RuralConnect® Gen3

TV White Space Radio

User Manual

V1.0

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Carlson Headquarters: 3134 Jacobs Ave. Suite C, Eureka, CA 95501 USA

Purchasers of Carlson products are required to make their own evaluations of product suitability for their specific application(s). Regarding the use and/or application of our products and/or the use of this manual, Carlson's obligations are limited to the terms set forth in the Standard Terms and Conditions of Sale for a delivered product.

Technical Support

Training and support are only available for products purchased directly from Carlson or its direct distribution channel; the purchaser is responsible for technical assistance for all other system components. Local product support is provided by Indigo Broadband in South Africa. The first point of contact should always be via their support facilities which is available from 8:00 AM to 5:00 PM CAT, excluding weekends and public holidays.

Tel: +27 72 268 5150

Email: support@indigobroadband.co.za

Repair and Return

Carlson will replace or repair this product within one year from the date of shipment if it does not meet published specifications, or if it fails while in service due to a manufacturer's defect. You must obtain a Return Merchandise Authorization (RMA) prior to returning equipment to Carlson. To submit an RMA request, please contact Indigo Broadband Support.

Qualified Personnel

Only professionally trained personnel can perform the testing and/or configuration steps outlined in this manual. Technicians are responsible for adhering to all applicable safety regulations and industry-standard best practices. Carlson does not authorize non-certified personnel to work on equipment without the direct supervision of a certified trained service technician.

Safety Warnings

In order to prevent personal injury, property damage, and/or equipment failure; it is essential that the installer employ appropriate safety measures when testing, installing, and/or maintaining RuralConnect® equipment. You are required to review all safety warnings in this manual prior to testing, installing, and/or maintaining the system.

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Proper Handling and Grounding

The electronic components of the RuralConnect® equipment are sensitive to electrostatic discharge (ESD). In order to prevent potential warranty voiding damage, you must use an adequately grounded anti-static wrist strap when handling the equipment. It is also important to avoid the use of conductive tools. In order to prevent electric shock, always disconnect the remote power source and all cables from the system prior to disconnecting the grounding connection.

Outdoor Installation

You must never perform any installation work on a tower, mast, or rooftop during lightning storms or other inclement weather. Dangerous work of this nature could result in serious injury and/or death. It is important to adhere to all of the applicable local, state, and federal regulations pertaining to safety equipment and tower climbing practices.

Electrical Installation

The electrical installation must be accomplished in accordance with the National Electrical Code (NEC) and with any local codes effective at the time of installation.

To eliminate risk of electric shock, DO NOT connect/disconnect cables while units are powered up.

Safety will be compromised if external quality cables are not used for connections that will be exposed to the weather.

Antenna installation near power lines is dangerous and contacting power lines can be lethal. When selecting an installation site, keep safety and performance in mind. Make sure there are no power lines anywhere where possible contact can be made. Carefully check the distance to any power lines before starting installation. The distance from the mast or antenna to the nearest power line should be at least twice the total length of the mast/antenna combination.

ETSI Instructions

This equipment design typically applies to commercial or industrial equipment expected to be installed in locations where only adults are normally present. Instructions to ensure correct and safe installation and interconnection of the equipment. For equipment intended only for use in a restricted access area, the instructions shall so state. If the equipment is intended to be fastened in place, the instructions shall explain how to securely fasten the equipment. Graphical symbols placed on the equipment and used as an instructional safeguard shall be explained. If a replaceable component or module provides a safeguard function, identification of a suitable replacement component or module shall be provided in the ordinary person instructions or instructed person instructions, or skilled person instructions, as applicable. (Power Supply)

RF Exposure

This equipment complies with radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with minimum distance 40 cm between the radiator and your body. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

It is advisable to use the device only in the normal operating position as described in this guide.

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When the system is operational, avoid standing directly in front of the antenna. Strong RF fields are present when the transmitter is on. The antenna must not be deployed in a location where it is possible for people to stand or walk inadvertently in front of the antenna.

Regulatory Compliance Information

Warning: Changes or modifications to this device not expressly approved by Carlson Wireless Technologies Inc. could void the user's authority to operate the equipment.

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to ETSI EN 301 489-1 regulations. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Spectrum Database Registration Requirements

Per ICASA regulations, your RuralConnect® system must be enrolled with a certified White Space Database (WSDB) prior to performing any bench tests and/or completing the final installation.

ETSI Regulatory Compliance Information

ETSI Identifiers:

OPA-RC3-BS	(Base Station)
OPA-RC3-CPE	(Client Station)

ETSI EN 301-598

470-694 MHz	(TV channels 21-48) (South Africa)

Emission designators

8 MHz channels	6M00F1D

Declaration of Conformity

Manufacturer's Name: Carlson Wireless Technologies Inc.

Manufacturer's Address: 3134 Jacobs Ave, Eureka, CA 95501 USA

Declares that the product:

Product Name: RuralConnect® Gen3

Conforms to the following standard(s) or other normative document(s):

EMC: EN 301 489-1 & EN 61000-4 part 2-6 & 8

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1. Introduction

1.1. Scope of Manual

The purpose of this manual is to provide professional planning and installation personnel with the appropriate information and procedures required to install and operate the RuralConnect TV White Space Broadband Radio and accessory equipment. In order to avoid harm to persons or damage to the product, please ensure that you have read and understand the safety, unpacking, and installation sections before proceeding.

1.2. Product Overview

The RuralConnect® TV White Space Broadband Radio utilizes “white space” spectrum within the UHF TV band from 470 MHz to 698 MHz (up to 790 MHz in EU/some African regions), for applications where traditional microwave solutions will not provide adequate RF performance.

The RuralConnect Base Station (BS) is an outdoor unit (ODU) with three radios, each to be connected to a 120-degree sector antenna.

The BS functions as an Internet gateway router via its 10/100 Base-T Ethernet connection. Using three radios, the BS distributes up to 72 Mbps (6 MHz) or 96 Mbps (8 MHz) over the air, utilizing three RF channels with three sector antennas, via 75-Ohm F-connectors. Together, the three radios may host up to 100 subscribers.

The Customer Premise Equipment (CPE) ODU has a single TVWS radio with 75-Ohm F-connector. The CPE utilizes a directional log-periodic antenna to receive up to 24 Mbps (6 MHz) or 32 Mbps (8 MHz) over the air.

Both units are powered via an external Power-over-Ethernet (POE) injector. The Base Station consumes up to 25 Watts, while the CPE consumes up to 8 Watts.

Figure 1: RuralConnect® Outdoor Unit

The RuralConnect® uses the IEEE 802.11af standard, also called “White-Fi.” As with other 802.11 standards, 802.11af includes the use of Orthogonal Frequency Division Multiplexing (OFDM) to provide protection against signal fading caused by multipath interference (phase-shifting) while offering a robust clean transmit spectrum. Reflections from trees, buildings, and hills are inevitable for long-range wireless links. These reflections arrive at slightly different times, causing deep fading across the channels used by white space systems. OFDM mitigates fading effects to ensure reliable wireless communications even in mountainous, forested, and/or built-up areas where strong signal reflections are common, even with non-line-of-sight (NLOS). The robustness and high data rate is obtained with an adaptive modulation algorithm using BPSK, QPSK, 16QAM, 64QAM, and 256QAM modulation types.

To prevent interference with licensed users, the RuralConnect® combines an integrated GPS receiver with a secured connection to a White Space Database (WSDB) using the PAWS standard.

Our international models ensure worldwide compatibility, regardless of the TV broadcast technology in use. International users must ensure compliance with their regulatory authorities. For export only, international models are available in both 6 MHz and 8 MHz versions.

In Africa, the RuralConnect® is only available with an 8 MHz channel bandwidth. The system is fully compliant with ETSI EN 301-598 regulations.

To prevent exceeding an authorized power limit the radio includes an internal RF sensor that reads the RF power output. The radio then adjusts the output across its operating band, according to the power limit set by the ETSI. All power controls are factory set; no user controls are available.

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2. System Planning

2.1. Proper Handling

You must follow precautionary measures when handling RuralConnect® devices. Improper handling of your equipment may cause damage and void your warranty. The electronic components of the RuralConnect® equipment are sensitive to electrostatic discharge (ESD). Whenever handling the equipment, always use adequate ESD protection, such as a grounded anti-static wrist strap. It is also important to avoid the use of conductive tools, metal or otherwise. Where a plug on the power supply cord is used as the disconnect device, the socket-outlet must be easily accessible.

2.2. Grounding

Grounding is the most important aspect of any electrical system.

It is recommended, and often required by law, to hire a certified electrician to install any required electrical infrastructure.

For dissipation of hazardous energy, a ground is a low impedance electrical connection to the earth. Grounding the RuralConnect® is very important for safety reasons, as well as protecting the system from damage due to lightning and/or static charge/build up. Since lightning strikes and surges are high in frequency, current, and voltage, the installation should use short, straight ground wires (not coiled or looped). For optimal electrical conductivity, it is best to use the largest diameter ground wire the ground connectors will accept. We recommend using a solid copper wire no smaller than eight gauge.

It is required that the connection of the equipment protective earthing conductor to the installation protective earthing conductor is made.

The impedance of your grounding should never exceed five Ohms. Carlson recommends maintaining a ground with less than three Ohms.

An earth ground can be achieved, for example, using a utility company ground, grounding rod(s), well casing, and/or cold-water pipes constructed of continuous metal.

A note of caution: sometimes repaired and/or extended metal cold-water pipes include PVC sections hidden behind drywall. PVC will disrupt conductivity and render the pipe unacceptable as a ground.

Conductivity is often poor in desert areas, so multiple ground rods may be required (preferably bonded together to make a suitable connection). Undesirable grounds include, but are not limited to: sprinkler pipes, PVC pipes, conduit, and buried wire.

Never use an unverified ground.

Caution must be taken to avoid electric shock. Prior to disconnecting a grounding connection, always disconnect all power sources and cables from the system.

2.3. Lightning Protection

Poorly grounded lightning protection is the same as having no protection at all!

Lightning is one of the most dangerous and most common natural hazards for outdoor wireless systems such as the RuralConnect®. It is essential to install and maintain adequate lightning

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protection for your equipment. Verified ground connections are imperative for lightning protection to work correctly.

Primary lightning protection is located outside the enclosure. Install primary lightning protection with a good ground on all RF and/or data connections that have even a moderate outdoor line build-out. Best practices dictate all lines entering or exiting a building need protection. You must use protection on both ends of the cables between buildings! Contact your sales representative for detailed specifications and usage information for the primary lightning protection solutions available from Carlson.

In areas with frequent lighting activity, augmenting the Client Station install with a nearby lightning rod is strongly recommended. Lightning can unpredictably strike and miss the antenna mast altogether, making contact with the underlying wiring/cabling instead. Lightning discharges into the lowest impedance path to ground, i.e. earth. In many cases this will be the master ground in the primary AC panel unless nearby grounding is installed.

2.4. Cable Recommendations

Use of factory-approved high-quality cabling is important to ensure the best performance for your RuralConnect® system. Carlson extensively researched and tested cabling before selecting those offered for RuralConnect® customers. It is strongly recommended that you use only Carlson-approved cables. Discuss your cabling options with your Carlson Sales Representative.

Carlson carries professional-grade RF coax cables that provide greater durability and less attenuation than those readily available. We offer and recommend well-insulated 75-Ohm broadband coaxial cable with gas-injected foam polyethylene insulation. For short jumper connections, use 18 AWG RG-6/U cables with a solid .040” bare copper conductor. For longer runs, use 14 AWG RG-11 cables with a .064” bare copper conductor.

Only use cable with 100-percent solid copper center conductors. Lower-quality copper-clad conductors have decreased performance and can lead to failures.

The 75-Ohm cabling used for RuralConnect® installation should not exceed 45 meters. Terminate all coax cables with weather-sealed 75-Ohm F-type compression connectors with PVC jackets. Do not use crimp-type connectors.

Avoid cable bends as much as possible; do not put more than a 90-degree bend in any cable run.

Network performance is greatly affected by the quality of data cabling used. Carlson carries and recommends UV-resistant, shielded and grounded twisted pair cabling (CAT-5 or greater) rated for outdoor use.

2.5. Recommended Tools

These are the tools commonly used to set up and install a RuralConnect® system. To ensure a seamless installation, make sure you have these tools available.

- ESD protection gear
- Wrench set (metric)
- Socket set (metric)
- Screwdriver set (Phillips and Standard)
- Multimeter/multi-tester
- CAT5/CAT6 cable tester
- CAT5/CAT6 wire cutter/stripper tool(s)
- RG-6/RG-11 RF cable cutter/stripper and compression/termination tool(s)

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- Butyl tape (Vapor Wrap®)
- Vinyl/electrical tape

2.6. Computer Required

You will need a computer with the following:

- Web browser (Internet Explorer 9 +, Firefox, Chrome, etc.).
- At least one gigabyte (GB) of RAM.
- Keyboard and mouse (or other compatible pointing device).
- Display adapter and monitor (1024x768 or higher resolution).
- 100/1000 Mbps Ethernet network adapter.

2.7. Spectrum Management

2.7.1. Unlicensed Operation using a White Space Database

Described in ETSI EN 301 598"Fixed devices must access a TV bands database over the Internet to determine the TV channels that are available at their geographic coordinates…"

In accordance with this requirement, the RuralConnect® currently supports the FCC-approved White Space Databases (WSDB) operated by Spectrum Bridge, iConnectiv and Google as well as the ICASA approved CSIR S-GLSD (Secondary Geo Location Spectrum Database)

For European operation, Carlson has chosen WSDB partner Nominet. Other WSDB providers may be available in your area.

To allow unlicensed operation, RuralConnect® radios must be enrolled and registered with a WSDB. In most cases, enrollment is a one-time process performed by the factory prior to shipment. After a radio has been enrolled and connected to the Internet, it will attempt to register with the WSDB and request channel allocations. Via software, unit registration requires both the owner and operator's contact information and geo-location information. After configuration of your system, if you see any error messages or cannot obtain channel allocations, contact Indigo Technical Support.

2.7.2. Licensed/Fixed-Channel Operation

ETSI Region 1 Domestic Operators (Africa)

Unless the system has been registered with a White Space Database (WSDB), it is necessary for the equipment operator to hold an ICASA (South Africa) special issue license to operate in the UHF band. Without a spectrum database, you will manually select the operating channel of the system.

Prior to powering your radios and conducting tests, you must have a list/map of allowable channels specific to the Base Station and Client Station locations. To obtain a list of channels available in the you need to connect to the relative Regulatory Authority to use one of the approved databases hosted by Local Regulator -approved White Space Database providers:

South Africa - CSIR : https://whitespaces.csir.co.za

International Operators

If you will not be using a WSDB, refer to your spectrum regulatory authority to determine the TV channels you can use. Without a spectrum database, you will manually select the operating channel of the system.

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2.8. Carlson Knowledge Base

Prior to unpacking your RuralConnect® equipment, we recommend reviewing the latest documentation available on our Knowledge Base.

The online Carlson Knowledge Base contains a variety of useful articles that will help you get started with your new RuralConnect® system. To access the Knowledge Base, open your web browser and navigate to www.carlsonwireless.com. Hover your cursor over “Support” and click the “Knowledge Base” link.

To access the Knowledge Base directly, follow the link below:

http://hosted.comm100.com/helpdesk/main/main.aspx?siteid=129483

If you are new to the Knowledge Base, click the “New to Register?” link. You will receive a confirmation email with an activation link. Follow the link to finalize your registration and select an initial password.

If you forgot your password, click the “Forgot Password?” link.

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3. Receiving and Testing - Quick Start Guide

This section outlines the needed steps to set up the software and conduct an initial bench test before entering the field. Prior to starting these steps, you will need the following:

- A RuralConnect® Bench Test Kit
- Two (2) compatible computers
- Four (4) standard CAT5 Ethernet cables
- An Internet connection

3.1. Unpacking

Always inspect a package before opening. Report any damage to the shipping carrier. Unpack and compare the contents against the packing slip and inspect everything for damage. Report any missing or damaged components to your Carlson Customer Service Representative.

3.2. Setting up the Bench

Warning: do not power up a unit without proper cabling and attenuation. Failure to do so could result in system damage that may void the warranty. You must have at least 60 dB of attenuation between a RuralConnect® Base Station and each CPE.

3.2.1. RF Connections

Attach three (3) of the included attenuators to a Base Station and one (1) to the CPE. Cable the units together with one (1) RG6 coax jumper. If you are testing two CPEs at a time, attach an RG6 jumper to each unit and then to the splitter. Note the splitter adds additional cable/connector loss.

