HAMWAN RADIO-BASED DATA NETWORK

NETWORK DESIGN DOCUMENT

PDX HAMWAN PROJECT

DOCUMENT VERSION 1.0

June 6, 2019

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Table of Contents

0.0 Change History

Document Revision	Date	Author of Change	Changes/Notes
1.0	06/06/2019	Scott Burrows	Initial

1.0 Introduction

??

2.0 Problem Overview

The Cascadia Rising Exercise was conducted June 7-10, 2016 to evaluate the readiness of emergency plans and the ability of Emergency Operation Centers (EOCs) to coordinate and communicate priorities and objectives. Specifically, it was designed to test the capabilities of voice and data in support of Emergency Disaster Communications, especially challenges posed by degraded communication environments. Below lists the top five findings within the After-Action Reports (AARs) reports, which are specifically related to Amateur Radio Operator (ARO) support.

1. Many jurisdictions were unable to overcome the challenges posed by a degraded communications environment. (FEMA AAR – Page 11)

2. Most EOCs relied solely on internet and telephones as their means of communication; when those services were interrupted by communication outages; there was limited capacity to communicate with outside partners. (FEMA AAR – Page 11)

3. Additionally, many EOCs lacked sufficient wireless network capacity to support the influx of personnel into their facilities. These deficiencies rendered many jurisdictions and agencies unable to send or receive information, resulting in a lack of regional situational awareness. (FEMA AAR – Page 11)

4. Existing auxiliary amateur radio processes are slow and not capable of handling the large volumes of traffic expected during an event of this size, mostly due to radio bandwidth issues. (Oregon AAR - Page 7)

5. Demonstrate the ability of Emergency Operation Centers (EOCs) to establish and sustain voice and data communications with other EOCs and with the general public to include

basic restoration of communications infrastructure within the impacted area to support response operations and coordinated messaging. (Oregon AAR - Page 17)

3.0 Solution Overview

The solution is to establish a disaster-resilient backup voice and data network for the Portland Metro Area. The focus is to establish a backbone of a modern, multi-megabit, IP-based, digital communications network, which will operate over radio frequencies allocated by the Federal Communications Commission (FCC) to the Amateur Radio Service. This network will touch the Internet in one or more places, and can exchange data with the Internet, but it will be designed to function independently should the Internet fail during a disaster.

When fully operational, this HamWAN Radio-Based Data Network will enable digital communications between the Oregon Office of Emergency Management, the Washington Emergency Management Division, Emergency Operation Centers in jurisdiction region-wide, public safety entities, and public health facilities, all at speeds of several orders of magnitude greater than what amateur radio volunteers are currently able to provide to the emergency management sector.

4.0 Potential Sites
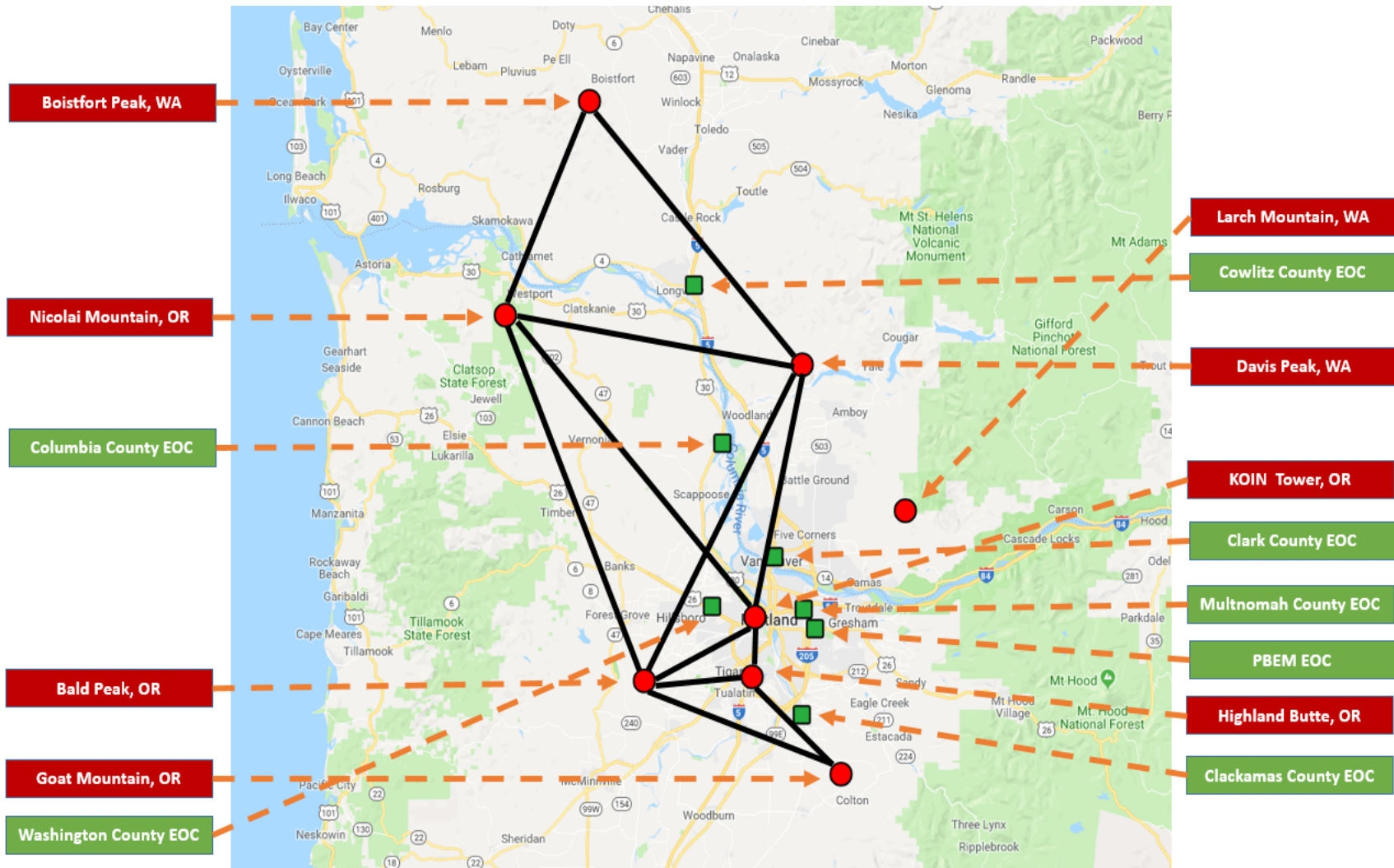
5.0 Logical Design

<<This is the major part of your design document. All aspects of the proposed solution have to be explained in detail and justified.>>

5.1 Logical Network Diagram

5.2 Addressing and Naming Structure

- <u>AMPRnet:</u> The data network will use the IPv4 Internet address space (44.0.0.0/8), known as AMPRnet. These IP addresses are routable to the Internet and will facilitate communications beyond the data network. Since the network will be accessible on the Internet, carefulness must be taken to protect sensitive data or communications, in accordance with the FCC Part 97 rules.

