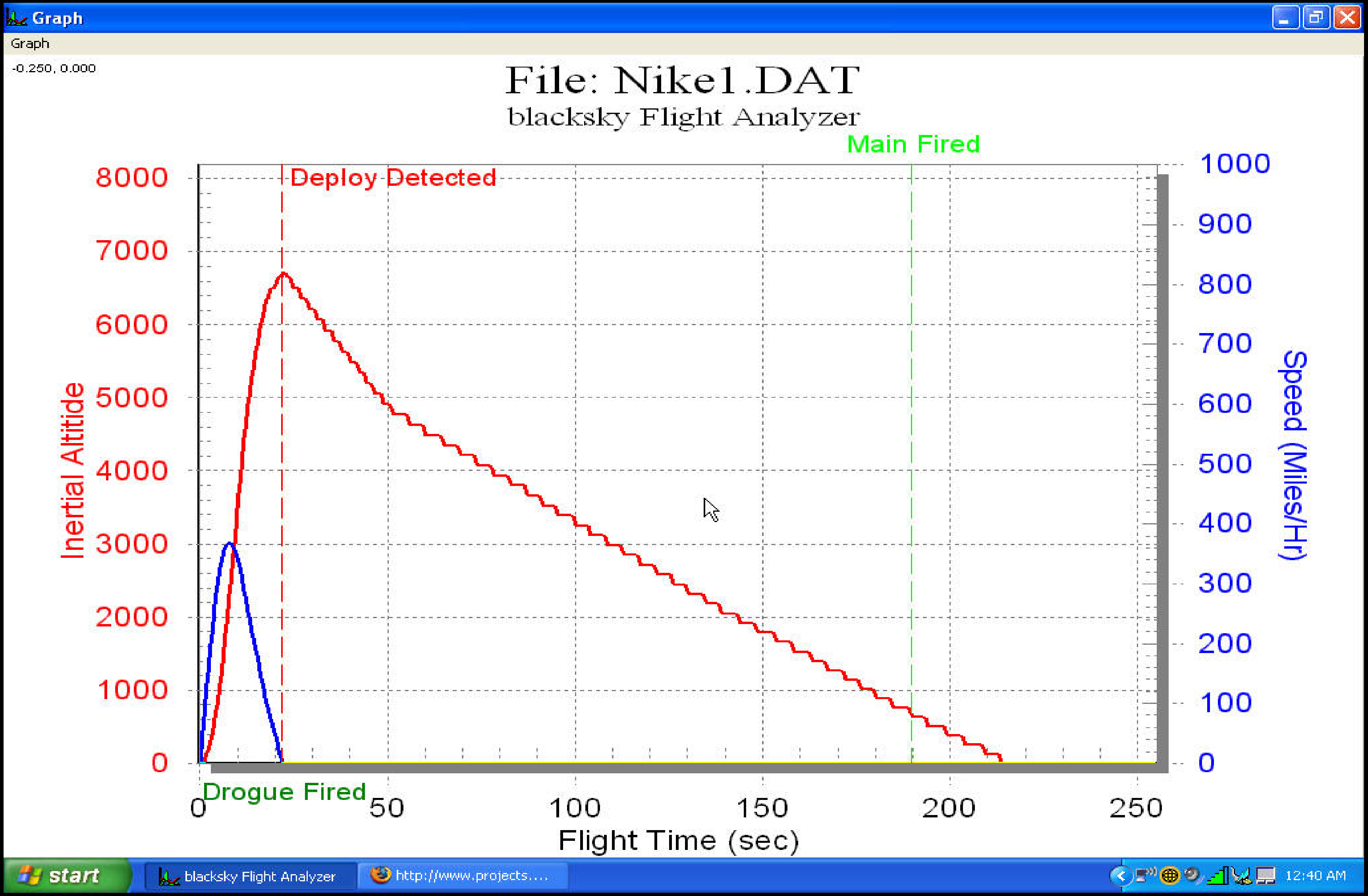
Nike Smoke Launch

- Following is a ~ 5 min.Video & Slide Presentation of the Nike Smoke “WiFi” Rocket Launch
- Rocket Payload: (1) Deliberant A/P & (1) iPAQ 3975
- Culpeper, VA - July 24,2006
- Level 2 Cert. Attempt (Tripoli)