3.2.2. Power & Network Connections

From the “OUT” jack of each POE injector, run a CAT5 Ethernet cable (not supplied) to each unit to. From the “IN” port of the Base Station POE injector, connect your LAN/Internet connection. Connect your first computer to Local Area Network (LAN) to which the Base Station is connected. From the “IN” port of the CPE POE injector, connect your other computer. Connect each POE injector to a power source.
Wait two to three minutes for the system to initialize.

3.3. Registration Information

NOTE: The following registration details are required to configure the system. Incomplete or invalid information may prevent the system from operating correctly. In countries that require use of a spectrum database, inaccurate information could be a violation of the law.

3.3.1. Base and CPE Registration Details

MAC Addresses

Each radio has a unique MAC address, which is used to register with a White Space Database (WSDB) and for client access controls. Each unit housing includes a sticker with the MAC address. Though Base Stations have multiples radios within, WSDB registration is done using Radio/Sector 1. This is the MAC address referenced next to “RAD” on the sticker (RAD: 70:B3:D5:xx:xx:xx). The Base Station has a separate MAC address for the Ethernet interface, labeled “ETH” on the sticker. The CPE has one MAC address, labeled “MAC” on the sticker.

Please note: If you are operating your RuralConnect® system with a spectrum database, you should only register CPEs with a single Base Station. This is to prevent conflicting registrations, which will nullify and cause the radio(s) to cease operation.

Geolocation Details (Latitude/Longitude)

You must have each unit's geolocation in **decimal degrees**. For radios not deployed, enter the coordinates for their storage location.

NOTE: ETSI regulations mandate these values be accurate within 30 meters. International regulations may vary.

Antenna Height

WSDB registrations for each site include the antenna height above ground level (HAGL) in meters. GPS-enabled units determine HAGL, with reference to the location of the GPS antenna. GPS values are accurate within eight (8) meters*. If using GPS, you must include the difference in height between the GPS antenna and the TVWS antenna*.

NOTE: ETSI regulations mandate the antenna height cannot exceed 30 meters AGL, nor 250 meters Height Above Average Terrain (HAAT). International regulations may vary.

3.3.2. Owner & Operator Information

Where use of a spectrum database is required, contact information is required for both the owner and operator of the equipment. This information is used to register each radio with a White Space Database (WSDB).

NOTE: Registration details imply explicit responsibilities and are public record.

If you own and operate the equipment, you can enter the same information for both the owner and operator details. You may want to specify a different "operator" contact, a lead technician that will be responsible for the system hereon.

If your networks are operated by an organization that does not own the equipment, be sure the owner and operator fields accurately detail the appropriate contacts.

3.4. Software Configuration

The following section is a brief overview of the steps required to configure your RuralConnect® system.

Most management of a RuralConnect® system is done via the web-based Graphical User Interface (GUI) that runs on the Base Station. Once the equipment has been set up on your bench, you will access the GUI via your web browser.

3.4.1. Finding the Base Station on Your Network

You may access the unit from your local network via an IP address or hostname.

IP Address

The local IP address of a Base Station can be static or assigned dynamically by your DHCP server. If your unit came with a default IP address, it would include a paper and/or sticker with the address. Otherwise, the unit is likely DHCP-enabled and you will need to determine its address.

Using the Address Resolution Protocol (ARP), you can find the local IP address of a Base Station. From a Windows PC open a command prompt and run the command "arp -a". You will see a list of IP and MAC addresses. Look for a MAC address starting with "70-b3-d5-17". You can use the corresponding IP address to connect to the Base Station.

This ARP method only works if your computer is on the same subnet as the Base Station and both have shared information on that network. You can download and use a "ping scanner" utility to

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search for the Base Station. For example, “Angry IP Scanner” is a free and open-source program that will ping any range of IP addresses to determine which, if any, are active. Visit http://angryip.org to learn more.

The Client Station, or “CPE”, has a DHCP server running by default. If the attached computer is configured to obtain an IP address via DHCP, it will automatically obtain an IP address from the CPE. The default IP address of the CPE is 192.168.2.1, accessible via URL: https://192.168.2.1.

Hostname

The hostname of a RuralConnect® Base Station is configured at the factory and can be changed. The default Base Station hostname is “tvws_bs”. If your computer and Base Station are hosted on a network with a local DNS server, you should be able to access the unit via its hostname, using URL: https://tvws_bs.

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3.4.2. Log into the GUI

Open a web browser and type the URL, starting with “https://” followed by the IP address or hostname.

You may be prompted with a security warning.

Depending on your browser, you may need to choose an option to continue or ignore the error. Some browsers allow or require you to add an exception for this particular address/machine. For example, in Google Chrome you may get a warning that states, “Your connection is not private.” Toward the bottom of the message, click “Advanced” and then click “Proceed to {ip address of your Base Station}.” In Firefox, you may be directed to click “Add Exception”. Once you click the link, the details of the Base Station security certificate will be displayed. Click “Add Exception” to continue.

Figure 2: Security warning while attempting to access the GUI

Enter the default username (“Admin”) and password (“Admin”) and click the “Log in” button.

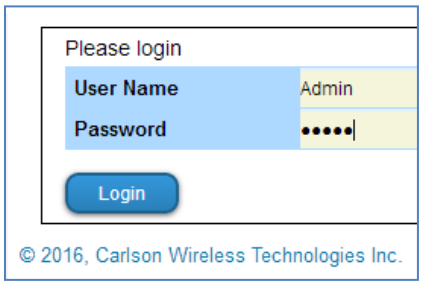

Figure 3: GUI Login

3.4.3. Home Page

This page includes an overview of your TV White Space network, including some configuration and status details.

System Status

Note the up time. This time should be similar to the amount of time the Base Station has been powered.

Sector Status

The BSID is the MAC address of each radio. Each radio can operate on a different channel. A new system should not show a valid channel until it has been configured.

CPE Status

Registered CPEs will be listed here. New systems should not have any CPEs listed.

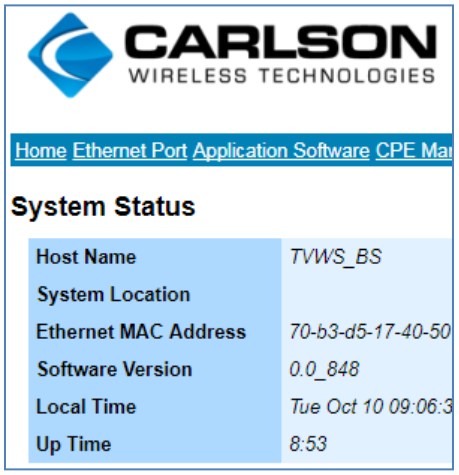

Figure 4: System Status

3.4.4. CPE Management

From the navigation bar at the top of the GUI, click “CPE Management”.

Click the “New” button.

To the right of the “Hardware Address”, click the address field, enter the MAC address of your CPE and then press “Enter” or click the green checkmark to save the value.

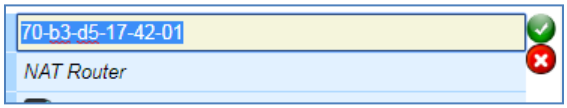

Figure 5: Setting up new CPE

Scroll to the bottom of the page and click the “Close” button.

3.4.5. Radio Manager

From the navigation bar at the top of the GUI, click “**Radio Manager**”.

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Manager

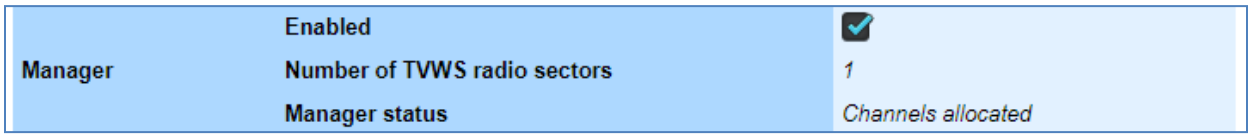

Figure 6: Manager Screen

You should see a check in the “Enabled” box. The status must show “Channels allocated” to allow the radio(s) to transmit.

Location

GPS-enabled units should show the number of GPS satellites visible from the Base Station.

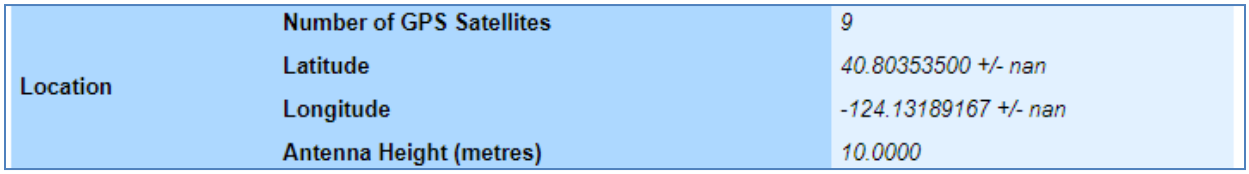

Figure 7: Location Screen

Location & Antenna Height Manual Override

If the unit is not GPS-enabled or no satellites are within range, click the “GPS Details” button at the bottom of the **Radio Manager** Screen. Under “Location Manual Override”, check the box next to “Use” and then click the green checkmark.

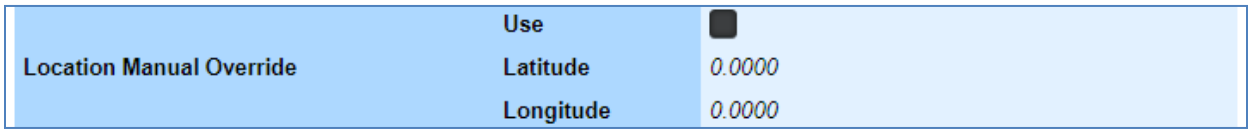

Figure 8: Location Override Screen

For both the latitude and the longitude click on the appropriate field, enter the value, and then click on the green checkmark.

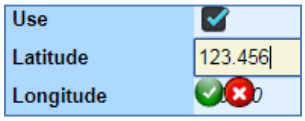

Figure 9: Setting Manual Location Details

Do not use the manual override function if GPS communication is available.

Once done, click the “Close” button.

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PAWS

For compliance in regions with spectrum-sharing regulations, the RuralConnect® supports the IETF Protocol to Access White Space (PAWS). PAWS is a standard used by the Base Station to connect with a White Space Database (WSDB) and get a list of available channels based on the geolocation of each radio in its network.

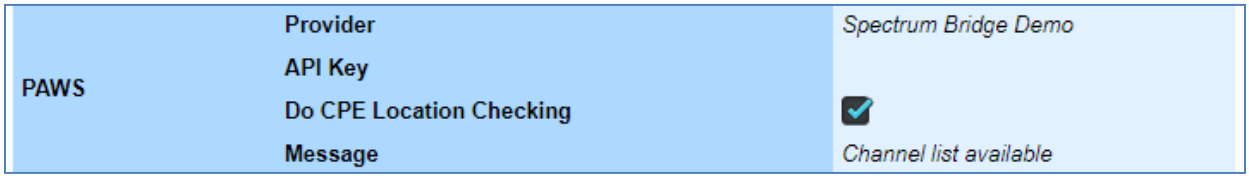

Figure 10: PAWS Screen

GPS-enabled units do not require you to enter geolocation details; however, registration with a WSDB requires complete contact details. Per FCC Part 15H regulations, all White Space Devices (WSDs) must be registered with a WSDB, including the contact details of the parties who own the equipment and those responsible for its operation.

At the bottom of the Screen, click the “Contact Details” button and fill in every field. After you complete a field, press “Enter” or click the green checkmark.

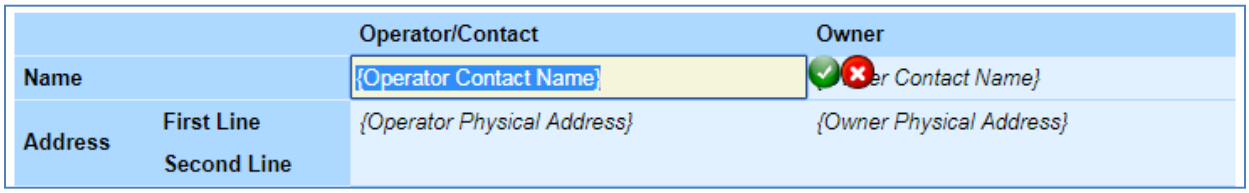

Figure 11: Operator Details

NOTE: These contact details define the parties responsible for the equipment and its use. Additionally, these details are public record.

Once you have completed all contact details, click the “Close” button at the bottom of the Screen. After the PAWS registration and channel requests are complete, you should see “Channel list available” in the **Radio Manager** PAWS “Message” field.

Configuration

For testing, leave a check in the box for both “Automatic Channel Selection” and “Enabled.” Enter a Service Set Identifier (**SSID**) and **Passphrase**.

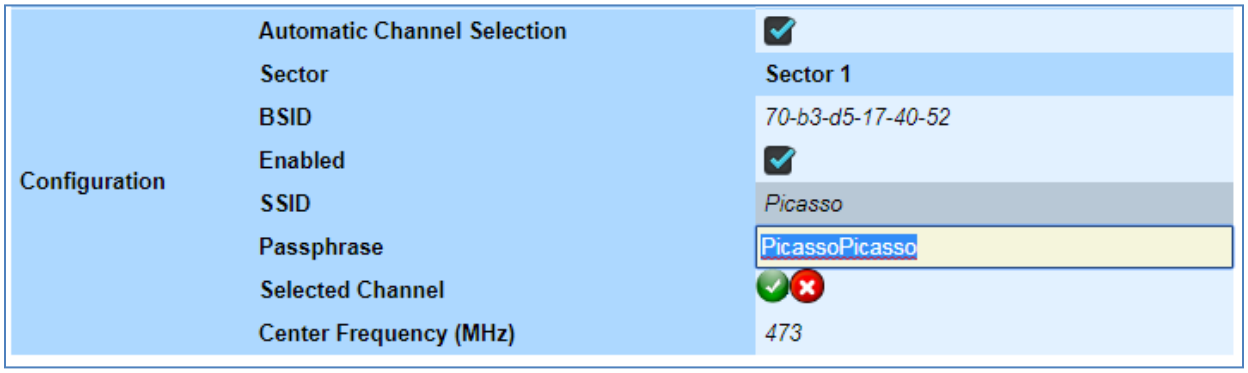

Figure 12: Radio Manager Passphrase

After making a change, press “Enter” or click the green checkmark.

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Once the PAWS and wireless configuration details are complete, the Base Station should acquire channels from the WSDB and begin transmitting. You should see a value next to “Center Frequency (MHz)”.

Browse to the **Home** page to view the status of each sector and any connected CPEs.

3.5. Test Internet Connection

Open a web browser and navigate to a webpage of your choice. You may wish to visit your favorite streaming or performance-testing site.

Repeat link verification steps for each Client Station.

Once you have verified the operational status of each unit, congratulations! You have completed the first step in testing your new RuralConnect® system.

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4. Base Station Graphical User Interface (GUI)

The following section provides an overview of the web-based Graphical User Interface (GUI) that operates within your Local Area Network (LAN). When used with a limited number of Base Stations, the GUI provides a cost effective and simple way to manage the units both in the field and remotely. We recommend you familiarize yourself with the GUI on the bench prior to outdoor testing and deployment.