- <u>IP Address Allocations:</u> The data network will use

IP Address Space		
Block	**Range**	**Use**
44.x.x.0/27	44.x.x.1 – 44.x.x.30	Network Devices
44.x.x.20/32	44.x.x.20	Radio0 ether1
44.x.x.32/27	44.x.x.33 – 44.x.x.62	Radio0 wlan1
44.x.x.62/32	44.x.x.62	Radio0 vrrp1
44.x.x.21/32	44.x.x.21	Radio120 ether1
44.x.x.64/27	44.x.x.65 – 44.x.x.94	Radio120 wlan1
44.x.x.94/32	44.x.x.94	Radio120 vrrp1
44.x.x.22/32	44.x.x.22	Radio240 ether1
44.x.x.96/27	44.x.x.97 – 44.x.x.126	Radio240 wlan1
44.x.x.126/32	44.x.x.126	Radio240 vrrp1
44.x.x.128/27	44.x.x.129 – 44.x.x.158	TBD
44.x.x.160/27	44.x.x.161 – 44.x.x.190	TBD
44.x.x.192/27	44.x.x.193 – 44.x.x.222	TBD
44.x.x.224/27	44.x.x.225 – 44.x.x.254	TBD

- <u>IP Address Management:</u> The data network will use

Management Network	
IP Address	**Use**
44.x.x.1	Edge Router
44.x.x.9	PoE Switch/Router
44.x.x.10	PtP-LINK01

44.x.x.11	PtP-LINK01
44.x.x.12	PtP-LINK02
44.x.x.13	PtP-LINK02
44.x.x.20	Radio0 ether1
44.x.x.21	Radio120 ether1
44.x.x.22	Radio240 ether1
44.x.x.23	Server1
44.x.x.24	Server2

- IP Address for Services: The data network will use

Service	IP Address
Gateway	44.x.x.1
DNS	44.x.x.1
NTP	132.163.96.1 132.163.96.2
Logging	44.24.244.8
DHCP (Network)	44.x.x.2 – 44.x.x.30
DHCP (Radio0 – wlan)	44.2x.x.33 – 44.x.x.62
DHCP (Radio120 – wlan)	44.x.x.65 – 44.x.x.94
DHCP (Radio240 – wlan)	44.x.x.97 – 44.x.x.126

5.3 Routing and Switch Protocols

- Border Gateway Protocol (BGP): The data network will be configured to use the BGP routing protocol for connecting Autonomous System (AS) networks together. An autonomous system is a collection of networks under a common administrative domain. The device owner (or system administrator) will need to configure devices to use the networking protocol between edge routers.

- Open Shortest Path First (OSPF): The data network will be configured to use the OSPF routing protocol to connect networks using the Internet Protocol (IP) for finding the best path for packets transmissions. The device owner (or system administrator) will need to configure devices to use the networking protocol on interior gateways.

- Virtual Router Redundancy Protocol (VRRP): The data network will be configured to use the VRRP networking protocol for providing automatic assignment of available Internet Protocol (IP) routers to participating hosts, which will increase the availability and reliability of routing paths. The device owner (or system administrator) will need to configure the sector radios to use VRRP protocol.

5.4 Security

- <u>Administrator Credentials:</u> The data network will be configured to disable the default account in favor of individual accounts. Do not use group, shared, or generic identification methods if possible.

- <u>Administrator Passwords:</u> The data network will be configured to use secure and strong passwords to prevent unauthorized access to RouterOS network operating system. These passwords are not enabled by default and must be activated during the initial setup.

- <u>RouterOS Software Packages:</u> The data network will be configured to disable or remove any software packages that are not needed.

- <u>RouterOS Software Updates:</u> The data network will be configured to automatically update the RouterOS software with new patches or releases.

- <u>IP Services:</u> The data network will be configured to turn off unsecured protocols in favor of more secure protocols. Most services are enabled by default and will require some reduction to secure the devices.

- <u>Login Banner:</u>

- <u>Wireless Security:</u>

- <u>Firewalls:</u>

- <u>Event and Log Monitoring:</u>

- <u>SNMP Community String:</u>

-

5.5 Quality of Service (QoS)

- <u>Xxxx</u>

- <u>Xxxx</u>

5.6 Networking

- <u>Secure Shell (SSH) Keys:</u> The data network will be configured to use encryption-free SSH keys for remote administration of network devices and applications. The device owner (or system administrator) must use disable SSH encryption to comply with the FCC Part 97 rules.

- <u>Remote Logging:</u> The data network will send all network and application logs to an off-site centralized logging server. The device owner (or system administrator) will need to configure the devices to send electronic logs to the HamWAN logging server (i.e. 44.24.244.8).

- <u>Network Time Protocol (NTP):</u> The data network will be configured to use NTP for clock synchronization of network devices and applications. The device owner (or

system administrator) will need to configure the devices to use the HamWAN time server (i.e. 44.24.244.4).

- Domain Names Service (DNS): The data network will be configured to use DNS service for translating domain names to IP addresses. The device owner (or system administrator) will need to configure the devices to use the HamWAN DNS server (i.e. 44.24.244.1).