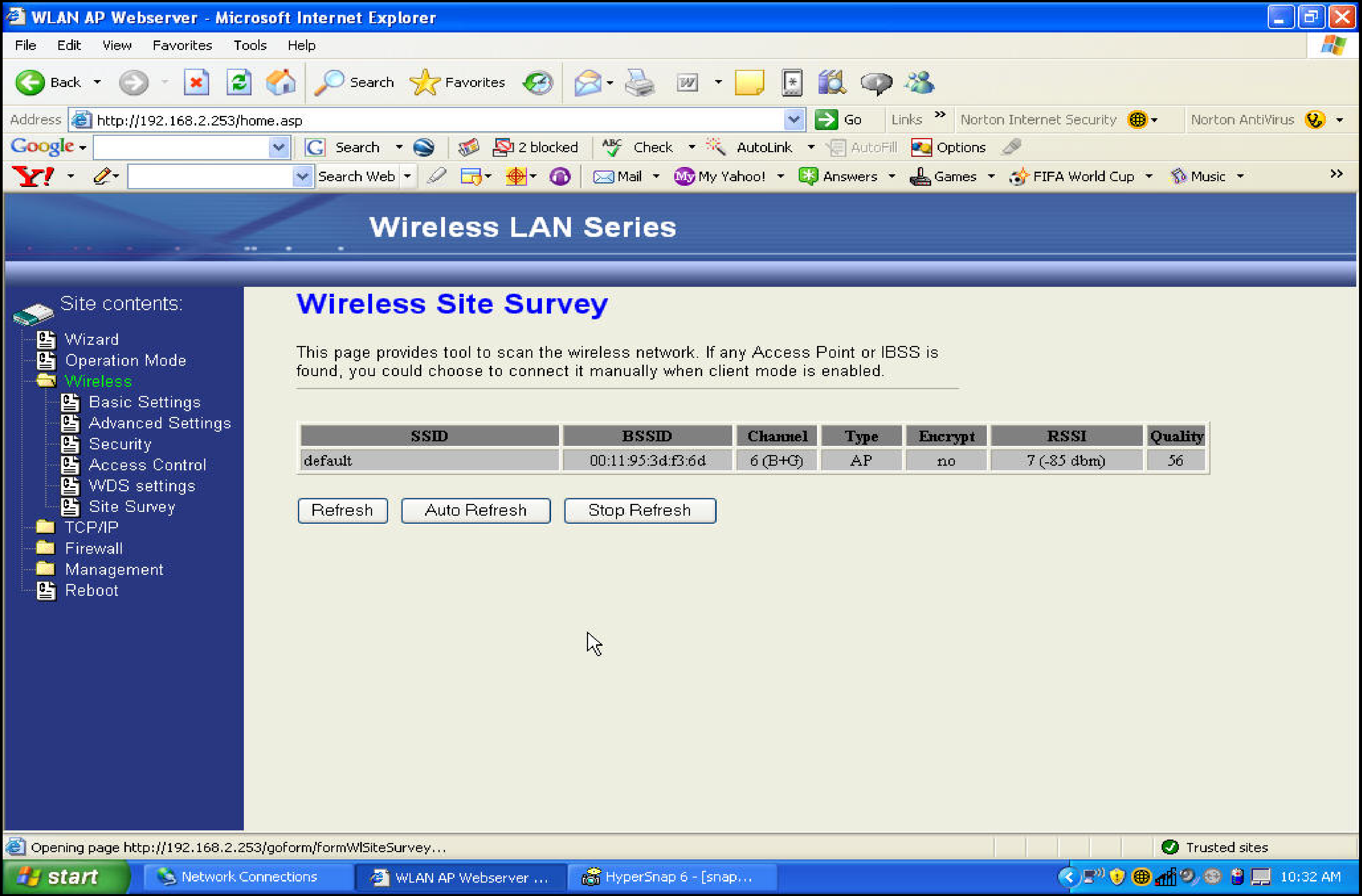
Two Additional Launches @ MD & VA Sites

- Centerville, MD – Central Sod Farm launch took place July 18, 2006. The launch vehicle was the smaller Patriot Rocket. Payload: (1) iPAQ + Orinoco Gold Card & Antenna.
- Charlottesville, VA – Launch just north-east of the city on July 26, 2006. Again, the payload consisted of the iPAQ stumbling gear.

Accelerometer Results



Stumbling Results - Culpeper



Address: http://192.168.2.253/home.asp

Wireless LAN Series

Wireless Site Survey

This page provides tool to scan the wireless network. If any Access Point or IBSS is found, you could choose to connect it manually when client mode is enabled.

SSID	BSSID	Channel	Type	Encrypt	RSSI	Quality
default	00:11:95:3d:f3:6d	6 (B+G)	AP	no	7 (-85 dbm)	56

Opening page http://192.168.2.253/goform/formWlSiteSurvey...

Stumbling Results – All Sites

- Culpeper, VA – Nike Launch
- Maryland Sod Farm – Patriot
- Charlottesville, VA - Patriot

