

# Building Point to Point Links With Mikrotik and RouterOS

Network Startup Resource Center  
[www.nsrc.org](http://www.nsrc.org)

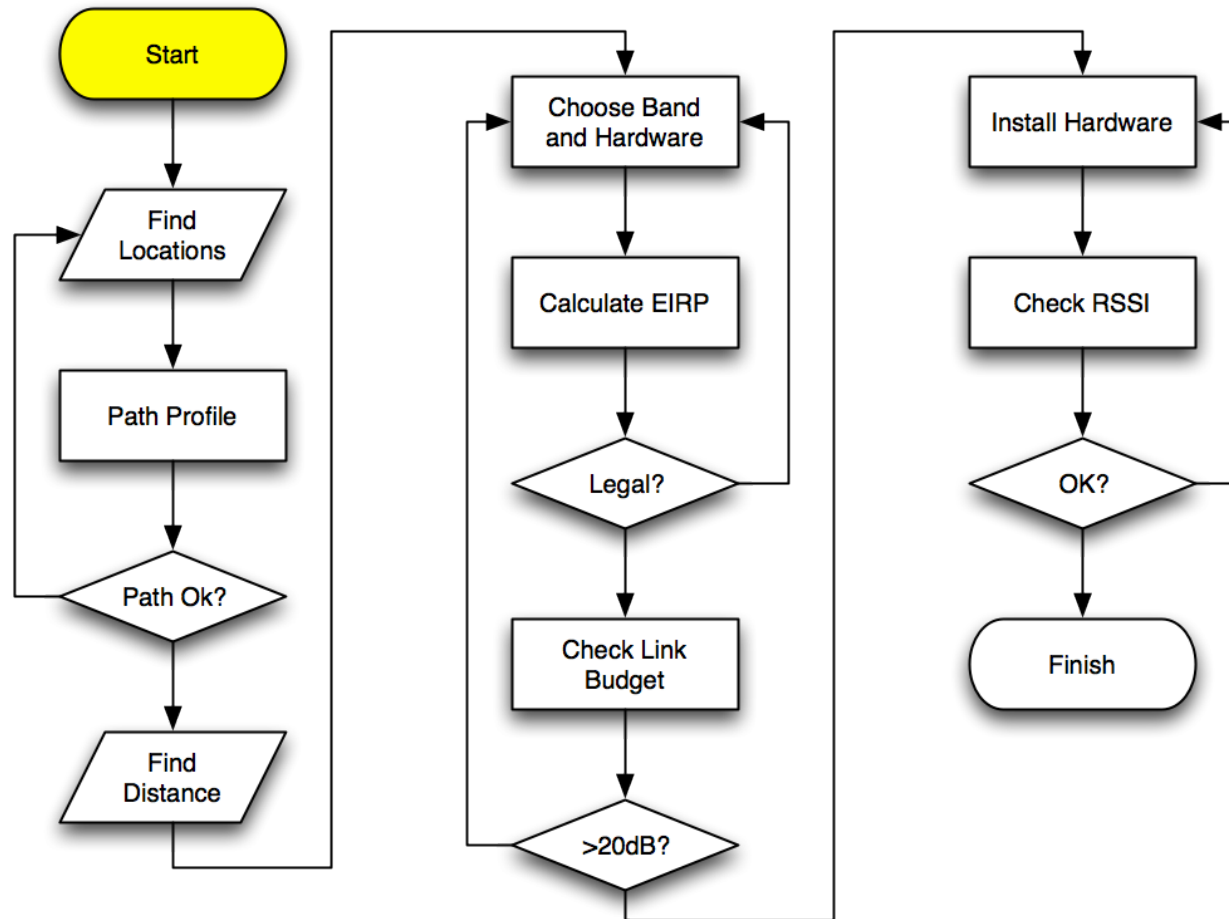


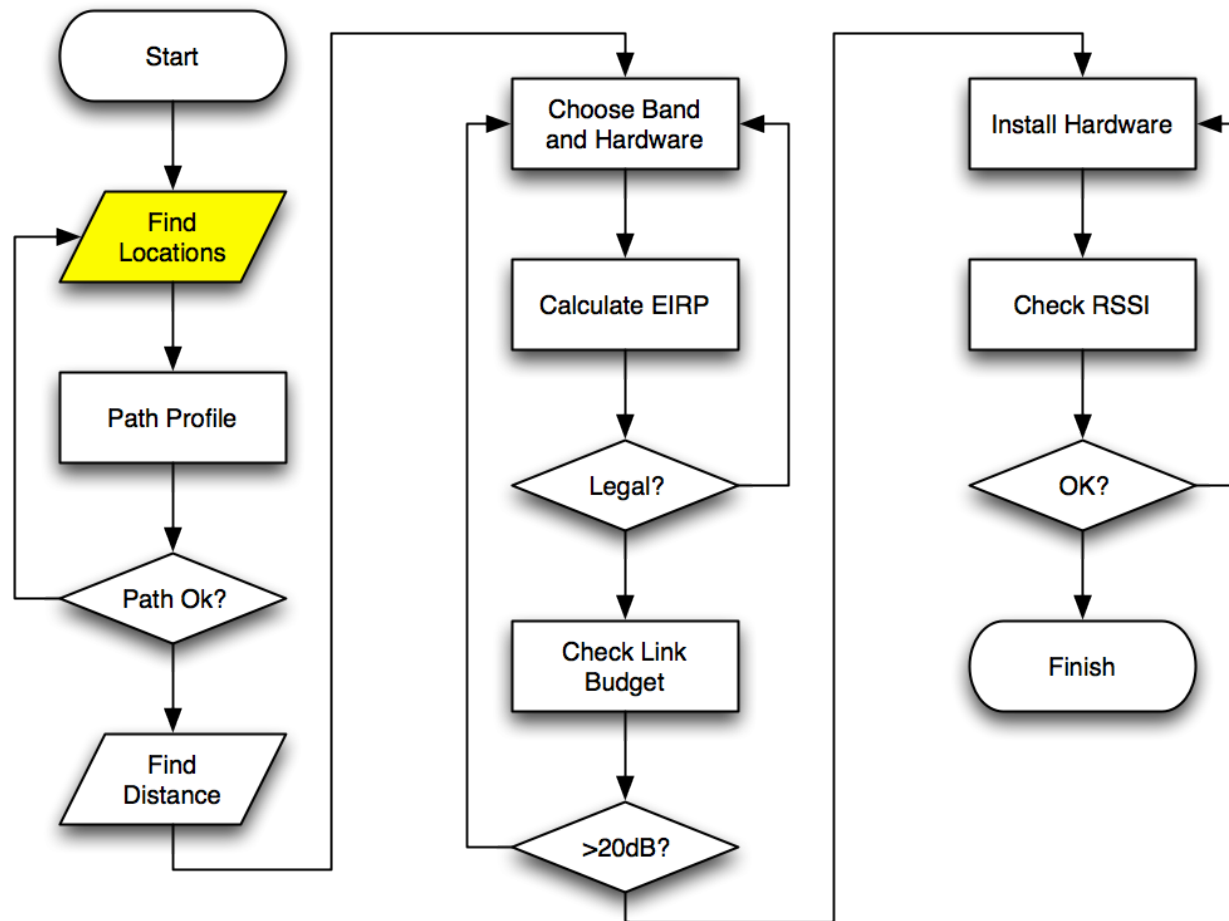
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# Planning the Link – Locations

## 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



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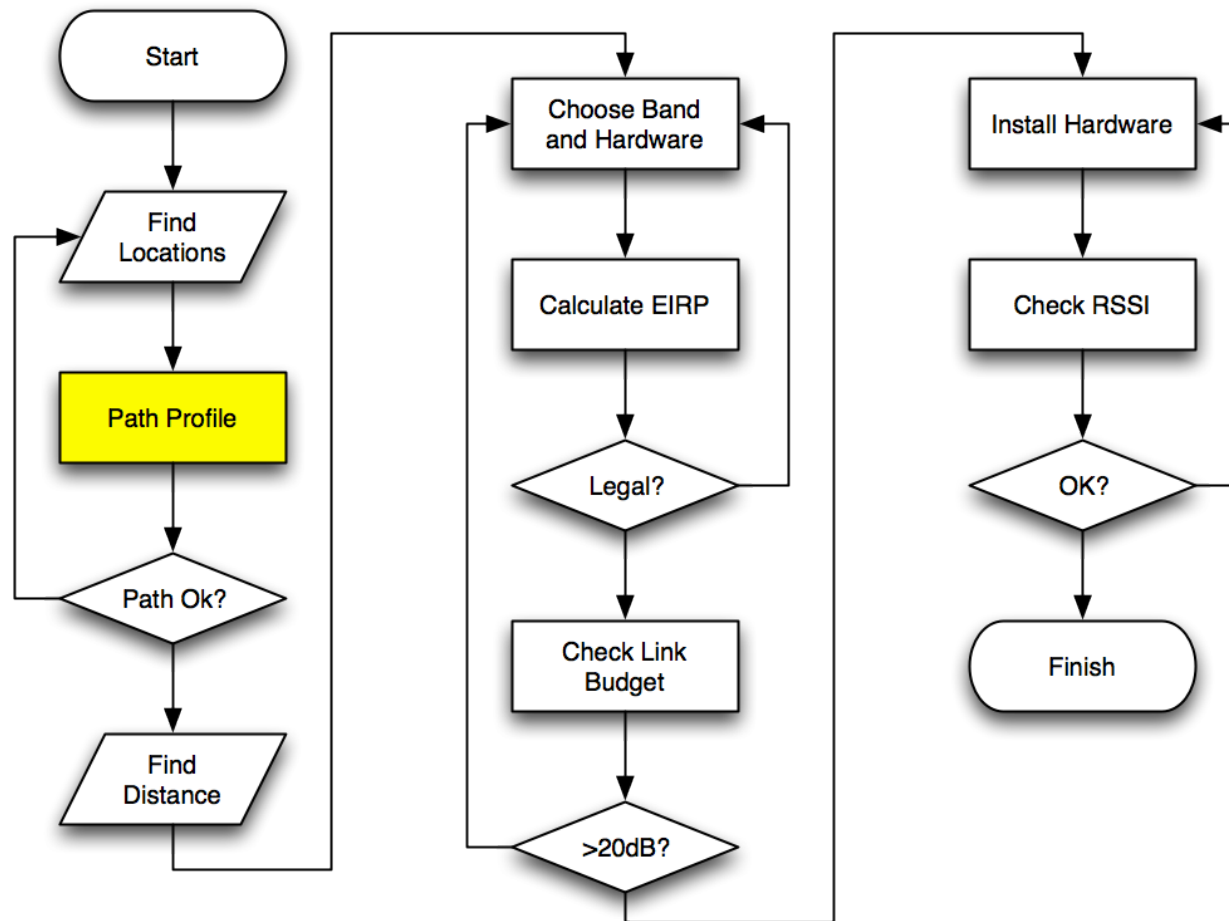
# Planning the Link – Example Locations

- Saipan to Tinan
- Tinan to Rota
- Rota to Guam
- Honiara to ...
- Suva to ...



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# Planning the Link – Profile

## Check the path profile

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

## Is there line of sight?

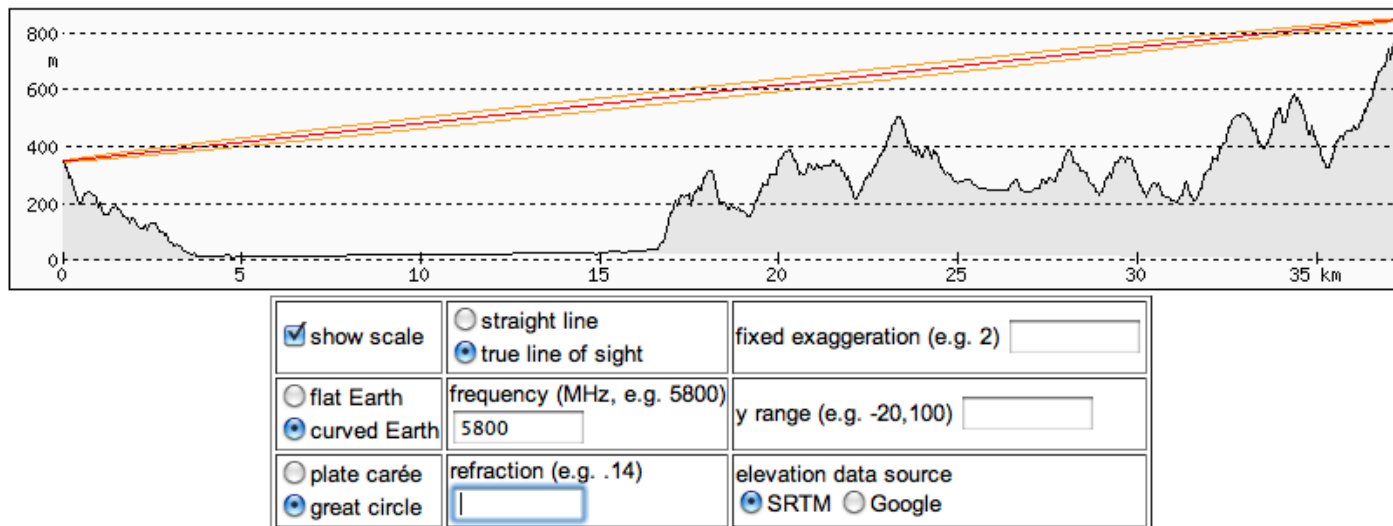
- What's a Fresnel zone?
- Is the Fresnel zone clear?



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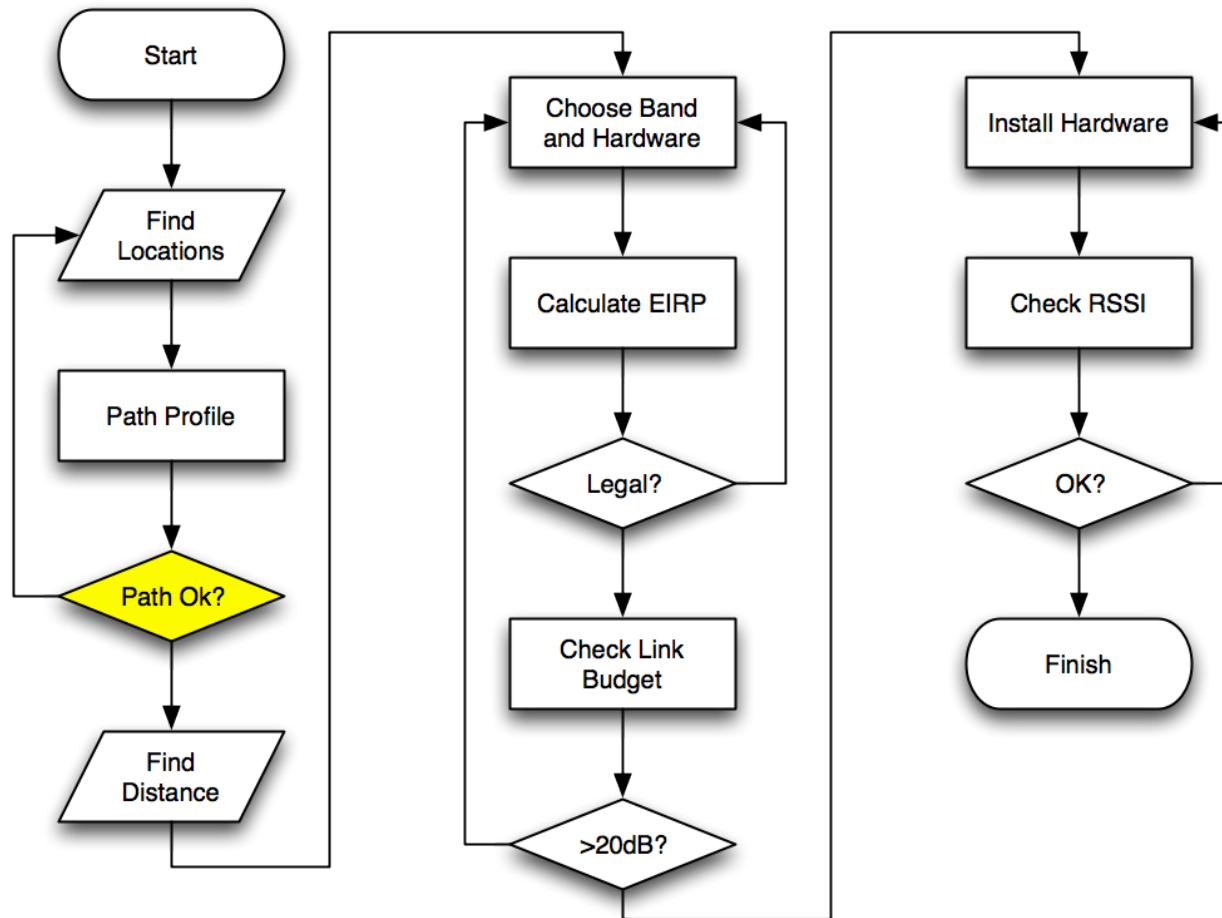
# Planning the Link – Profile



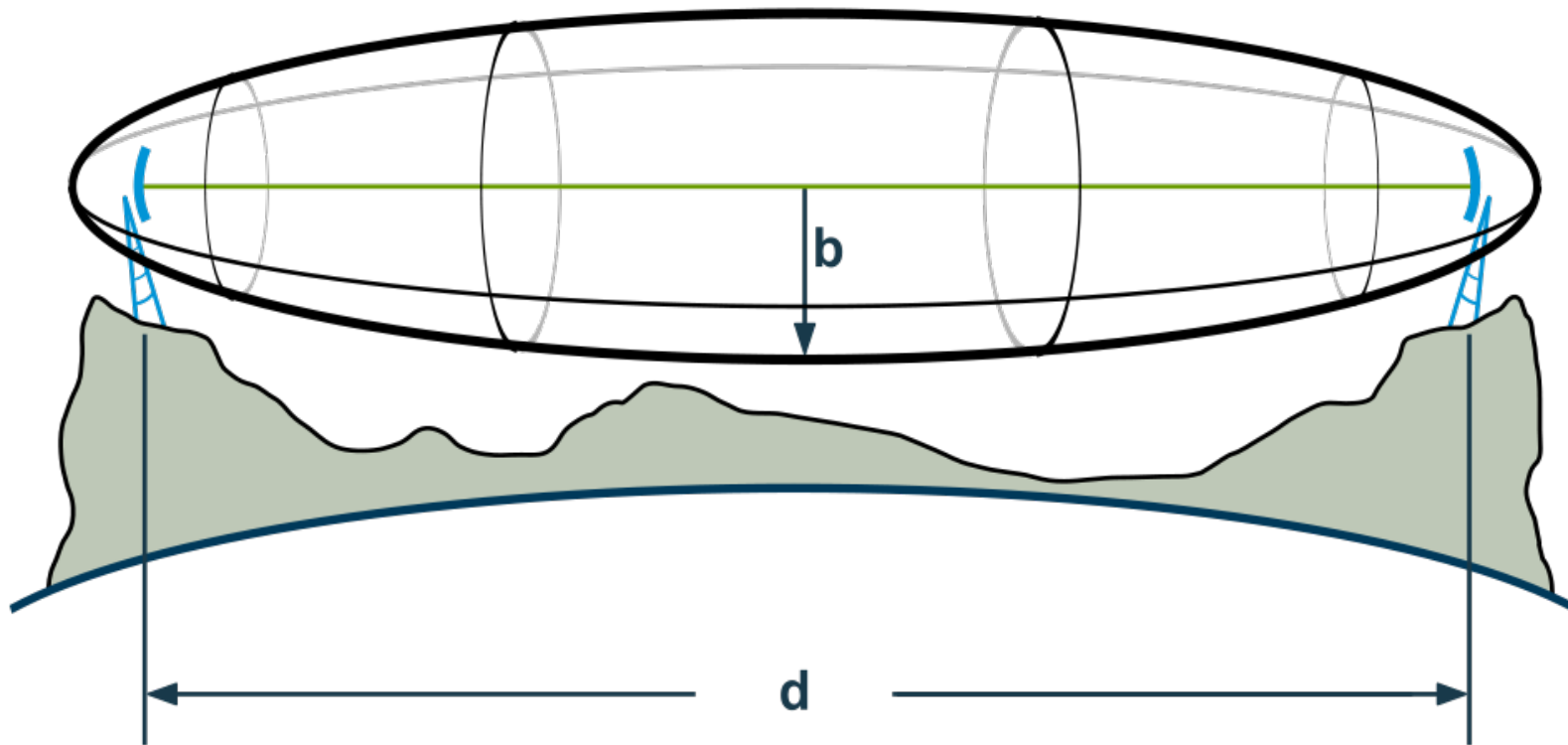
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# Planning the Link - Fresnel