The flow charts below describe how you access the GUI, setup and maintain the system (see Figures below):

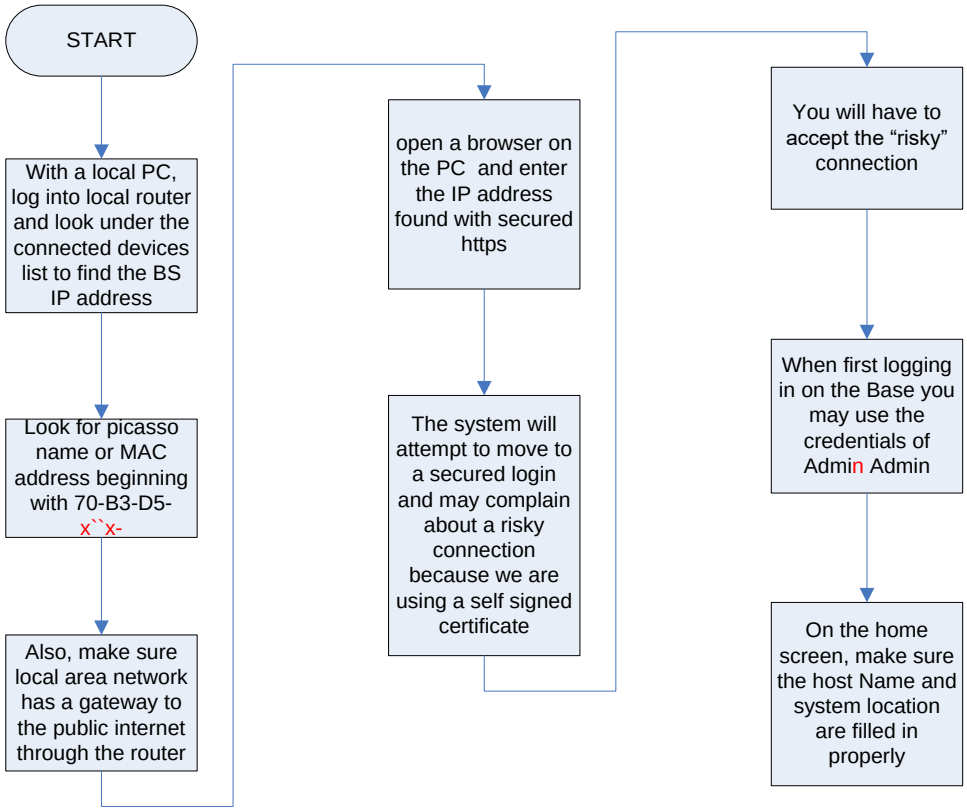

Figure 13: Base Station User Interface - Home Screen Flowchart

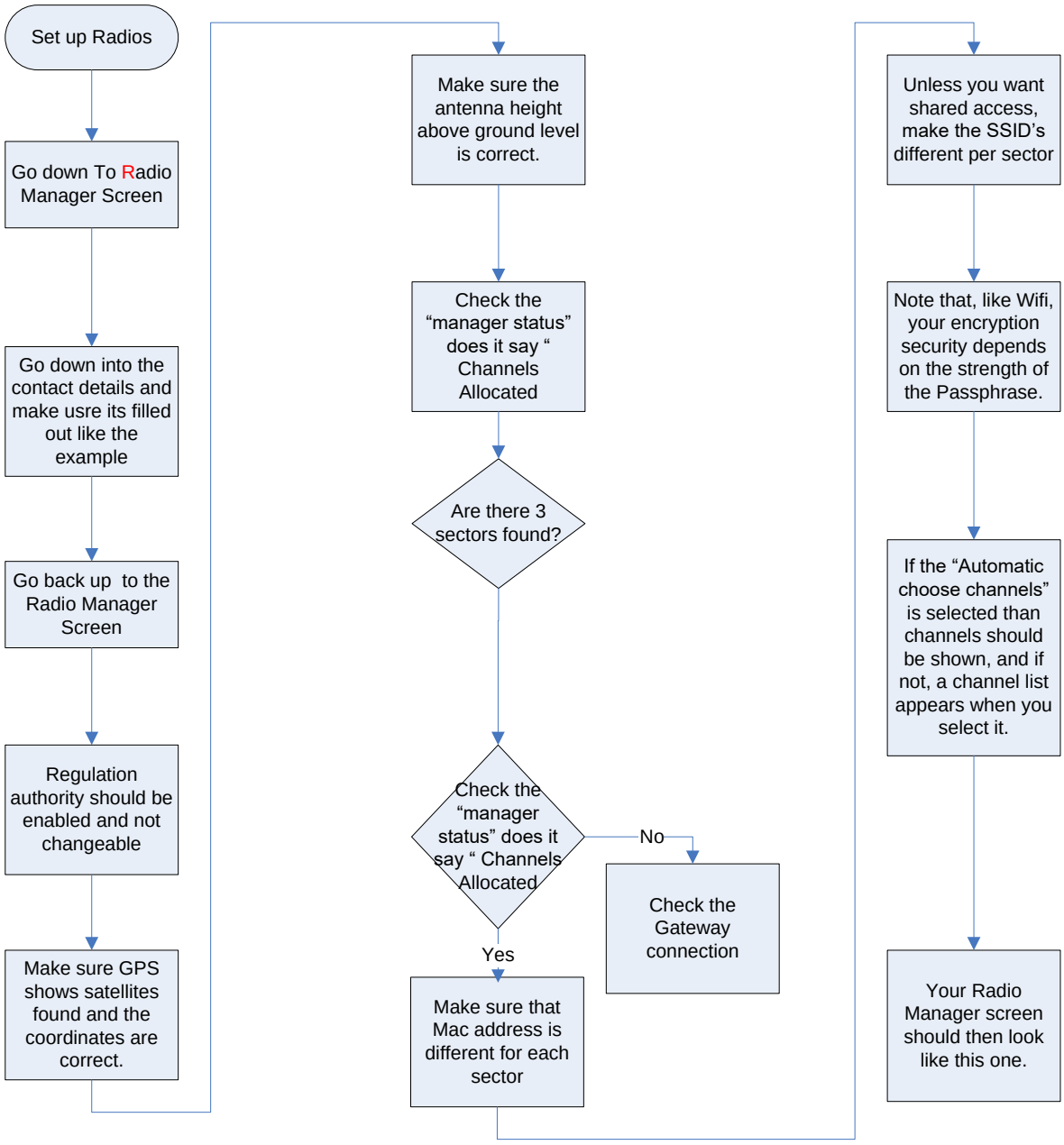

Figure 14: Base Station User Interface - Radio Manager Flowchart

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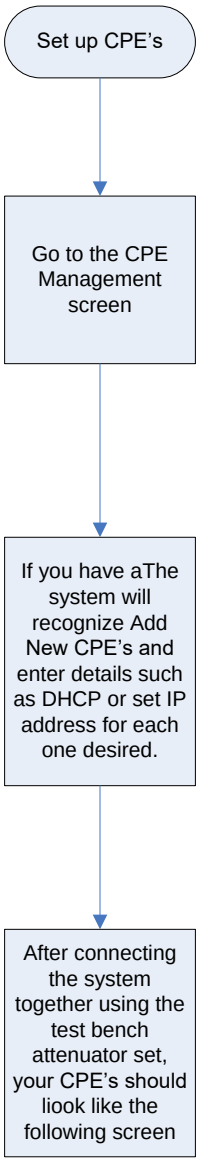

Figure 15: Base Station User Interface - CPE Management Flowchart

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4.1. Connecting to the Base Station

To begin the login process, start by plugging the base unit into your Ethernet network.

You will use a web browser to connect to the web-based Graphical User Interface, or “GUI”. From a computer on your LAN, open a web browser and browse to “http://{ip address}”. If you do not know the IP address, or for more information, see Section 3.4.1: Finding the Base Station.

4.2. Home

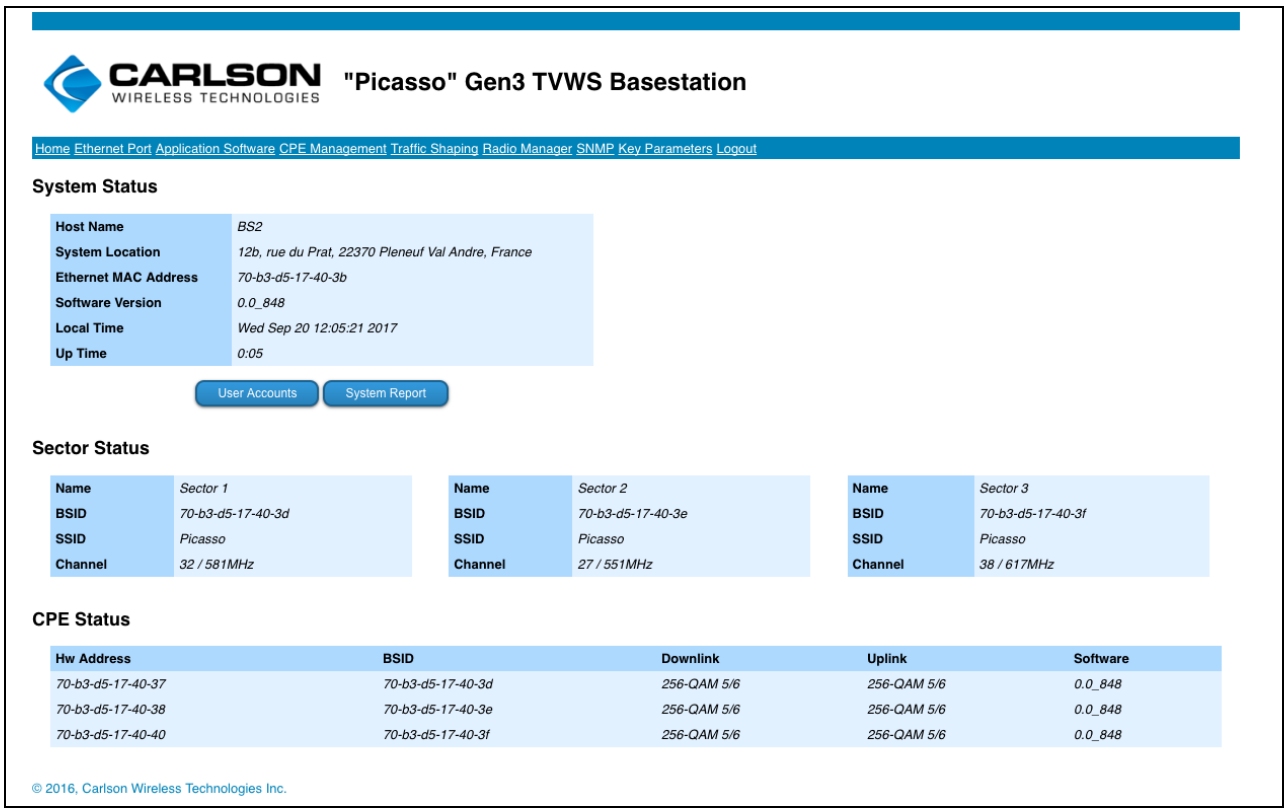

Figure 16: Base Station User Interface - Home Screen

The first page shown after login is the **Home** page. Its primary purpose is to display summary system, sector and link status information and allow access to the other status and configuration pages. There are three sections:

At the top is a block containing system information. The host name and system location may be changed by clicking on them and typing new values. There is also a button that allows an administrator to manage the device’s accounts.

In the middle is a summary of the state of the radio sectors. There will be an entry for each radio card installed in the system, the figure shows a base station fully populated with three. The sector names may be changed here, but everything else is configured through the **Radio Manager** top level page (accessed through the menu bar at the top).

At the bottom is a list showing the Customer Premise Equipment, or “CPEs”. that are currently connected to this base station through the radio. More information and access to CPE configuration is available on the CPE Management top level page (from the Menu Bar).

4.2.1. User Accounts

Clicking the **Home** screen’s “User Accounts” button will display this page (see below):

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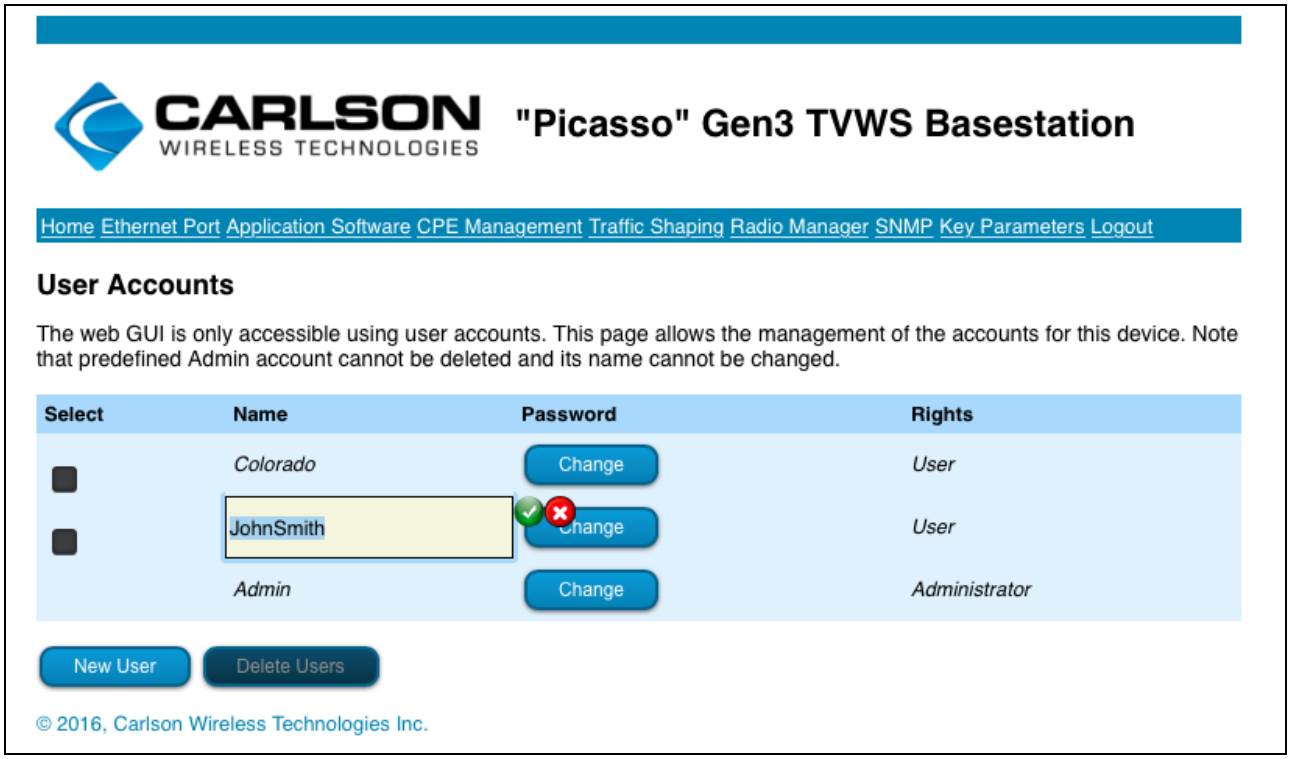

Figure 17: Base Station User Interface - User Accounts Screen

New accounts may be created by pressing the “New User” button. This adds a line to the account list. Usernames may be changed by clicking on them and typing a new name, as shown in the figure. Accounts may be deleted by placing a tick in the check box on the left and clicking the “Delete Users” button.

The password of a user may be changed here by clicking the “Change” button in the “Password” column.

An account is allocated a set of privileges, shown in the “Rights” column. There are two levels, “User” and “Administrator”. The general principle is that a “User” account only has sufficient rights to be able to operate the system, while “Administrator” rights are required for installation and commissioning.

Note that, as mentioned on the web page, the default “Administrator” account cannot be deleted nor have its name or rights changed.

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4.2.2. Radio Manager

The **Radio Manager** top-level page allows the installation and commissioning of the base station.

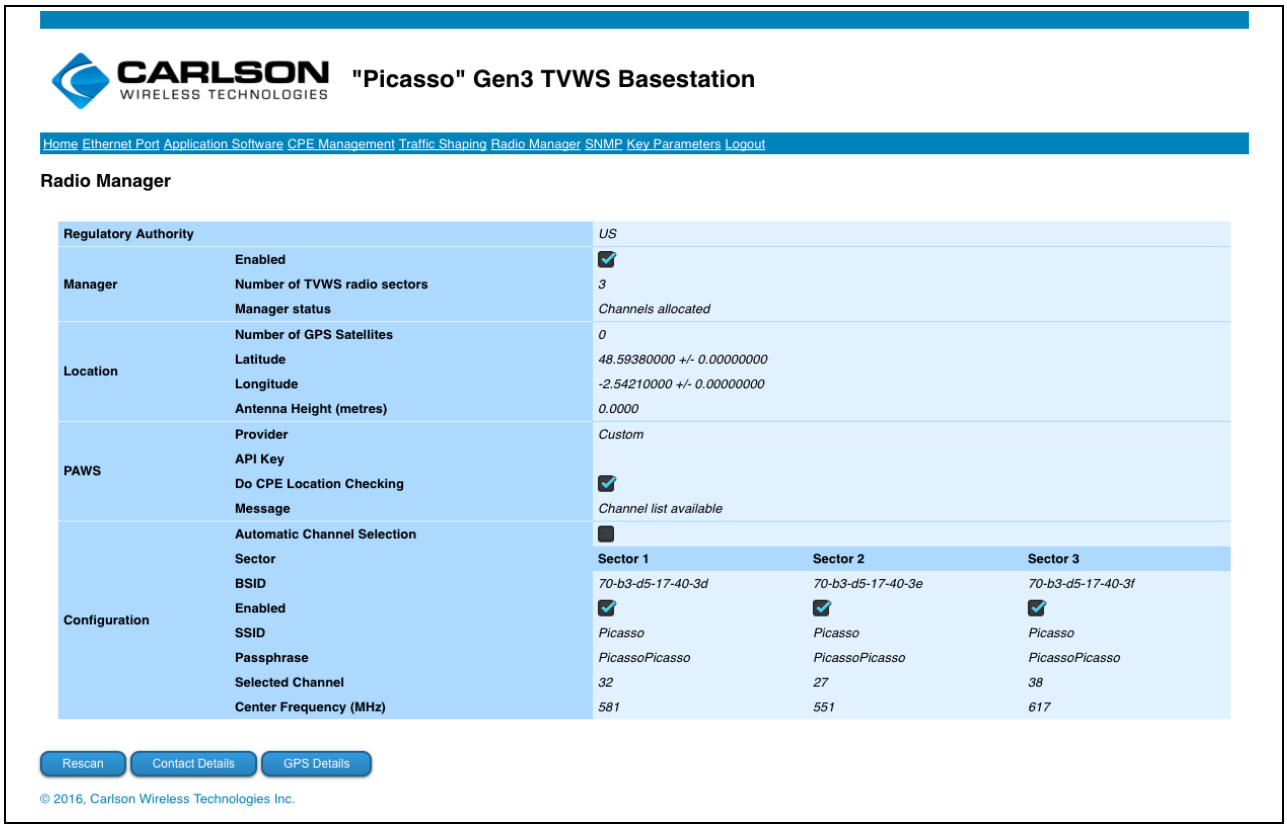

Figure 18: Base Station User Interface - Radio Manager Screen

This page is divided into sections. At the top is the regulatory authority for which the base station is constructed. This is set during manufacture and cannot be changed.
Next is the overall **Radio Manager** block. In normal operation, the **Radio Manager** should be enabled. The **Manager Status** shows the current state of the radios. The status may be any one of the following:

Awaiting GPS	The system is waiting for the GPS module to report a valid location for the base station. Check the location block (described below) or the **GPS Details** page.
Disabled	The **Radio Manager** is disabled. Place a tick in the Manager Enabled tick box to switch on the **Radio Manager**.
Awaiting PAWS	Before the base station can switch on the radios it must be granted access by a TV white space database (the PAWS). See the PAWS section of the **Radio Manager** page, described below.
Channels Allocated	The **Radio Manager** has allocated channels to all the enabled radio cards and switched them on. The base station is operating.
Not all Radios have Channels	Some of the radio cards have been given channels but for at least one this was not possible. The most likely reason is the PAWS not granting access to enough channels for all the radio cards.