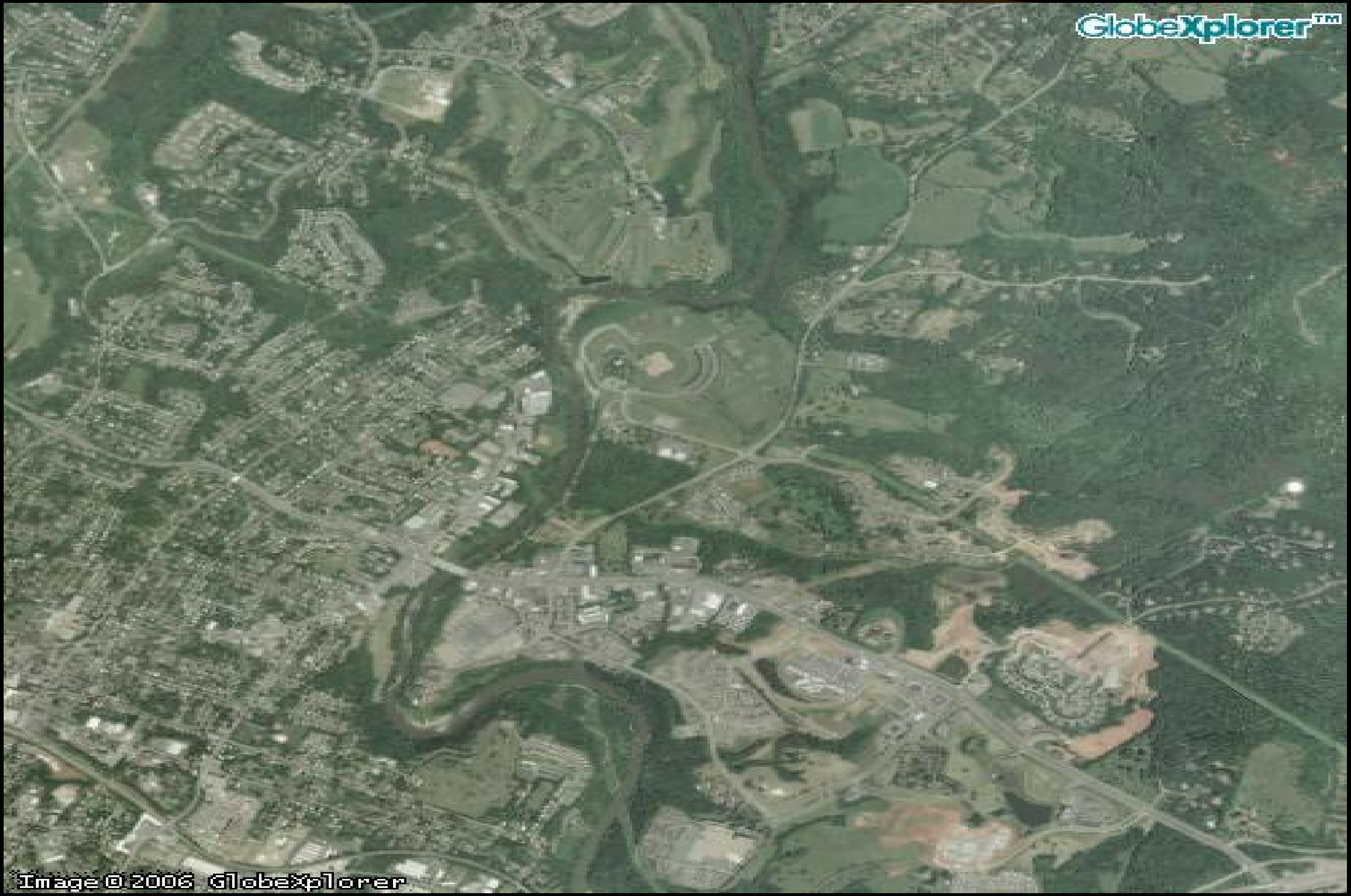
Stumbling Results – All Sites

Site	**# AP's**	**Altitude 1st Detect**	**# AP's Gnd Lvl**	**% Encrypt**
Culpeper	2	2000, 6800 ft	0	0
Maryland	3	2000 ft	0	0
Charlottesville	7	200 ft	2	86%

Culpeper, VA Launch Site

MD Sod Farm Launch

Charlottesville, VA Launch Site



Conclusions

- Wireless A/P’s scarce in Rural America (most fed by VSAT’s)
- WarRockets picked up AP’s in the 50 sq. mile circle at two remote MD and VA sites
  - None of these AP’s were visible to Stumbling gear on the ground.

Pro's & Con's

- Limits of WarRocketing:
  - Expensive: Propellant costs $35- $200 / Launch
  - Parachute Time: Limits Stumbling Time to Recovery Drift Time
  - Electronics Size & Weight: Ultimately, bigger Rockets are needed for more sophisticated equipment to perform Stumbling
- Advantage: Large Areas can be Stumbled from the sky in a matter of seconds
- Its just cool!

Lessons Learned

- Laptops & Sunshine do NOT Mix.
- Rockets without Parachutes on (Ballistic) trajectories are dangerous to your health
- If it can fail – it will.