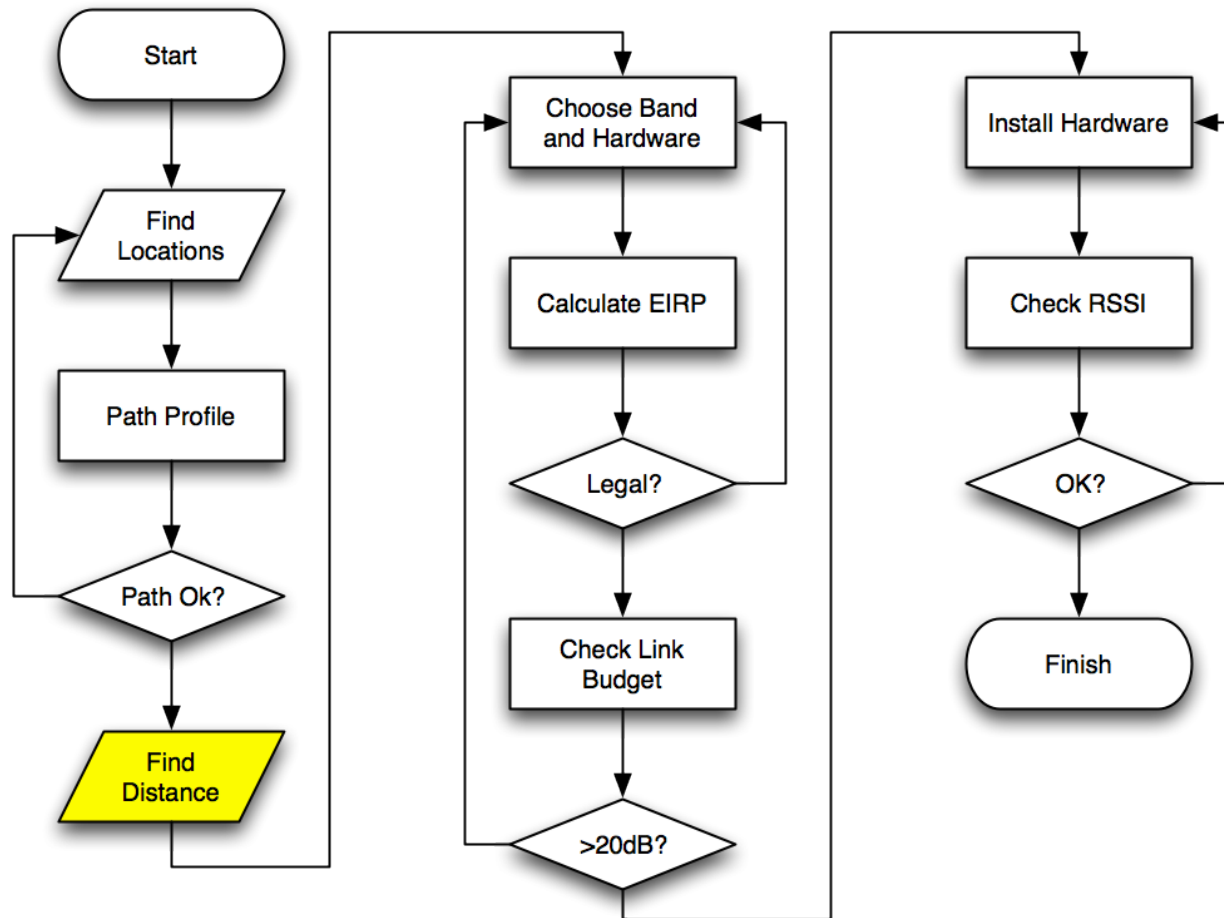


Licensed under the GFDL by Averse - <http://en.wikipedia.org/wiki/File:FresnelSVG.svg>



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# Planning the Link - Distance

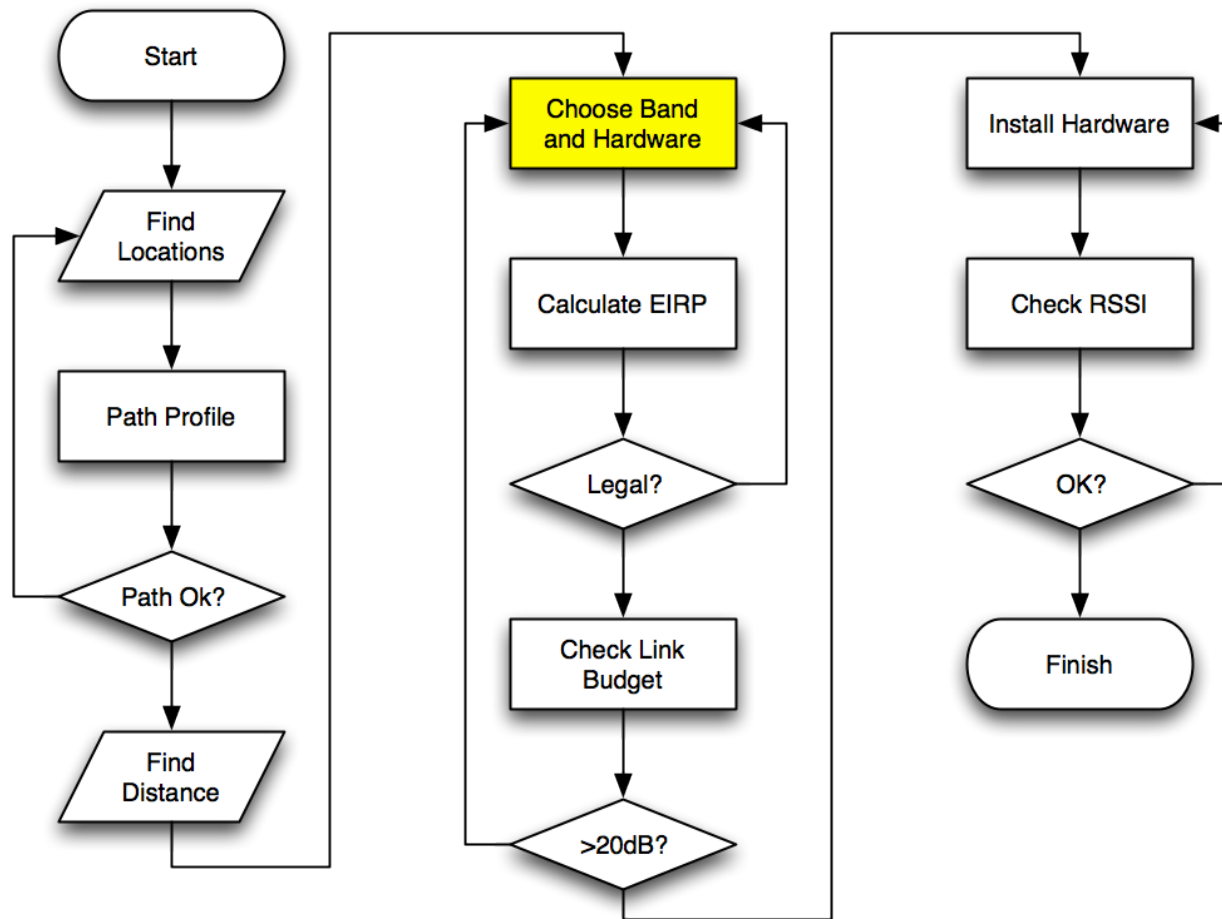
## Find the path distance

- In kilometres – always!
- Required for decision on band
- Later required for link budget
- Example Rota to Saipan xx kilometers



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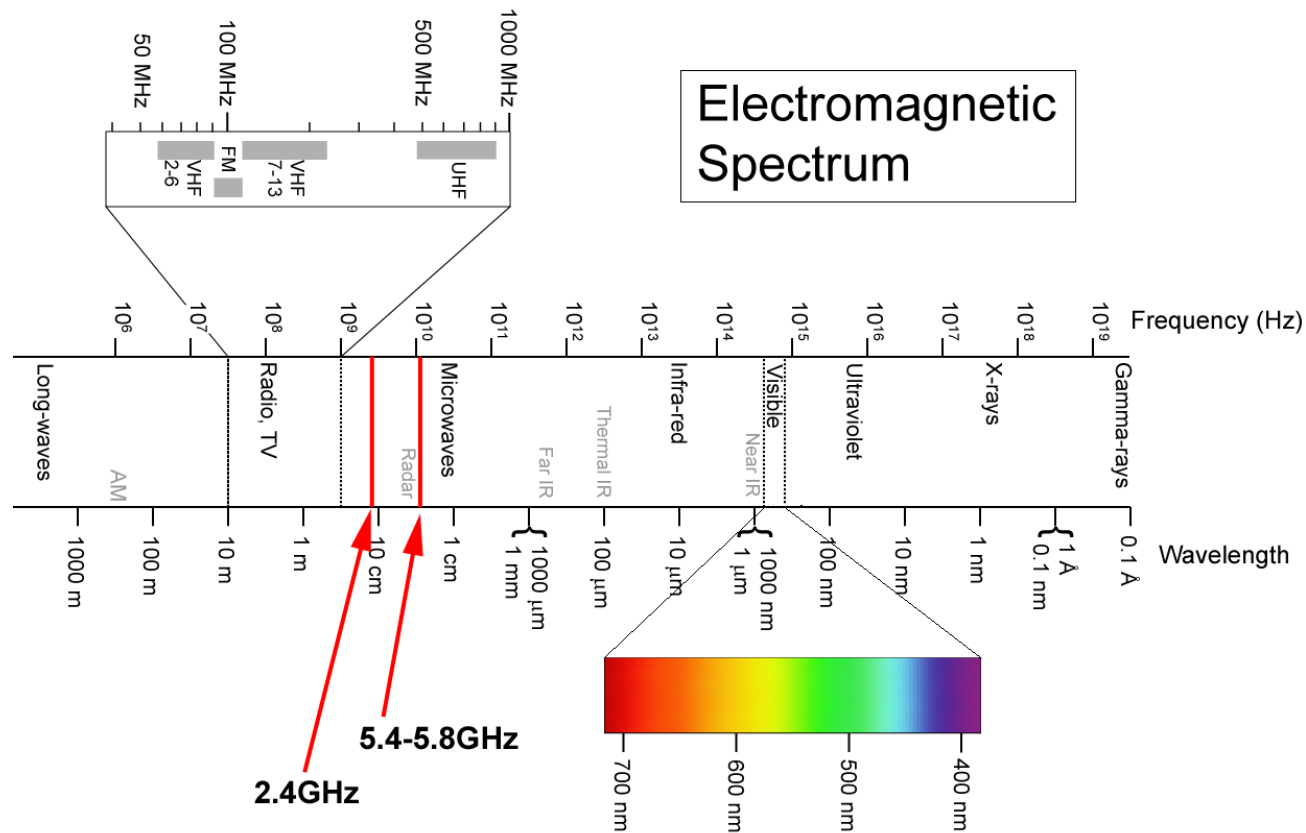


# NZ Bands & Power Limits

- 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



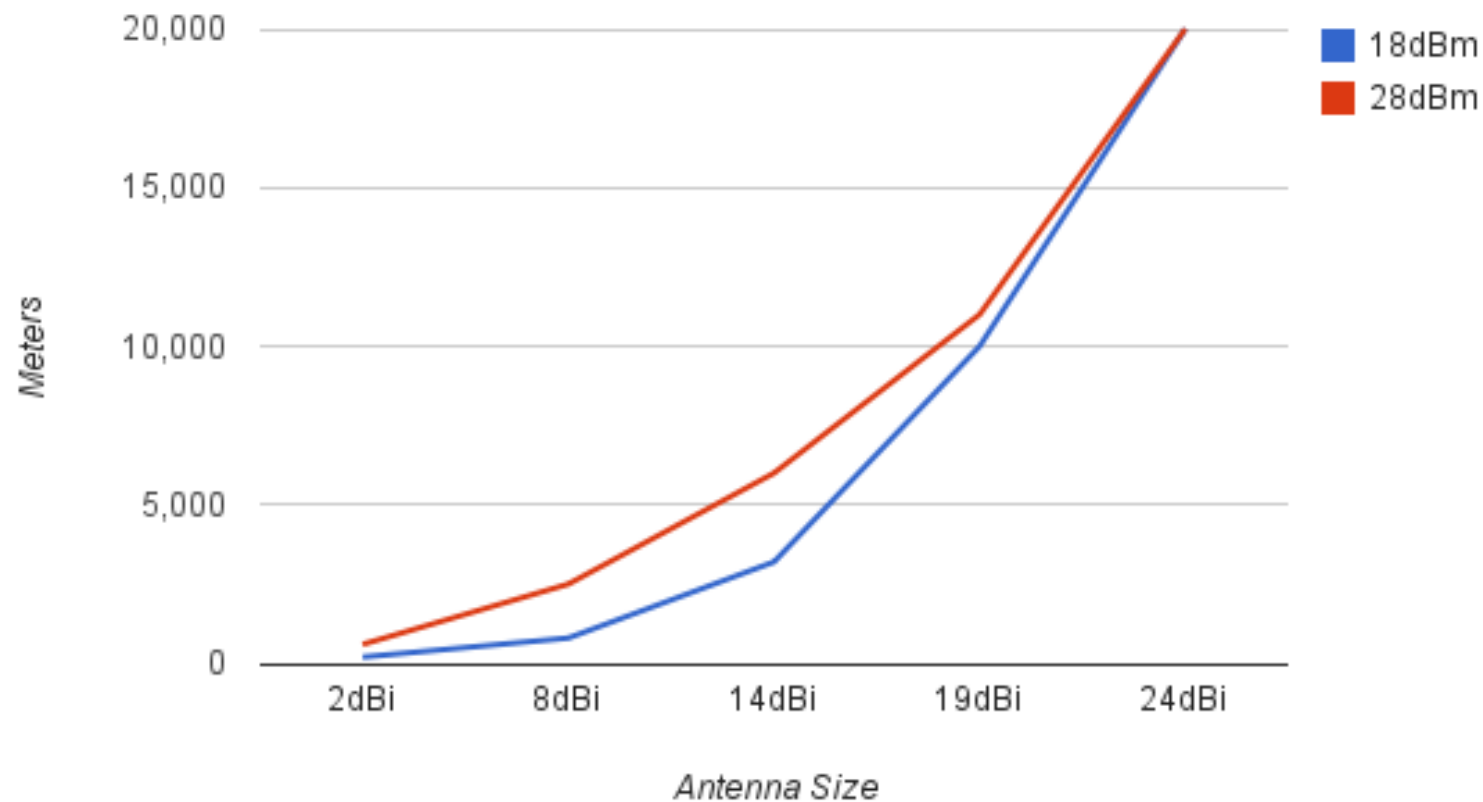
Creative Commons Share-Alike 2.5 - <http://en.wikipedia.org/wiki/File:Electromagnetic-Spectrum.png>



