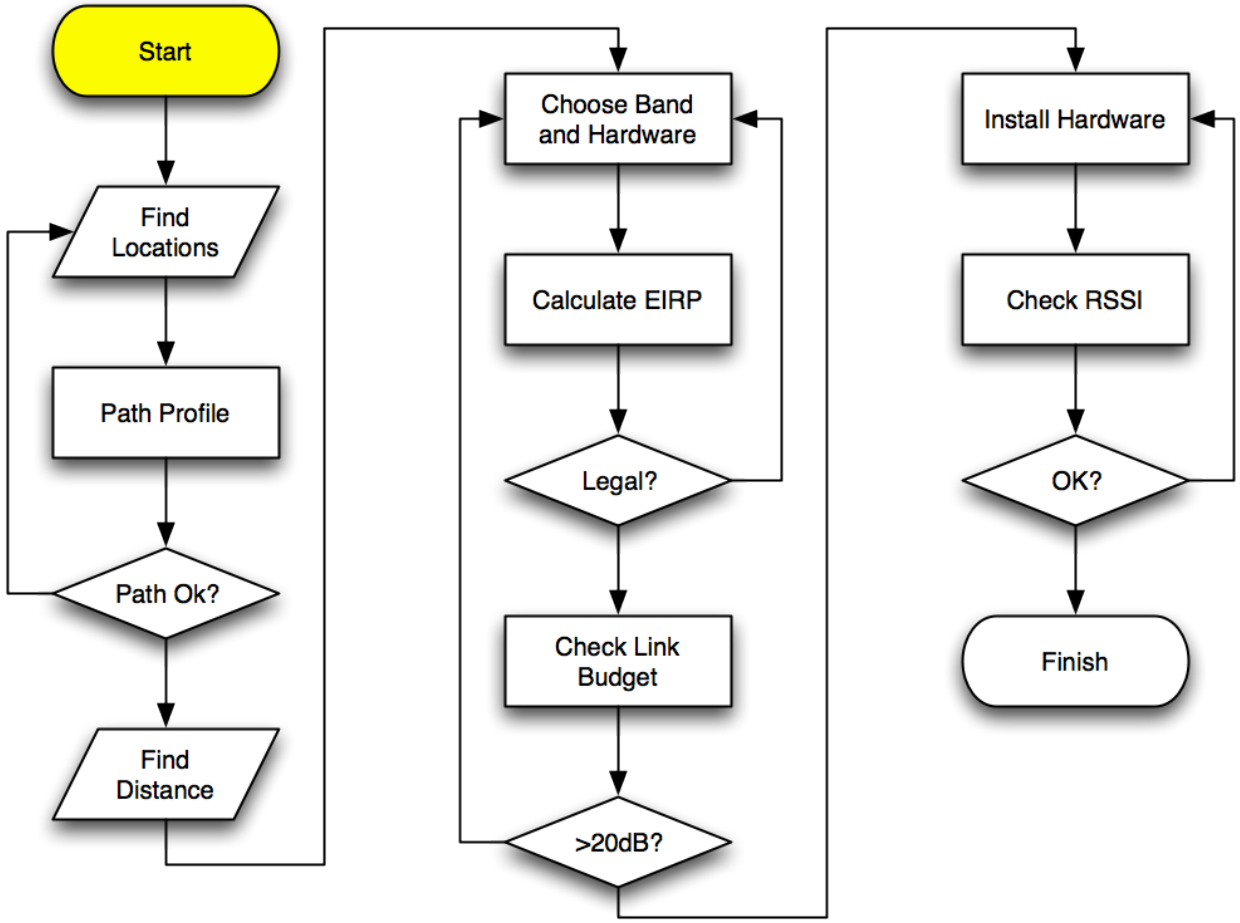
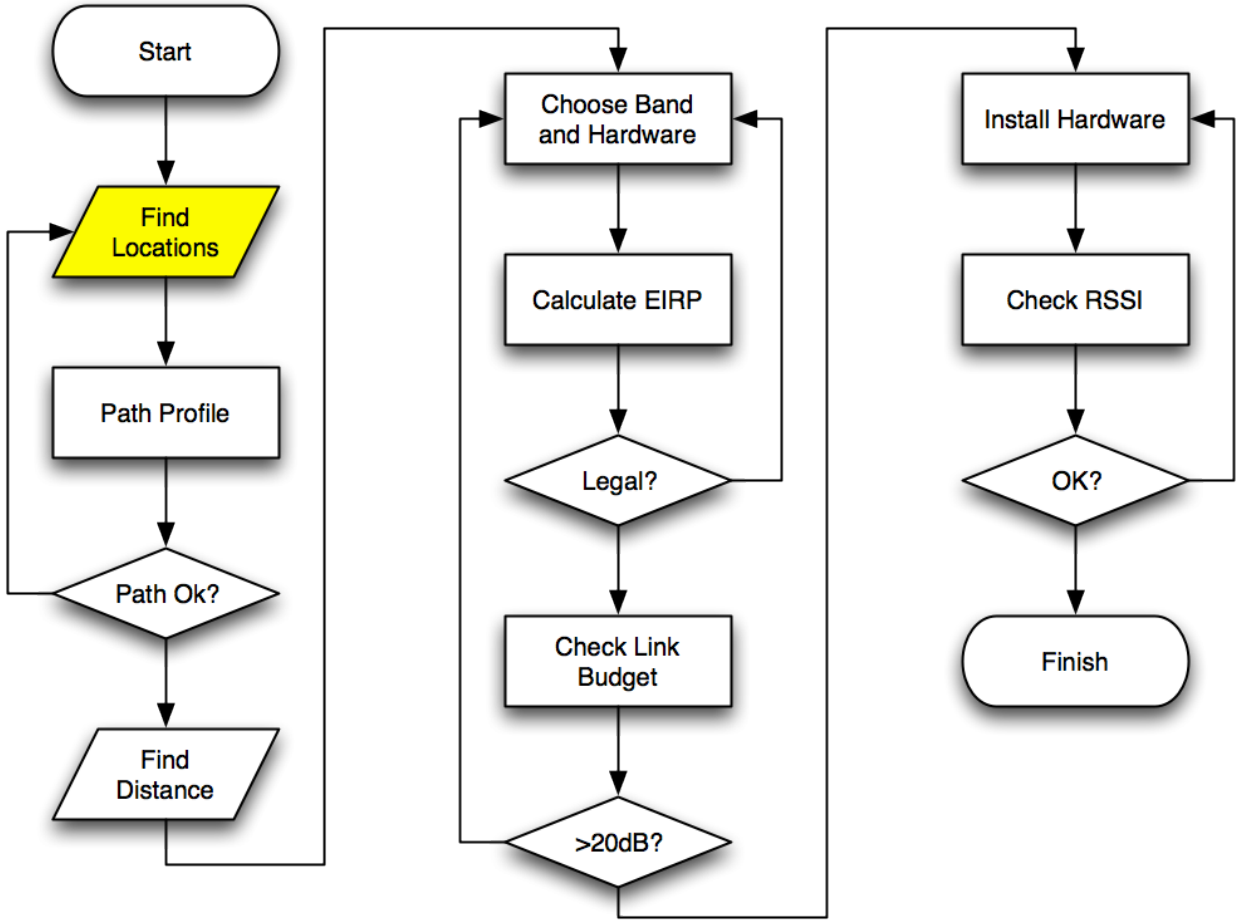
Building Point to Point Links With Mikrotik and RouterOS

Network Startup Resource Center
www.nsrc.org

UNIVERSITY OF OREGON

NSRC
Network Startup Resource Center


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

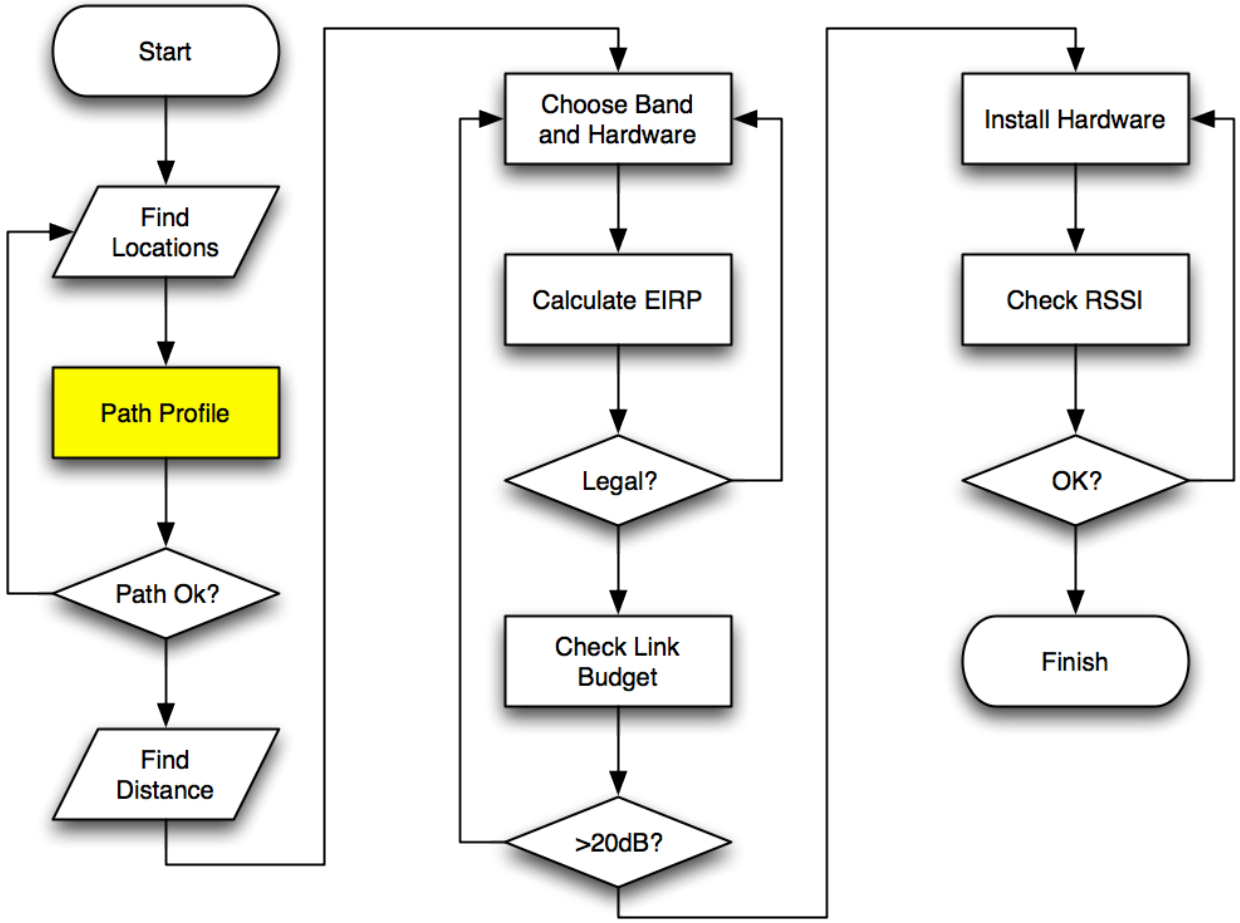
Planning the Link – Locations

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

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


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

Planning the Link – Profile

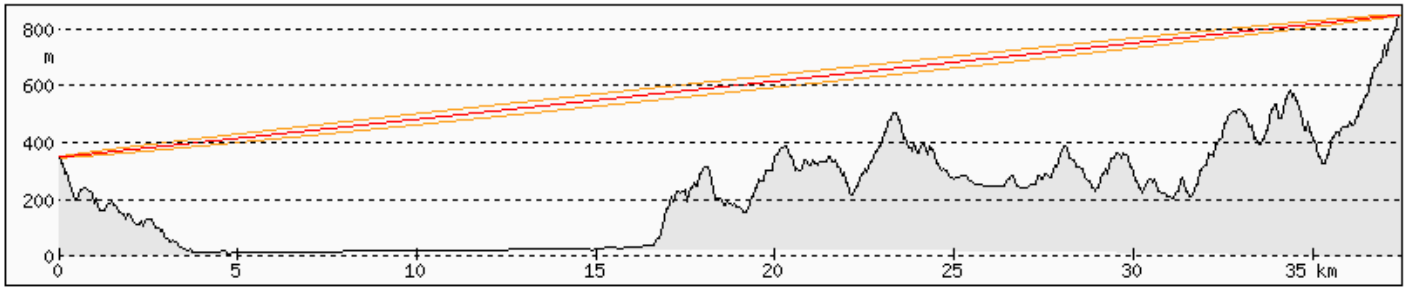
Check the path profile

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

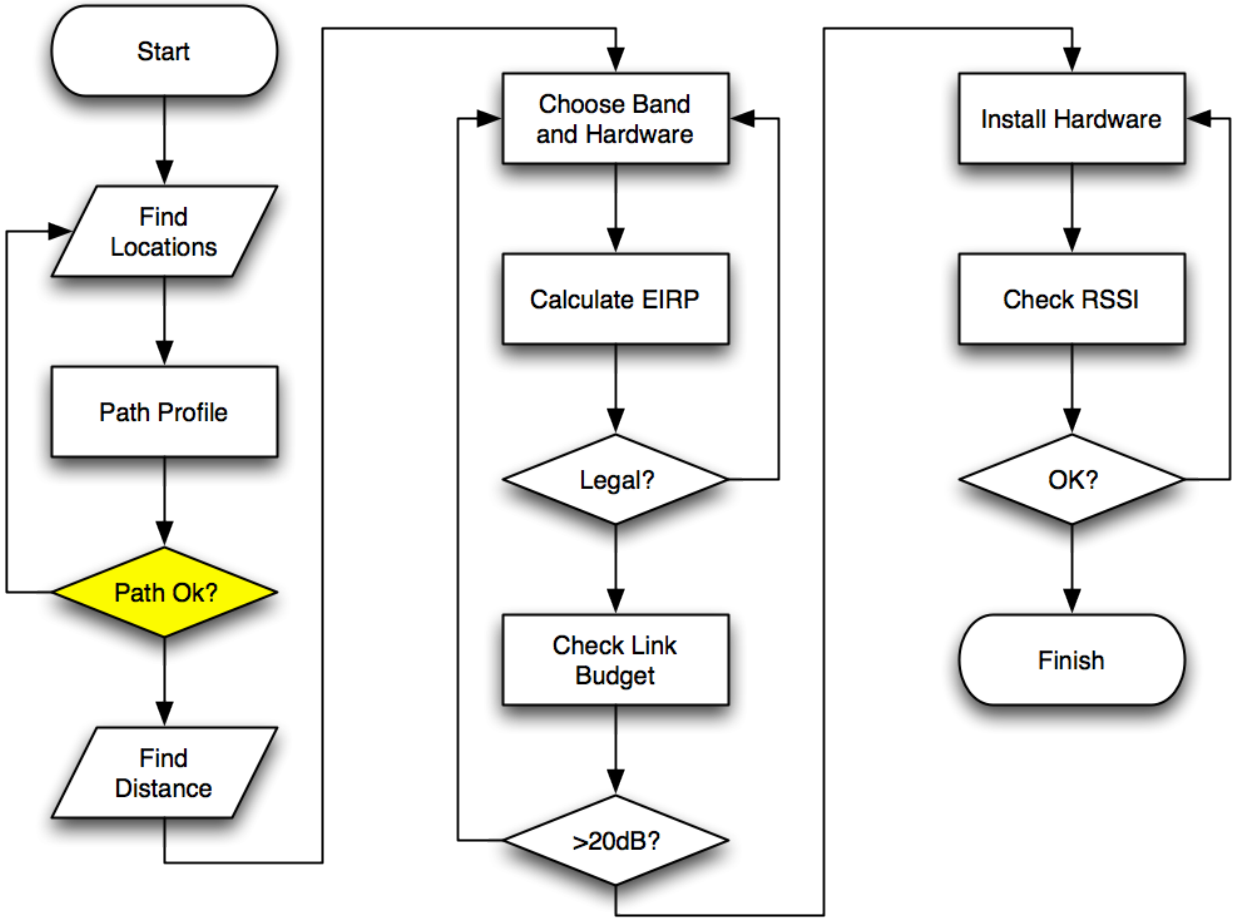
Is there line of sight?

