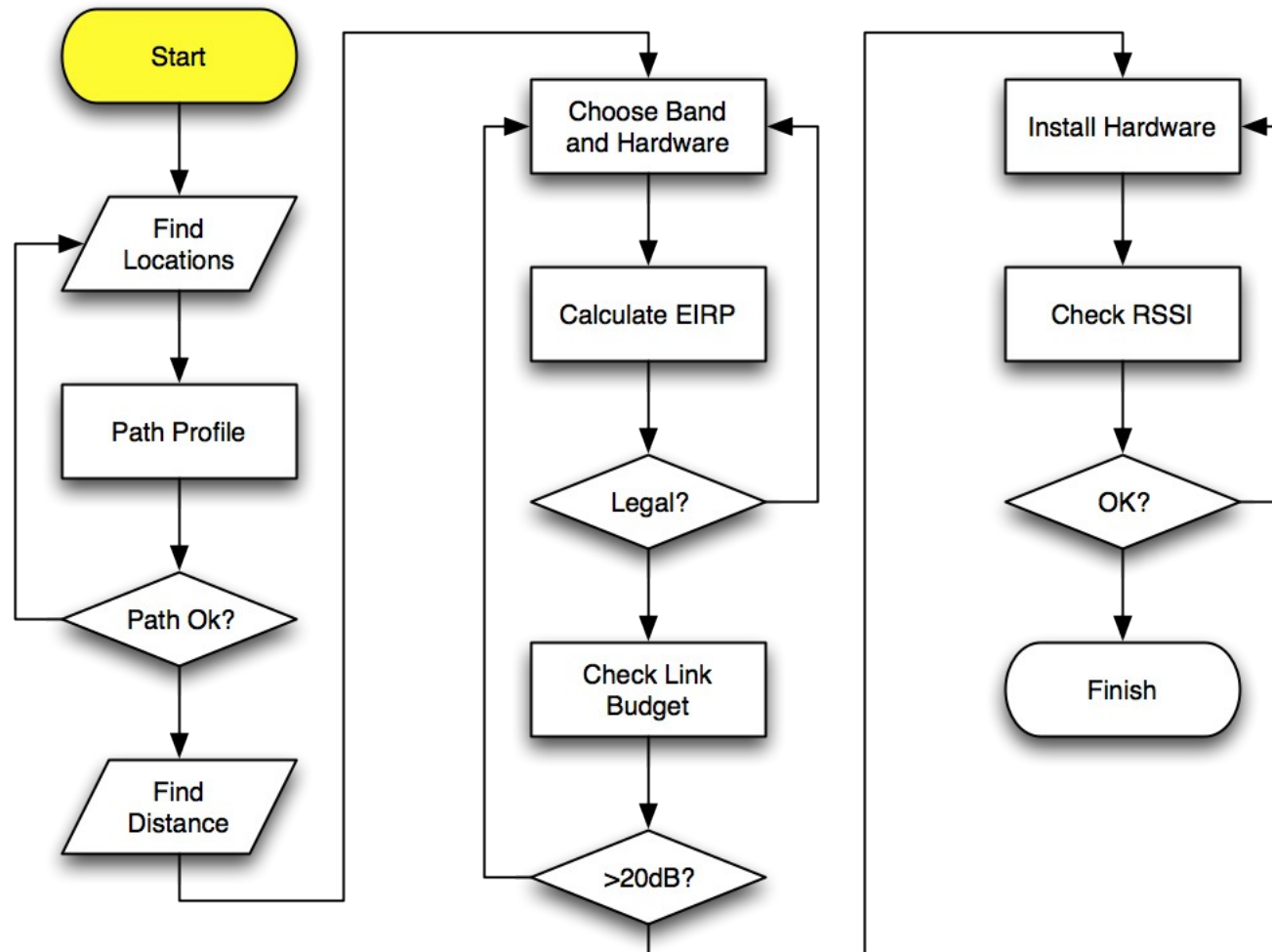
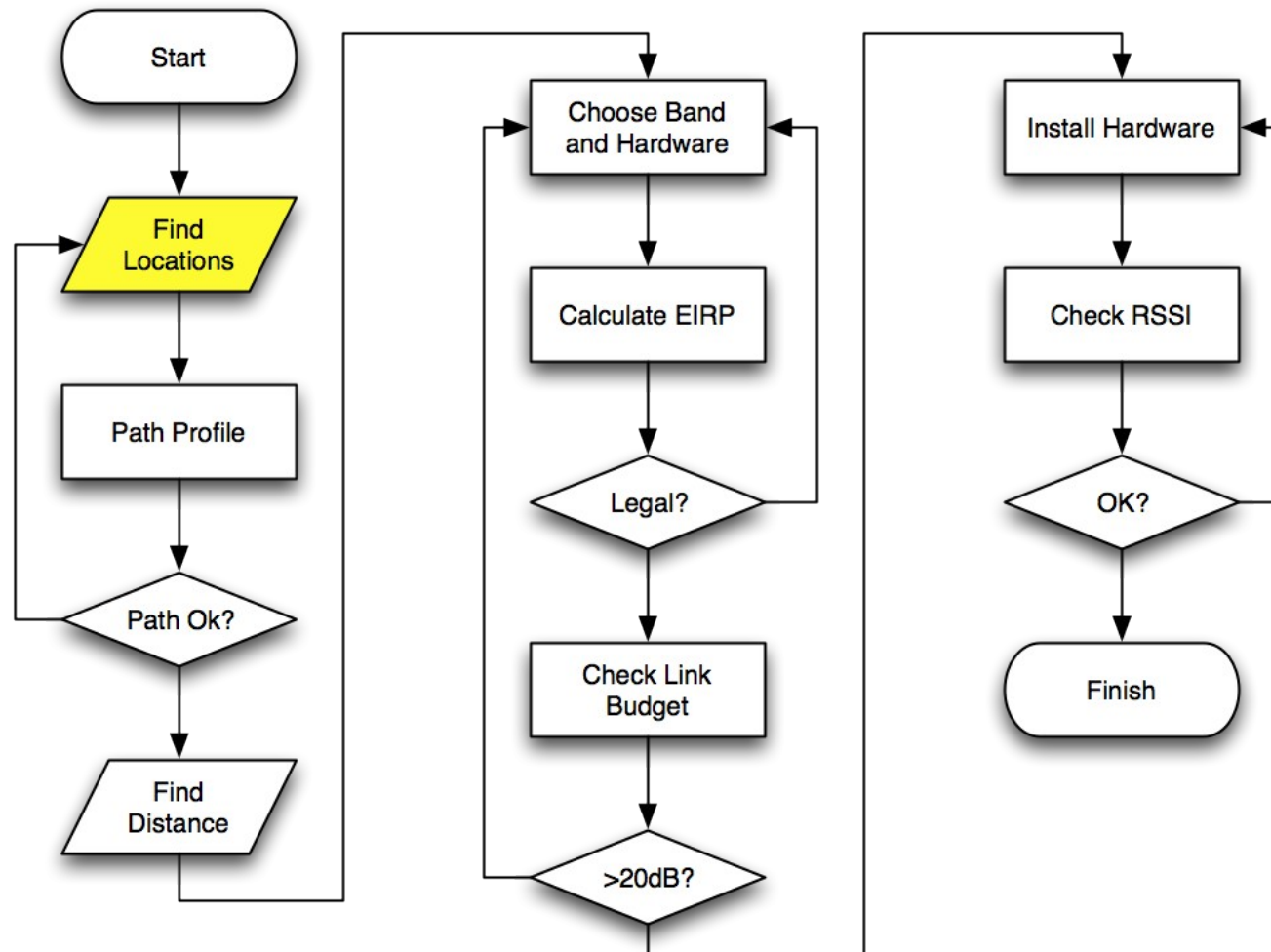


Wireless Linking

with Mikrotik





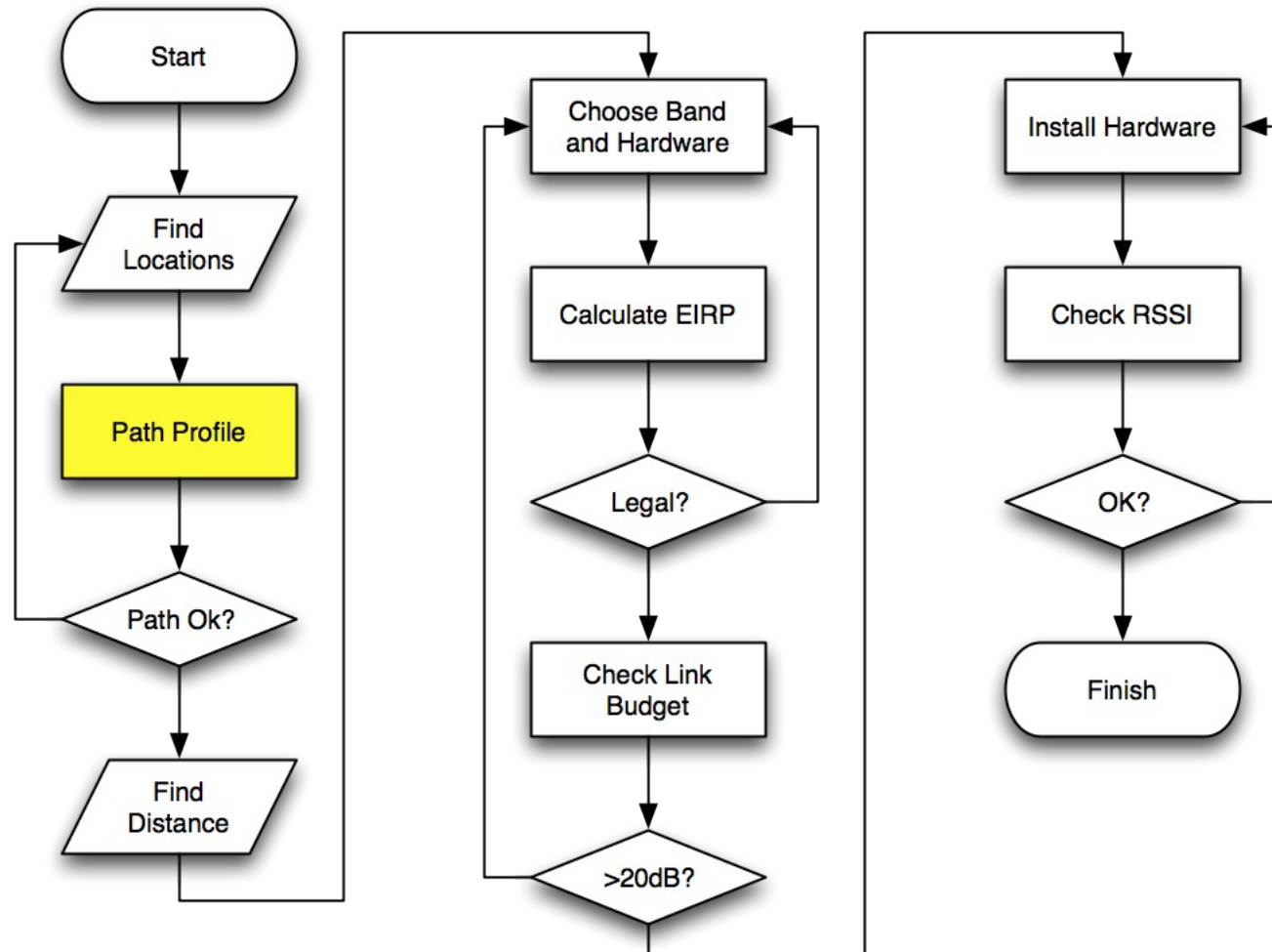
Planning the Link – Locations

Find the locations

- On Google Maps/Earth, if visible
- With GPS coordinates if not visible on Google Earth
- WGS84 for most uses, NZTM 2000 for commercial tools

Planning the Link – Example Locations

- Mt Kaukau to Somes Island
- Mount Maunganui to Motiti Island
- Titirangi Drive, Gisborne (Kaiti Hill) to Mahia
- Summit Drive, CHC (Sugarloaf) to CHC Airport
- Mt Kaukau to Blenheim Airport



Planning the Link – Profile

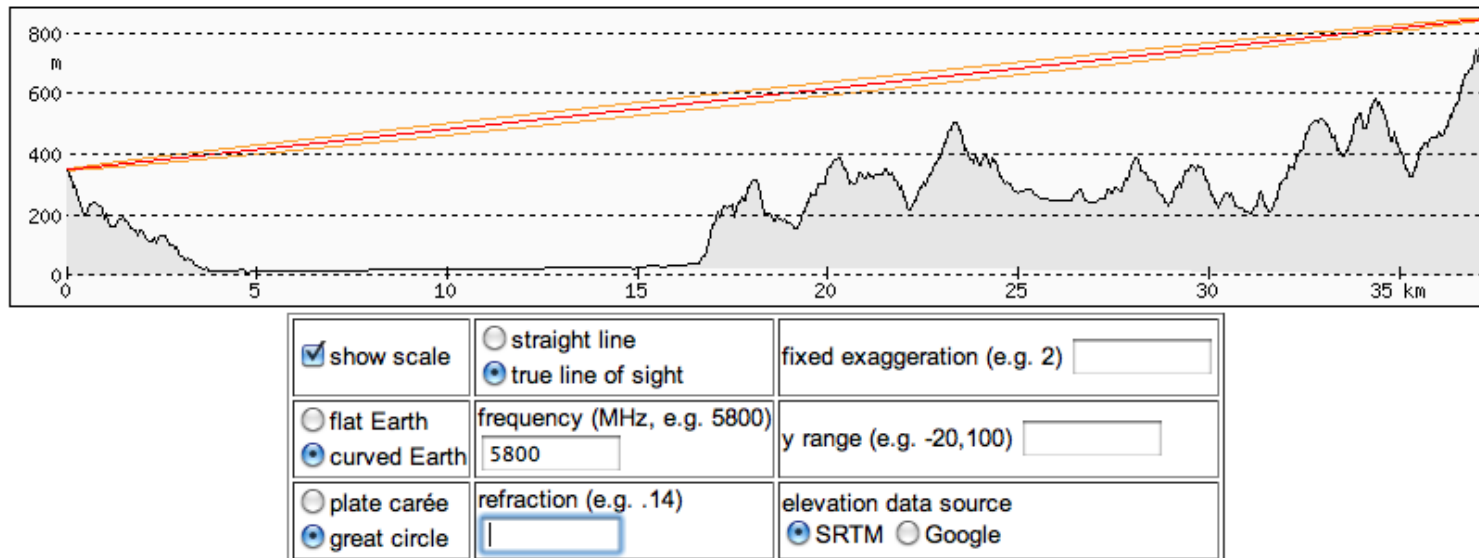
Check the path profile

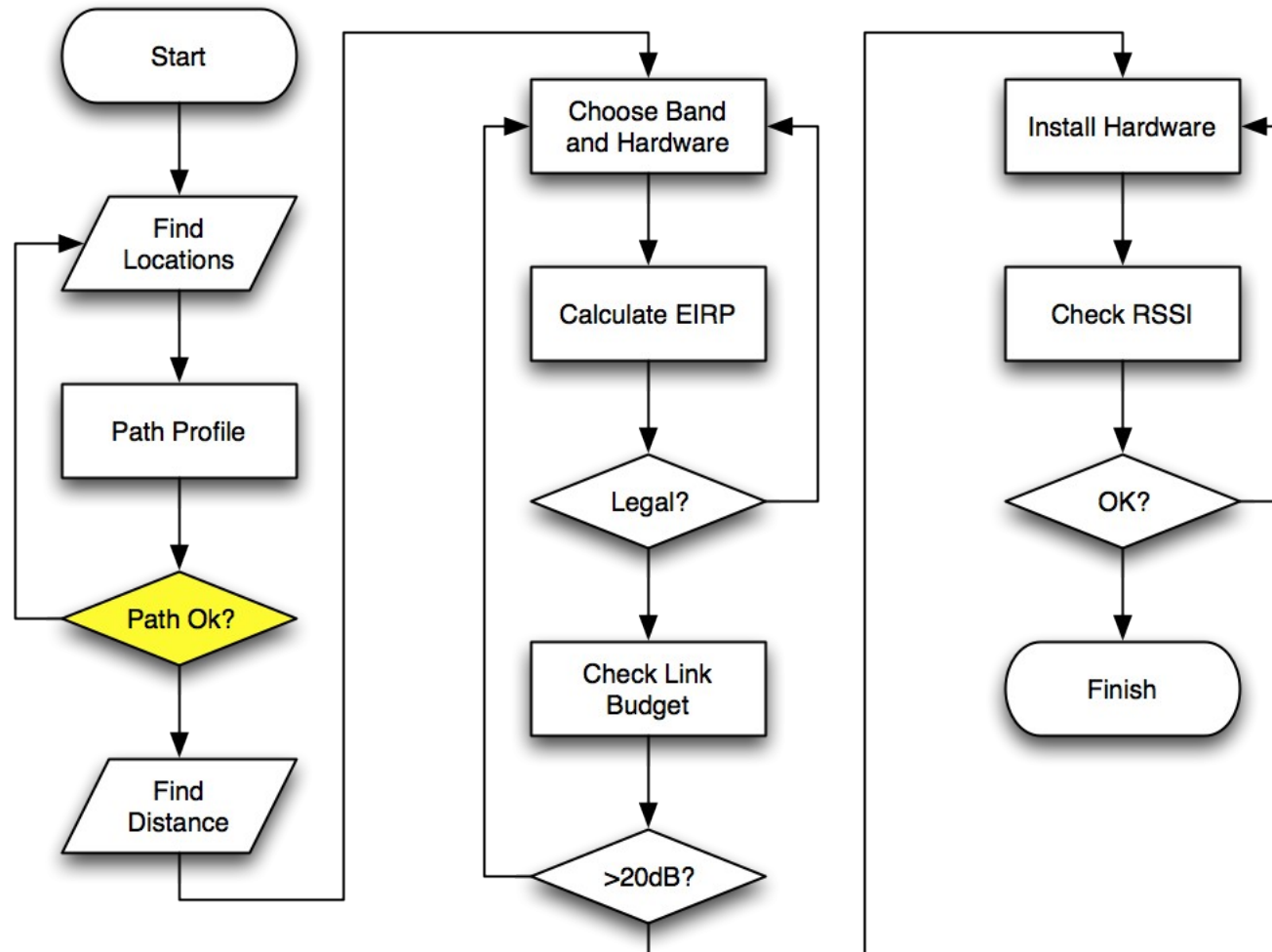
- (using freeware tools, online, or using commercial tools)
- Radio Mobile, Motorola PTP Link Planner
- <http://www.heywhatsthat.com/profiler-0904.html>
- PathLoss, EDX

Is there line of sight?

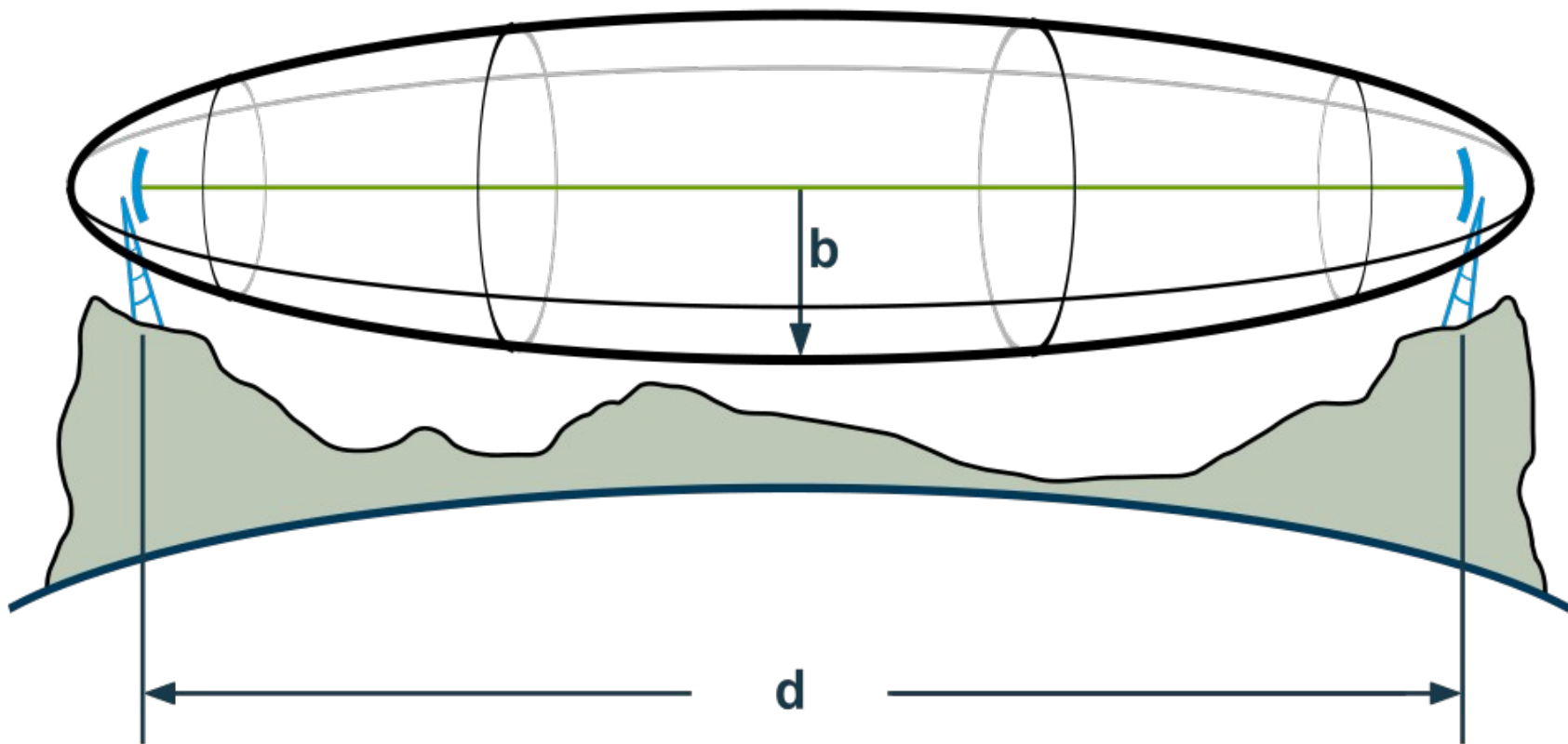
- What's a fresnel zone?
- Is the fresnel zone clear?