- System Host Name:

- Device Backups:

-

5.7 Client Radios

- System Identity: The client radios will be configured to tell which site it's connected into and where it's located. This will be done by listing the call sign of the device owner and the cell site name. (i.e. N7ABC-Larch)

- Administration Passwords: The client radio administrator (or owner) will set the administrator password to restrict unauthorized users from making changes to the device. This will be done by creating a unique and strong password known only to the administrator. (i.e. 4Score&7yrsAgo)

- Radio Name: The client radio will be configured to announce the call sign and location of the device. This will be done by listing the call sign, city, and destination cell site. (i.e. N7ABC/Portland->Larch)

- Location: The client radio will be configured with the location of the device, so the station will show up on the HamWAN map. This will be done by listing your latitude and longitude in decimal degrees. (i.e. location=47.1234,-121.4321)

5.8 Sector Radios

- Radio Name: The sector radios will be configured to announce the call sign; location; and sector name of the device. All sector radios will use the standard naming conventions used by HamWAN. (i.e. N7ABC/Portland-Radio0; N7ABC/Portland-Radio120; and N7ABC/Portland-Radio240)

- Wireless Channels: The sector radios will be configured with cell site radiation direction and corresponding radio frequencies. The wireless channels will be listed for each sector radio, in accordance with the HamWAN standards. (i.e. 0 degrees (north) at 5920 GHz; 120 degrees (south-east) at 5900 GHz; and 240 degrees (south-west) at 5800 GHz)

- Wireless Protocol (NV2): The sector radios will be configured to use the NV2 wireless protocol, which is based on Time Division Multiple Access (TDMA) media access technology. Currently, this proprietary protocol is only used by RouterOS (Mikrotik) wireless devices.

5.9 Point-to-Point Radios

- <u>Wireless Channels:</u> The point-to-point (or multi-point) radios will be configured to protect wireless communications between EOCs and other RF links. The wireless devices will use the 5700 GHz frequency, which falls under FCC Part 15 rules, and will use pre-shared keys (passwords) for securing transmissions.

- <u>NV2 Security:</u> The point-to-point (or multi-point) radios will be configured to enable the NV2 security feature, which consists of activating pre-shared keys (passwords). The use of NV2 protocol will provide additional security measures because only RouterOS (Mikrotik) wireless devices are able to detect this protocol.

- <u>System Identity:</u> The point-to-point radios will be configured to tell the owner name, type of connection, and the other connection site location. This will be done by listing the call sign of the device, connection link number, and other cell site name. (i.e. N7ABC-PtP1-Larch)

5.10 Edge Routers

- <u>HamWAN Certificate Authority (CA):</u> The uplink radios will need to generate a private key and contact the HamWAN Certificate Authority (CA) to the Certificate Signing Request (CSR) signed. The device owner (or system administrator) must contact the HamWAN mailing list to ask for permission to be an uplink into the wired network.

- <u>IPIP Interface Tunnels:</u> The uplink radios will need to create IP in IP (IPIP) tunnels for encapsulating IP packets in IP to make a tunnel between two routers. The device owner (or system administrator) will need to notify a HamWAN network operator to let them know IPIP is ready on your end.

- <u>IPSec VPN:</u> The uplink radios will be configured to use IPSec VPN for wired private network connection to HamWAN. The device owner will need to notify a HamWAN network operator to let them know IPsec is ready on your end.

5.11 Emergency Power

- <u>Xxxxxxx</u>
- <u>Xxxxxxx</u>

6.0 Physical Design

6.1 Physical Network Diagram
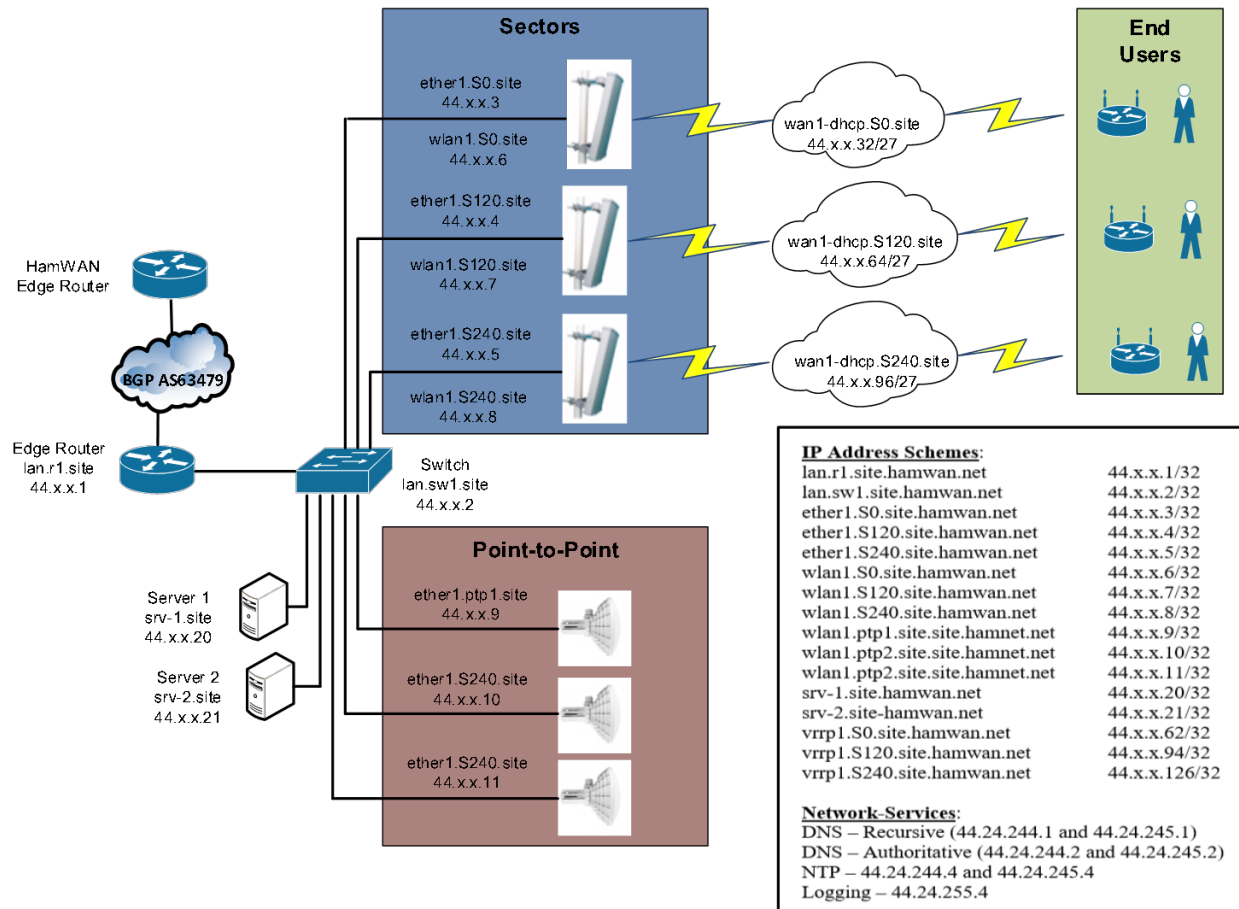
6.2 Physical Network Design

- ▪ Client Radios: The client radios will be deployed at EOC sites and installed on building rooftops or antenna towers for clear line of sight communications with the sector radios. The client radios will be connected to a computer or router using Power over Ethernet (PoE) cable, which can be powered by 12-volt batteries. The client radios will be connected to Wi-Fi router, the Wi-Fi signals can be shared by laptops and phones.