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

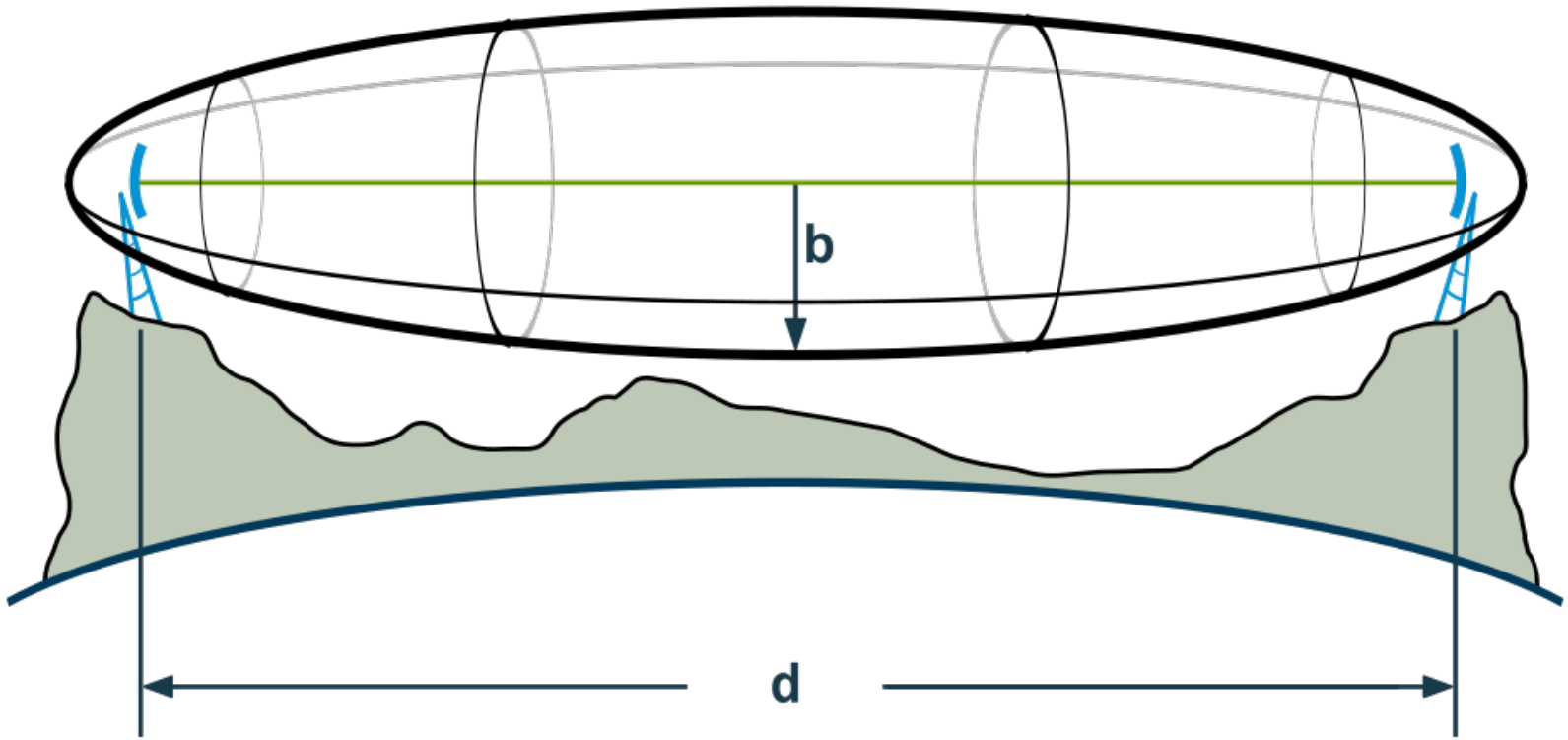
Planning the Link – Profile



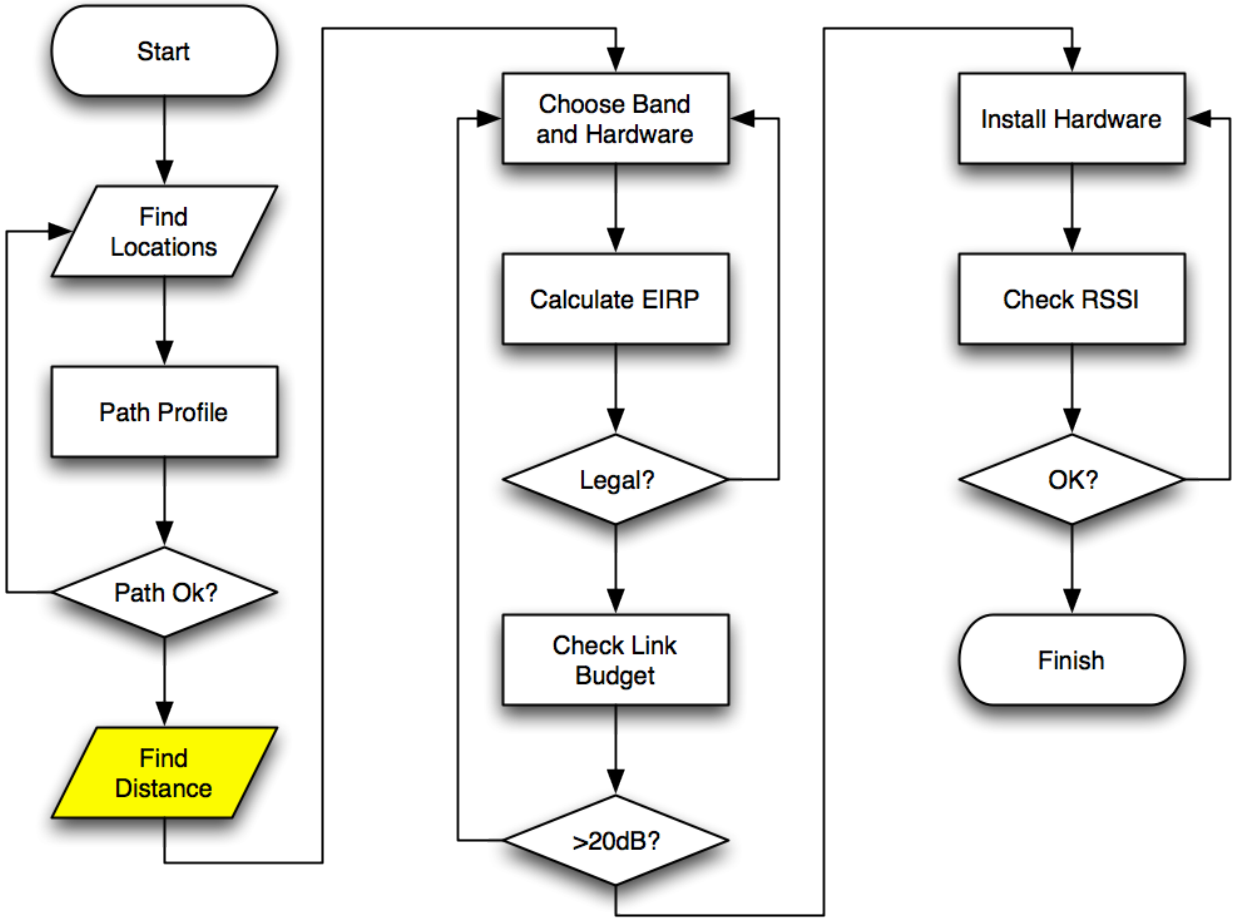
☑ show scale	○ straight line ◉ true line of sight	fixed exaggeration (e.g. 2)
○ flat Earth ◉ curved Earth	frequency (MHz, e.g. 5800) 5800	y range (e.g. -20,100)
○ plate carée ◉ great circle	refraction (e.g. .14)	elevation data source ◉ SRTM ○ Google


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

Planning the Link - Fresnel



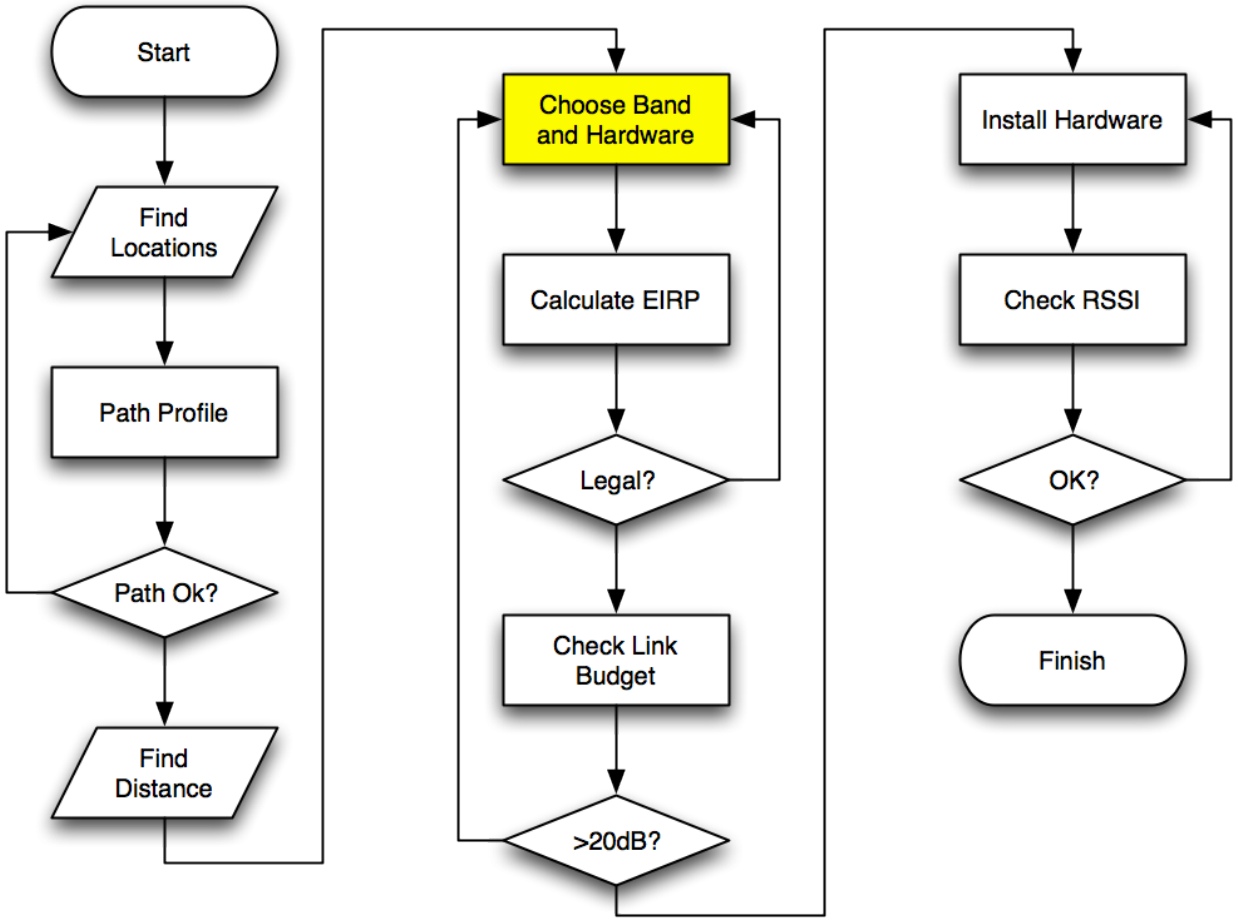
Licensed under the GFDL by Averse - http://en.wikipedia.org/wiki/File:FresnelSVG.svg


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

Planning the Link - Distance

Find the path distance

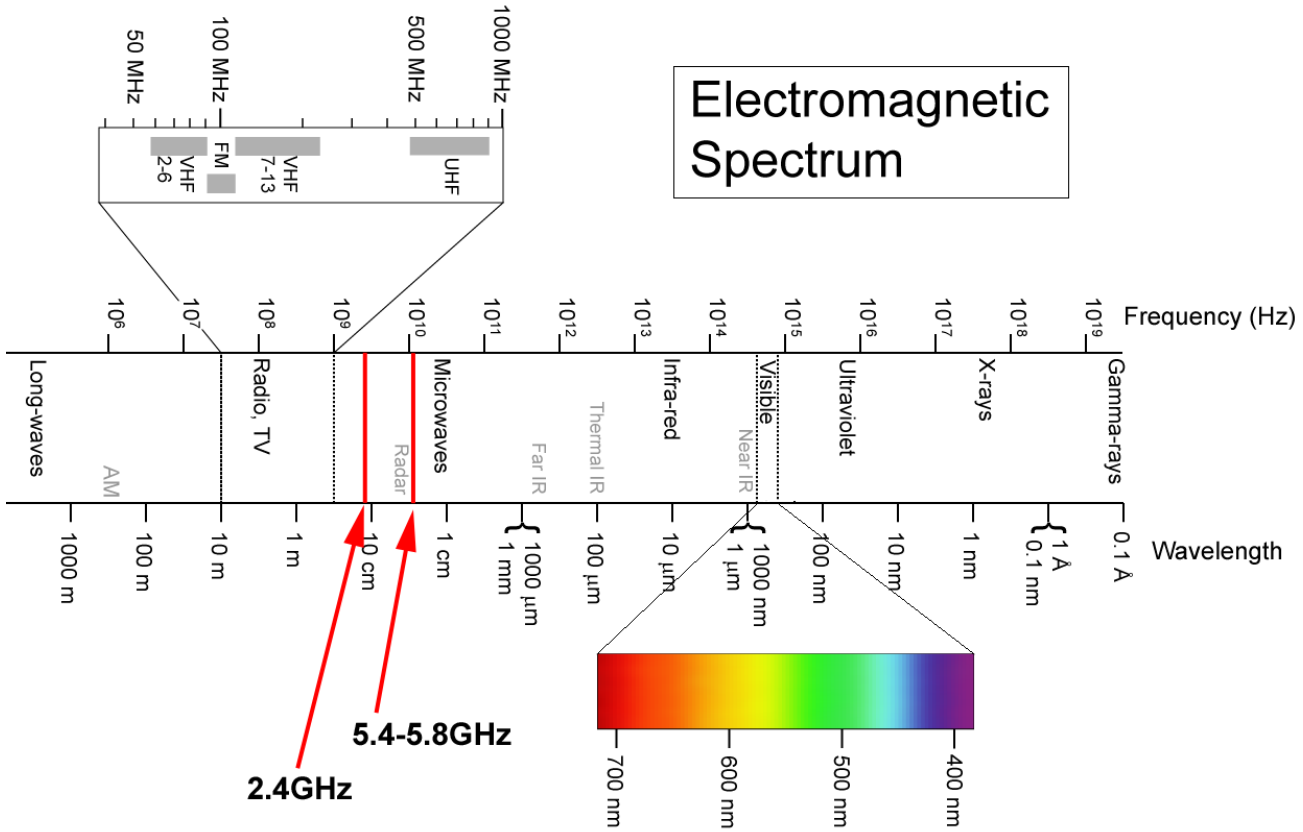
- In kilometres – always!
- Required for decision on band
- Later required for link budget
- Example Rota to Saipan xx kilometers


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

NZ Bands & Power Limits

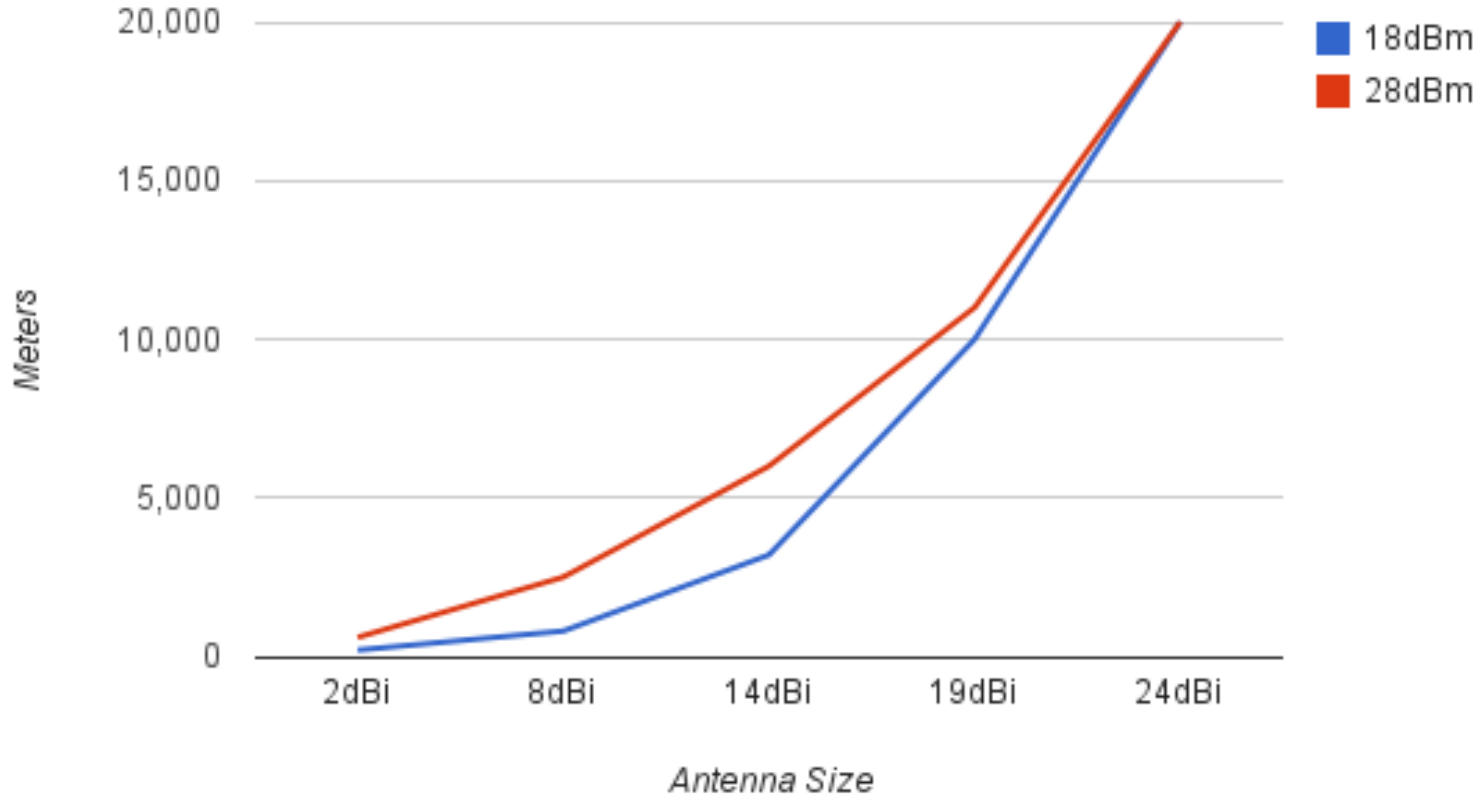
- 2.4GHz
  - 2400-2483MHz
  - 4W (36dBm) EIRP
- 5.2 & 5.8GHz
  - 5250-5350MHz
  - 5470-5725MHz
  - 1W (30dBm) EIRP
  - ATPC, DFS
- 5.8GHz
  - 5725-5875 P-P, P-MP @ 4W (36dBm) EIRP
  - 5725-5825 P-P @ 200W (53dBm) EIRP

NZ Bands in the Spectrum

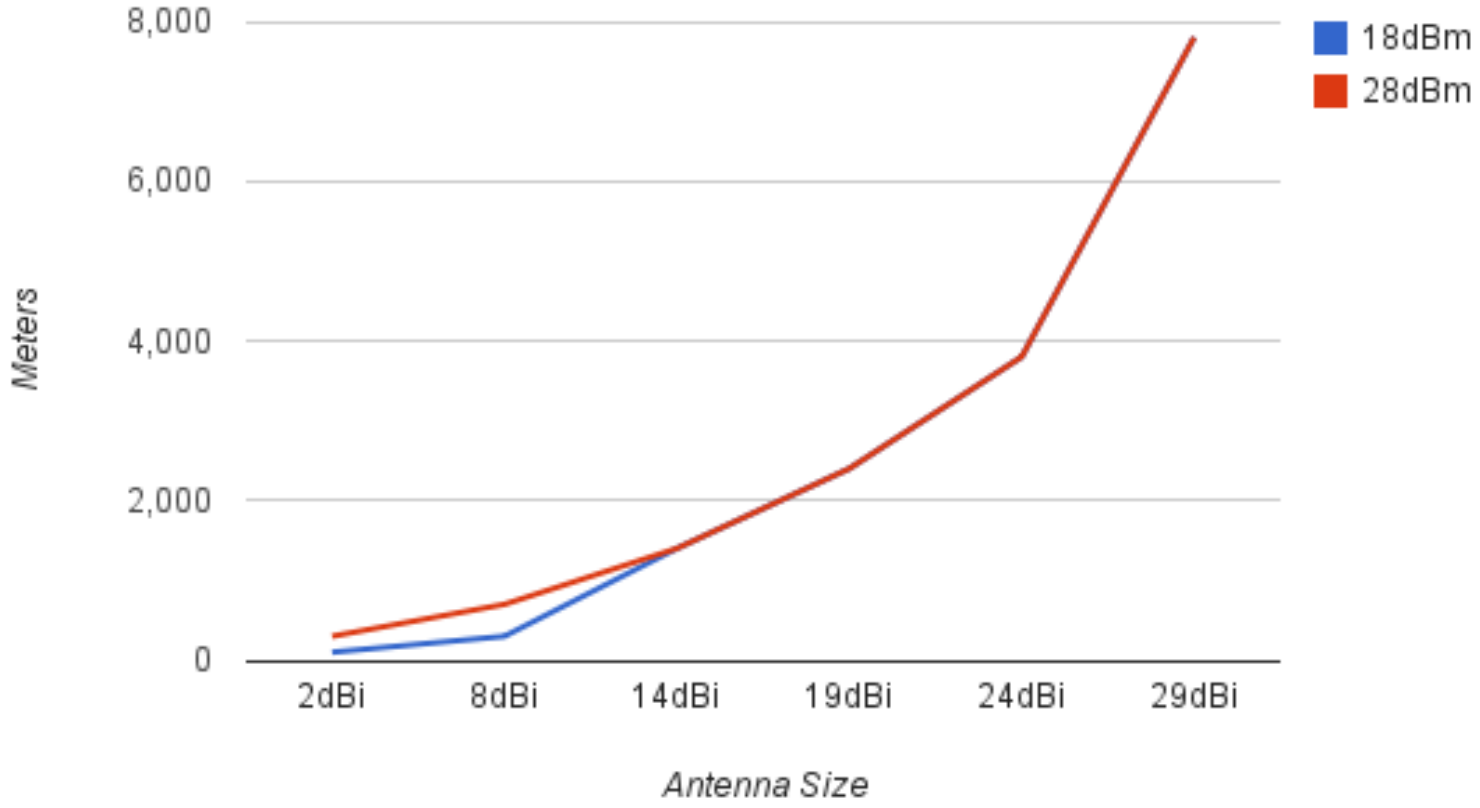


Creative Commons Share-Alike 2.5 - http://en.wikipedia.org/wiki/File:Electromagnetic-Spectrum.png