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# 2.4GHz for P-P, P-MP

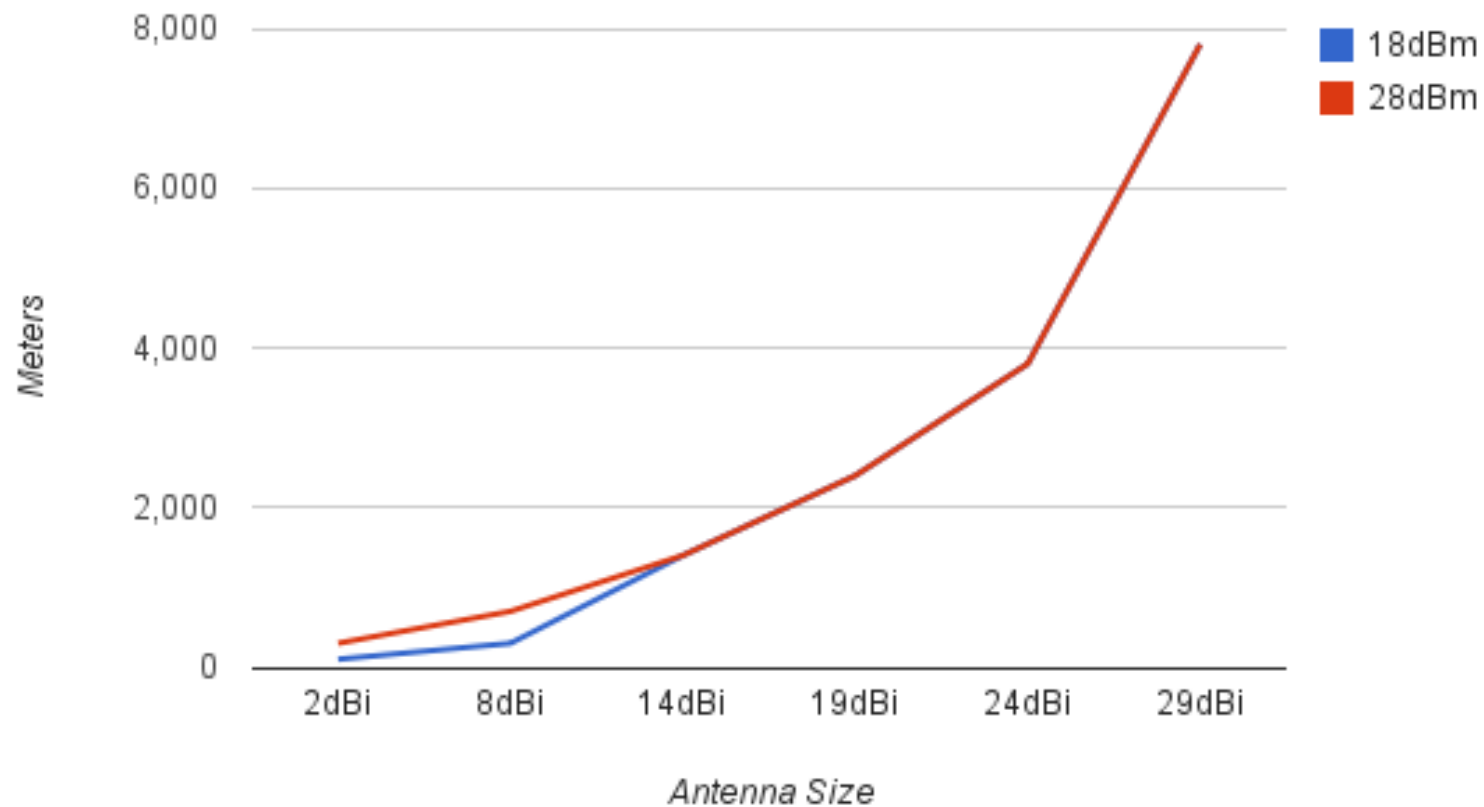


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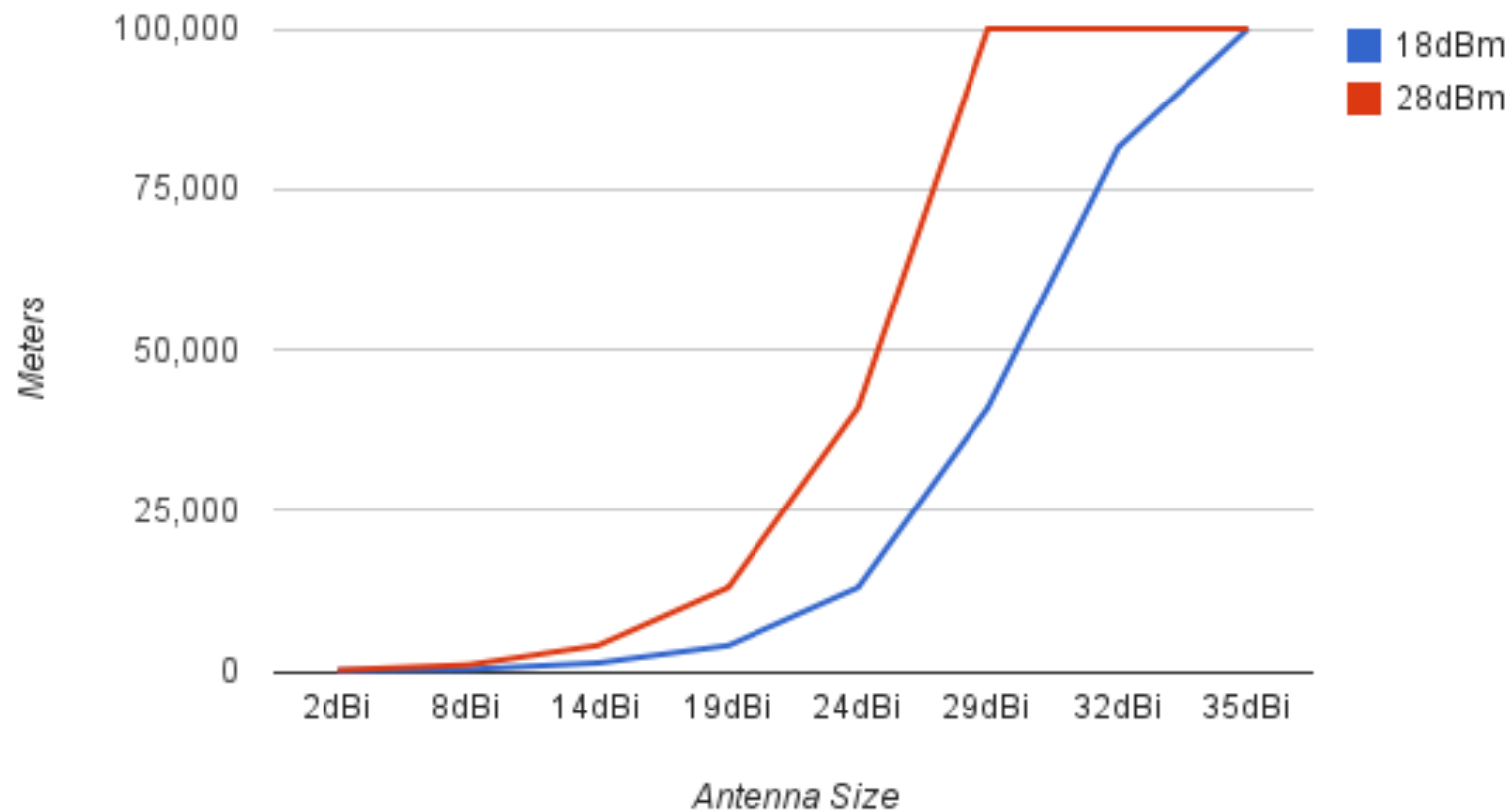
# 5.4GHz for P-P, P-MP



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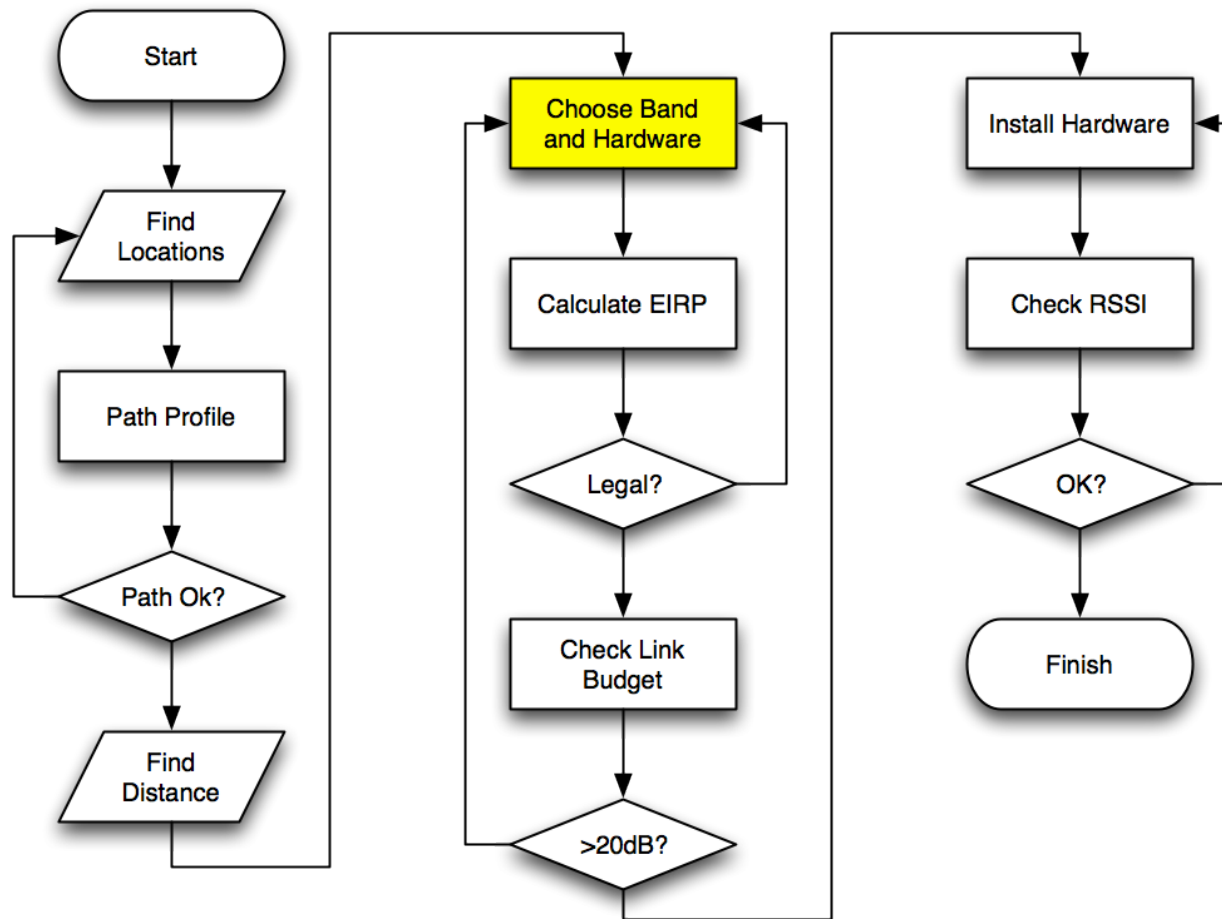


# 5725-5825MHz P-P Only



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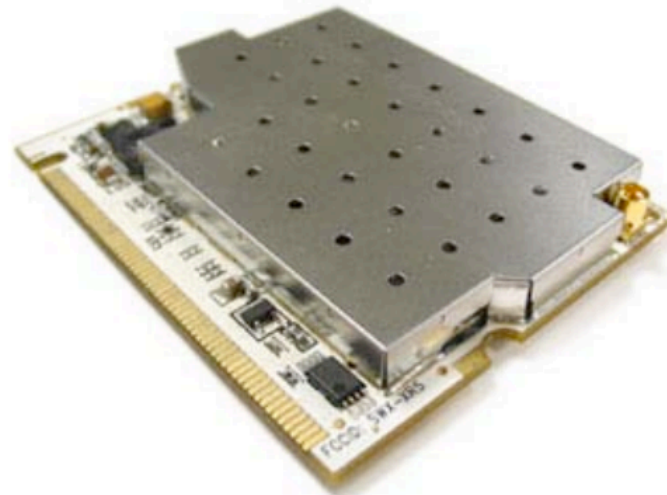


# Standard Radio Cards



Mikrotik R52

\$79



Ubiquiti XR5

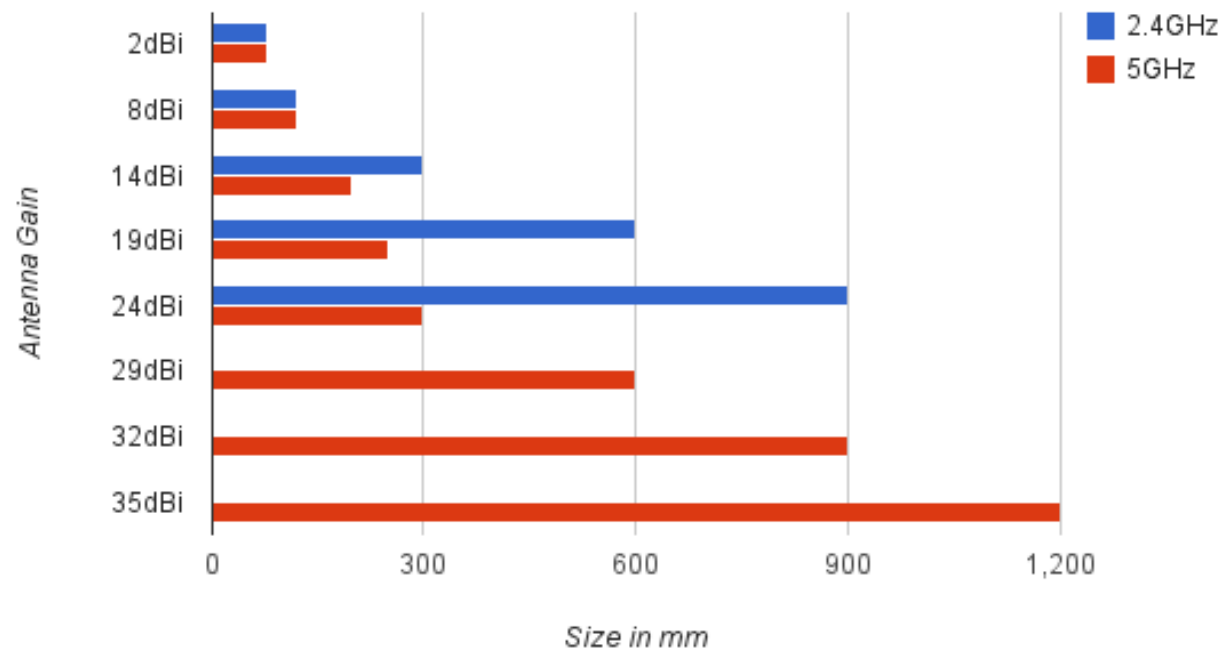
\$179



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# Antenna Sizes & Gain



# 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

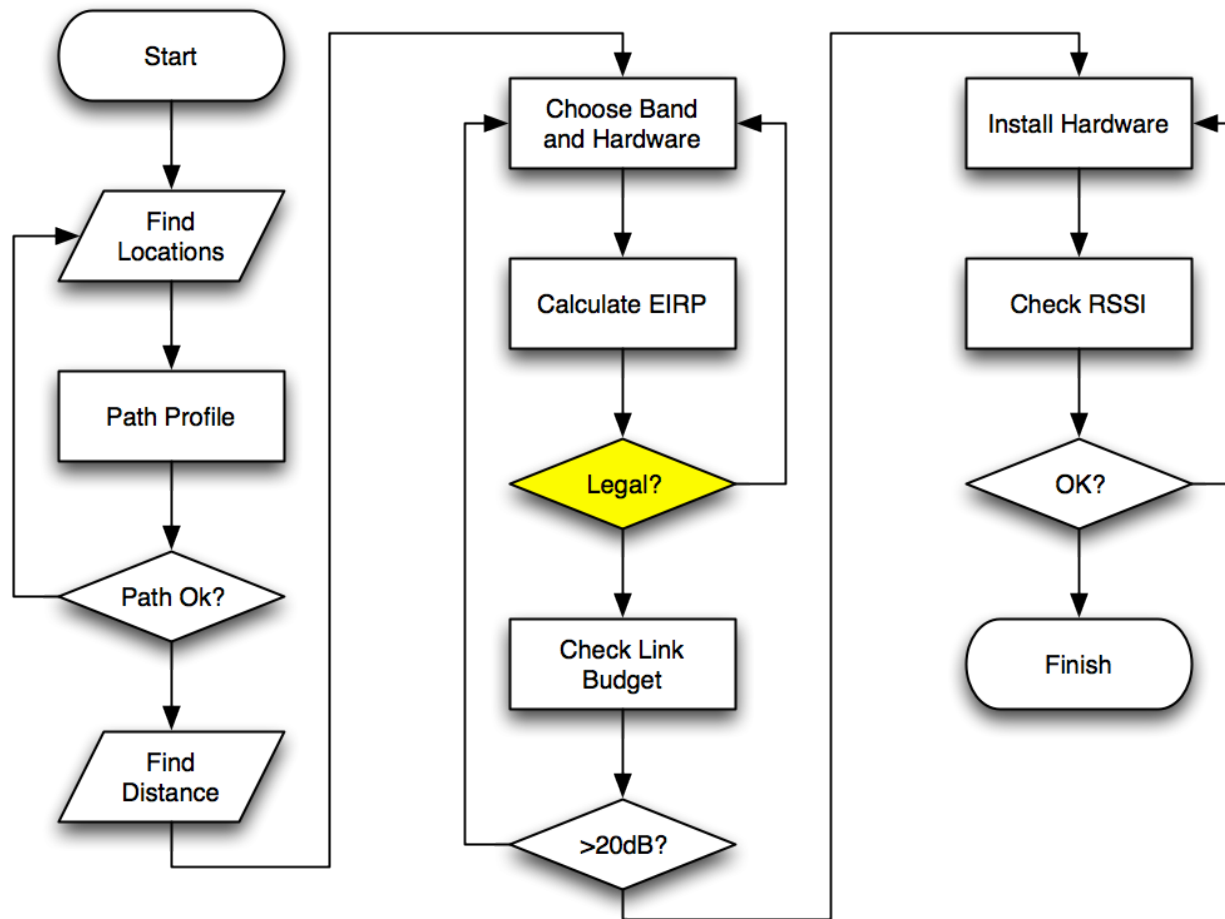
36dBm = 4W

53dBm = 200W



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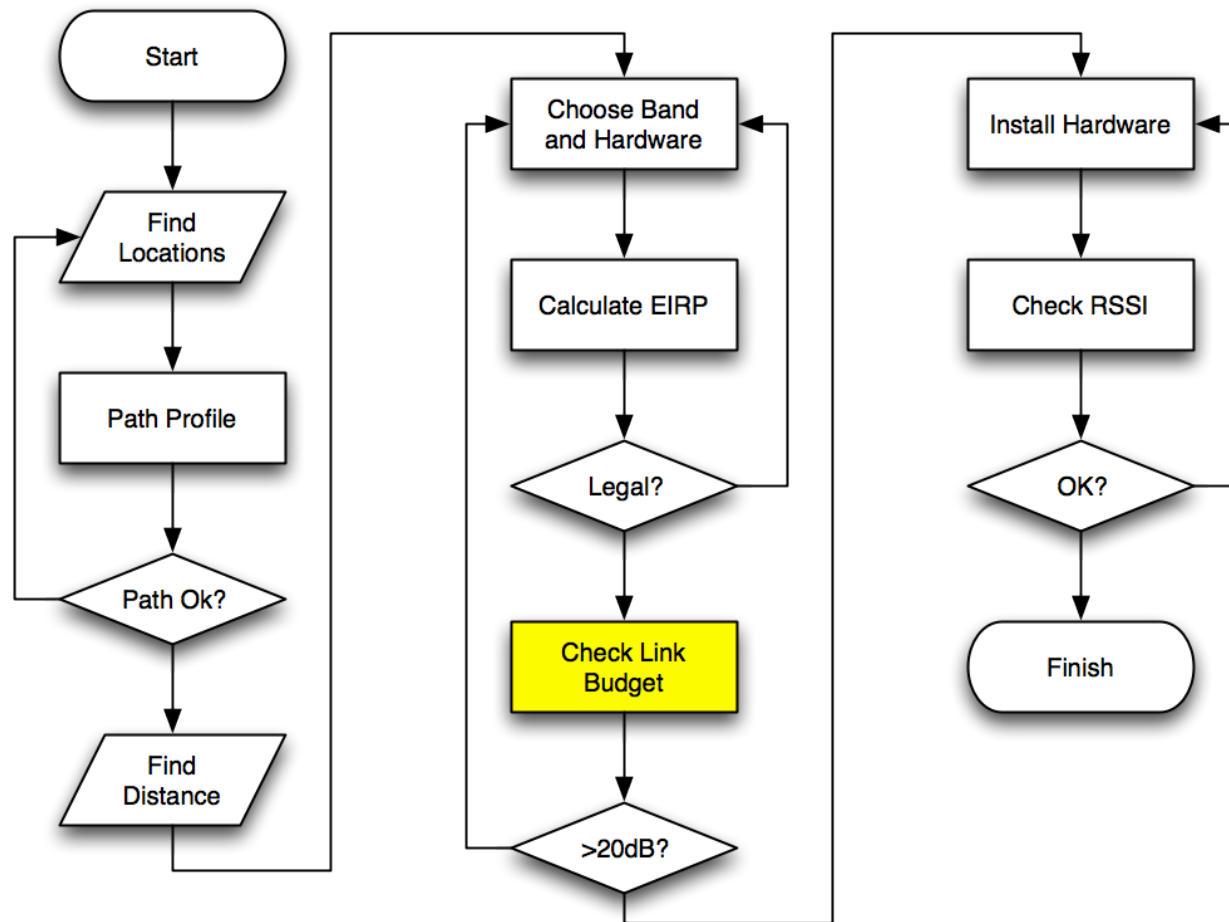