Planning the Link – Profile

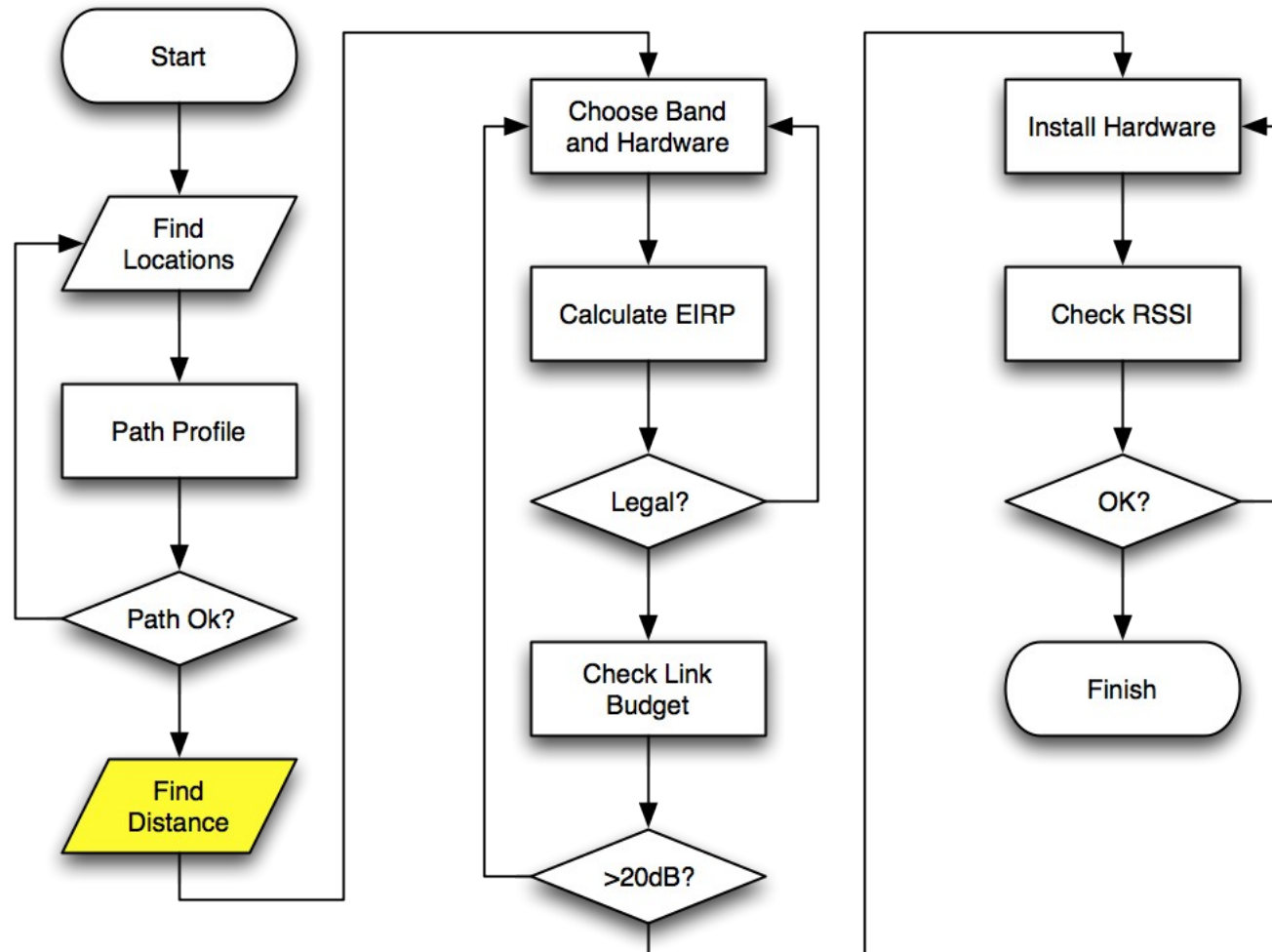




Planning the Link - Fresnel



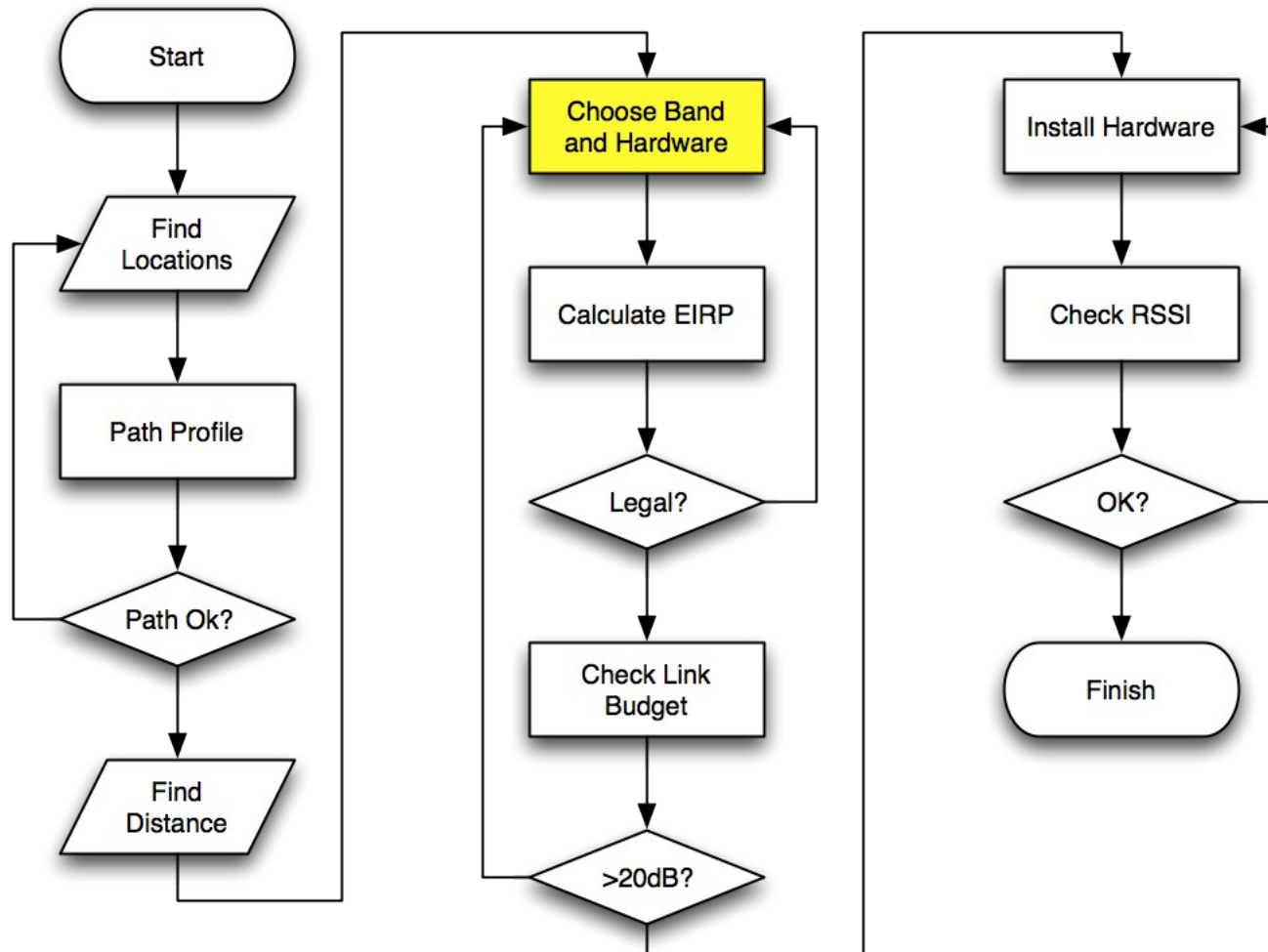
Licensed under the GFDL by Averse - <http://en.wikipedia.org/wiki/File:FresnelSVG.svg>



Planning the Link - Distance

Find the path distance

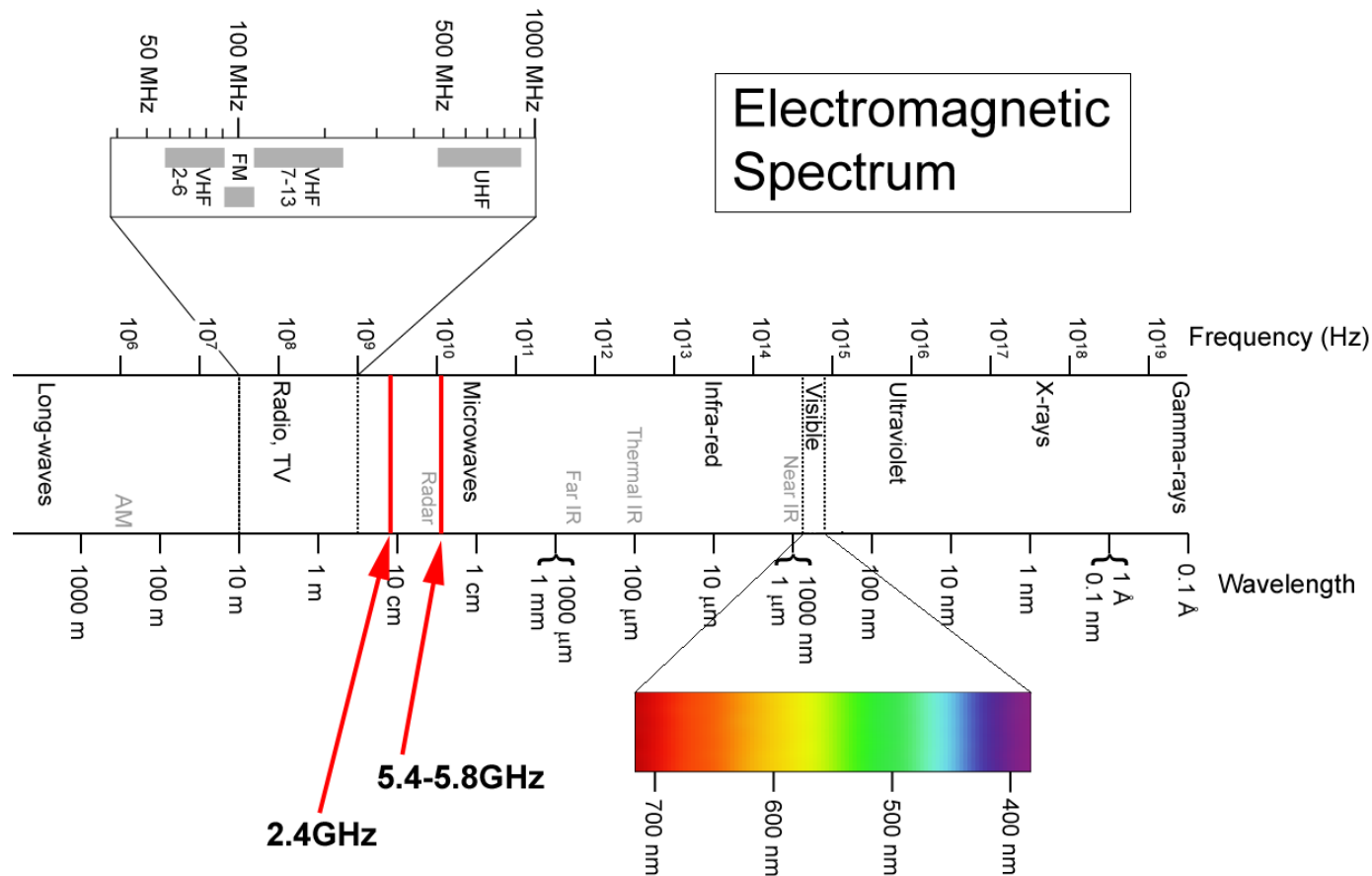
- In kilometers FTW
- Required for decision on band
- Later required for link budget
- Example WSH to MCL = 37km



NZ Bands & Power Limits

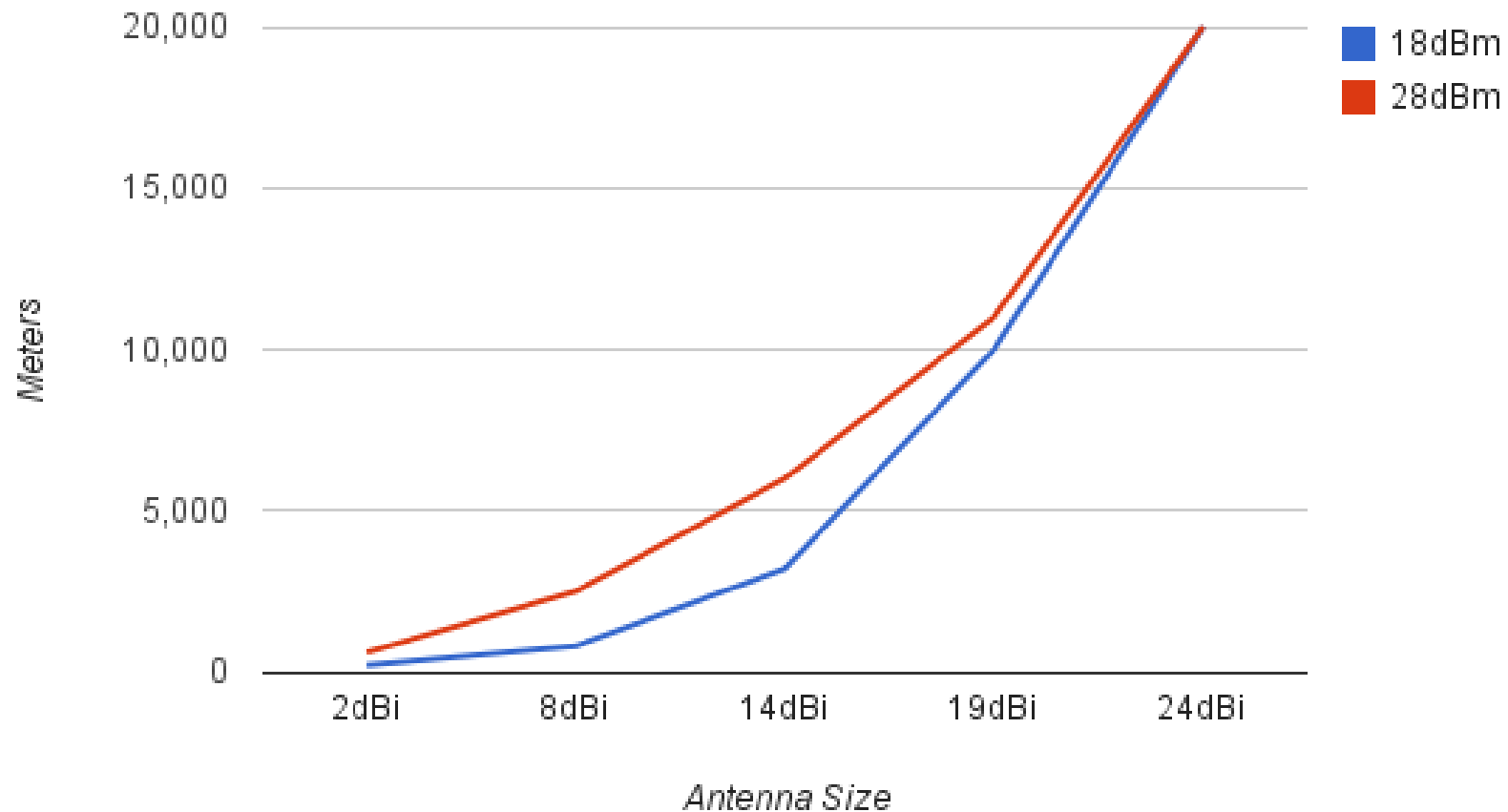
- 2.4GHz
 - 2400-2483MHz
 - 4W (36dBm) EIRP
- 5.2 & 5.8GHz
 - 5250-5350MHz
 - 5470-5725MHz
 - 1W (30dBm) EIRP
 - ATPC, DFS
- 5.8GHz
 - 5725-5875 P-P, P-MP @ 4W (36dBm) EIRP
 - 5725-5825 P-P @ 200W (53dBm) EIRP

NZ Bands in the Spectrum

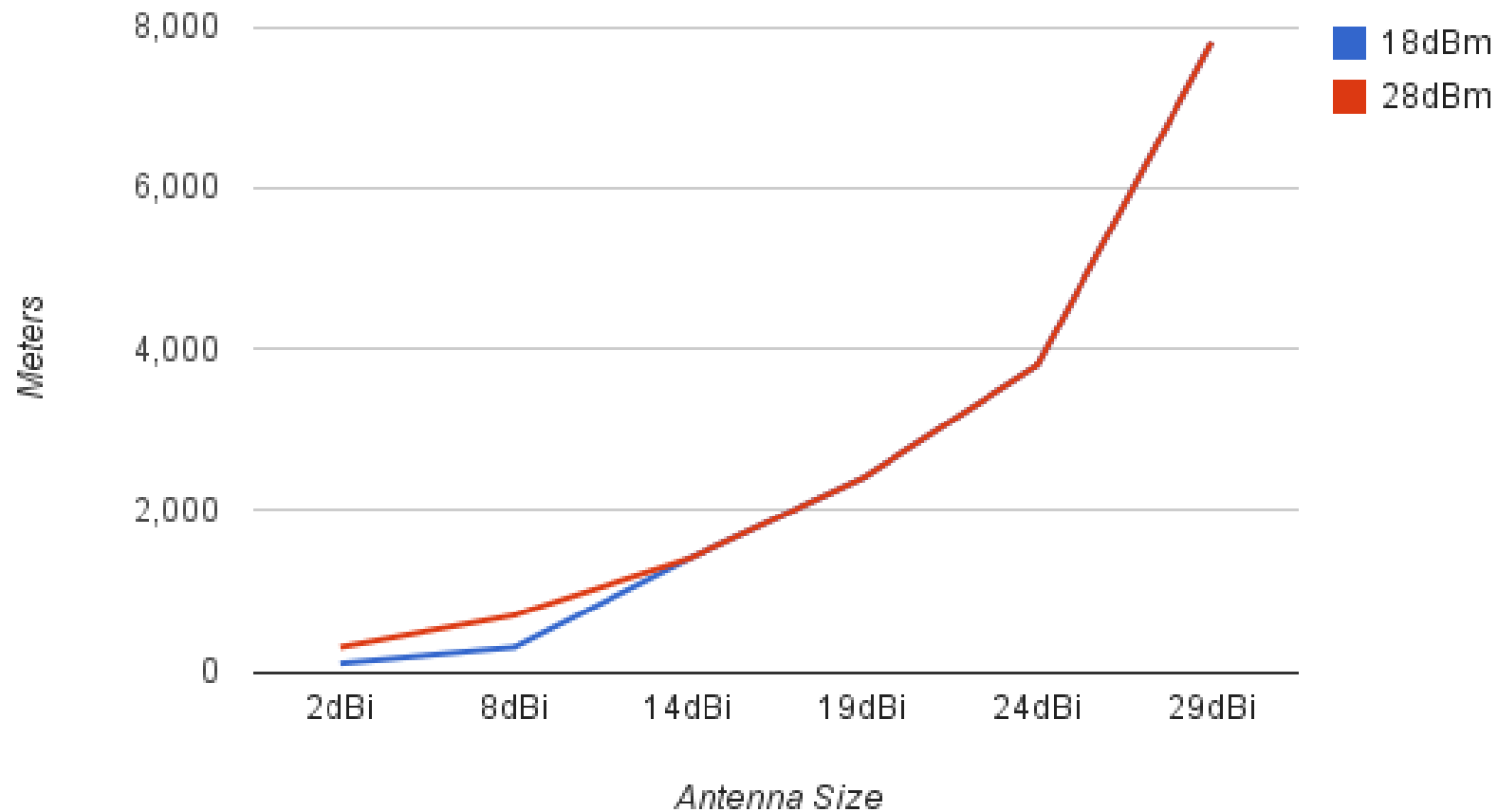


Creative Commons Share-Alike 2.5 - <http://en.wikipedia.org/wiki/File:Electromagnetic-Spectrum.png>