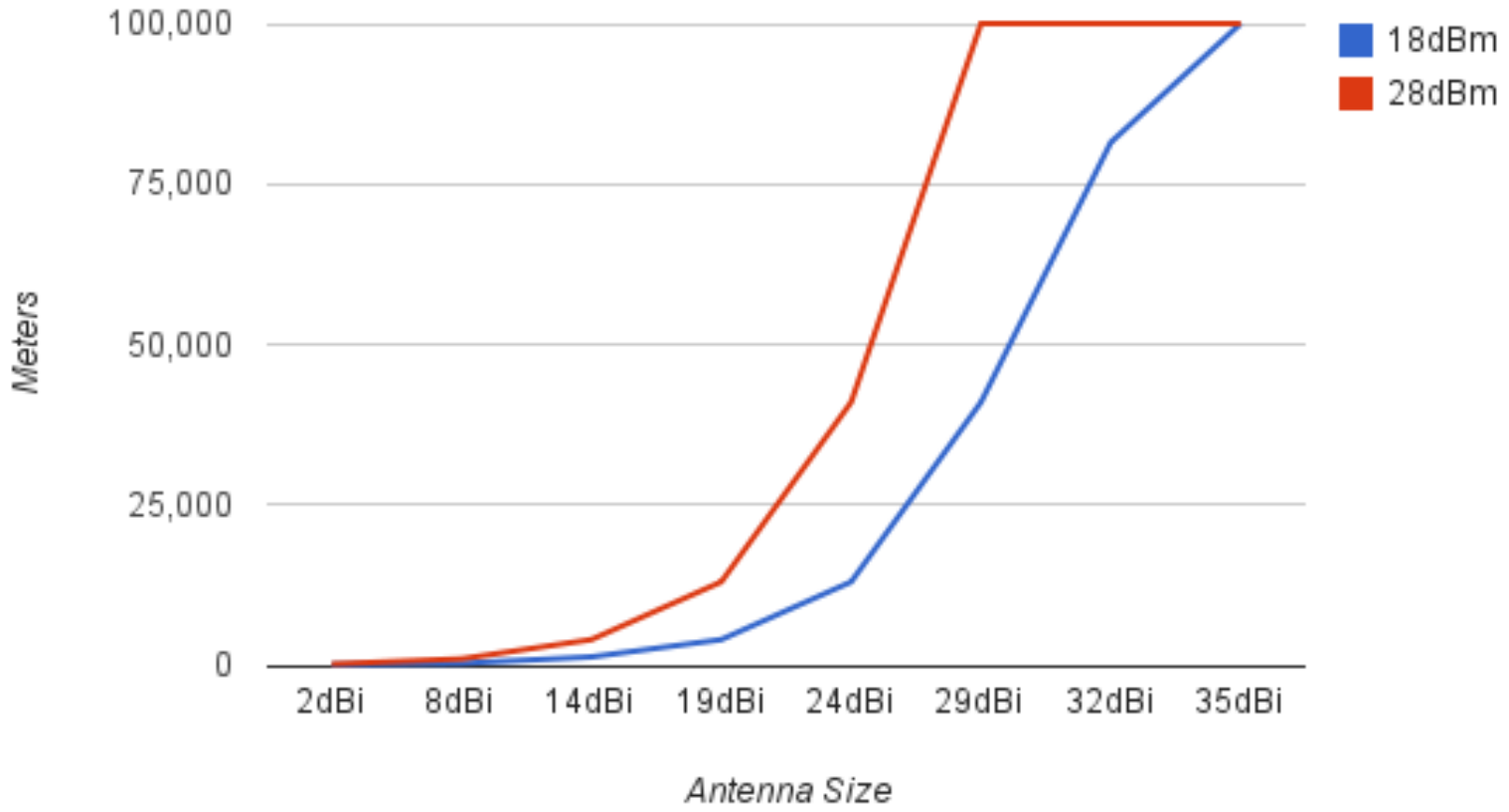
2.4GHz for P-P, P-MP

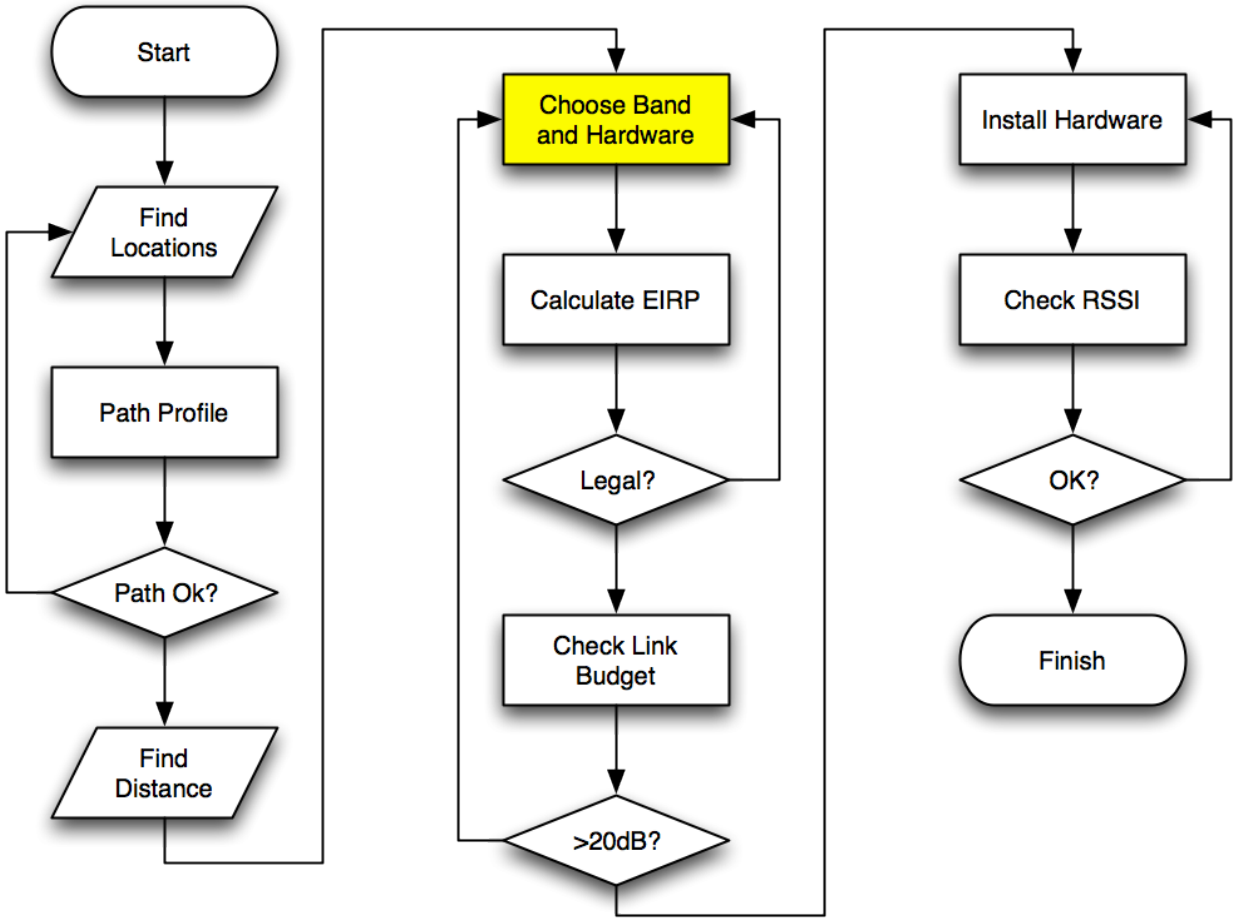


5.4GHz for P-P, P-MP



5725-5825MHz P-P Only




Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

Standard Radio Cards

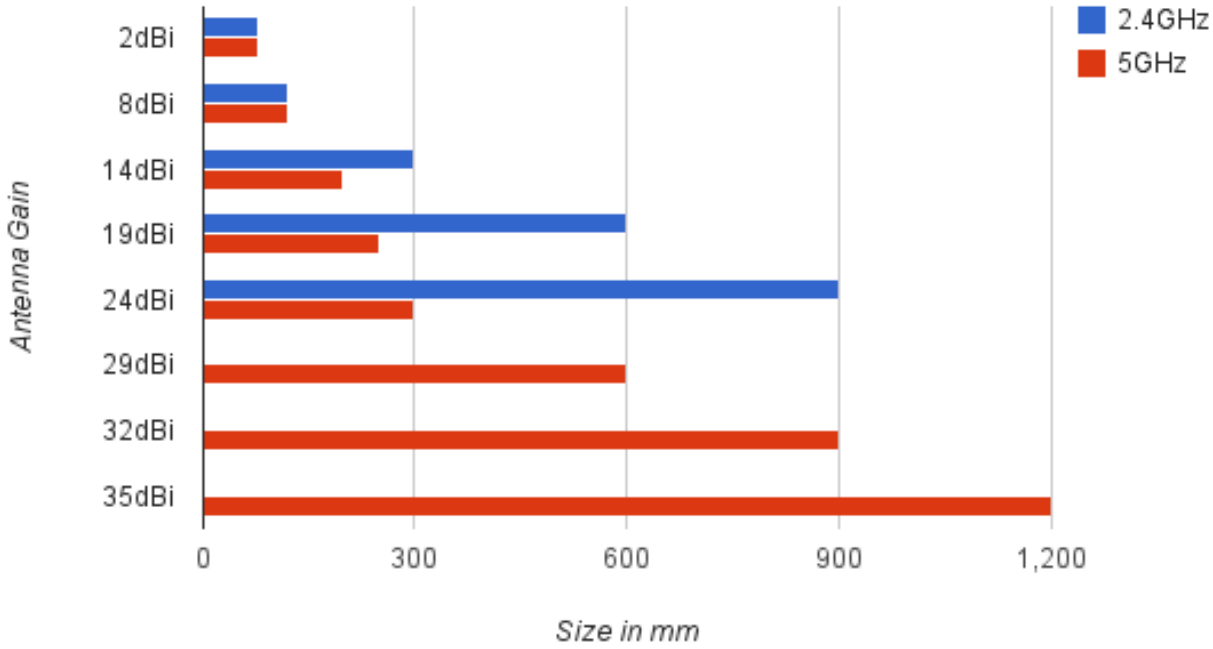
Mikrotik R52

$79

Ubiquiti XR5

$179

Antenna Sizes & Gain



Calculating EIRP

EIRP = Effective Isotropic Radiated Power

EIRP = PT (power of transmitter) (dBm)

- Lc (cable losses) (dB)

+ Ga (antenna gain) (dBi)

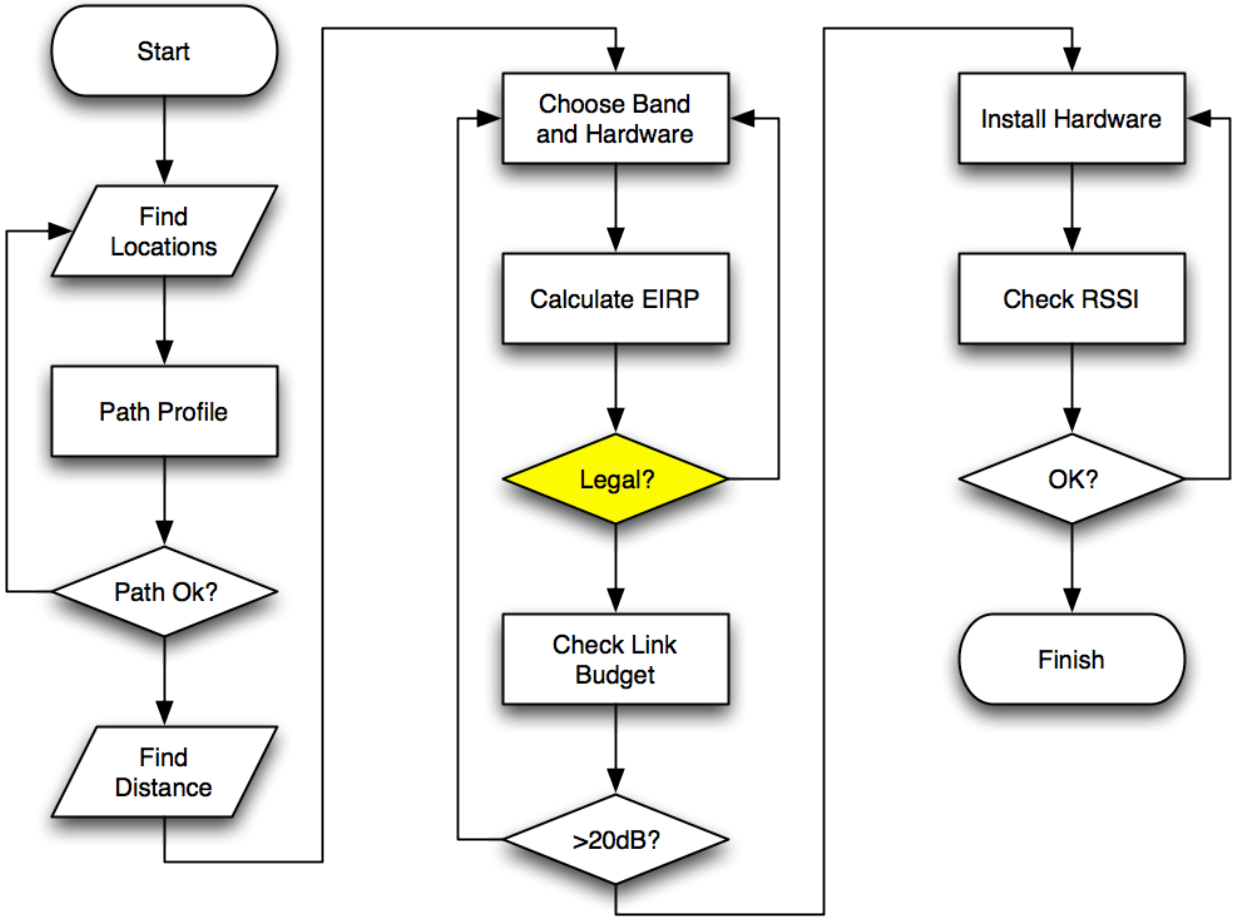
18dBm card - 2dB cable + 14dBi antenna = 30dBm

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

30dBm = 1W

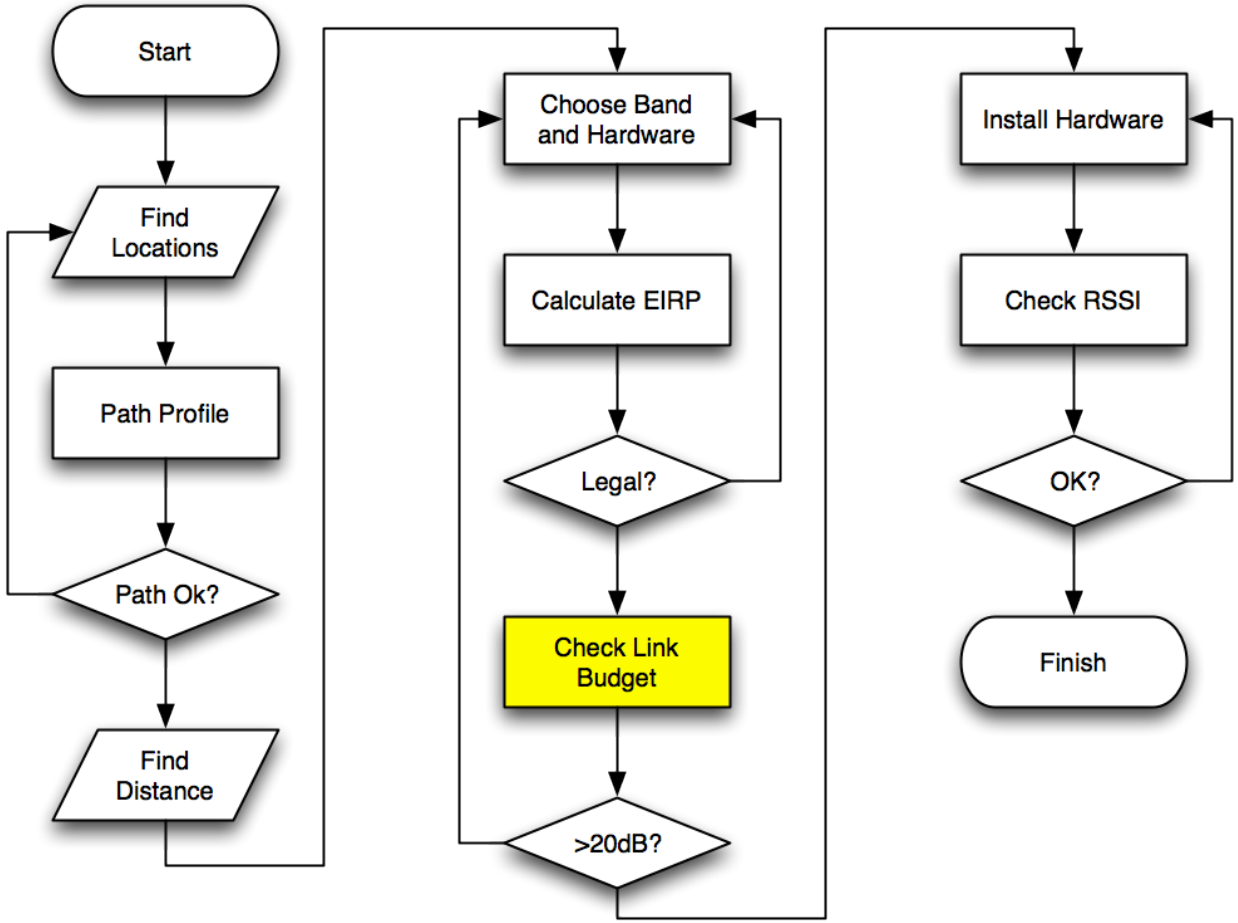
36dBm = 4W

53dBm = 200W


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

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


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

Link Budget Calculation

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

P_{RX} = received power (dBm)

P_{TX} = transmitter output power (dBm)

G_{TX} = transmitter antenna gain (dBi)

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

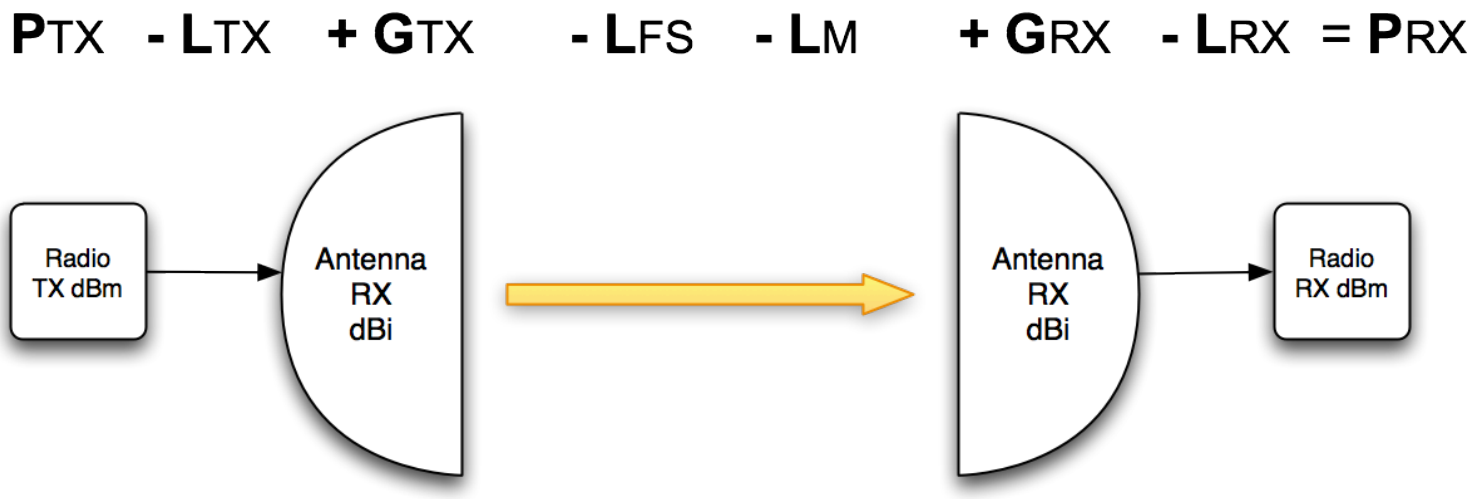
L_{FS} = free space loss or path loss (dB)