- ▪ Sector Radios: The sector radios will be deployed on towers, and generally use three radios, each with 120 degrees of coverage, for a full 360 degrees of coverage. The sector radio will have line of sight communication to at least one other sector antenna to complete the Radio Frequency (RF) exchange. The sector radios may have Internet Gateway network connectivity to allow routing of packets between the network and the Internet. The sector radio sites must have reliable emergency power to maintain operations during power outages.

- Point-to-Point Radios: The point-to-point radio will be deployed on the same towers as sector radios, and connected to sector radios using network switches and Power over Ethernet (PoE) cables. The point-to-point radios will be line of sight to at least one other point-to-point radio in the distance to complete the Radio Frequency (RF) connection.
- Edge Router Devices: Xxxx

6.3 LAN Technologies

<<You have to discuss and justify your choice of LAN technologies.>>

Quantity	Model	Description
1	Mikrotik RB750r2 RouterBOARD hEX Lite	5 Port Ethernet Router, PoE
1	Mikrotik RB911G-5HPacD-QRT	5GHz Client Node
1	Cat5E (500 feet)	Outdoor Shielded Cat5E Cable
1	APC BX1500M Back-UPS Pro	Uninterruptible Power Supply

6.4 WLAN Technologies

<< You have to discuss and justify your choice of WLAN technologies.>>

Quantity	Model	Description
3	RB921GS-5HPacD-19S	5GHz Sector Modem
3	WaveGuard WG-MANT-19	Sector Shield
1	RF Armor UCM3T	3 Gang Cluster Mount
2	Mikrotik RBDynaDishG-5HacD	DynaDish Uplink
1	Mikrotik RB493	Router/Switch
1	APC AP7900	Switched Rack PDU
3	Cat5E (500 feet)	Outdoor shielded Cat5E

6.5 WAN Technologies

<< You have to discuss and justify your choice of WAN technologies.>>

Quantity	Model	Description
1	Mikrotik RBDynaDishG-5HacD	DynaDish Uplink
1	Mikrotik RB750r2 RouterBOARD hEX Lite	5 Port Ethernet Router, PoE, Edge Router (Internet)
1	Cat5E (500 feet)	Outdoor shielded Cat5E

7.0 Appendix A – WLAN Router (RB493AH) Configuration

```
# may/05/2019 08:35:19 by RouterOS 6.44.3
# software id = 7ZCX-V60N
#
# model = 493
# serial number = 279701A9D286
/interface bridge
add name=bridge1
/interface ethernet
set [ find default-name=ether1 ] advertise=\
    10M-half,10M-full,100M-half,100M-full,1000M-half,1000M-full
set [ find default-name=ether2 ] advertise=\
    10M-half,10M-full,100M-half,100M-full,1000M-half,1000M-full
set [ find default-name=ether3 ] advertise=\
    10M-half,10M-full,100M-half,100M-full,1000M-half,1000M-full
set [ find default-name=ether4 ] advertise=\
    10M-half,10M-full,100M-half,100M-full,1000M-half,1000M-full
set [ find default-name=ether5 ] advertise=\
    10M-half,10M-full,100M-half,100M-full,1000M-half,1000M-full
set [ find default-name=ether6 ] advertise=\
    10M-half,10M-full,100M-half,100M-full,1000M-half,1000M-full
set [ find default-name=ether7 ] advertise=\
    10M-half,10M-full,100M-half,100M-full,1000M-half,1000M-full
set [ find default-name=ether8 ] advertise=\
    10M-half,10M-full,100M-half,100M-full,1000M-half,1000M-full
set [ find default-name=ether9 ] advertise=\
    10M-half,10M-full,100M-half,100M-full,1000M-half,1000M-full
/interface list
add name=WAN
add name=LAN
/interface wireless security-profiles
set [ find default=yes ] supplicant-identity=MikroTik
/ip pool
add name=dhcp ranges=192.168.1.1-192.168.1.100
/ip dhcp-server
add address-pool=dhcp disabled=no interface=bridge1 name=dhcp1
/interface bridge port
add bridge=bridge1 interface=ether2
add bridge=bridge1 interface=ether3
add bridge=bridge1 interface=ether4
add bridge=bridge1 interface=ether5
add bridge=bridge1 interface=ether6
add bridge=bridge1 interface=ether7
add bridge=bridge1 interface=ether8
```

```
add bridge=bridge1 interface=ether9
/interface list member
add interface=ether1 list=WAN
add interface=bridge1 list=LAN
/ip address
add address=192.168.1.1/24 interface=ether2 network=192.168.1.0
/ip dhcp-client
add dhcp-options=hostname,clientid disabled=no interface=ether1
/ip dhcp-server lease
add address=192.168.1.100 client-id=1:b8:27:eb:ff:6b:1 mac-address=\
    B8:27:EB:FF:6B:01 server=dhcp1
add address=192.168.1.99 client-id=1:0:b:82:38:27:af mac-address=\
    00:0B:82:38:27:AF server=dhcp1
add address=192.168.1.98 client-id=1:0:b:82:38:27:b4 mac-address=\
    00:0B:82:38:27:B4 server=dhcp1
/ip dhcp-server network
add address=192.168.1.0/24 gateway=192.168.1.1 netmask=24
/ip dns
set allow-remote-requests=yes servers=192.168.1.1
/ip route
add disabled=yes distance=1 gateway=192.168.88.1
/ip service
set www-ssl disabled=no
/ip ssh
set allow-none-crypto=yes forwarding-enabled=remote
/system clock
set time-zone-autodetect=no time-zone-name=America/Los_Angeles
/system identity
set name=RB-493
/system ntp client
set enabled=yes primary-ntp=132.163.96.1 secondary-ntp=132.163.96.2 \
    server-dns-names=""
/system routerboard settings
set auto-upgrade=yes
```