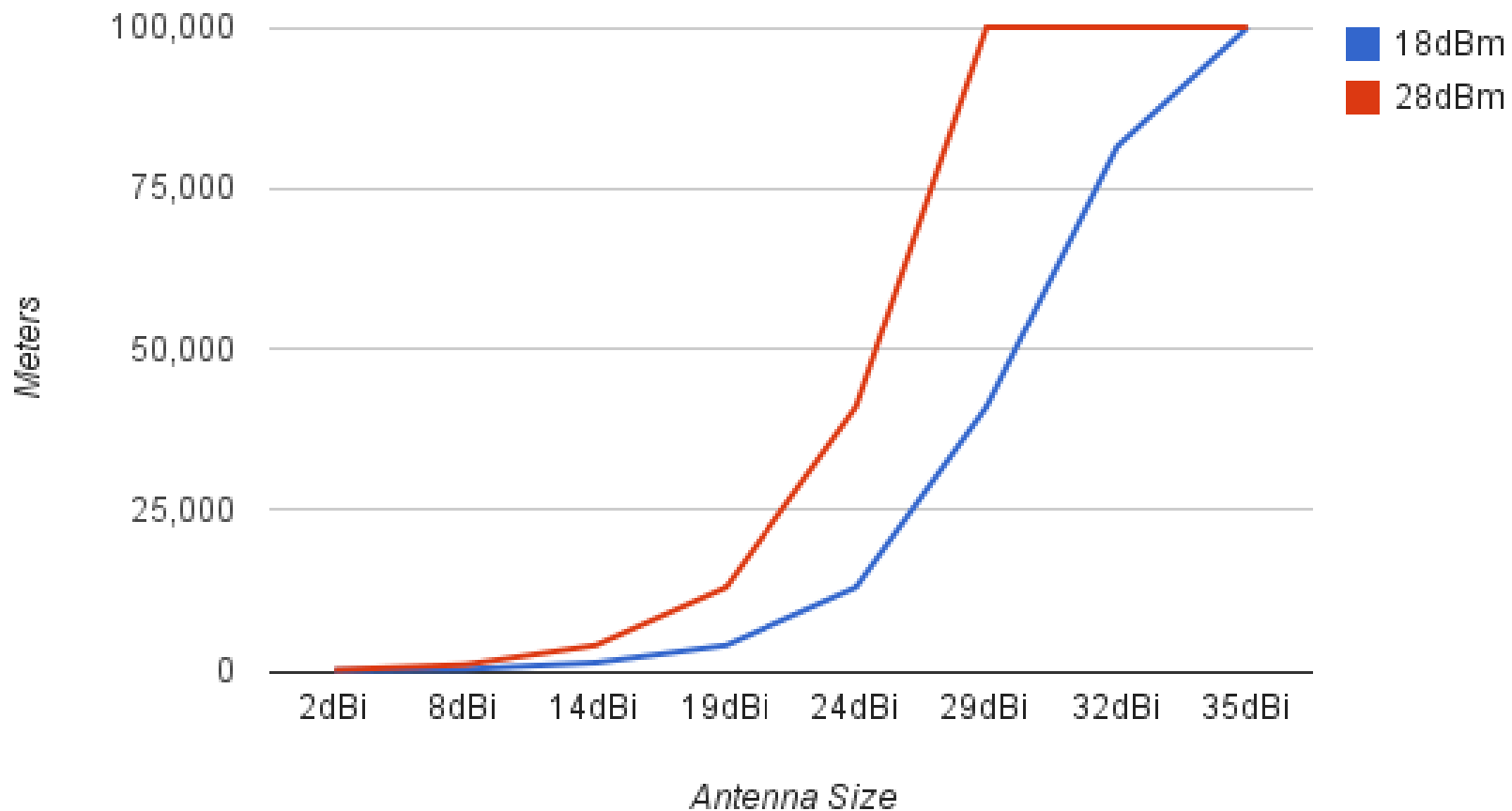
2.4GHz for P-P, P-MP

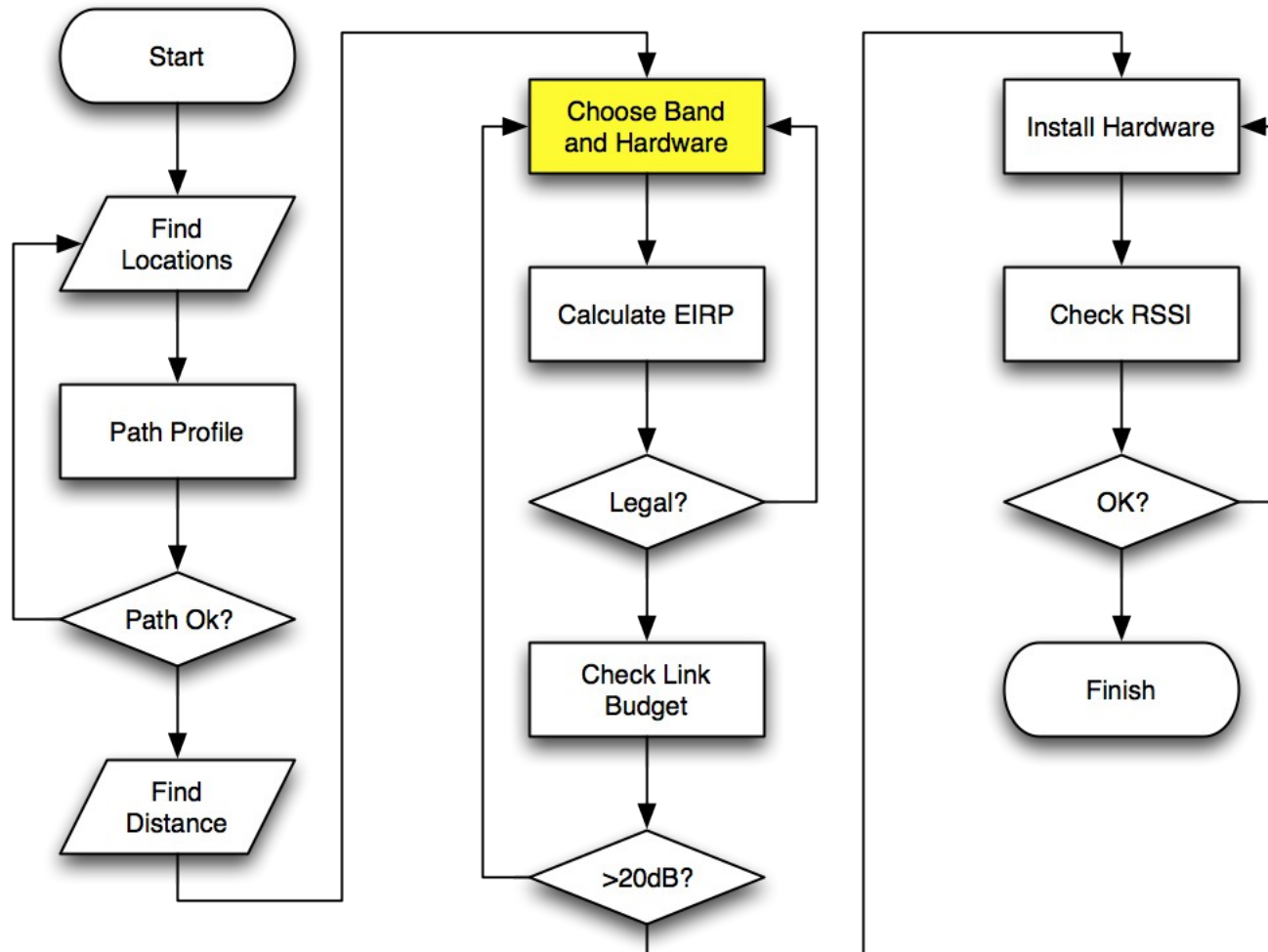


5.4GHz for P-P, P-MP



5725-5825MHz P-P Only





Standard Radio Cards



Mikrotik R52

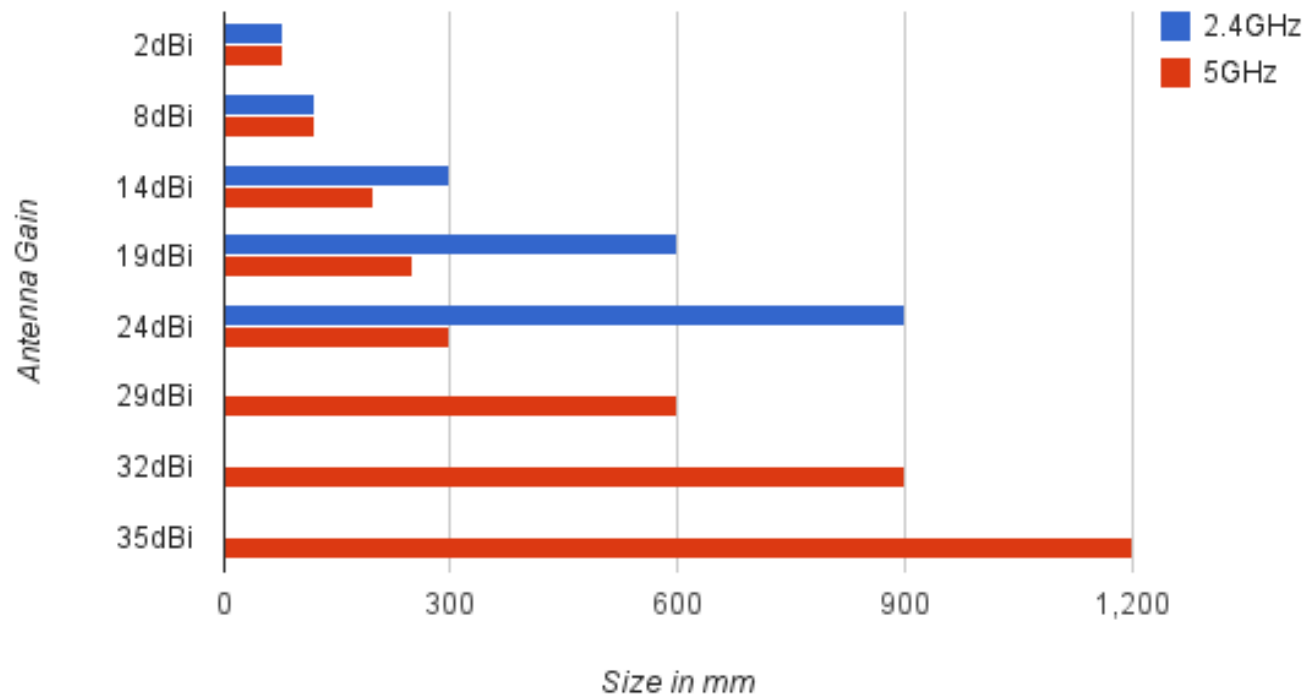
\$79



Ubiquiti XR5

\$179

Antenna Physical Sizes



Calculating EIRP

EIRP = Effective Isotropic Radiated Power

EIRP = PT (power of transmitter) (dBm)

- Lc (cable losses) (dB)

+ Ga (antenna gain) (dBi)

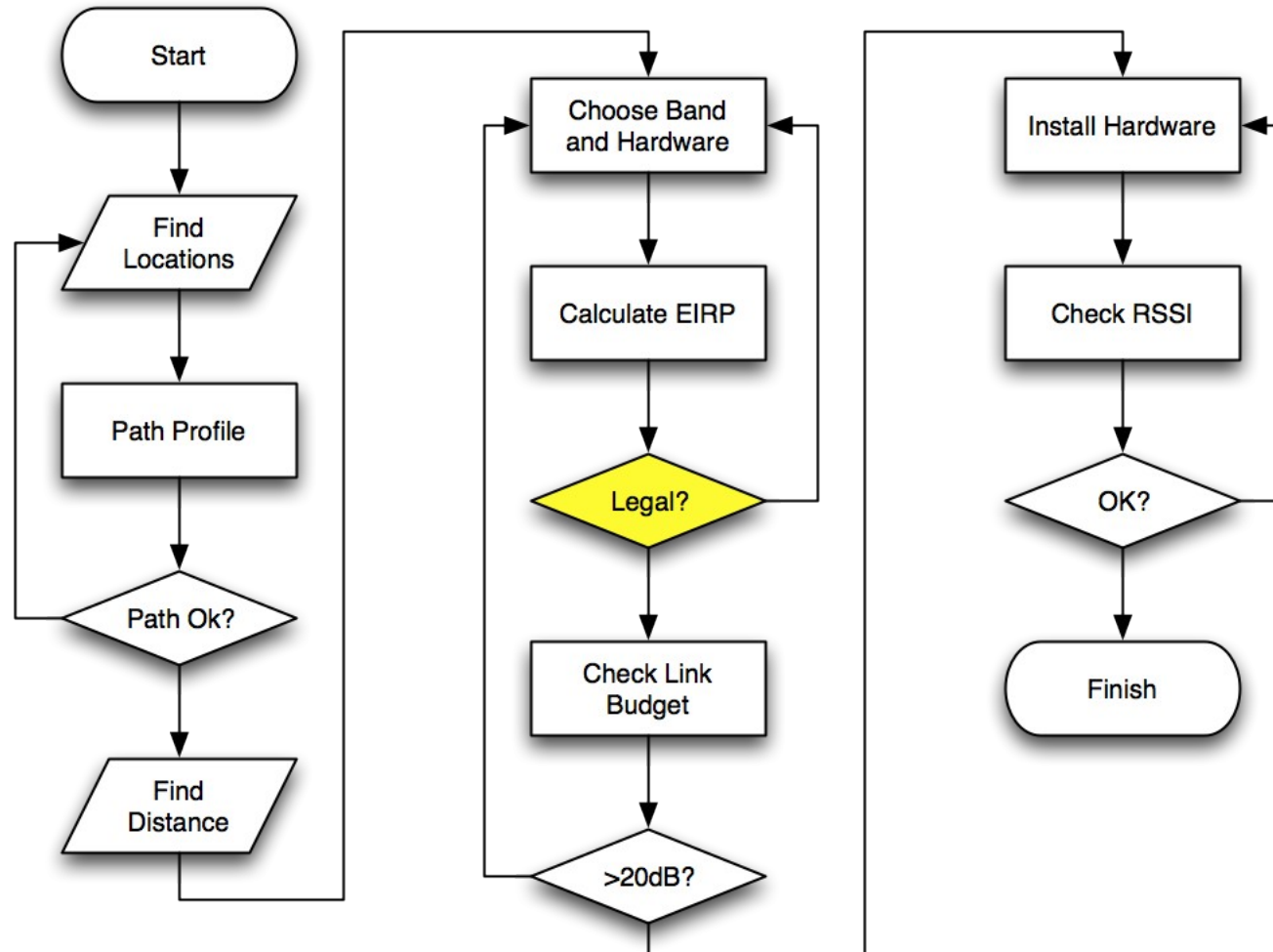
18dBm card - 2dB cable + 14dBi antenna = 30dBm

Calculate dBm to Watts the hard way: <http://en.wikipedia.org/wiki/DBm>, Or use these hints below:

30dBm = 1W

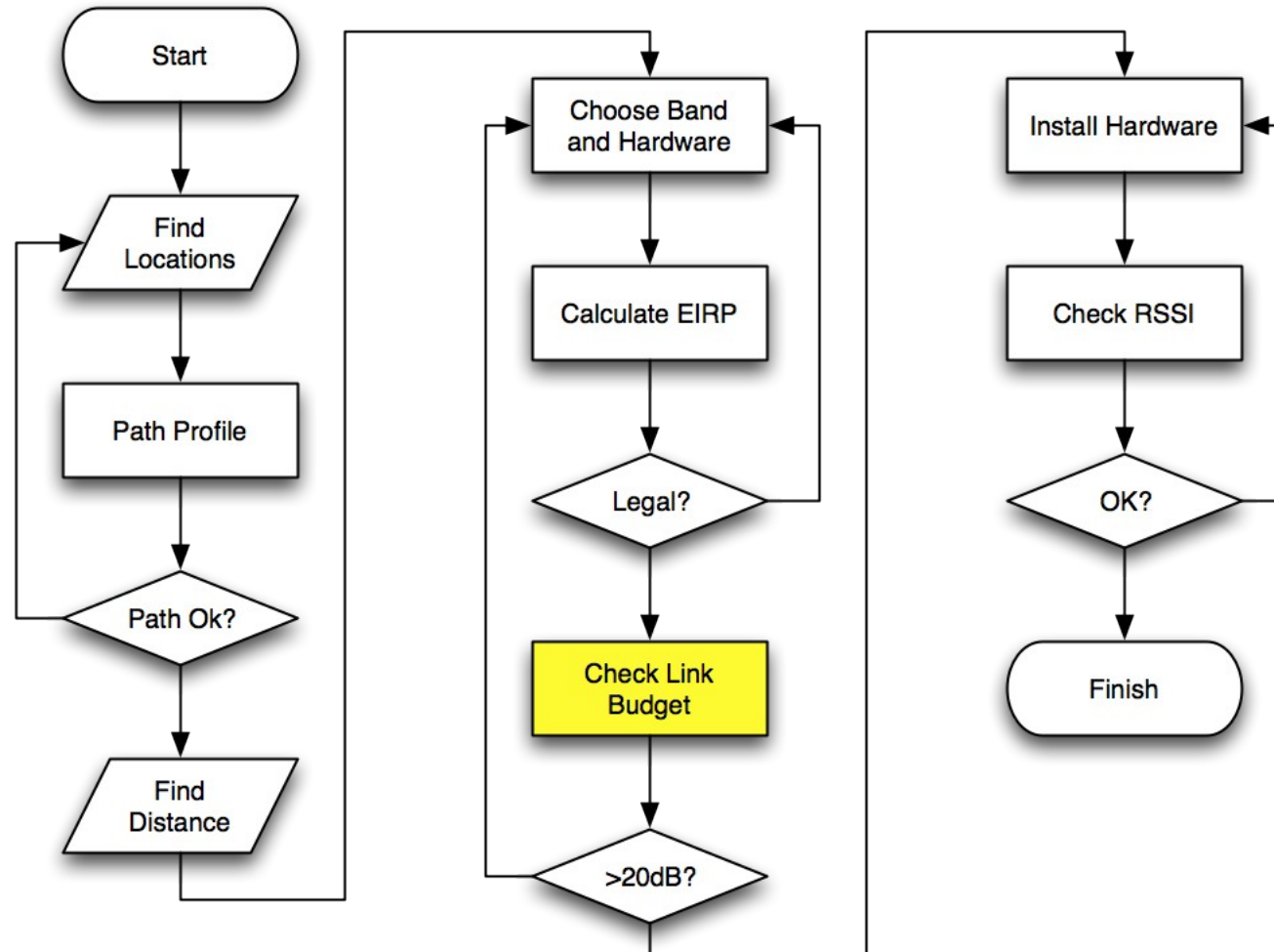
36dBm = 4W

53dBm = 200W



NZ Bands & Power Limits

- 2.4GHz
 - 2400-2483MHz
 - 4W (36dBm) EIRP
- 5.2 & 5.8GHz
 - 5250-5350MHz
 - 5470-5725MHz
 - 1W (30dBm) EIRP
 - ATPC, DFS
- 5.8GHz
 - 5725-5875 P-P, P-MP @ 4W (36dBm) EIRP
 - 5725-5825 P-P @ 200W (53dBm) EIRP



Link Budget Calculation

$$\mathbf{P_{RX}} = \mathbf{P_{TX}} + \mathbf{G_{TX}} - \mathbf{L_{TX}} - \mathbf{L_{FS}} - \mathbf{L_M} + \mathbf{G_{RX}} - \mathbf{L_{RX}}$$

P_{RX} = received power (dBm)

P_{TX} = transmitter output power (dBm)

G_{TX} = transmitter antenna gain (dBi)

L_{TX} = transmitter losses (coax, connectors...) (dB)

L_{FS} = free space loss or path loss (dB)

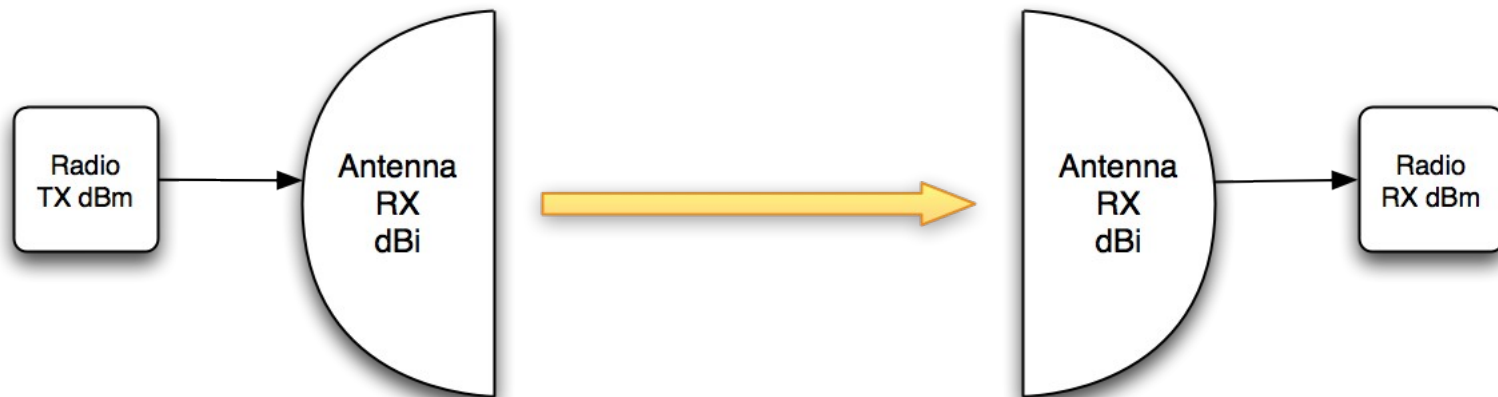
L_M = miscellaneous losses (other losses...) (dB)

G_{RX} = receiver antenna gain (dBi)

L_{RX} = receiver losses (coax, connectors...) (dB)

Link Budget Diagram

$$P_{TX} - L_{TX} + G_{TX} - L_{FS} - L_M + G_{RX} - L_{RX} = P_{RX}$$



Free Space Loss

$$L_{FS} \text{ (dB)} = 20 \cdot \log[4 \cdot \pi \cdot \text{distance} / \text{wavelength}]$$