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The third block shows a summary of the **Location** information. The antenna height above the ground should be entered here; the height is used when communicating with the PAWS database. More information regarding the state of the GPS module is available by clicking the "GPS Details" button.

The **PAWS** block shows the state of the communication with the TV white space database system and allows it to be configured. The provider should be set from the factory to the correct provider. Some providers require an Application Programming Interface (API) key, which can also be entered. In normal operation, the location of the CPE is also checked with the PAWS database, but removing the tick from the Do CPE Location Checking checkbox can disable this. Finally, this block shows the result of the PAWS communication. This will normally "indicate channel list available" if the communication was successful.

Finally, there is the **Configuration** block at the bottom. In this block, each radio card's configuration can be set. If "Automatic Channel Selection" is checked, the system will choose the available channel containing the lowest detected noise for each radio card.

4.2.3. Contact Details

At the bottom of the **Radio Manager** page, there is a button that allows the contact details to be entered. These are required for the PAWS communication; some providers will reject transactions if these are not filled in.

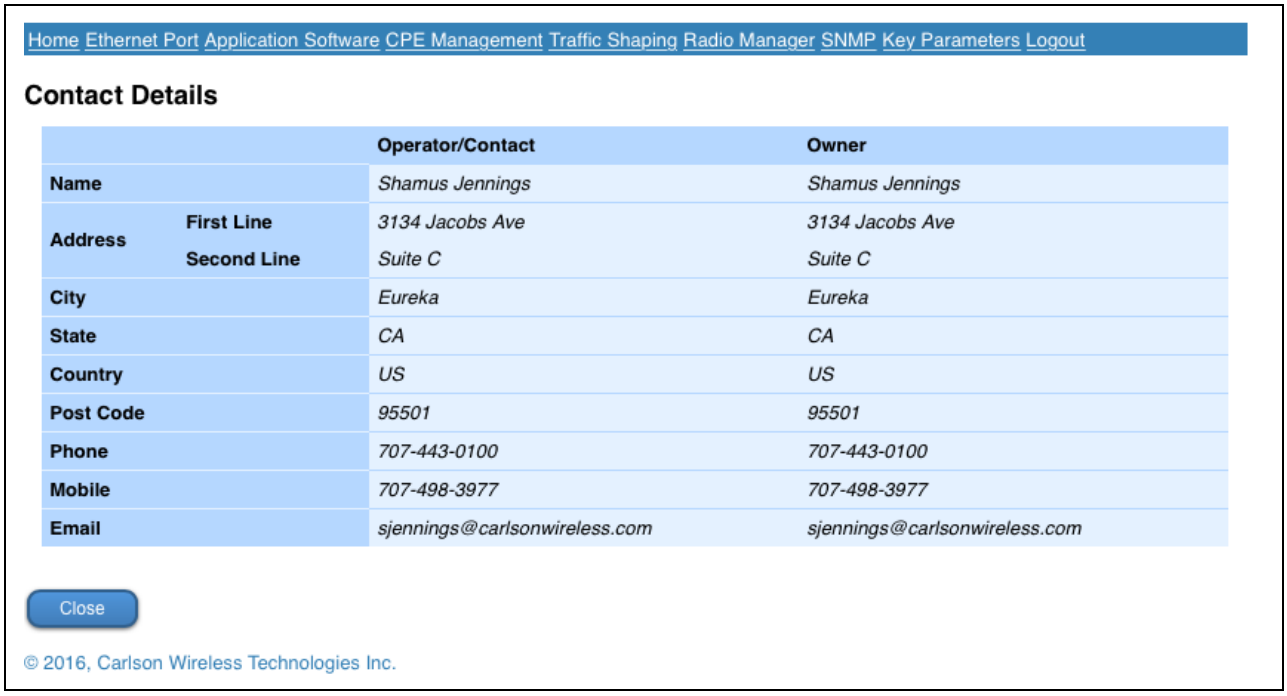

Figure 19: Base Station User Interface - Setup Contact Details for PAWS White Space Database (WSDB)

4.2.4. GPS Details

This page, accessed from the **Radio Manager** page, shows details of the operation of the GPS module. There is also provision for a manual override: tick the *Use* checkbox and enter a desired location in the **Latitude** and **Longitude** boxes.

At the bottom of the **GPS Details** page, the communications with the GPS module is shown. If there is nothing scrolling, verify the GPS antennas has a clear view of the sky. For assistance, contact Carlson Technical Support.

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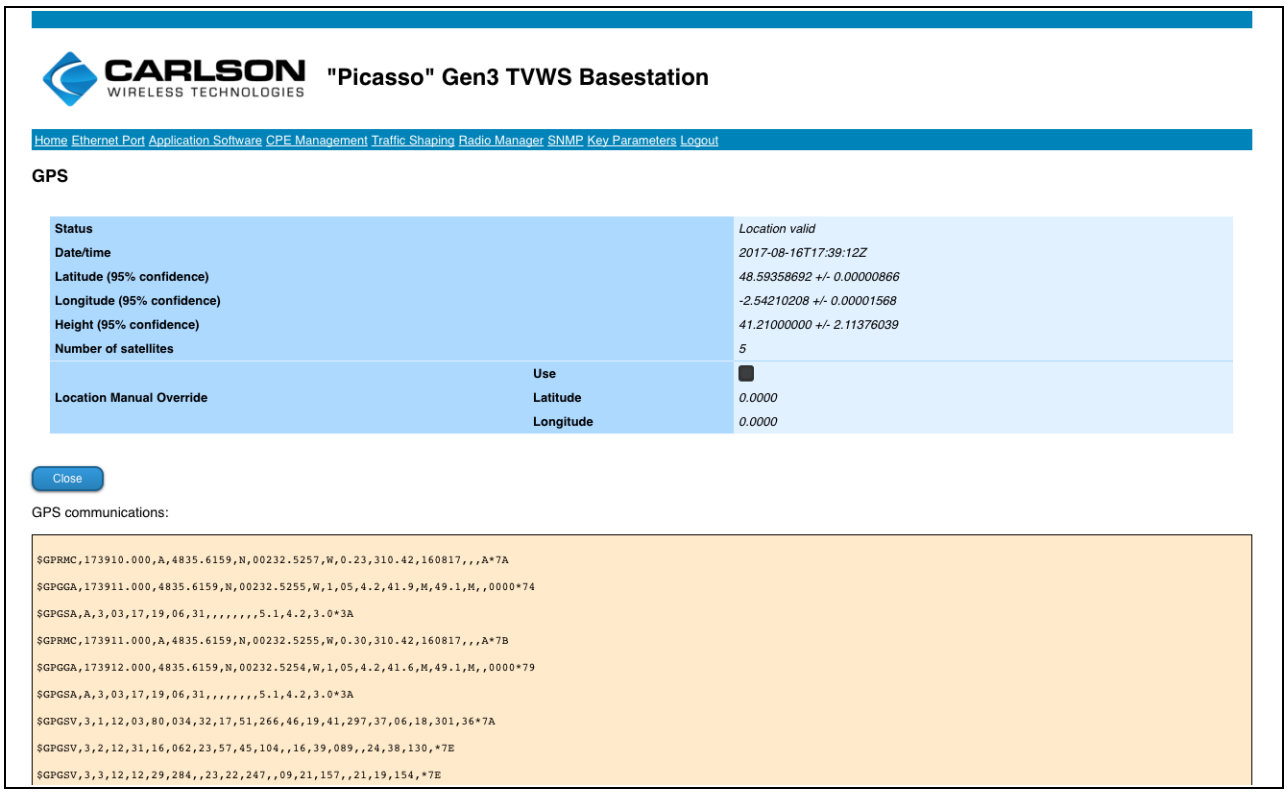

Figure 20: Base Station User Interface - GPS Screen

4.3. CPE Management

This is one of the most important Screens on the user interface. It shows details of the CPEs that are connected to the base station and allows their configuration, both before and after they connect.

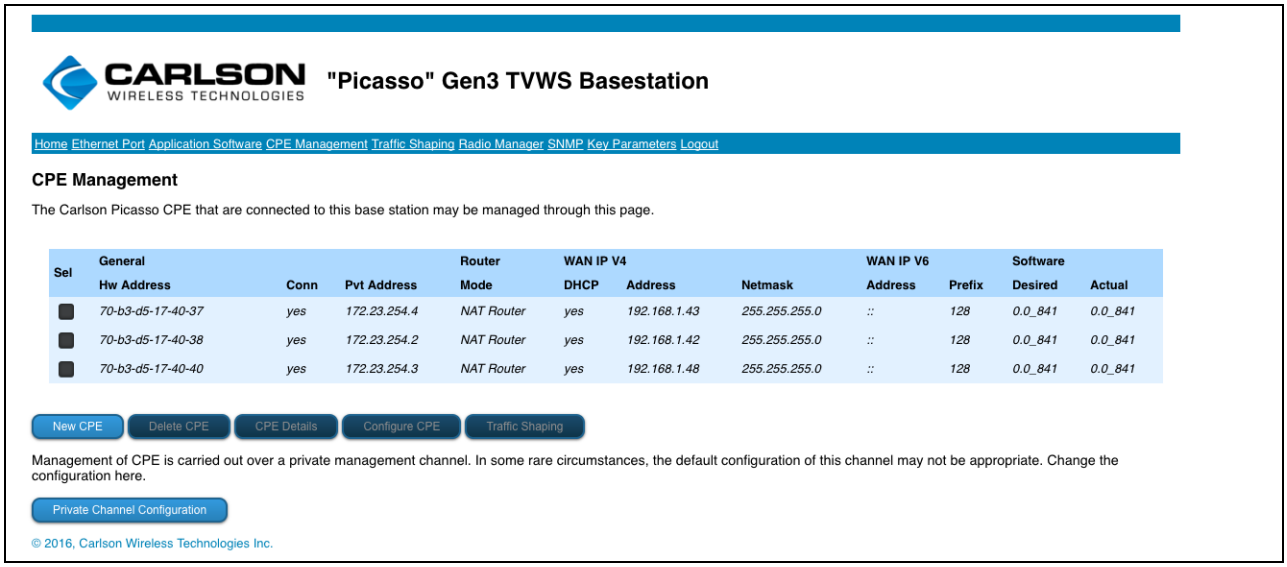

Figure 21: Base Station User Interface - CPE Management

The **CPE Management** page consists of a list of CPE that are connected and/or configured. The figure shows three connected and configured CPE.

A CPE can be pre-provisioned by clicking the “New CPE” button. This displays the **Edit CPE Configuration** page (described below).

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Enter the MAC address of the CPE (it is the MAC address that is used to globally identify CPE) along with other appropriate configuration.

A CPE can also be provisioned once it is connected. A CPE that is connected to the base station that does not have provisioning information will appear in the list without the configuration columns. Place a tick in that CPE's select check box and click the "Configure CPE" button. This will once again show the **CPE Configuration** page, although this time the hardware address will be filled in.

Placing a tick mark in the CPE's select check box and clicking *CPE Details* can access the same panel for an already configured CPE.

A CPE can be deleted by ticking its select check box and clicking the "Delete CPE" button. Confirmation is requested for this operation. If currently connected to the base station, the CPE will lose its configuration and disconnect.

Finally, the traffic shaping configuration for a CPE can be accessed by selecting the CPE and clicking **Traffic Shaping**. The operation of the traffic shaping system is described in a later section.

4.3.1. Edit CPE Configuration

This sub-page shows the configuration and status details of a selected CPE.

Hardware Address		*00-00-00-00-00-00*
Router	**Mode**	*NAT Router*
WAN IP V4	**DHCP Client**	☑
	Address	*0.0.0.0*
	Subnet Mask	*0.0.0.0*
	Default Gateway	*0.0.0.0*
	Primary DNS	*0.0.0.0*
	Secondary DNS	*0.0.0.0*
WAN IP V6	**Address**	*::*
	Prefix	*128*
Software	**Desired**	
	Actual	
Radio	**Channel**	*14*
	BSID	*70-b3-d5-17-40-02*
	Downlink Modulation	*256-QAM 5/6*
	Uplink Modulation	*256-QAM 5/6*
	Downlink RSSI	*0.0000*
	Uplink RSSI	*0.0000*
	Downlink PER (%)	*0.0000*
Location	**Has GPS**	☐
	Use GPS if available	☑
	Latitude	*0.0000*
	Longitude	*0.0000*
	Allowed to transmit	☑
	PAWS information	

Figure 22: Base Station User Interface - Setting up CPE Details

The first block on this page shows the CPE MAC address. This can only be changed if you are pre-provisioning a CPE before it connects.

Next is the Main Router mode. There are three modes: NAT Router, Router and Bridge.

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NAT Router	The most common operating mode of a CPE for IP version 4. This mode behaves in the same way as many domestic DSL routers. The CPE separates the network in the uplink direction (through the radio) from the network in the customer premises. The uplink network is called the WAN (Wide Area Network) and the customer premises network is called the LAN (Local Area Network). The LAN consists of any devices connected through the CPE's Ethernet or Wi-Fi. The CPE routes traffic between these two networks while performing address translation so that the WAN network only sees the CPE's WAN address and never sees any addresses from the LAN. In effect, the entire customer LAN accesses the wider network through a single IP address. The LAN must be configured from the CPE web pages.
Router	The CPE acts as an IP **router**. Much like the NAT router mode, the separation into WAN and LAN exists and the CPE WAN address is defined in the same way. The LAN however is assigned a routable subnet and LAN addresses that do appear on the WAN must be configured from the CPE web pages. In this mode, IP version 6 can also be configured.
Bridge	In **Bridge** mode, the CPE acts as a simple learning bridge. It operates in much the same way as standard network switches. The TV White Space (TVWS) radio, the WiFi and the Ethernet ports are all bridged together, transferring traffic between them according to the destination MAC addresses contained in the packets. Inspecting the source MAC addresses of packets as they travel through the system are how locations of addresses are learned. This mode is agnostic to whether the traffic is IP version 4 or IP version 6. The source and destination must still agree on which IP version they are using. The only configuration required in this mode is the selection of 'Bridge' for the 'Router Mode' parameter. The devices behind the CPE are on the same network as those behind the base station so they see DHCP servers, DNS servers, etc. automatically.

The WAN IP V4 block allows the CPE WAN IP version 4 addresses to be configured in **NAT Router** and **Router** modes. The WAN IP V6 does the same for IP version 6 addresses in **Router** mode.

The software block controls the software version the CPE is running. The desired version can be selected from those available on the base station. The actual version is the version the CPE is running now. If these are different, the BS will download the desired version to the CPE and instruct it to be run.

The radio block displays useful information regarding the state of the radio link connecting the CPE to the base station.

Finally, the location block shows the CPE location information that is being reported by its GPS module, along with the results of the request to the TV white space database to be allowed to transmit on the radio channel at the CPE's location.

4.4. Ethernet Port

The base station communicates with the wider area network through its Ethernet port. All the traffic that travels to and from the CPEs is passed through this port. In addition, the base station software itself can be accessed through this port and for this purpose it must be assigned an IP address. The **Ethernet Port** page allows the configuration of this address.