- Shooting Rockets is a lot like gambling in Vegas - Don’t launch anything you’re not prepared to loose.
- Once you push the Launch Button -> “You’re DONE”

Web Sites

- tripoli.org - Tripoli Rocketry Association
- polecataerospace.com - Nike Smoke
- pro38.com - Cesaroni Rocket Motors
- deliberant.com - High Power A/P’s
- hyperlinktech.com - 2.4 Ghz Antennas
- swisswireless.org - Link Budget Calculator
- gore.com - Radomes & Microwave Fabrics

Thanks

Thanks to Everyone who made it happen! -> flying the Wifi Rocket:

- Dave Cantrell – Ground Computers, Video
- Mike Showalter & Ben Russell – Tripoli Rocketry Assn.
- Leo Fox, Matt Wilmoth, Tenacity, Inc.– Photography & Video Editing
- Edward McKulsky, Tenacity, Inc. – Graphic Design & Editing
- Caleb Knauer, Deliberant Systems – A/P advice.

Questions?

Reference

- FCC Part 15.247 - 2.4 GHz ISM (Industrial, Scientific, Medical) Band
- Tripoli Rocketry Assn. High Power Safety Code
- National Fire Protection Association (NFPA-1127)
- Bureau of Alcohol, Tobacco, & Firearms Permits required under 18 U.S.C. , chapter 40, explosives
- FAA Order 7400.2F, chapter 31, “Rocket & Launch Vehicle Operations.”