- where distance and wavelength are in the same units

$$2.4\text{GHz} = 0.125\text{M}$$

$$10\text{KM} = 10,000\text{M}$$

$$L_{FS} \text{ (dB)} = 20 \cdot \log[4 \cdot 3.14 \cdot 10,000 / .125]$$

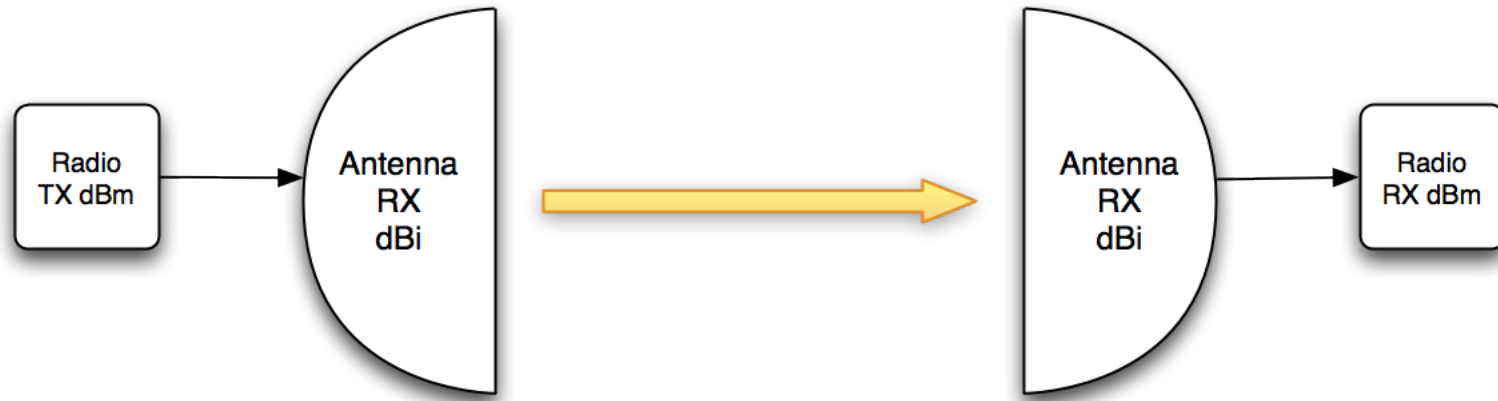
$$L_{FS} \text{ (dB)} = 20 \cdot \log[1,004,800]$$

$$L_{FS} \text{ (dB)} = 20 \cdot 6$$

$$L_{FS} \text{ (dB)} = 120$$

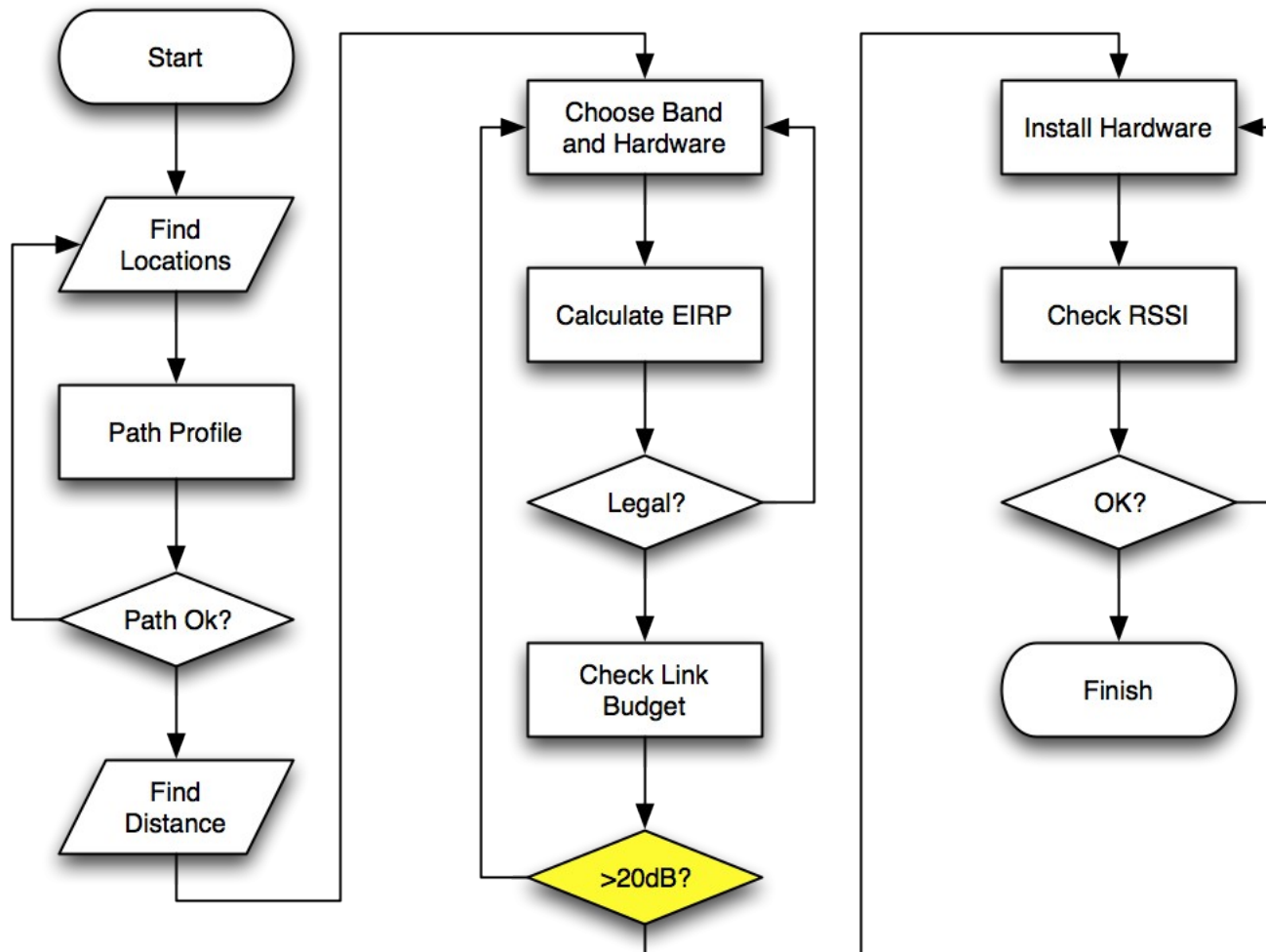
Link Budget Solved

$$P_{TX} - L_{TX} + G_{TX} - L_{FS} - L_M + G_{RX} - L_{RX} = P_{RX}$$



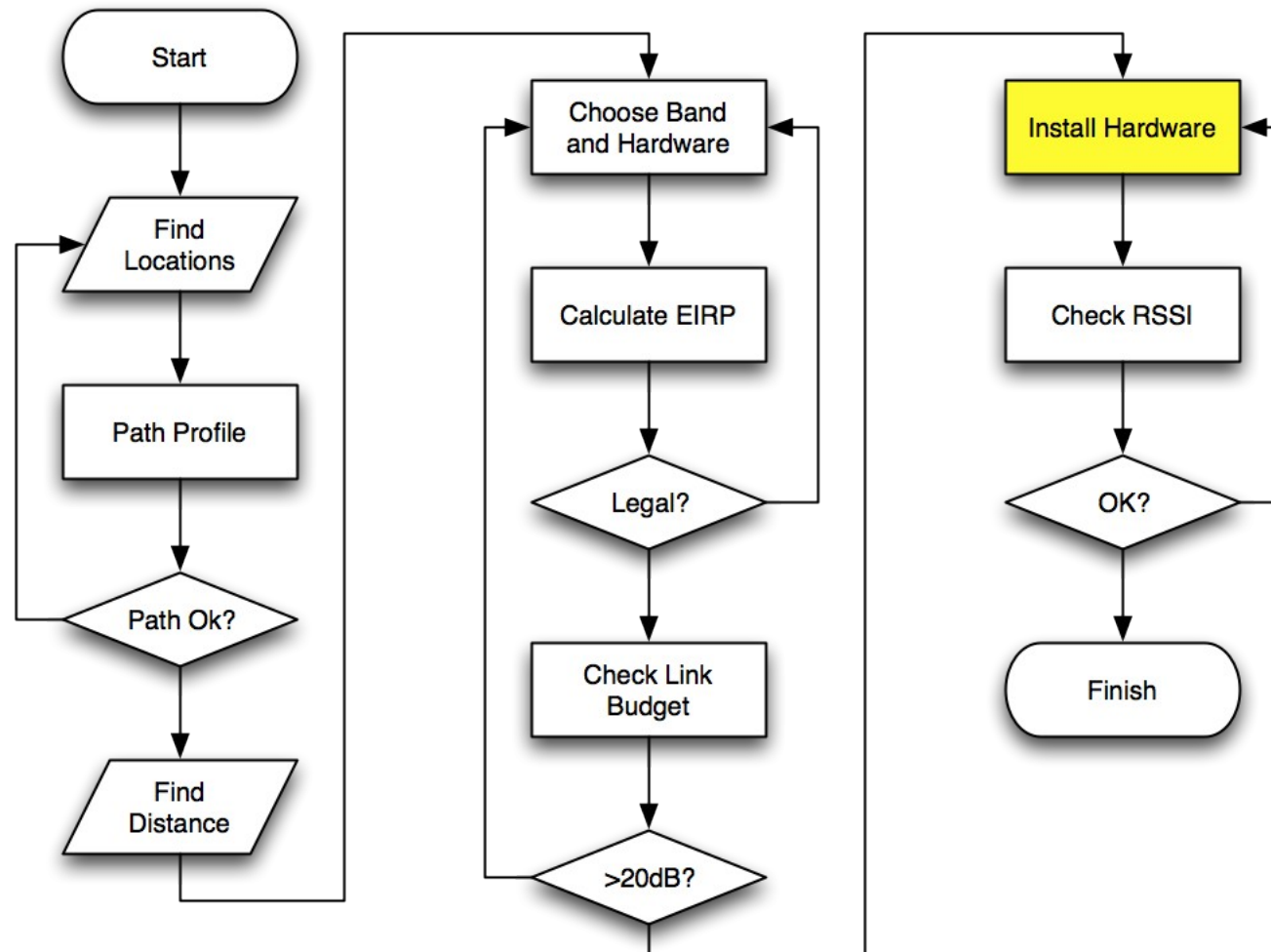
$$18\text{dBm} - 2\text{dB} + 19\text{dBi} - 120\text{dB} - 0\text{dB} + 19\text{dBi} - 2\text{dB} =$$

-68dBm Received Signal Level



Receive Sensitivities

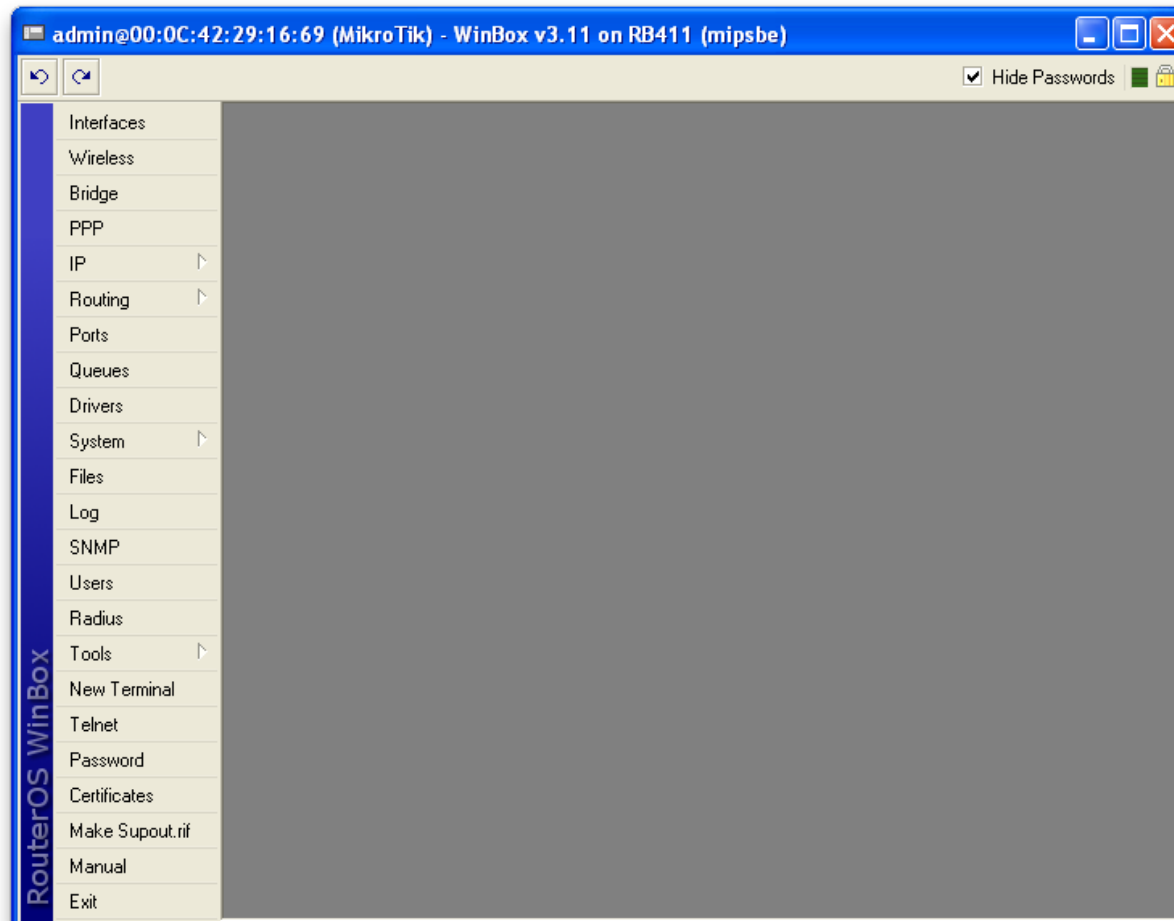
- Mikrotik R52
 - -71dBm required for 54mbps (64QAM)
 - -88dBm required for 6mbps (BPSK)
- Ubiquiti XR5
 - -74dBm required for 54mbps (64QAM)
 - -94dBm required for 6mbps (BPSK)



Upgrade & Configure Mikrotik

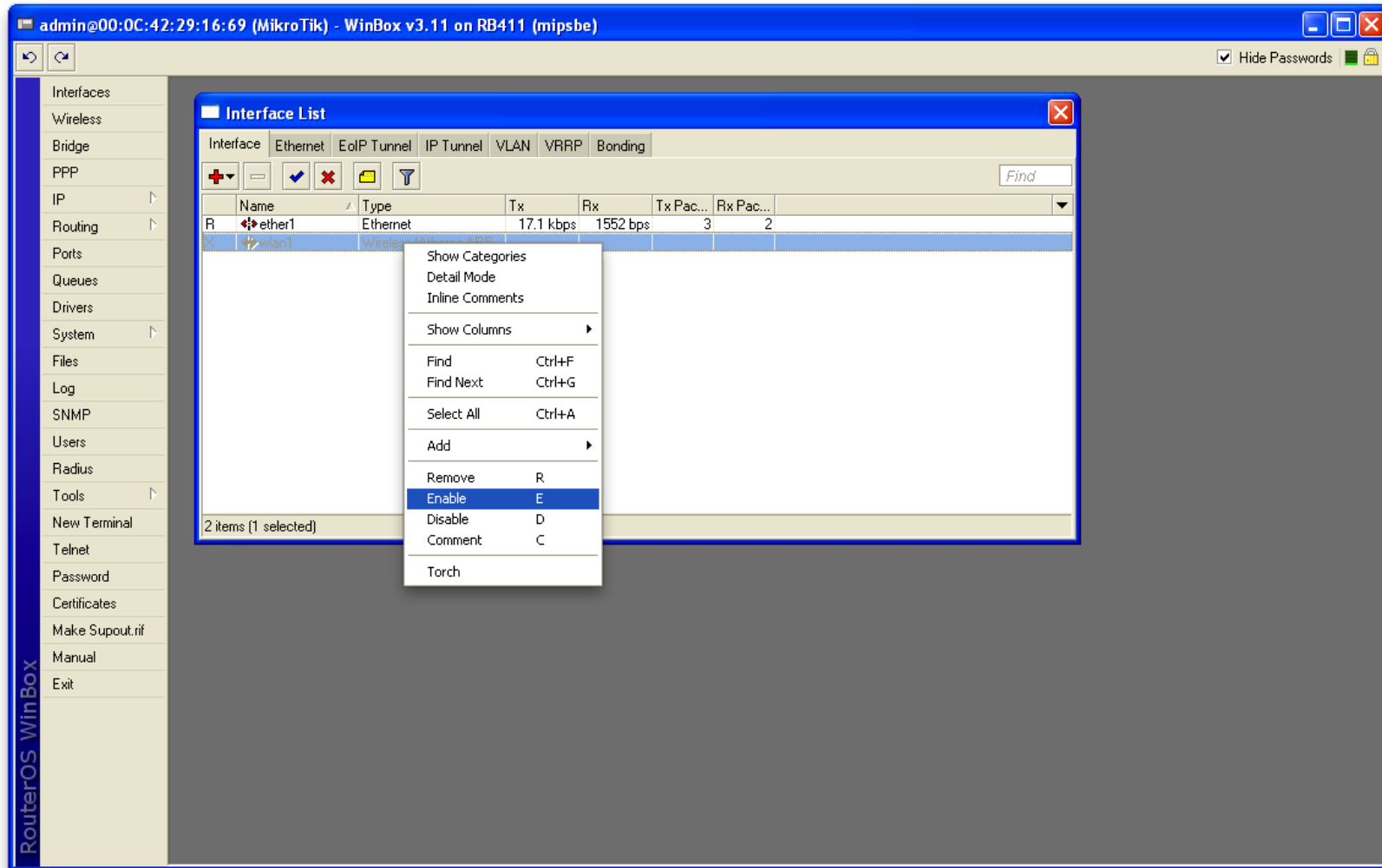
- Download Winbox from Mikrotik
 - It works under Wine and VMWare
 - Alternatively use a serial cable
- If using VM, make sure you're bridged to Ether
- Find the mac address of your unit & click
- You're now in “Winbox”