8.0 Appendix B – WLAN Radio0 (RB912UAG) Configuration

```
# may/05/2019 10:49:35 by RouterOS 6.44
# software id = AV6P-6GT5
#
# model = 912UAG-5HPnD
# serial number = 57770400AB6D
/interface bridge
add name=bridge1
/interface wireless
set [ find default-name=wlan1 ] band=5ghz-onlyn channel-width=10mhz disabled=\
    no frequency=5920 frequency-mode=superchannel mode=ap-bridge \
    nv2-cell-radius=100 radio-name=N7DOD-Radio0 rx-chains=0,1 ssid=HamWAN \
    tdma-period-size=4 tx-chains=0,1 wireless-protocol=nv2
/interface vrrp
add authentication=ah disabled=yes interface=ether1 name=vrrp1 password=\
    <VRRP-KEY> version=2
/interface list
add name=WAN
add name=LAN
/interface wireless channels
add band=5ghz-onlyn comment="Cell sites radiate this at 0 degrees (north)" \
    frequency=5920 list=HamWAN name=Sector1-5 width=5
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 120 degrees (south-east)" frequency=5900 \
    list=HamWAN name=Sector2-5 width=5
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 240 degrees (south-west)" frequency=5880 \
    list=HamWAN name=Sector3-5 width=5
add band=5ghz-onlyn comment="Cell sites radiate this at 0 degrees (north)" \
    frequency=5920 list=HamWAN name=Sector1-10 width=10
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 120 degrees (south-east)" frequency=5900 \
    list=HamWAN name=Sector2-10 width=10
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 240 degrees (south-west)" frequency=5880 \
    list=HamWAN name=Sector3-10 width=10
/interface wireless security-profiles
set [ find default=yes ] supplicant-identity=MikroTik
/ip pool
add name=dhcp ranges=44.26.161.33-44.26.161.62
/ip dhcp-server
add address-pool=dhcp authoritative=after-2sec-delay disabled=no interface=\
    bridge1 lease-time=1h name=dhcp1
/routing ospf instance
set [ find default=yes ] distribute-default=if-installed-as-type-1 in-filter=\
```

```
    AMPR-default out-filter=AMPR-default redistribute-connected=as-type-1 \
    redistribute-other-ospf=as-type-1 redistribute-static=as-type-1 \
    router-id=44.24.241.134
/snmp community
set [ find default=yes ] addresses=44.24.240.0/20 name=hamwan
/system logging action
set 3 remote=44.24.244.8
/interface bridge port
add bridge=bridge1 interface=wlan1
add bridge=bridge1 disabled=yes interface=ether1
/interface list member
add interface=ether1 list=WAN
add interface=bridge1 list=LAN
/ip address
add address=44.26.161.33/27 interface=wlan1 network=44.26.161.32
add address=44.26.161.20/27 interface=ether1 network=44.26.161.0
add address=44.26.161.62 interface=vrrp1 network=44.26.161.62
/ip dhcp-client
add dhcp-options=hostname,clientid disabled=no interface=bridge1
add dhcp-options=hostname,clientid interface=ether1
/ip dhcp-server network
add address=44.26.161.32/27 dns-server=44.24.244.1,44.24.245.1 domain=\
    HamWAN.net gateway=44.26.161.1 netmask=27 ntp-server=\
    44.24.244.4,44.24.245.4
/ip dns
set allow-remote-requests=yes servers=44.26.161.1
/ip firewall mangle
add action=change-mss chain=output new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
add action=change-mss chain=forward new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
/ip firewall nat
add action=masquerade chain=srcnat out-interface-list=WAN
/ip route
add distance=1 gateway=44.26.161.1
/ip service
set telnet disabled=yes
set ftp disabled=yes
set www disabled=yes
set ssh port=222
set api disabled=yes
set winbox disabled=yes
set api-ssl disabled=yes
/routing filter
add action=accept chain=AMPR-default prefix=44.0.0.0/8 prefix-length=8-32
add action=accept chain=AMPR-default prefix=0.0.0.0/0
```

```
add action=reject chain=AMPR-default
/routing ospf interface
add authentication=md5 authentication-key=<OSPF-KEY> interface=ether1 \
    network-type=broadcast
/routing ospf network
add area=backbone network=44.24.241.128/28
/snmp
set contact="#HamWAN-Support on irc.freenode.org" enabled=yes
/system clock
set time-zone-name=America/Chicago
/system identity
set name=N7DOD-Radio0
/system logging
add action=remote topics=!debug,!snmp
/system ntp client
set enabled=yes primary-ntp=44.24.244.4 secondary-ntp=44.24.245.4
```

9.0 Appendix C – WLAN Radio120 (RB912UAG) Configuration

```
# may/05/2019 10:54:06 by RouterOS 6.44
# software id = 76RQ-P3CV
#
# model = 912UAG-5HPnD
# serial number = 577704BC690C
/interface bridge
add name=bridge1
/interface wireless
set [ find default-name=wlan1 ] band=5ghz-onlyn channel-width=10mhz disabled=\
    no frequency=5900 frequency-mode=superchannel mode=ap-bridge \
    nv2-cell-radius=100 radio-name=N7DOD-Radio120 rx-chains=0,1 ssid=HamWAN \
    tdma-period-size=4 tx-chains=0,1 wireless-protocol=nv2
/interface vrrp
add authentication=ah disabled=yes interface=ether1 name=vrrp1 password=\
    <VRRP-KEY> version=2
/interface list
add name=WAN
add name=LAN
/interface wireless channels
add band=5ghz-onlyn comment="Cell sites radiate this at 0 degrees (north)" \
    frequency=5920 list=HamWAN name=Sector1-5 width=5
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 120 degrees (south-east)" frequency=5900 \
    list=HamWAN name=Sector2-5 width=5
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 240 degrees (south-west)" frequency=5880 \
    list=HamWAN name=Sector3-5 width=5
add band=5ghz-onlyn comment="Cell sites radiate this at 0 degrees (north)" \
    frequency=5920 list=HamWAN name=Sector1-10 width=10
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 120 degrees (south-east)" frequency=5900 \
    list=HamWAN name=Sector2-10 width=10
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 240 degrees (south-west)" frequency=5880 \
    list=HamWAN name=Sector3-10 width=10
/interface wireless security-profiles
set [ find default=yes ] supplicant-identity=MikroTik
/ip pool
add name=dhcp ranges=44.26.161.65-44.26.161.94
/ip dhcp-server
add address-pool=dhcp authoritative=after-2sec-delay disabled=no interface=\
    bridge1 lease-time=1h name=dhcp1
/routing ospf instance
set [ find default=yes ] distribute-default=if-installed-as-type-1 in-filter=\
```