# NZ Bands & Power Limits

- 2.4GHz
  - 2400-2483MHz
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- 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

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

$\mathbf{P_{RX}}$  = received power (dBm)

$\mathbf{P_{TX}}$  = transmitter output power (dBm)

$\mathbf{G_{TX}}$  = transmitter antenna gain (dBi)

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

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

$\mathbf{L_M}$  = miscellaneous losses (other losses...) (dB)

$\mathbf{G_{RX}}$  = receiver antenna gain (dBi)

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

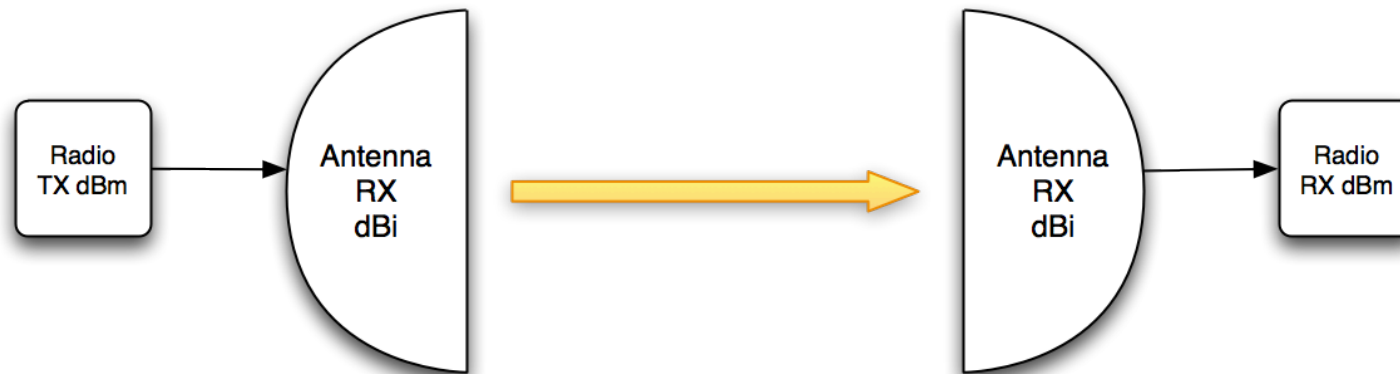


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# Link Budget Diagram

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



# 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

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

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

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

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

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

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

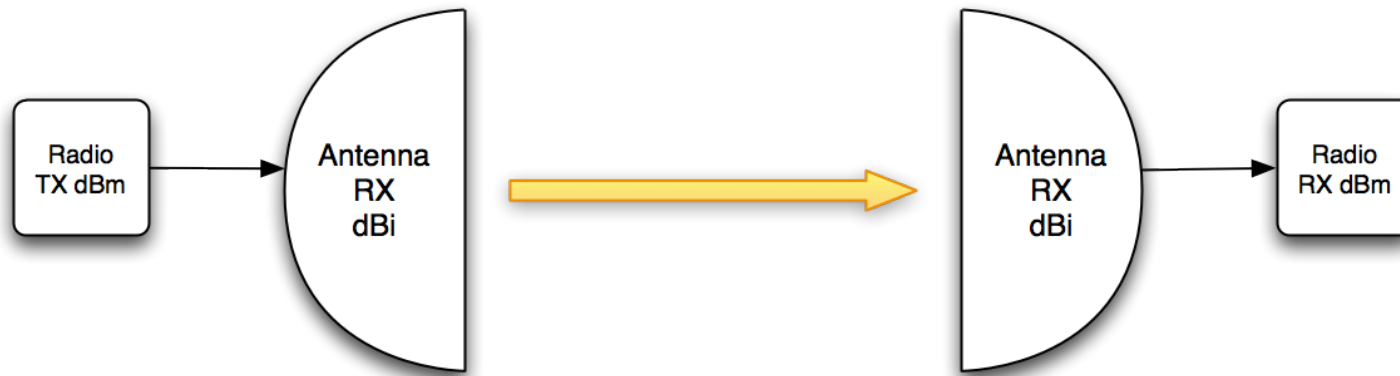


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# Link Budget Solved

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



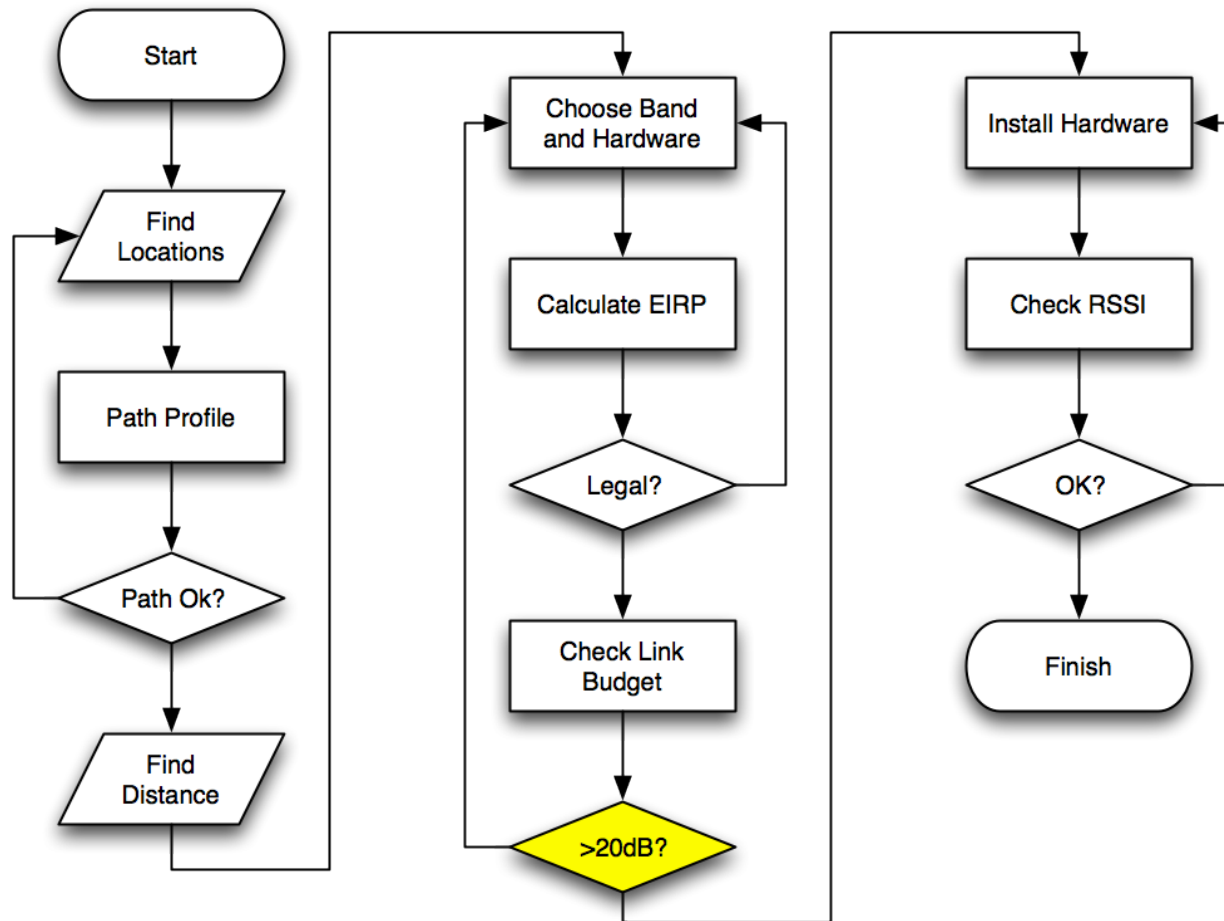
$$18\text{dBm} - 2\text{dB} + 19\text{dBi} - 120\text{dB} - 0\text{dB} + 19\text{dBi} - 2\text{dB} =$$

**-68dBm Received Signal Level**



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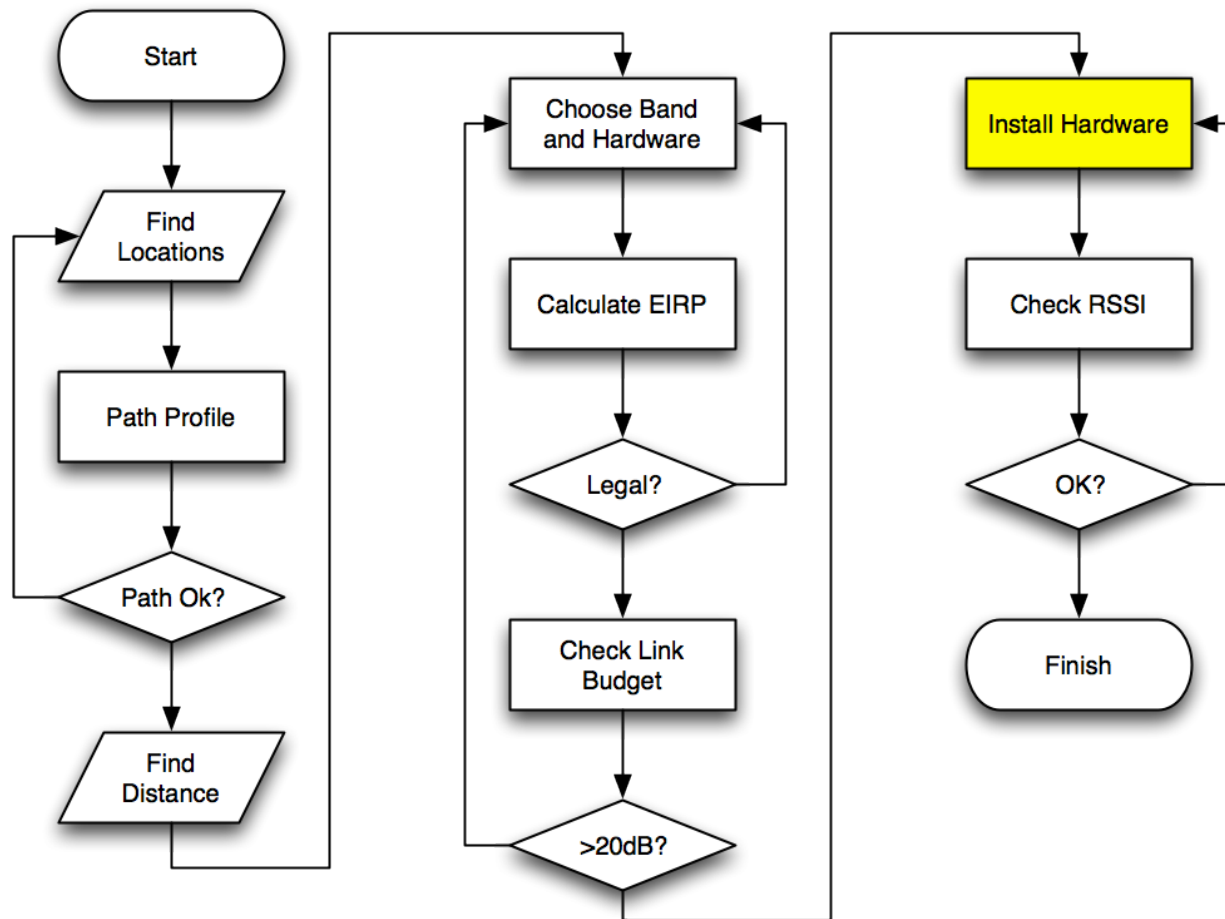




# Receive Sensitivities

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





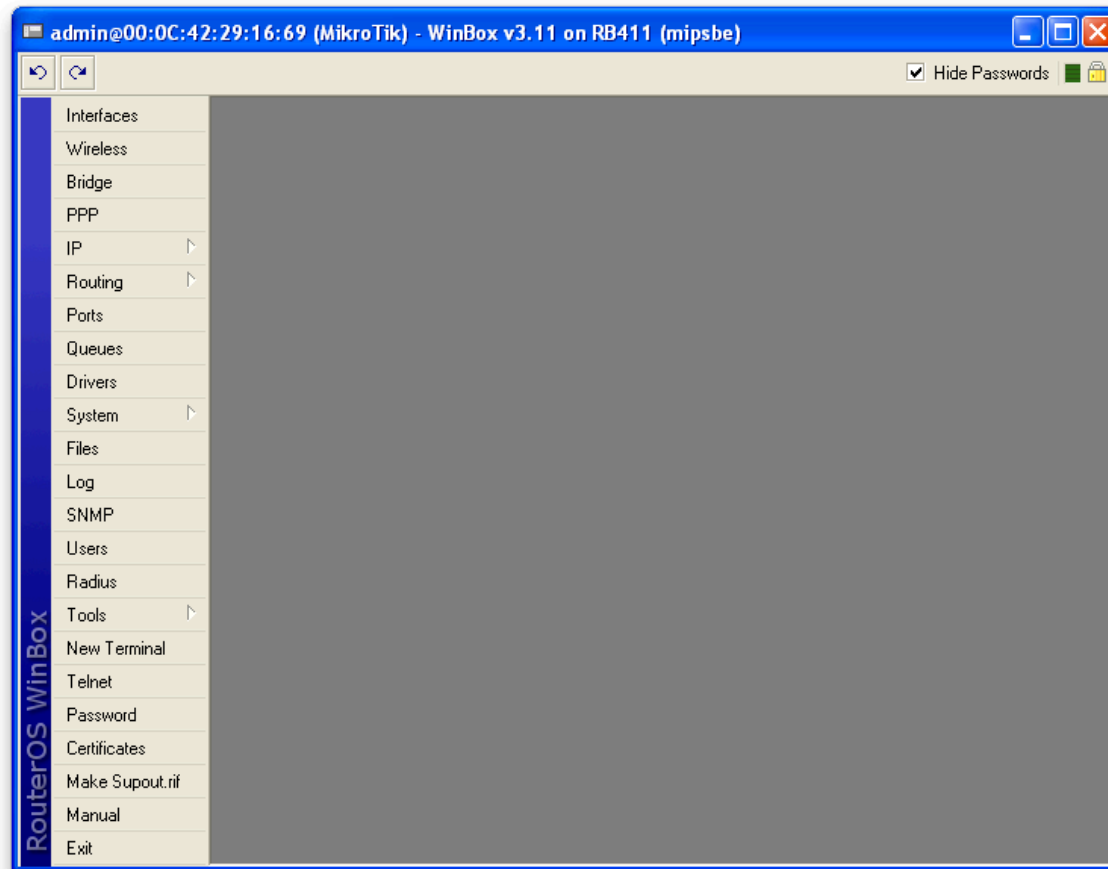


# Upgrade & Configure Mikrotik

- 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"