L_{M} = miscellaneous losses (other losses...) (dB)

G_{RX} = receiver antenna gain (dBi)

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

Link Budget Diagram



Free Space Loss

L*FS* (dB) = 20*log[4*π*distance/wavelength]

- where distance and wavelength are in the same units

2.4GHz = 0.125M

10KM = 10,000M

L*FS* (dB) = 20*log[4*3.14*10,000/.125]

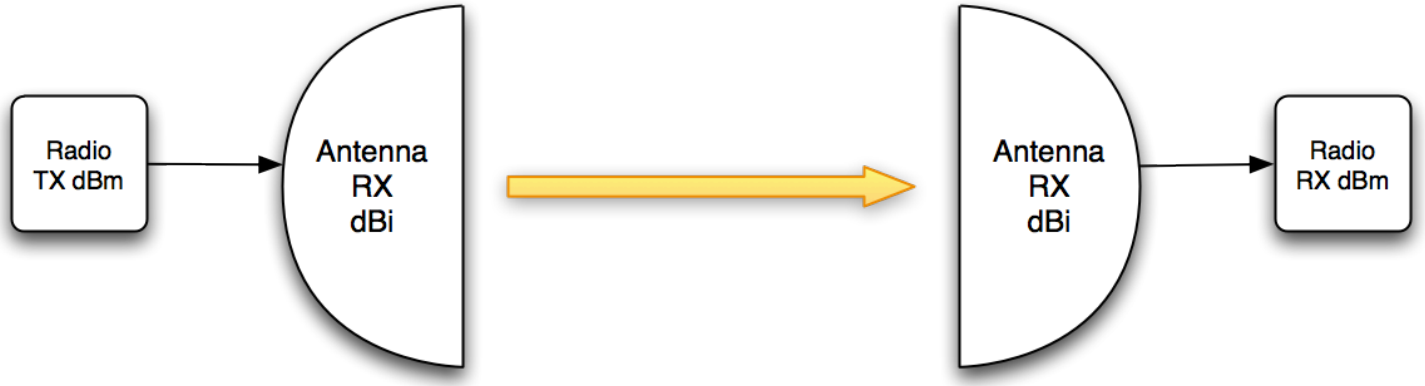
L*FS* (dB) = 20*log[1,004,800]

L*FS* (dB) = 20*6

L*FS* (dB) = 120

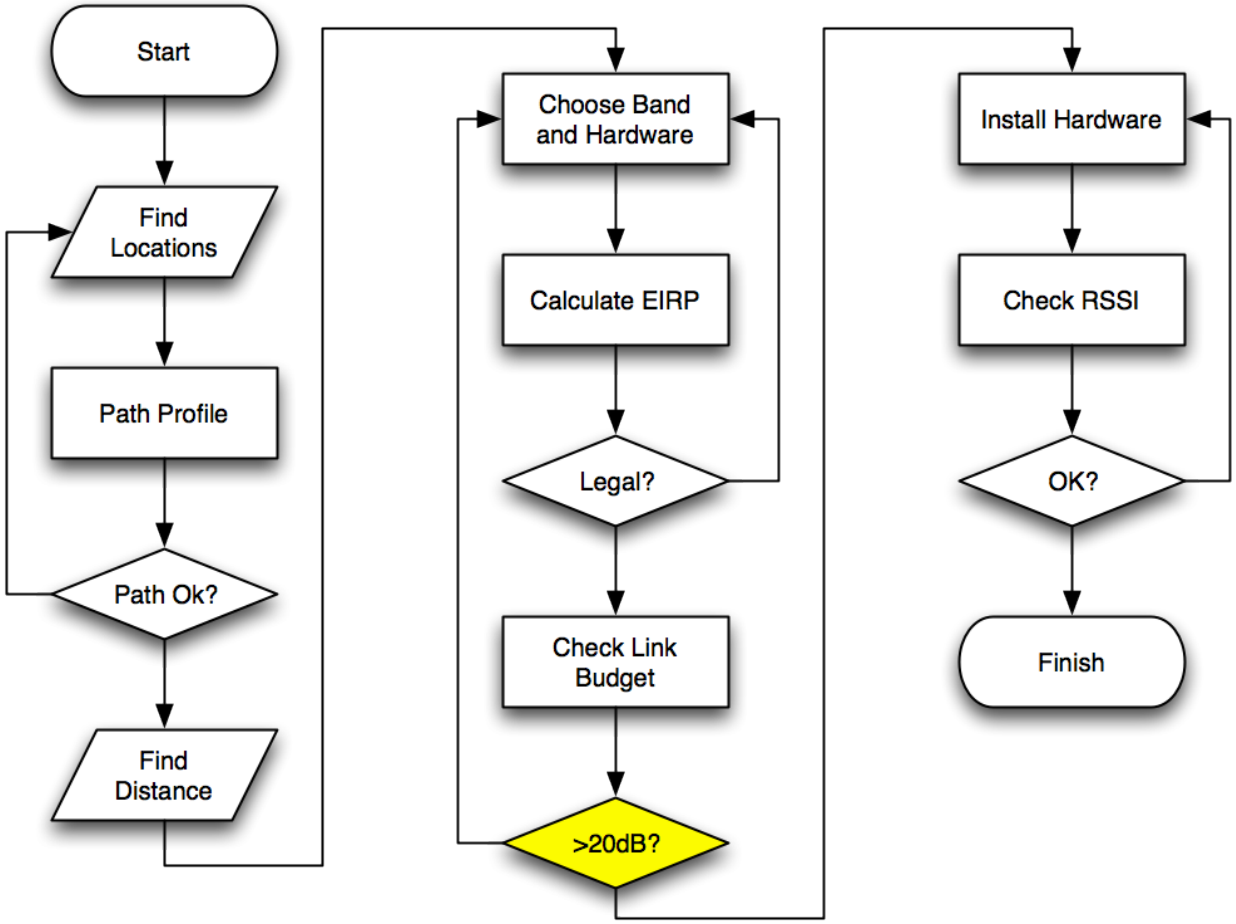
Link Budget Solved

PTX - LTX + GTX - LFS - LM + GRX - LRX = PRX



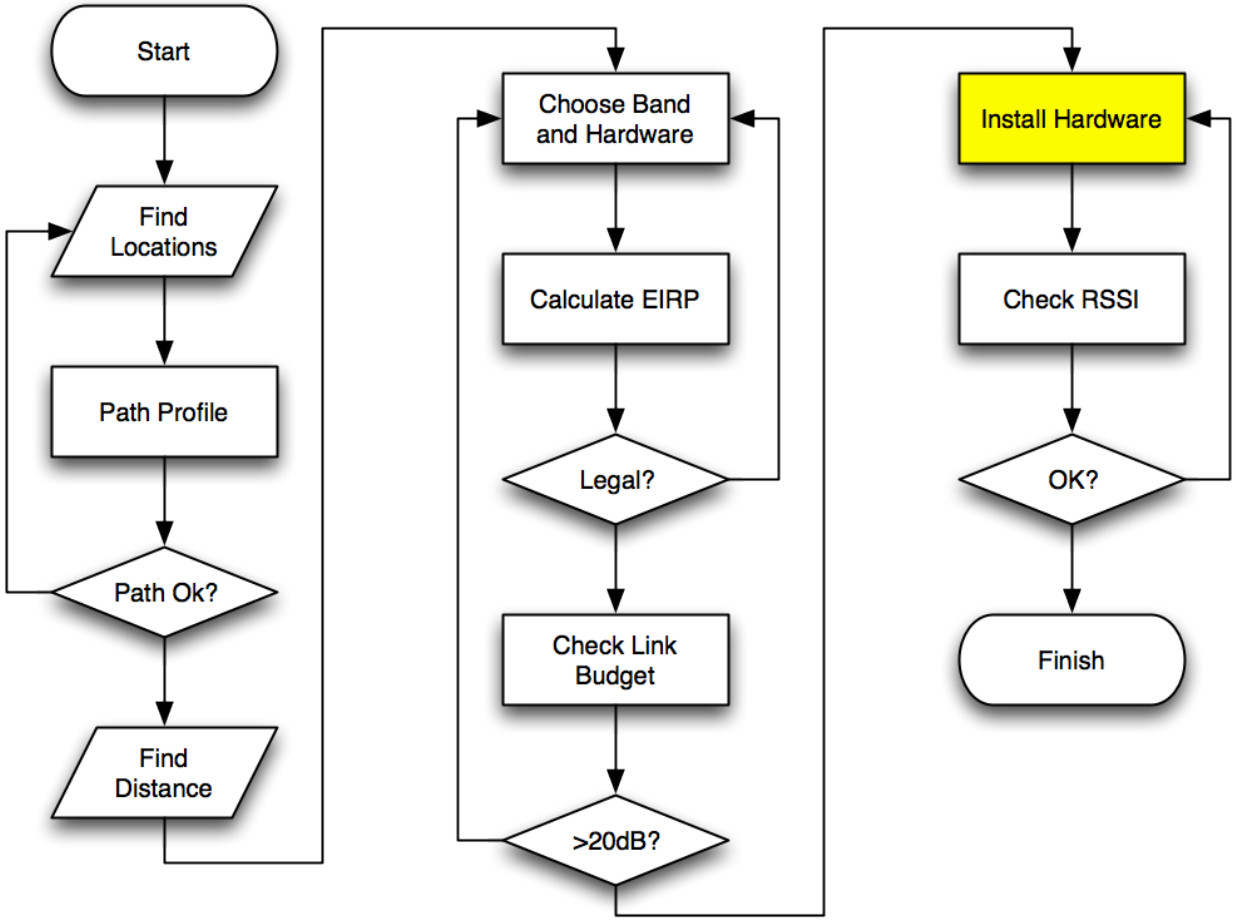
18dBm - 2dB + 19dBi - 120dB -0dB + 19dBi -2dB =

-68dBm Received Signal Level


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

Receive Sensitivities

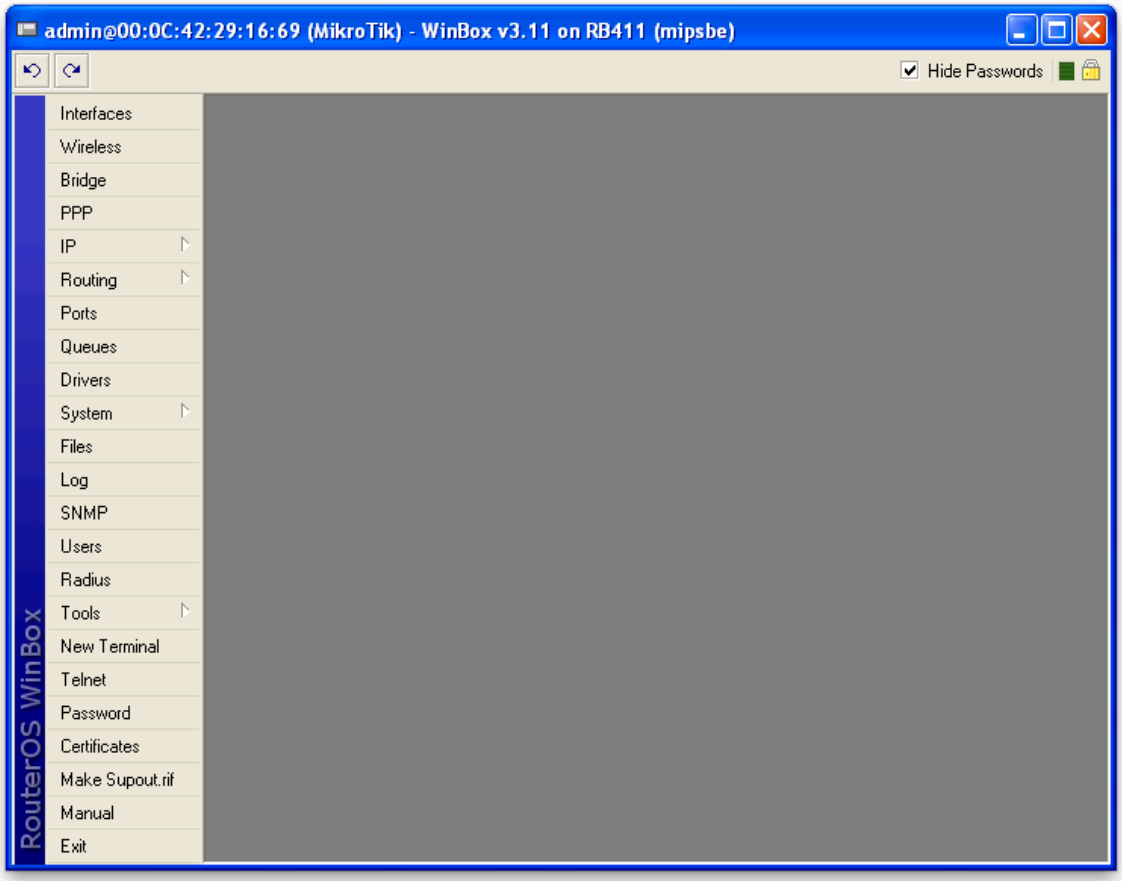
- Mikrotik R52
  - -71dBm required for 54mbps (64QAM)
  - -88dBm required for 6mbps (BPSK)
- Ubiquiti XR5
  - -74dBm required for 54mbps (64QAM)
  - -94dBm required for 6mbps (BPSK)


Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

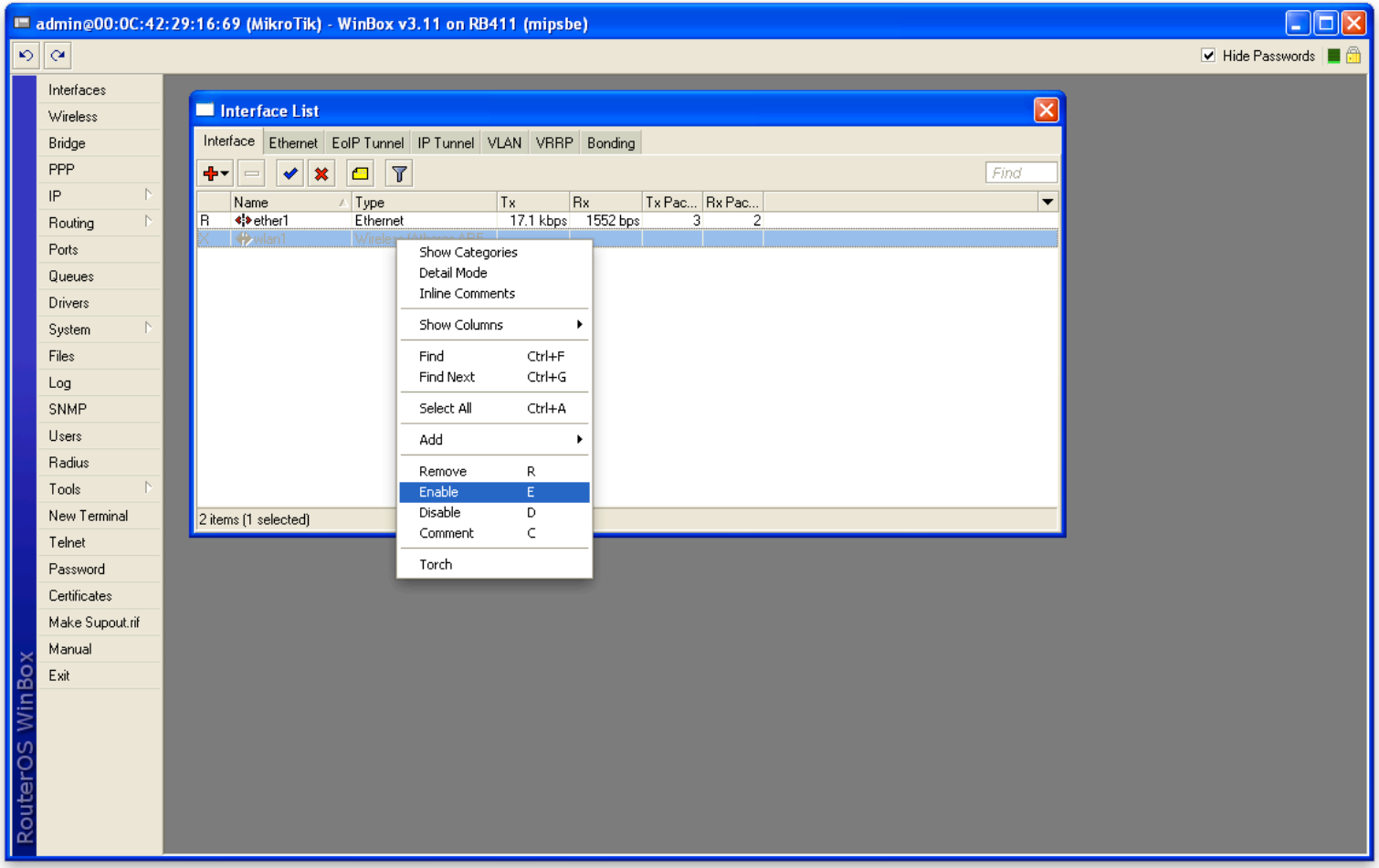
Upgrade & Configure Mikrotik

- 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”