AMPR-default out-filter=AMPR-default redistribute-connected=as-type-1 \
    redistribute-other-ospf=as-type-1 redistribute-static=as-type-1 \
    router-id=44.24.241.134
/snmp community
set [find default=yes] addresses=44.24.240.0/20 name=hamwan
/system logging action
set 3 remote=44.24.244.8
/interface bridge port
add bridge=bridge1 interface=wlan1
/interface list member
add interface=ether1 list=WAN
add interface=bridge1 list=LAN
/ip address
add address=44.26.161.65/27 interface=wlan1 network=44.26.161.64
add address=44.26.161.21/27 interface=ether1 network=44.26.161.0
add address=44.26.161.94 interface=vrrp1 network=44.26.161.94
/ip dhcp-client
add dhcp-options=hostname,clientid interface=ether1
/ip dhcp-server network
add address=44.26.161.64/27 dns-server=44.24.244.1,44.24.245.1 domain=\
    HamWAN.net gateway=44.26.161.65 netmask=27 ntp-server=\
    44.24.244.4,44.24.245.4
/ip dns
set allow-remote-requests=yes servers=44.26.161.1
/ip firewall mangle
add action=change-mss chain=output new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
add action=change-mss chain=forward new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
/ip firewall nat
add action=masquerade chain=srcnat out-interface-list=WAN
/ip route
add distance=1 gateway=44.26.161.1
/ip service
set telnet disabled=yes
set ftp disabled=yes
set www disabled=yes
set ssh port=222
set api disabled=yes
set winbox disabled=yes
set api-ssl disabled=yes
/routing filter
add action=accept chain=AMPR-default prefix=44.0.0.0/8 prefix-length=8-32
add action=accept chain=AMPR-default prefix=0.0.0.0/0
add action=reject chain=AMPR-default
/routing ospf interface

```
add authentication=md5 authentication-key=<OSPF-KEY> interface=ether1 \
    network-type=broadcast
/routing ospf network
add area=backbone network=44.24.241.128/28
/snmp
set contact="#HamWAN-Support on irc.freenode.org" enabled=yes
/system clock
set time-zone-name=America/Chicago
/system identity
set name=N7DOD-Radio120
/system logging
add action=remote topics=!debug,!snmp
/system ntp client
set enabled=yes primary-ntp=44.24.244.4 secondary-ntp=44.24.245.4
```

10.0 Appendix D – WLAN Radio240 (RB912UAG) Configuration

```
# may/05/2019 10:56:25 by RouterOS 6.44
# software id = QGVZ-X5H2
#
# model = 912UAG-5HPnD
# serial number = 577704C7F066
/interface bridge
add name=bridge1
/interface wireless
set [ find default-name=wlan1 ] band=5ghz-onlyn channel-width=10mhz disabled=\
    no frequency=5880 frequency-mode=superchannel mode=ap-bridge \
    nv2-cell-radius=100 radio-name=N7DOD/PDX-Radio240 rx-chains=0,1 ssid=\
    HamWAN tdma-period-size=4 tx-chains=0,1 wireless-protocol=nv2
/interface vrrp
add authentication=ah disabled=yes interface=ether1 name=vrrp1 password=\
    <VRRP-KEY> version=2
/interface list
add name=WAN
add name=LAN
/interface wireless channels
add band=5ghz-onlyn comment="Cell sites radiate this at 0 degrees (north)" \
    frequency=5920 list=HamWAN name=Sector1-5 width=5
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 120 degrees (south-east)" frequency=5900 \
    list=HamWAN name=Sector2-5 width=5
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 240 degrees (south-west)" frequency=5880 \
    list=HamWAN name=Sector3-5 width=5
add band=5ghz-onlyn comment="Cell sites radiate this at 0 degrees (north)" \
    frequency=5920 list=HamWAN name=Sector1-10 width=10
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 120 degrees (south-east)" frequency=5900 \
    list=HamWAN name=Sector2-10 width=10
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 240 degrees (south-west)" frequency=5880 \
    list=HamWAN name=Sector3-10 width=10
/interface wireless security-profiles
set [ find default=yes ] supplicant-identity=MikroTik
/ip pool
add name=dhcp ranges=44.26.161.97-44.26.161.126
/ip dhcp-server
add address-pool=dhcp disabled=no interface=bridge1 name=dhcp1
/routing ospf instance
set [ find default=yes ] distribute-default=if-installed-as-type-1 in-filter=\
    AMPR-default out-filter=AMPR-default redistribute-connected=as-type-1 \
```

```
    redistribute-other-ospf=as-type-1 redistribute-static=as-type-1 \
    router-id=44.24.241.134
/snmp community
set [ find default=yes ] addresses=44.24.240.0/20 name=hamwan
/system logging action
set 3 remote=44.24.244.8
/interface bridge port
add bridge=bridge1 interface=wlan1
/interface list member
add interface=ether1 list=WAN
add interface=bridge1 list=LAN
/ip address
add address=44.26.161.97/27 interface=wlan1 network=44.26.161.96
add address=44.26.161.22/27 interface=ether1 network=44.26.161.0
add address=44.26.161.126 interface=vrrp1 network=44.26.161.126
/ip dhcp-client
add dhcp-options=hostname,clientid interface=ether1
/ip dhcp-server network
add address=44.26.161.64/27 dns-server=44.24.244.1,44.24.245.1 domain=\
    HamWAN.net gateway=44.26.161.65 netmask=27 ntp-server=\
    44.24.244.4,44.24.245.4
/ip dns
set allow-remote-requests=yes servers=44.26.161.1
/ip firewall mangle
add action=change-mss chain=output new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
add action=change-mss chain=forward new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
/ip firewall nat
add action=masquerade chain=srcnat out-interface-list=WAN
/ip route
add distance=1 gateway=44.26.161.1
/ip service
set telnet disabled=yes
set ftp disabled=yes
set www disabled=yes
set ssh port=222
set api disabled=yes
set winbox disabled=yes
set api-ssl disabled=yes
/routing filter
add action=accept chain=AMPR-default prefix=44.0.0.0/8 prefix-length=8-32
add action=accept chain=AMPR-default prefix=0.0.0.0/0
add action=reject chain=AMPR-default
/routing ospf interface
add authentication=md5 authentication-key=<OSPF-KEY> interface=ether1 \
```

```
    network-type=broadcast
/routing ospf network
add area=backbone network=44.24.241.128/28
/snmp
set contact="#HamWAN-Support on irc.freenode.org" enabled=yes
/system clock
set time-zone-name=America/Chicago
/system identity
set name=N7DOD-Radio240
/system logging
add action=remote topics=!debug,!snmp
/system ntp client
set enabled=yes primary-ntp=44.24.244.4 secondary-ntp=44.24.245.4
```