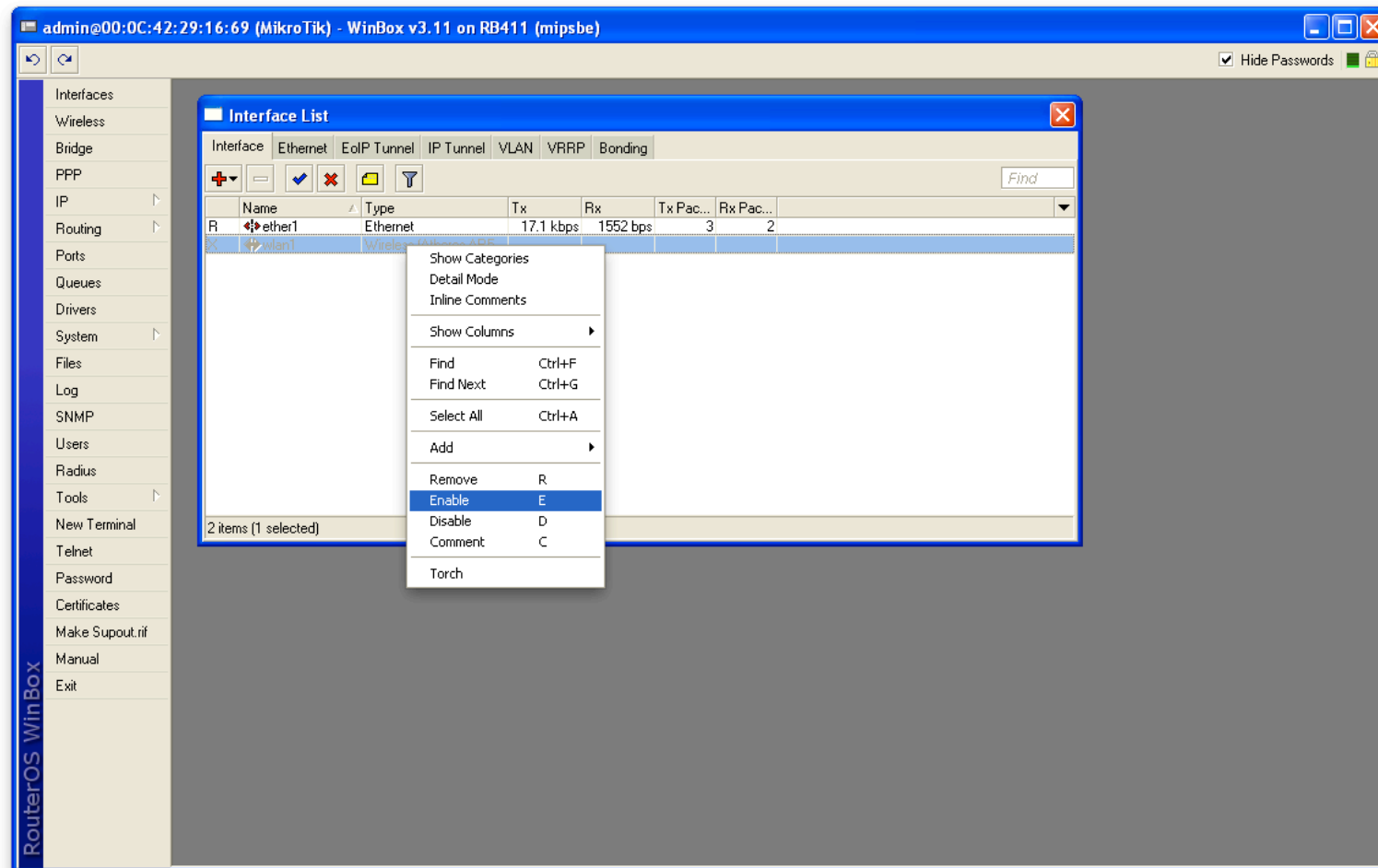
# Mikrotik Winbox



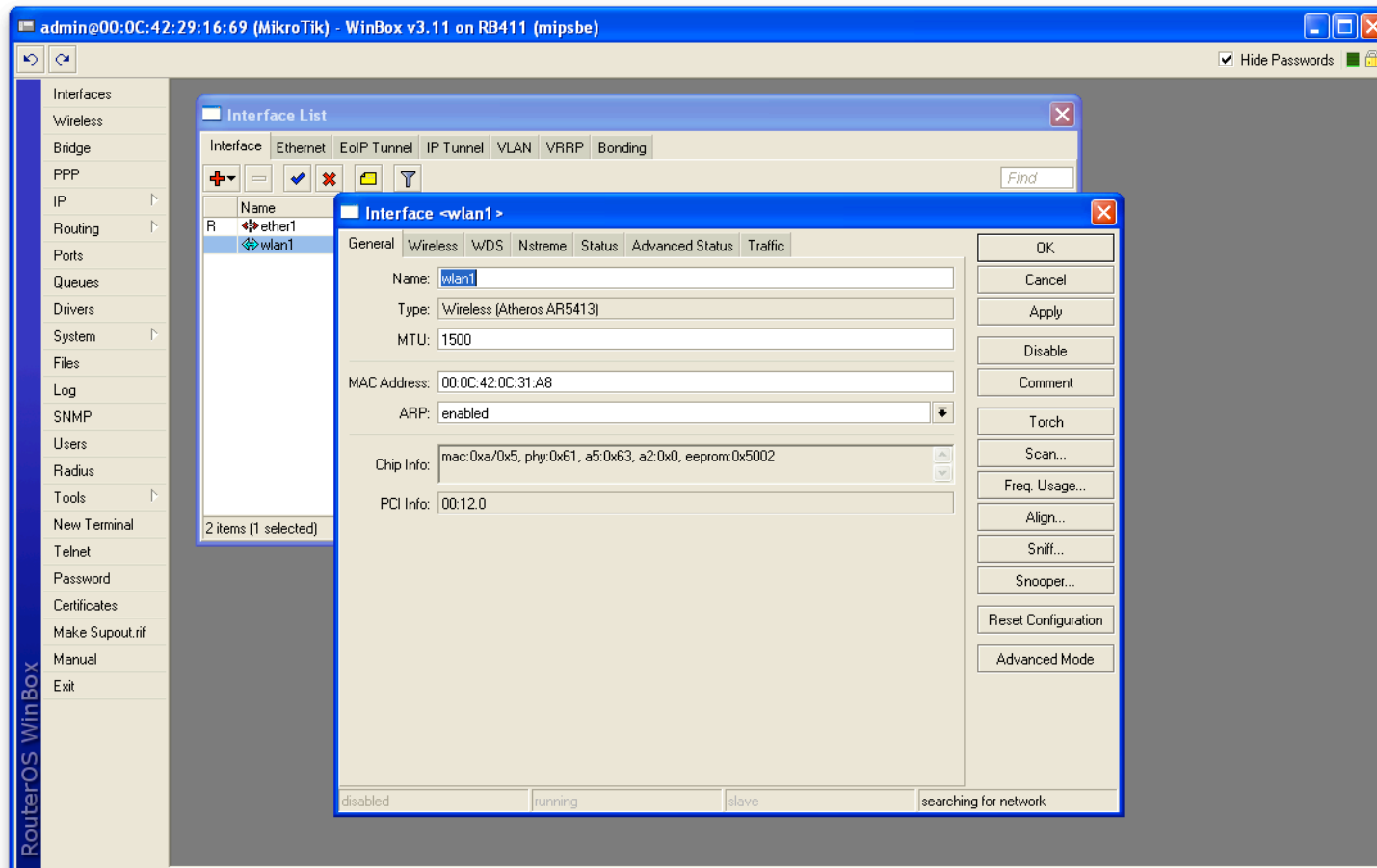
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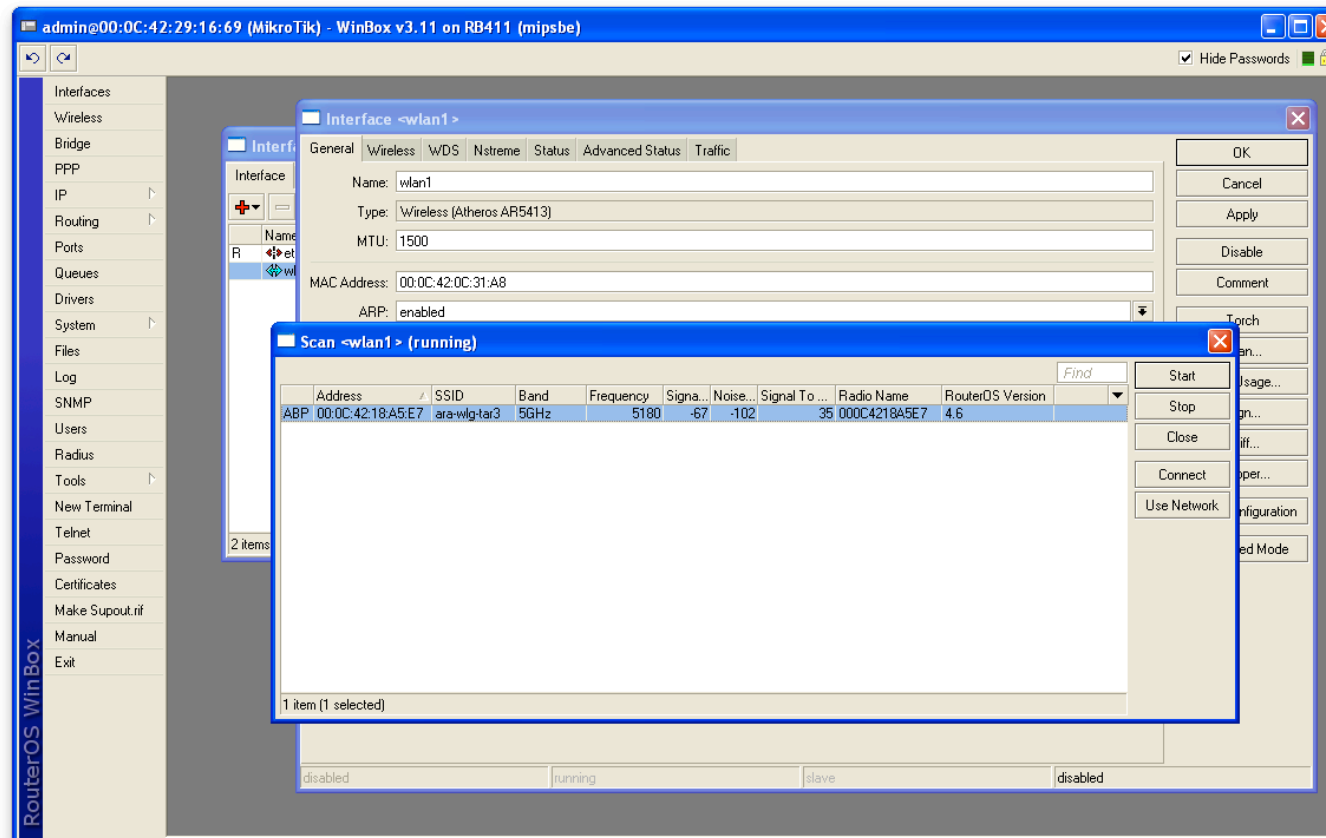
# Enable a Wireless Interface



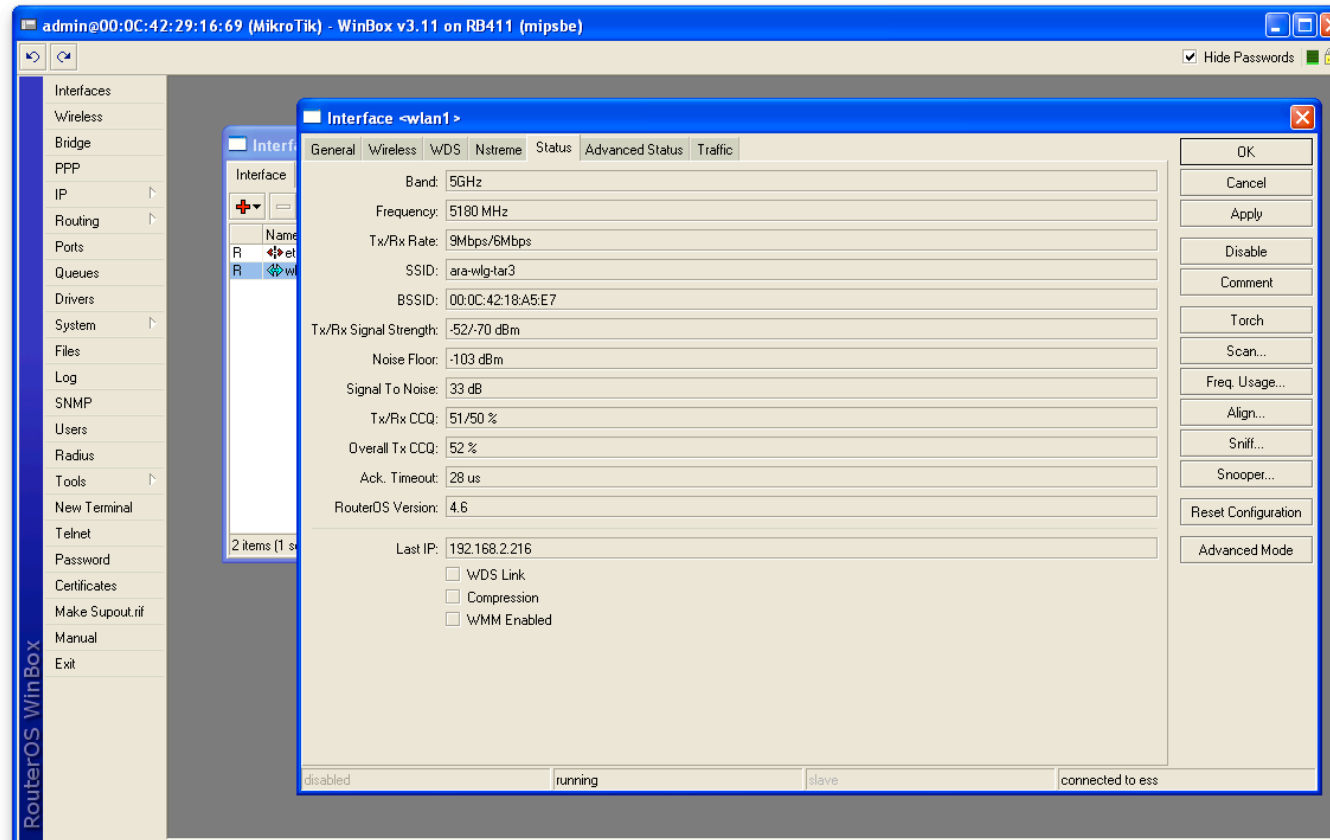
# Open wlan1 & Browse Tabs



# Scan and Connect to Network



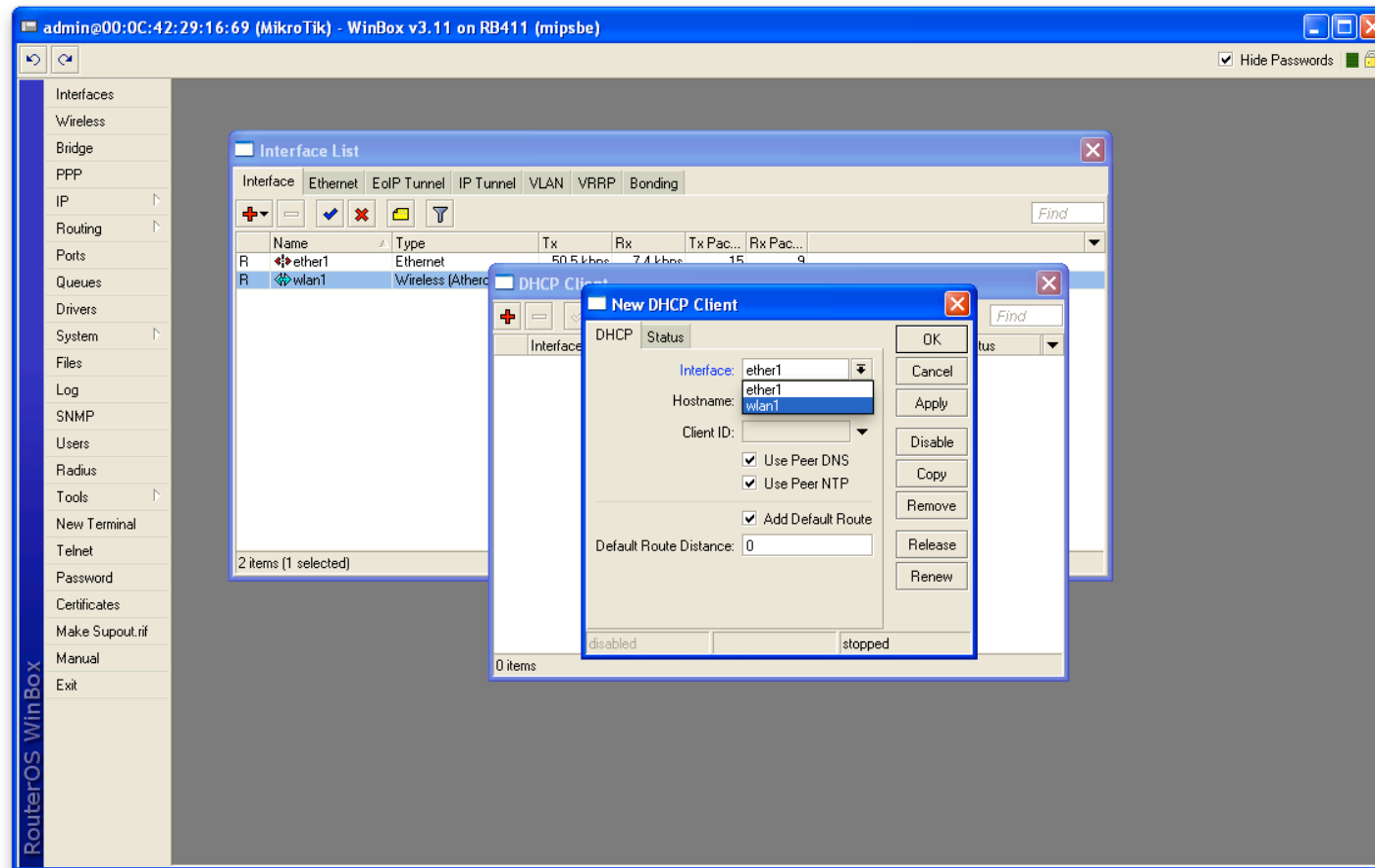
# Close Scan & View Status



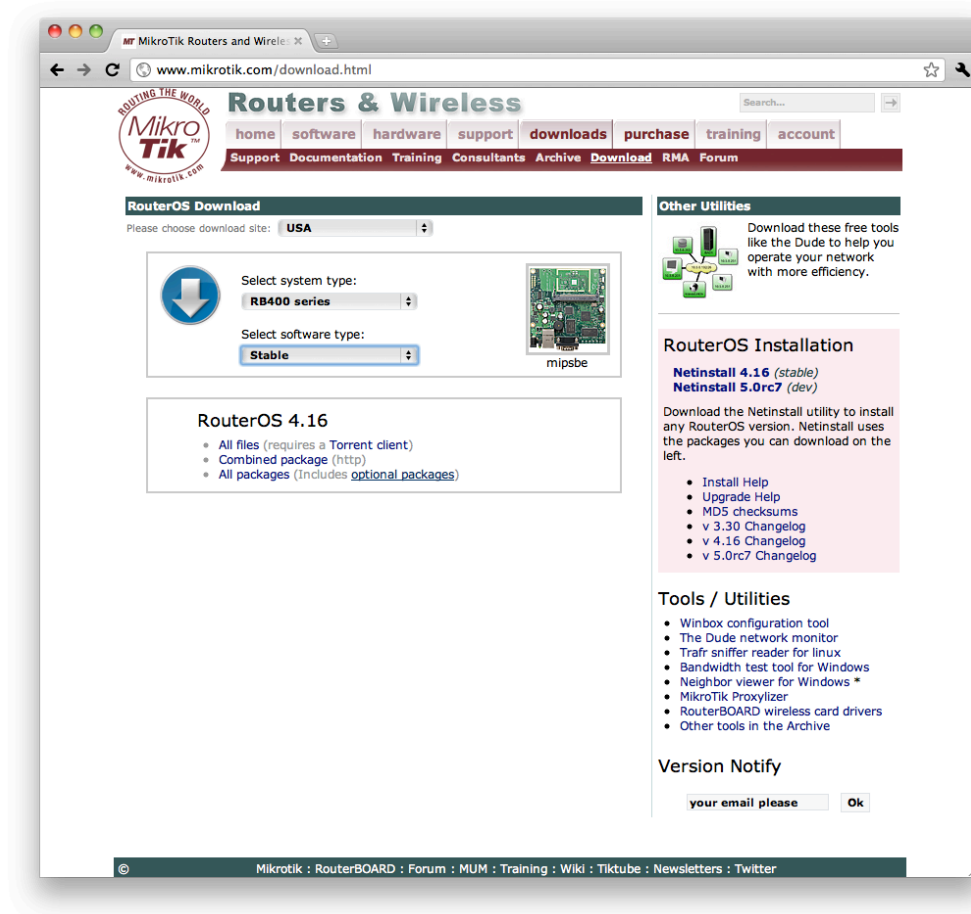
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# Get Online with DHCP