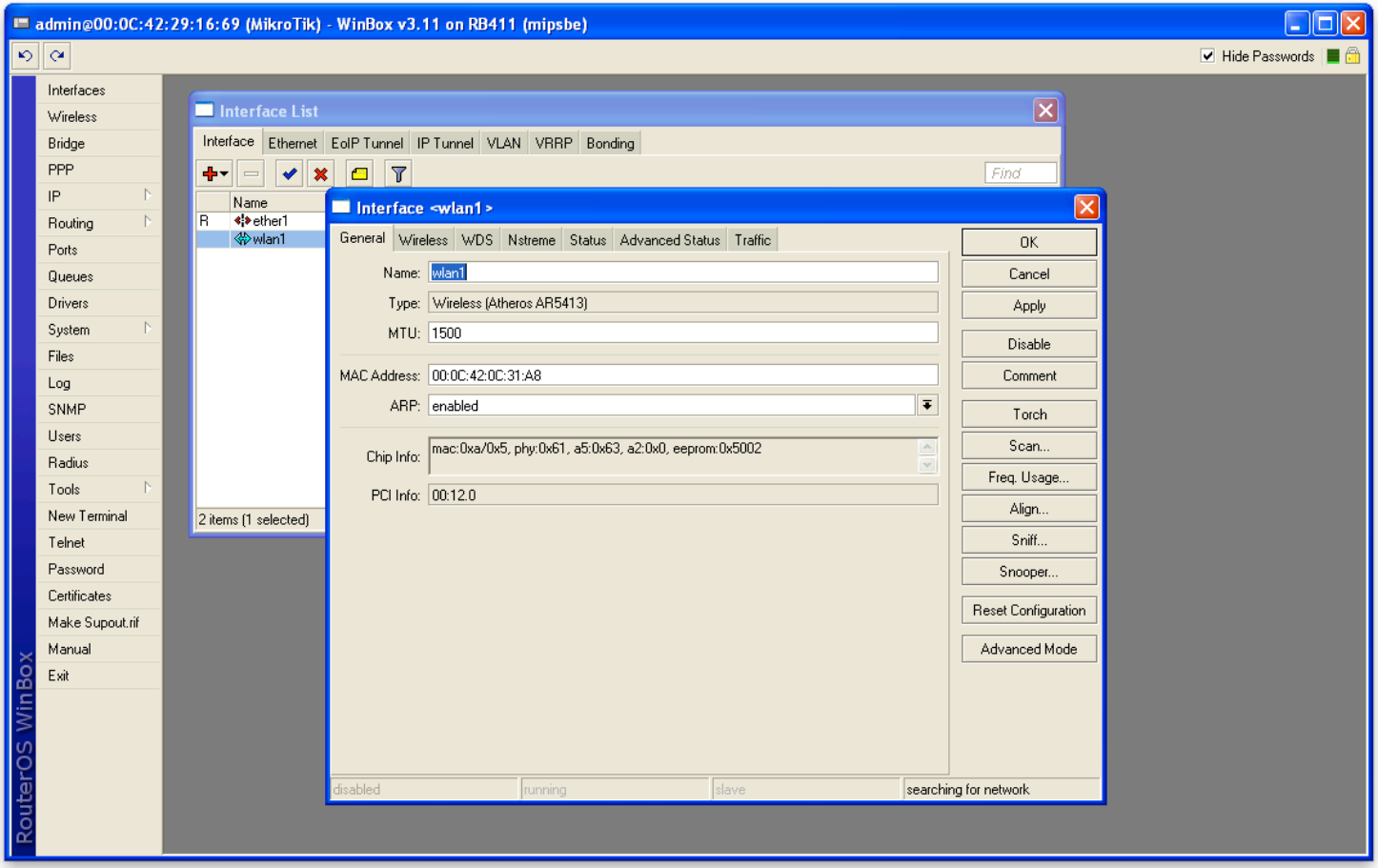
Mikrotik Winbox



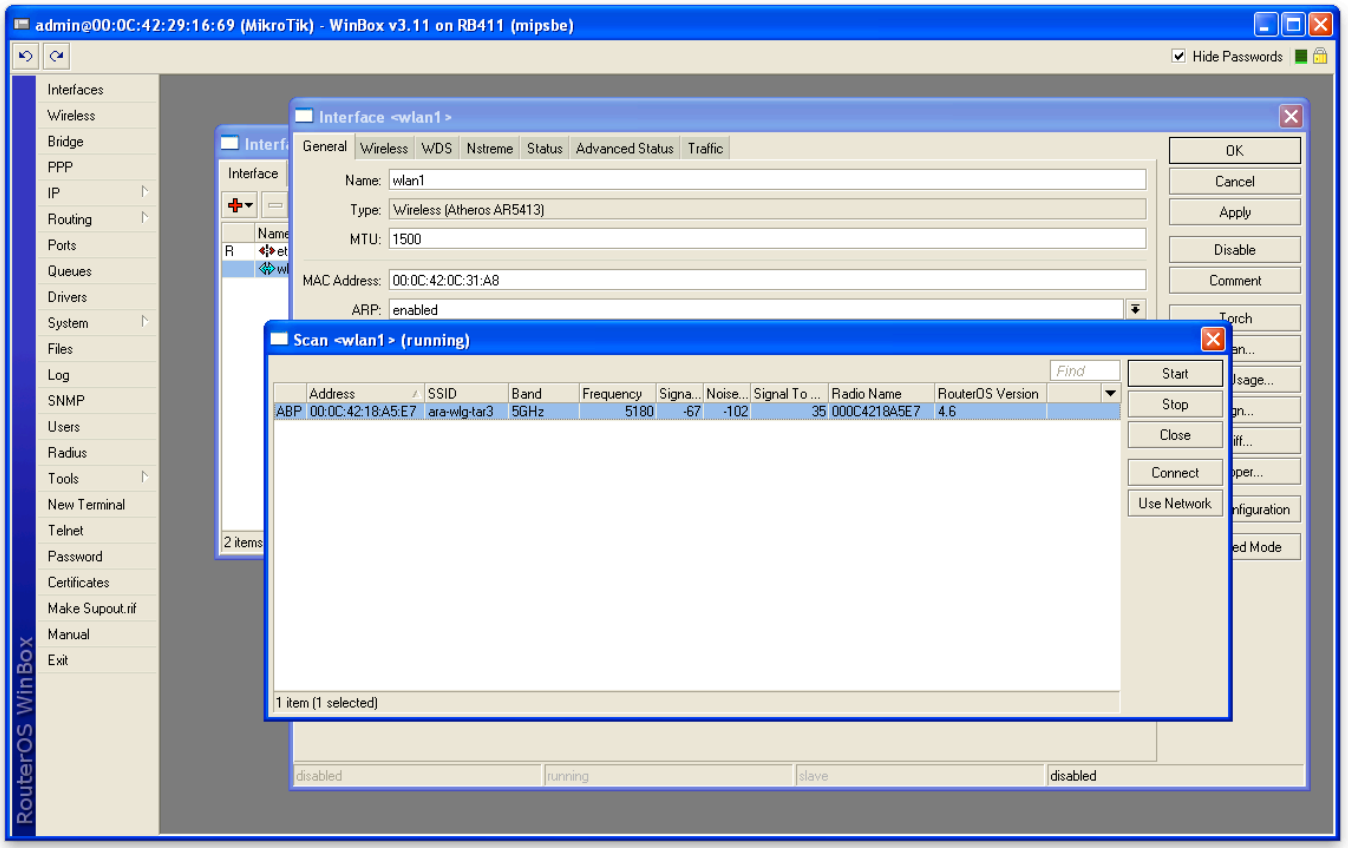
Enable a Wireless Interface



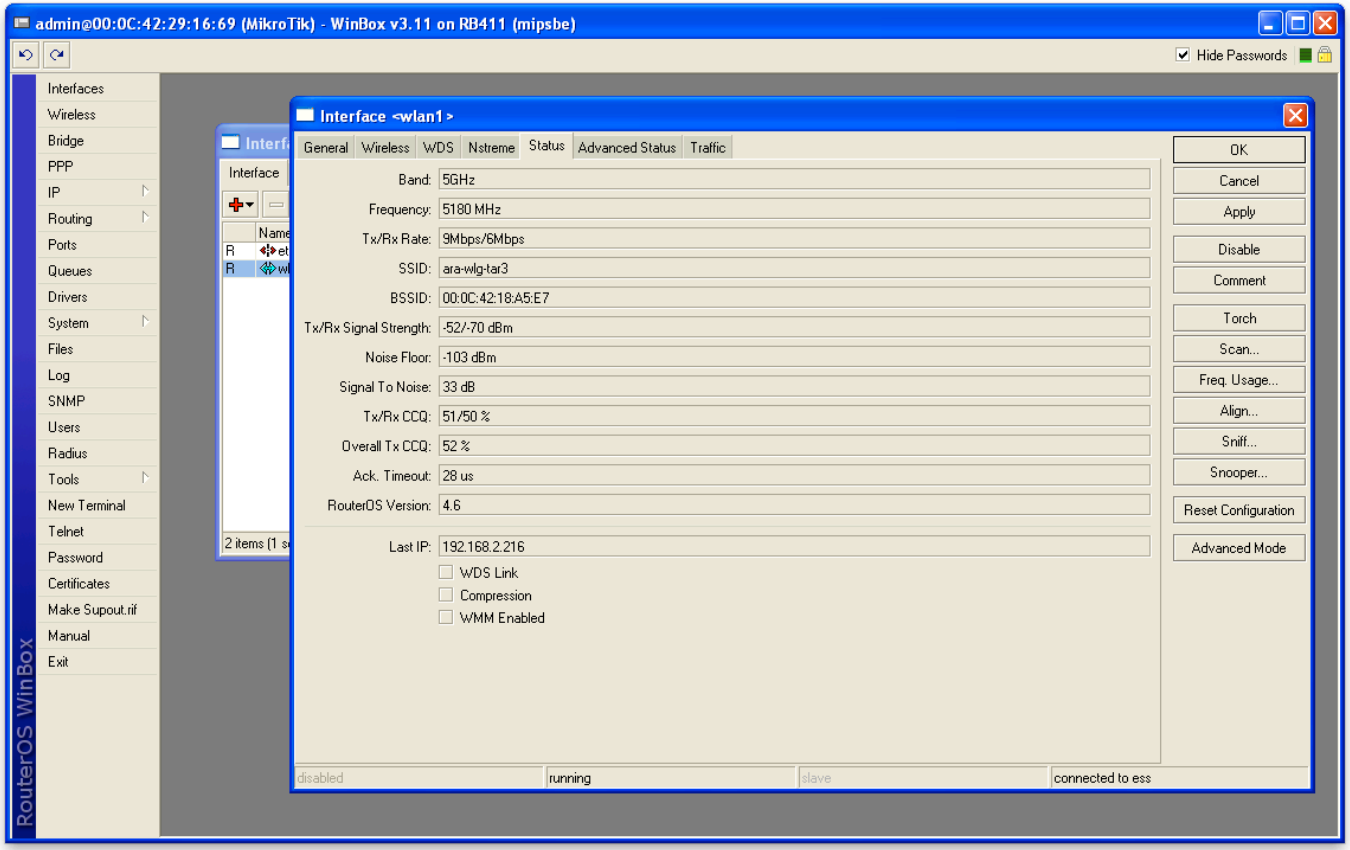
Open wlan1 & Browse Tabs



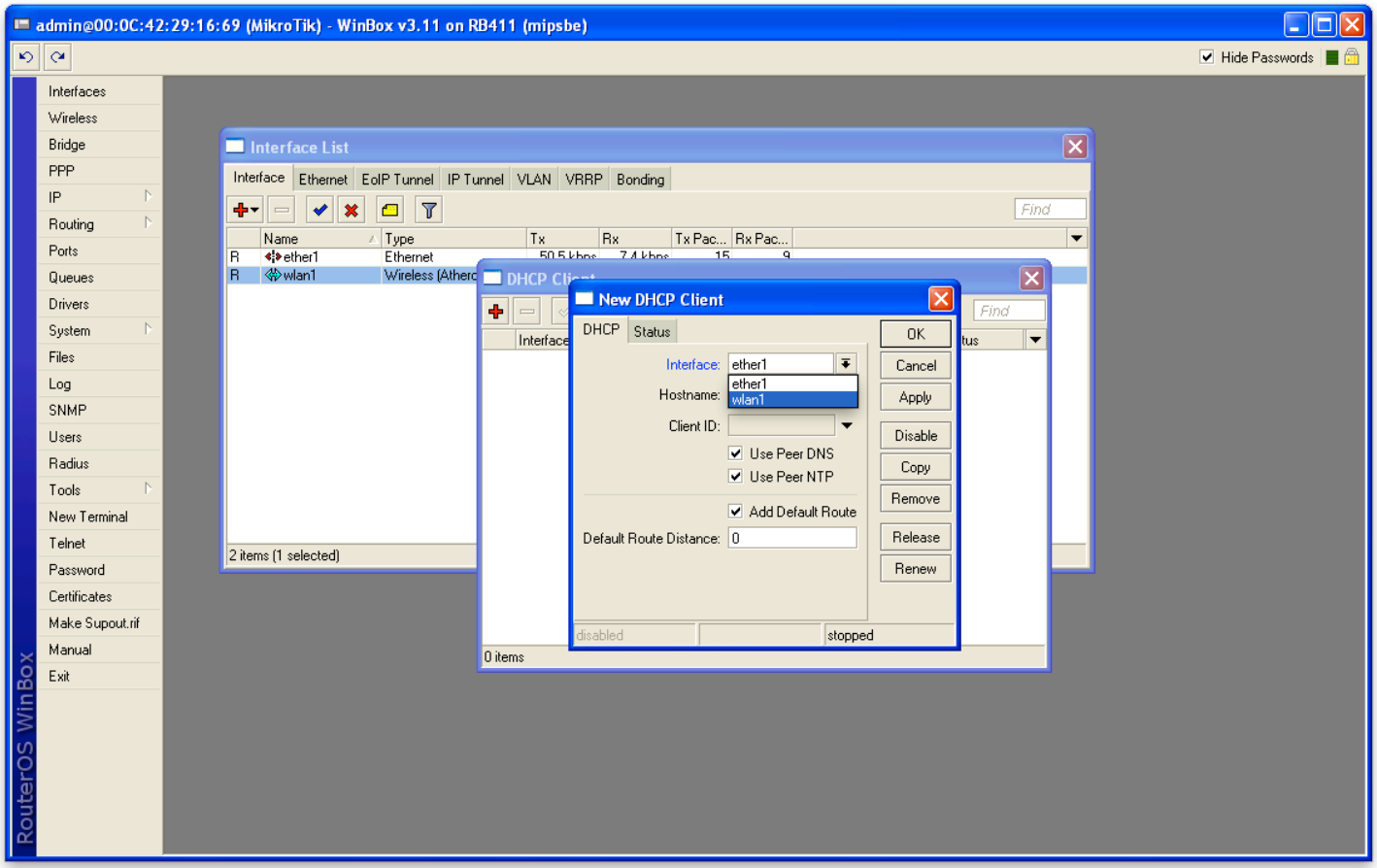
Scan and Connect to Network



Close Scan & View Status

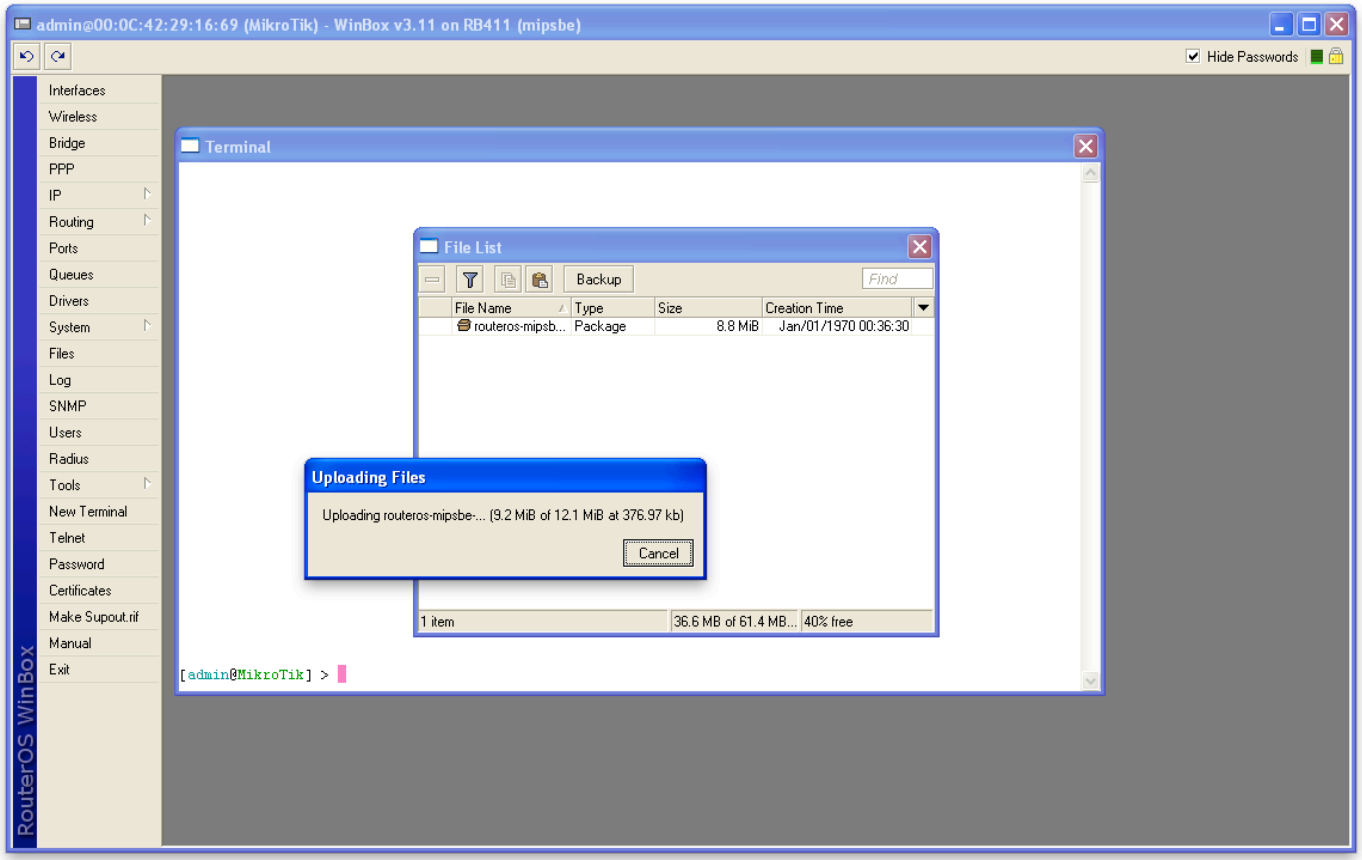


Get Online with DHCP

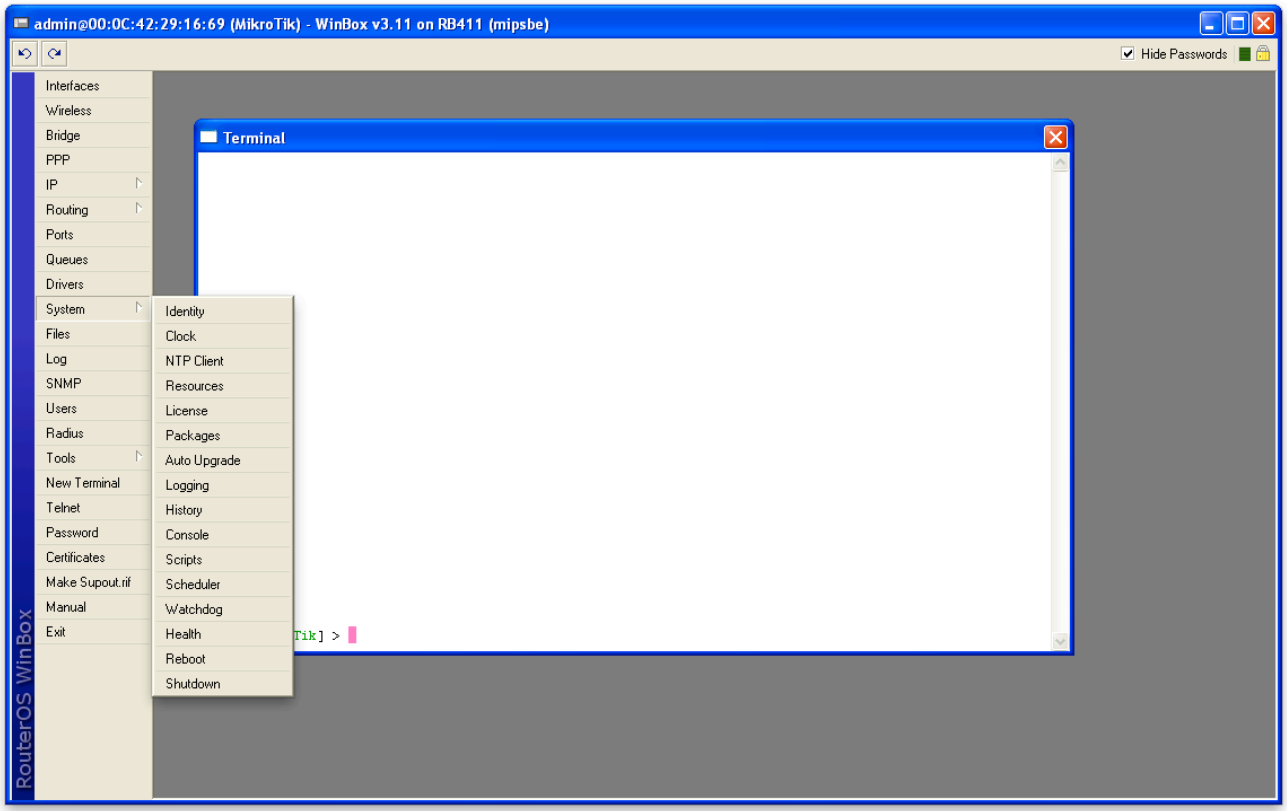


Download Latest Software

Upgrade Using Winbox



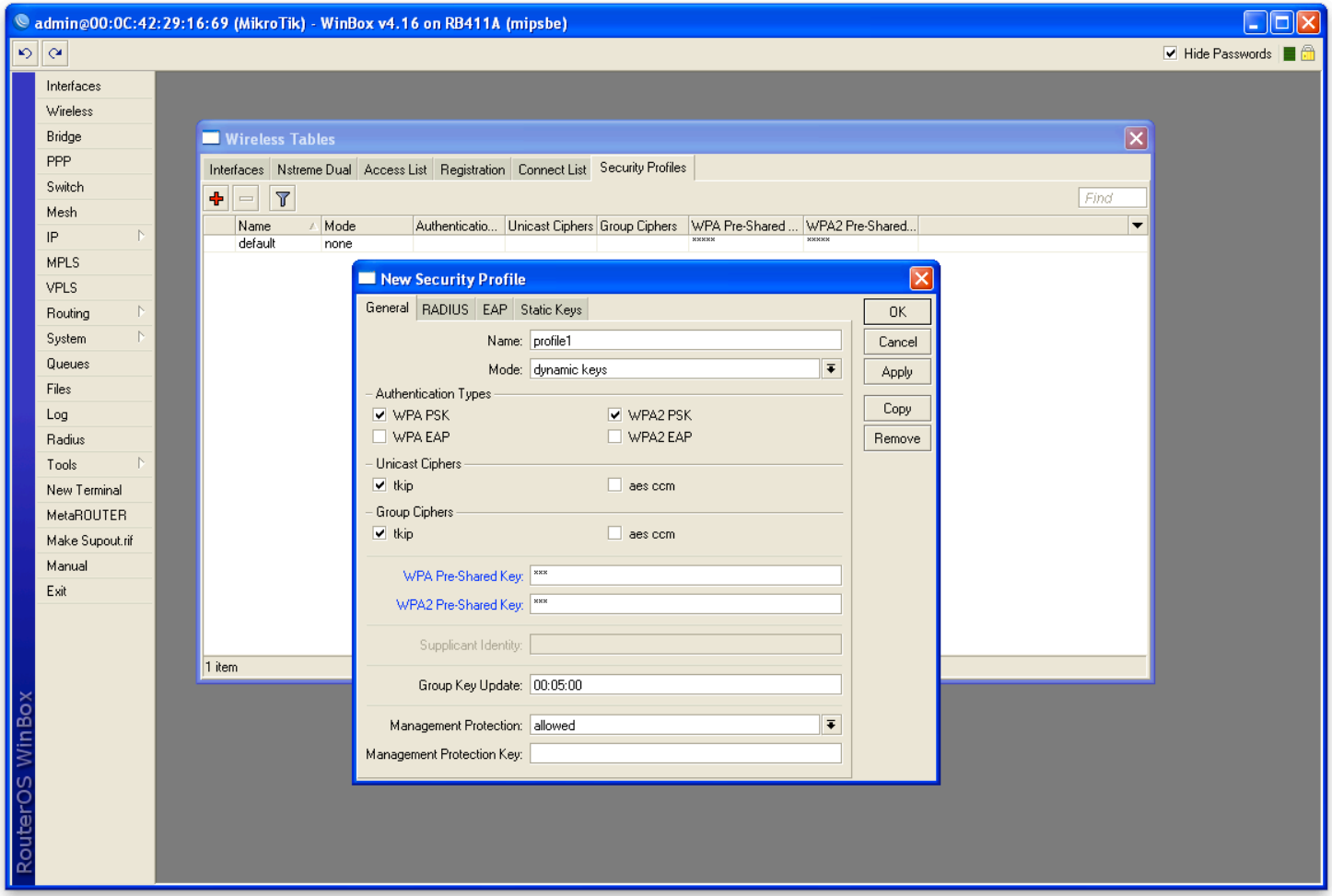
Reboot to Upgrade (x2)