11.0 Appendix E – WLAN Point-to-Point Node Configuration

```
# jan/01/1970 17:03:59 by RouterOS 6.42.7
# software id = 6A7T-M0QK
#
# model = RouterBOARD LHG G-5acD
# serial number = 80B908C7A8CB
/interface bridge
add name=loopback0
/interface wireless
set [ find default-name=wlan1 ] band=5ghz-onlyac disabled=no frequency=5700 \
    frequency-mode=superchannel mode=ap-bridge nv2-cell-radius=100 \
    nv2-preshared-key=HARC@p03 nv2-security=enabled radio-name=N7DOD-PtP-1 \
    scan-list=5700 ssid=HamWAN tdma-period-size=4 wireless-protocol=nv2
/interface vrrp
add authentication=ah interface=ether1 name=vrrp1 password=<VRRP-KEY> \
    version=2
/interface wireless security-profiles
set [ find default=yes ] supplicant-identity=MikroTik
/ip hotspot profile
set [ find default=yes ] html-directory=flash/hotspot
/routing ospf instance
set [ find default=yes ] distribute-default=if-installed-as-type-1 in-filter=\
    AMPR-default out-filter=AMPR-default redistribute-bgp=as-type-1 \
    redistribute-connected=as-type-1 redistribute-other-ospf=as-type-1 \
    router-id=44.24.240.135
/snmp community
set [ find default=yes ] addresses=44.24.240.0/20 name=hamwan
/system logging action
set 3 remote=44.24.244.8
/interface bridge port
add bridge=loopback0 interface=wlan1
/ip settings
set send-redirects=no
/ip address
add address=44.26.161.10/31 interface=ether1 network=44.26.161.10
add address=44.26.161.130/31 interface=wlan1 network=44.26.161.130
add address=44.26.161.66 interface=vrrp1 network=44.26.161.66
/ip dns
set servers=44.24.244.1,44.24.245.1
/ip firewall mangle
add action=change-mss chain=output new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
/ip service
set telnet disabled=yes
set ftp disabled=yes
```

```
set www disabled=yes
set ssh port=222
set api disabled=yes
set winbox disabled=yes
set api-ssl disabled=yes
/routing filter
add action=accept chain=AMPR-default prefix=44.0.0.0/8 prefix-length=8-32
add action=accept chain=AMPR-default prefix=0.0.0.0/0
add action=reject chain=AMPR-default
/routing ospf interface
add authentication=md5 authentication-key=<OSPF-KEY> interface=wlan1 \
    network-type=point-to-point
add authentication=md5 authentication-key=<OSPF-KEY> interface=ether1 \
    network-type=broadcast
/routing ospf network
add area=backbone network=44.24.240.128/28
add area=backbone network=44.24.242.50/32
/snmp
set contact="#HamWAN-Support on irc.freenode.org" enabled=yes
/system clock
set time-zone-autodetect=no time-zone-name=America/Los_Angeles
/system identity
set name=N7DOD-PtP-1
/system logging
add action=remote topics=!debug,!snmp
/system ntp client
set enabled=yes primary-ntp=44.24.244.4 secondary-ntp=44.24.245.4
/system routerboard settings
set silent-boot=no
/tool bandwidth-server
set authenticate=no
```

12.0 Appendix F – WAN Point-to-Point Node Configuration

```
# jan/01/1970 17:00:55 by RouterOS 6.42.7
# software id = 71BK-YKAU
#
# model = RouterBOARD LHG G-5acD
# serial number = 810807A1888A
/interface bridge
add name=loopback0
/interface wireless
set [ find default-name=wlan1 ] band=5ghz-onlyac disabled=no frequency=5700 \
    frequency-mode=superchannel mode=station-bridge nv2-cell-radius=100 \
    nv2-preshared-key=HARC@p03 nv2-security=enabled radio-name=N7DOD-PtP-2 \
    scan-list=5700 ssid=HamWAN tdma-period-size=4 wireless-protocol=nv2
/interface vrrp
add authentication=ah interface=ether1 name=vrrp1 password=<VRRP-KEY> \
    version=2
/interface wireless security-profiles
set [ find default=yes ] supplicant-identity=MikroTik
/ip hotspot profile
set [ find default=yes ] html-directory=flash/hotspot
/routing ospf instance
set [ find default=yes ] distribute-default=if-installed-as-type-1 in-filter=\
    AMPR-default out-filter=AMPR-default redistribute-bgp=as-type-1 \
    redistribute-connected=as-type-1 redistribute-other-ospf=as-type-1 \
    router-id=44.24.240.135
/snmp community
set [ find default=yes ] addresses=44.24.240.0/20 name=hamwan
/system logging action
set 3 remote=44.24.244.8
/interface bridge port
add bridge=loopback0 interface=wlan1
/ip settings
set send-redirects=no
/ip address
add address=44.26.161.11/31 interface=ether1 network=44.26.161.11
add address=44.26.161.142/31 interface=wlan1 network=44.26.161.142
add address=44.26.161.66 interface=vrrp1 network=44.26.161.66
/ip dns
set servers=44.24.244.1,44.24.245.1
/ip firewall mangle
add action=change-mss chain=output new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
/ip service
set telnet disabled=yes
set ftp disabled=yes
```

```
set www disabled=yes
set ssh port=222
set api disabled=yes
set winbox disabled=yes
set api-ssl disabled=yes
/routing filter
add action=accept chain=AMPR-default prefix=44.0.0.0/8 prefix-length=8-32
add action=accept chain=AMPR-default prefix=0.0.0.0/0
add action=reject chain=AMPR-default
/routing ospf interface
add authentication=md5 authentication-key=<OSPF-KEY> interface=wlan1 \
    network-type=point-to-point
add authentication=md5 authentication-key=<OSPF-KEY> interface=ether1 \
    network-type=broadcast
/routing ospf network
add area=backbone network=44.24.240.128/28
add area=backbone network=44.24.242.50/32
/snmp
set contact="#HamWAN-Support on irc.freenode.org" enabled=yes
/system clock
set time-zone-autodetect=no time-zone-name=America/Los_Angeles
/system identity
set name=N7DOD-PtP-2
/system logging
add action=remote topics=!debug,!snmp
/system ntp client
set enabled=yes primary-ntp=44.24.244.4 secondary-ntp=44.24.245.4
/system routerboard settings
set silent-boot=no
```