# Download Latest Software

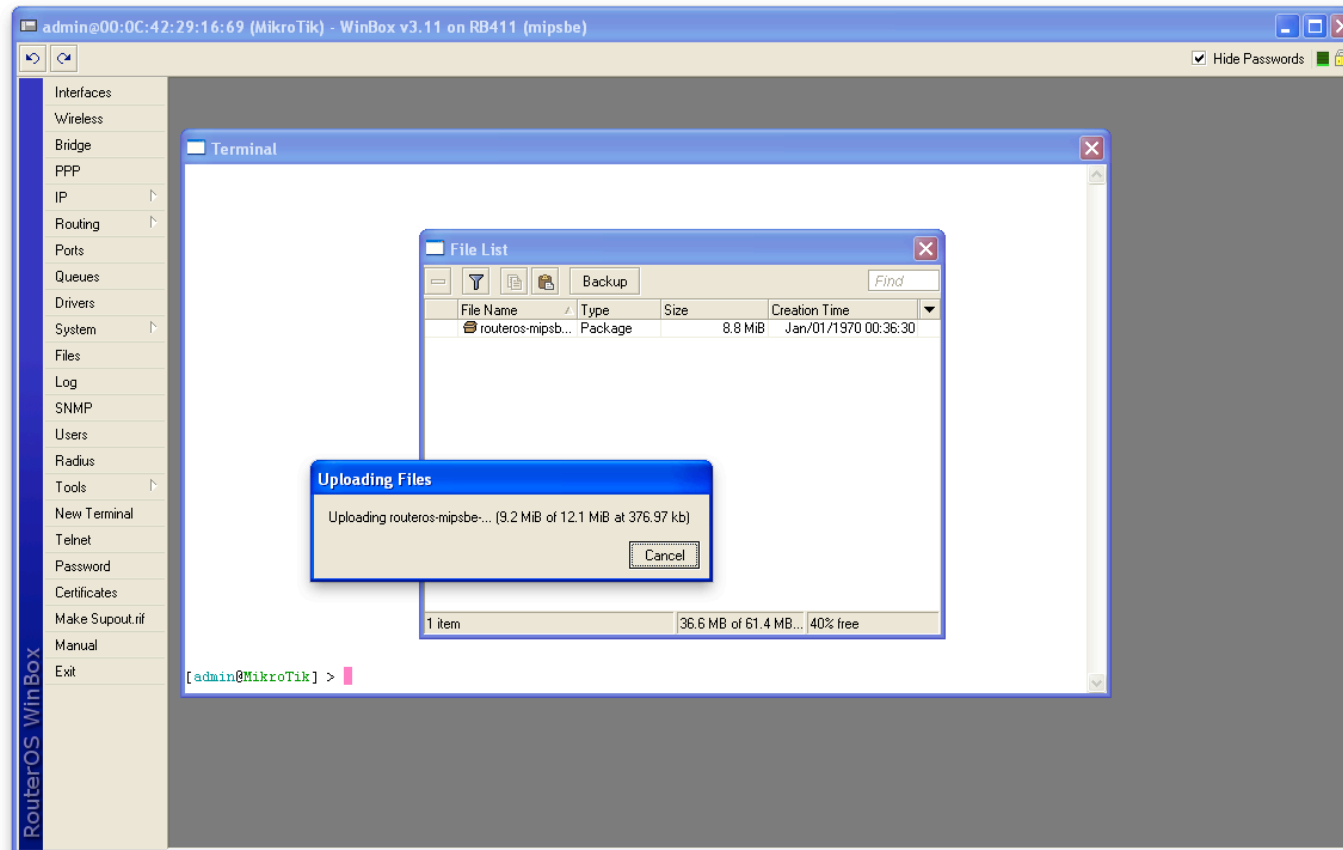


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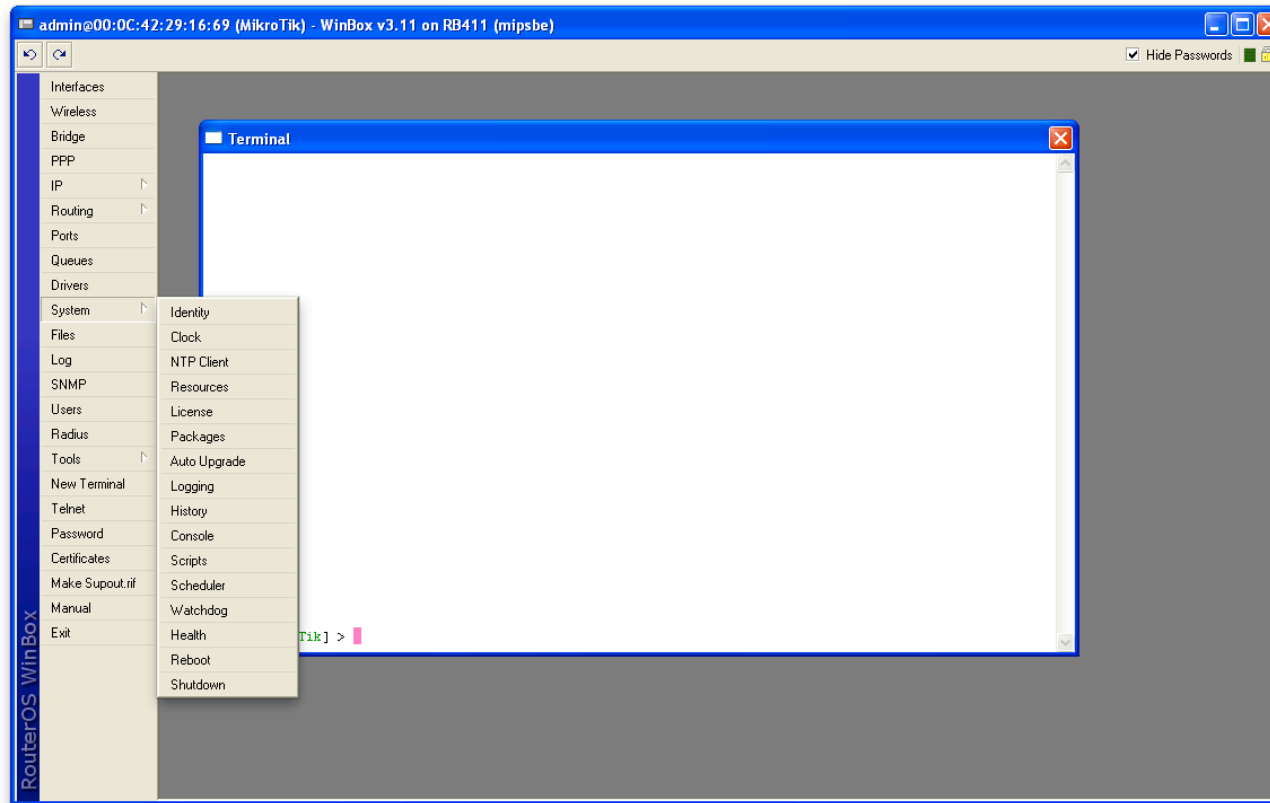




# Upgrade Using Winbox



# Reboot to Upgrade (x2)



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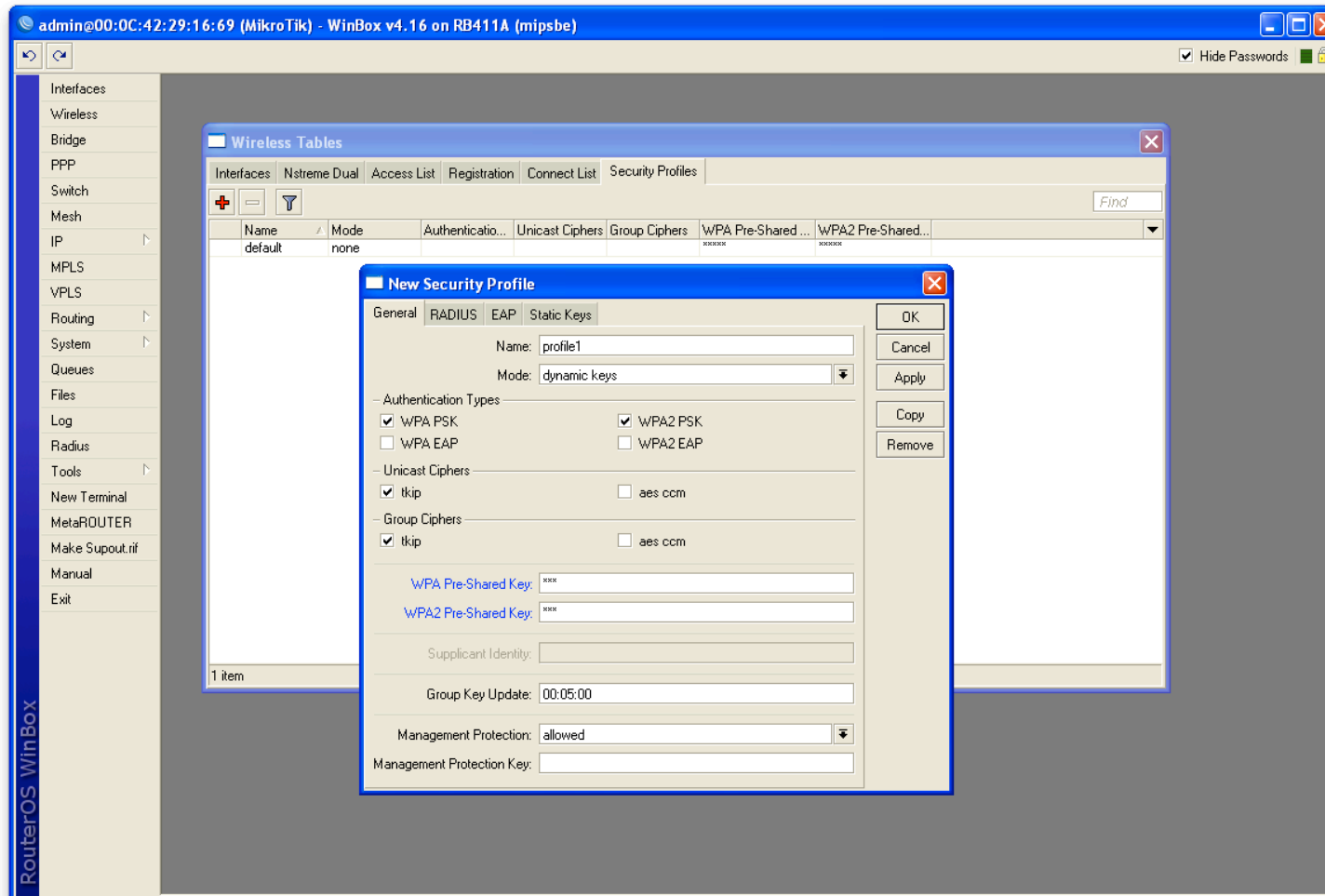


# Making a Simple Hotspot

- 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



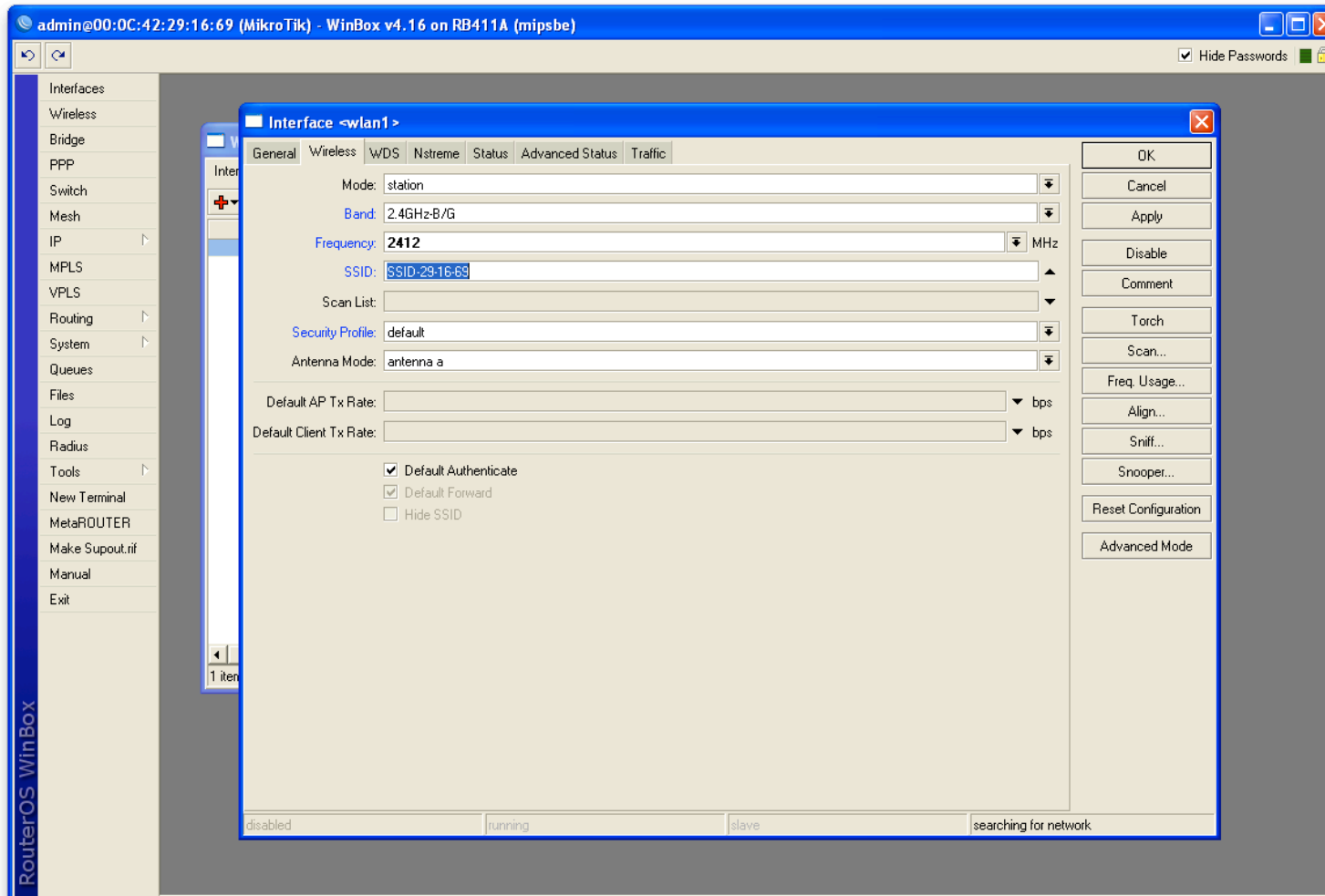
# Make a Security Profile



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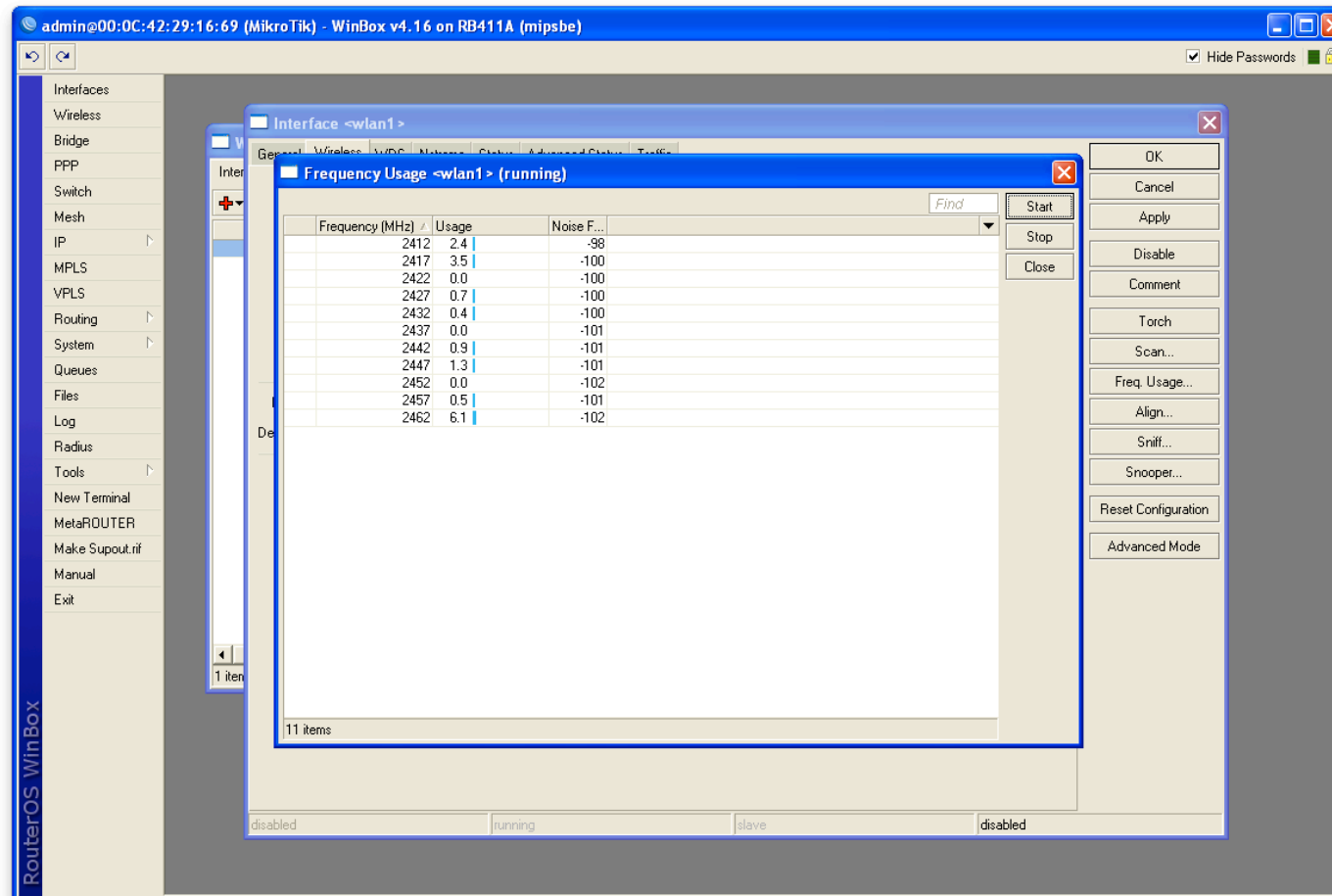
# Assign a Unique SSID



