Ad-Hoc IP Networking

A Case Study using the Dirty 30 Race

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Outline

Why IP?

The history of the Dirty 30

Available IP technologies

Designing and Planning

Deployment and Execution

Summary

Why IP?

- IP is a disruptive technology
- Served agencies like IP transparency
  - Email
  - VoIP and Cell phone
  - Video
- We like IP transparency
  - Linking repeaters
  - Data transfer
  - Control

Challenges

Practical use require speed (bandwidth)

Bandwidth implies UHF-SHF frequencies

UHF-SHF means line of sight

Mountainous terrain means no line of sight

- No plug-and-play operation
- Need to plan, deploy and test beforehand

Solutions

- IP supports flexible networking
  - Redundancy
  - Configurability
- Point-to-point microwave has high throughput
  - Light weight
  - Low power
  - High gain
  - Reasonable cost

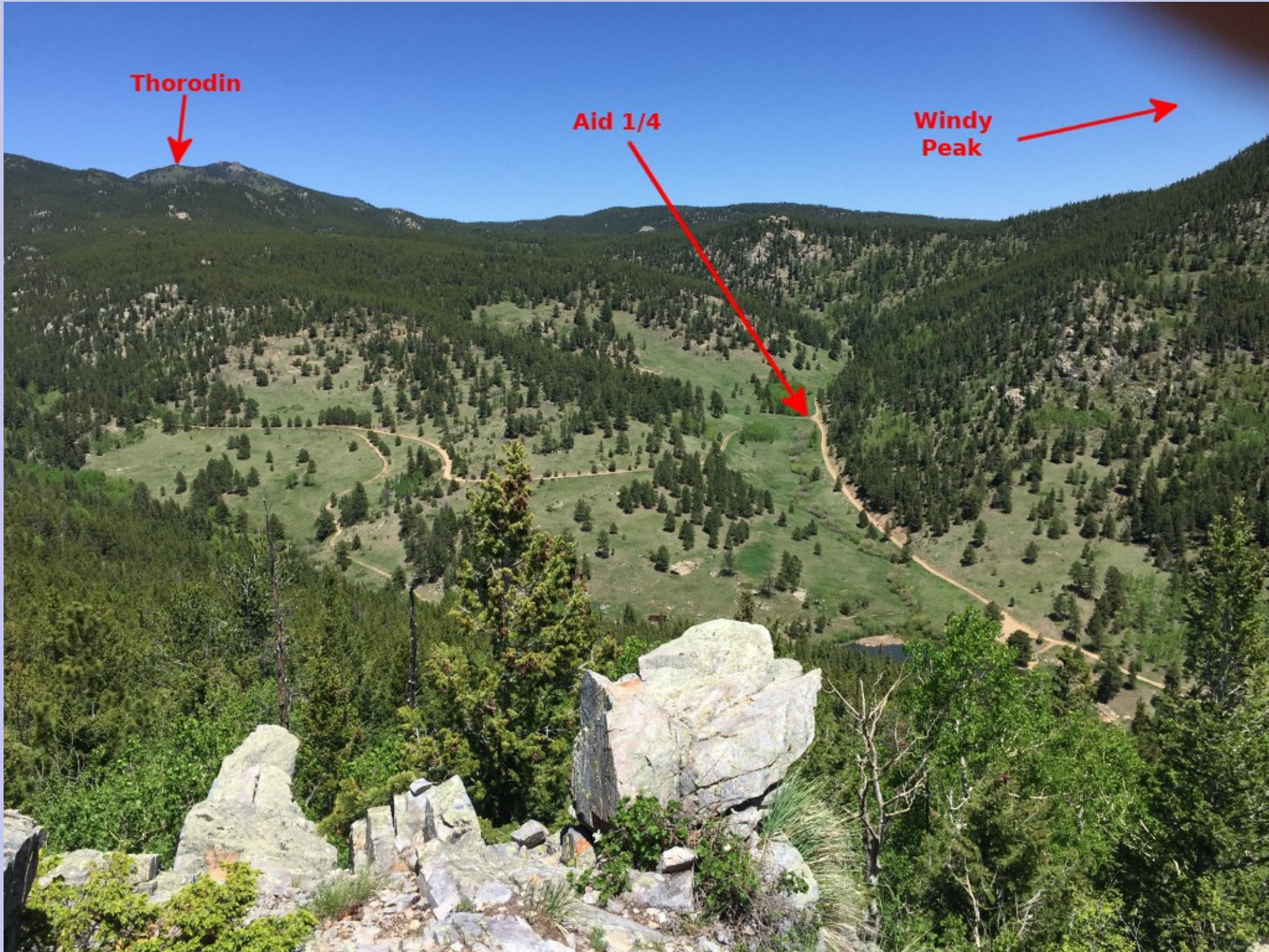
Case Study: Dirty30

- Ultra-marathon (30 miles/50 km)
  - 7250 feet elevation change
  - Most trails not vehicle accessible
  - 400+ runners
- Golden Gate State Park
  - Mountainous 7,500’ to 10,500’

Considerations

- Tracking hundreds of runners is critical
  - Accurately recording bibs
  - May have dozens of runners per minute
  - Finding lost runners is difficult
  - Consequences of a lost runner are serious
- Communications are difficult
  - No cell service
  - VHF radio works well
  - Aid stations are in valleys
  - Mountains everywhere


AID #1 / AID #4
5.0 mi / 24.5 mi
Lead: 7:45am / 10:25am
Sweep: 8:40am / 2:30pm
AID #1
5.0 mi
Lead: 10:45am
Sweep: 11:45am
AID #5
29.5 mi
Lead: 11:00am
Sweep: 4:30pm
AID #2
10.0 mi
Lead: 11:25am
Sweep: 1:05pm
AID #2
12.1 mi
Lead: 8:40am
Sweep: 11:00am
AID #3
17.2 mi
Lead: 9:20am
Sweep: 12:30pm
START/FINISH
AT RED BARN
50KM: 7:00am
12MI: 10:00am
50KM IN RED
12MI IN BLUE
DIRTY 30 TRAIL RUN
SATURDAY, MAY 30TH, 2015


Thorodin
Aid 1/4
Windy
Peak

Dirty30 2014

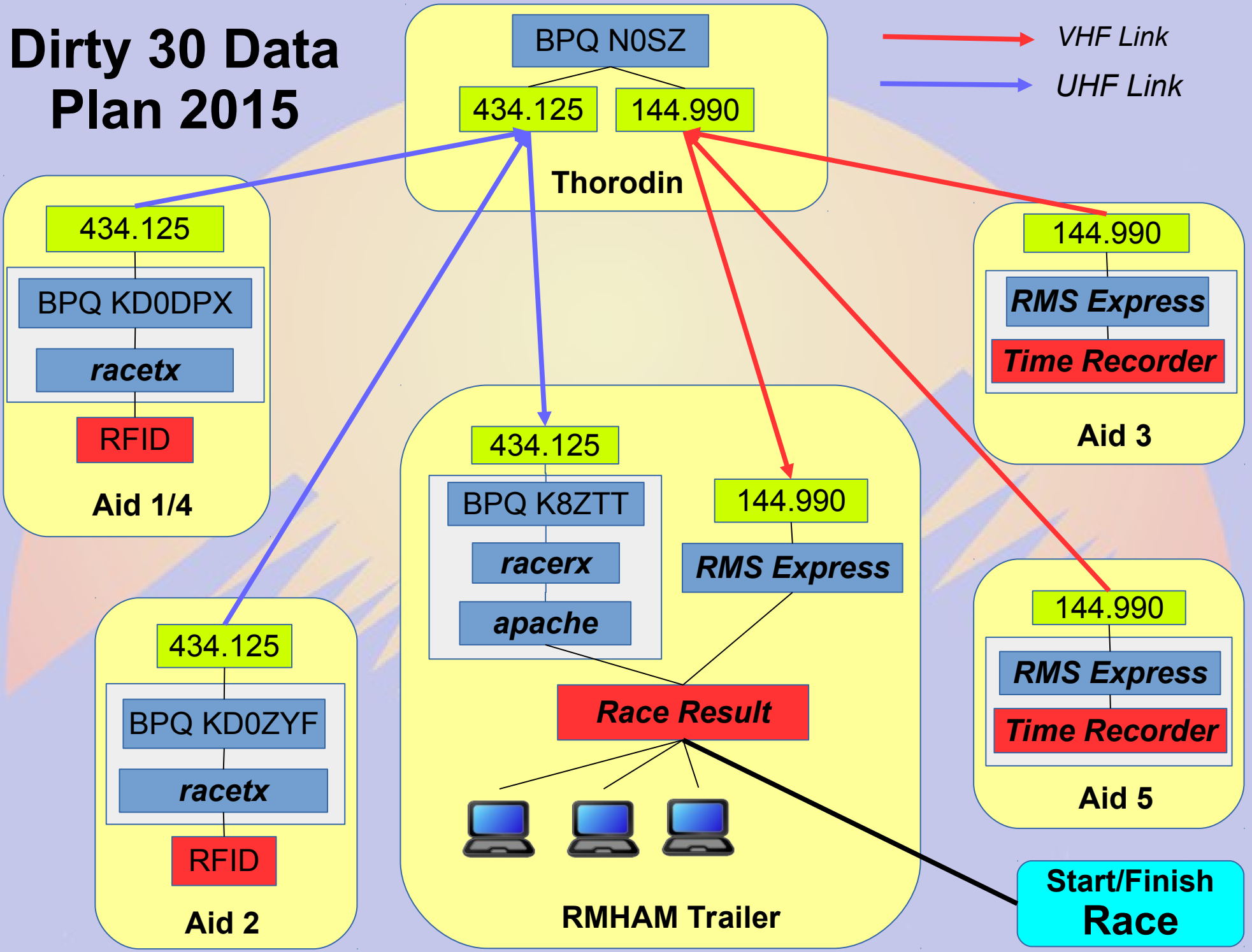
100 runners

Record bibs by hand

Packet from aid stations to start/finish
Aid1/4 BPQ relay

6 hams

Dirty 30 Data Plan 2015



Dirty30 2016

- Self contained data radios
  - 300 runners
  - RFID at Aid 1/4, 2, 3 and Windy
- Problems
  - Encrypted bibs
  - Data radio failures
  - Insufficient training

Dirty30 2017

- First use of microwave
  - 350 runners
  - RFID at Aid 1/4, 2, 3 and Windy
- Problems
  - Wind blowing antennas out of alignment
  - Lack of coordination

Windy Peak

Dirty30 2018

- Success with microwave
  - 400 runners
  - RFID at all aid stations and Windy
  - Redundant satellite and microwave
  - WiFi at Start/Finish
- Problems
  - Two day event

City Lights

High Gain
- Tremont Peak

Sector Antenna
- Aid 1/4
- Aid 5
- Windy Peak
- Start/Finish

Secrets to Success

- Planning
  - Months of mapping
  - Weeks of configuration
  - Days of deployment
  - Hours of enjoyment
- Lots of help
  - Training session

What never works

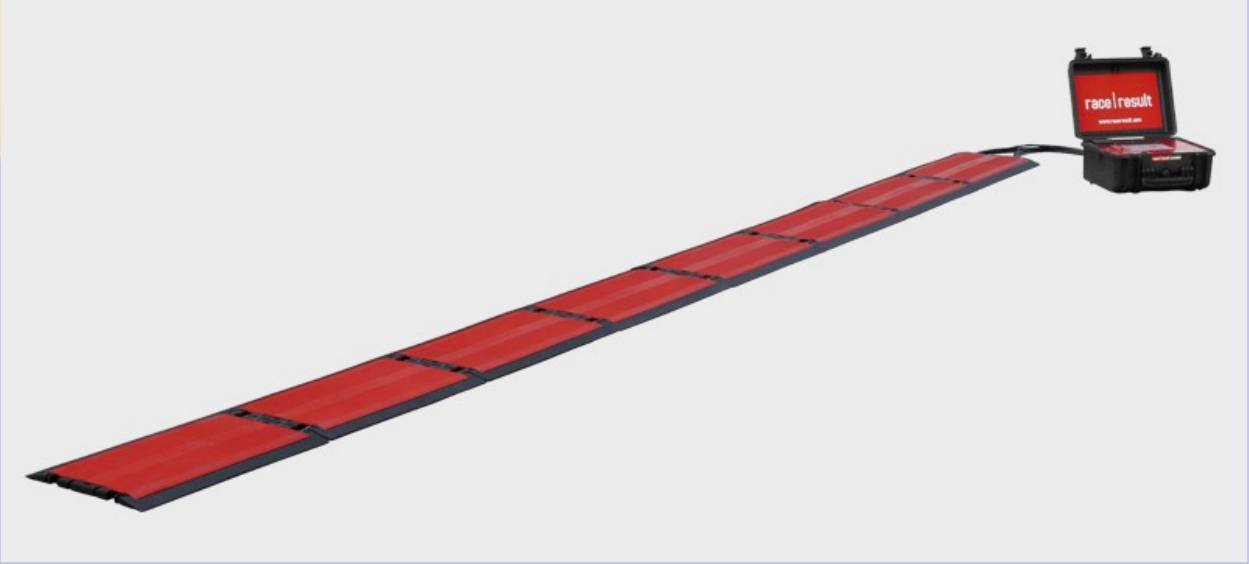
- Expecting plug-and-play
- People showing up unprepared
  - Hardware not tested
  - Unfamiliar with software
  - Unclear objectives
- Remember the seven Ps

RFID for Tracking

- Reliably reads bibs
  - Hand entry approximately 1% error
  - Can read clumps of runners
  - Must still be visually checked
    - Folded bibs, water bottles
    - Keeps people occupied, fail safe
  - Still the best available technology
- Crucial due to size and difficulty of event

RaceRite

- Well built
- Self contained
  - Battery
  - AC power
  - DC power
- Web interface
- Reliable



Surprises

Mountain top noise in ISM band

Effect of wind on tree mounts

Difficulty in locating peaks/sites

Time it takes to deploy

Overall complexity

Other things considered

BBHN/AREDN mesh

Balloon/drone mounted microwave

900MHz data radios

DMR Data

VHF APRS with custom data protocol

Satellite modems

Available Technology

Our weapon of choice is Mikrotik product due to configurability and flexibility. Each device has its use.

LHG
Light Head
Grid 0-10 mi

Dish &
Netmetal
10-50mi

MANTbox
0-20 miles

QRT Panel
0-15 miles

Available Technology

Our weapon of choice is Mikrotik product due to configurability and flexibility. Each device has its use.

The LHG “Light Head Grid” is used for medium distance shots, has dual chain “MIMO” radios. They are very light and transport well where weight is a concern.

International versions will do 5650-5925 out of the box with Superchannel selection.

Cost is about $50.00 each.

Available Technology

Our weapon of choice is Mikrotik product due to configurability and flexibility. Each device has its use.

For longer distance shots we use MIMO radios called “Netmetal 5” 2W International radios with 2’ 30dBi dishes.

The distances achieved with this is easily 50 miles with a -68 signal.

Dishes are $150-250
Netmetal 5 2xMiMo International $130

Available Technology

Our weapon of choice is Mikrotik product due to configurability and flexibility. Each device has its use.

For point-to-multipoint applications, we use the International version of the MantBox. They make these units in 15dBi and 19dBi versions. This unit is the 15dBi.

Can do 10 miles with an LHG and a MantBox in point to multipoint configurations.

Cost is about $115.00 for the international version.

Available Technology

Our weapon of choice is Mikrotik product due to configurability and flexibility. Each device has its use.

The QRT Panel is used for shorter distance than the LHG, LHG-XL or Dish. It can be used like all Mikrotik product for Point-To-Point or Point-To-Multipoint to provide flexibility. Nice looking, and robust.

Panel can be used out to 8-10 miles on a point to multipoint or 10-15 miles point to point.

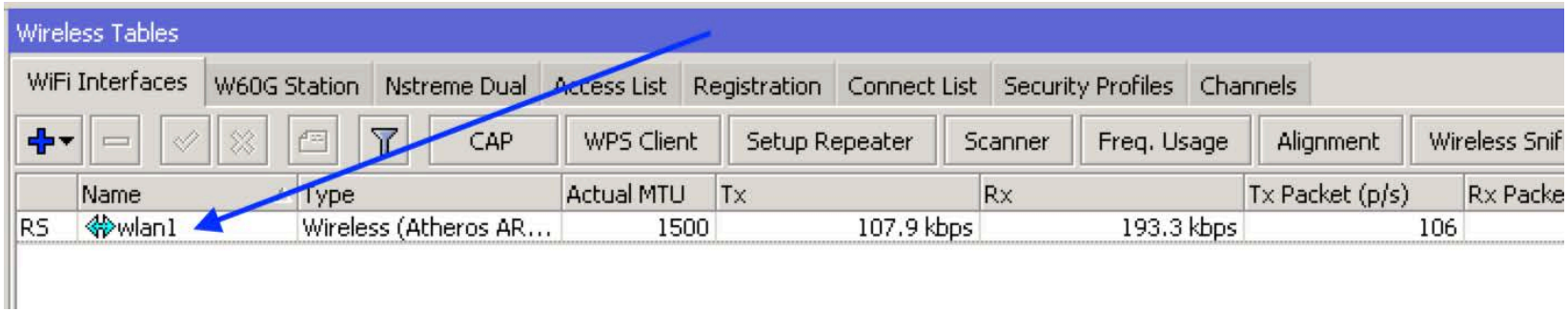
$120.00-160.00

Configuration

- Superchannel configuration is used to allow the radio transmitter to work outside of the normal frequencies.
- These radios can be set up to operate from 5650-5925 which is the ham band.
- Ultimate flexibility paves the road to futility. Be careful! Remember your band edges and channel width. 20MHz channel at 5650MHz would put your low skirt at 5640!

Configuration

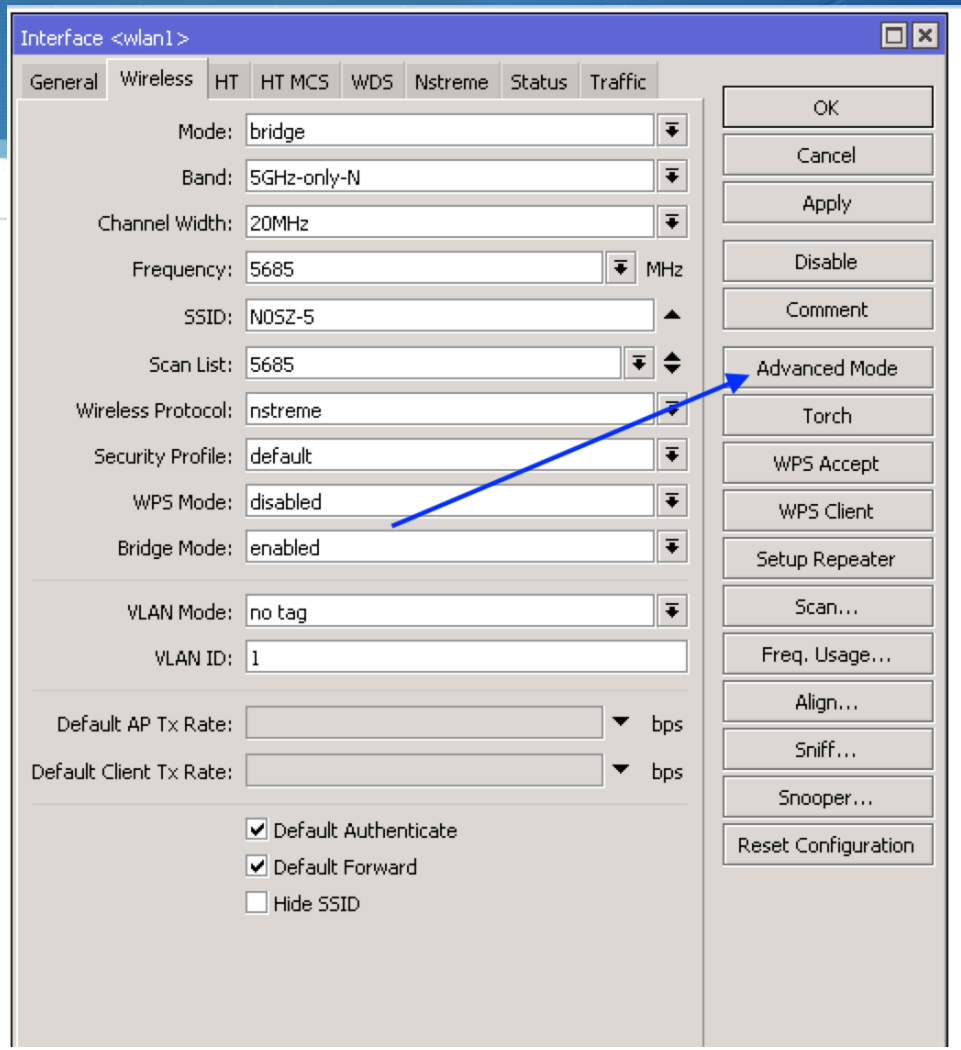
Under Wireless, Double Click the line that shows wlan1 which will bring you to the actual configuration screen.



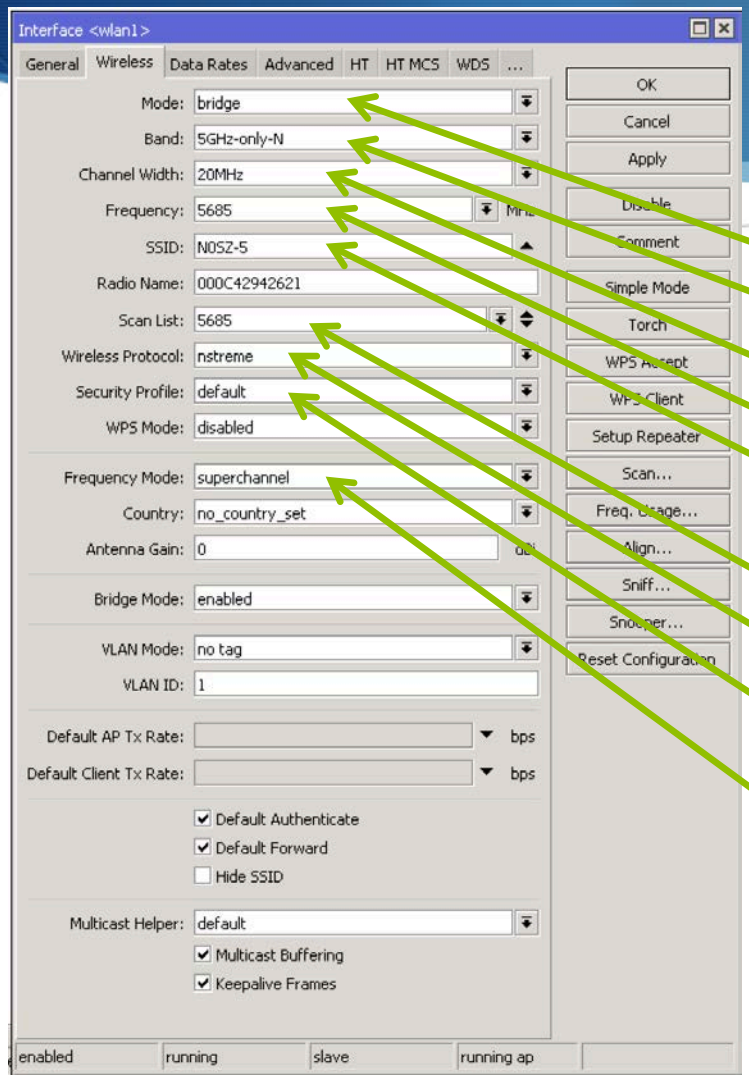
Configuration

Click on Advanced Mode to be able to access the "Superchannel" option

This does require an international radio in order to get this option!



Basic Wireless Configuration



Mode changes depending on function
Band is freq and modulation type
Channel width generally is 20mhz
Frequency is “center” of channel
SSID Required to match each end! Use callsign on ham.
Scan List is required for station!
Wireless Protocol nstreme best for distance
Security profile is encryp. (NOT ON HAM)

Freq Mode “Superchannel” allow out of band. This function is not available in NON-INTL radios. You must use international radios in order to get out of band functions!