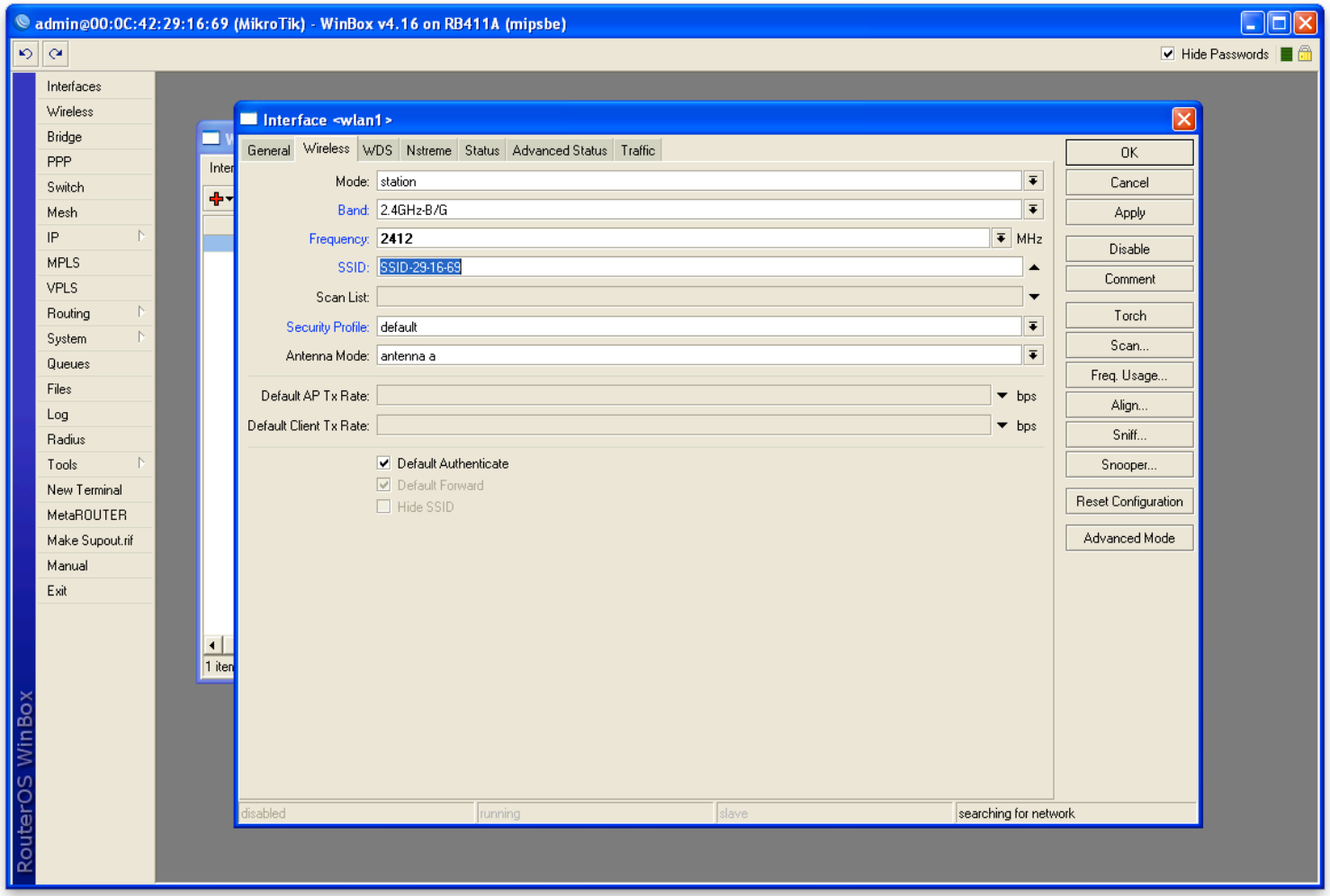
Making a Simple Hotspot

- 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

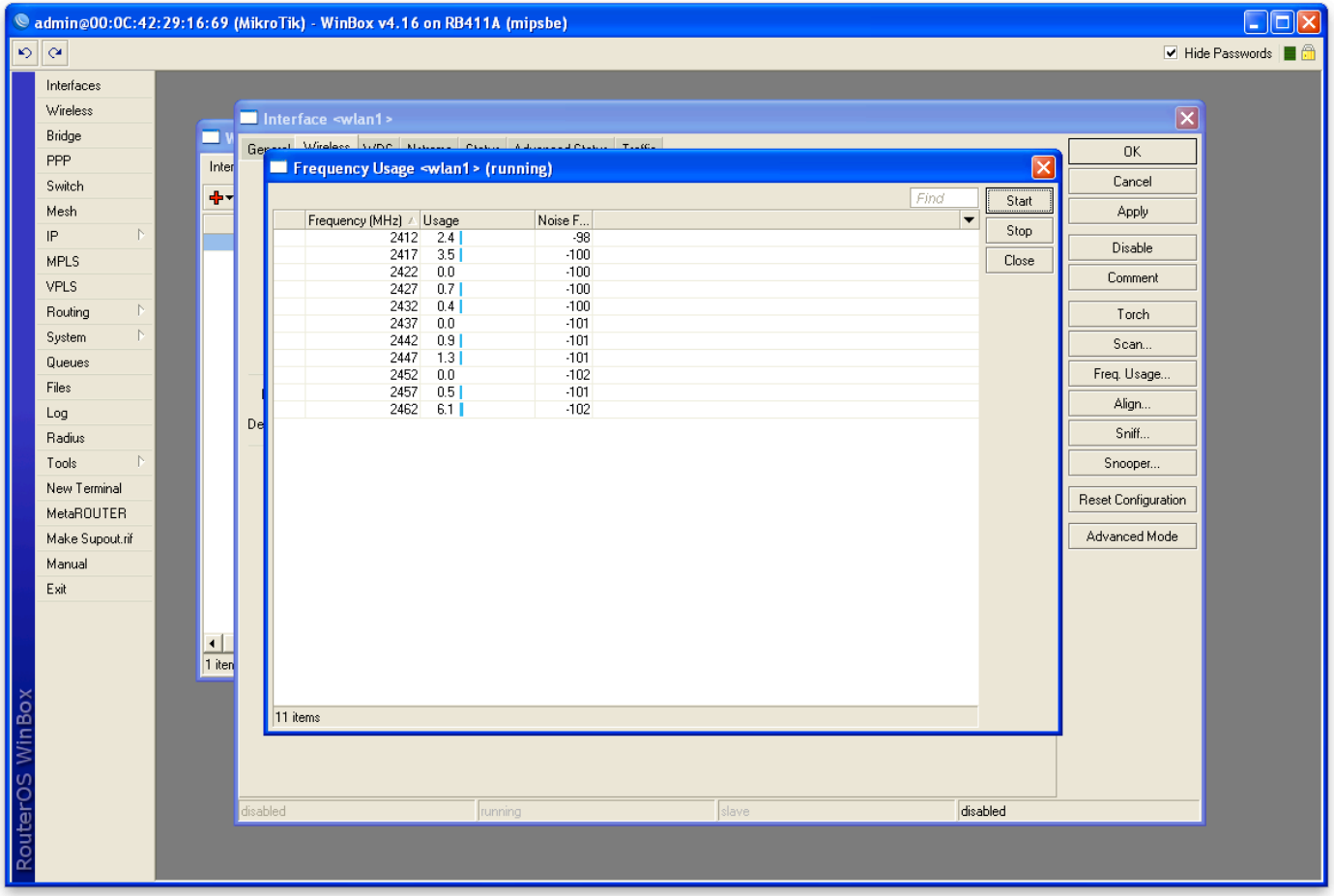
Make a Security Profile



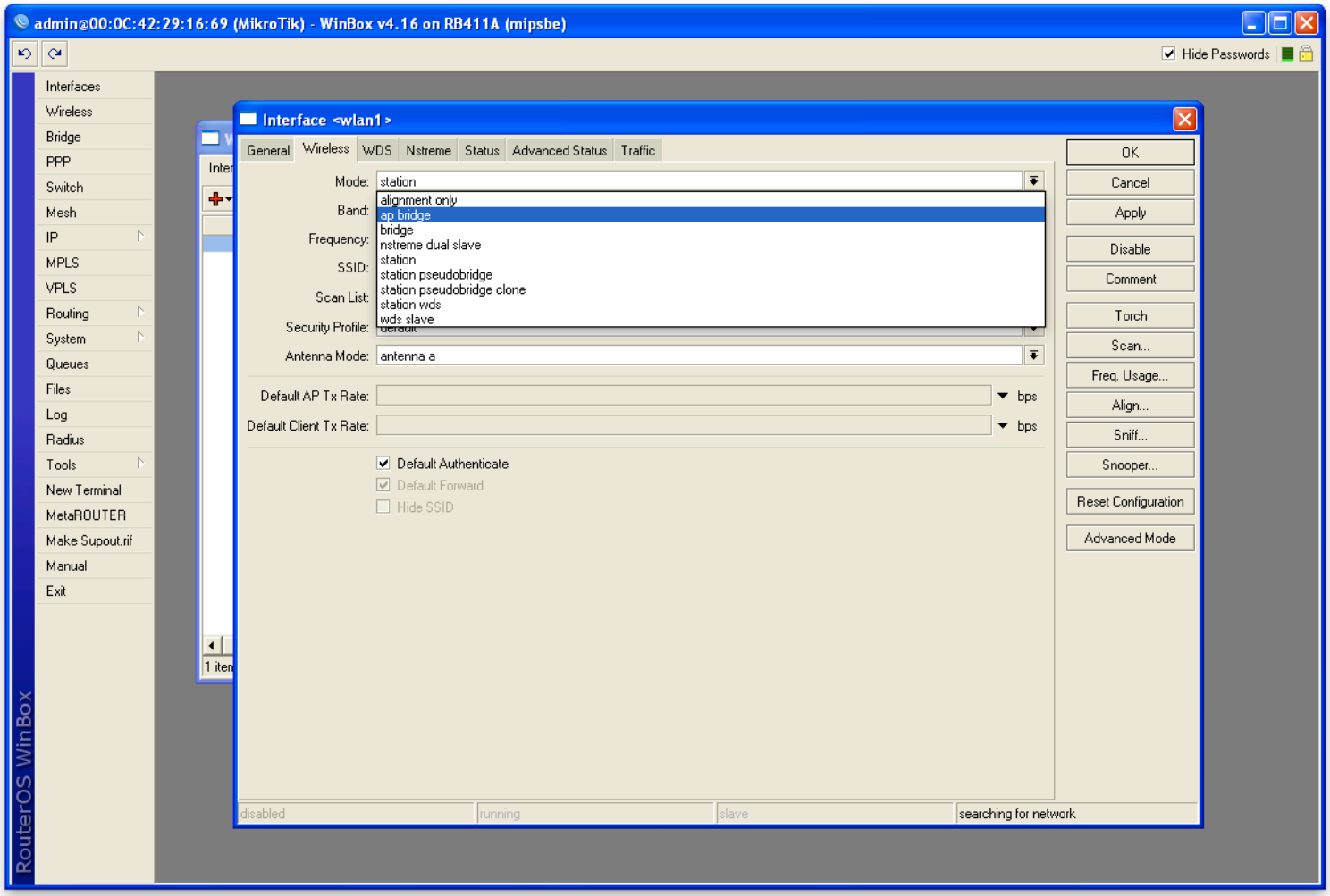
Assign a Unique SSID



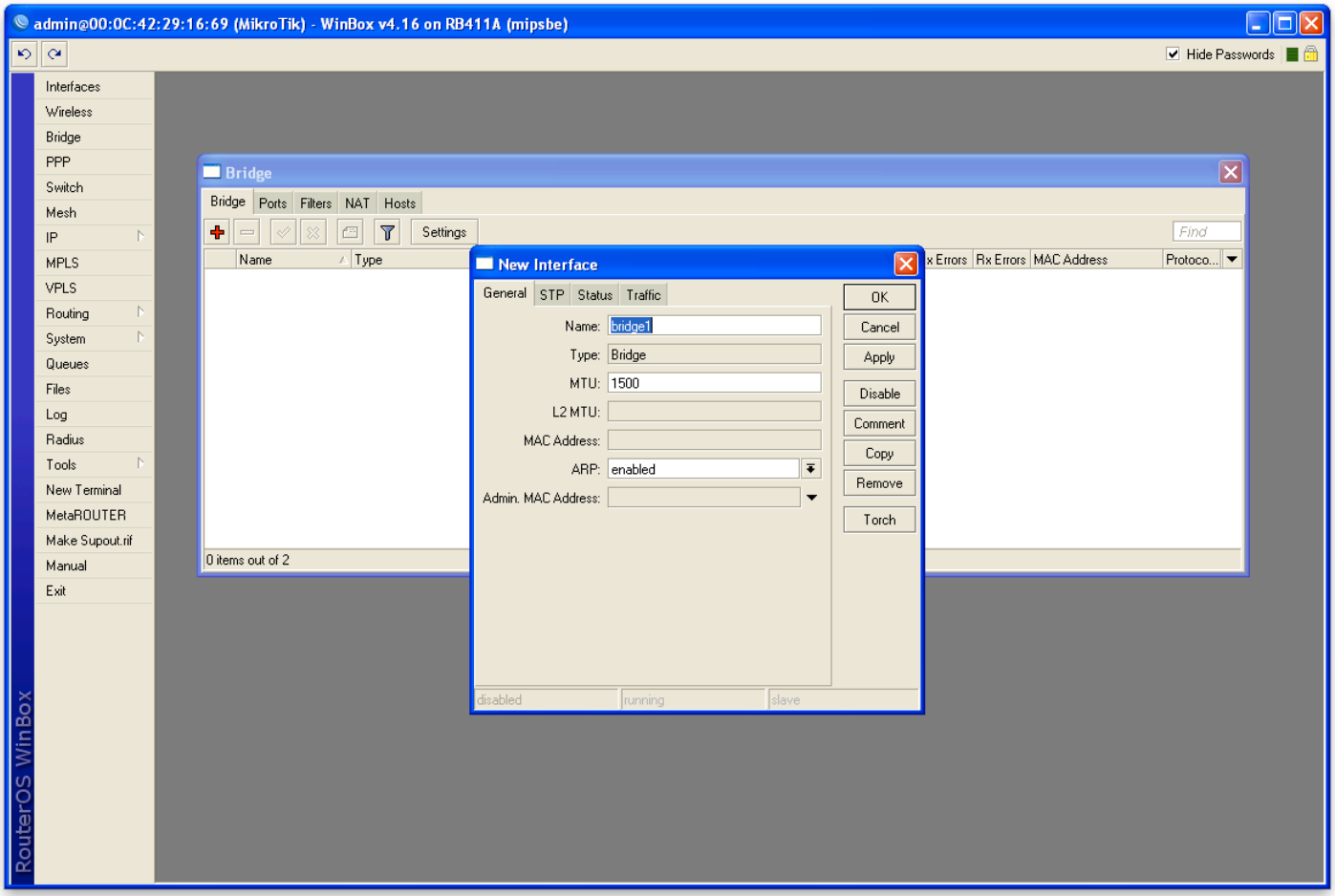