13.0 Appendix G – WAN Edge Router (RB960PGS) Configuration

?

14.0 Appendix H – LAN Router (RB750) Client Configuration

```
# may/05/2019 09:44:14 by RouterOS 6.43.4
# software id = ZHJP-UNFK
#
# model = RouterBOARD 750P r2
# serial number = 67D60776FC45
/interface bridge
add name=bridge1
/interface list
add name=WAN
add name=LAN
/interface wireless security-profiles
set [ find default=yes ] supplicant-identity=MikroTik
/ip hotspot profile
set [ find default=yes ] html-directory=flash/hotspot
/ip pool
add name=dhcp ranges=44.26.161.10-44.26.161.30
/ip dhcp-server
add address-pool=dhcp disabled=no interface=bridge1 name=dhcp1
/interface bridge port
add bridge=bridge1 interface=ether2
add bridge=bridge1 interface=ether3
add bridge=bridge1 interface=ether4
add bridge=bridge1 interface=ether5
/interface list member
add interface=ether1 list=WAN
add interface=bridge1 list=LAN
/ip address
add address=44.26.161.1/27 interface=ether2 network=44.26.161.0
/ip dhcp-client
add dhcp-options=hostname,clientid disabled=no interface=ether1
/ip dhcp-server network
add dns-server=44.26.161.1
add address=44.26.161.0/27 gateway=44.26.161.1 netmask=27
/ip dns
set allow-remote-requests=yes servers=44.26.161.1
/ip dns static
add address=44.26.161.1 name=router.lan
/ip firewall nat
add action=masquerade chain=srcnat out-interface-list=WAN
/ip service
set telnet disabled=yes
set ftp disabled=yes
set www disabled=yes
set ssh port=222
```

```
set api disabled=yes
set winbox disabled=yes
set api-ssl disabled=yes
/system clock
set time-zone-name=America/Chicago
/system identity
set name=N7DOD-RTR-1
/system logging
add topics=bgp
/system ntp client
set enabled=yes primary-ntp=132.163.96.1 secondary-ntp=132.163.96.2
/system ntp server
set broadcast=yes enabled=yes
/system routerboard settings
set silent-boot=no
```

15.0 Appendix I – LAN Client (RB911G)

```
# feb/07/2019 12:57:18 by RouterOS 6.43.7
# software id = 5GUH-NLDL
#
# model = 911G-5HPacD
# serial number = 8CEE08C47A94
/interface bridge
add name=bridge1
/interface wireless
set [ find default-name=wlan1 ] band=5ghz-a/n channel-width=5mhz disabled=no \
    frequency=5880 frequency-mode=superchannel mode=station-bridge \
    radio-name=N7DOD-Node-1/Gresham->Larch scan-list=HamWAN ssid=HamWAN \
    wireless-protocol=nv2
/interface ethernet
set [ find default-name=ether1 ] speed=100Mbps
/interface list
add name=WAN
add name=LAN
/interface wireless channels
add band=5ghz-onlyn comment="Cell sites radiate this at 0 degrees (north)" \
    frequency=5920 list=HamWAN name=Sector1-5 width=5
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 120 degrees (south-east)" frequency=5900 \
    list=HamWAN name=Sector2-5 width=5
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 240 degrees (south-west)" frequency=5880 \
    list=HamWAN name=Sector3-5 width=5
add band=5ghz-onlyn comment="Cell sites radiate this at 0 degrees (north)" \
    frequency=5920 list=HamWAN name=Sector1-10 width=10
```

```
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 120 degrees (south-east)" frequency=5900 \
    list=HamWAN name=Sector2-10 width=10
add band=5ghz-onlyn comment=\
    "Cell sites radiate this at 240 degrees (south-west)" frequency=5880 \
    list=HamWAN name=Sector3-10 width=10
/interface wireless security-profiles
set [ find default=yes ] supplicant-identity=MikroTik
/ip pool
add name=dhcp ranges=192.168.88.100-192.168.88.199
/ip dhcp-server
add address-pool=dhcp disabled=no interface=bridge1 name=dhcp
/snmp community
set [ find default=yes ] addresses=44.24.240.0/20 name=hamwan
/system logging action
set 3 remote=44.24.244.8
/interface bridge port
add bridge=bridge1 interface=ether1
/interface list member
add interface=wlan1 list=WAN
add list=LAN
add interface=bridge1 list=LAN
/ip address
add address=192.168.88.1/24 interface=ether1 network=192.168.88.0
/ip dhcp-client
add dhcp-options=hostname,clientid disabled=no interface=wlan1
/ip dhcp-server network
add address=192.168.88.0/24 dns-server=44.24.244.1,44.24.245.1 gateway=\
    192.168.88.1
/ip dns
set servers=44.26.161.1
/ip firewall mangle
add action=change-mss chain=output new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
add action=change-mss chain=forward new-mss=1378 protocol=tcp tcp-flags=syn \
    tcp-mss=!0-1378
/ip firewall nat
add action=masquerade chain=srcnat out-interface=wlan1 out-interface-list=WAN
/snmp
set contact="#HamWAN-Support on irc.freenode.org" enabled=yes location=\
    45.4949,-122.4752
/system clock
set time-zone-name=America/Chicago
/system identity
set name=N7DOD-Node-1->Larch
/system logging
```

```
add action=remote topics=info
add action=remote topics=warning
add action=remote topics=error
/system ntp client
set enabled=yes primary-ntp=44.24.244.4 secondary-ntp=44.24.245.4
```