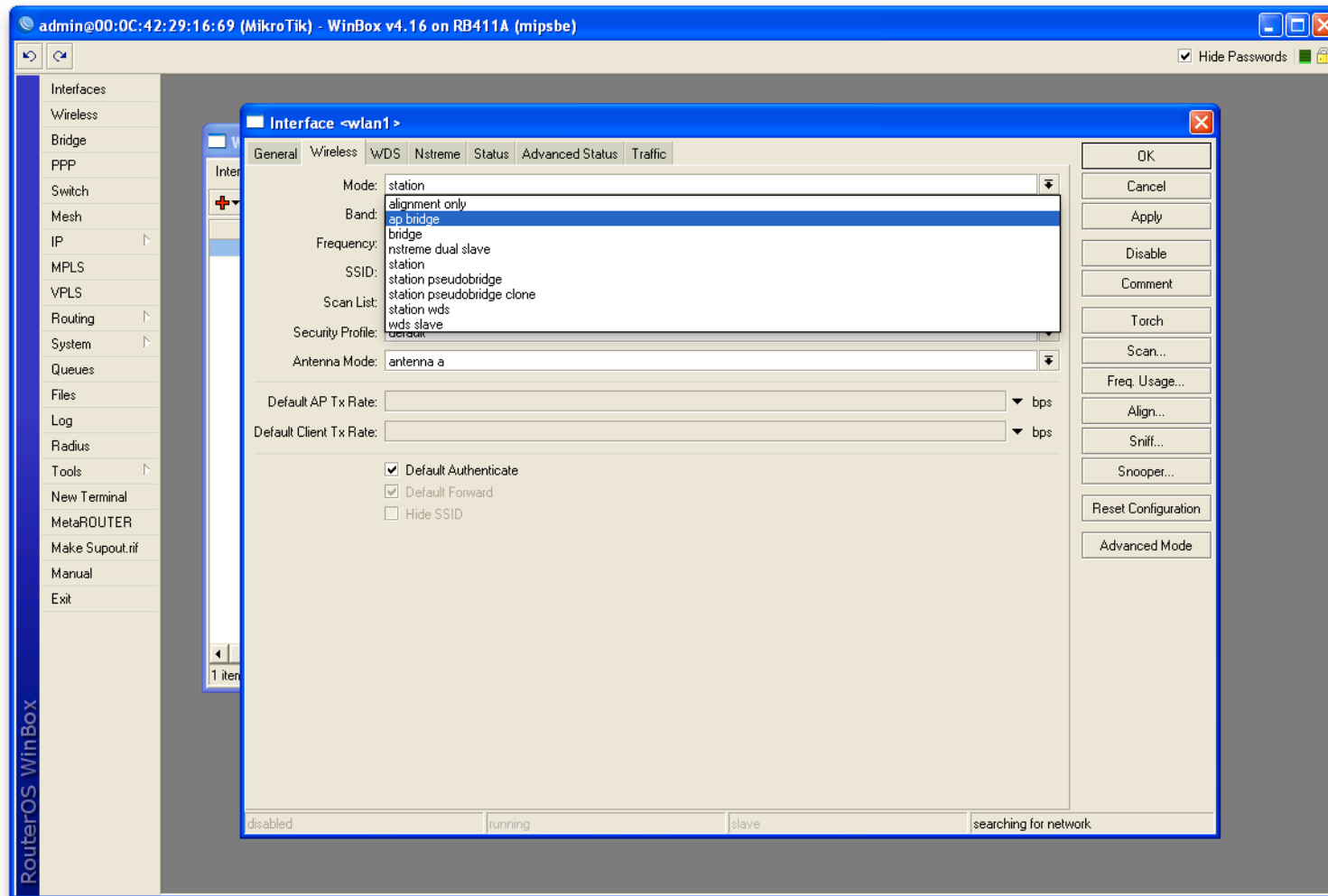
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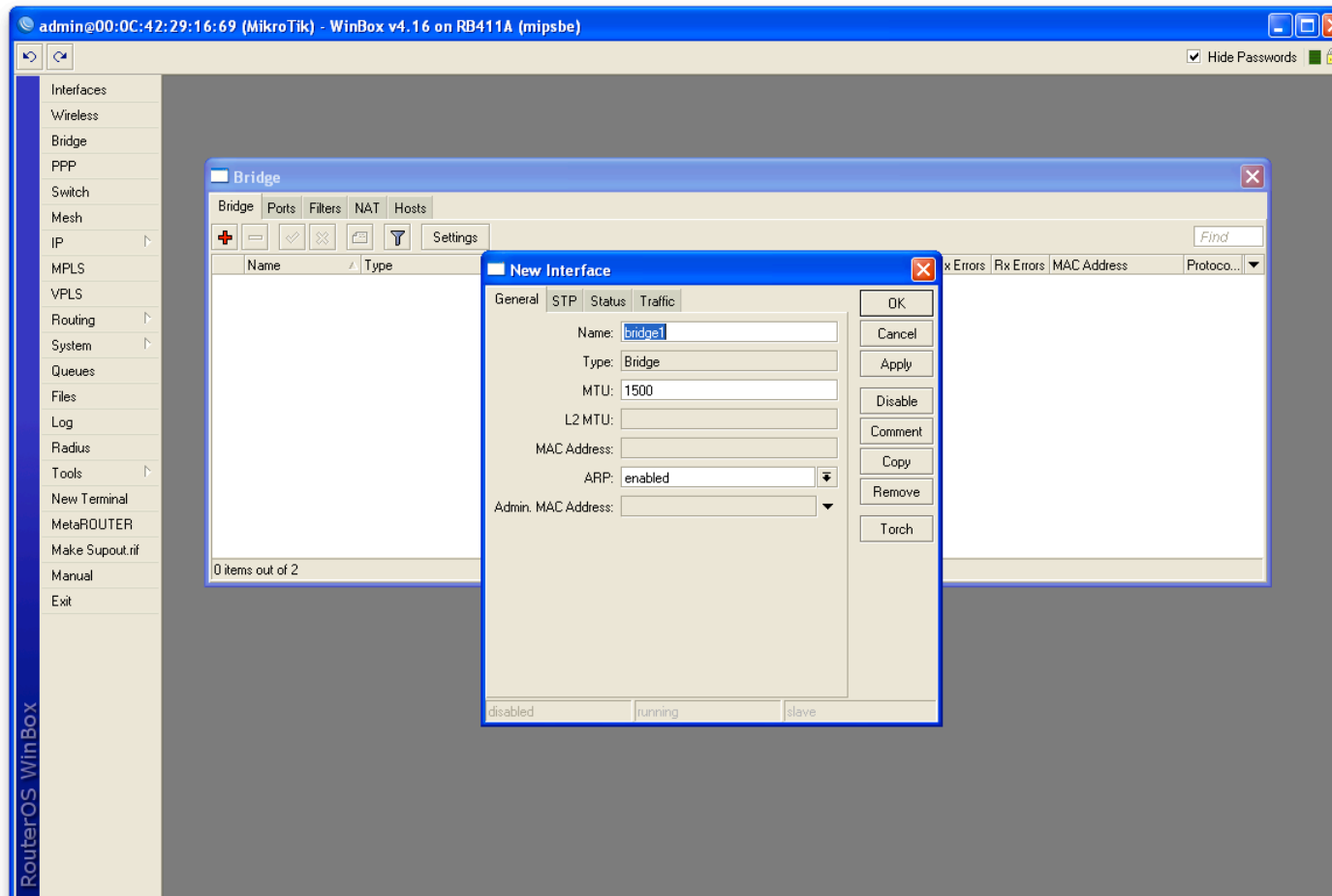
# Choose an Unused Channel



# Make WLAN an AP

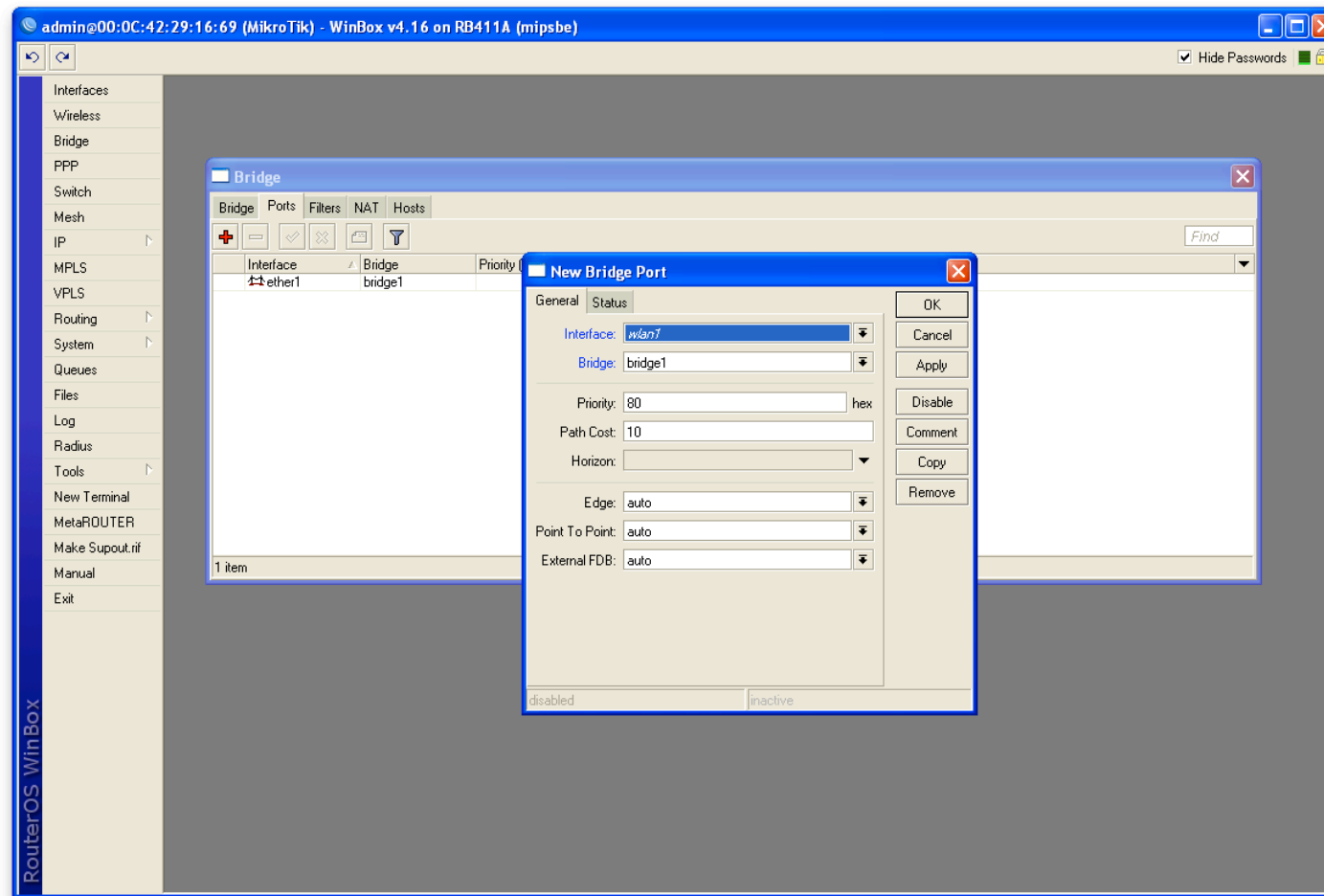


# Create a Bridge





# Add wlan and Ether to Bridge



# Associate & Check RSSI

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

RouterOS WinBox

Wireless Tables

Interfaces Nstreme Dual Access List Registration Connect List Security Profiles

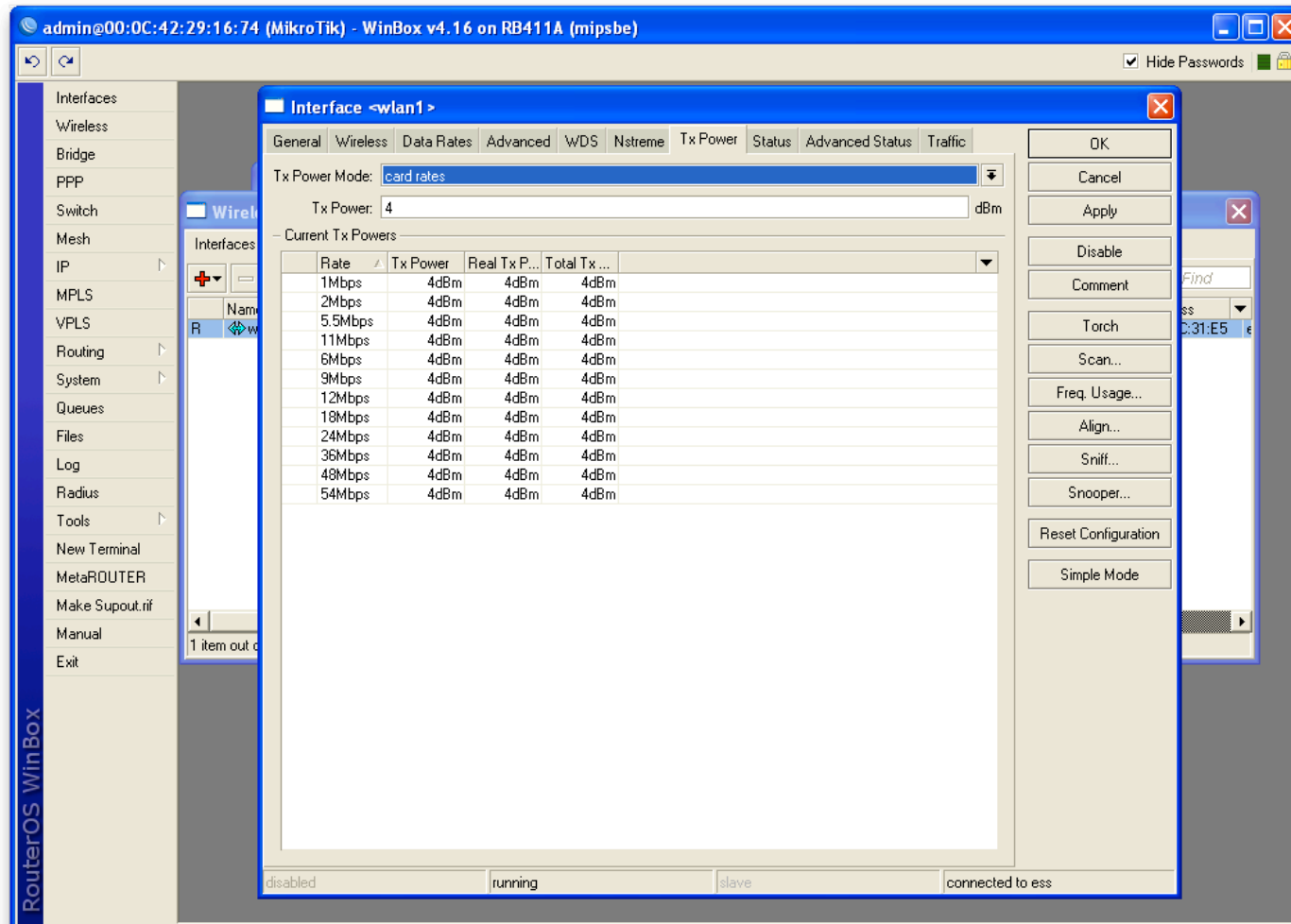
Find

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...

1 item



# Adjust Power Levels Down?



# More Complex? Virtual AP

The screenshot shows the Mikrotik WinBox interface. The main window is titled "admin@00:0C:42:29:16:69 (MikroTik) - WinBox v4.16 on RB411A (mipsbe)". The left sidebar contains a menu with the following items: 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 "Wireless" menu item is selected. The main content area displays the "Wireless Tables" window. This window has tabs for "Interfaces", "Nstreme Dual", "Access List", "Registration", "Connect List", and "Security Profiles". The "Interfaces" tab is active, showing a table of wireless interfaces. The table has columns for "Type", "L2 MTU", "Tx", "Rx", "Tx Pac...", "Rx Pac...", "Tx Drops", "Rx Drops", "Tx Errors", "Rx Errors", and "MAC Address". The table contains two rows: "Wireless (Atheros AR5..." and "VirtualAP". The "VirtualAP" row is highlighted. The status bar at the bottom of the window indicates "2 items out of 4".

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



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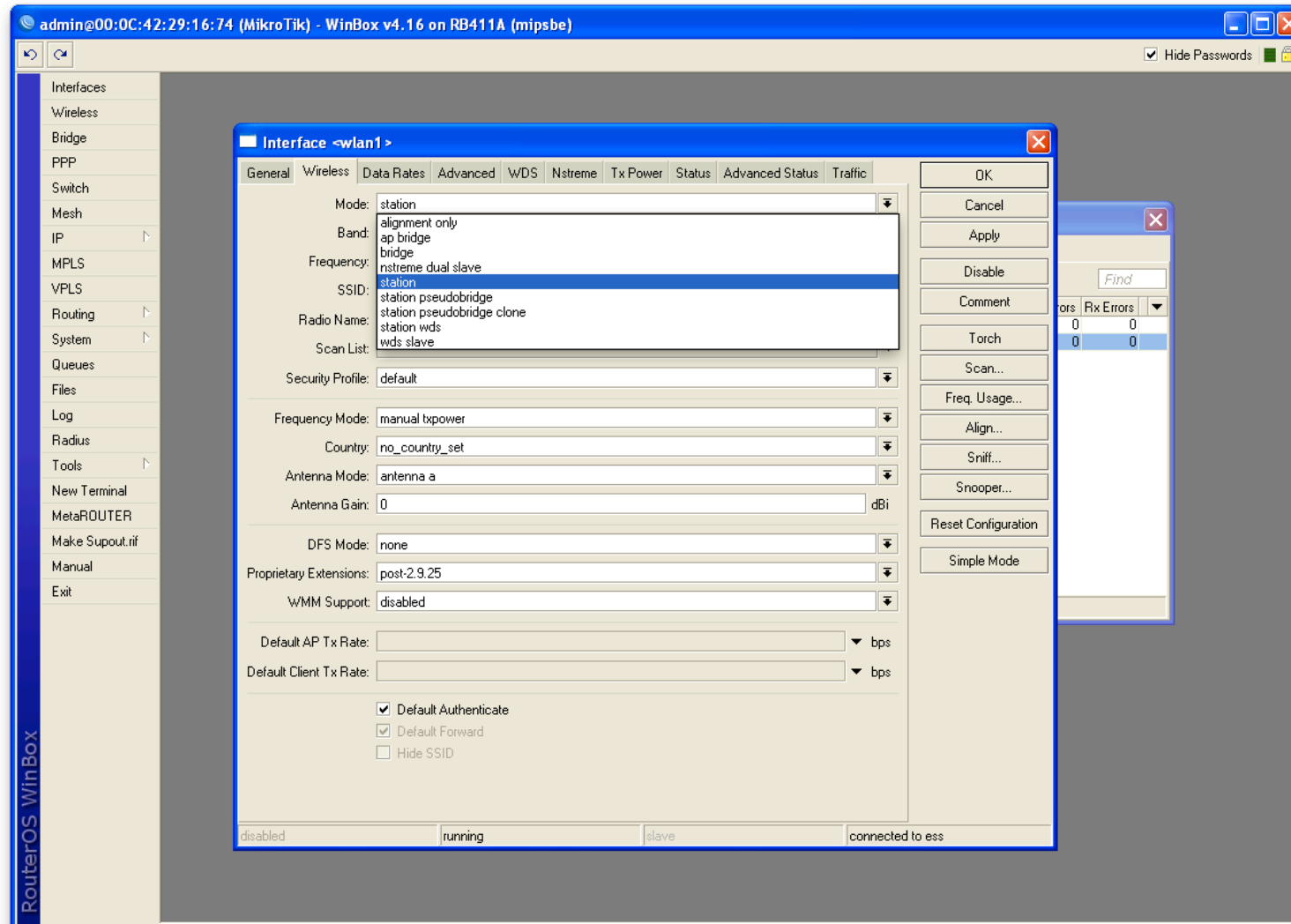