Mikrotik Winbox

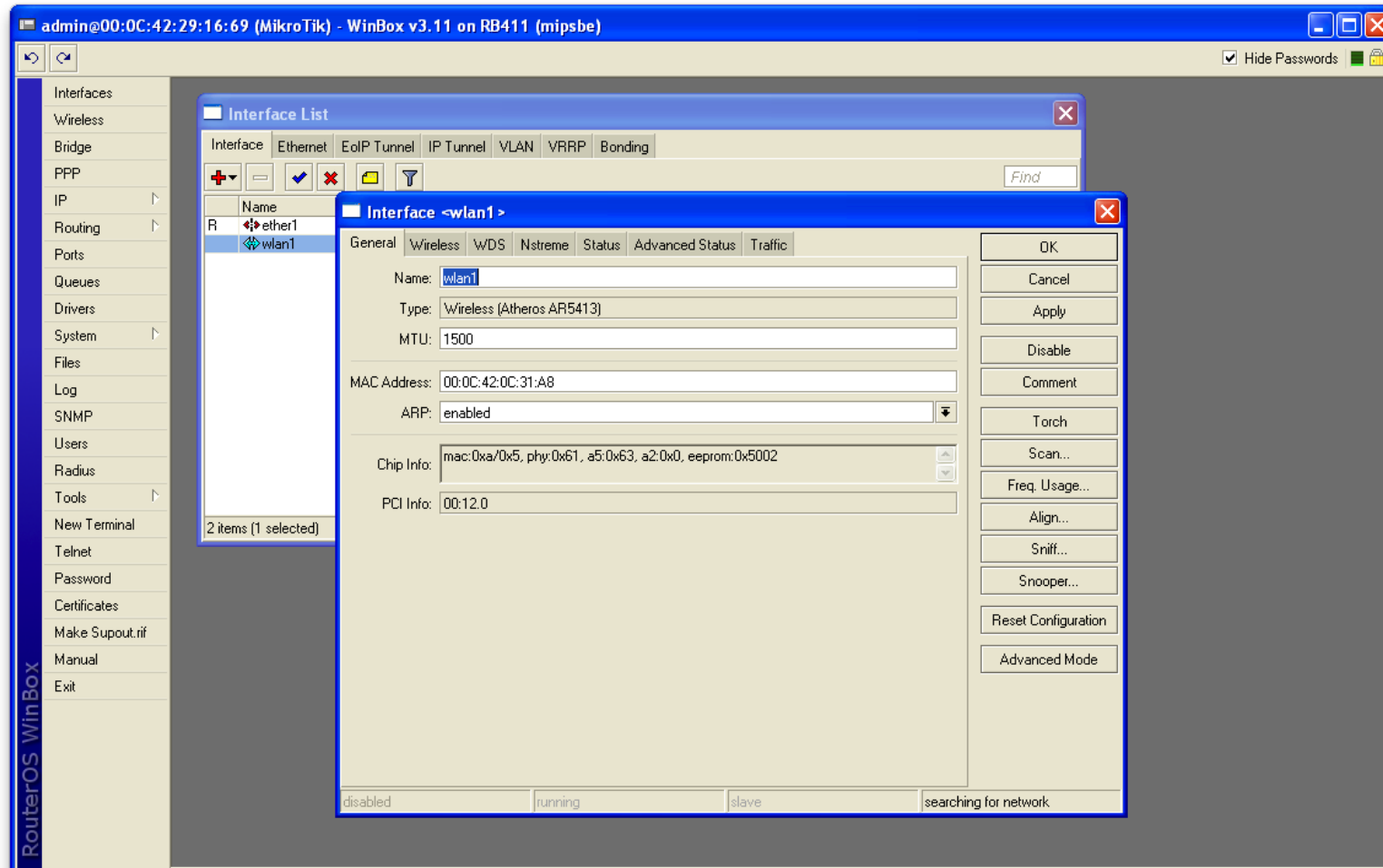


**Microwave Radio Linking
With Mikrotik**

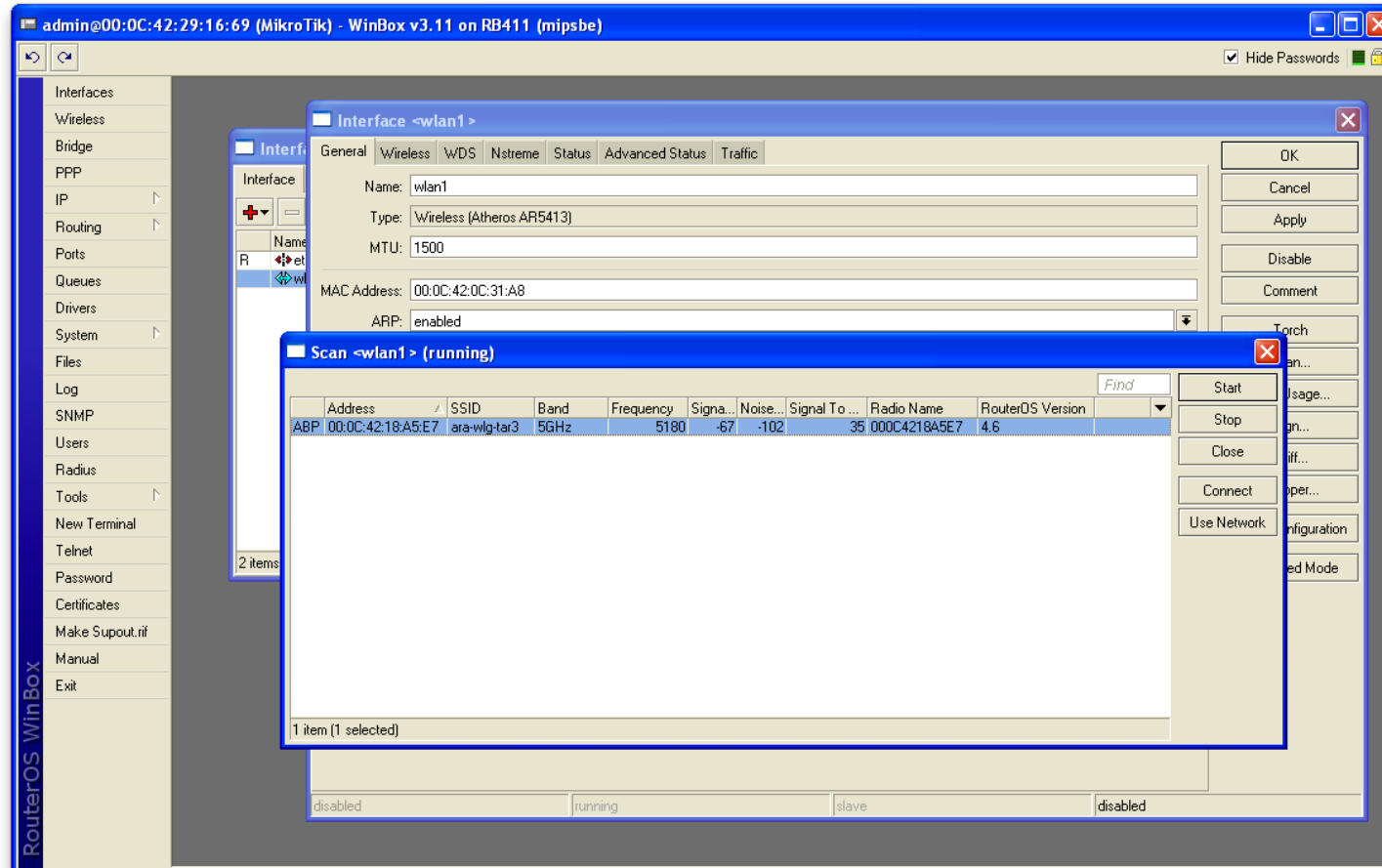
Enable a Wireless Interface



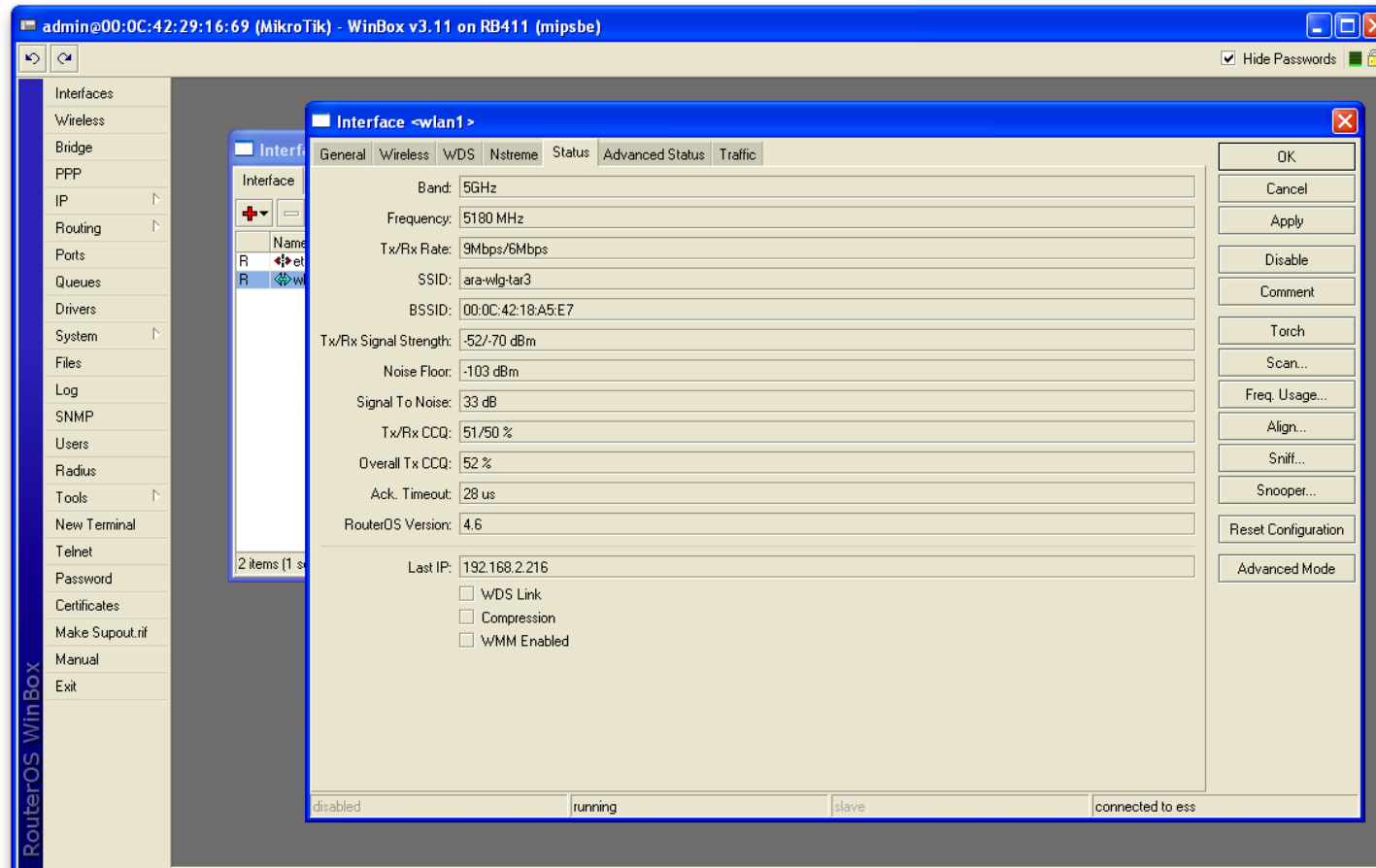
Open wlan1 & Browse Tabs



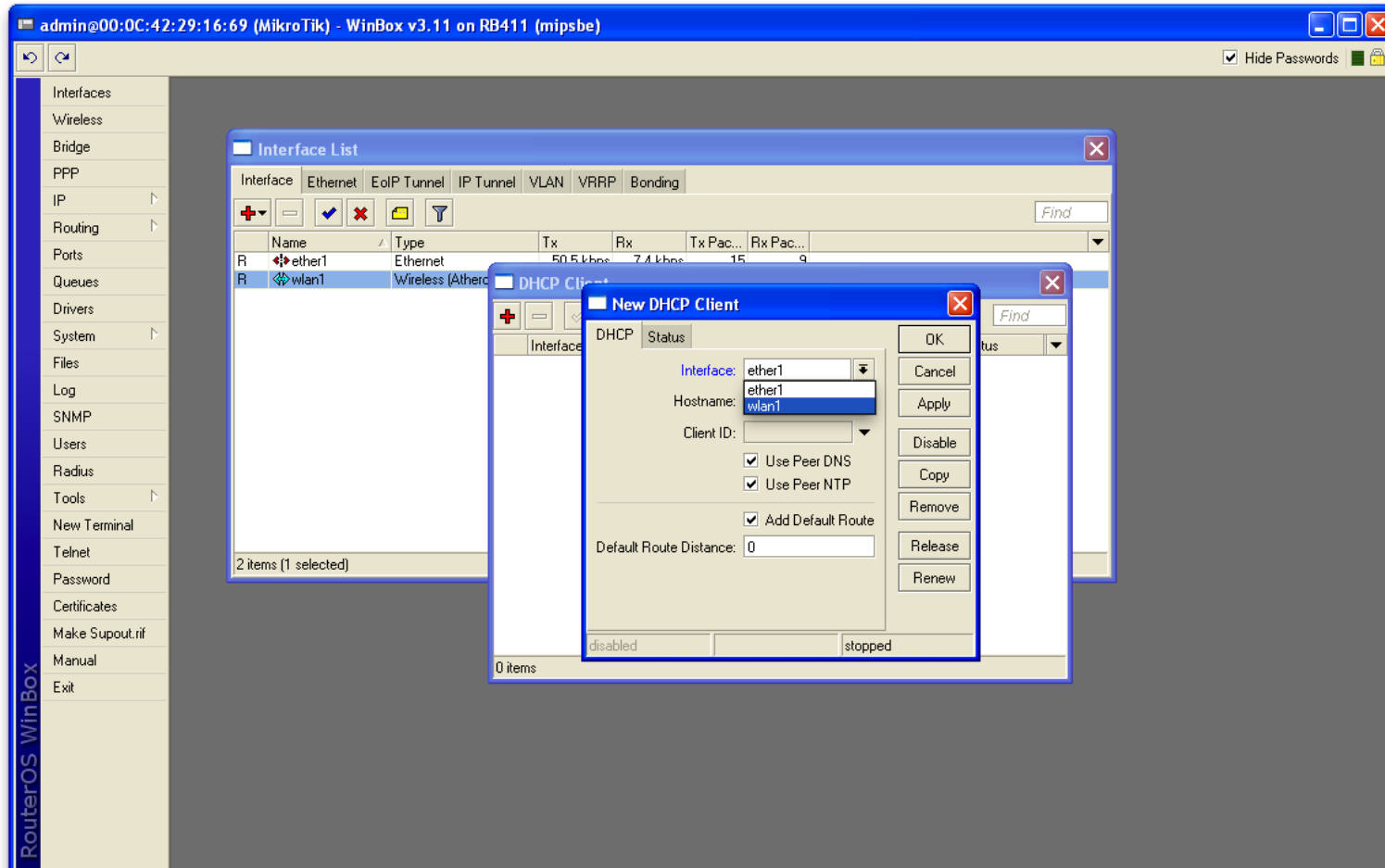
Scan and Connect to Network



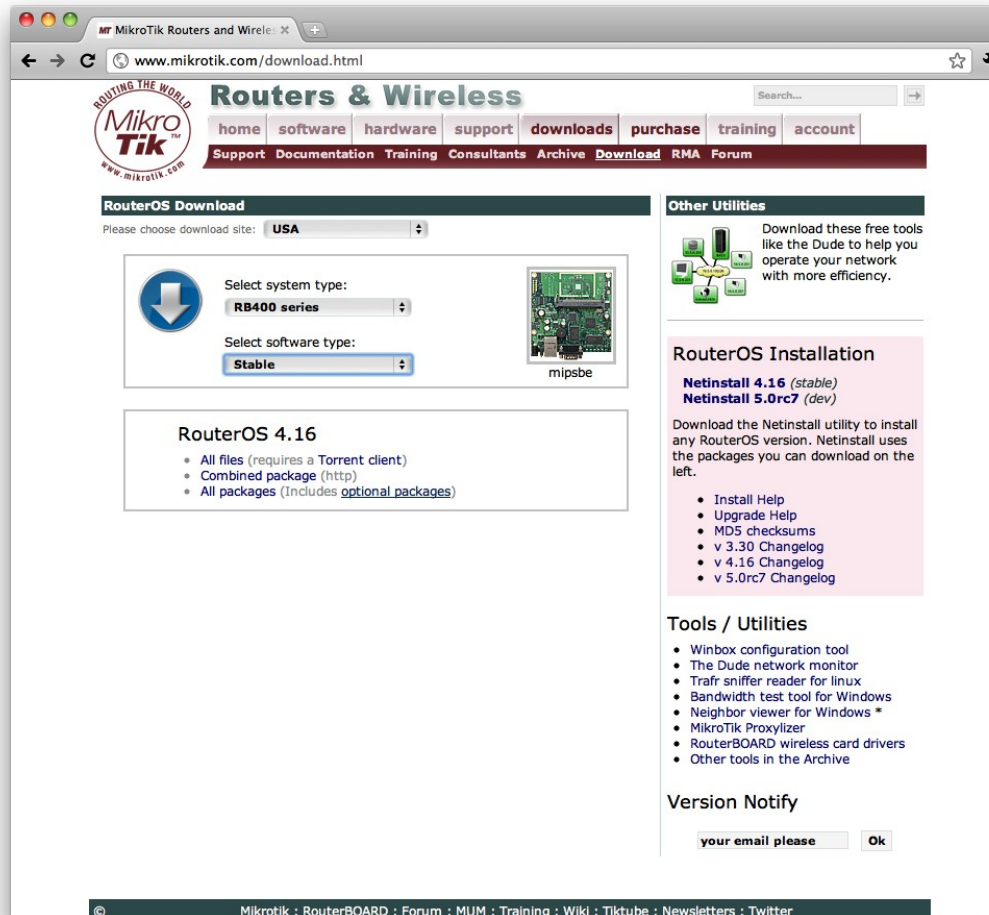
Close Scan & View Status



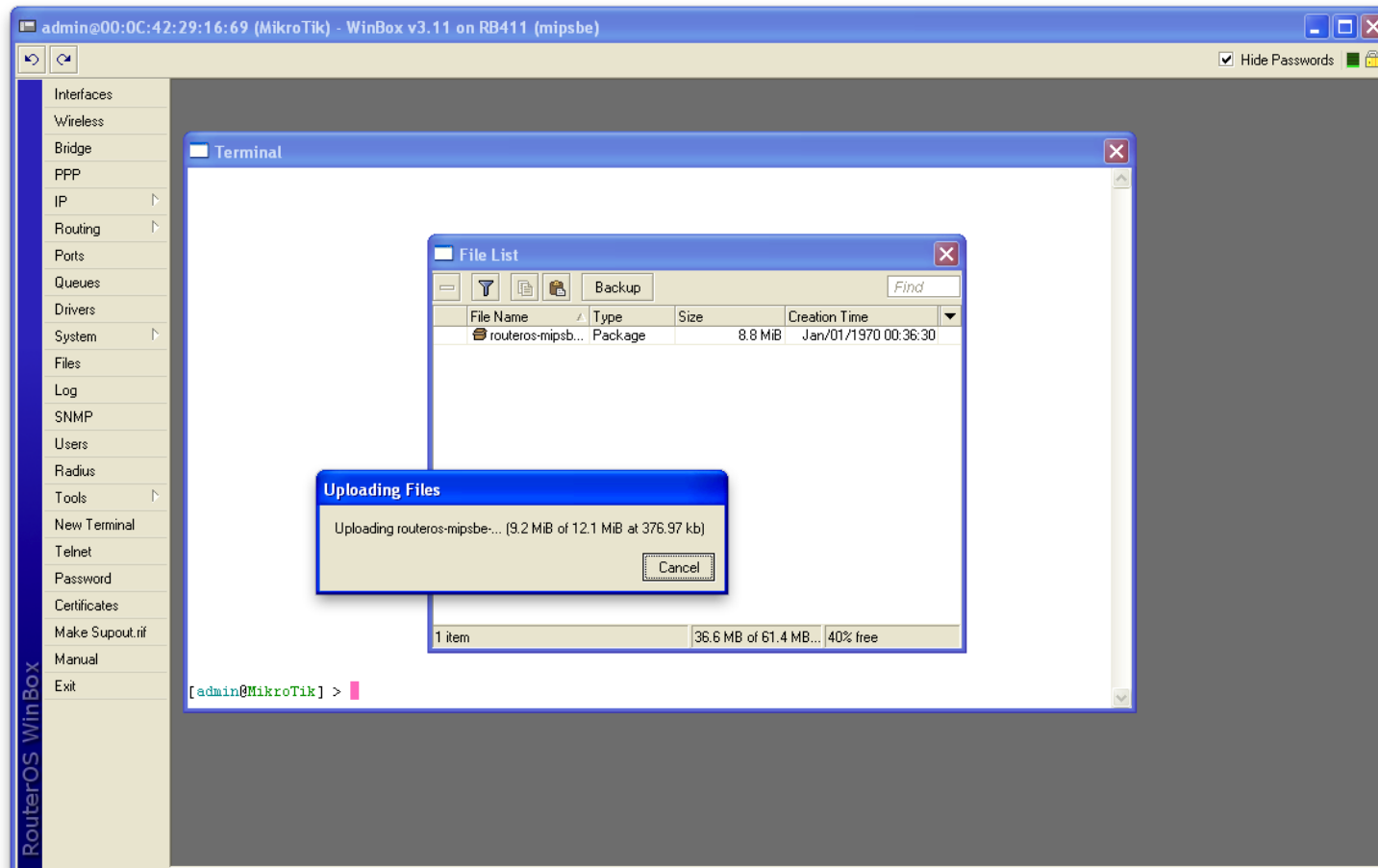
Get Online with DHCP



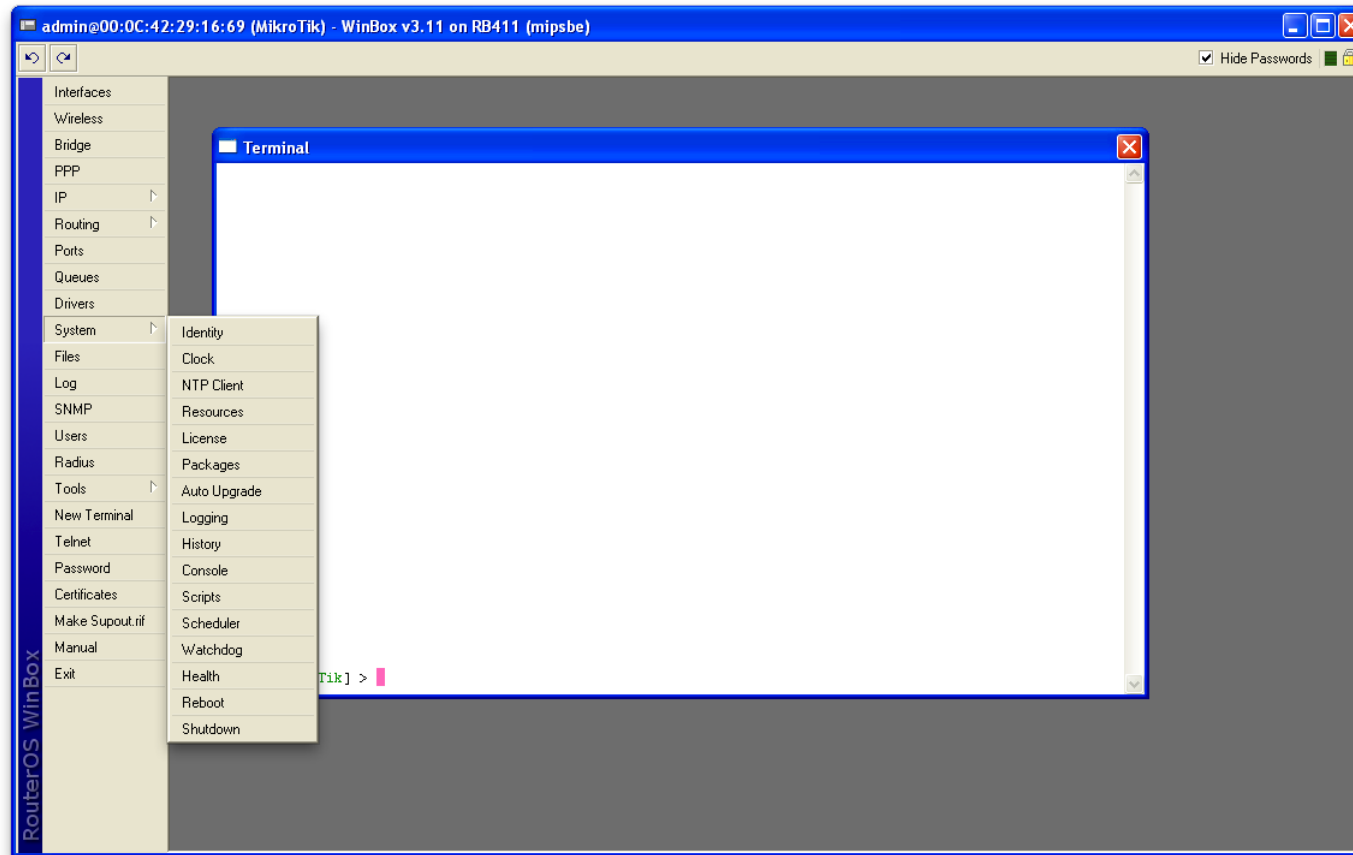
Download Latest Software



Upgrade Using Winbox



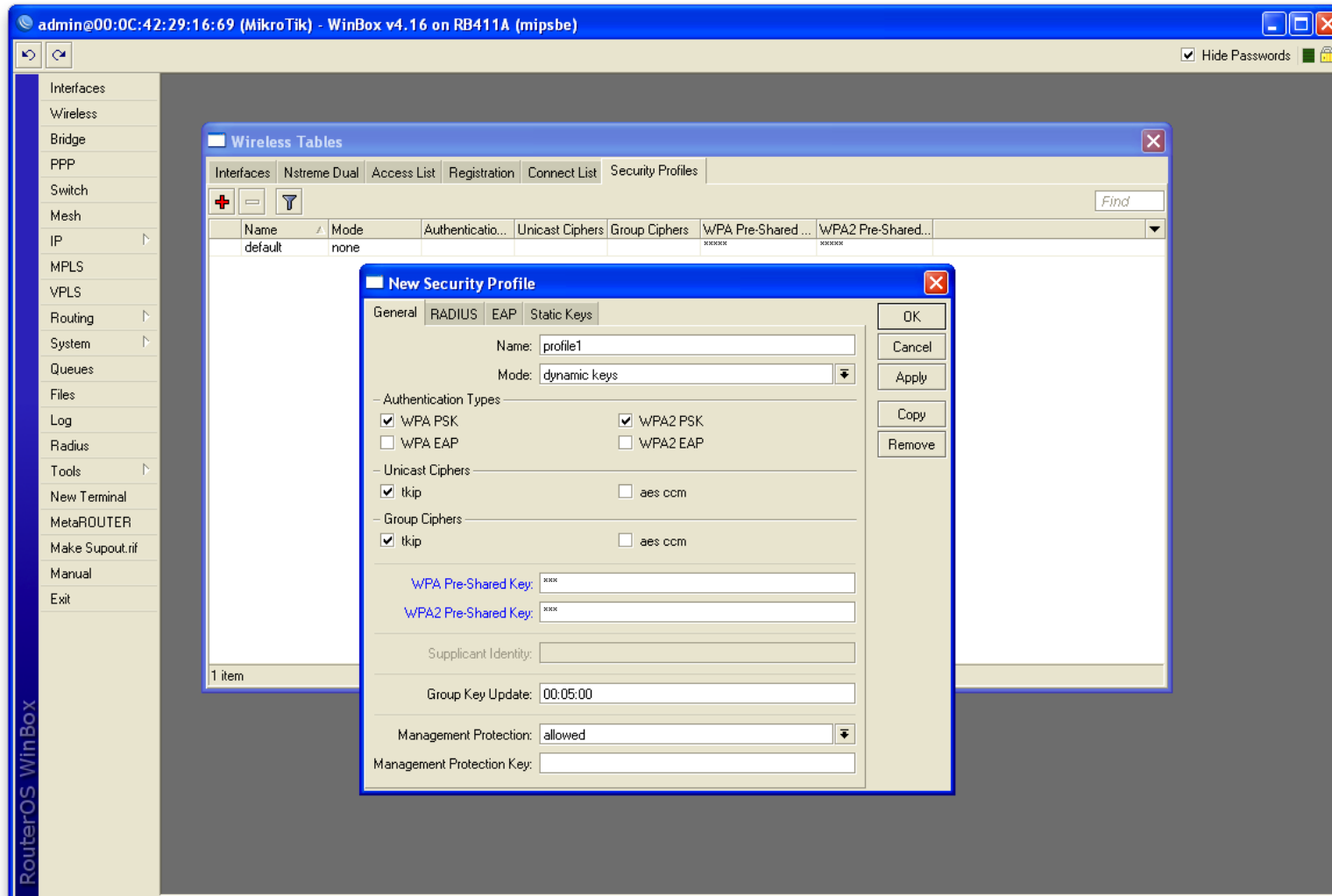
Reboot to Upgrade (x2)



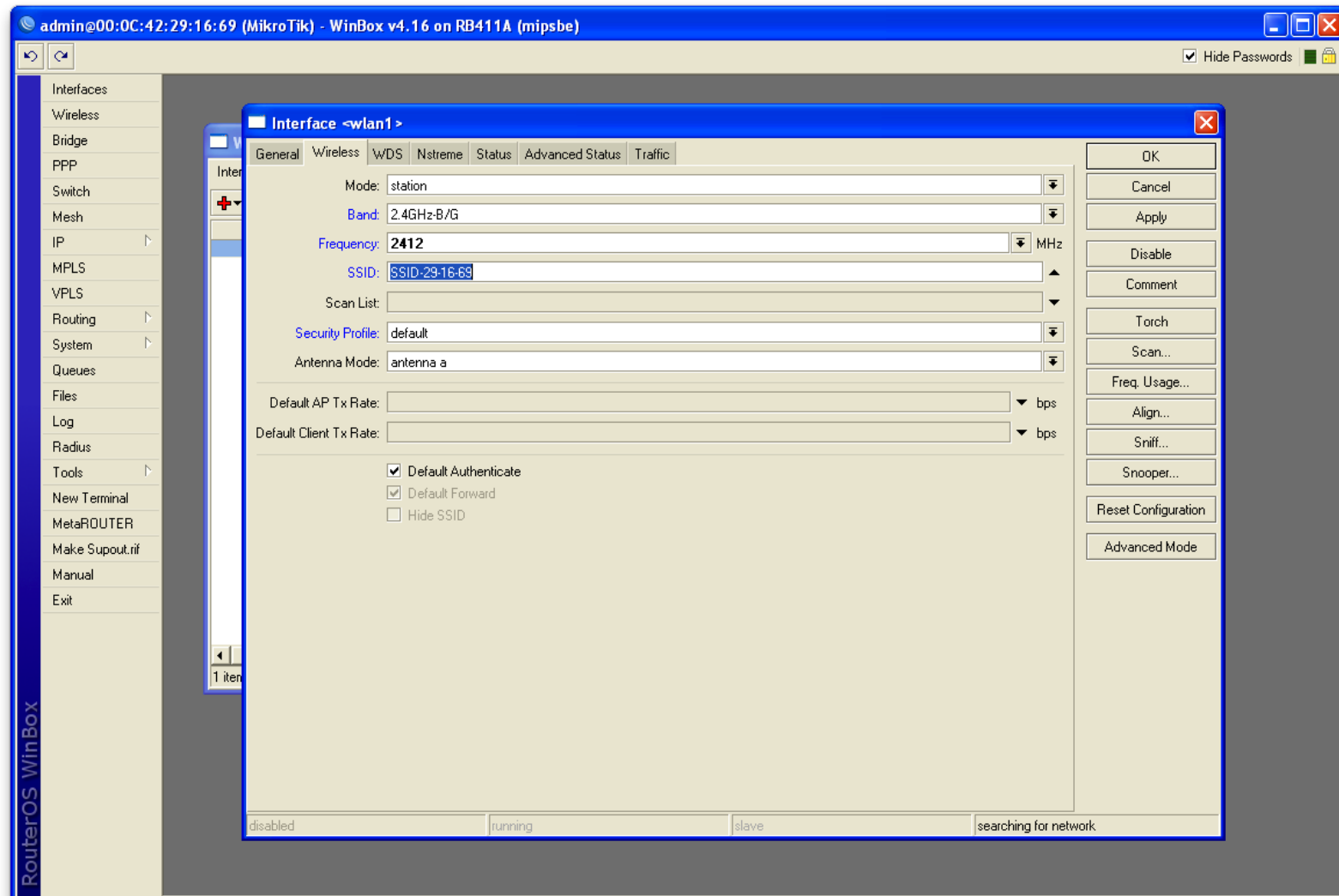
Making a Simple Hotspot

- Make a Security Profile
- Assign a unique SSID
- Choose an unused channel
- Make the wireless interface an AP
- Bridge the Wireless interface to the Ethernet

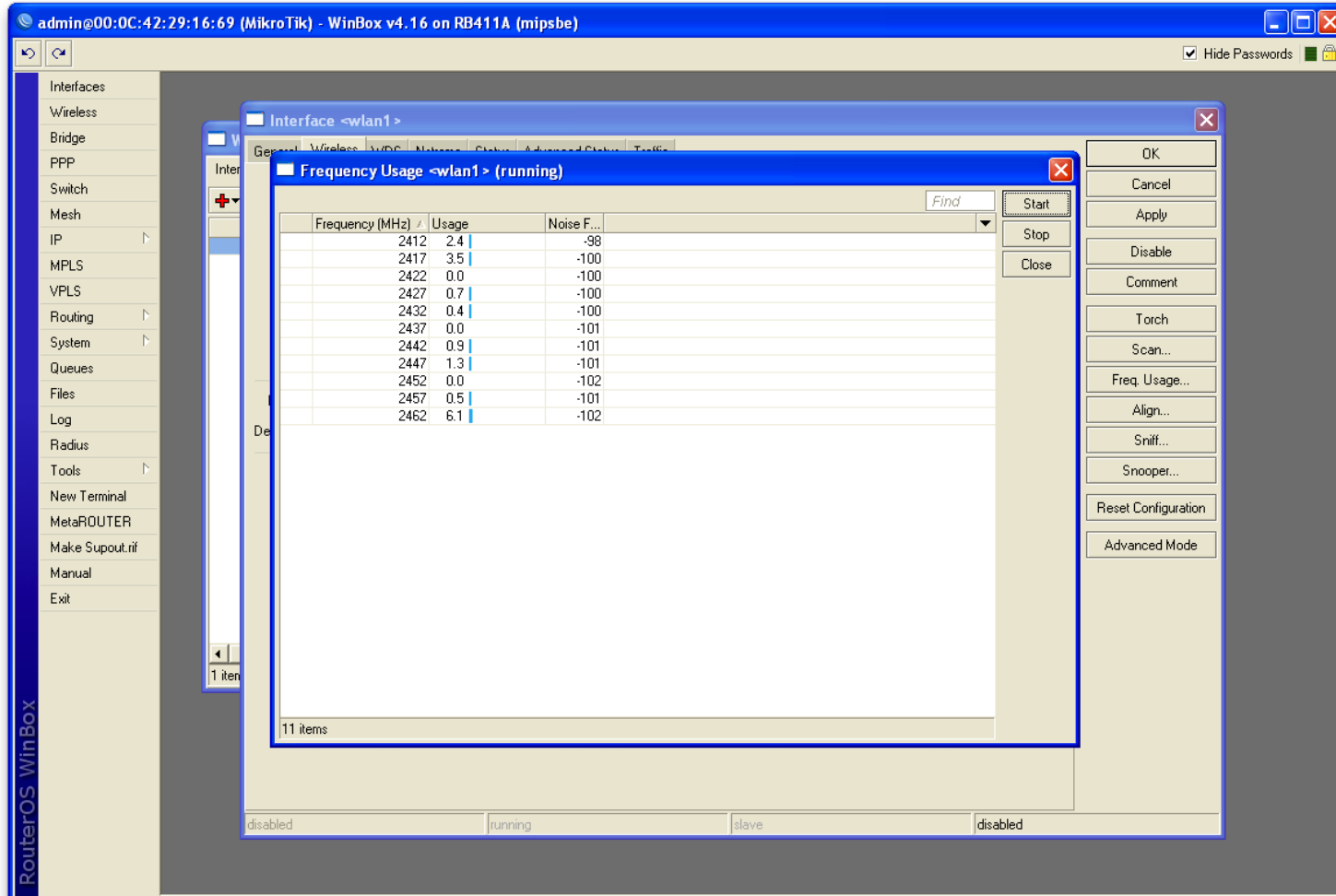
Make a Security Profile



Assign a Unique SSID



Choose an Unused Channel

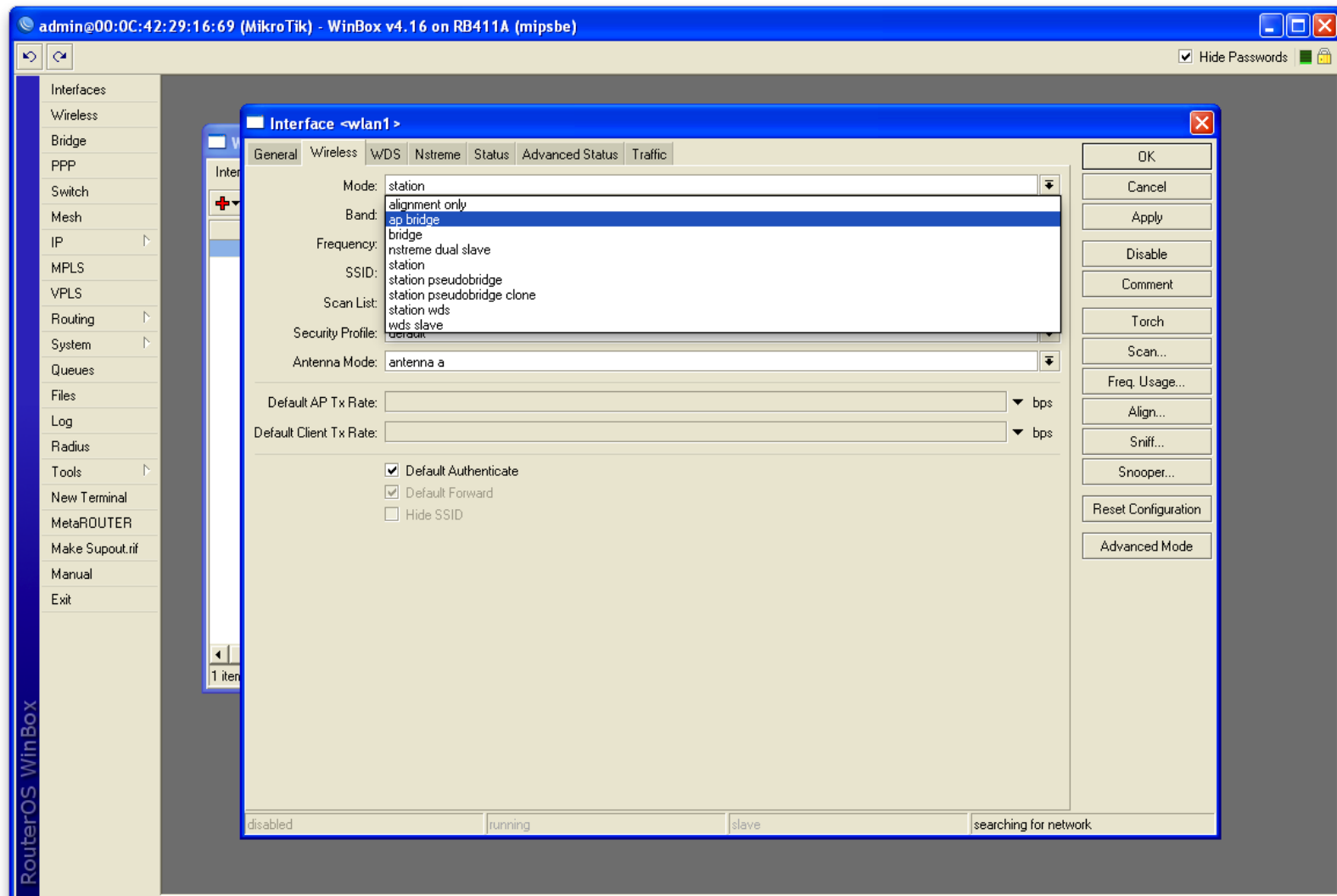