The factory supplied default is for this address to be acquired using DHCP from a server located on the wider area network. It is however, possible to change this through the **Ethernet Configuration** page. Follow the instructions on the page.

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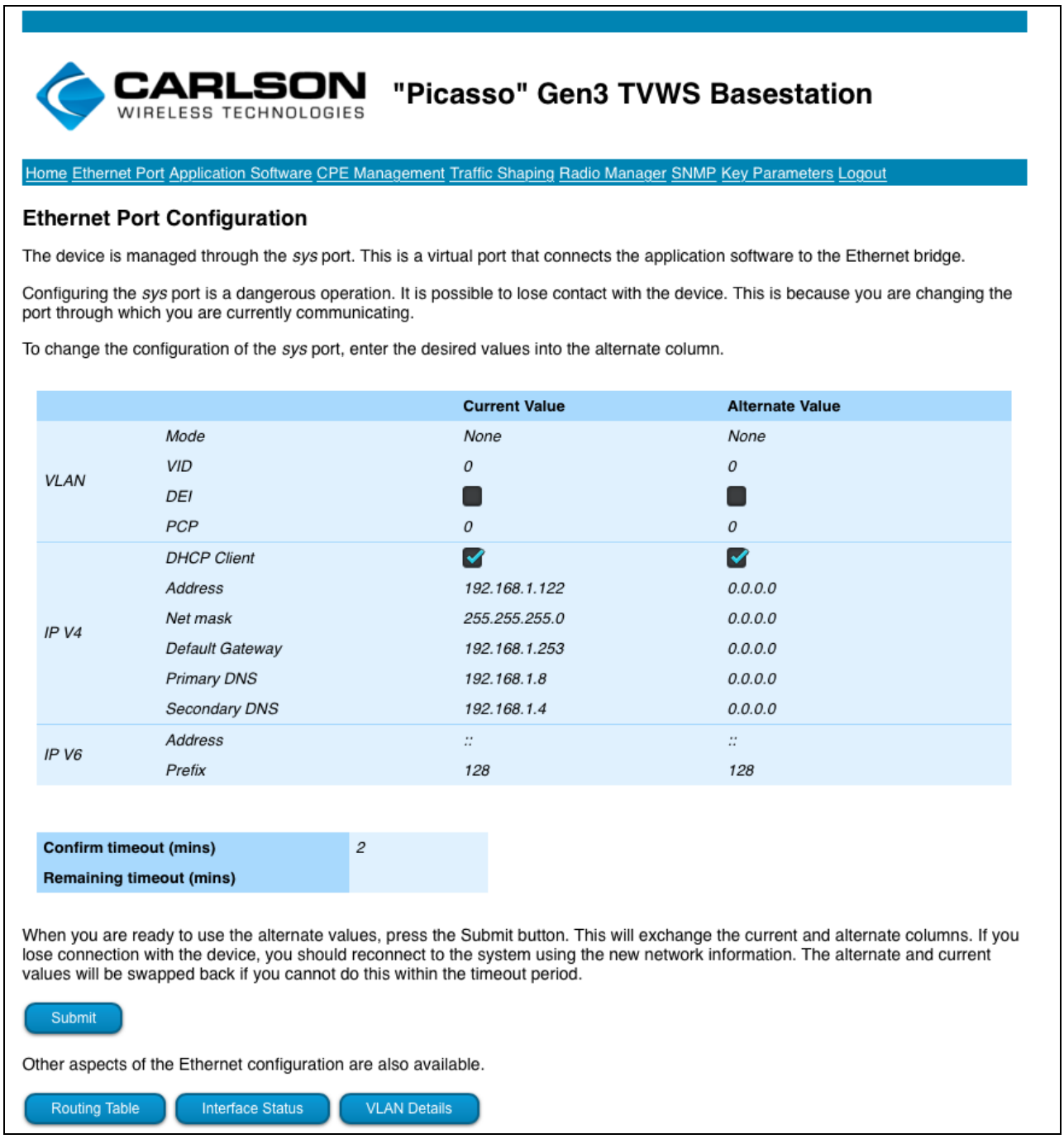

Figure 23: Base Station User Interface - Ethernet Port Setup Screen

In addition to the **Port Configuration** function, there are buttons at the bottom of the page that provide access to other Ethernet related Screens.

4.4.1. Bridge Routing Table

The base station contains a learning bridge that is used to route traffic between the Ethernet port and the radios. This page shows the Ethernet MAC addresses learned and ports to route Ethernet frames for each.

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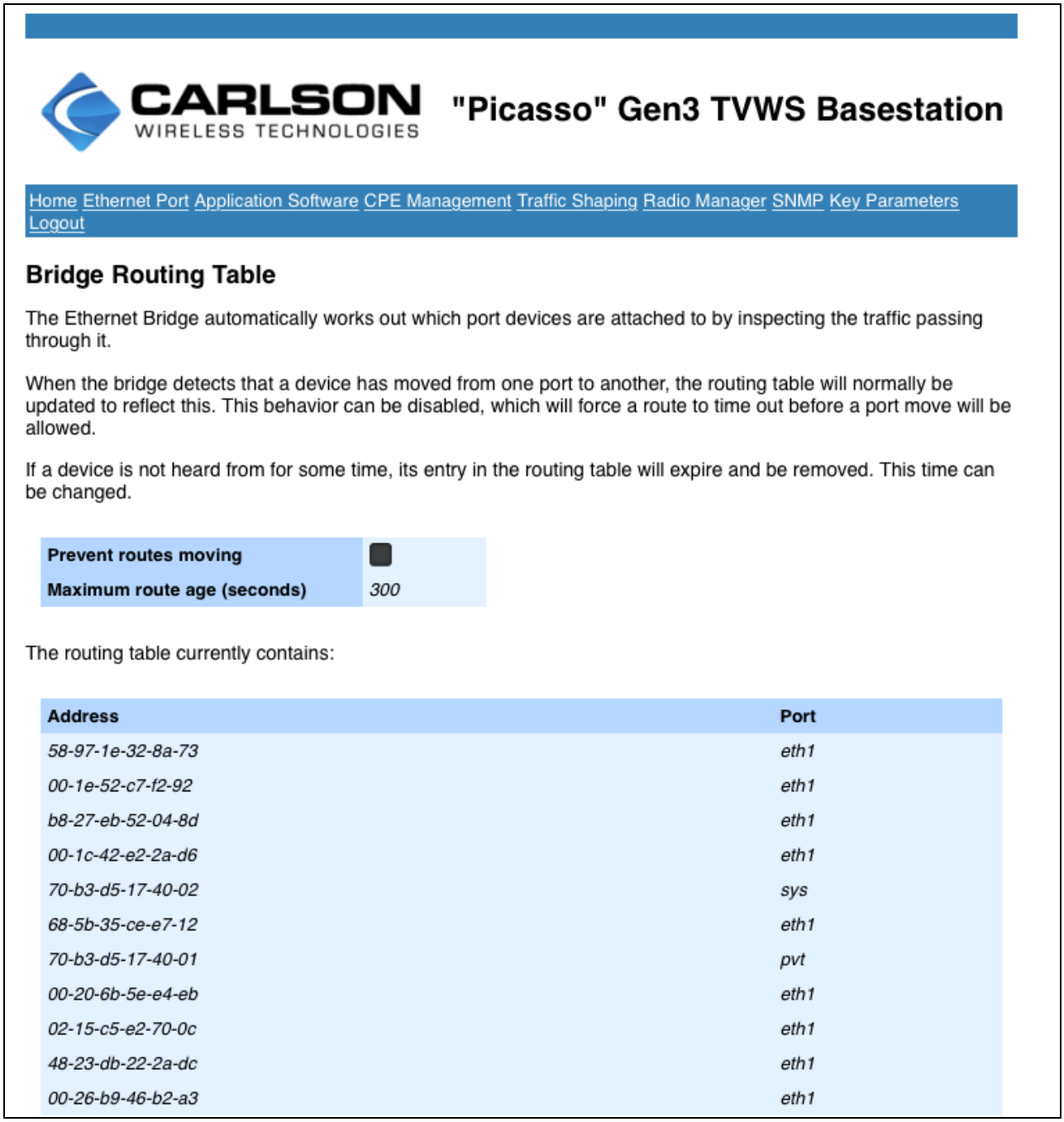

Figure 24: Base Station User Interface - Ethernet Port Bridge Routing

4.4.2. VLAN Details

The base station has basic support for 802.1q VLAN tagging. This sub-page allows the VLAN configuration of the Ethernet and radio ports to be specified. In addition, packet counts on each port are shown, which is sometimes useful for diagnosing issues.

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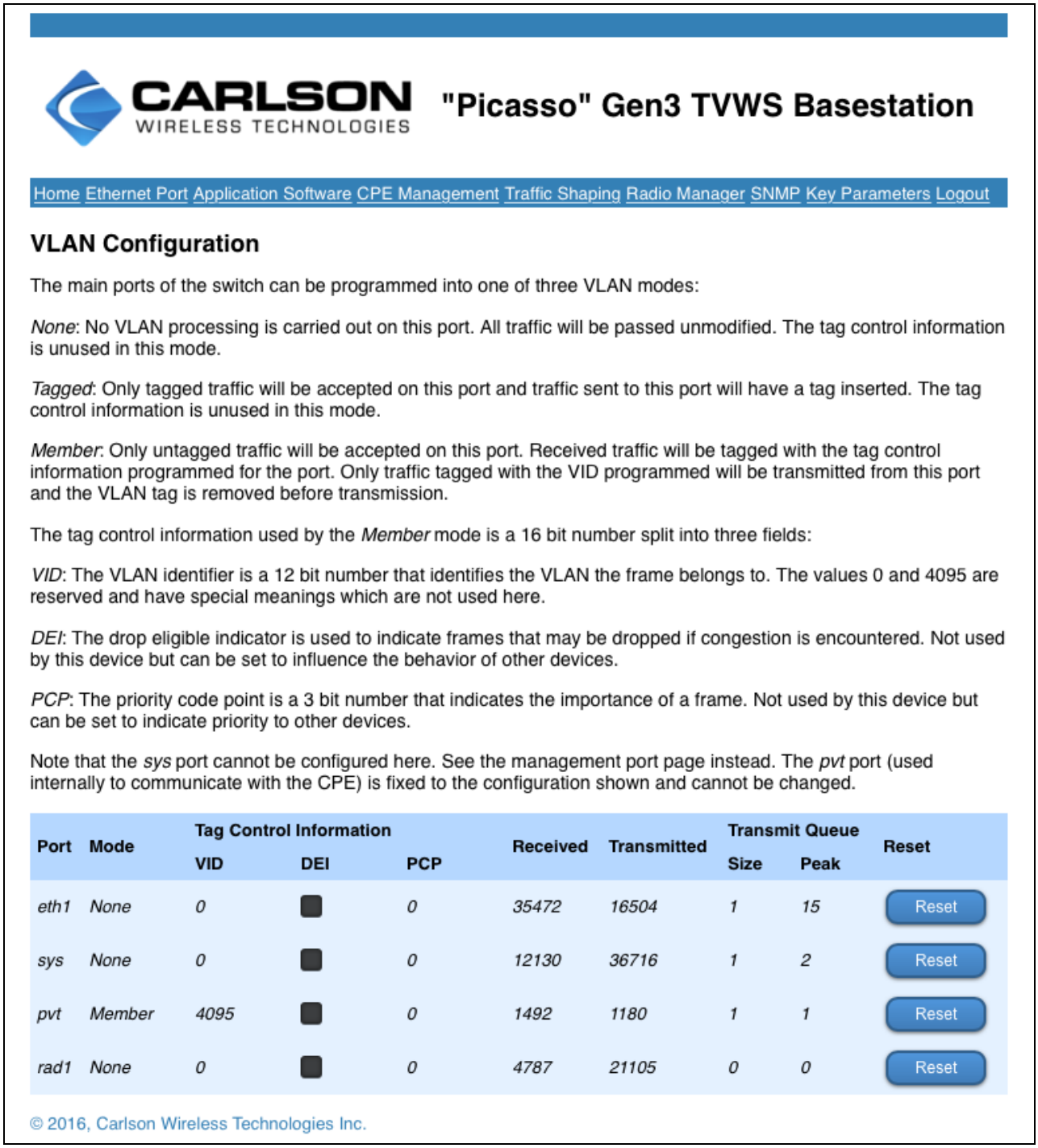

Figure 25: Base Station User Interface - Ethernet Port VLAN Settings

4.4.3. Interface status

The **Interface Status** sub-page indicates the connection state and speed of the Ethernet connection.

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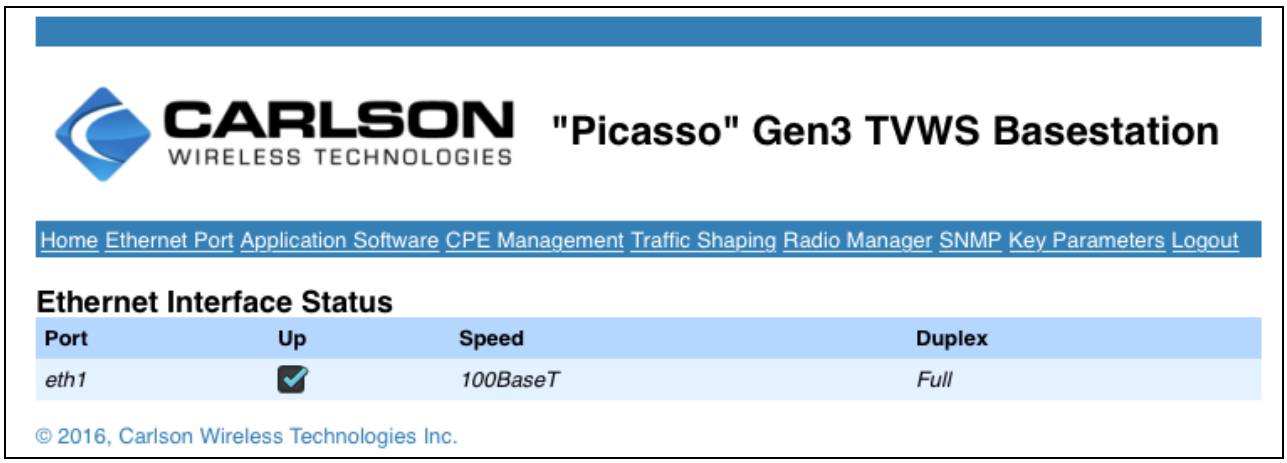

Figure 26: User Interface Ethernet Interface Status

4.5. Traffic Shaping

The base station and CPE together provide a traffic shaping scheme that allows individual CPE (and in router and bridge modes, individual devices behind the CPE) to be assigned maximum and committed information rates (MIR and CIR) in both the downlink and uplink directions. This is controlled by configuration contained in the base station. The downlink control is performed by the base station, while the uplink is performed by the CPE.

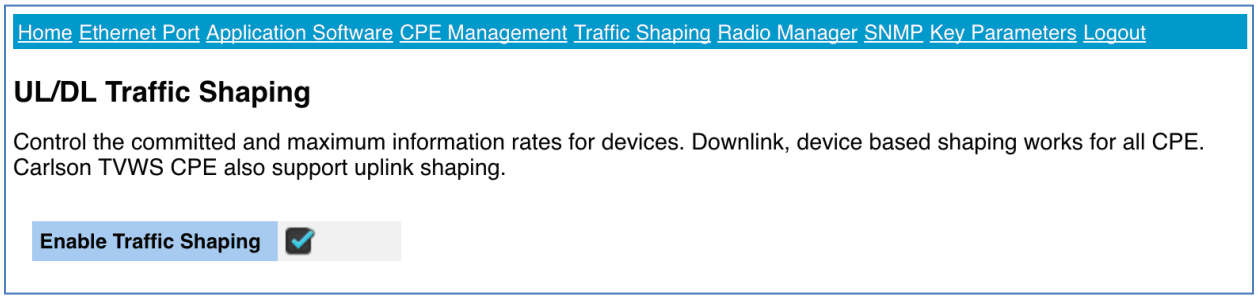

Figure 27: Base Station User Interface - UL/DL Traffic Shaping

The first step in configuring traffic shaping is via the **Traffic Shaping** page. Here, the classes of shaping that are to be available are defined. A traffic shaping class specifies the MIR and CIR in both the uplink and downlink. The “New Class” button will create a new class with some defaults. The “Delete Classes” button will delete the selected classes. The name and bit rates may all be changed.