# Transparent Bridge

- 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



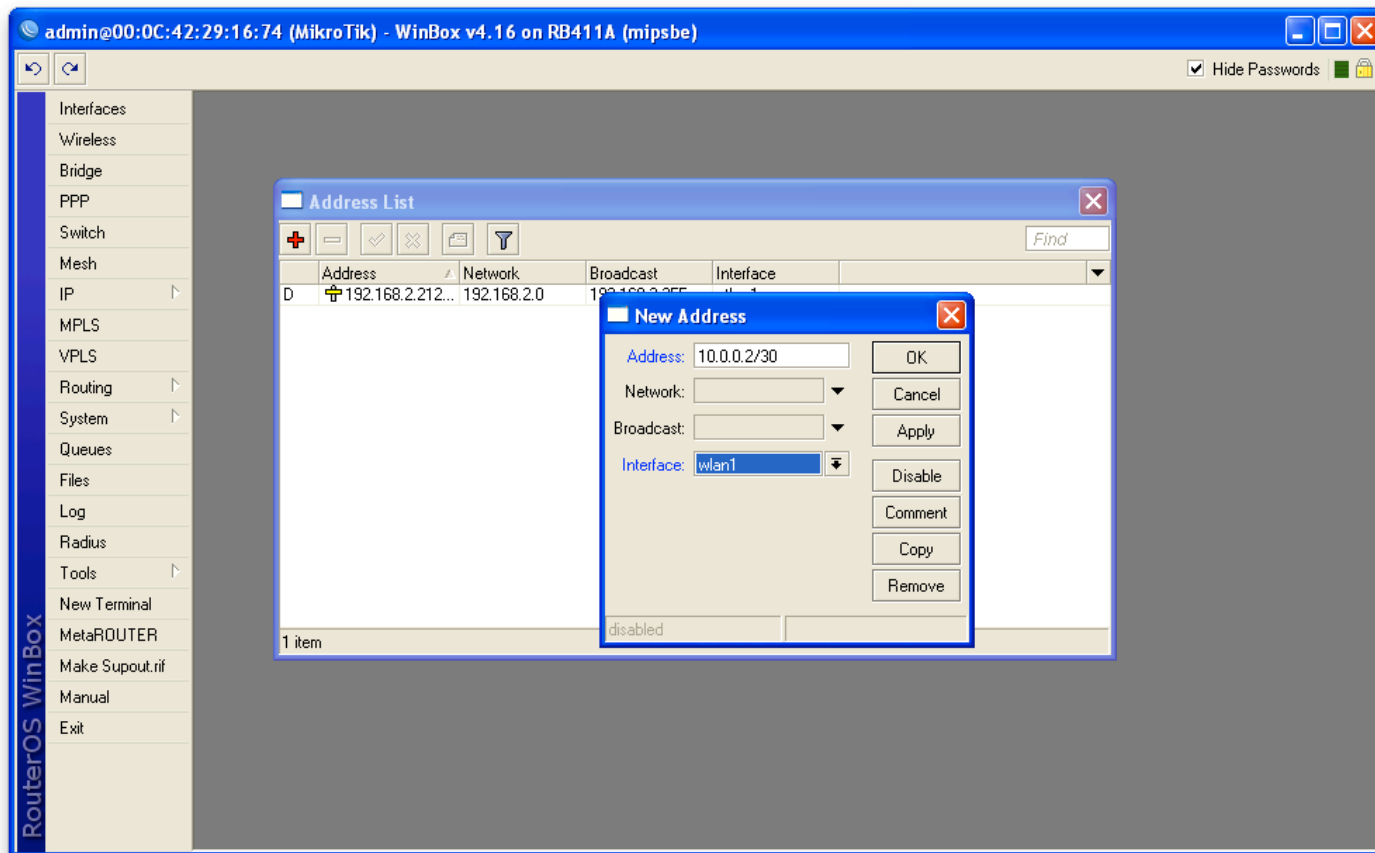
# Set Up a Station



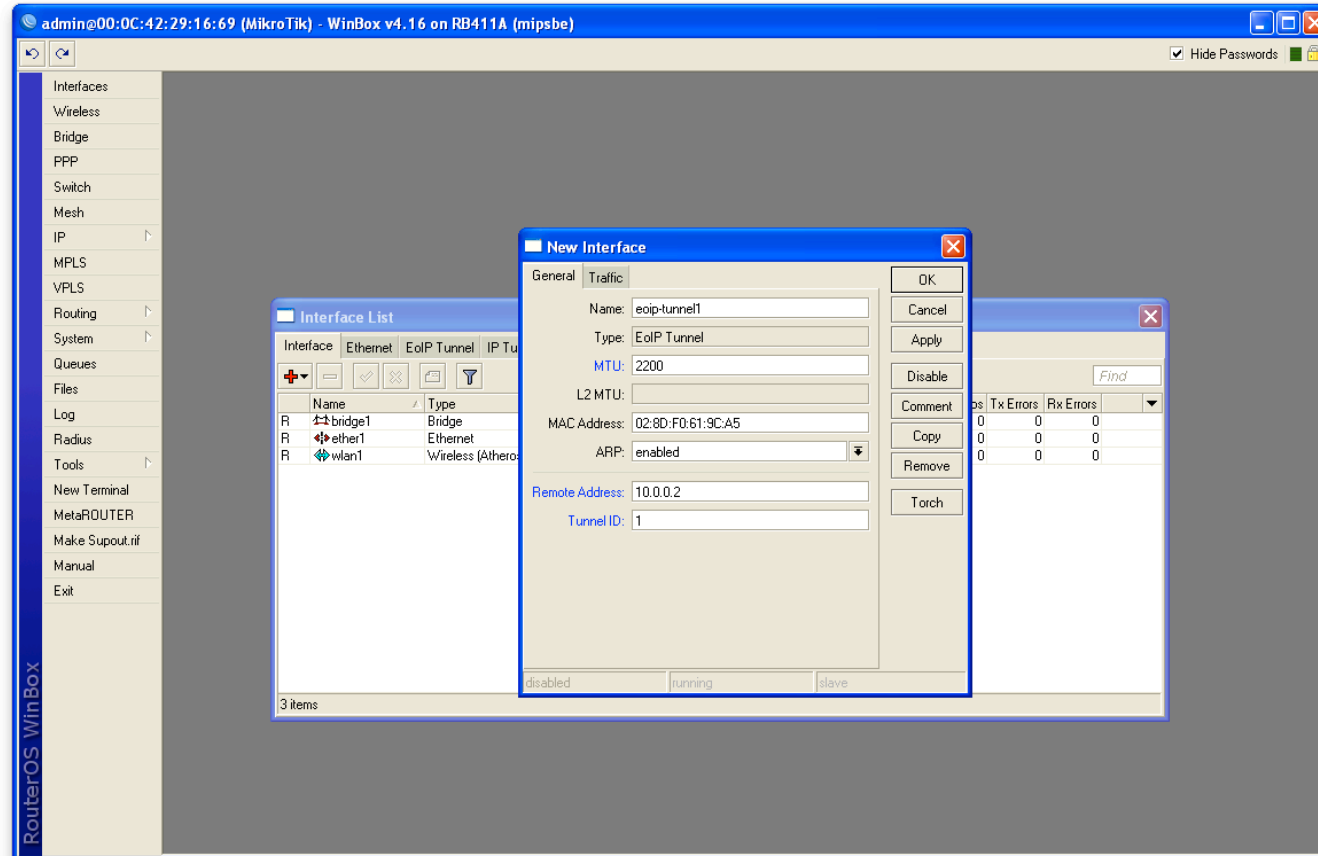
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# Add a /30 to the wlan Interfaces

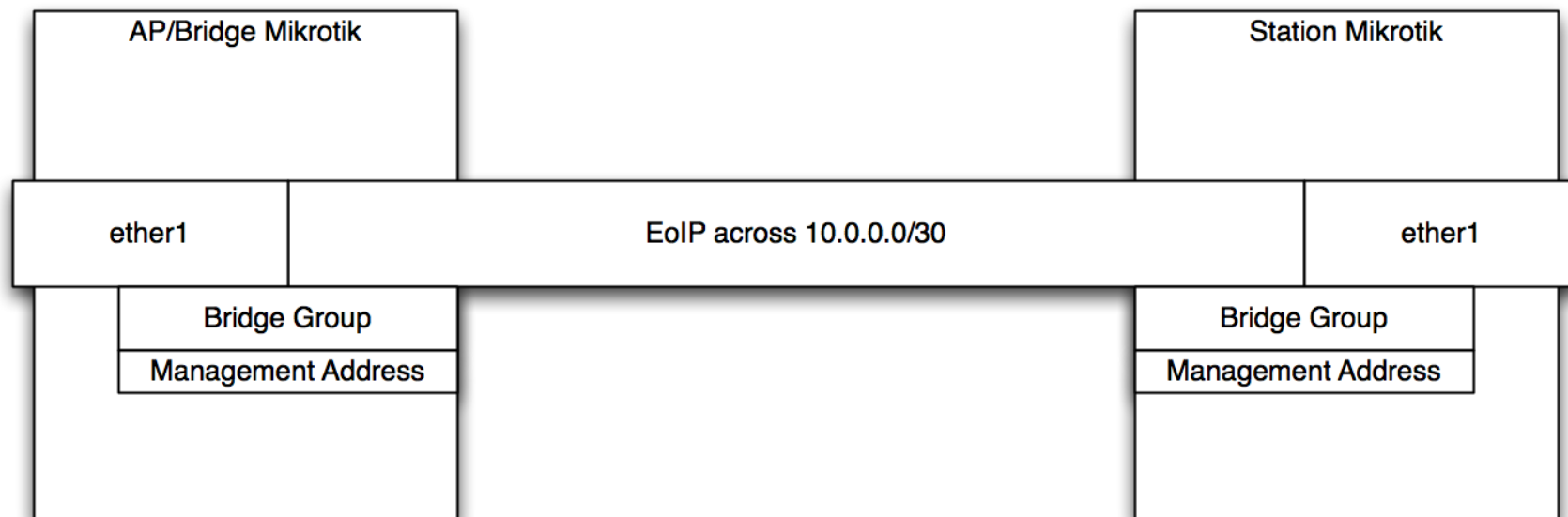


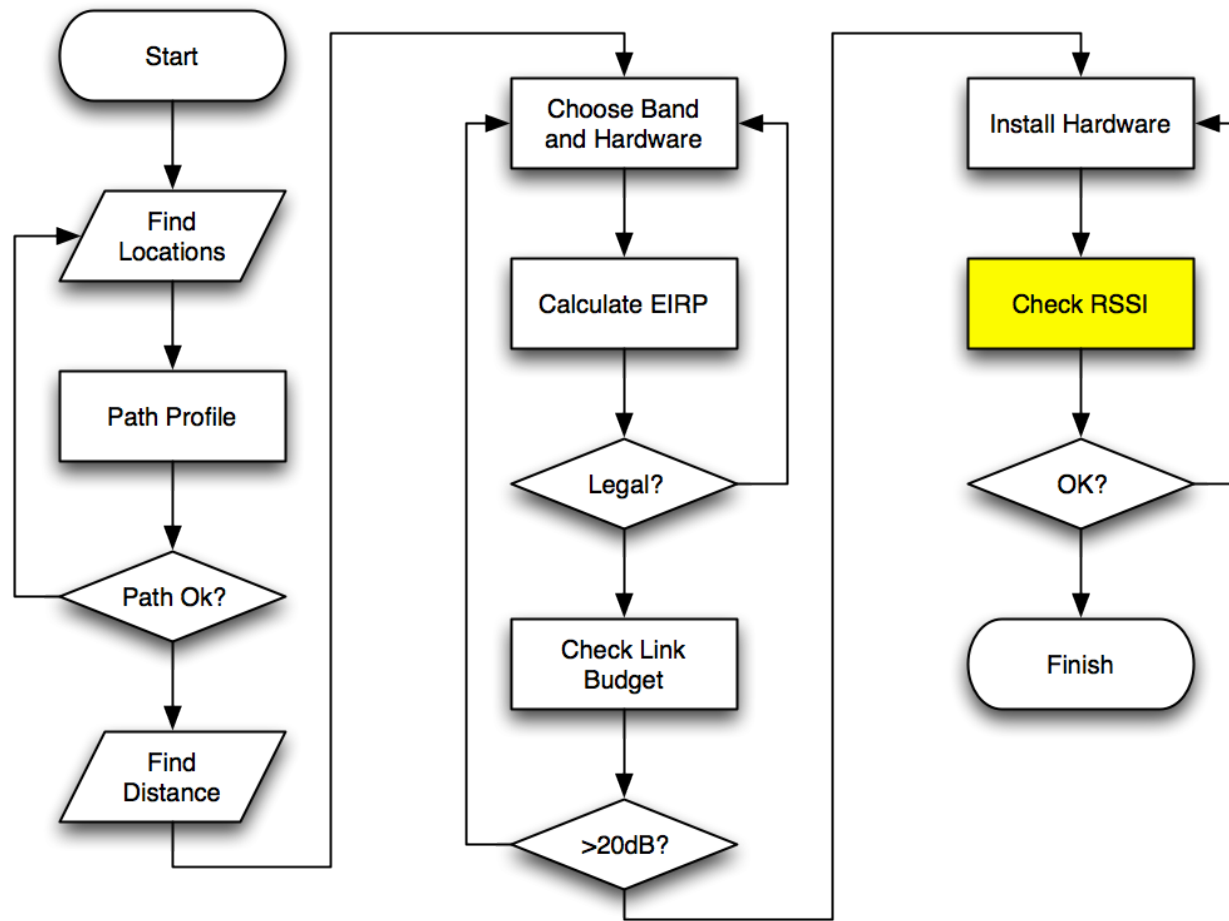
# EoIP Tunnel Between Radios



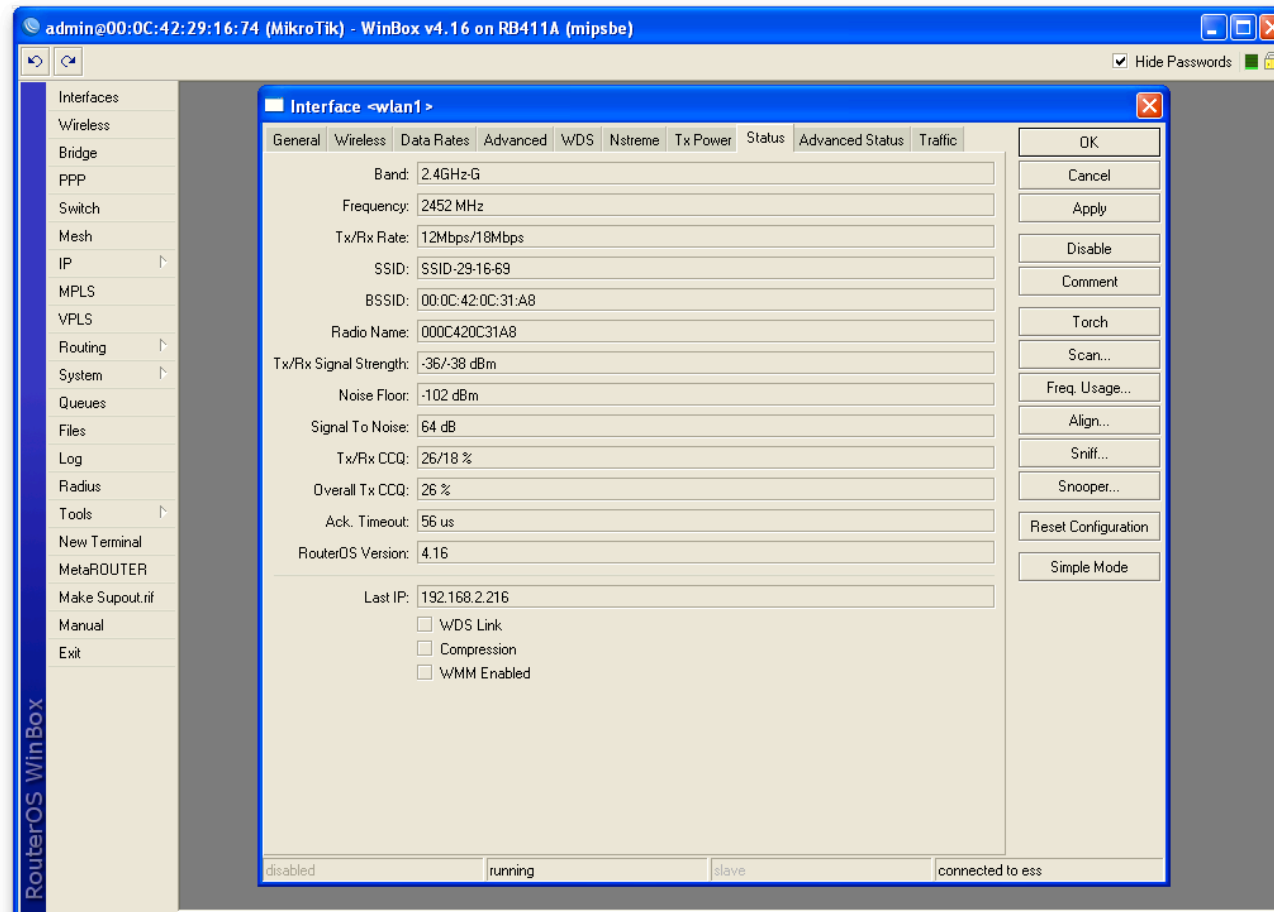


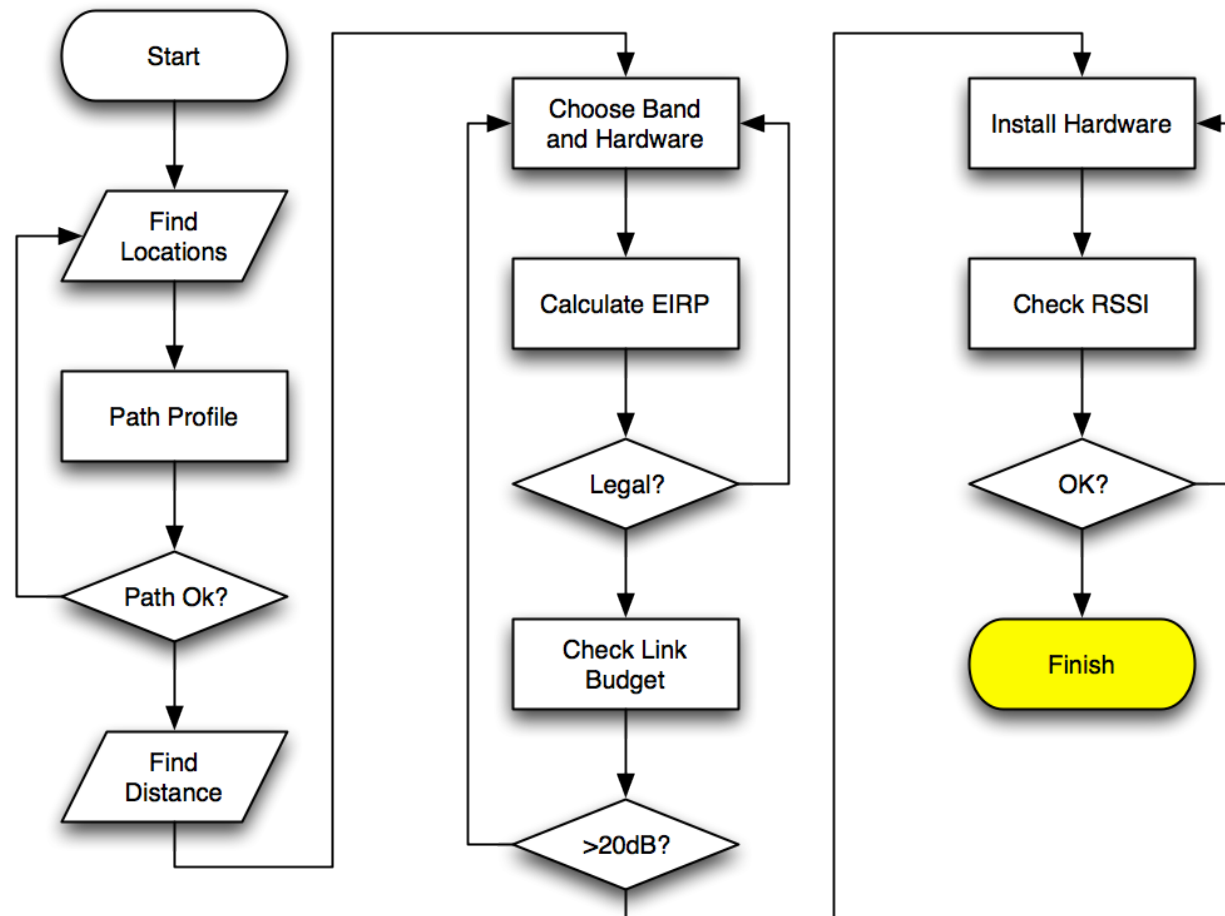
# EoIP Bridged to Ethernet





# 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](http://en.wikipedia.org/wiki/Link_budget)
- Calculating Free Space Loss: [http://en.wikipedia.org/wiki/Free-space\\_loss](http://en.wikipedia.org/wiki/Free-space_loss)
- Mikrotik Software: <http://www.mikrotik.com/>



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