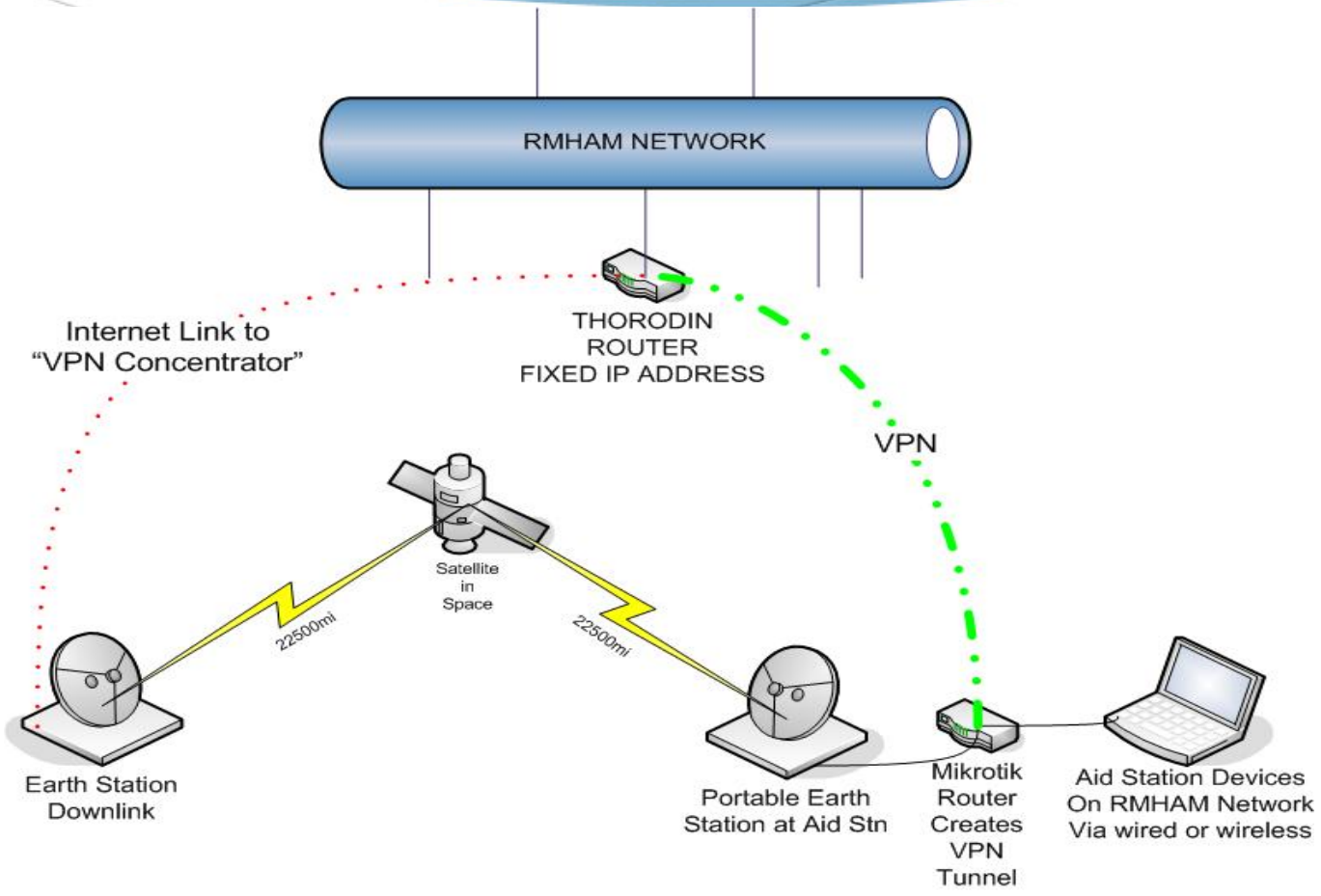
Satellite Integration

- There are some places that you CANNOT use line of sight devices and higher bandwidth is not available.
- Geosynchronous satellites may be needed. Ping times of 600-700ms. If you need low latency, don't use satellite!
- Satellite service will get you 15+mbps down and 2-4mbps up
- VPN would be required to connect you to a terrestrial network like the RMHAM network.

VPN

- VPN is a protocol to extend a remote IP network securely through certain protocols over an IP tunnel.
- PPTP, SSTP, L2TP, OpenVPN
- Mikrotik supports all of these protocols out-of-the-box and more.
- Static IP address is required for at least one endpoint connectivity or tears and brain damage will be involved!

VPN


RMHAM NETWORK
THORODIN
ROUTER
FIXED IP ADDRESS
Internet Link to
"VPN Concentrator"
VPN
Satellite
in
Space
22500mi
22500mi
Earth Station
Downlink
Portable Earth
Station at Aid Stn
Mikrotik
Router
Creates
VPN
Tunnel
Aid Station Devices
On RMHAM Network
Via wired or wireless

Commercial Cellular Options

- Cradlepoint/Pepwave units are good for areas that have cellular/LTE service to create a solid network link. 10-50ms Price is anywhere from $150-$600 depending on models. There are options for any carrier.

Wireless ISP Options

- Wireless ISPs provide a good service that will give you reliable internet and may likely be in your area. They use 5.8GHz and 2.4GHz wireless service to provide internet to many locations.
- They use "point to multipoint" hardware from manufacturers like Mikrotik or Ubiquiti hardware to create a network.
- We use Mountain Broadband in the Golden Gate Canyon area to feed the network and create our internet tunnel at Aid 2 and backfeed commercial internet to the aid stations via Tremont.
- Most terrestrial ping times are from 1ms-30ms.
- This is a prime example of "Learn Your Course!"

Freewave 900mhz NLOS

Freewave is a 900MHz Near-Line-Of-Sight option for ethernet and serial connectivity at 128kbps. Many ethernet and serial radios are available on Ebay CHEAP.

Requires high gain antennas

Requires 12v external power

Only 128kbps. VERY SLOW.

Don't allow browsing and turn off automatic updates!!

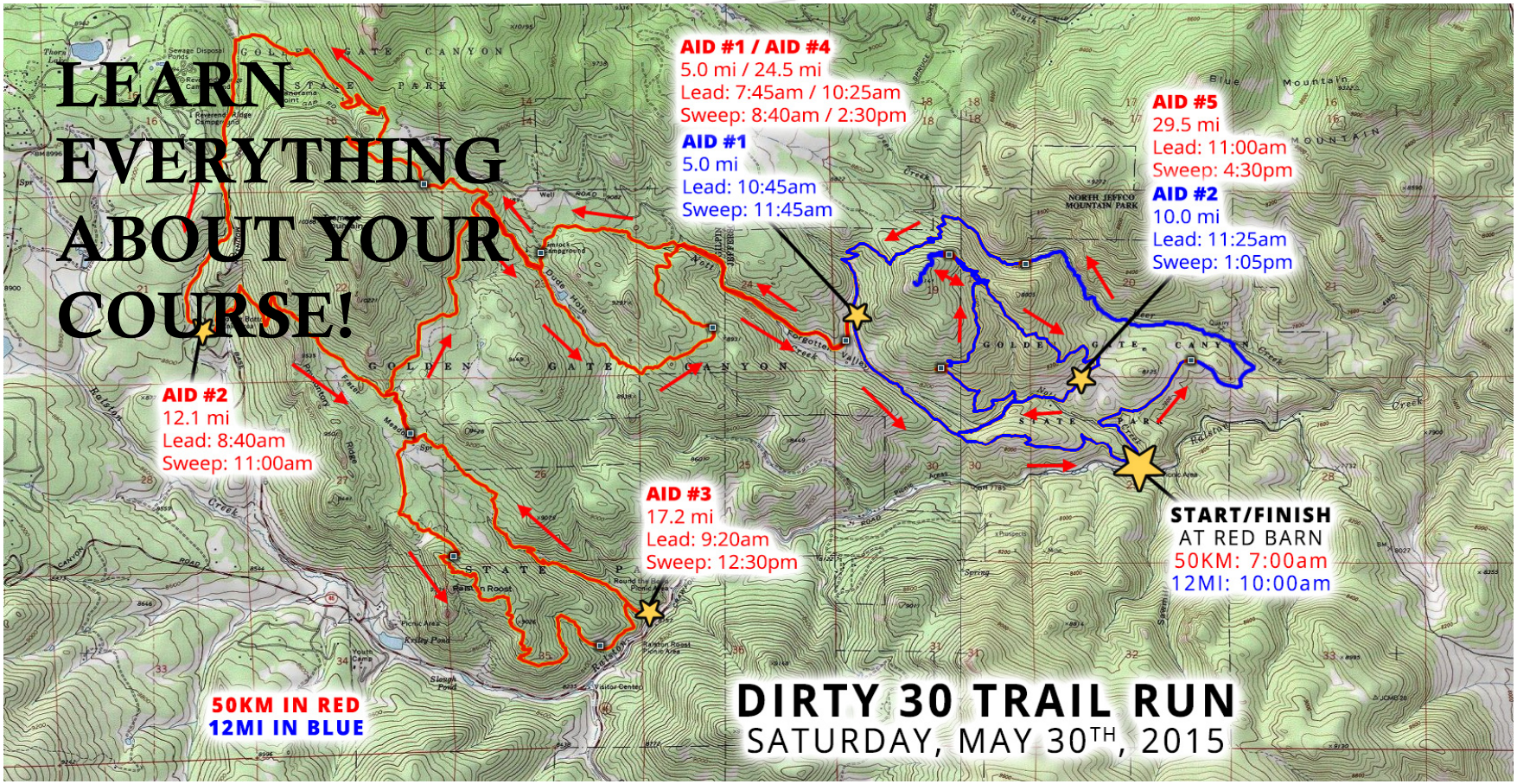
Power Budget and Weight

- Remote locations have a finite lifetime
- Each Mikrotik draws 60mA at 24V and 120mA at 12V
- Two devices is 240mA at 24V
- Event lasts two full days, plus time to get the devices in place. 240ma over 60 hours is 14400mAh or 14.4 amp hours at 24V or two 10AH 12V batteries in series. HEAVY.
- Your pack is going to be miserable to hike with.

Power Budget and Weight

- Mikrotik has a wide power input. 8-36 volt DC input allows many options for powering your devices.
- Two batteries in parallel put out 12V at double the amperage
- Two batteries in series put out 24V at the same amperage but the efficiency of the devices is a bit better and will run a bit longer.
- Some thought needs to be there about what power is required.

Design and Planning

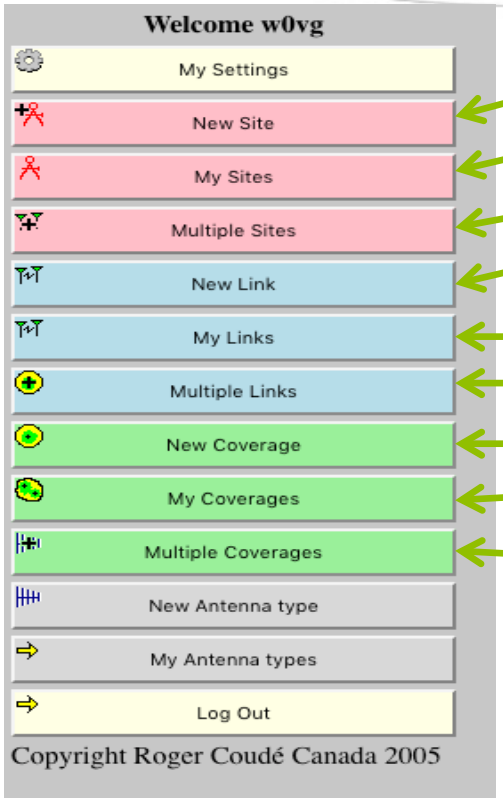


Design and Planning

The tool we use:

- Radio Mobile Online by VE2DBE
- http://www.ve2dbe.com/rmonline.html
- Great path design, propagation design and handles multiple sites! Works only on Ham Band frequencies as they sell a commercial package to ISPs.

Design and Planning



- Add site FIRST here
- Edit your sites here
- See multiple sites on map
- Add a new link here (requires two sites!)
- Edit your existing links
- View Multiple Links
- Add new coverage (add site first!)
- View and edit coverages
- Show multiple coverages at the same time

Design and Planning

We use Radio Mobile Online to do our point-to-point calculations. This will be a quick-step-through as to how to add a site, and create a point-to-point calculation.

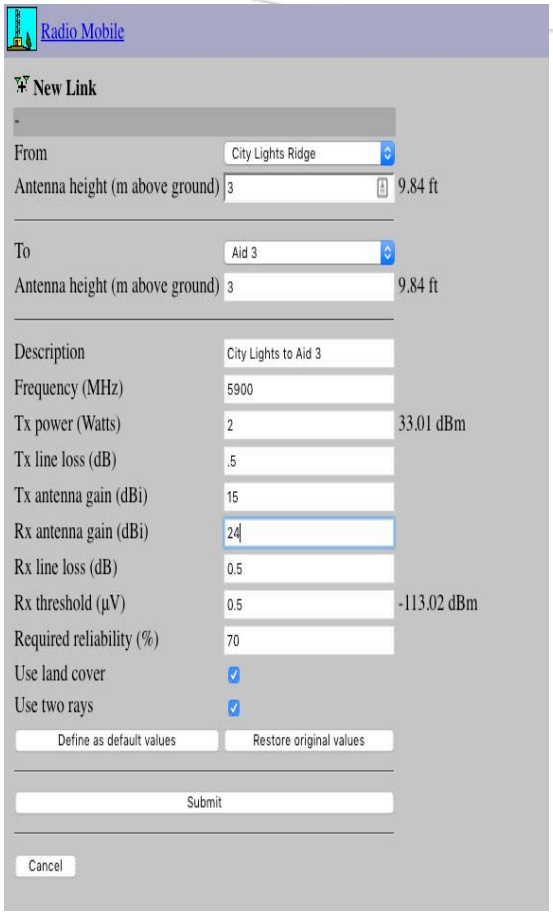
Click New Site, then drag the map pointer close to where it needs to be. Submit.

This window will pop up. You may change Lat/Lon at this point, and then you MUST name it.

Then click to “Add to My Sites”

This will create a usable endpoint. Create a separate second site to do point-to-point.

Design and Planning



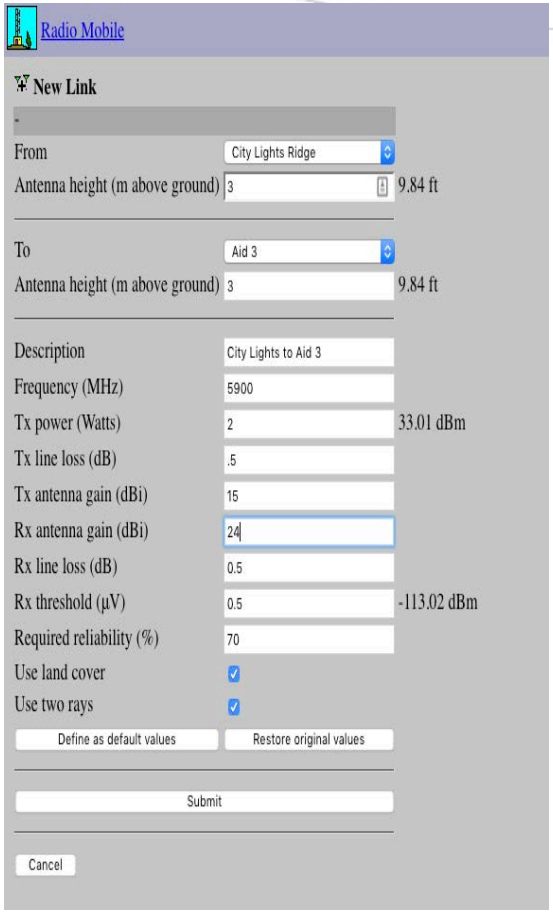
In the list, now click on New Link. This menu will come up.

Choose the first site in From and tell the program antenna height in METERS!!!

Choose the second site in To and tell the program the receive site antenna height in METERS.

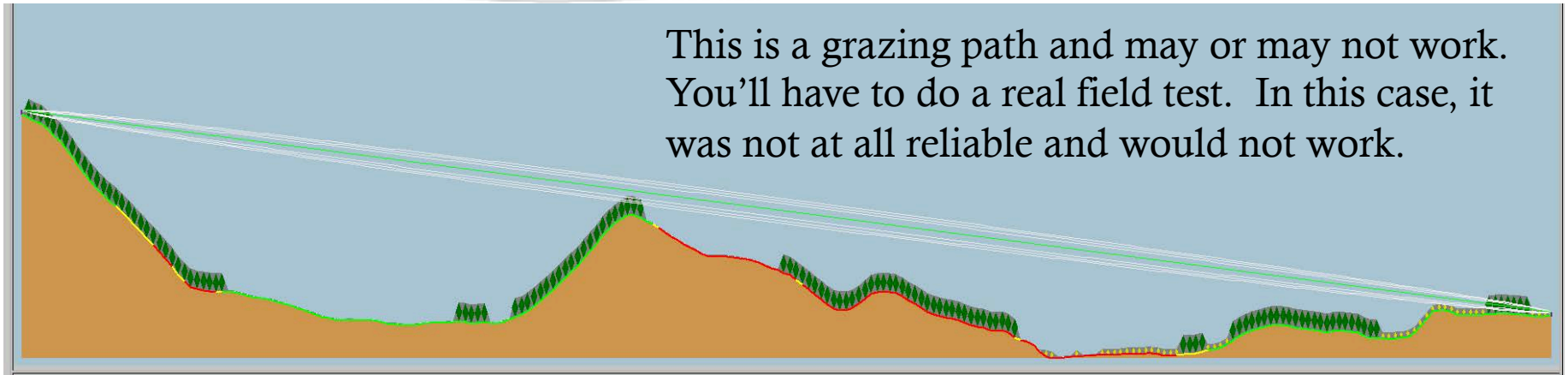
Name the site under Description

Design and Planning



- In Frequency, you should put a ham-band frequency in this box in MHz. 5900 is 5.9GHz.
- TX Power in Watts 30dBm=1W
- TX Line Loss in dB (actual line loss on TX side)
- TX Antenna Gain (actual antenna gain of TX Site)
- RX Antenna Gain (actual antenna gain of RX Site)
- RX Line Loss in dB (actual line loss on the RX side)
- Receiver threshhold in uV can be found on the specific radio cut sheet. Most radios are -90ish in this realm
- Choose use land cover (trees) and Use two rays.
- Click Submit and the program will whir and spin for a while.

Design and Planning

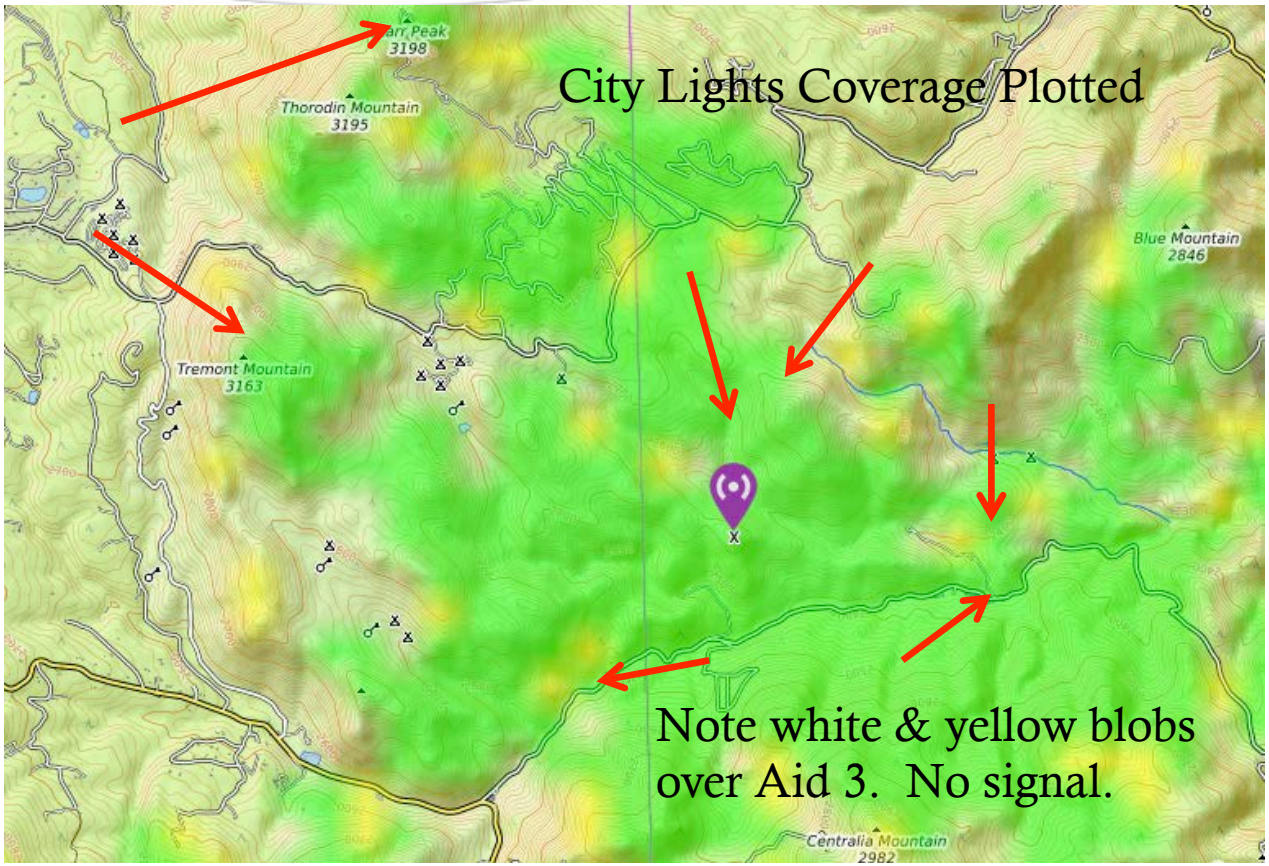


City Lights to Aid 3

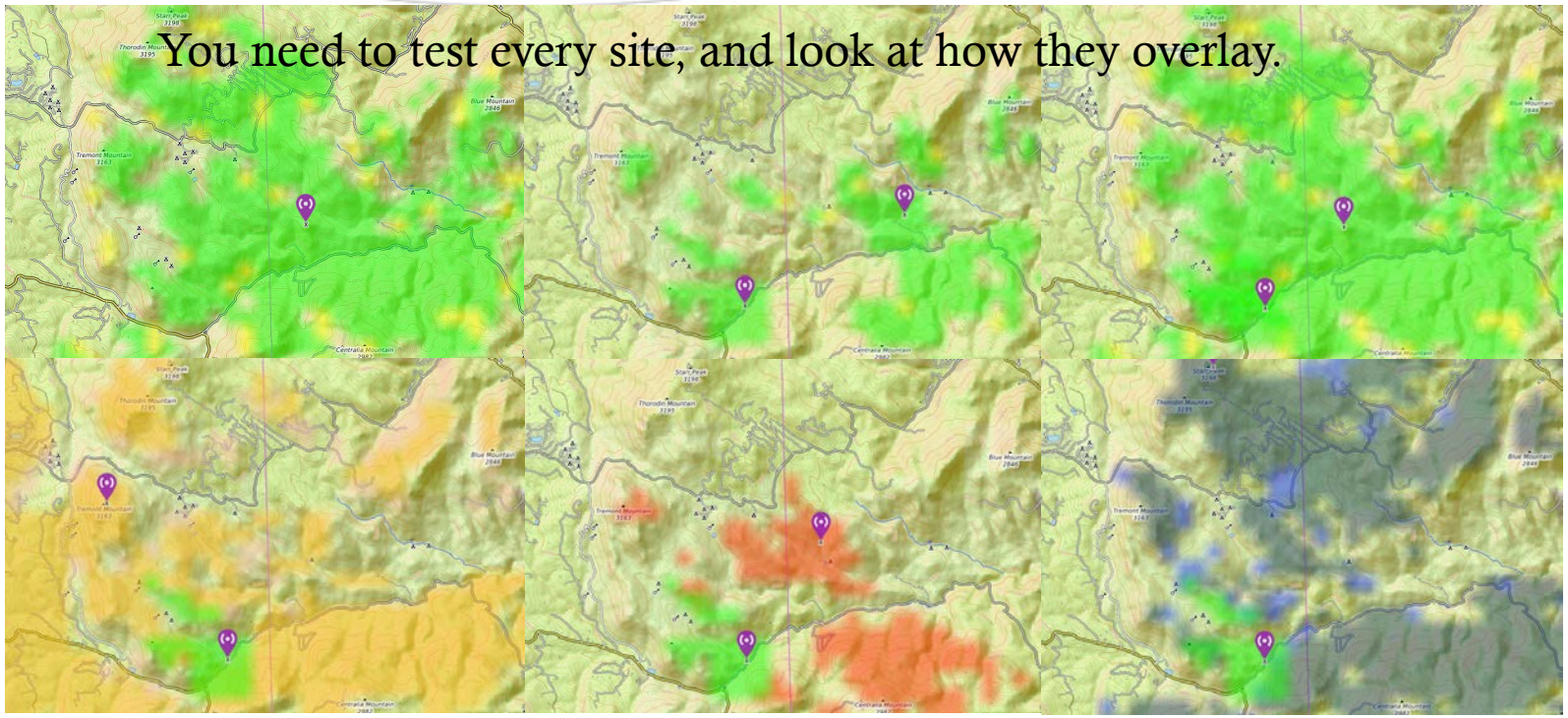
City Lights Ridge (1)		(2) Aid 3	
Latitude	39.851891 °	Latitude	39.835984 °
Longitude	-105.385301 °	Longitude	-105.405151 °
Ground elevation	2647.9 m	Ground elevation	2488.3 m
Antenna height	3.0 m	Antenna height	3.0 m
Azimuth	223.78 TN | 215.72 MG °	Azimuth	43.77 TN | 35.70 MG °
Tilt	-3.74 °	Tilt	3.72 °