The screenshot shows the Mikrotik WinBox interface. The left sidebar contains a menu with options: Interfaces, Wireless, Bridge, PPP, Switch, Mesh, IP, MPLS, VPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, MetaROUTER, Make Supout.tif, Manual, and Exit. The main window displays the 'Interface <wlan1>' configuration page. A 'Frequency Usage <wlan1> (running)' window is open, showing a table of frequency usage data. The table has three columns: Frequency (MHz), Usage, and Noise Floor (dBm). The data is as follows:

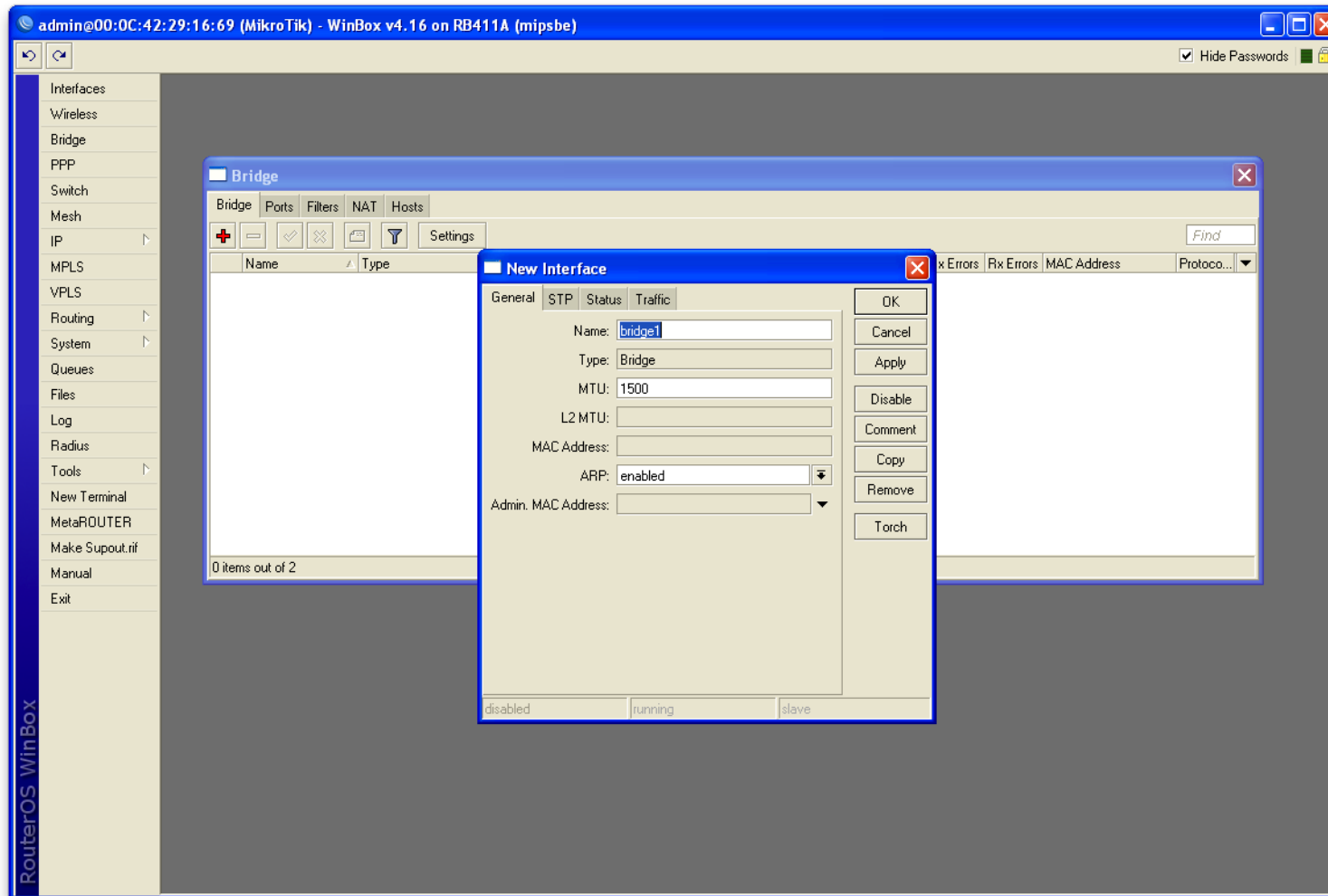
Frequency (MHz)	Usage	Noise Floor (dBm)
2412	2.4	-98
2417	3.5	-100
2422	0.0	-100
2427	0.7	-100
2432	0.4	-100
2437	0.0	-101
2442	0.9	-101
2447	1.3	-101
2452	0.0	-102
2457	0.5	-101
2462	6.1	-102

The window also includes a 'Find' search bar, 'Start', 'Stop', and 'Close' buttons. On the right side of the window, there are buttons for 'OK', 'Cancel', 'Apply', 'Disable', 'Comment', 'Torch', 'Scan...', 'Freq. Usage...', 'Align...', 'Sniff...', 'Snooper...', 'Reset Configuration', and 'Advanced Mode'. The status bar at the bottom of the window shows 'disabled', 'running', 'slave', and 'disabled'.