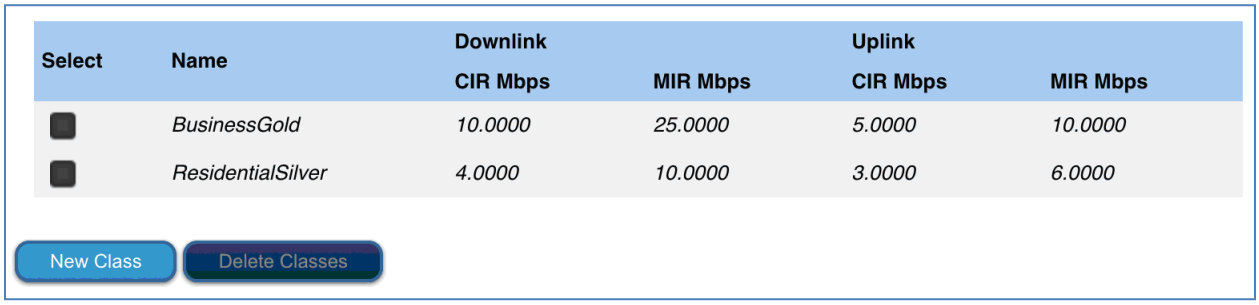

Figure 28: Base Station User Interface - UL/DL Traffic Shaping Classes

The bottom of this page shows a list of devices that the base station is going to enforce MIR and CIR for. This will get populated automatically once classes have been assigned to CPE devices.

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Device MAC	Downlink CIR (Mbps)	Downlink MIR (Mbps)
No devices defined		

Figure 29: Base Station User Interface - UL/DL Traffic Shaping Device List

The second step is to assign classes to CPE devices. This is done through the **CPE Management** page. Go there, select the desired CPE and click the "Traffic Shaping" button.

Clicking "New Device" on this page will create a new shaping device, whose MAC address will default to the CPE MAC address. If the CPE is operating in NAT router mode this is the only device shaping can work with, otherwise change this to the MAC address of the device on the CPE's LAN. Then select the class this device is to conform to.

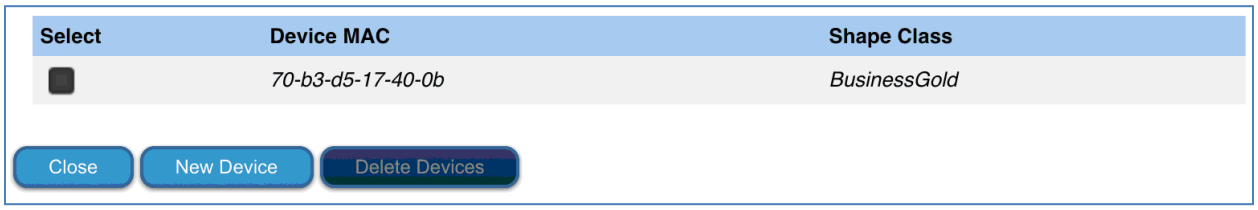

Figure 30: Base Station User Interface - CPE Traffic Shaping Screen

If you now return to the main **Traffic Shaping** page, the device list at the bottom will now show an entry.

Device MAC	Downlink CIR (Mbps)	Downlink MIR (Mbps)
70-b3-d5-17-40-0b	*10.0000*	*25.0000*

Figure 31: Base Station User Interface - Traffic Shaping Confirmation Screen

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4.6. SNMP

The base station supports element management systems that communicate using SNMP version 1 or 2. This page allow configuration according to your SNMP management plan.

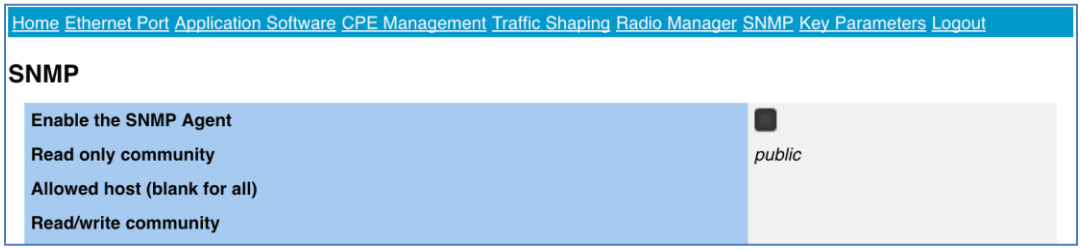

Figure 32: Base Station User Interface - SNMP Setup Screen

4.7. Application Software

The **Application Software** page reports the current version of software running on the unit. The base station can store two versions of the application, one of which is currently running.

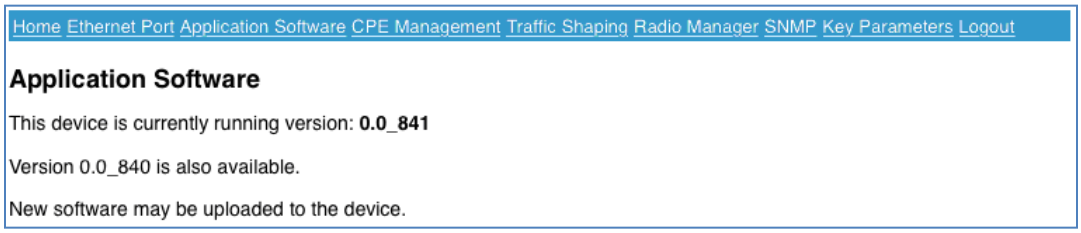

Figure 33: Application Software

Follow the instructions on the page to upload a new version and reboot to run it.

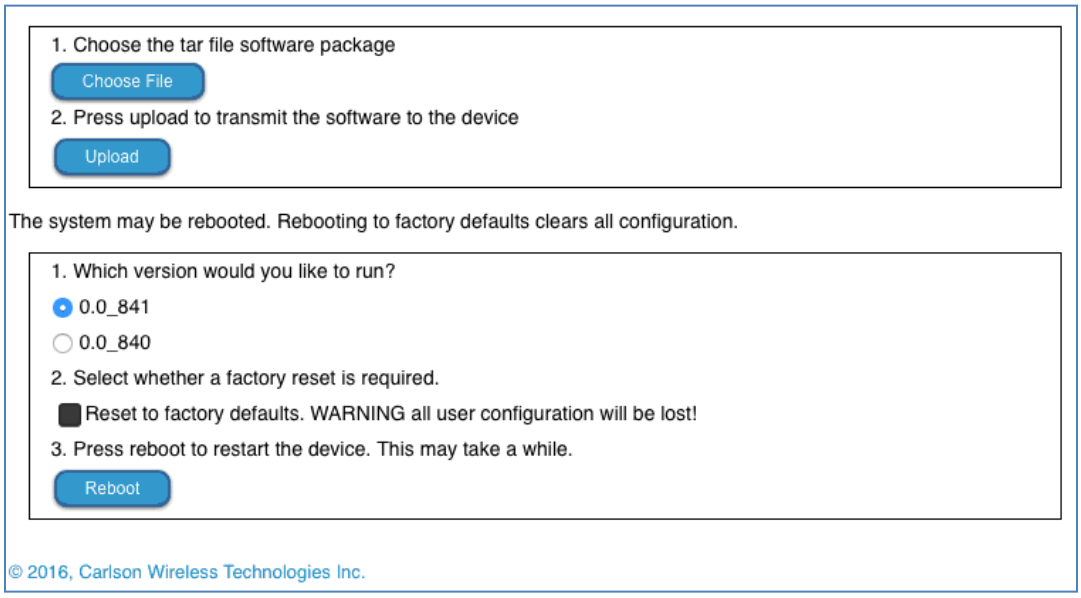

Figure 34: Base Station User Interface - Software Selection Screen

An application load contains software that runs on the base station, as well as software that runs on the CPE. CPE software is controlled via the **CPE Configuration** page.

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4.8. **Key Parameters**

The base station collects statistical information from various sources while running. This information is available for view and download on the **Key Parameters** page.

Users can choose what information is displayed on the live graph by placing tick marks against their desired items. The selected items are allocated a color and then shown in the graph area.

The sample period can be configured. However, be aware that the CPE information is only transferred from the CPE to the base station roughly once every 10 seconds, so higher sample rates for these parameters make little sense.

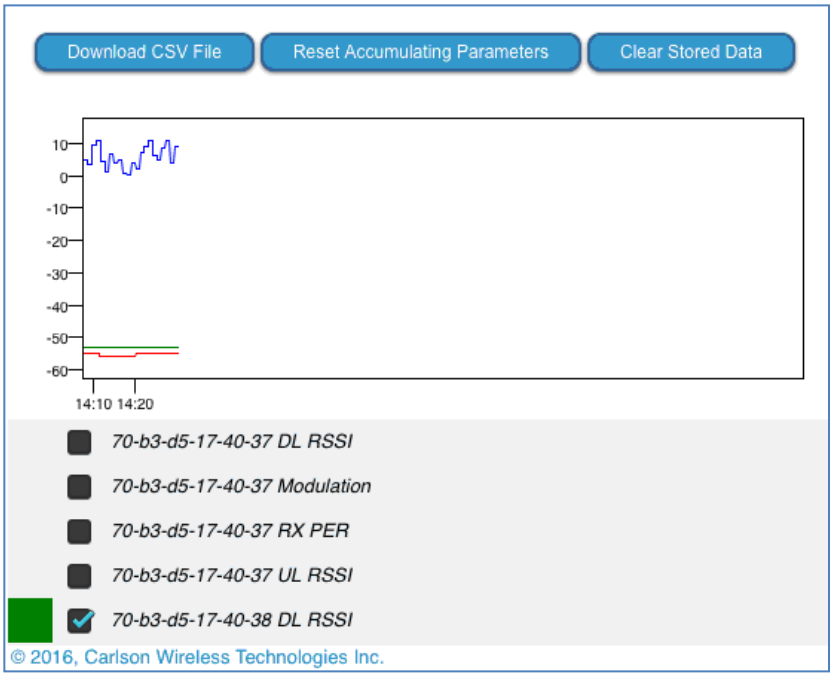

Figure 35: Base Station User Interface - Key Parameters Logging

Clicking the “Download CSV File” button will download a comma-separated values file containing the parameters from your browser. This file can then be loaded into Excel or similar programs.

Some of the parameters that are available accumulate. For example, the packet count for the Ethernet port. The “Reset Accumulating Parameters” button will reset these parameters back to zero.

The “Clear Stored Data” button deletes all samples the base station has collected and starts the collection again.

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5. CPE User Management Interface

The CPE provides a similar set of web pages as the base station to allow local monitoring and configuration. Setting a CPE up and connecting a browser to it is a little different.
The factory default state for the CPE Ethernet port is a fixed IP address of 192.168.2.1 and subnet mask of 255.255.0.0. Configure a PC Ethernet port for another address in this subnet and connect an Ethernet cable directly from the PC to the CPE Ethernet port. Open a browser on the PC and enter the URL “https::/192.168.2.1”. This should bring you to a similar login page to the base station (after the same issues with the browser and the self-signed certificate).
The default username and password is the same as for the base station. Username is “Admin” and password is “Admin.” Once you successfully log in, you will arrive at the **Home** page.

5.1. Home Page

The CPE **Home** page contains some top-level information about the CPE along with the “User Accounts” button. User accounts are managed in the same way as the base station, as described in section 4.2.1.

Figure 36: CPE User Interface – Home Screen

5.2. LAN Configuration

The configuration of the LAN port is carried out in a similar manner to the base station’s Ethernet port. Usually, the CPE is the router device on the LAN, so it will be configured with a static IP address, often “.1” in the desired subnet. If the CPE is configured by the base station for bridging mode, the LAN configuration is ignored, and the CPE’s WAN address will be accessible through the LAN port. To change the configuration, follow the instructions on the Screen.

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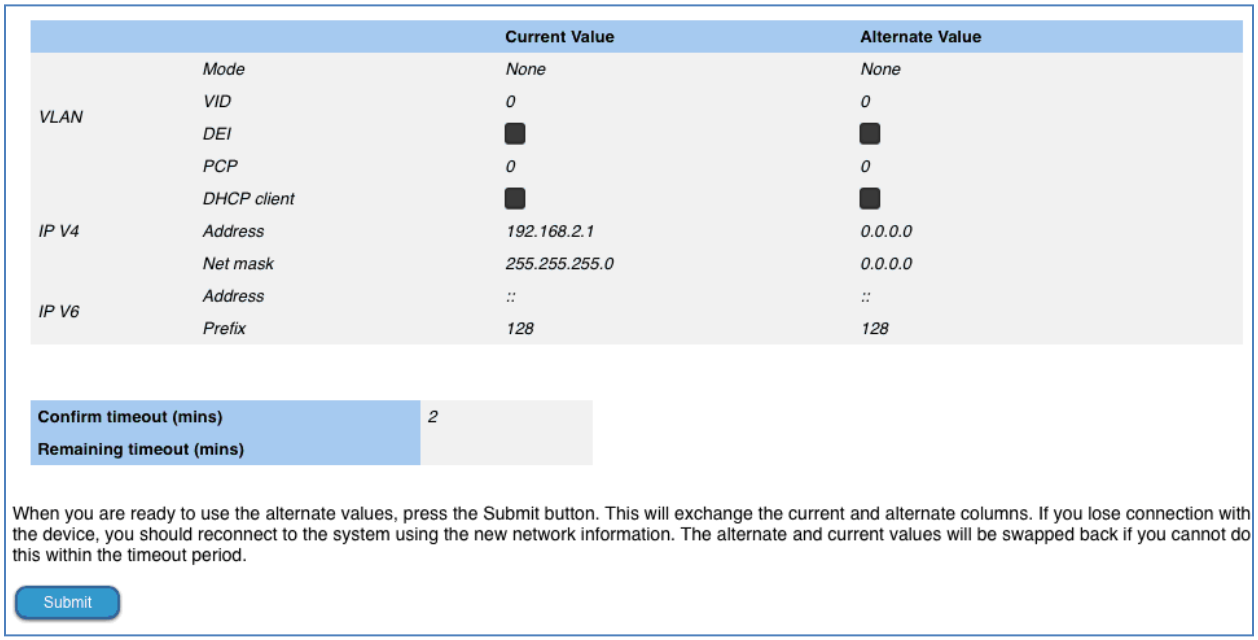

Figure 37: CPE User Interface – LAN Configuration Screen

LAN Configuration Buttons - CPE

The page also has buttons for the **Routing Table** (see 4.4.1), **Interface Status** (see 4.4.3) and **VLAN Details** (see 4.4.2); all identical in operation to the base station. Finally, there is a button for the **DHCP Server**.

Figure 38: CPE User Interface - Additional LAN Configuration Options

5.2.1. DHCP Server

The CPE provides a DHCP server that can be configured to supply IP addresses to devices on the LAN in NAT Router and Router modes. This feature is disabled in Bridge mode; the central DHCP server on the WAN will be available in this case.

The first part of the page allows the user to define the range of addresses that can be allocated. Make sure the range of addresses is in the same subnet as the CPE LAN port address, but that the LAN port address is not actually in the range. The lease period is usually 86,000 seconds (just under 24 hours).

The second part of the page lists the addresses that have currently been allocated by the DHCP server.

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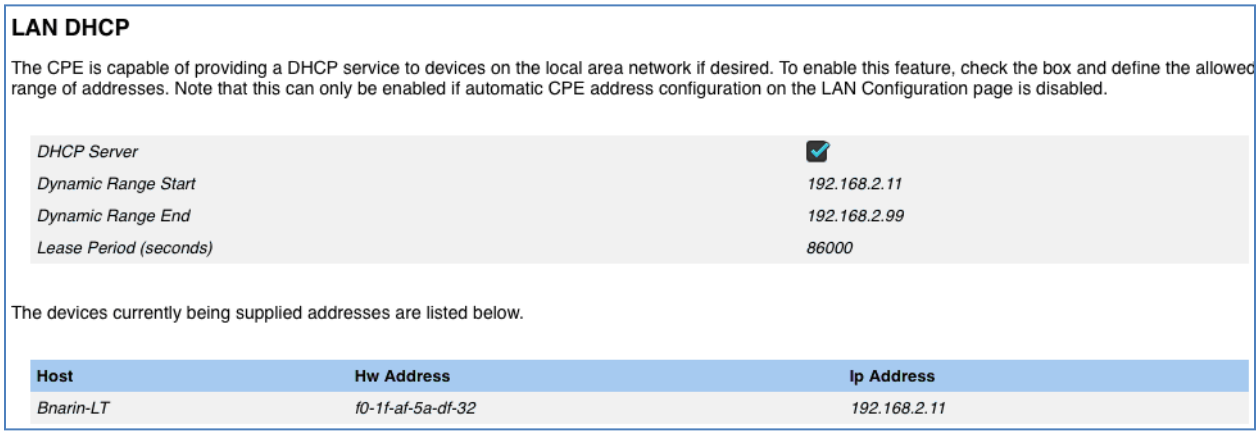

Figure 39: CPE User Interface – DHCP Server Screen

5.3. Traffic Shaping

The traffic shaping system is controlled by the base station, as described in section 4.5. The traffic shaping page on the CPE shows the devices that the CPE will shape the traffic for in the uplink for diagnostic purposes.