Radio system		Propagation	
TX power	33.01 dBm	Free space loss	115.62 dB
TX line loss	0.50 dB	Obstruction loss	9.86 dB
TX antenna gain	15.00 dBi	Forest loss	4.06 dB
RX antenna gain	24.00 dBi	Urban loss	0.00 dB
RX line loss	0.50 dB	Statistical loss	6.69 dB
RX sensitivity	-113.02 dBm	Total path loss	136.23 dB

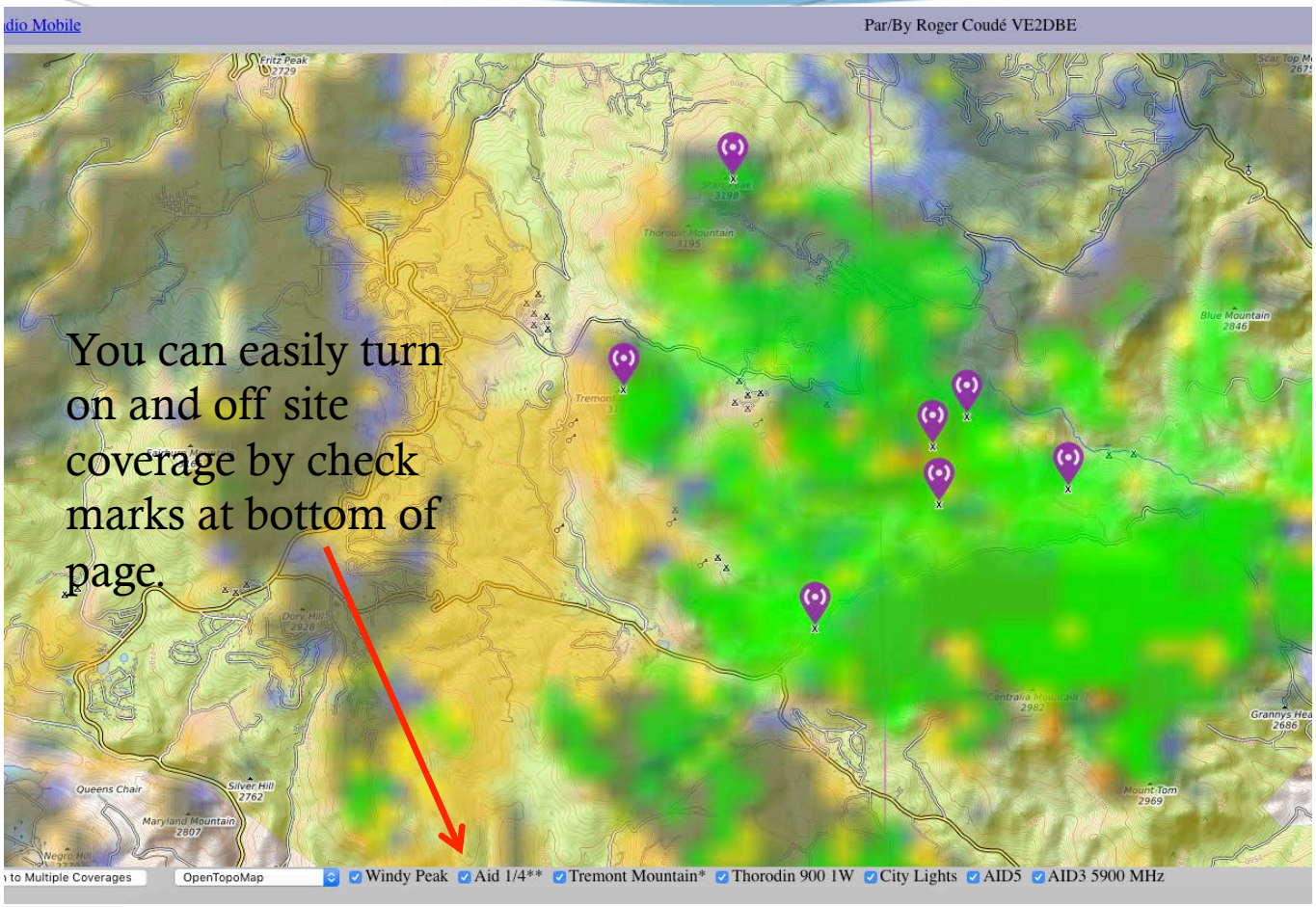
Design and Planning



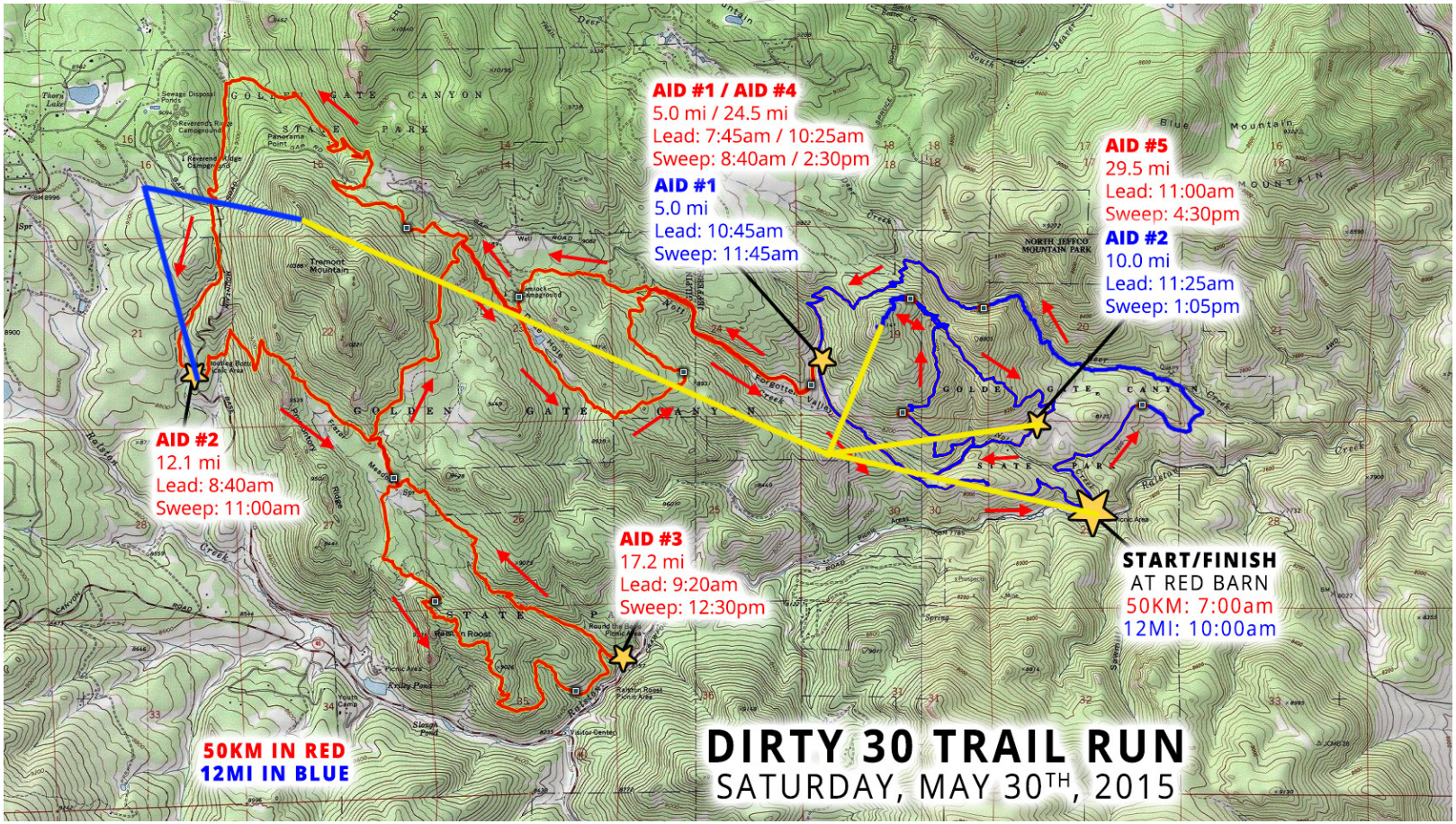
Lather, Rinse and Repeat



Editing Coverage Map Content



Here's what you get…



The Moral of the Story…

- When designing an event, know your territory and everything in the territory.
- Find new and improved ways of connecting the remote locations.
- Amateur Radio is not your only tool in the toolbox.
- Plot and check every permutation. Think about the results of each of the options.
- Test everything in real-world conditions!

Quick Show and Tell

Quick Show and Tell



Quick Show and Tell

Have plenty of photos from your intended area!

Quick Show and Tell

Practical Considerations

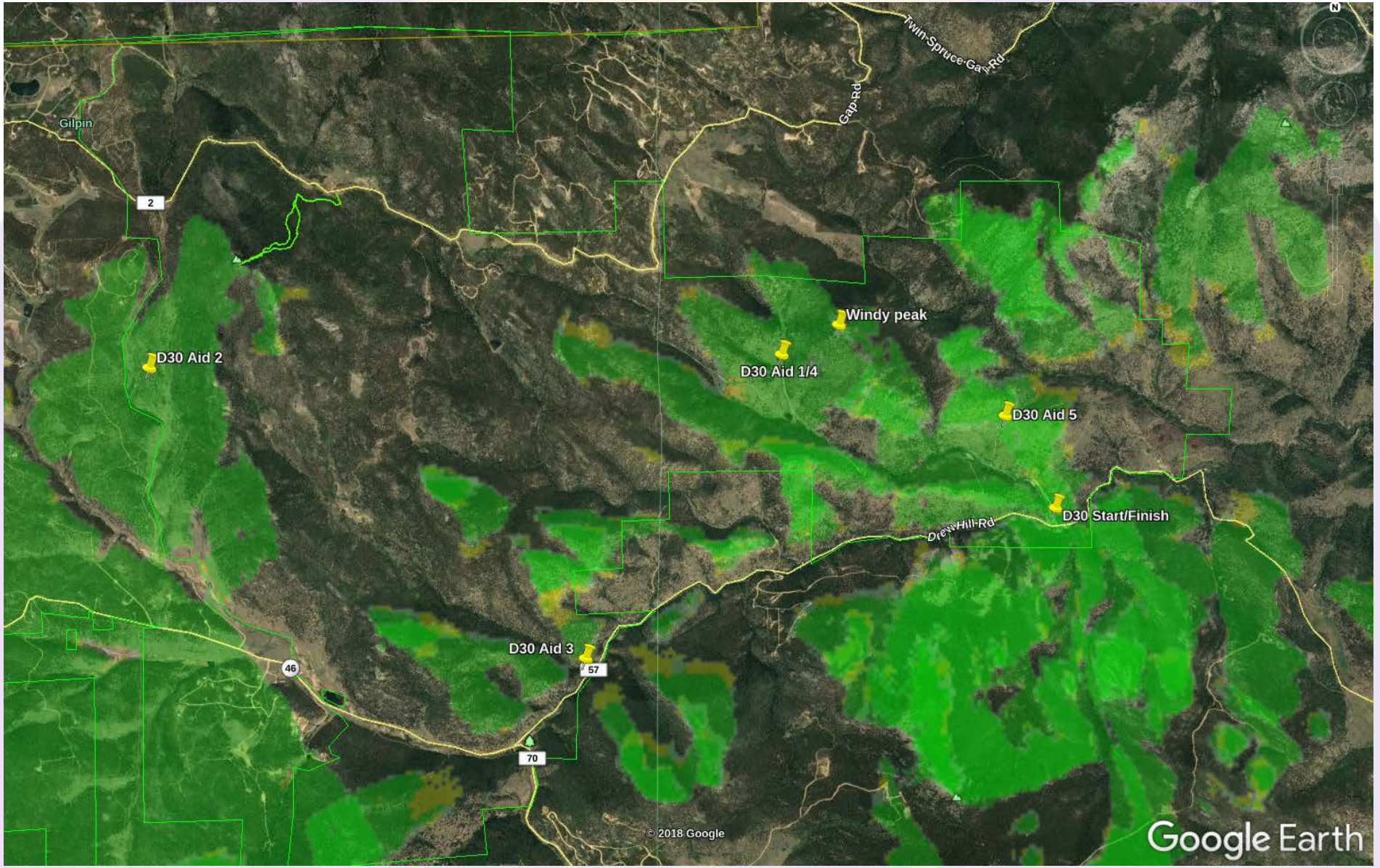
You’re building a physical thing

A *lot* of physical things

17 microwave radios in 2018

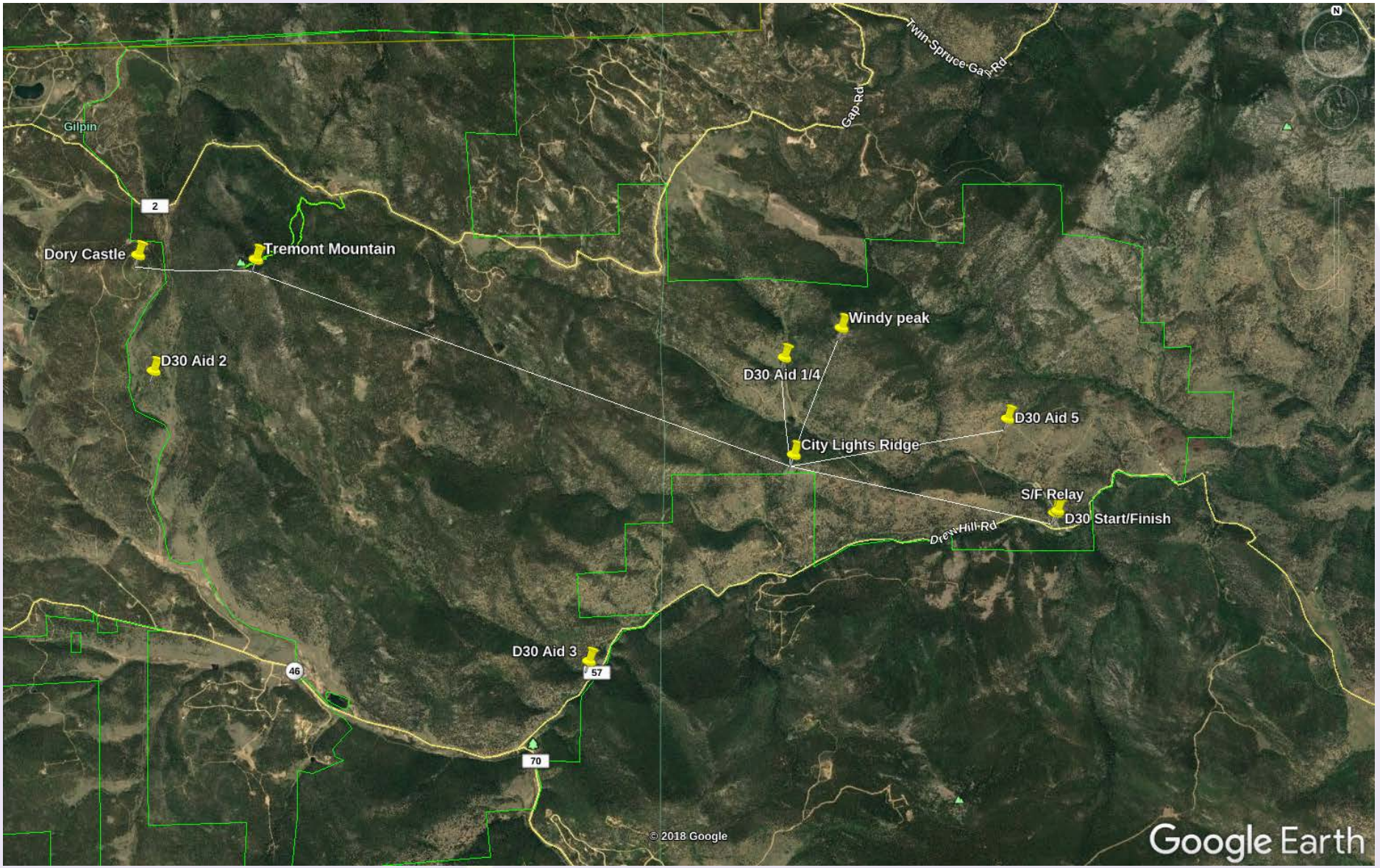
Plus mounts, power, cables, etc

Weather, terrain, time



Coverage overlays

Identify likely areas all or most sites can see



Starting point for physical network layout

Practical Considerations

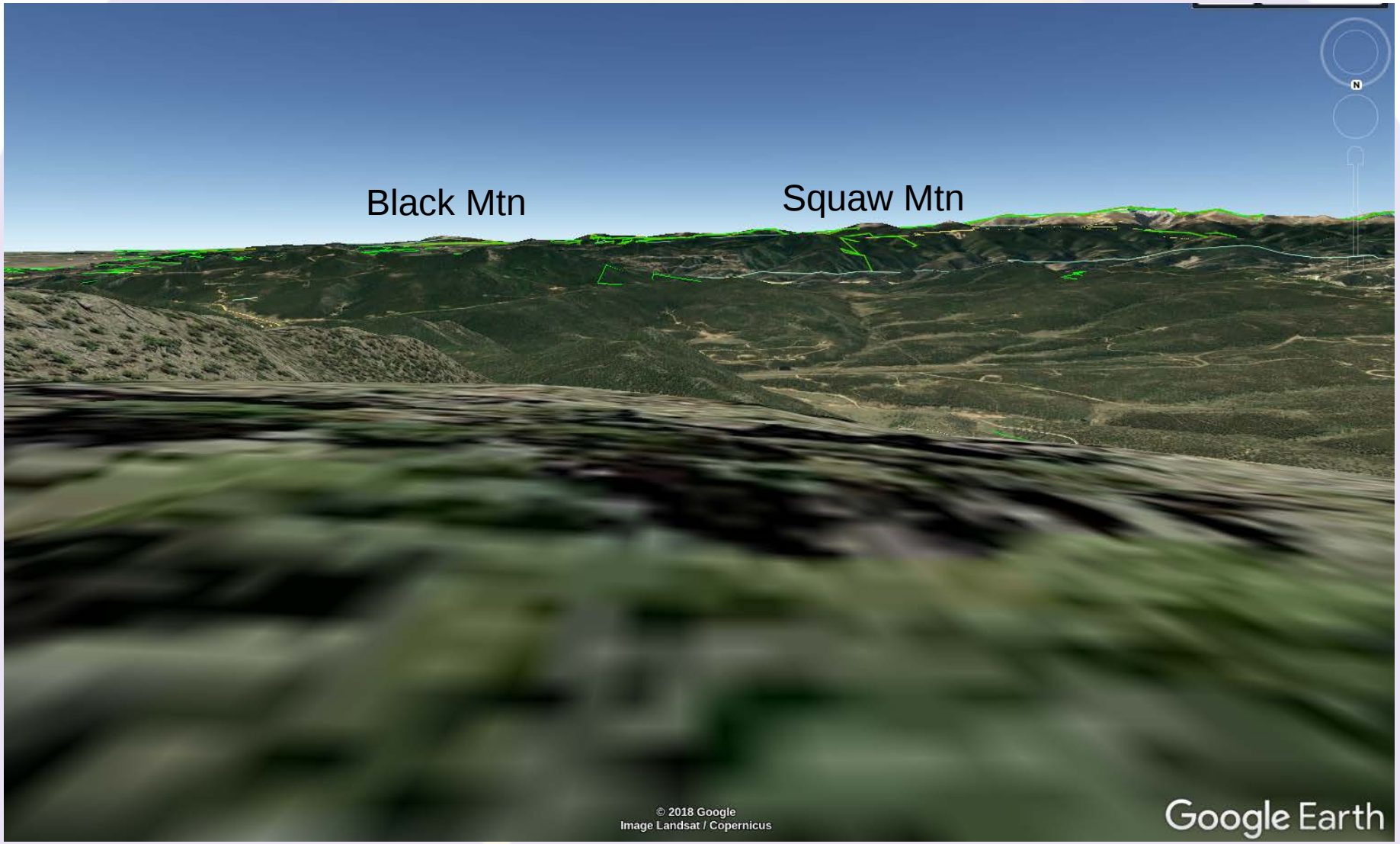
Predictions and models are fantastic tools for initial planning