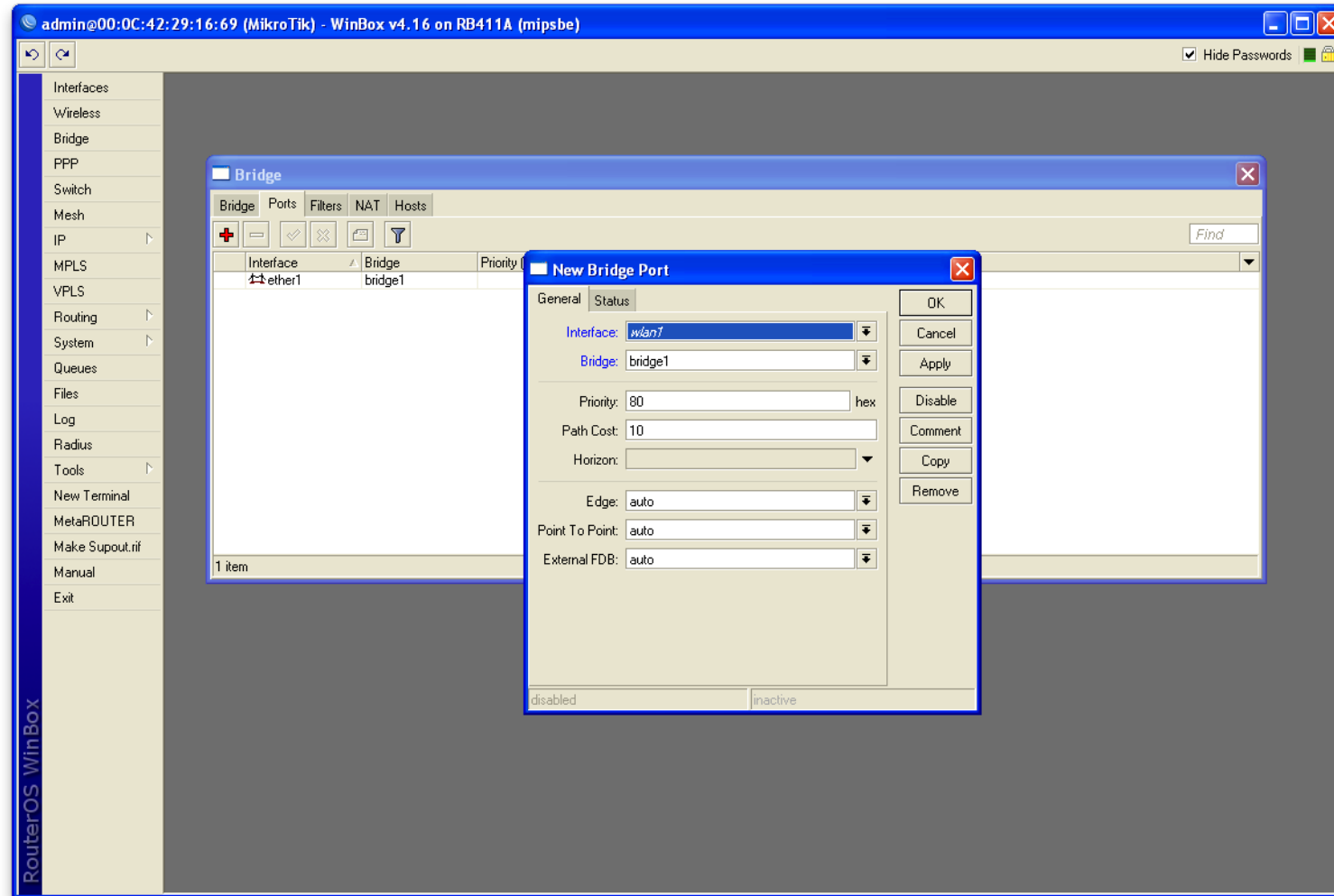
Make WLAN an AP



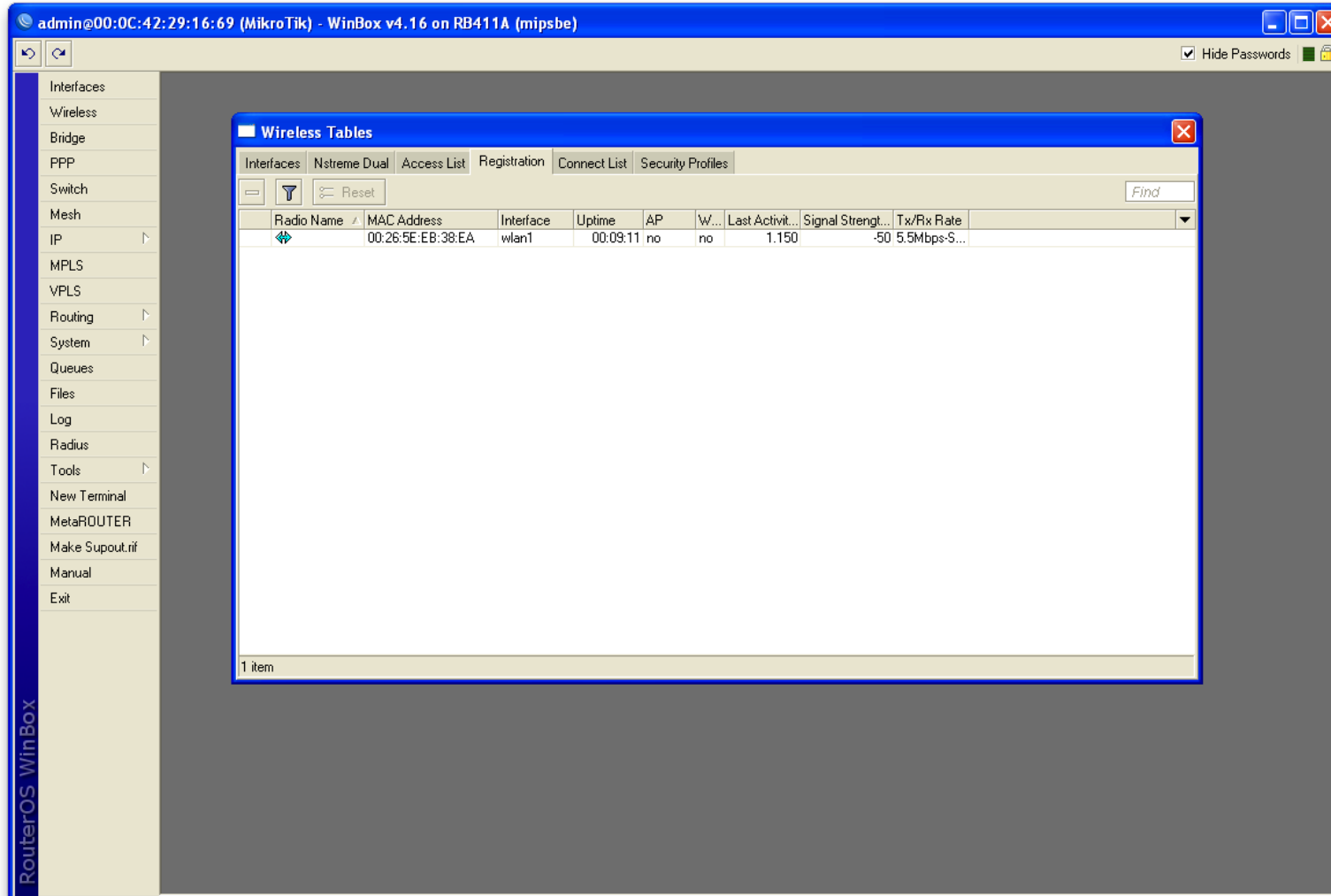
Create a Bridge




Add wlan and Ether to Bridge



Associate & Check RSSI

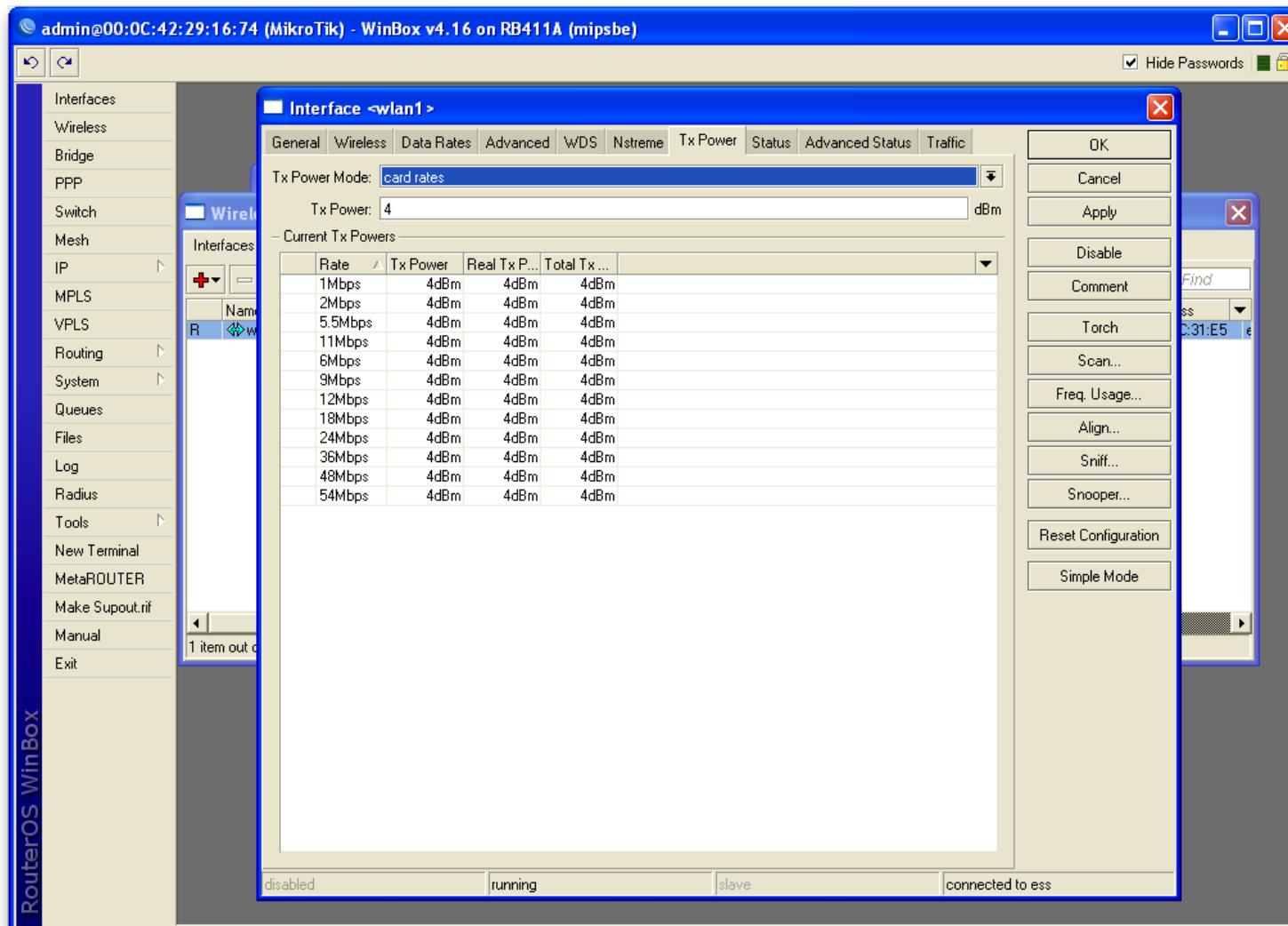


The screenshot shows the Mikrotik WinBox v4.16 interface. The left sidebar contains a menu with options: Interfaces, Wireless, Bridge, PPP, Switch, Mesh, IP, MPLS, VPLS, Routing, System, Queues, Files, Log, Radius, Tools, New Terminal, MetaROUTER, Make Supout.tif, Manual, and Exit. The main window displays the 'Wireless Tables' window, which has tabs for Interfaces, Nstreme Dual, Access List, Registration, Connect List, and Security Profiles. The 'Access List' tab is selected, showing a table with the following data:

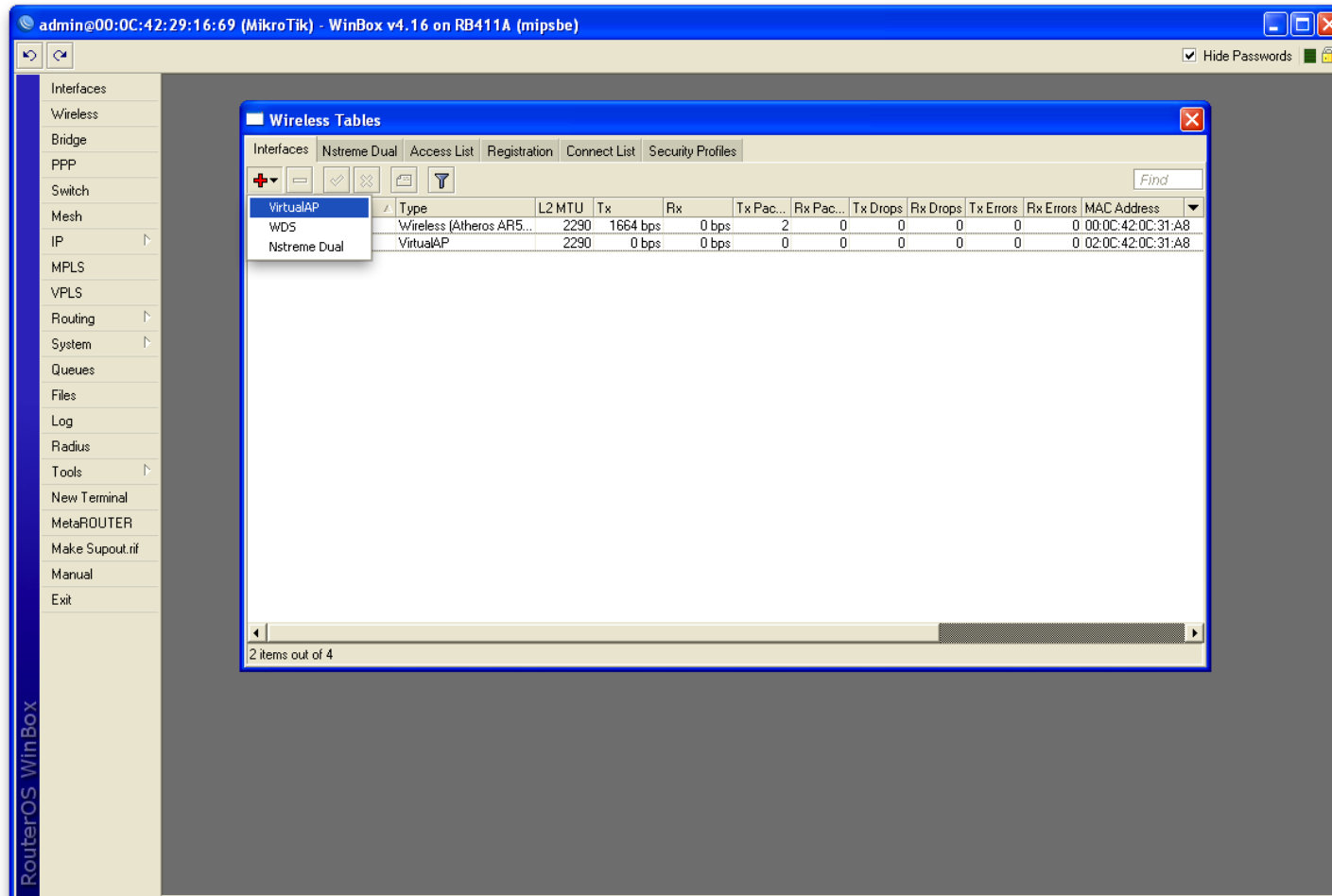
Radio Name	MAC Address	Interface	Uptime	AP	W...	Last Activit...	Signal Strengt...	Tx/Rx Rate
	00:26:5E:EB:38:EA	wlan1	00:09:11	no	no	1.150	-50	5.5Mbps-S...

At the bottom of the table, it indicates '1 item'.

Adjust Power Levels Down?



More Complex? Virtual AP



admin@00:0C:42:29:16:69 (MikroTik) - WinBox v4.16 on RB411A (mipsbe)

Wireless Tables

Interfaces | Nstreme Dual | Access List | Registration | Connect List | Security Profiles

Find

Type	L2 MTU	Tx	Rx	Tx Pac...	Rx Pac...	Tx Drops	Rx Drops	Tx Errors	Rx Errors	MAC Address
WDS	Wireless (Atheros AR5...	2290	1664 bps	0 bps	2	0	0	0	0	00:0C:42:0C:31:A8
Nstreme Dual	VirtualAP	2290	0 bps	0 bps	0	0	0	0	0	02:0C:42:0C:31:A8

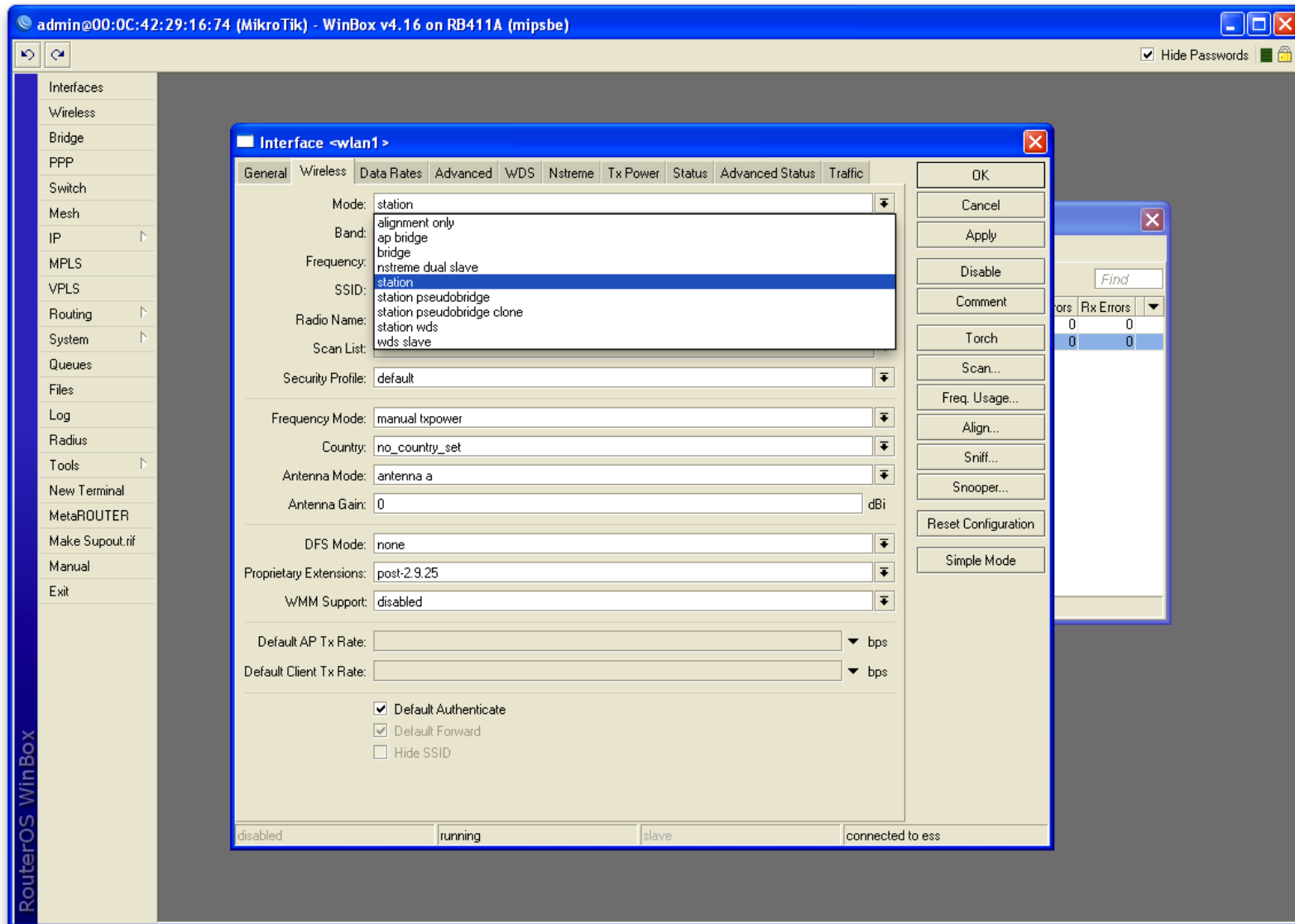
2 items out of 4

Microwave Radio Linking
With Mikrotik

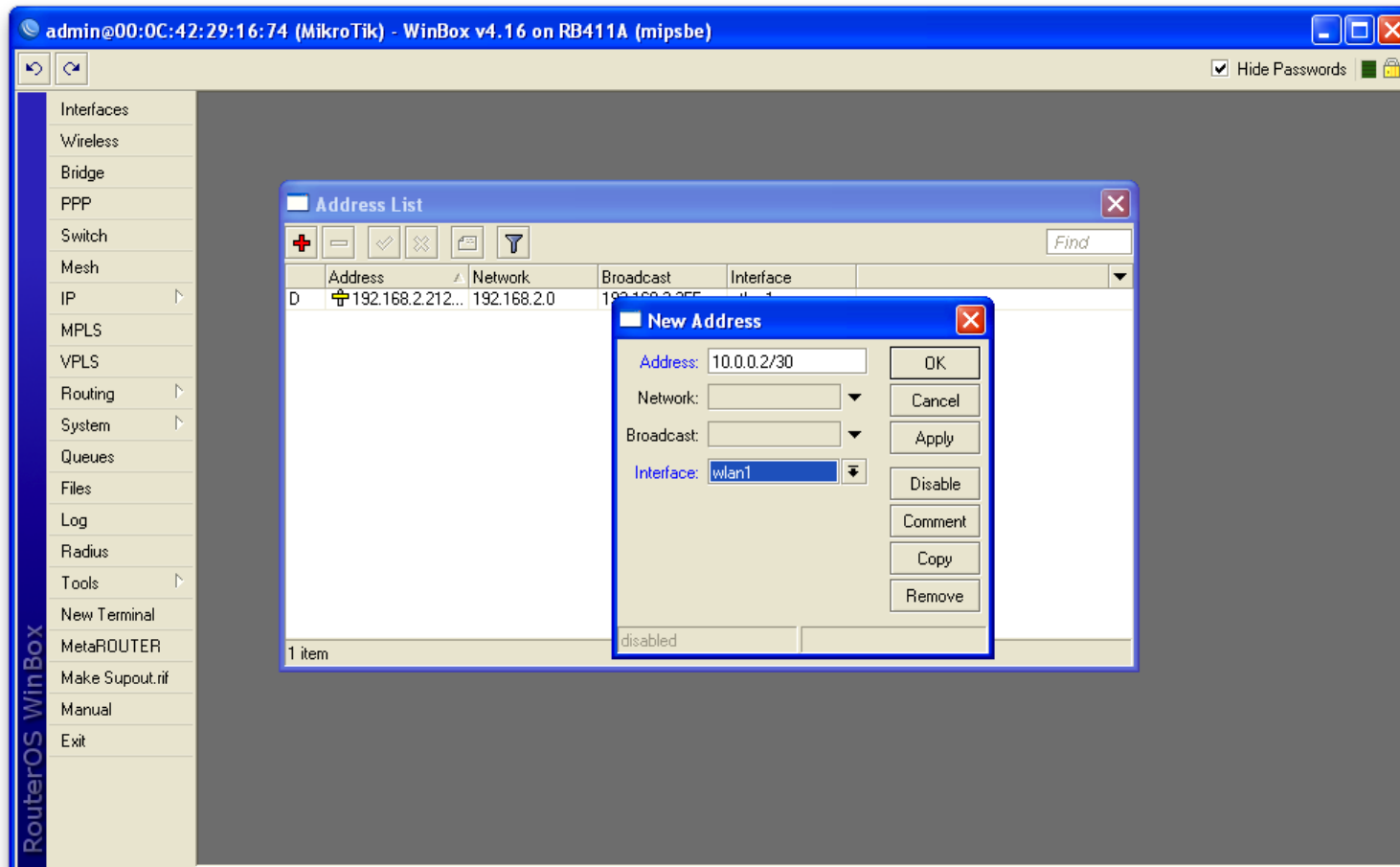
Transparent Bridge

- Two methods
 - Easy = Station Pseudobridge
 - Fails for Ipv6, ugly hack
 - Harder = EoIP + Bridging
 - Just works, even for jumbo frames to 2200 bytes
 - Adds CPU overhead, but we have plenty of CPU