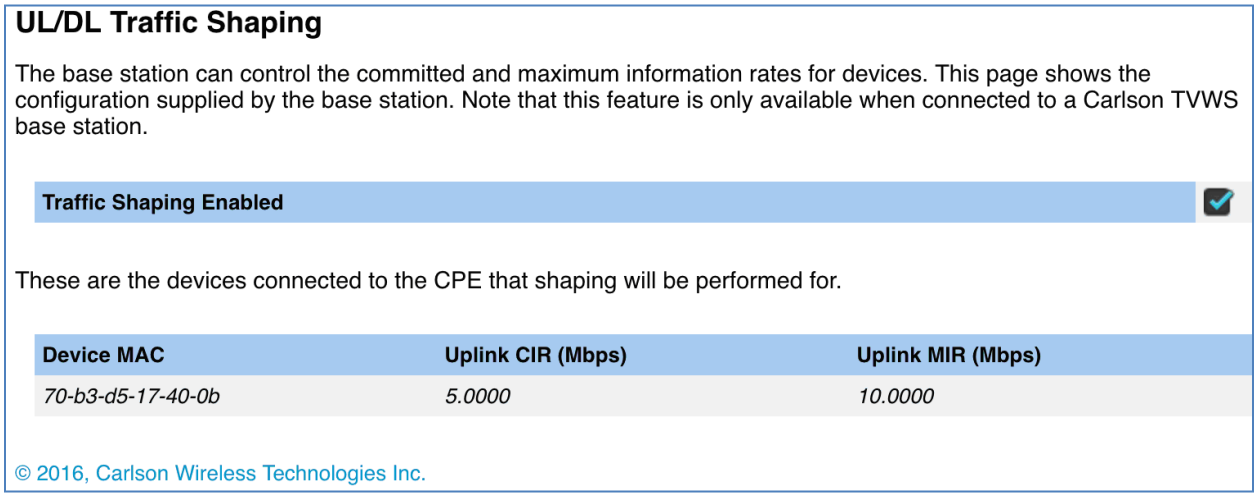

Figure 40: CPE User Interface – UL/DL Traffic Shaping

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5.4. TVWS Status

The CPE radio's status is monitored through the **TVWS Status** page. The few items of radio configuration are also on this page. The main ones are the SSID and Passphrase, which must match the base station configuration.

Part of the acquisition sequence the CPE goes through is a survey of available channels. The results of this are shown near the bottom of the page.

Finally, there is a "GPS Details" button that shows the state of the on-board GPS module. This page is identical to the base station.

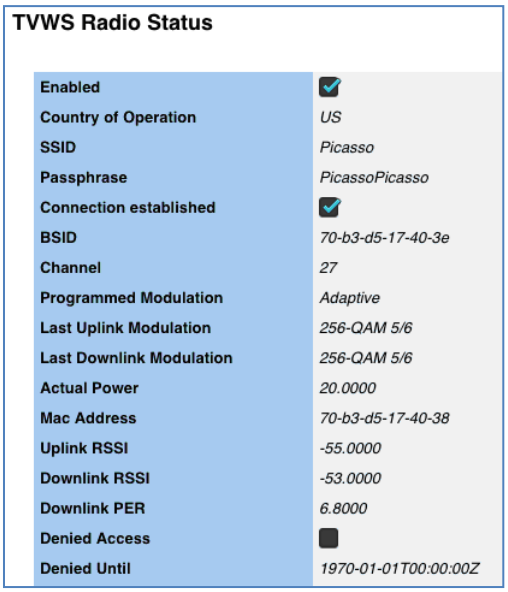

Figure 41: CPE User Interface – Radio Status Screen

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6. Field-Testing and Installation

6.1. Professional Installers

RuralConnect® radios and antennas can only be installed by professionally trained personnel.

6.2. Antenna Height and RF Exposure Warnings

RuralConnect® installations must adhere to all local, state, and federal regulations. Failure to follow those guidelines could result in costly fines, damage to the equipment, and/or inadequate RF protection for end users. Per ETSI regulations, antennas used with fixed TV Band devices may not be more than 30 meters above ground level, or 250 meters above average terrain. All persons are required to maintain at least a 40 cm distance from the device; additional hardware may be required to ensure that separation. All regulatory compliance requirements related to the installation and operation of RuralConnect® devices are the sole responsibility of the operator.

6.3. Outdoor Unit (ODU)

RuralConnect® Gen3 radio uses external antennas that operate over the entire UHF band (470 MHz to 790 MHz). Speak to your Indigo Sales Representative about the antenna selection available.

Clients connect to a Base Station via a UHF radio signal. Due to the unique propagation characteristics of signals in the UHF band, good connections are generally possible even if there is a non-line-of-sight path to the Base Station. Once a link to the Base Station is established, clients provide local network access via a standard Ethernet connection.

The top plate of the ODU has one or more RF ports, while the bottom plate has an Ethernet port. Client Stations also have LEDs to indicate signal strength.

Figure 42: Pole-mounted RuralConnect® Gen3 Unit

6.3.1. Mounting the ODU

Installers will use pole/wall mounting kit (part #: 900-7220) to install the RuralConnect® ODU. Most installs will mount the unit directly behind or below the antenna, with grounded inline surge protection.

The mounting bracket allows installation using poles with a diameter up to 50mm.

Using the 900-7220 mounting kit, follow the below instructions for pole mounting the RuralConnect® ODU:

1. Attach the mounting flanges to the enclosure using the 10-32 x 20mm" Bolts, and Nylock® hex nuts.
2. Tighten the hex nuts to a maximum of 2.71Nm. **Do not over tighten!**
3. Position the enclosure on the pole.
4. Place the U-Bolts around the pole and slide the pipe flanges over them with the serrated sides facing the pole.
5. Apply an anti-seizing compound to the threads of the U-Bolts.
6. Slide the mounting flanges (now attached to the enclosure) over the U-Bolts and secure those using the 8mm lock washers and 8mm hex nuts.
7. Tighten the 8mm nuts. **Do not over tighten!**

Figure 43: ODU Mounting Kit

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6.4. RuralConnect® Antennas

The following ETSI - authorized antennas are available for use with the RuralConnect® in the United States. Currently, no other manufacturer produces antennas authorized for use with the RuralConnect®. For 360-degree coverage, you will use three (3) 120-degree Carlson Sector Antennas (model # 053-470-786-75-8), each connected to one of the three Base Station radios. For the Client Station, you will use the Carlson Log Periodic Antenna (model # 057-470-786-8-F).

6.4.1. Base Station Sector Antenna

The RuralConnect® Sector Antenna (model # 053-470-786-75-8) includes a female F-type connector and heavy-duty mounting bracket (part # 920-7215) for mounting to a pole with a diameter up to 55mm.

Model Number	053-470-786-75-8
Antenna Type	2-Bay sector
Beam width	120 degrees
Polarity	Vertical
Antenna Connector	“F” type female 75 Ohms
Frequency Range	470-790 MHz
Gain	8 dBi
Weight & Dimensions	3.6Kg – 24cm x 43cm x 25cm
Mounting Kit Part #	920-7215
Pole Mast	25mm – 55mm

Table 1: Sector Antenna Specifications

Mounting Sector Antenna

Using the 920-7215 mounting kit, follow these instructions for pole mounting the Sector Antenna:

1. Attach the mount plate
    a. **Place the U-bolts around the bottom section of the antenna** and place the mount saddles over them the curved side facing the antenna.
    b. Keeping the mount plate perpendicular to the antenna, slide the U-bolts into the mount plate and fasten them using the 6mm flat washers and Nylock® nuts. **Do not over tighten!**

2. Attach to mounting pole:
    a. Place the V-bolts over mounting pole and slide the V-clamp pipe flanges onto the bolts with the serrated sides facing the pole.
    b. Apply an anti-seizing compound to the threads of the V-bolts.
    c. Slide the V-bolts into the antenna mount plate and fasten them using the 8mm flat washers, lock washers and nuts. **Do not over tighten!**

6.4.2. Client Station Log Periodic Antenna

The log periodic directional antenna (model #: 057-470-862-10.5-F) includes a female F-type connector and a heavy-duty mounting bracket for mounting to a pole with a diameter up to 60mm.

Below are the specifications for the log periodic antenna:

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Model Number	057-470-862-10.5-F
Antenna Type	Log Periodic
Polarity	Vertical or Horizontal
Front-to-back-ratio	36 dB
Return Loss	-15 dB
Beamwidth (-3 dB)	+/- 28 degrees
Maximum Mast Diameter	60 mm
Antenna Connector	“F” type female 75 Ohms
Frequency Range	470-862 MHz
Gain	10 - 11 dBi
Weight & Dimensions	1kg – 38cm x 35cm

Table 2: Log Periodic Directional Antenna Specifications

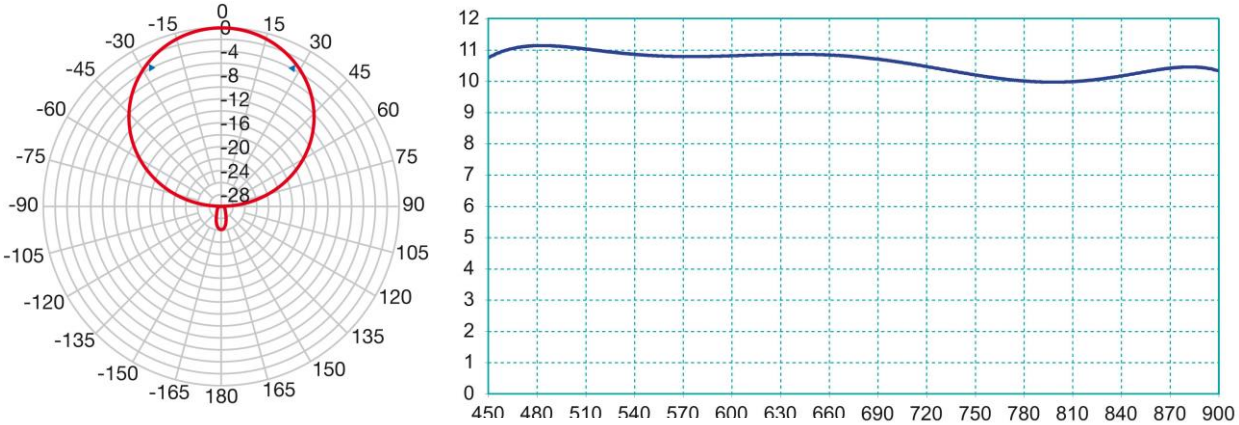

Figure 44: Log Periodic Direction Antenna Radiation Pattern and Gain Chart

Mounting Log Periodic Antenna

Installers mount the log periodic antenna with the elements vertically aligned. Use the included pole mounting kit and instructions.

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6.5. **Weatherproofing RF Connections**

Once you have mounted and secured your antenna, we recommend completing the installation by properly weatherproofing the RF connector. The connector must be waterproof, durable, and easy to remove/service. You will need:

- Vinyl/electrical tape
- Rubber (butyl) tape, a thick, sticky sealing tape, commonly known as “vapor wrap.” We recommend 3M 3339 tape.

Step 1: Connect Cable Assembly to Antenna or Enclosure

Attach the RF cable F-type male connector to the F-type female connector of the antenna or enclosure. Ensure connections are clean and dry, then hand-tighten the connector firmly.

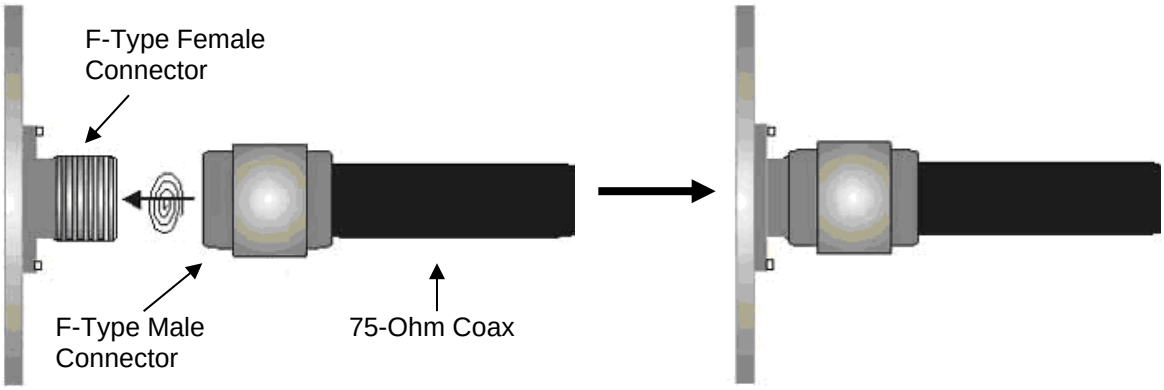

Figure 45: Step 1: Securing RF Cable to Radio or Antenna

Step 2: Seal the Connector Assembly

Tightly wrap the connectors with one layer of electrical tape and extend 15mm beyond the F-Type male connector. This step is highly recommended, as it will make removal of the weatherproofing faster, easier and cleaner.

Tightly wrap the connectors with two layers of butyl tape. Note: The butyl tape should seal entire connection and extend 40mm beyond the F-Type male connector (25mm beyond electrical tape). It is important to cover all of the underlying electrical tape, or water could creep in underneath the vapor wrap.

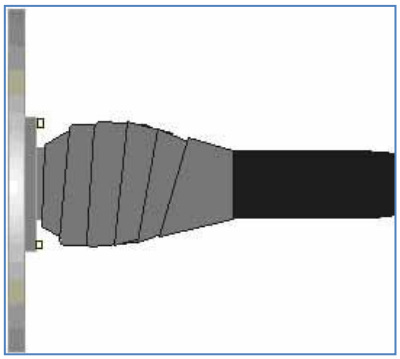

Figure 46:Step 2: Seal the Connector Assembly

Step 3: Cover Rubber Tape with Electrical Tape

Tightly wrap the rubber tape with two layers of electrical tape to protect the vapor wrap. The electrical tape should extend 25mm beyond the vapor wrap to ensure full coverage. You can easily remove the weatherproofing by cutting down one side of the wrap and peeling it away.

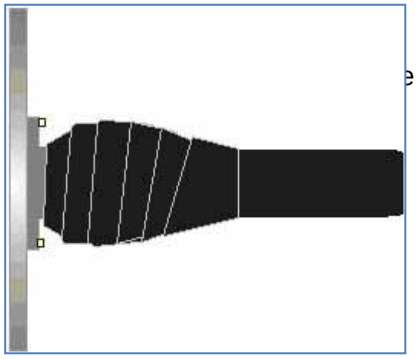

Figure 47: Step 3. Covering Rubber Tape with Electrical Tape

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6.6. **Antenna Alignment**

Omni-Directional Base Station Antenna

While Omni-directional antennas do not require alignment, you must consider placement concerns. Avoid mounting adjacent to a metal object when possible. When mounting to the side of a tower, always use a standoff of one meter or more. Place the mount toward the top of the standoff pole.

For cabling, always mount securely near the antenna and use a small jumper coax cable to avoid tension on the antenna connections. Always use cable service loops to mitigate water damage and allow slack for future service.

Client Station Antenna

The available log periodic antenna allows simple mounting and alignment. This antenna is vertically aligned (elements perpendicular to the ground). The CPE antenna has a horizontal beamwidth up to 28 degrees. In most conditions, simply powering up the radio with an attached antenna will provide enough signal strength to establish a link with the Base Station.

Initial Antenna Alignment

While you do not need line of sight between radios, careful alignment will ensure maximum performance. Here are several methods that have worked for installers:

Aim towards the Base Station antenna.

Plot out the path on a topographical map and set the antennas using a compass

In non-line-of-sight installations, the signal will be travelling around obstructions. Aim the CPE antenna toward the nearest clearing next to/between obstructions.

How closely aligned do the antennas need to be? With the wide beam width of the log periodic antenna, rated performance can be achieved at +/- 28 degrees, while best performance can be achieved at +/-5 degrees.

Receive Signal Level Indicator (RSSI) Lights (on new models)

The CPE has RSSI LEDs on the bottom of the enclosure to help the installer align the CPE antenna during testing and installation. The “sweet” spot is usually between two points where the LEDs indicate a lower signal. For example, if you see two solid lights both at 270-degrees and 180-degrees, but the third light comes on between both points, your best signal will be around 225-degrees.

Precision Antenna Alignment & Performance Testing

Network performance fluctuates naturally with link performance. In short, you can test and find the best performance with the best antenna alignment. Try a continuous round-trip latency/ping test. To perform this test in Windows, open a command prompt and send the command “ping -t {ip address}”. For the IP address, use a network device at or near the Base Station. Align the antenna until you find the lowest, most consistent ping times.