Reality will surprise you – trees, hills, outcrops, boulders

Groundtruth! Hike, climb, glass, build, repeat

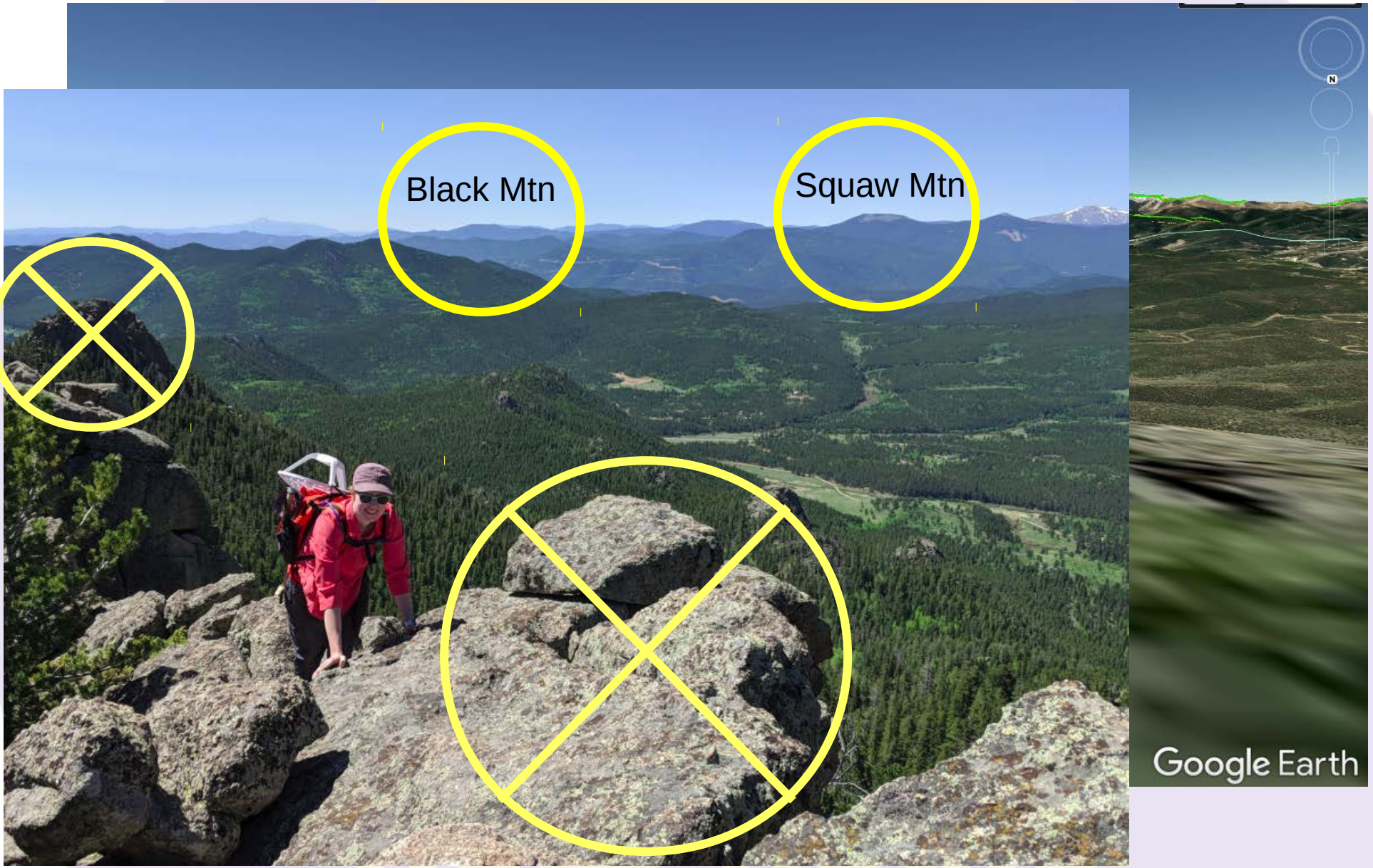
2017 five separate test deployments

Total overhaul two weeks before event



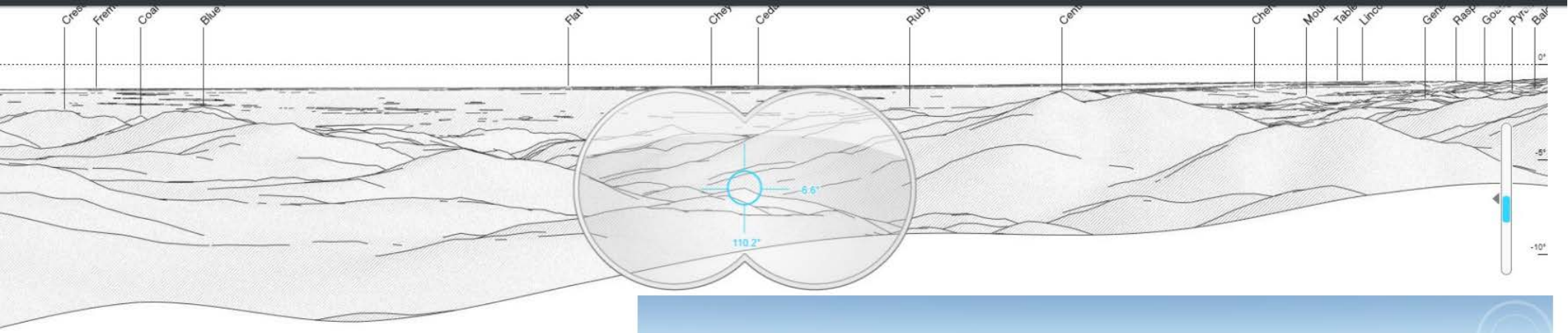
Radio Mobile, Google Earth, PeakFinder all based on USGS terrain data

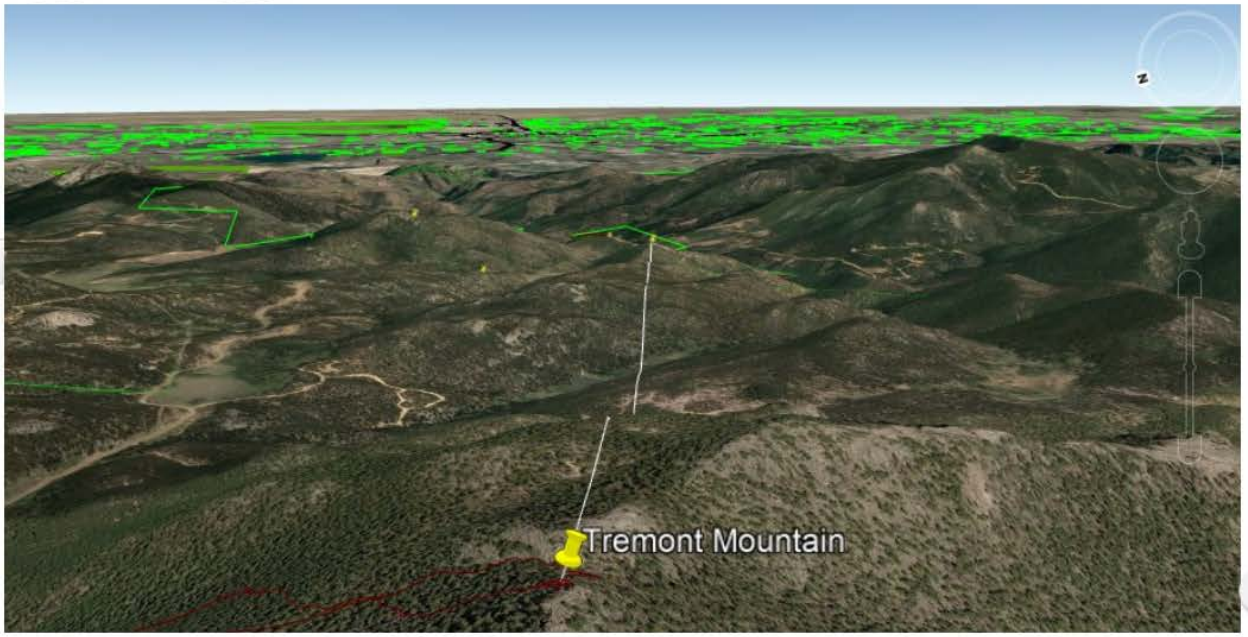
Objects smaller than about 40 ft will be missing



Entire hills wiped out of existence!

And there are trees!

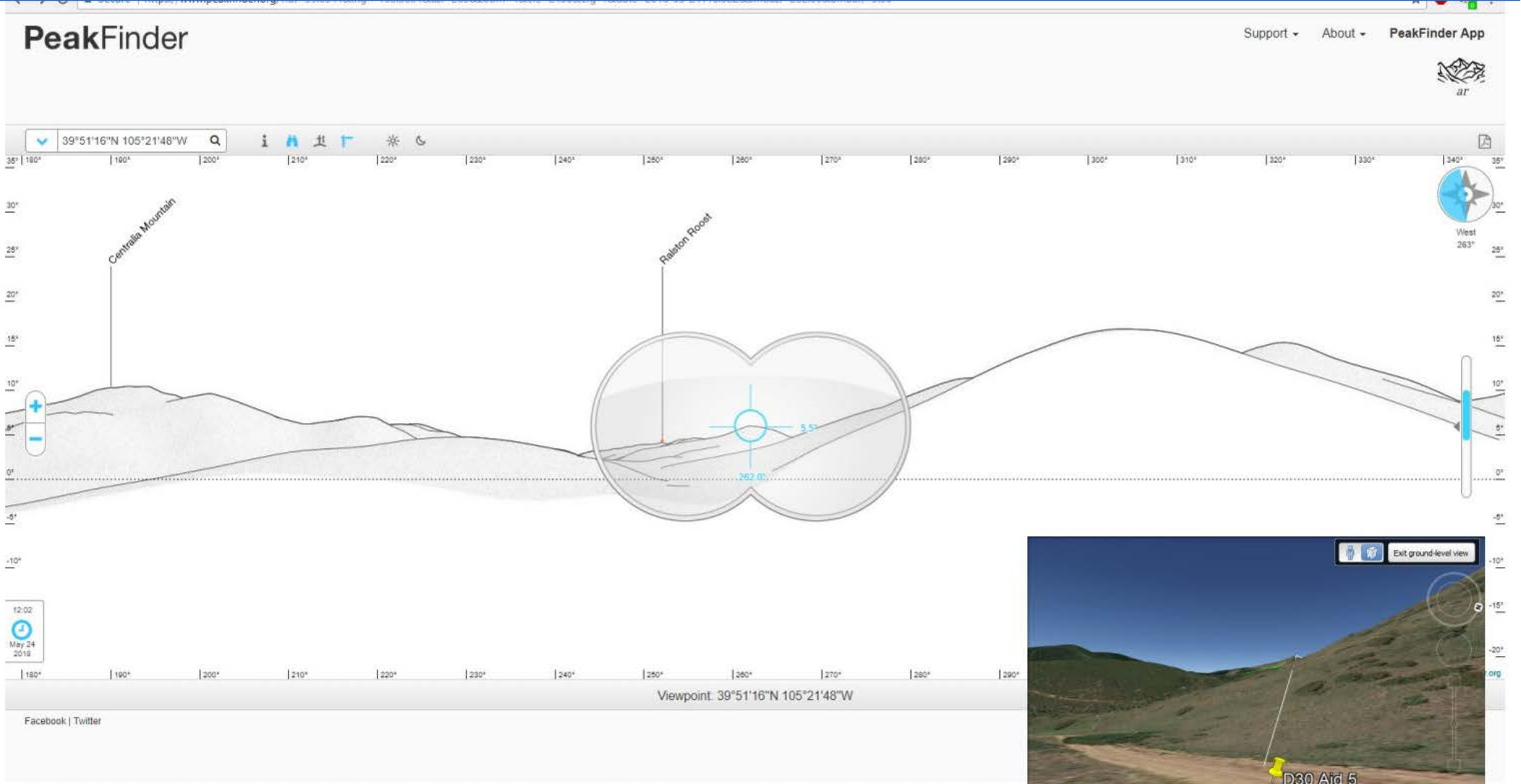




ictured:
Tremont to Dory Castle:
iles @ 274 - 18 degrees

With directional antennas it helps to know where you're aiming.
Peakfinder gives high-contrast terrain diagrams
Google Earth overlays satellite imagery over terrain
Compass headings and elevation angles
***True or magnetic north?* ~ 10 degree difference near Denver**

Cut sheets provided for every site and target



Forecast is centered 120 feet southwest (downhill) from the service road intersection. You may relocate your gear along the route as needed in order to ensure reception, exact location is not critical.

Some sites are easier!

At least when it's sunny.

Build with the masts you have…

…not necessarily the masts you *want!*

It’s always winter in the mountains

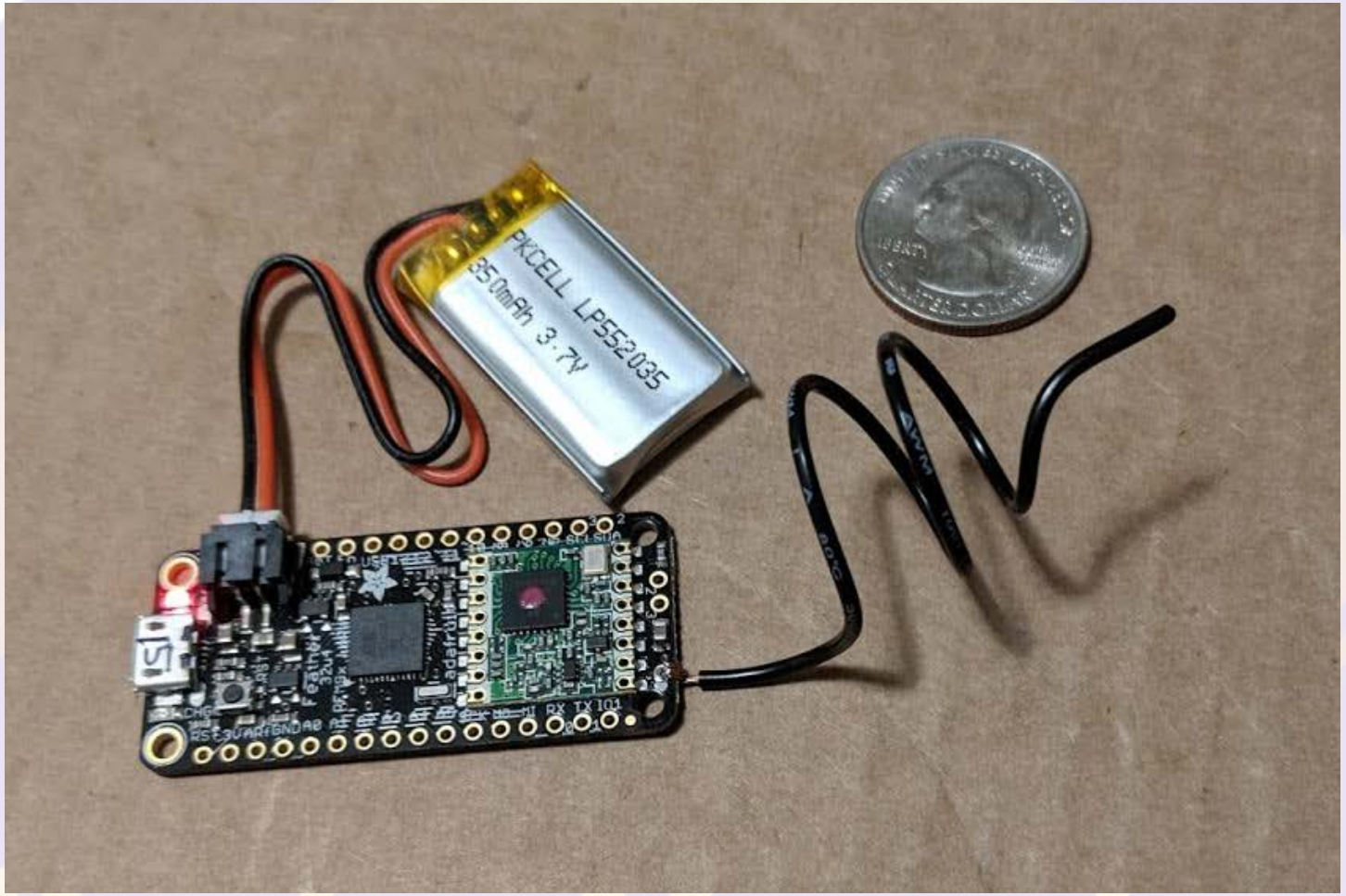
Practical Considerations

You'll have a lot of work to do

Deploy as early as you can

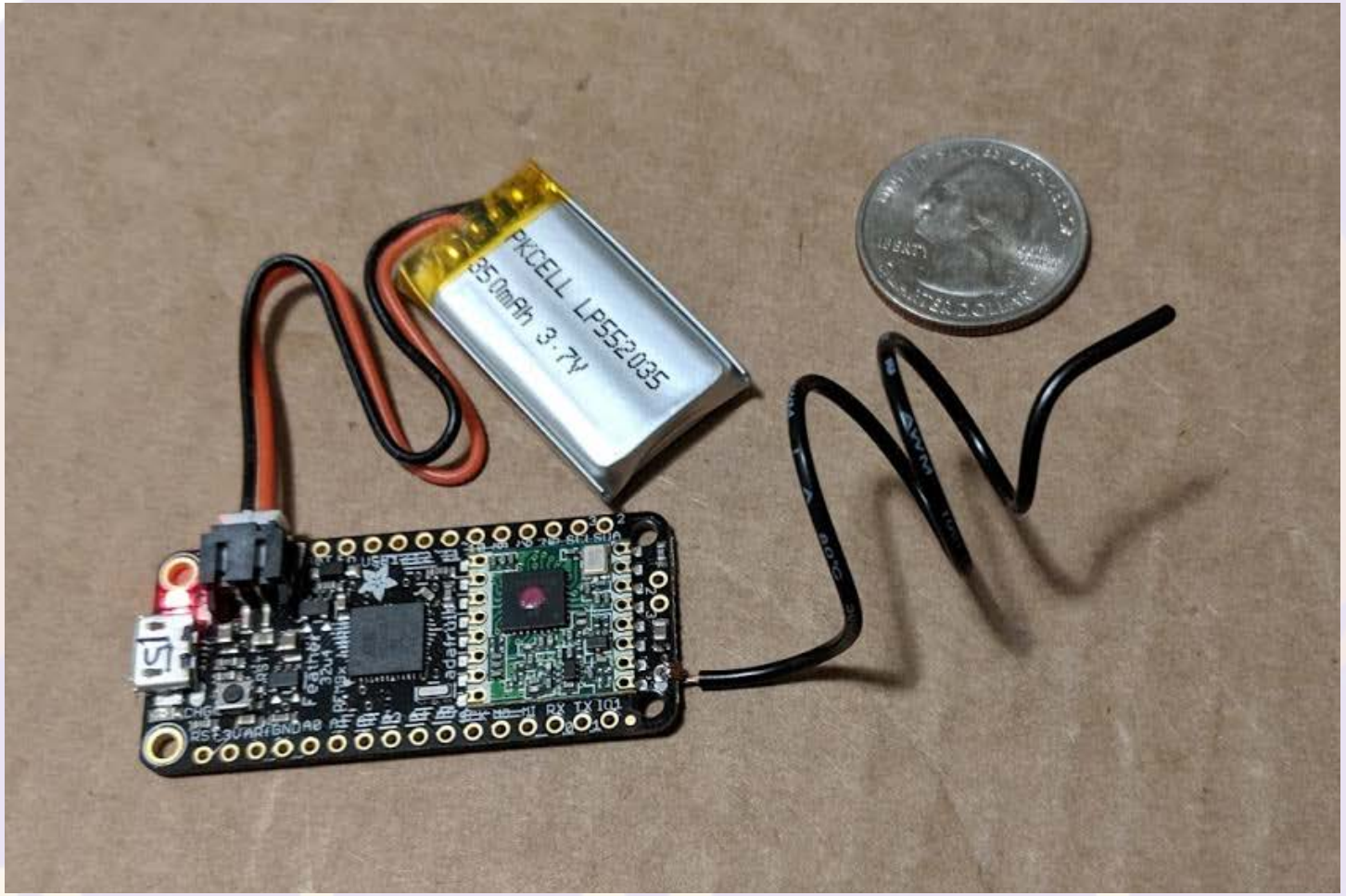
***...But no earlier!* Early setup vs. power budget**

Remote sites on timers, or remotely activated?



LoRA Feather power switch
Hourly check for activation signal
Latching relay to control high-current equipment

...but every useful tool is also another thing to break



LoRA - “Low-power long-range”
Proprietary packet network
Low data rate, noise-tolerant
3 - 100 mW, 70cm and 33cm bands
~2.5 mile range on simple dipole
Adafruit Feather microcontroller line ~ $35

Adapted for Ham use by Travis Goodspeed KK4VCZ

Practical Considerations

Speaking of things breaking…

Multiple technology stacks to support

Have generalists at every site and mobile

Have specialists reachable on demand

Dedicated voice channel for technical support

Laptops, tools

Field Power

Cables

Rovers clearly identifiable to course marshals

...but no need to be (or invite) this guy

Event Headquarters

Computers, LAN, file sharing, collaborative docs

Microwave network tie-in

Commercial satellite

Packet

Field power

Cables

Aid stations

Packet

RFID readers
Configuration correct?
Are they turned on?

Field power

Cables

Microwave network

Physical build – wind, masts

IP routing, DHCP, VPN

Unit configuration (freq, modulation, etc)

Field power

Cables

Common Theme:

Cables cause 80% of your problems

Power issues cause the other 80%

Toolboxes

Wirecutters

Crimpers

Connectors

Butane soldering iron

Adapters

IP Networking

- Bridged
  - No configuration, traffic broadcast everywhere
- Static Routed
  - Configured to route traffic as needed
- Dynamic Routed (OSPF)
  - Configured to route automatically as needed
- Mesh Routing (OLSR, WDS,UniFi)
  - Little configuration, automatic routing

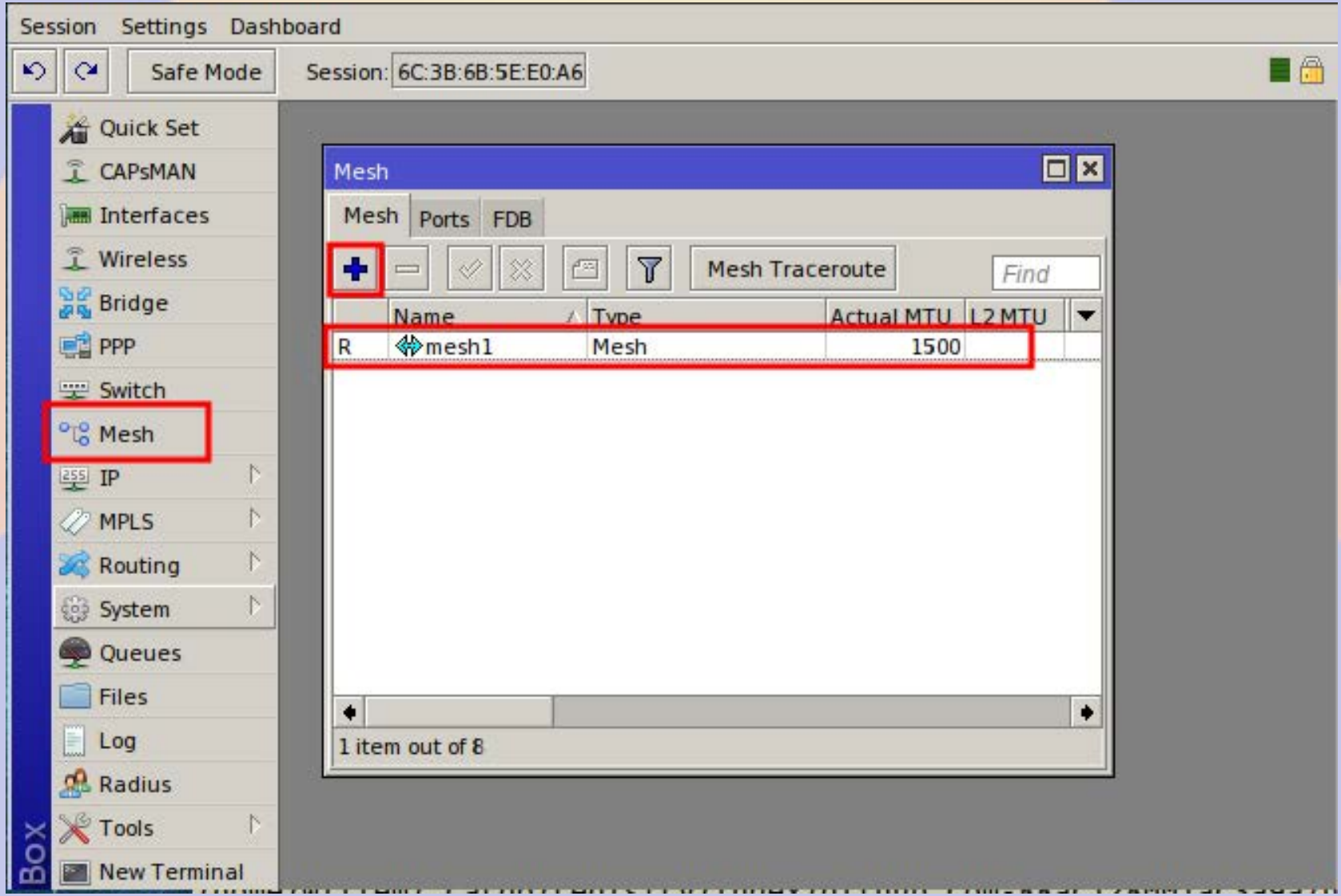
Ubiquiti UniFi Mesh

- Pros
  - Works out of the box with minimal configuration
  - Weather proof
  - Device is both Mesh Relay and Access Point
  - Excellent bandwidth
- Cons
  - Limited to ISM bands
  - Limited range
- Applications
  - Start/finish and vendor area