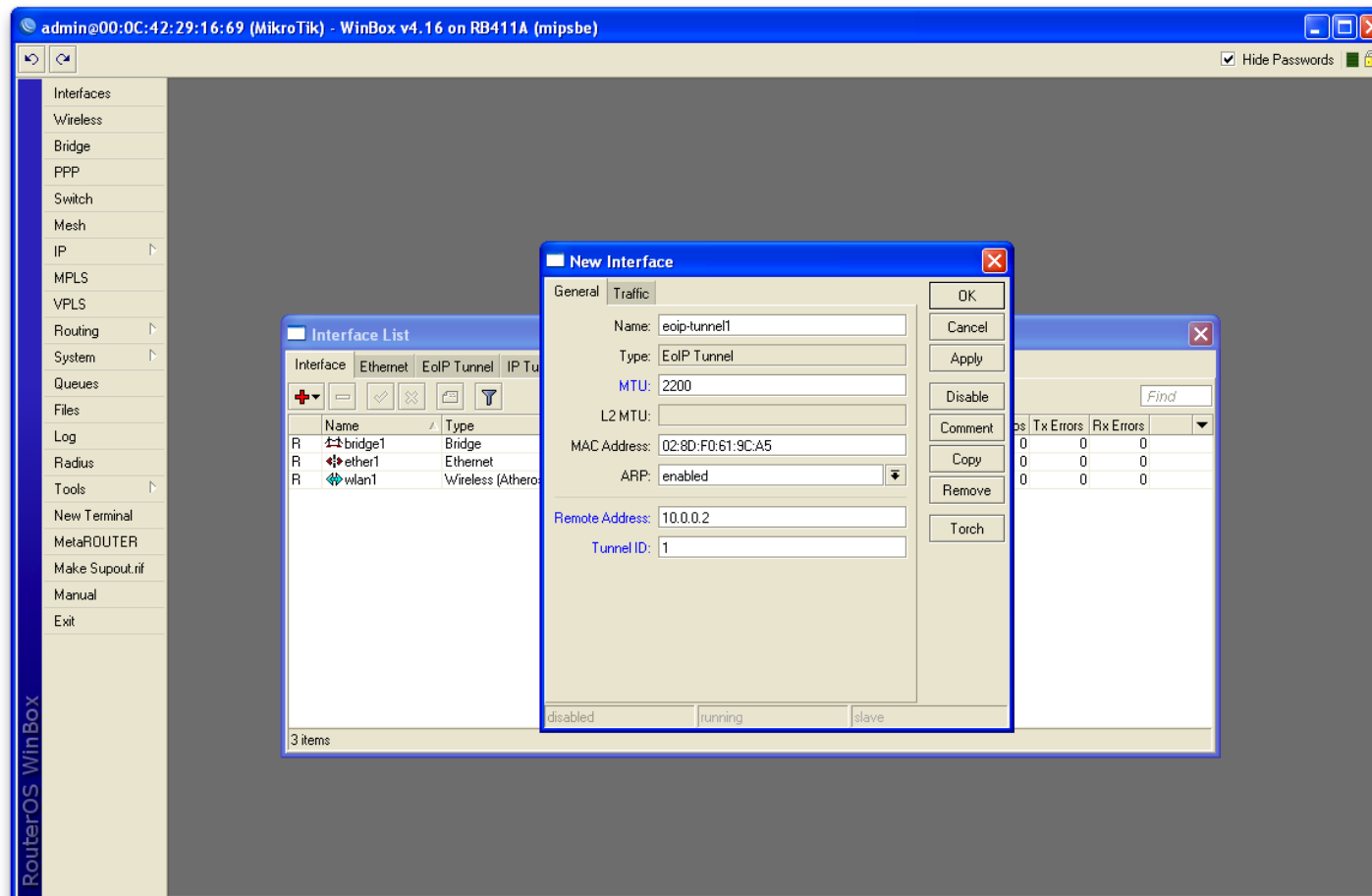
Set Up a Station



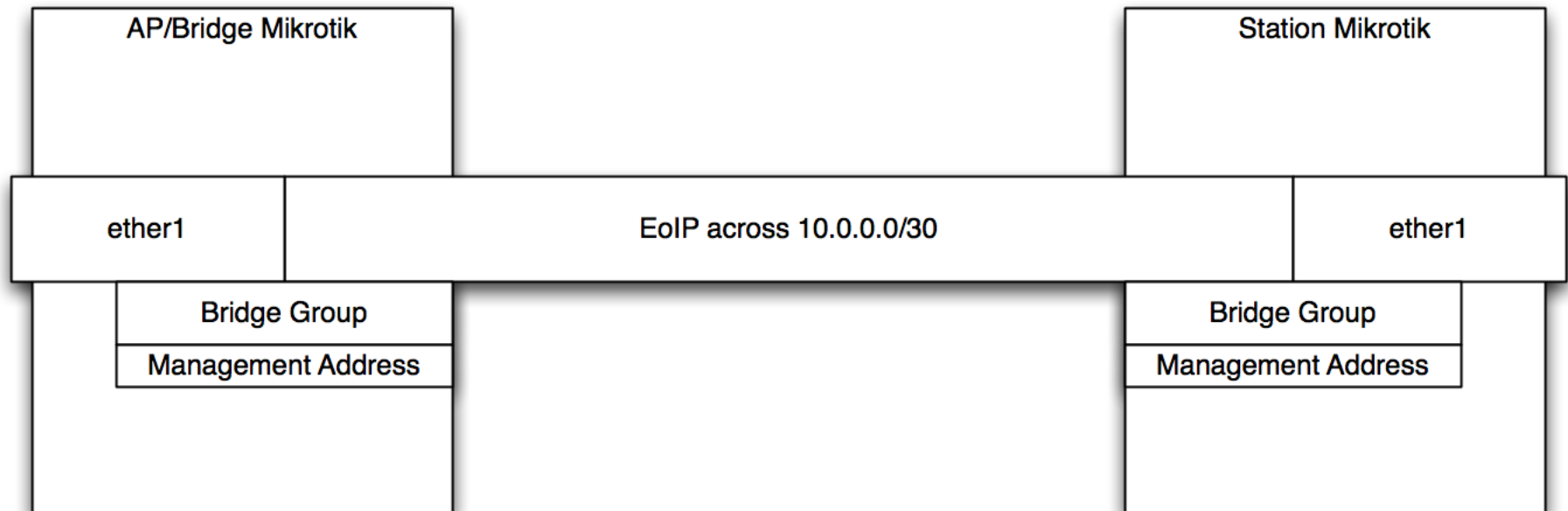
Add a /30 to the wlan Interfaces

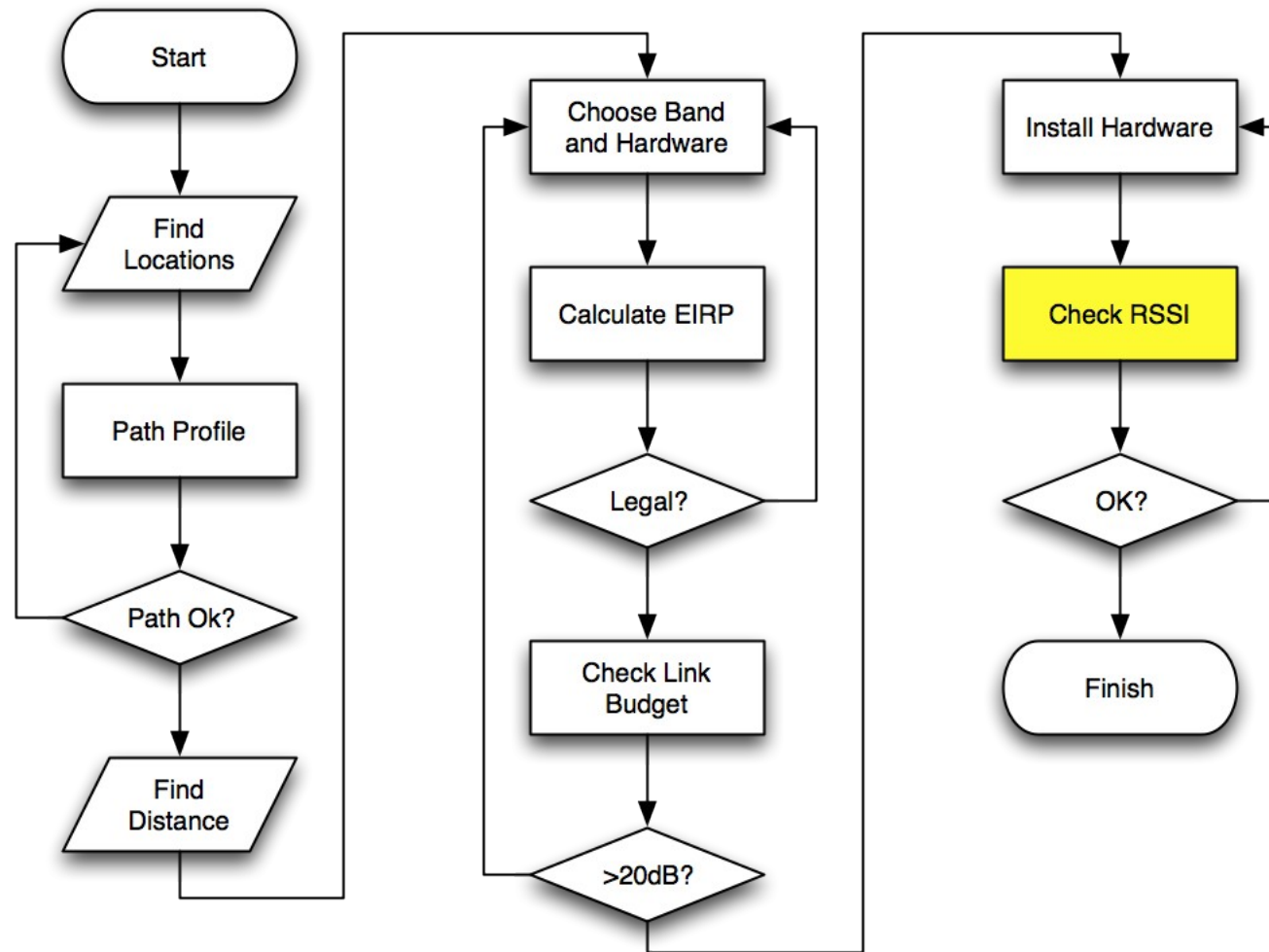


EoIP Tunnel Between Radios

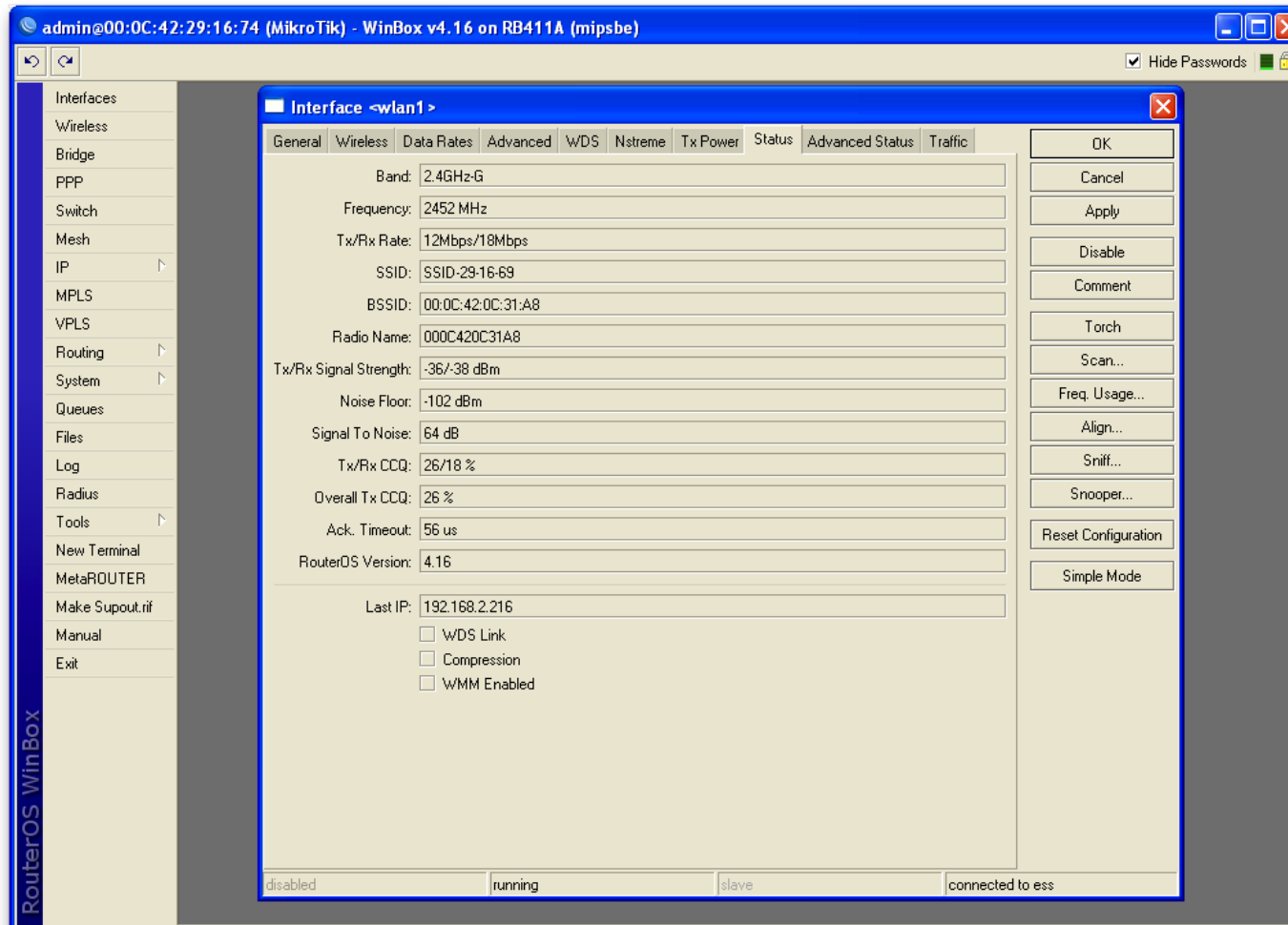


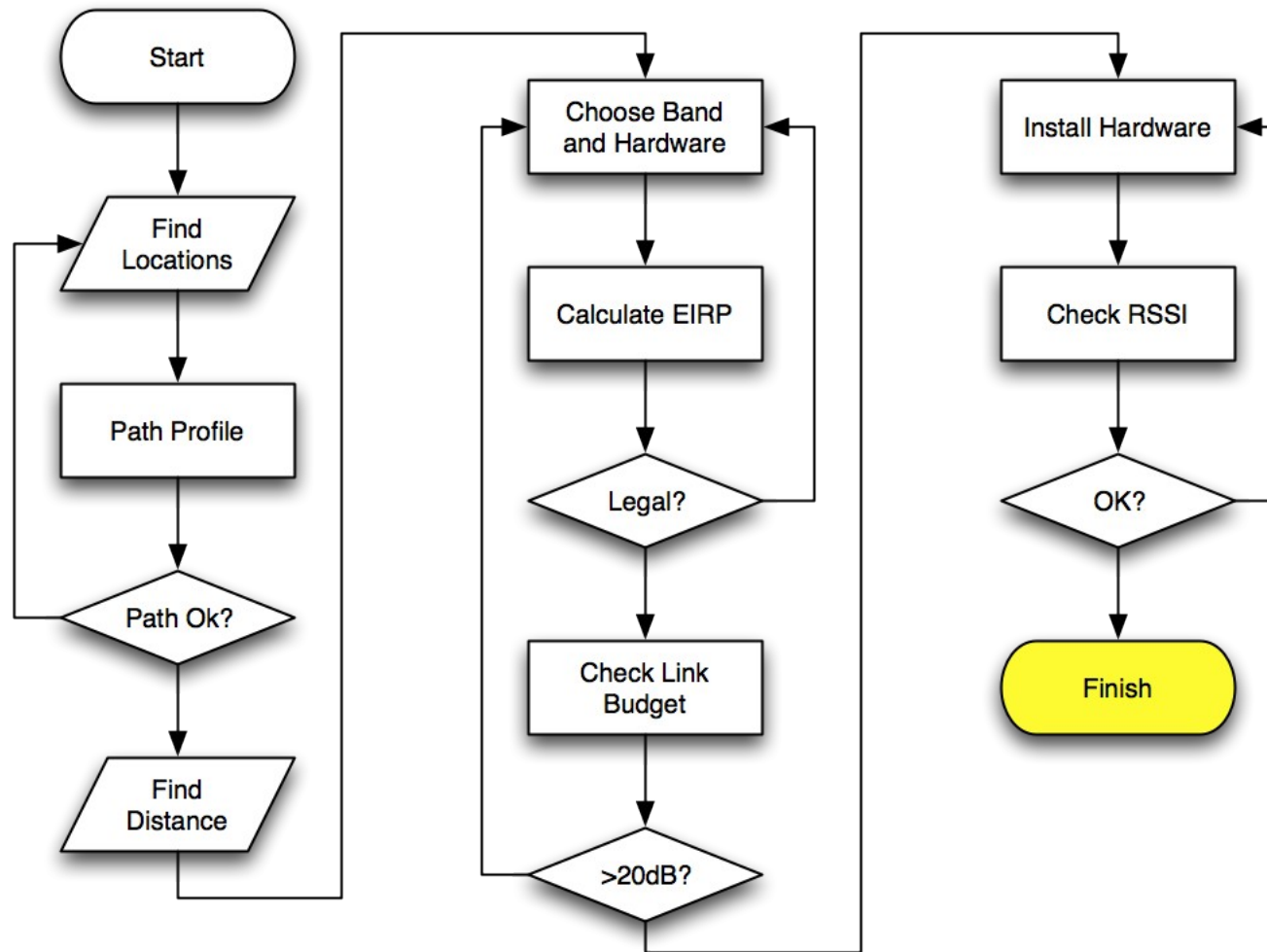
EoIP Bridged to Ethernet





Check RSSI Against Calcs





Further Reading

- SRD Regulations: <http://www.rsm.govt.nz/cms/licensees/types-of-licence/general-user-licences/short-range-devices>
- RF Link Budget Calculator: <http://www.afar.net/rf-link-budget-calculator/>
- EIRP Calculator: <http://www.distributed-wireless.com/calculators/EIRP.html>
- Calculating dBm: <http://en.wikipedia.org/wiki/DBm>
- Calculating Link Budget: http://en.wikipedia.org/wiki/Link_budget
- Calculating Free Space Loss: http://en.wikipedia.org/wiki/Free-space_loss
- Mikrotik Software: <http://www.mikrotik.com/>