Choose an Unused Channel



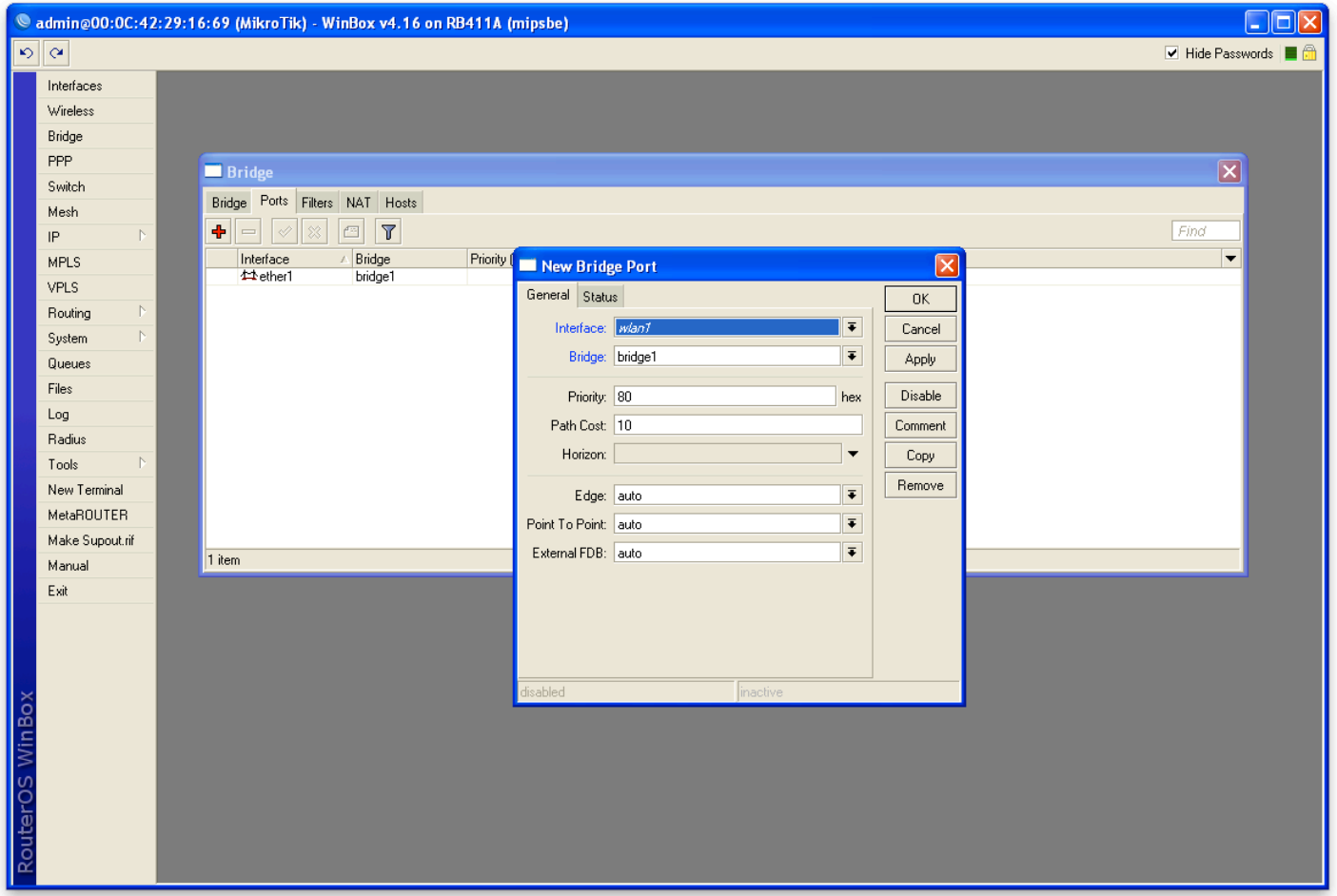
Make WLAN an AP



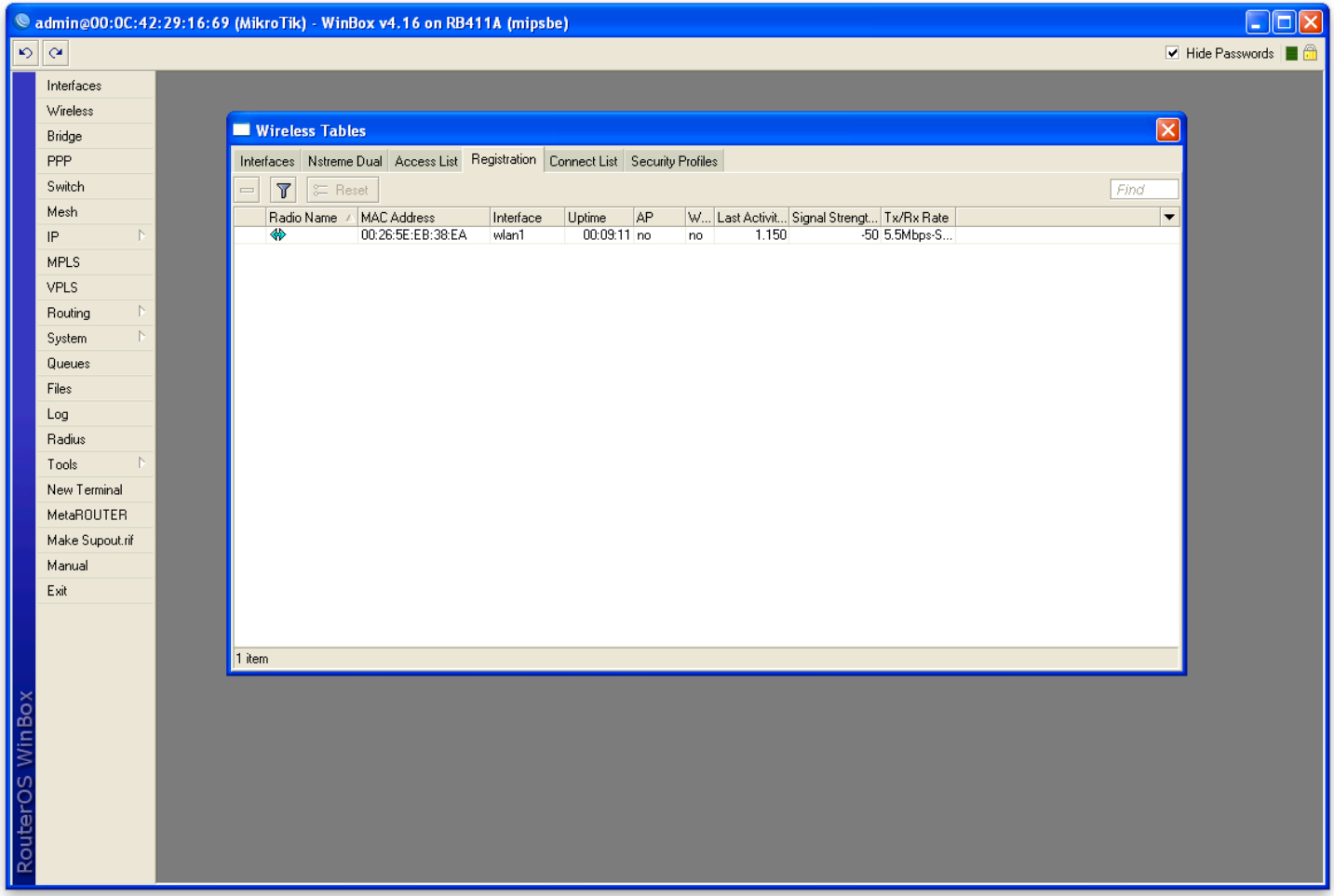
Create a Bridge



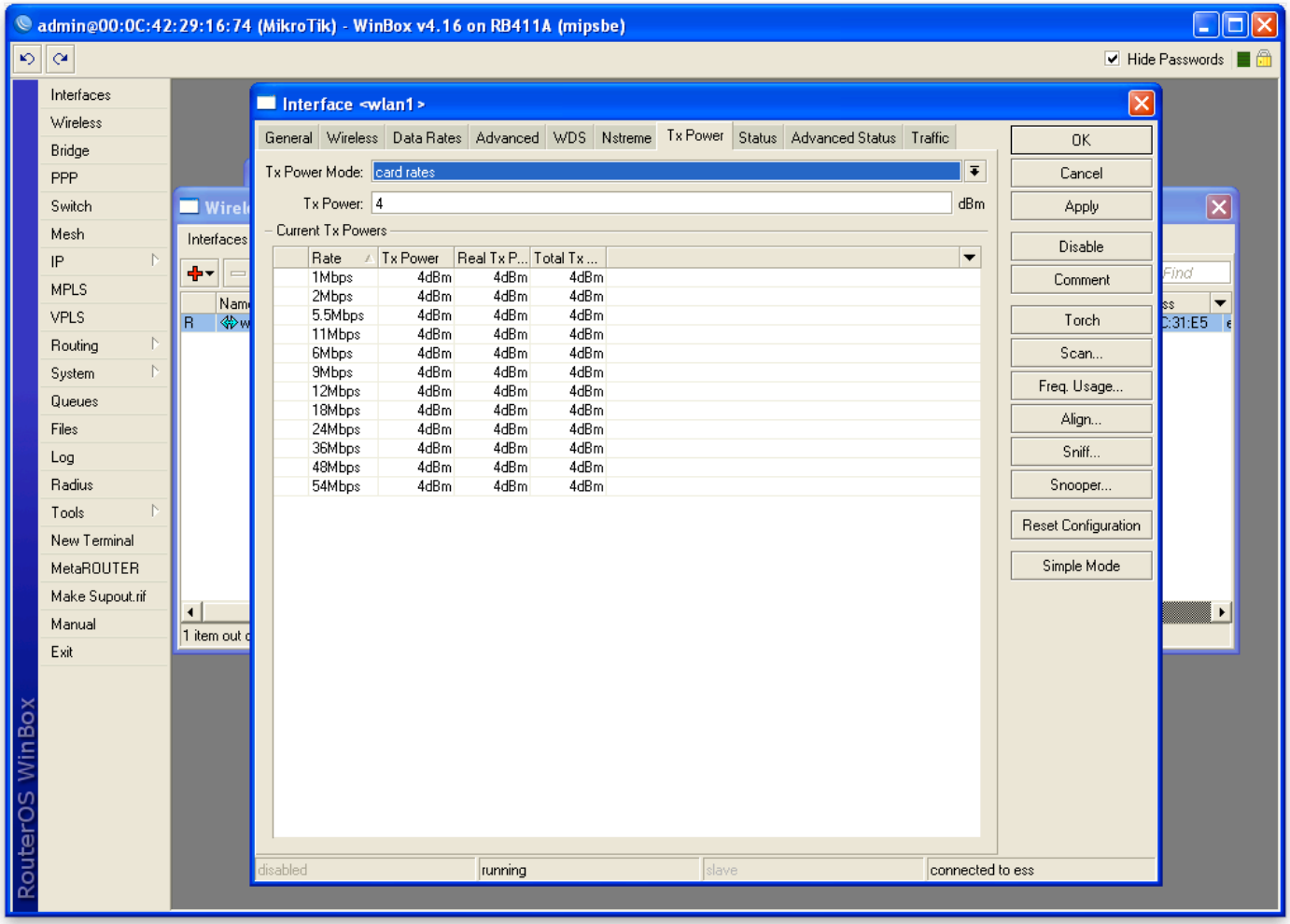
Add wlan and Ether to Bridge



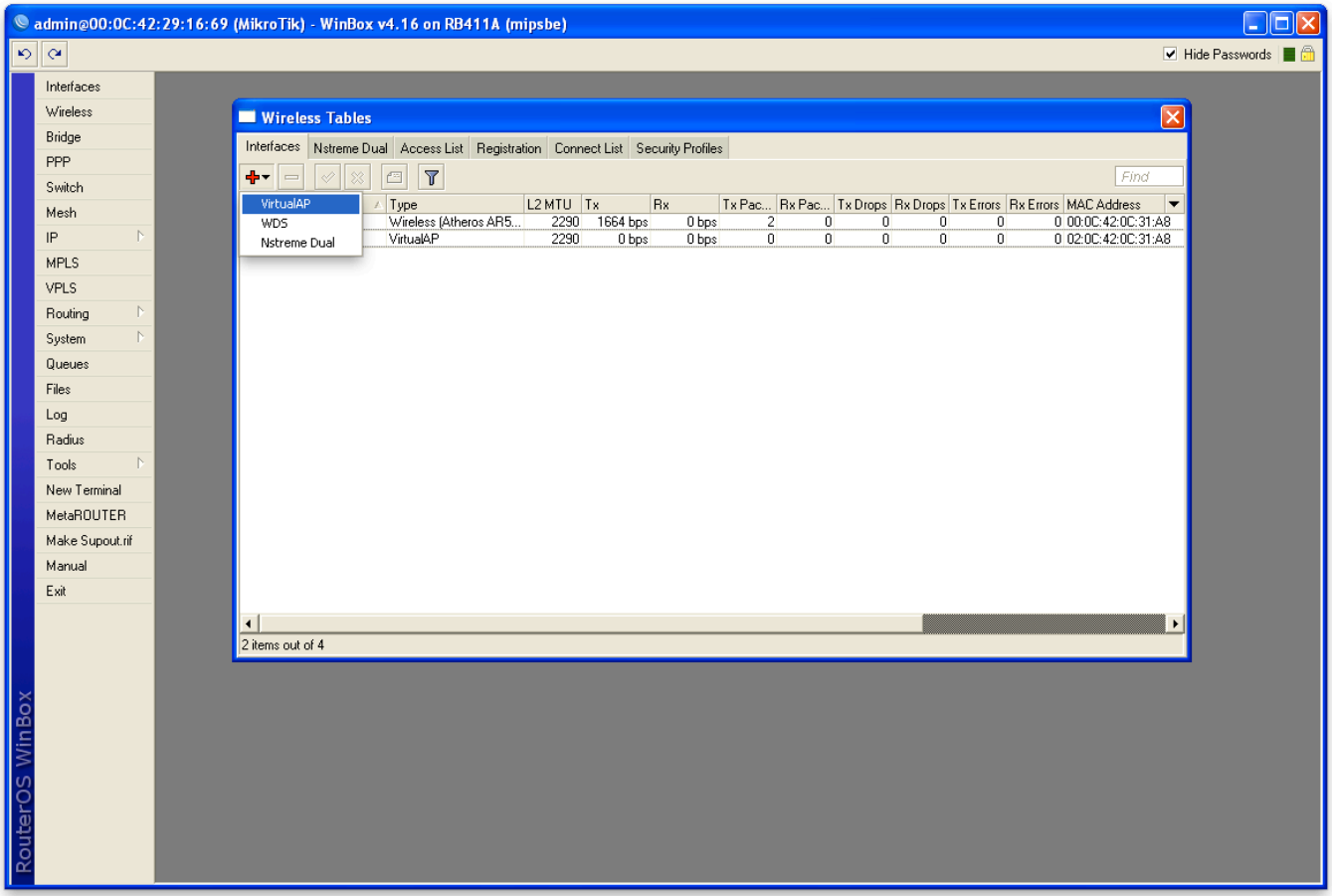
Associate & Check RSSI



Adjust Power Levels Down?