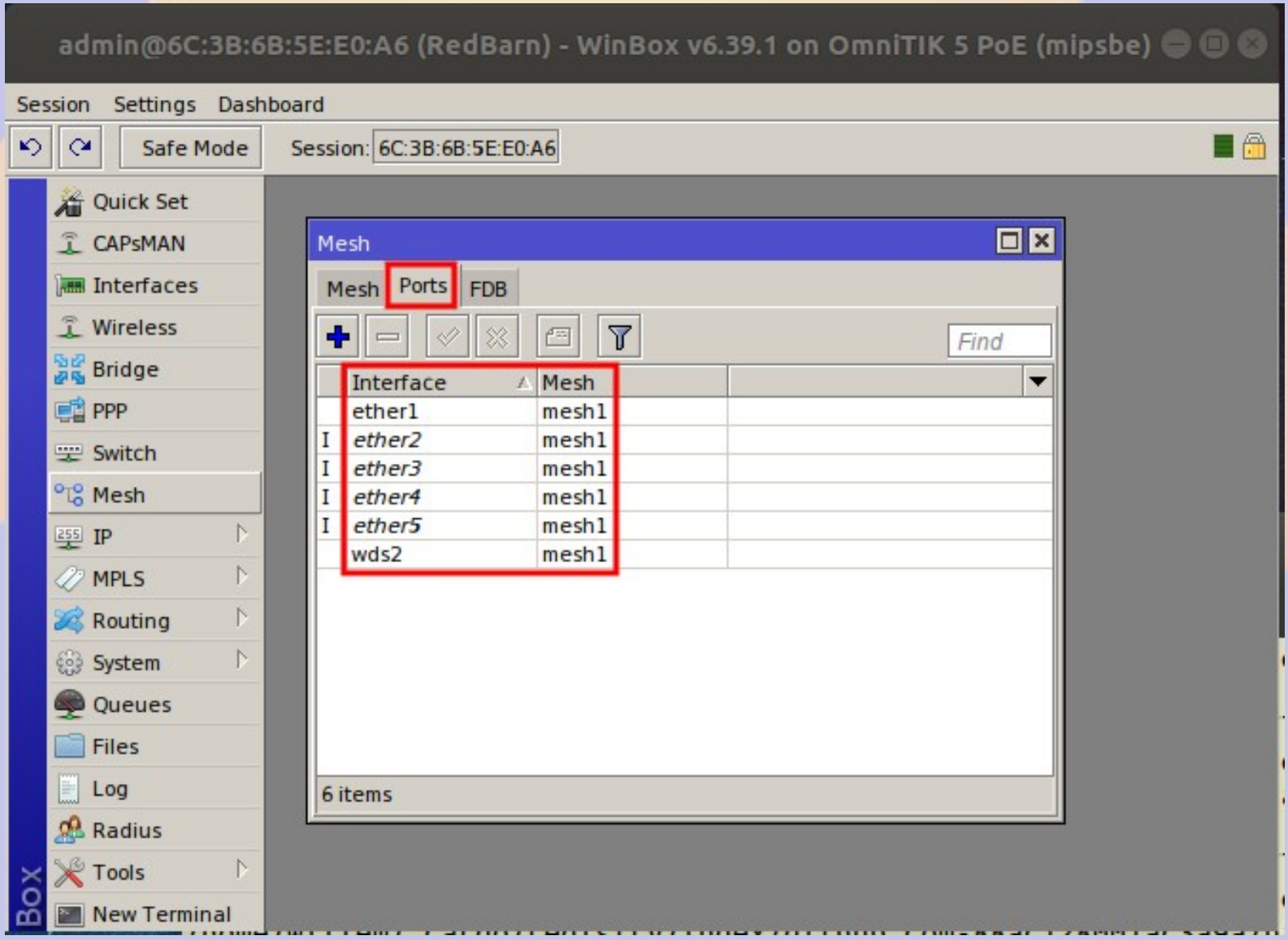
Mikrotik WDS Mesh

- Pros
  - Works out of the box, more difficult to configure
  - Weather proof (OmniTik)
  - Can be tuned to ham band (Superchannel)
- Cons
  - Needs separate access point
  - Limited range
- Applications
  - Relays over obstructions

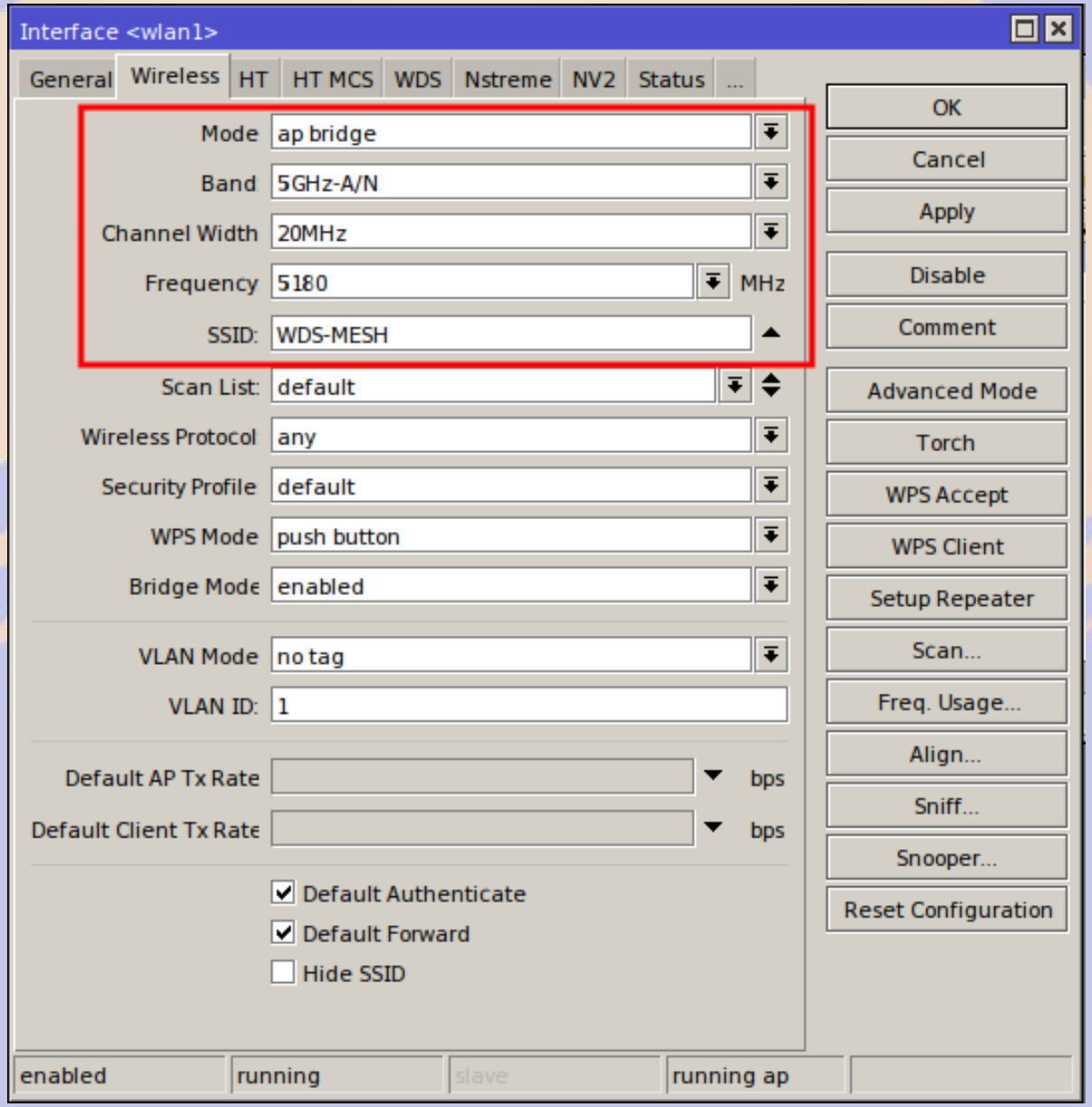
WDS Mesh 1


Session
Settings
Dashboard
Safe Mode
Session: 6C:3B:6B:5E:E0:A6
Quick Set
CAPsMAN
Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
Mesh
Mesh
Ports
FDB
Mesh Traceroute
Find
Name
Type
Actual MTU
L2 MTU
R
mesh1
Mesh
1500
1 item out of 8

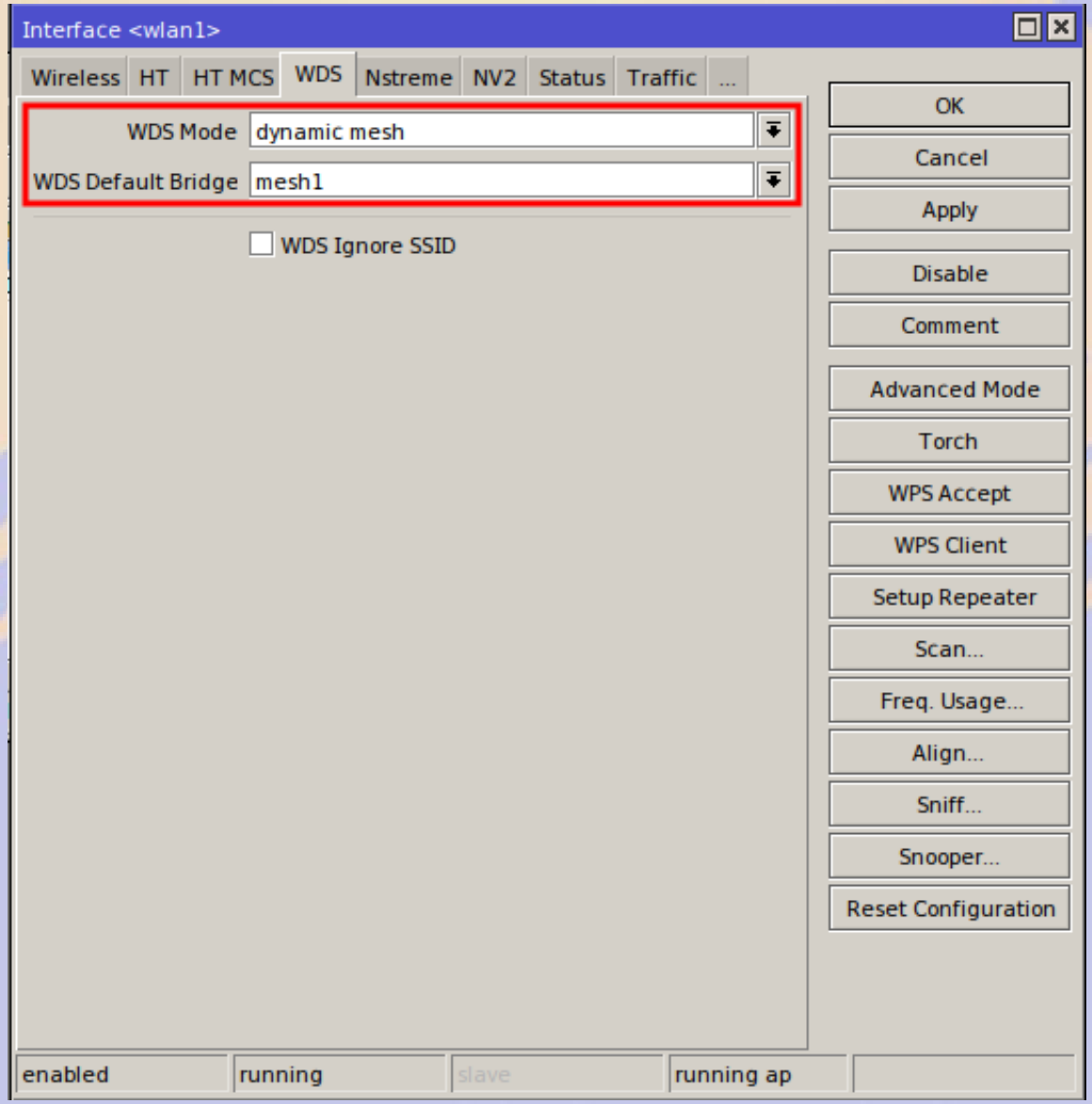
WDS Mesh 2


admin@6C:3B:6B:5E:E0:A6 (RedBarn) - WinBox v6.39.1 on OmniTIK 5 PoE (mipsbe)
Session Settings Dashboard
Safe Mode
Session: 6C:3B:6B:5E:E0:A6
Quick Set
CAPsMAN
Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
Mesh
Mesh Ports FDB
Find
Interface Mesh
ether1 mesh1
ether2 mesh1
ether3 mesh1
ether4 mesh1
ether5 mesh1
wds2 mesh1
6 items

WDS Mesh 3


Interface <wlan1>
General
Wireless
HT
HT MCS
WDS
Nstreme
NV2
Status
...
Mode
ap bridge
Band
5GHz-A/N
Channel Width
20MHz
Frequency
5180
MHz
SSID:
WDS-MESH
Scan List:
default
Wireless Protocol
any
Security Profile
default
WPS Mode
push button
Bridge Mode
enabled
VLAN Mode
no tag
VLAN ID:
1
Default AP Tx Rate
bps
Default Client Tx Rate
bps
Default Authenticate
Default Forward
Hide SSID
OK
Cancel
Apply
Disable
Comment
Advanced Mode
Torch
WPS Accept
WPS Client
Setup Repeater
Scan...
Freq. Usage...
Align...
Sniff...
Snooper...
Reset Configuration
enabled
running
slave
running ap

WDS Mesh 4


Interface <wlan1>
Wireless
HT
HT MCS
WDS
Nstreme
NV2
Status
Traffic
...
WDS Mode
dynamic mesh
WDS Default Bridge
mesh1
WDS Ignore SSID
OK
Cancel
Apply
Disable
Comment
Advanced Mode
Torch
WPS Accept
WPS Client
Setup Repeater
Scan...
Freq. Usage...
Align...
Sniff...
Snooper...
Reset Configuration
enabled
running
slave
running ap

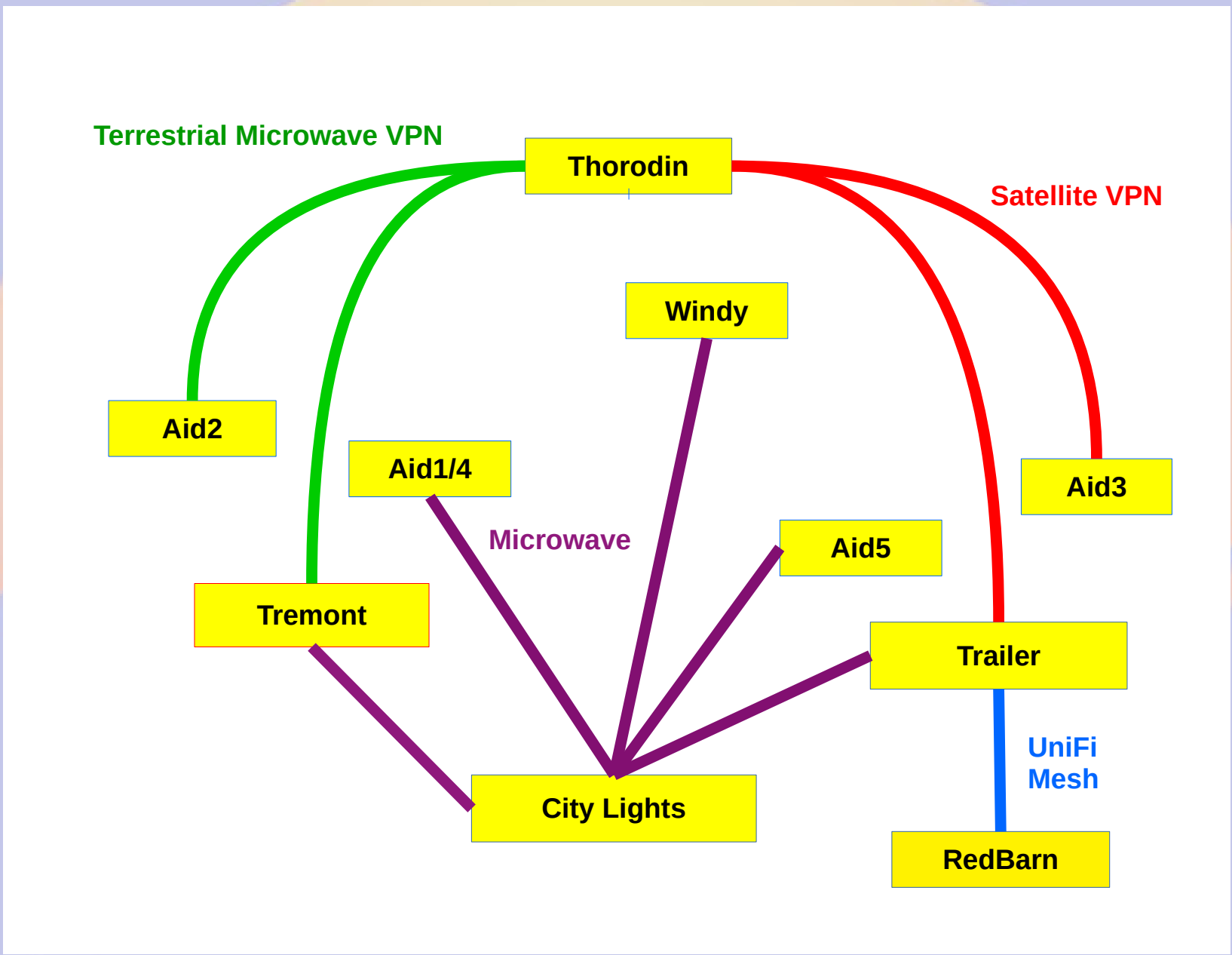
BBHN/AREDN Mesh

- Pros
  - Works on different hardware (mostly Ubiquiti)
  - Can be tuned to ham bands
- Cons
  - Needs custom firmware
  - Limited range
  - Does not handle topology changes well
  - Inflexible on addressing and routing

Point to Point & Point to Multi-Point

- Bridged
  - Packets are repeated everywhere
  - Cannot contain loops
- Static routes with failover
  - Configure primary and secondary routes
- Dynamic routes (OSPF)
  - Assign cost to each link
  - OSPF finds lowest cost route
  - Loops provide redundancy

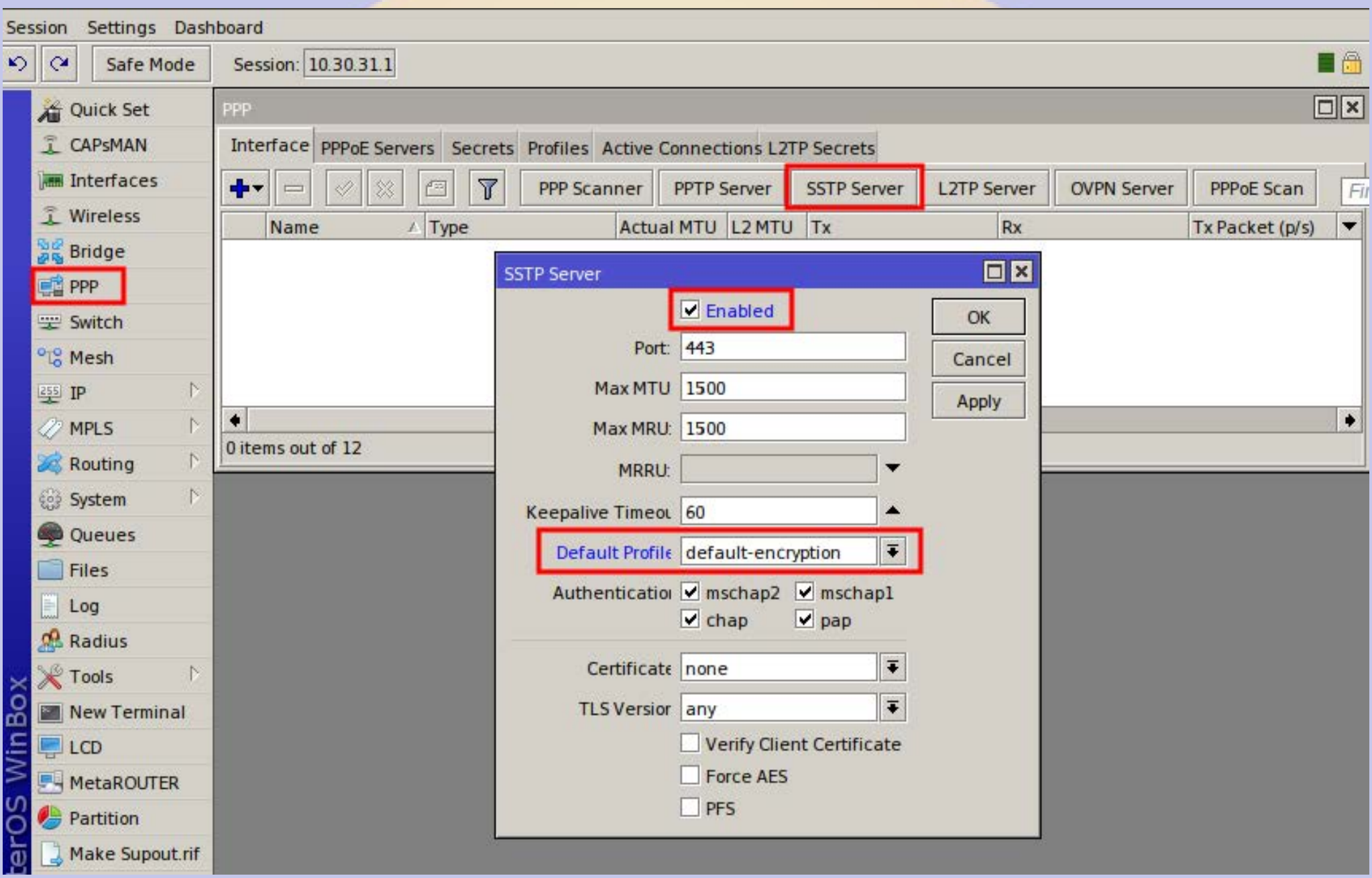
Dirty30 Network Design



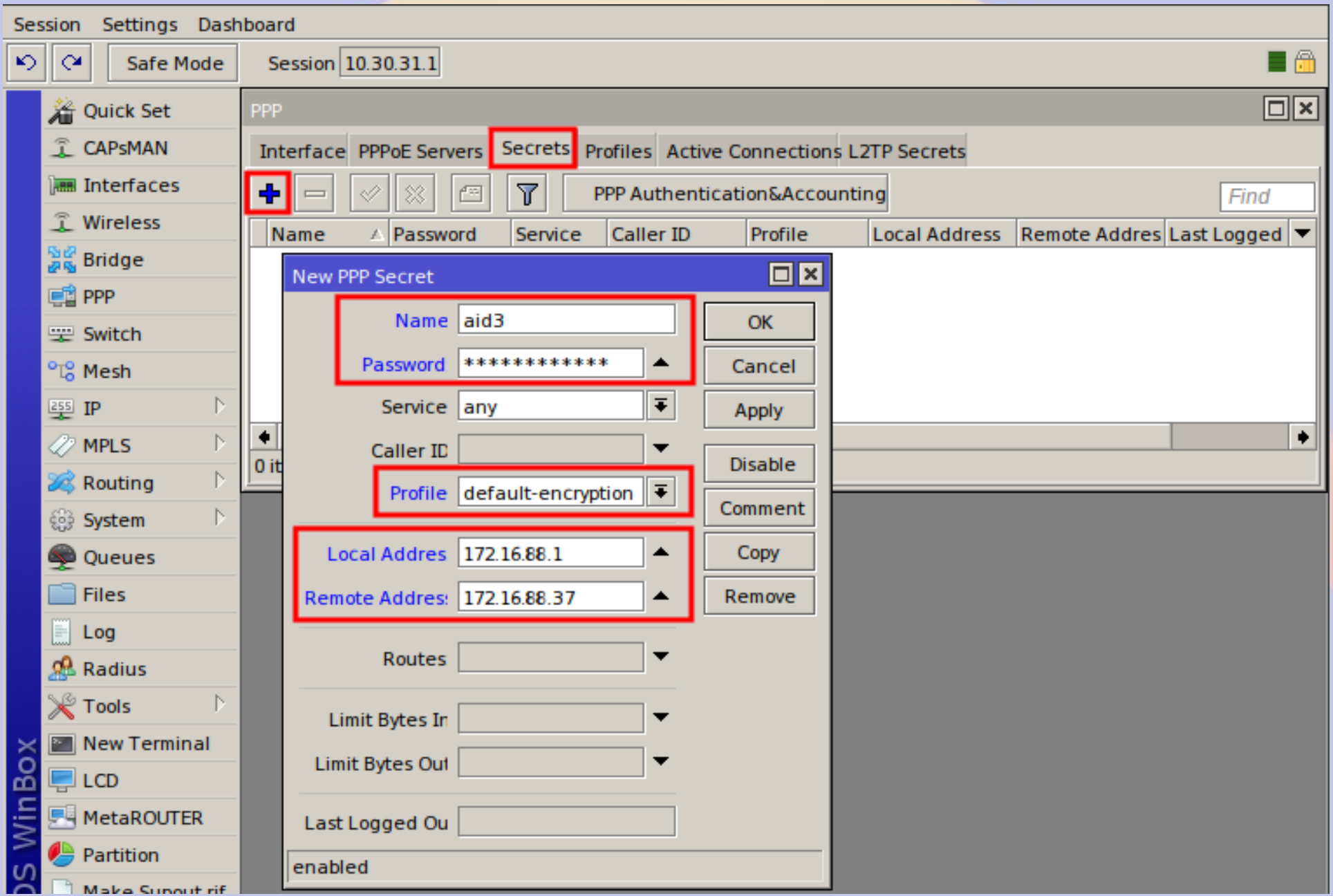
Dirty30 Network

- OSPF for general routing
- Static routes for spokes
- VPN to cross external networks
- Redundant paths
- City Lights remains single point of failure