Test the link throughput using your speed test of choice. Run this test three or more times and note the results. Move the CPE antenna a few degrees askew and test again. Skew the antenna the other direction a few degrees and test again. Keep performing these tests until you find the antenna alignment that provides the best network performance.

Management Interface Signal Level Values

Over a longer period, the web interface will provide you with averaged/time-lapsed information about the signal level of each link as it fluctuates. During deployment, you may find in some cases stronger signals (more lights) in multiple directions. During alignment, the uplink signal (not indicated on the

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LEDs) will be different between these points. The web interface can help you determine if the antenna needs to be realigned for an improved uplink.

6.7. Interference Solutions

Interference problems can arise with external devices installed near the antenna or radio, including external devices later installed. External interference can adversely affect the operation of a RuralConnect® TV White Space Radio, to the extent that the link is unusable.

To determine if a RuralConnect® is interfering with other equipment, power down the unit and check the other device(s) for interference issues.

Though less common, to determine if an external device is interfering with the RuralConnect®, shut down suspected devices while streaming audio or video over the link, or just run and monitor a continuous ping to a website. For the latter, open a Windows command prompt and run command "ping -t {ip address}."

Before calling Technical Support, the installer is encouraged to try correcting the problem by trying one or more of the following suggestions:

- Relocate the offending/offended device,
- Reorient or relocate the antenna to a new position,
- Change the frequency of the radio or offending device,
- Separate the power sources, or filter sources between the offenders,
- Use RF "trap" filter(s) to isolate interference from specific channels
- If you are not a professional installer, consult with the dealer, service provider or other experienced technician

6.8. Surge Protection

6.8.1. RF Lightning Protection

The most common source of damage to wireless products is lightning-induced power surges. These surges attribute to almost all wireless equipment failures in the field. A lightning strike generates tremendous currents whenever it touches down. These currents travel through towers, pipes, telephone wires, power wires, trees, lakes, rivers, and the ground.

The installer is responsible for the installation of proper surge protection on the power, data, and antenna lines.

For protecting the radio from power surges, Carlson stocks both coaxial and POE lightning surge suppressors as primary lightning protection. These are optional items, sold separately and included in all general system quotes.

In-line protectors mount in series with the coaxial cable, data or power line, which provides an excellent solution for a retrofit application. The installer will ground the protector using the external ground screw attached to the body of the surge protector.

6.8.2. Antenna Port Protection

Normally mounted high on a tower, antennas are subject to lightning surges when lightning strikes. Alternately, lightning can strike near a tower, and a momentary potential difference of thousands of volts can exist between the tower ground and other nearby ground systems, causing current surges through ground and antenna wiring.

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To protect against these current surges, Installer must use a coaxial lightning protector in the antenna line as primary protection. The RF Lightning Suppressor is often installed near the RF antenna port and/or the grounded antenna entry point of the building (or outdoor cabinet). The available shorted stub protectors are reliable and capable of protecting against powerful surges.

Ground the RF Lightning Suppressor by connecting a ground wire (usually #8 AWG solid) to the ground screw on the body of the surge protector. The other end of the ground wire must tie into the tower ground system or other verified earth ground. You must seal in-line lightning protectors from moisture, which can enter them through the grounding screw. Carlson recommends wrapping the lightning protector with butyl tape as the other RF connectors.

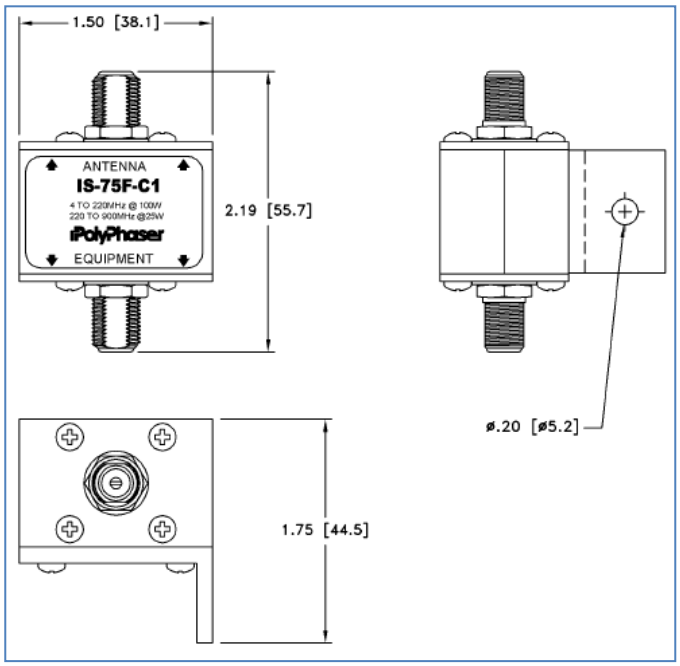

Figure 48: Base Station RF Surge Protector Diagrams

High-Value Base Station RF Surge Protector

Carlson Part Number	650-6560
Surge Rating	50 kA IEC 61000-4-5 8/20 us waveform 500 J
Turn-On	+/- 20%
Turn-On Time	2.5 ns for 2 kV/ns
Power	HF 100W, VHF 100W, UHF 25W
Frequency Range	4-900 MHz
VSWR	<= 1.2:1 over frequency range
Insertion Loss	<= 0.2 dB over frequency range
Temperature	-45 C to +85 C storage/operating +50 C

Table 3: High-Value Base Station RF Surge Protector Specifications

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CPE RF Surge Protector

Carlson Part Number	640-6565
Frequency Range	5-1000 MHz
Insertion Loss	<1 dB
Return Loss	>18 dB
DC Breakdown Voltage	120 min, 297 max
Surge Current (10 Operations 8/20µS)	10 kA
Capacitance	2 pF max
Impedance Match	75 Ohms

Table 4: CPE RF Surge Protector Specifications

Figure 49: CPE RF Surge Suppressor

6.8.3. Power-Over-Ethernet Surge Protection

Up tower radios, including the CPE, should have primary lightning protection installed at both ends of the POE line if the wiring travels outside or between buildings. It is critical to install primary protection at the customer end of the wiring to prevent possible electrocution of the customer when lightning strikes near the equipment. If the radio is not powered, the Ethernet and RF connections should be disconnected to protect the circuitry.

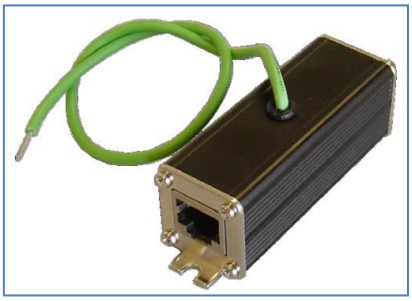

Figure 50: POE Surge Protector

640-6550 POE Surge Protector

Part #: 650-6550

The 640-6550 POE Surge Protector is not enclosed for outdoor mounting, though an optional plastic enclosure is available.

Carlson Part Number	640-6550
Operating Voltage	Data 5V; POE 48V
Clamping Voltage	7.5V Data (Pins 1,2,3,6), 70V POE (Pins 4,5,7,8)
Max Surge Discharge Current	10KA (8/20 µS)
Peak Pulse Current	100A (10/1000 µS)
Pins Protected	All 8 Pins
Protection Mode	Differential & Common Mode L-L, L-G
Insulation Resistance	>1000 M Ohm
Max Shunt Capacitance	<25 pF
Data Rate	100 Mbps
Response Time	<5 ns
Operating Temperature	-20 to +60°C
Storage Temperature	-20 to +80°C
Operating Humidity	0% to 95% non-condensing
Size (L x W x H)	68 x 25.4 x 25.4 mm
Size (overall)	82 x 25.4 x 25.4 mm
Weight	68 g
Ground Wire	16 AWG, 26 cm long
Connectors	RJ45 Shielded Jacks

Table 5: 640-6550 POE Surge Protector Specifications

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7. Appendices

7.1. Specifications

7.1.1. System

Frequency Bands	UHF 470-790 MHz (US and ETSI)
Channel Spacing	6 MHz (US), 8 MHz (ETSI)
Modulation	BPSK, QPSK, 16QAM, 64QAM, 256QAM
RF Data Rates	1.8 up to 32 Mb/s
RF Data Rate Control	Dynamic or Fixed
RF Receive Interface	Proprietary technology is used to reduce co-channel interference
RF Rx Sensitivity	-98 dBm for 10% PER using BPSK -90 dBm for 10% PER using 16QAM ½ -80 dBm for 10% PER using 64QAM 5/6 -73 dBm for 10% PER using 256QAM 5/6
RF Rx Blocking Resistance	-48 dBm TV transmission on channel N+2 -20 dBm cellular station transmissions
RF Rx Signal Maximum	-16 dBm with full linearity
Channel Access Method	CSMA (Carrier Sensing Multiple Access)
User Ports	10/100/1000 Mbps Ethernet
Ethernet Cable Connection- required	Cat 6 or 6a (8 pins, with ground)
Warranty	Limited Warranty, USA, Puerto Rico

7.1.2. Network

Typical Client Loading (per radio – 3 in a base station)	30 clients with 5 Mbps/1 Mbps residential SLA
Management	Web-based Graphical User Interface (GUI)
End-to-End Latency	5-35 ms

7.1.3. Regulatory

ACP and Spectrum Mask	Meets FCC and Ofcom specifications -55 dBr +/- 3 MHz relative to 12.2 dBm (measured at 100 KHz increments)

7.1.4. Environmental

Operating Temperature	-30° to 55° C
Operating Humidity	Up to 95%, non-condensing
Shock and Vibration	MIL-STD-810

7.1.5. Security

Security Mechanism	WPA2/AES 128-bit shared secret key

7.1.6. Antenna

Base Station Antenna	3 Bay Sector
Antenna Connector	Female “F” type 75 Ohms

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7.1.7. Mechanical

Dimensions	19cm x 8,25cm x 22,8cm
Enclosure Material	Painted steel
Weight	2,5kg
Mounting	25mm – 50mm vertical mast

7.1.8. Power Supply

Input Voltage	100-240 VAC, 50 - 60 Hz
Output Voltage	48 VDC (CPE), 56 VDC (Base Station)
Current Draw - Base Station	Tx: 25W, Rx: 9W, Idle: 7W
Current Draw - Client Station	Tx: 15W, Rx: 8W, Idle: 6W
Output Connector Type	8P8C “RJ45” Power-over-Ethernet (POE)

7.2. Warranty

Carlson Wireless Technologies, Inc. or Carlson Wireless USA (collectively referred to as “Carlson“) will repair this product with new or rebuilt parts, free of charge, in the United States or Puerto Rico for one (1) year from the date of original purchase in the event of a defect in material or workmanship.

This warranty extends to the original purchaser only. A purchase receipt or other proof of the date of original purchase will be required before the rendering of warranty services. This warranty only covers failures due to defects in materials or workmanship, which occur during normal use. It does not cover damages incurred in shipment or failures caused by products not supplied by Carlson. It also does not cover failures which result from accident, misuse, abuse, neglect, mishandling, misapplication, alteration, modification, lightning, power line surge, introduction of sand, dust, humidity and/or liquids, or service by anyone other than a Carlson Factory Service Center or authorized Carlson Service Center, or damage that is attributable to acts of God.

You can obtain mail-in service in the United States during the warranty period from a Carlson Factory Service Center by visiting http://www.carlsonwireless.com/support/rma-request.html for an RMA (Return Materials Authorization) number. After receiving your RMA number, ship your product adequately packed, postage paid and insured to the address provided.

Limits and Exclusions

There are no express warranties except as listed above.

CARLSON SHALL NOT BE LIABLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM THE USE OF THIS PRODUCT OR ARISING OUT OF ANY BREACH OF THIS WARRANTY. ALL EXPRESS AND IMPLIED WARRANTIES, INCLUDING THE WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED TO THE APPLICABLE WARRANTY PERIOD SET FORTH ABOVE.

Some states do not allow the exclusion or limitation of incidental or consequential damages or a limitation on how long an implied warranty lasts, so the above exclusions or limitations may not apply to you. This warranty gives you specific legal rights. You may also have other rights, which vary from state to state. If a problem with this product develops during or after the warranty period, you may contact your dealer or service center.

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7.3. Acronyms/Abbreviations

16QAM	Quadrature Amplitude Modulation (16-states)
256QAM	Quadrature Amplitude Modulation (256-states)
64QAM	Quadrature Amplitude Modulation (64-states)
API	Application Programming Interface
BPSK	Binary Phase-Shift Keying
BS	Base Station
CPE	Customer Premises Equipment (Client Station)
dB	Decibel
DL	Downlink
EMC	Electromagnetic Compatibility
ESD	Electrostatic Discharge
FTDI	Future Technology Devices International
GNSS	Global Navigation Satellite System (GPS, GLONASS, Galileo, BeiDou)
GUI	Graphical User Interface
IP	Internet Protocol
LAN	Local Area Network
NAT	Network Address Translation
OFDM	Orthogonal Frequency Division Multiplexing
OMC	Operations and Management Center
OSHA	Occupational Safety and Health Administration
PAWS	Protocol to Access White Space
PER	Packet Error Rate
POE	Power Over Ethernet
QPSK	Quadrature Phase-shift Keying
RF	Radio Frequency
RG-11	75-Ohm Cable Standard (1.63 mm core with triple/quad shielding)
RG-6/U	75-Ohm Cable Standard (1.0 mm core with double shielding)
RMA	Return Materials Authorization
Rx	Receive
STA	Special Temporary Authority
SU	Subscriber Unit
TVWS	TV White Space
Tx	Transmit
UL	Uplink
USB	Universal Serial Bus
VLAN	Virtual Local Access Network
WAN	Wide Access Network

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7.4. Glossary

Access Point

A device that allows a wireless device (or multiple devices) to connect to a network (or the Internet)

Attenuation

Amplitude reduction of an electrical signal

bps

Bits per second, the rate of at which data is transmitted

Byte

A digital “word” usually made up of eight bits

CPE or Client

Customer Premise Equipment or “Client Station”: An endpoint, usually at a customer’s location, that connects to a network (or the Internet) via an Access Point/Base Station

Ethernet

A set of computer networking technologies for local area networks (LANs)

IP

Internet Protocol: Provides for transmitting blocks of data between hosts identified by fixed-length addresses

LAN

Local Area Network: A privately owned network that offers high-speed communications channels connecting information processing equipment in a limited geographic area

Modulation

Process used to vary the properties of a carrier signal with a modulating signal

Packet

Data encapsulated with control information - the three principal elements of a packet include the header, text, and trailer bits (for error detection and correction) - a header contains the data needed to route the packet through a network to its final destination

Router

A network device used to forward data between multiple networks

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Orthogonal Frequency Division Multiplexing (OFDM)

A digital multi-carrier modulation method used with Fast Fourier Transform algorithms to achieve very high throughput and increase spectral efficiency

Special Temporary Authority (STA)

A temporary broadcast license that allows a broadcast station to operate outside of its normal technical or legal parameters

7.5. Useful URLs

Carlson provides the following URLs for reference purposes only. This is not a comprehensive source for this information. The purchaser must be familiar themselves with all relevant safety and/or regulatory information prior to the operation of a RuralConnect® system. Carlson does not authorize untrained and/or unqualified personnel to work on the system without the supervision of a qualified technician.

Spectrum Registration

ICASA information regarding White Space Database Administration in South Africa

https://tvwhitespaces.icasa.org.za/public/about

ESD Protection

General information
http://en.wikipedia.org/wiki/Electrostatic_discharge

ESD Association
http://www.esda.org/

IPC: Association Connecting Electronics Industries
http://www.ipc.org/default.aspx

Cable Information

General Coaxial Cable information
http://en.wikipedia.org/wiki/Coaxial_cable

General F Connector information
http://en.wikipedia.org/wiki/F_connector

Weatherproofing RF connections
http://www.dxengineering.com/pdf/WeatherProofingCoax-TechTip.pdf

RF Safety Information

FCC: Radio Frequency Safety
http://transition.fcc.gov/oet/rfsafety/rf-faqs.html

VHF/UHF Exposure information/warnings
http://transition.fcc.gov/oet/rfsafety/rf-faqs.html#Q17

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Tower Safety Information

Tower installation crews MUST be adequately trained, licensed, and properly equipped with all of the safety equipment required by law. Failure to follow federal and/or local regulations may result in warranty voiding equipment damage, personal injury, fines, and/or the loss of applicable licenses. Information provided here is strictly for reference purposes.

OSHA Guidelines: Part 1910 – Occupational Safety and Health Standards
https://www.osha.gov/pls/oshaweb/owastand.display_standard_group?p_toc_level=1&p_part_number=1910

South African Health and Safety Act of 1993

General Tower Safety Guide
http://homepower.com/view/?file=HP128_pg66_Woofenden

General TV White Space information
http://en.wikipedia.org/wiki/White_spaces_(radio)

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