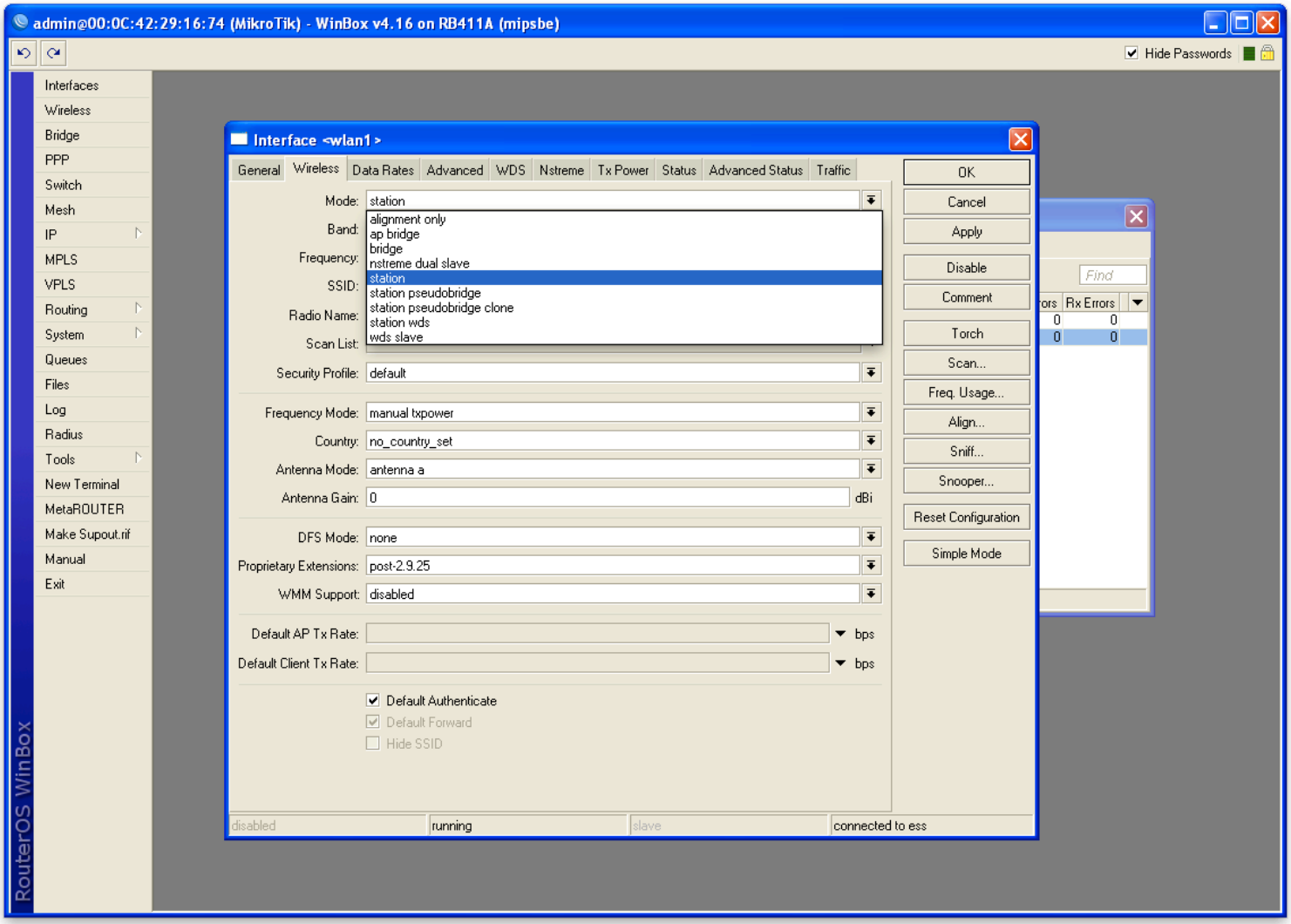
More Complex? Virtual AP



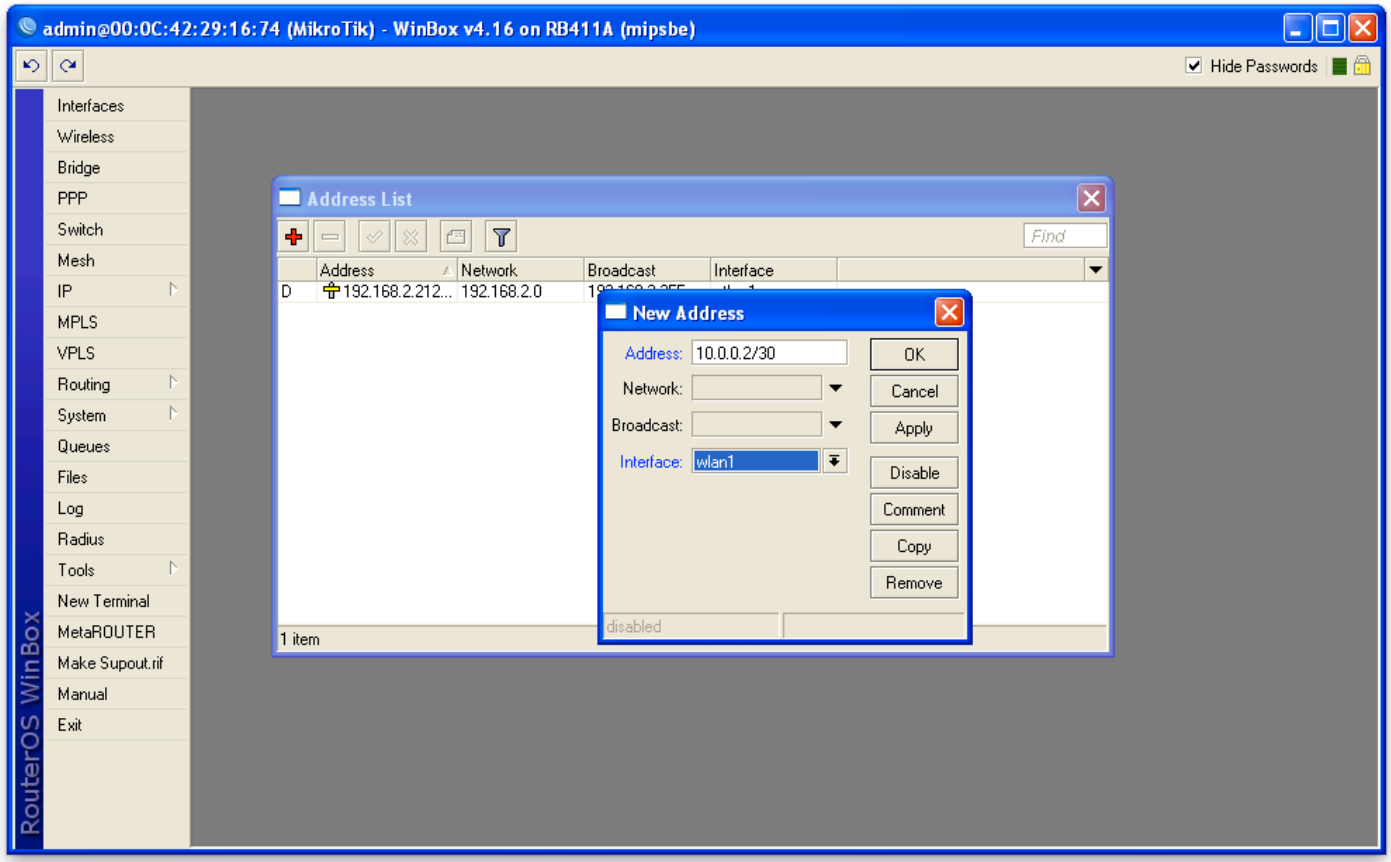
Transparent Bridge

- 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

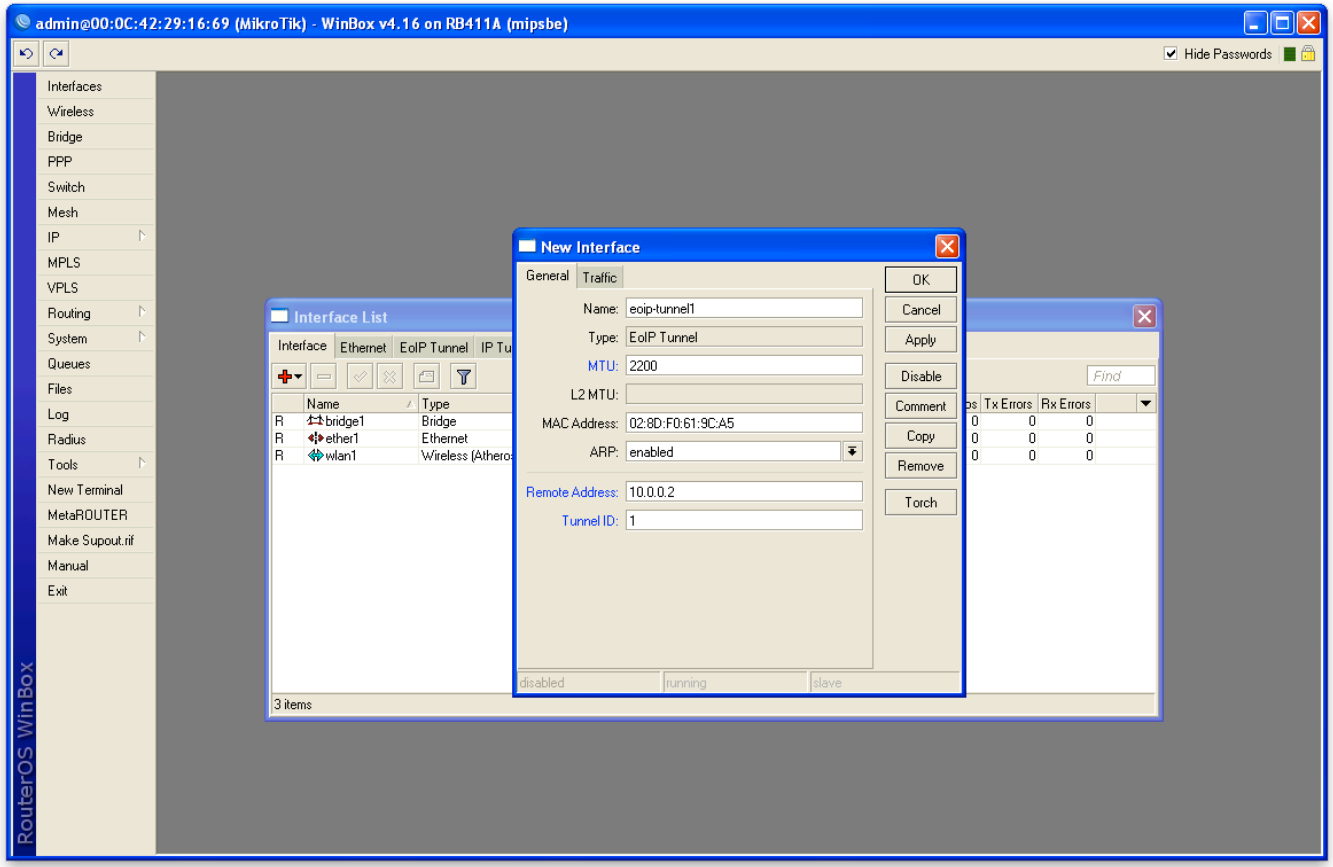
Set Up a Station



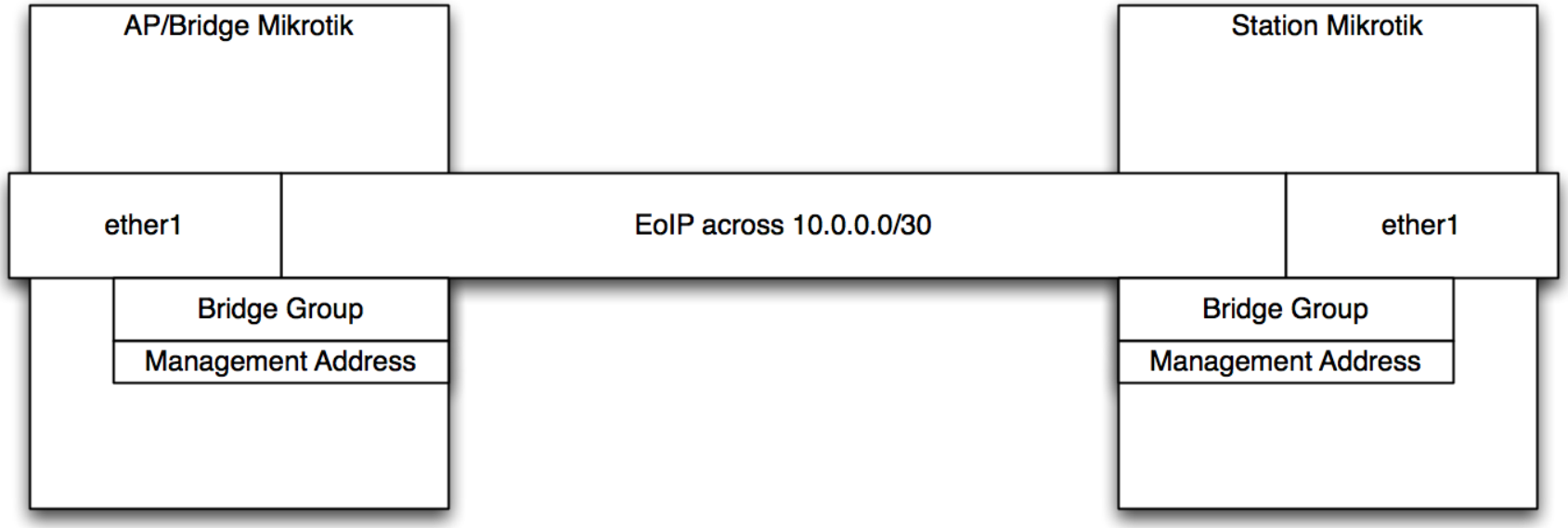
Add a /30 to the wlan Interfaces

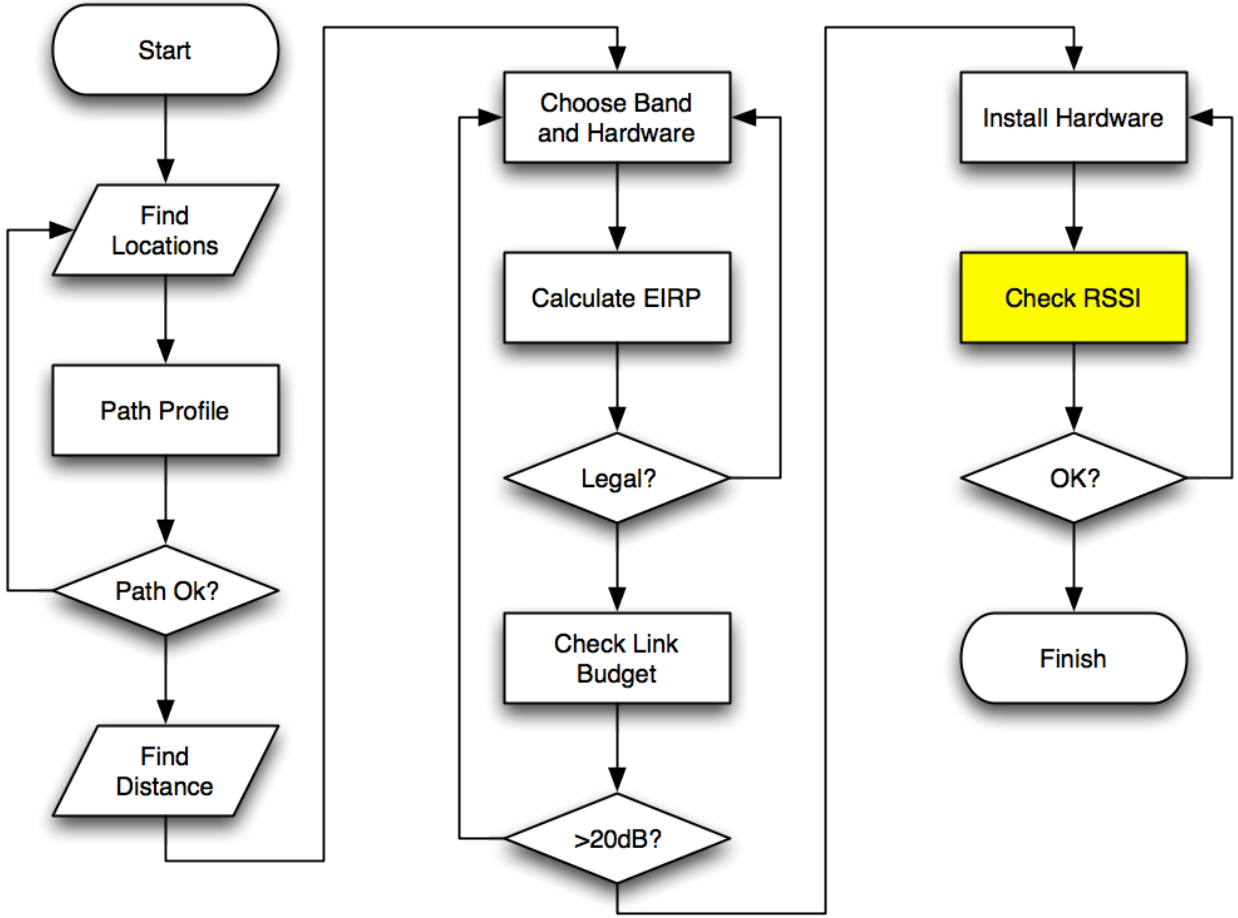


EoIP Tunnel Between Radios

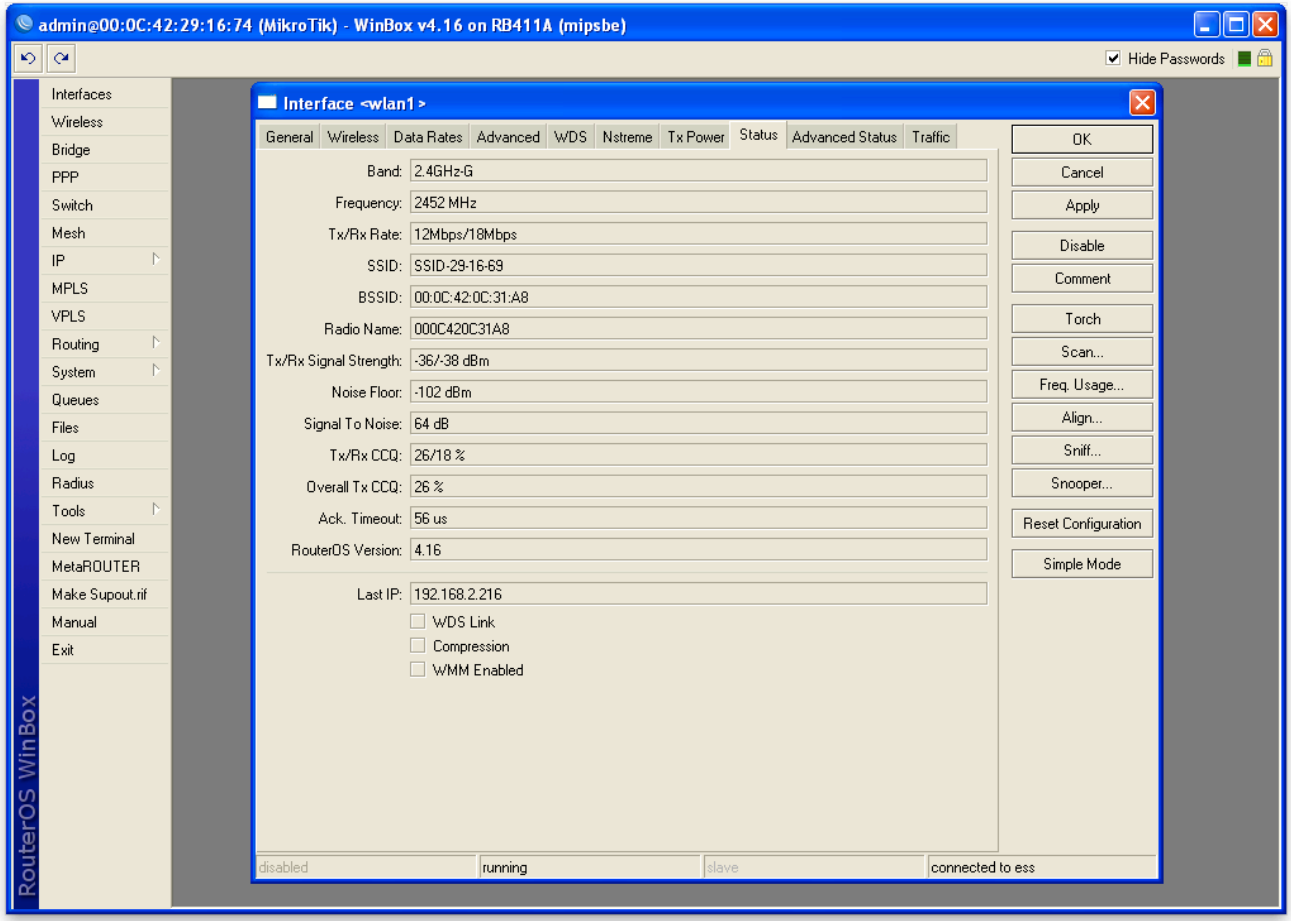


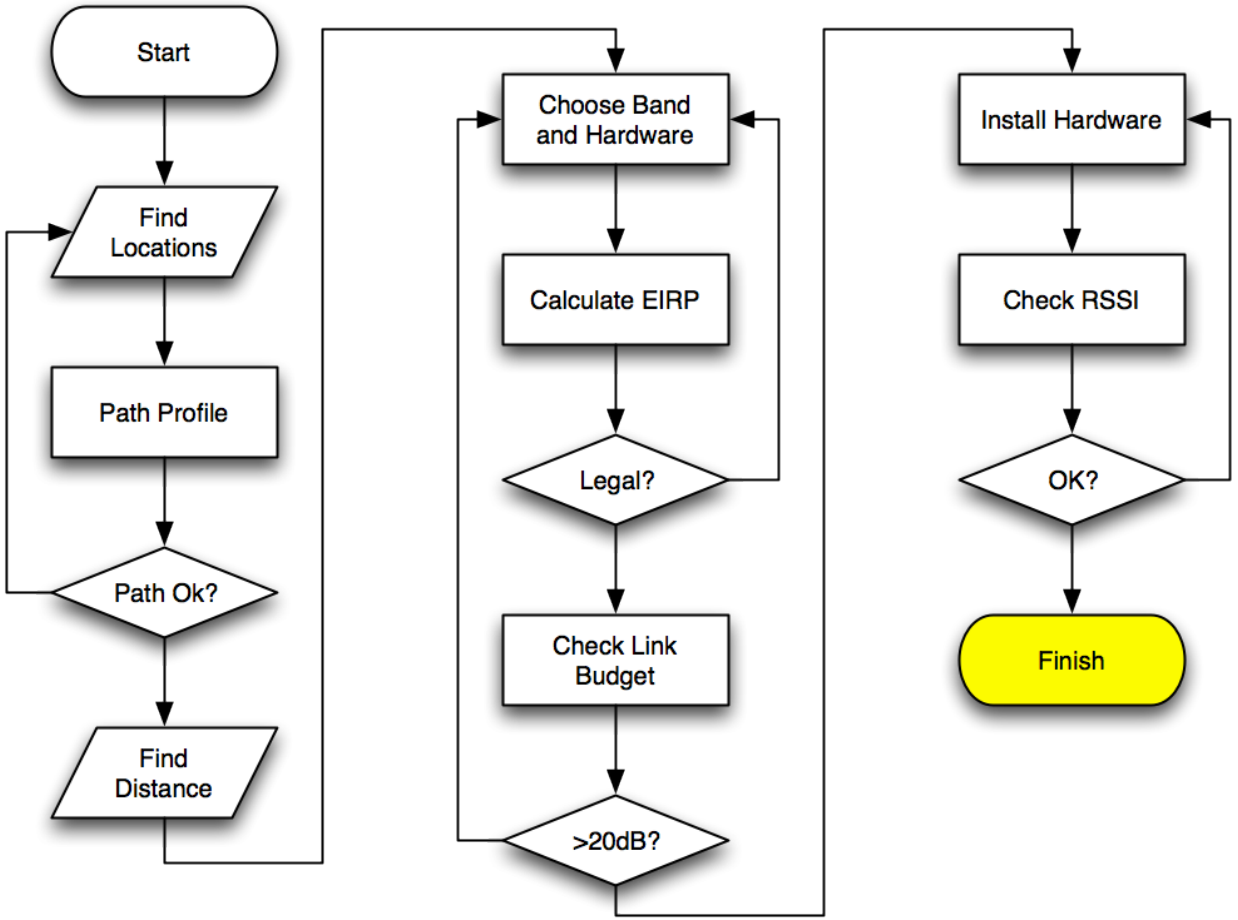
EoIP Bridged to Ethernet




Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

Check RSSI Against Calcs




Start
Find Locations
Path Profile
Path Ok?
Find Distance
Choose Band and Hardware
Calculate EIRP
Legal?
Check Link Budget
>20dB?
Install Hardware
Check RSSI
OK?
Finish

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/