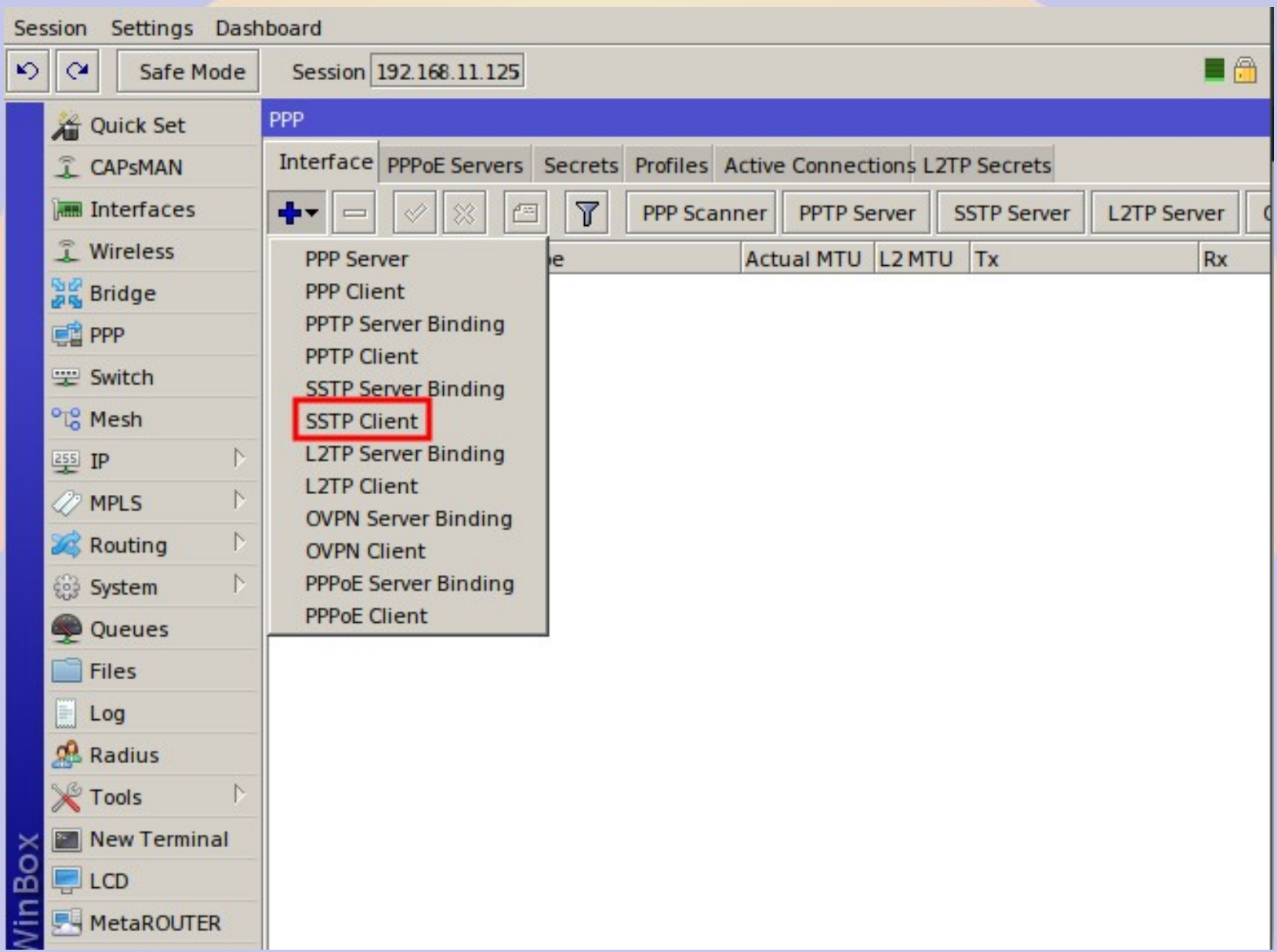
VPN Server 1


Session Settings Dashboard
Safe Mode
Session: 10.30.31.1
Quick Set
CAPsMAN
Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
LCD
MetaROUTER
Partition
Make Supout.rif
RouterOS WinBox
PPP
Interface
PPPoE Servers
Secrets
Profiles
Active Connections
L2TP Secrets
PPP Scanner
PPTP Server
SSTP Server
L2TP Server
OVPN Server
PPPoE Scan
Name
Type
Actual MTU
L2 MTU
Tx
Rx
Tx Packet (p/s)
0 items out of 12
SSTP Server
Enabled
Port: 443
Max MTU 1500
Max MRU: 1500
MRRU:
Keepalive Timeou 60
Default Profile default-encryption
Authenticatio mschap2 mschap1 chap pap
Certificate none
TLS Versior any
Verify Client Certificate
Force AES
PFS
OK
Cancel
Apply

VPN Server 2

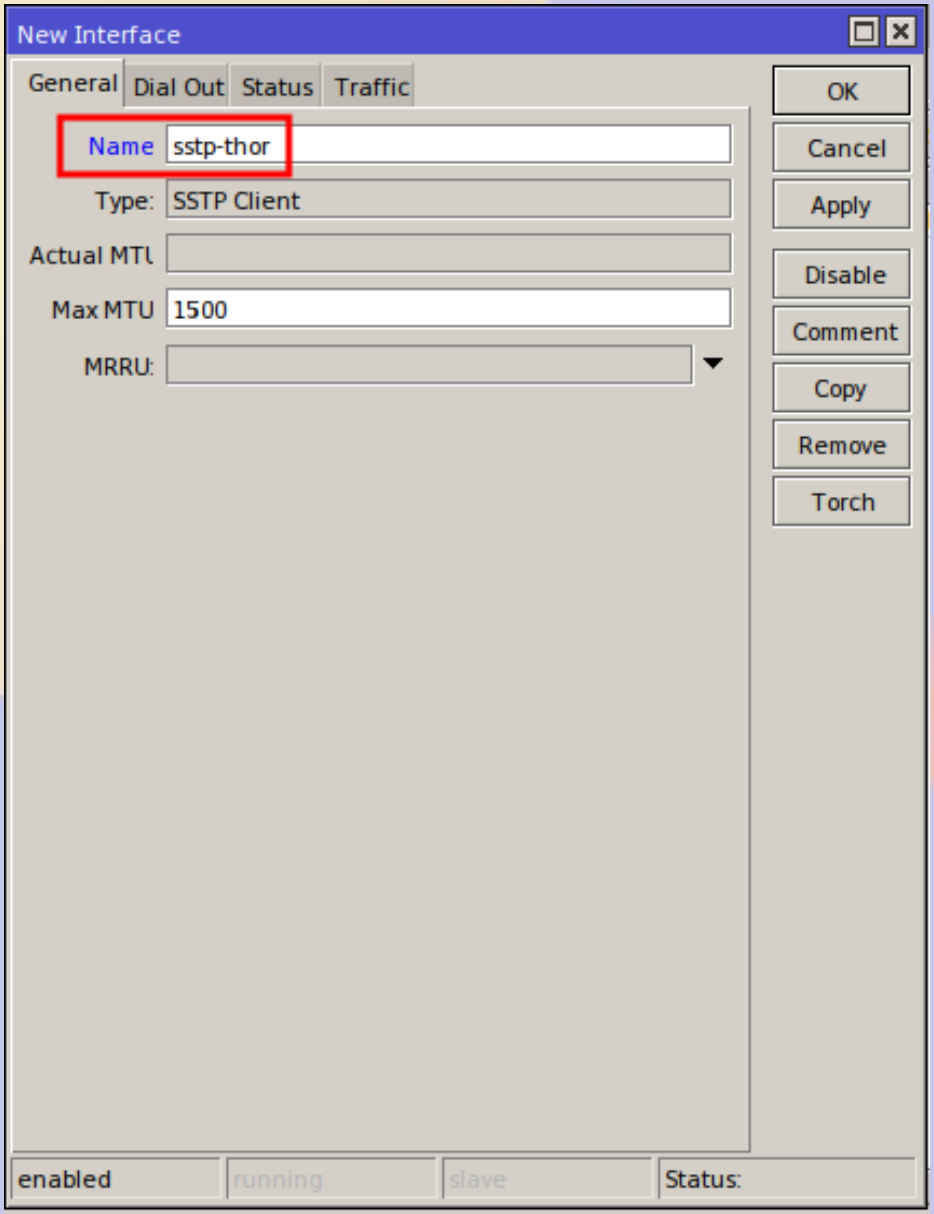

Session Settings Dashboard
Safe Mode
Session 10.30.31.1
Quick Set
CAPsMAN
Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
LCD
MetaROUTER
Partition
RouterOS WinBox
PPP
Interface
PPPoE Servers
Secrets
Profiles
Active Connections
L2TP Secrets
PPP Authentication&Accounting
Find
Name
Password
Service
Caller ID
Profile
Local Address
Remote Addres
Last Logged
New PPP Secret
Name aid3
Password ***********
Service any
Caller ID
Profile default-encryption
Local Addres 172.16.88.1
Remote Addres 172.16.88.37
Routes
Limit Bytes In
Limit Bytes Out
Last Logged Ou
enabled
OK
Cancel
Apply
Disable
Comment
Copy
Remove

VPN Client 1


Session Settings Dashboard
Safe Mode
Session 192.168.11.125
Quick Set
CAPsMAN
Interfaces
Wireless
Bridge
PPP
Switch
Mesh
IP
MPLS
Routing
System
Queues
Files
Log
Radius
Tools
New Terminal
LCD
MetaROUTER
WinBox
PPP
Interface
PPPoE Servers
Secrets
Profiles
Active Connections
L2TP Secrets
PPP Scanner
PPTP Server
SSTP Server
L2TP Server
Actual MTU
L2 MTU
Tx
Rx
PPP Server
PPP Client
PPTP Server Binding
PPTP Client
SSTP Server Binding
SSTP Client
L2TP Server Binding
L2TP Client
OVPN Server Binding
OVPN Client
PPPoE Server Binding
PPPoE Client

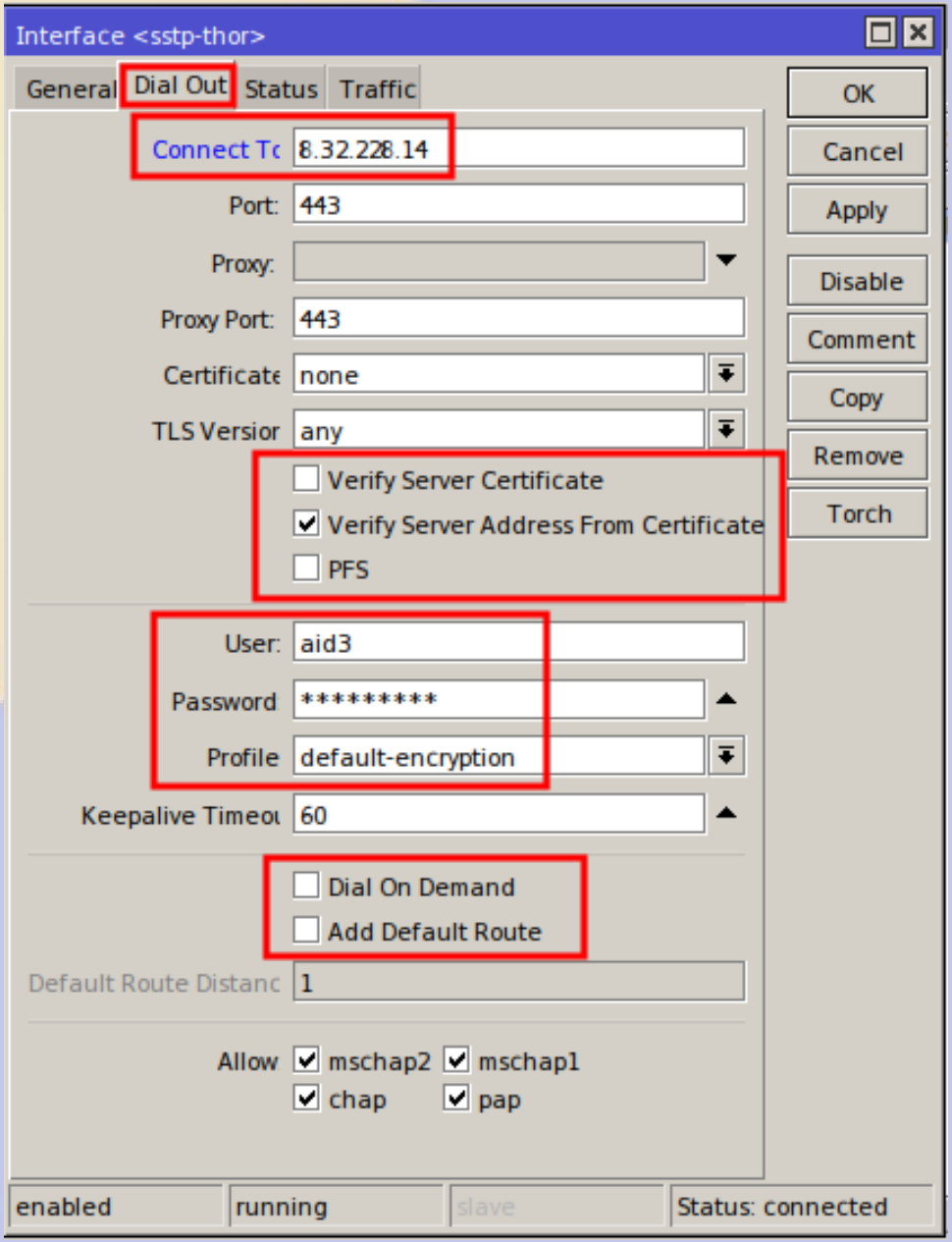
VPN Client 2

- Select a name that describes the VPN type and destination



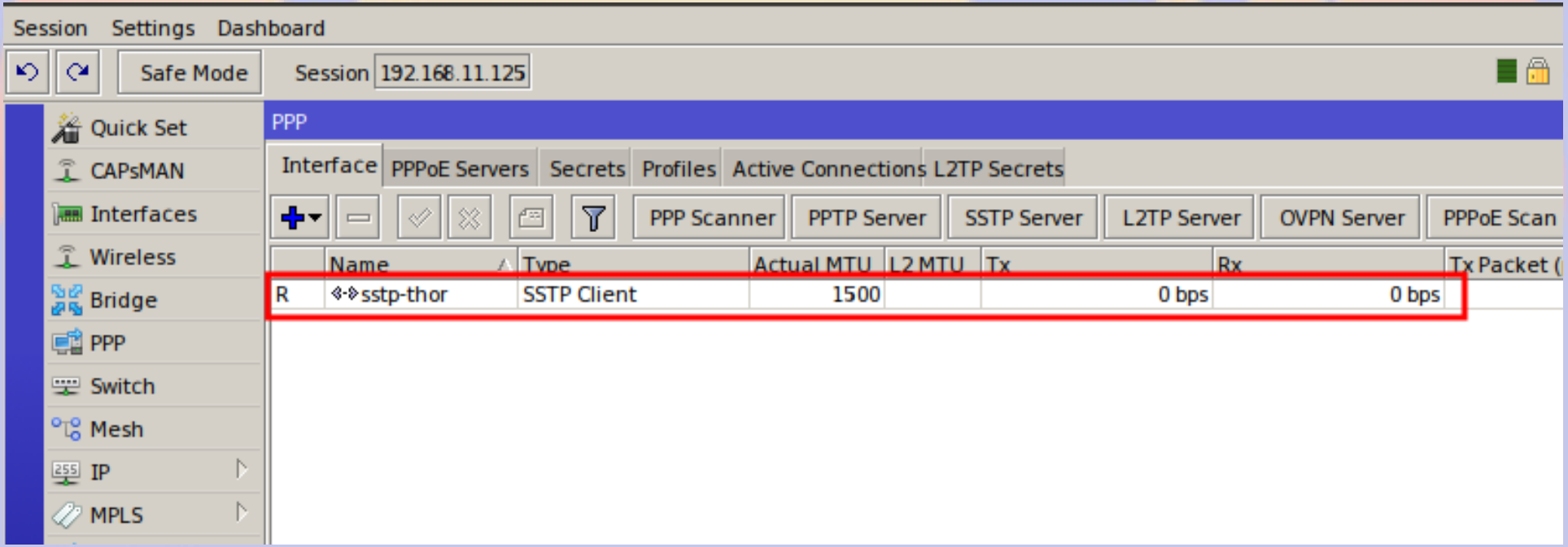
VPN Client 3

- Set IP of server
- DO NOT verify cert
  - (unless you set one)
- Set username, password and profile
- DO NOT select
  - Dial on Demand
  - Add Default Route



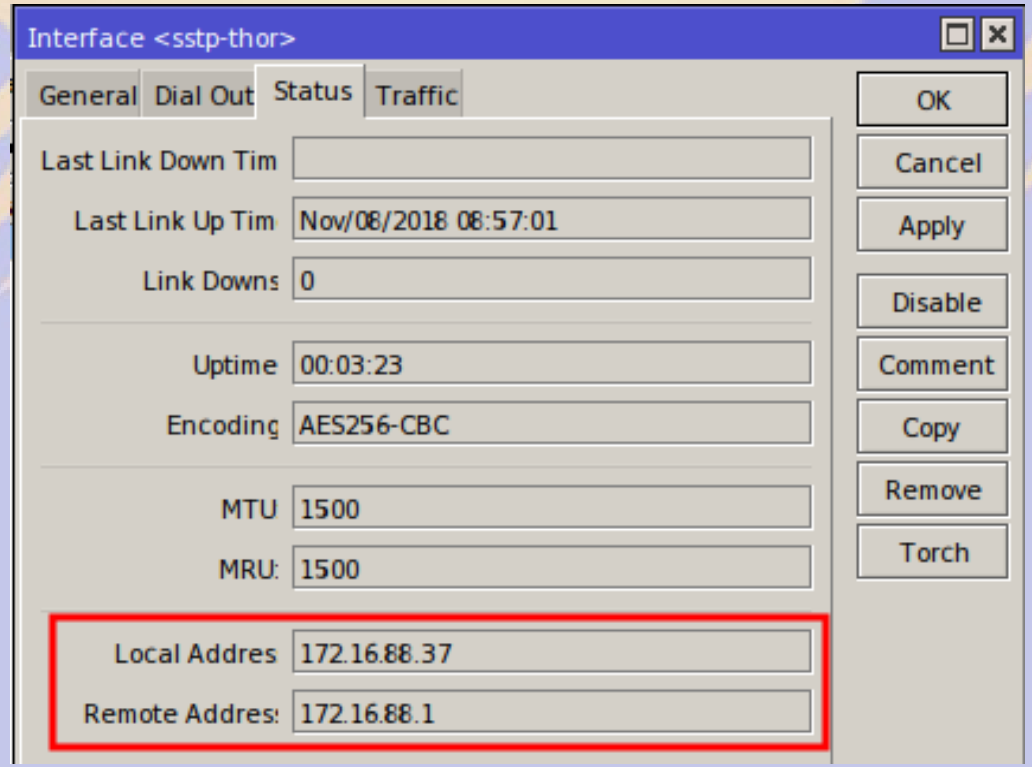
VPN Client 3

- Connection activates immediately
- MTU, Rx and Tx shows activity



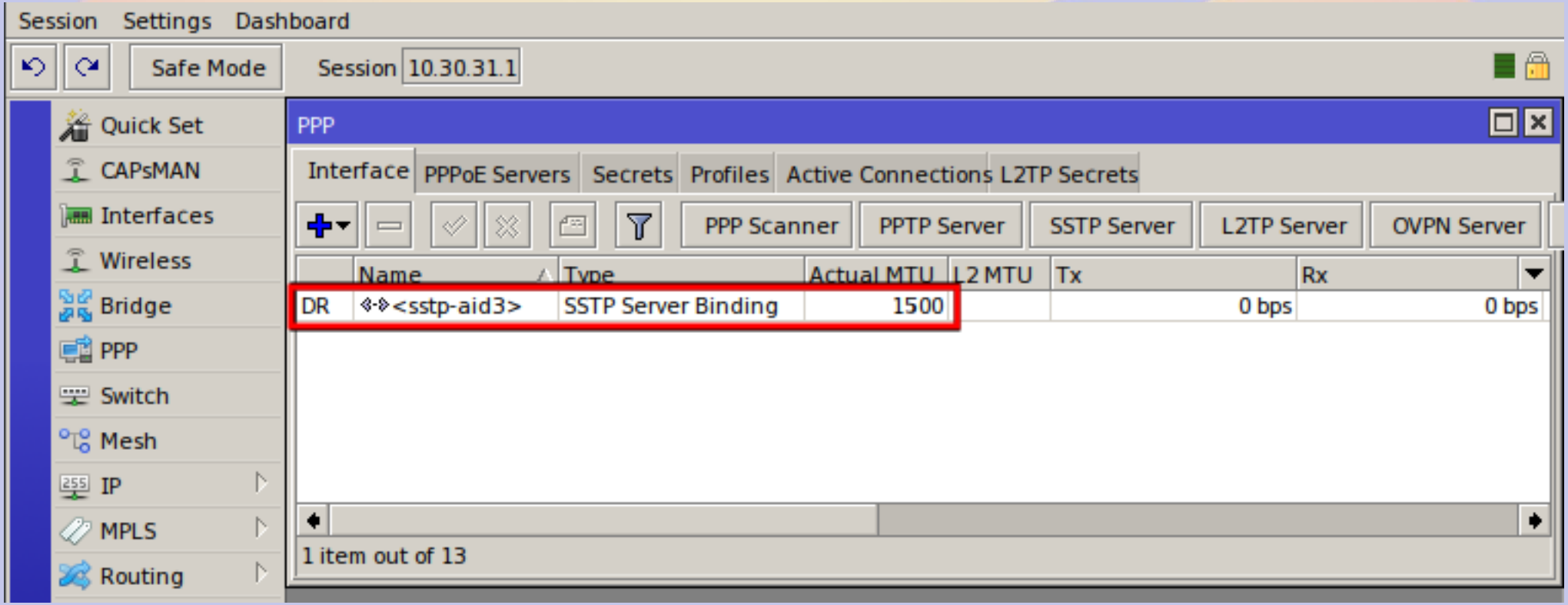
VPN Client 4

- VPN addresses obtained from server
- Note traffic is encrypted over public internet

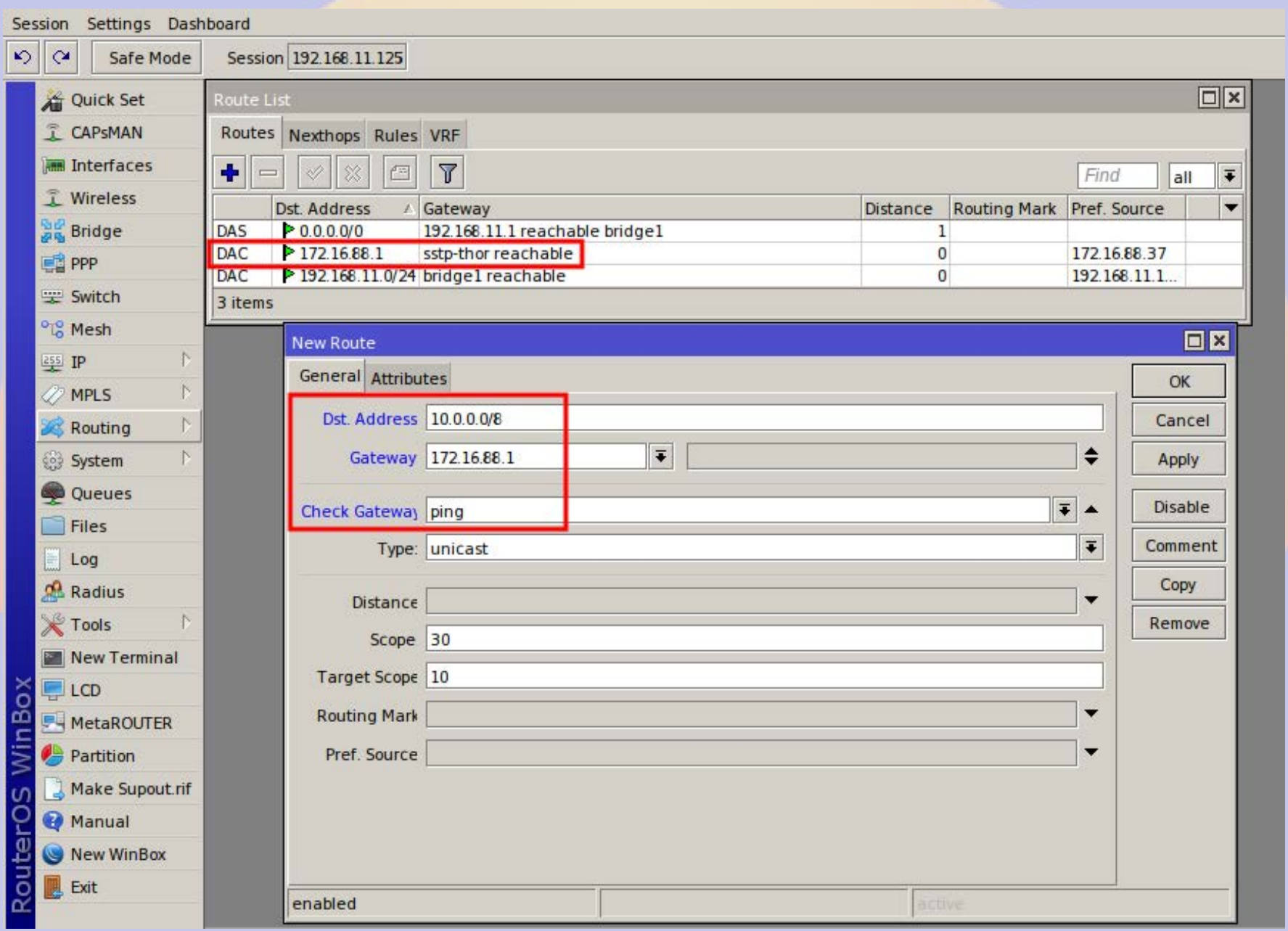


VPN server 3

- Client connection <service-username>
- <> means dynamically created
  - Copy to make static (see OSPF discussion)



VPN Static Client Side Route



VPN Routing Observations

- Route only 10.0.0.0/8 across VPN
  - All other traffic goes to default gateway
- Static route also required on server side
  - Server only knows link (172.16.X.X) address
  - Server probably OSPF - informs rest of network
- OSPF on client side will automatically route
  - Could use multiple VPNs to different end points
  - Add ospf-out filter to avoid flapping

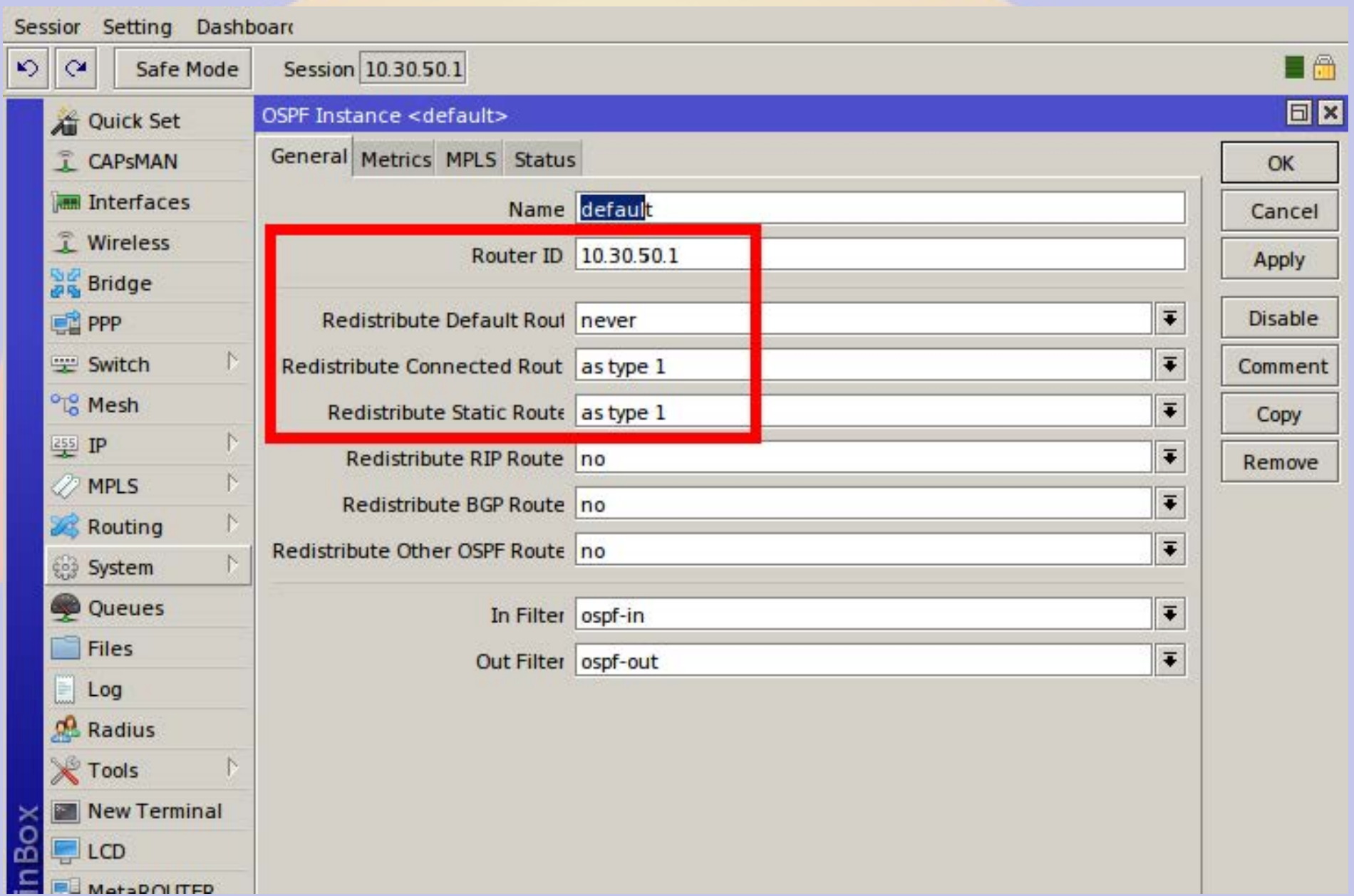
OSPF Tips and Tricks

- Use bridge IP as router ID
- Set network type to PtP or PtMP
  - Changes propagate faster
- Make sure link costs are symmetric
- Do not export default routes
- Static routes should appear ONCE
- OSPF does not cure a bad network design

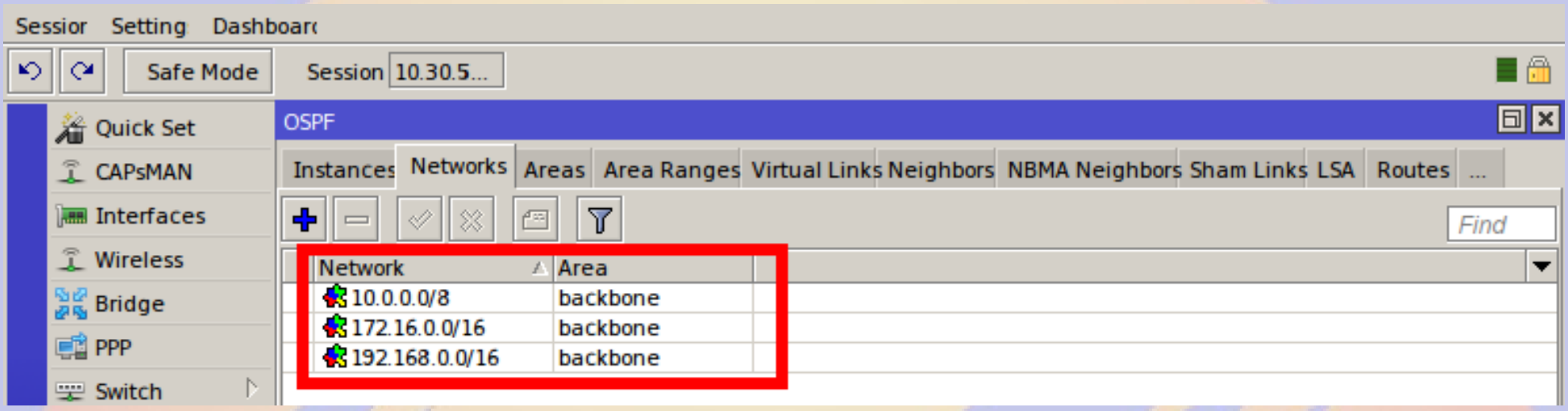
Configuring an OSPF Router

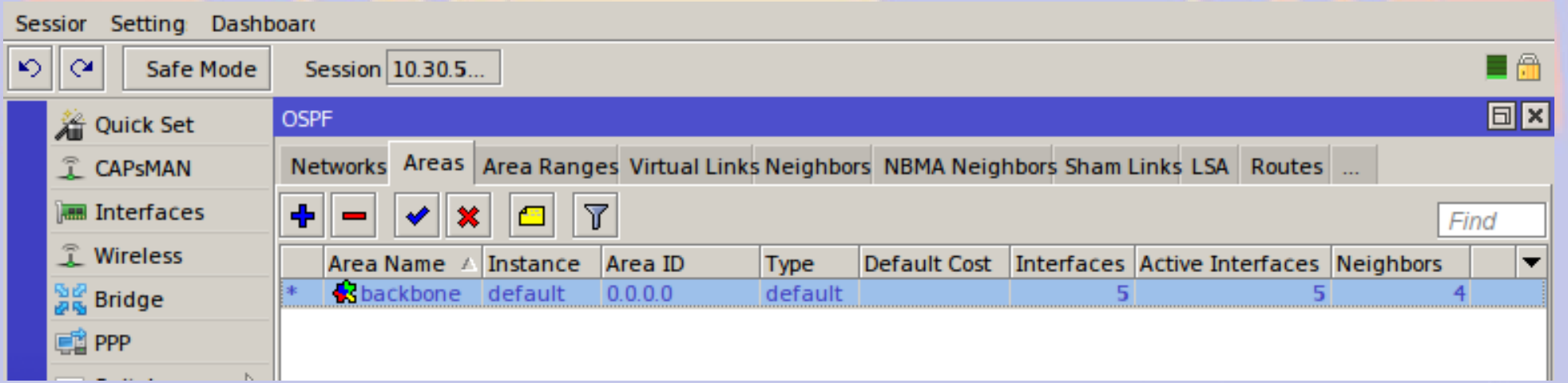
- Reset Configuration – No Default
- Add bridge and set ports
- Configure IP
  - address/subnet for bridge, etherX
  - set default route
  - set DNS
  - configure DHCP
- Configure OSPF
  - set Router ID, export connected and static as type 1
  - set OSPF network(s)
  - add OSPF filter(s) if you have a VPN WAN
- Customize rest to taste

Configuring OSPF Step 1



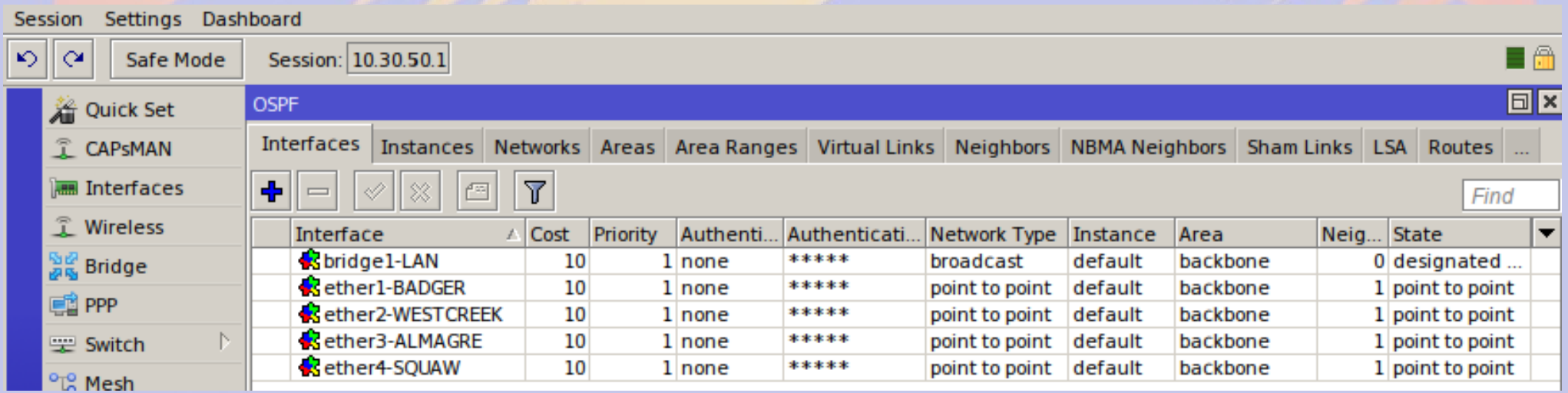
Configuring OSPF Step 2





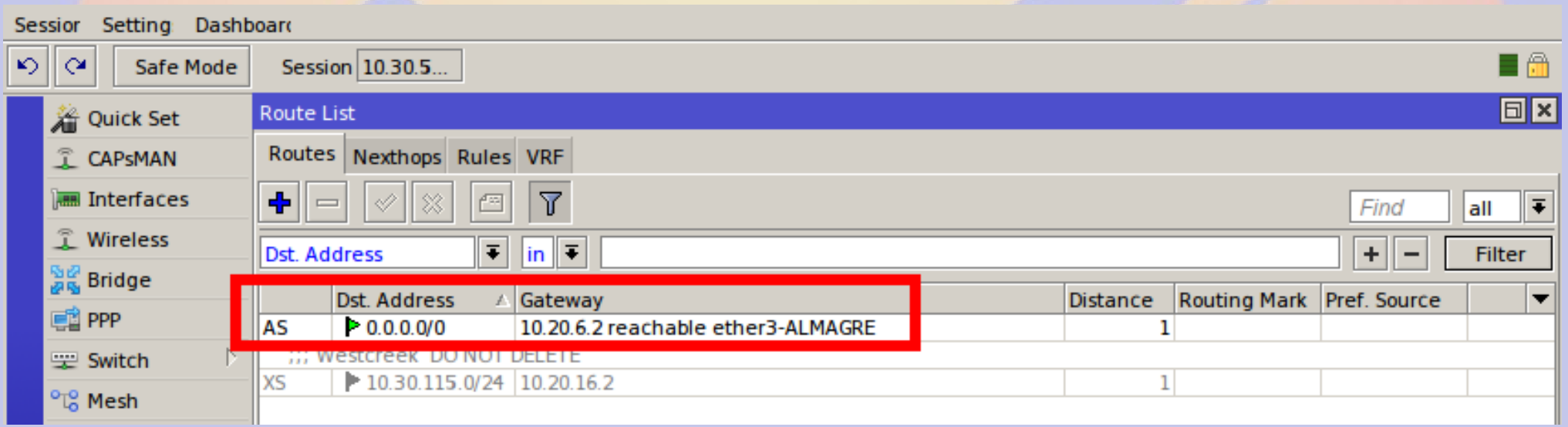
Configuring OSPF Step 3

- All interfaces are automatically added
- Different weights needed for failover or setting a preferred route
- Default ethernet network type is broadcast
  - Change this to point-to-point

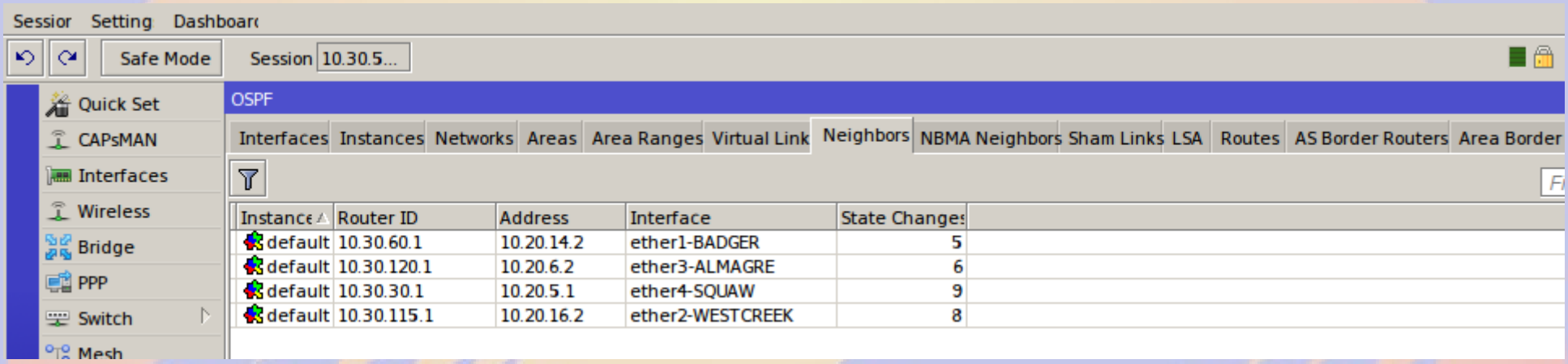


Configuring OSPF Step 4

- Only add static routes you absolutely must
  - A default static route
  - VPNs and routers NOT running OSPF

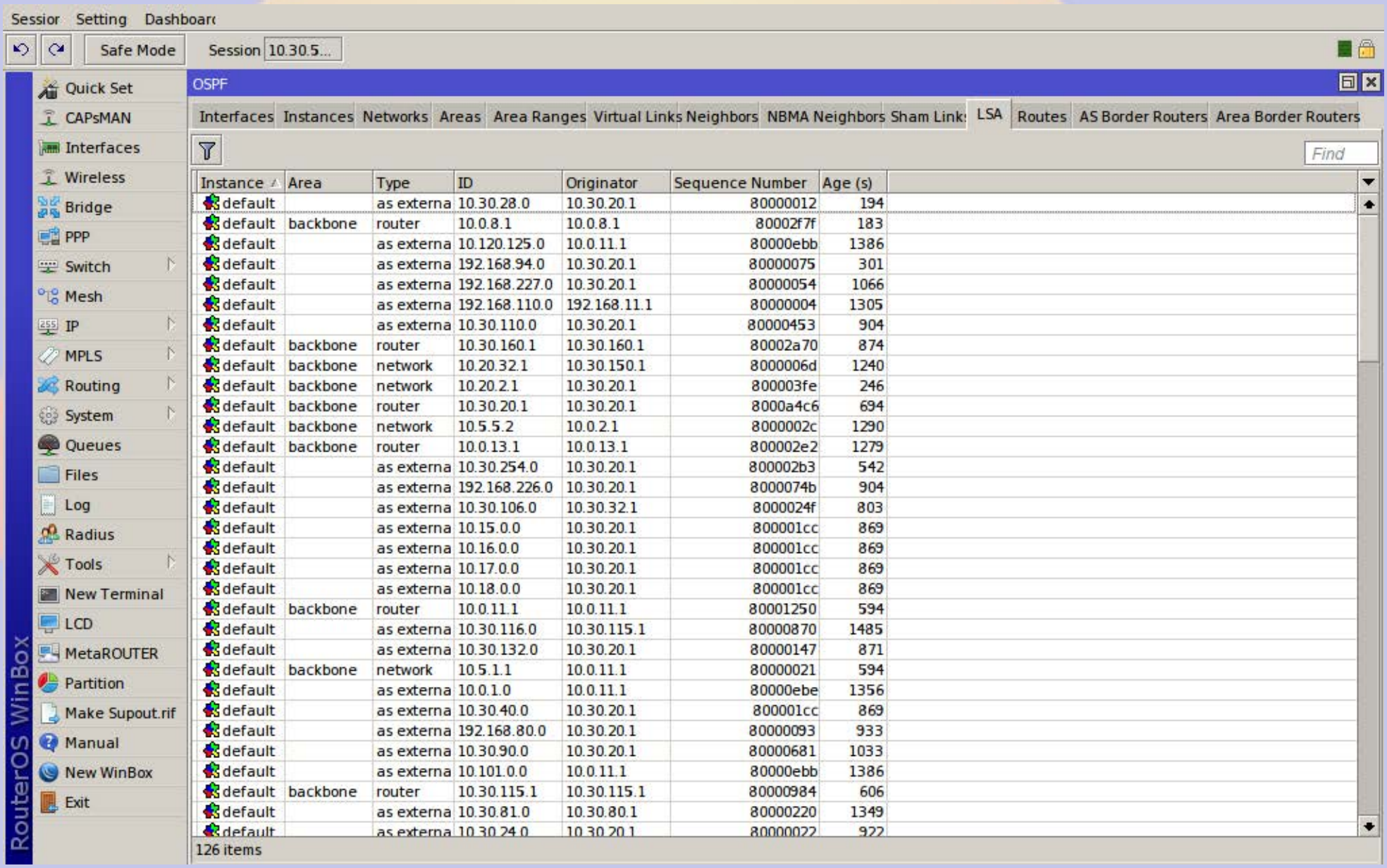


OSPF discovers its neighbors

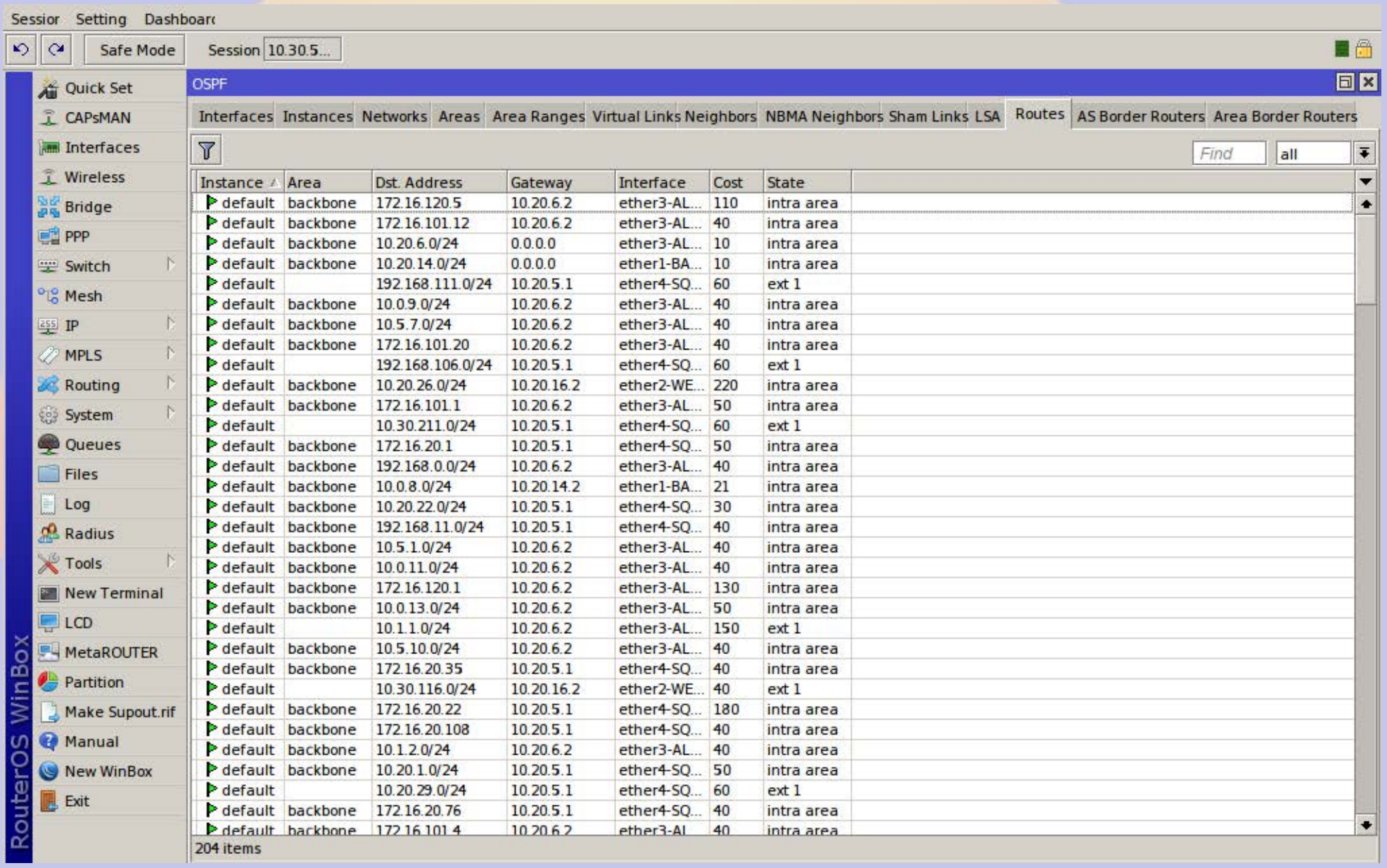


OSPF distributes link database

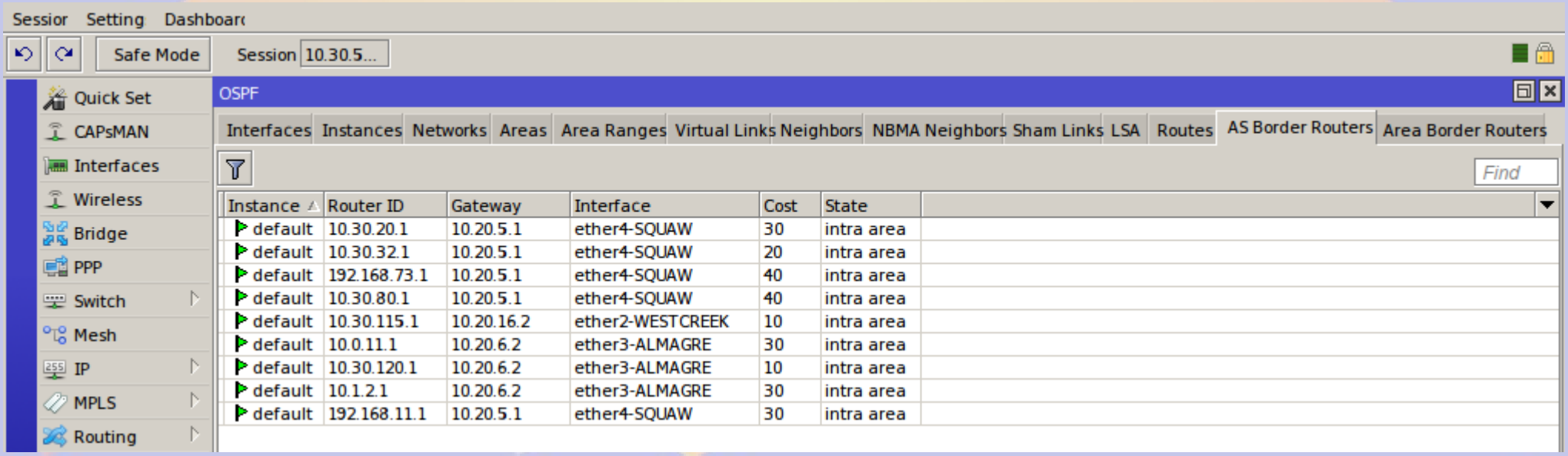
LSA = Link State Advertisement



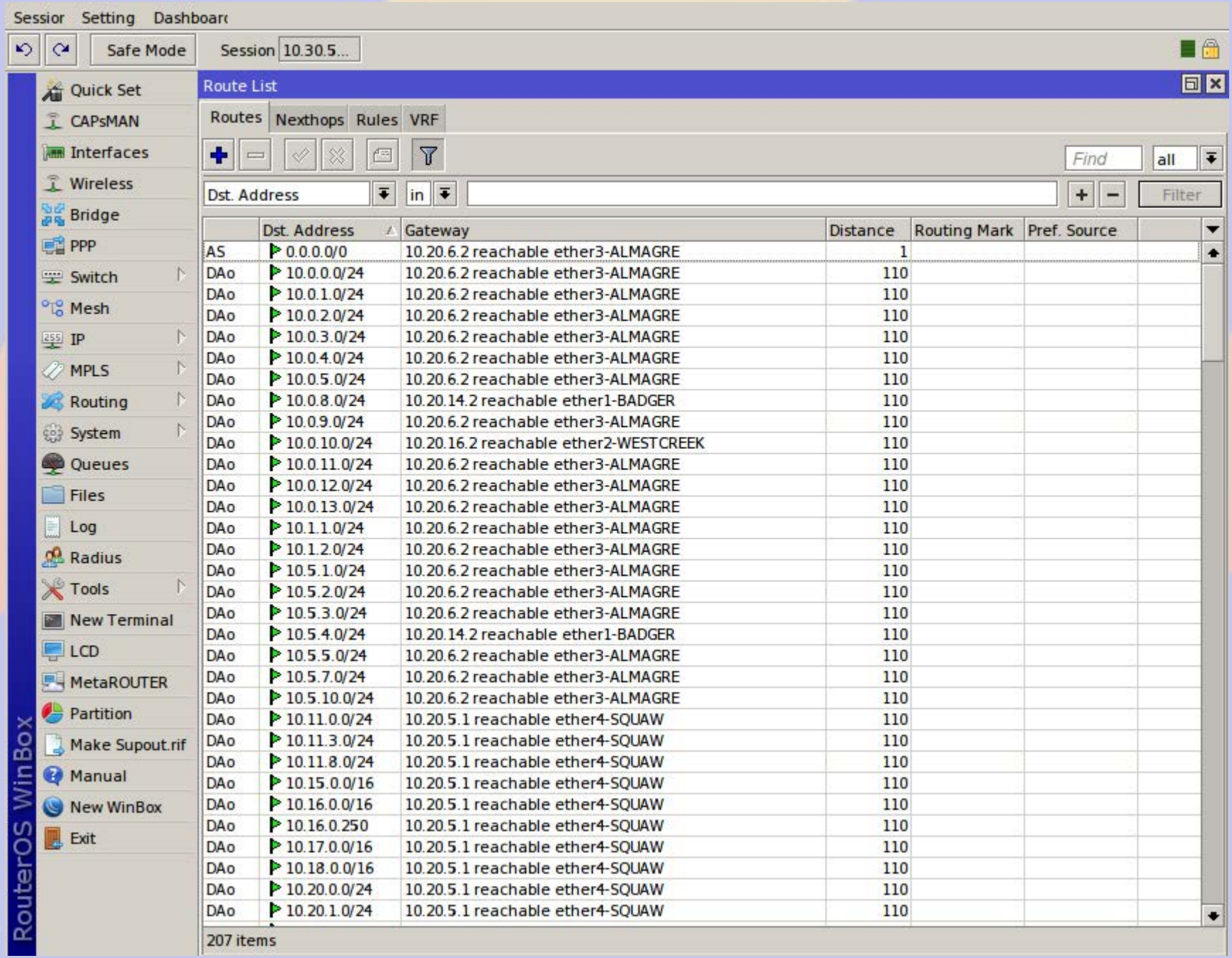
Each instance finds shortest path



Border routers are the edge of the OSPF Autonomous System



OSPF adds routes (DAo)



	Dst. Address	Gateway	Distance	Routing Mark	Pref. Source
AS	0.0.0.0/0	10.20.6.2 reachable ether3-ALMAGRE	1		
DAo	10.0.0.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.1.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.2.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.3.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.4.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.5.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.8.0/24	10.20.14.2 reachable ether1-BADGER	110		
DAo	10.0.9.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.10.0/24	10.20.16.2 reachable ether2-WESTCREEK	110		
DAo	10.0.11.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.12.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.0.13.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.1.1.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.1.2.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.1.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.2.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.3.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.4.0/24	10.20.14.2 reachable ether1-BADGER	110		
DAo	10.5.5.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.7.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.5.10.0/24	10.20.6.2 reachable ether3-ALMAGRE	110		
DAo	10.11.0.0/24	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.11.3.0/24	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.11.8.0/24	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.15.0.0/16	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.16.0.0/16	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.16.0.250	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.17.0.0/16	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.18.0.0/16	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.20.0.0/24	10.20.5.1 reachable ether4-SQUAW	110		
DAo	10.20.1.0/24	10.20.5.1 reachable ether4-SQUAW	110		

VPN Problems

- When the VPN drops, the dynamically created interface on the ***server*** is deleted and properties assigned to it is lost
  - Solution: Create a permanent instance by copying the dynamic interface after it connects.
- When OSPF discovers the WAN address of the VPN endpoint can be reached via RF, it will try to run the VPN over RF
  - Solution: Filter the WAN address so that other routers do not discover it

OSPF VPN Setup Procedure

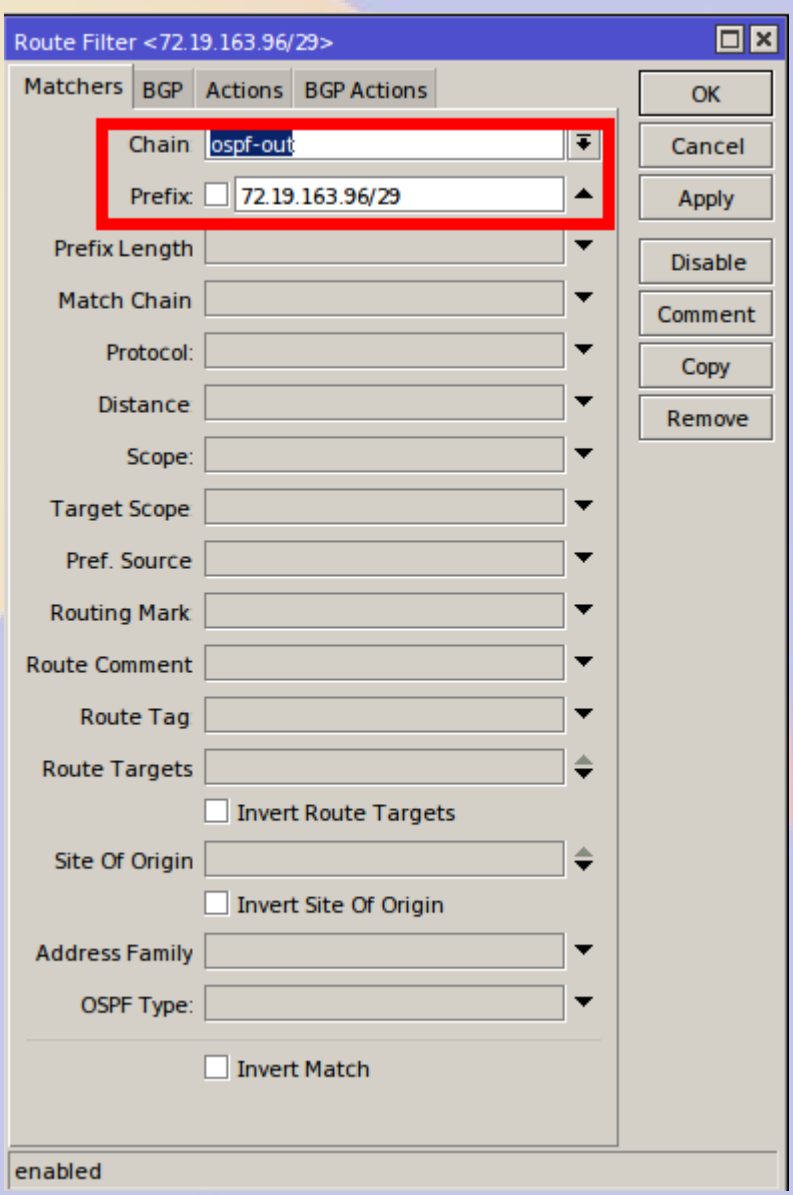
- Add VPN as shown above
  - Enable server
  - Add secret and IP info on server
  - Add VPN on client
- On the ***server*** right click and copy the dynamic interface
  - Create a permanent interface name
  - Delete the dynamic interface
- On the OSPF>Interfaces tab set the cost
- Add an ospf-out filter to prevent WAN export

OSPF Filters

- ospf-in
  - causes the local router to ignore these routes
  - routes are still shared with other routers
- ospf-out
  - prevents the router from exporting the route
  - works only for external routes
    - directly connected routes are still exported if set

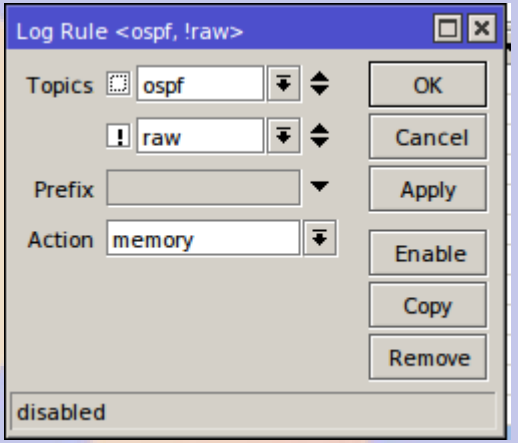
ospf-out

- Match the ***subnet***, not WAN address
- prefix-length
  - omit if just one
  - wildcard for multiple
    - 24-32 wildcards /24
- Actions=discard



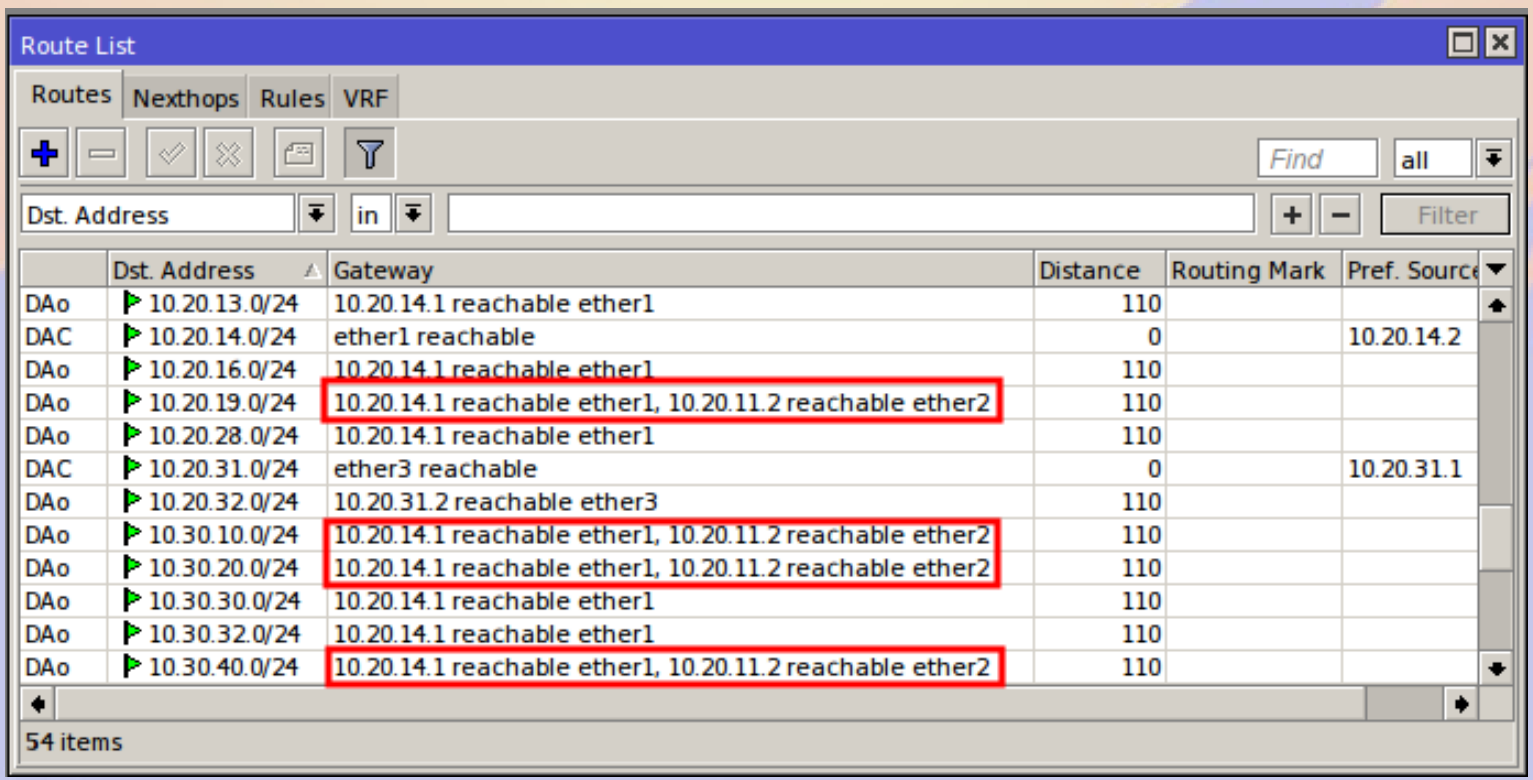
Debugging OSPF

- Add log rule for OSPF
  - /system logging add topics=ospf,!raw
- Weird log entries may require a reboot of the router
  - database out of date



Avoid split routes

- Make sure weights are symmetric
- Weight your preferred path lower
- **DO NOT ADD STATIC ROUTES**



OSPF Gochas

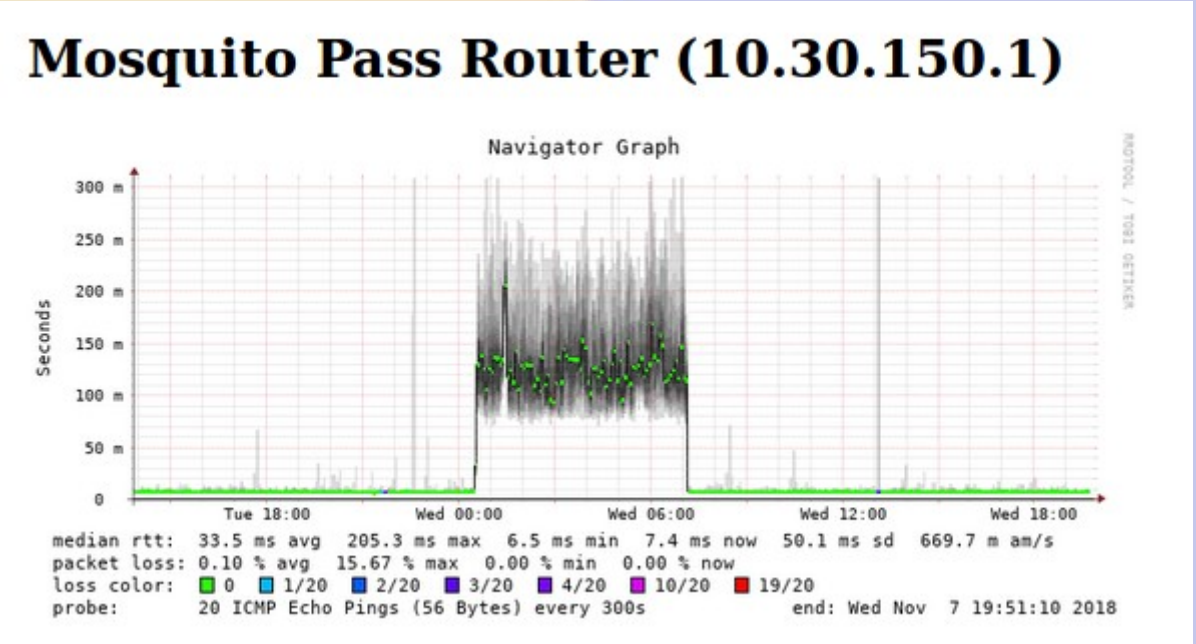
- VPN in PPP>Secrets
  - Only set local and remote address
  - Routes must be blank
- OSPF>Interfaces **+** adds a default ***all*** interface
  - Do not add any interfaces manually
- Link weight must be set on both ends
  - Different weights for a link may cause split routes

This is too complicated

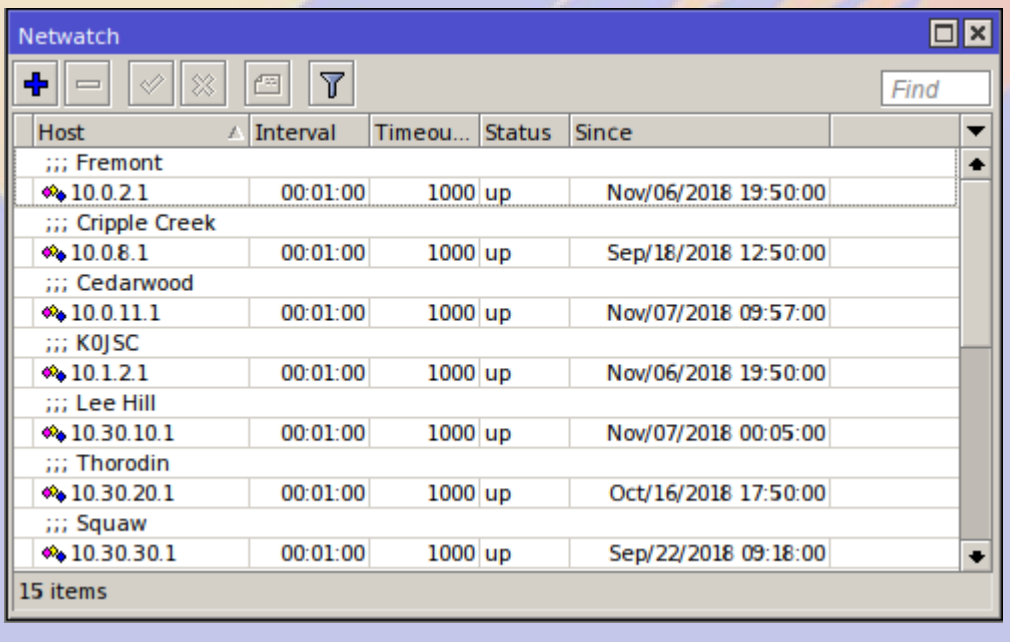
- It is worth it because you retain control
  - Weights determine a preferred route
    - Keep commercial traffic off the ham bands
    - Link states are on/off, you evaluate bandwidth/latency
  - Failover is fast and reliable
  - You can monitor what is going on
- If links are flaky revert to static routes
  - PtP/PtMP tolerates errors better than broadcast

Monitor your Network

- Smokeping shows VPN failover
  - RF 9ms
  - VPN 150ms



- Netwatch shows target status
  - Use shorter interval for real time monitoring



Aid Station Design

- How will runners pass by?
  - MUST read all runners
  - Multiple reads are inconvenient
  - Networked RFID
- Checking the reader
  - Make sure every runner is read
    - Folded bibs
    - Water bottles
  - Watch for false reads
    - Library cards
    - Toll passes

Backing up the Automated System

- Record bibs by hand
  - Compare with RFID
  - Download all readings
- Be ready to send data to the trailer
  - Forward via packet
- Use voice for drops and special cases
  - Cut armband as positive confirmation
  - Bibs that do no read
  - Medical issues

Manage the Wifi

- Password protect hotspots
- Do not share it with the aid station volunteers
  - Everybody has a phone wanting WiFi
  - Could violate Part 97
- Manage your own devices
  - Turn off Windows/iOS updates
  - Don't surf the web
- Bandwidth is at a premium
  - We have enough but it is a shared resource

Legal Issues

- We do not support commercial races
  - Must have a substantial charitable component
- We only do times for runner safety
  - We do ***tracking*** not ***timing***
- We satisfy Part 97 requirements
  - No encryption, plain text traffic
  - Nothing commercial on ham bands
    - Vendor are on commercial satellite only
    - Traffic marshals on commercial DMR

Summary

- IP is a disruptive technology
- Doing IP well requires UHF-SHF
- In mountainous terrain this is hard
  - Plan using RadioMobile, Google Earth, etc.
  - Test in the field to validate
  - Use OSPF to make it robust
- This is hard, but the payoff is huge
  - Our served agencies really want this