Agility White Space Radio (AWR)

User Manual

April 2011

Revision A.1 (DRAFT)

KTS Wireless Product Vision

Quick Start Procedure

Note: Prior to starting the installation process, go to the KTS Wireless website (ktswireless.com) and download a copy of the TVBD (TV Band Device) Element Management System (EMS) software. See Section 4.0 of this manual for detailed instructions on its installation and operation.

Follow the steps below to install and configure Agility White Space Radio (AWR):

1. Select the location for the AWR. Must be an area free of water intrusion with a temperature range of -30 to +55 deg C (-22 to 130 deg F). It is always best to use one of the mounting options shown below to provide good 'heatsinking' of the AWR case to a large metal surface. This will reduce the operating temperature of the AWR and surrounding equipment within the same enclosure.

L-DIN

Flat-DIN

Wall (with optional Fan)

See the KTS website for ordering information. Correct mounting is critical to maximizing AWR performance and reliability.

2. Locate the coaxial cable to the antenna. This should be a good quality, low-loss cable that is as short as possible. This cable should include an in-line surge arrestor to prevent lightning strike damage to the radio. The cable should have a BNC (F) connector or an adapter will be needed. See the KTS Wireless website for ordering information, if one is needed.

3. Locate the power source. The AWR requires a 9-14 VDC input and draws about 1.5 A (when transmitting). Power is supplied via the 2.5 mm connector on the side of the unit (See Figure 1). A power cable pigtail is available (ordered separately) and can be used to connect the AWR to an existing power supply. Alternately, a separate power supply with the proper 2.5mm connector can be purchased directly from the supplier or from KTS Wireless. See the website for ordering information.

4. Connect the power supply cable to the AWR and turn on. Observe that the green power LED is illuminated. It takes about 7-10 seconds for the AWR to boot-up. After this, only the green power LED should be on.

TX/RX RF Activity (Blinks amber for TX and Grn for RX)

Summary Fault (Red for fault)

Power (Grn when Power on)

5. Connect a laptop to the AWR as shown in the Figure 2. Double-click on the icon below to start the EMS software installation process.

TVBD_Installer.jar

6. After the installation process is complete and a valid password is entered, the Device Info screen will appear (See Figure 3). Contact KTS Wireless to obtain your password. **Section 4.0 of this manual contains the details of using the TVBD Element Management System (EMS)**. Jump to Section 4.0 for details on setting up the EMS and resetting the AWR IP addresses (i.e., changing from the default value). **The default IP address of the AWR is 192.168.1.4. Note: Pressing and holding the recessed Reset button (See Figure 1) for at least 12 seconds will force the radio back to its default settings.**

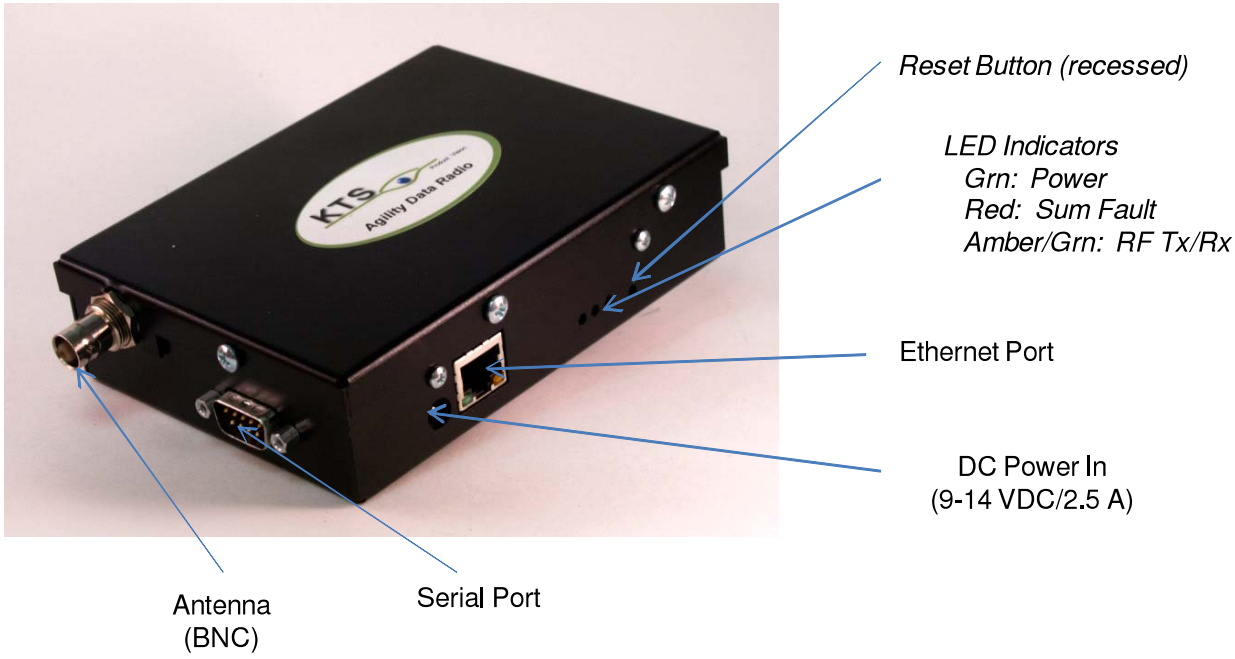


Figure 1: AWR Connections

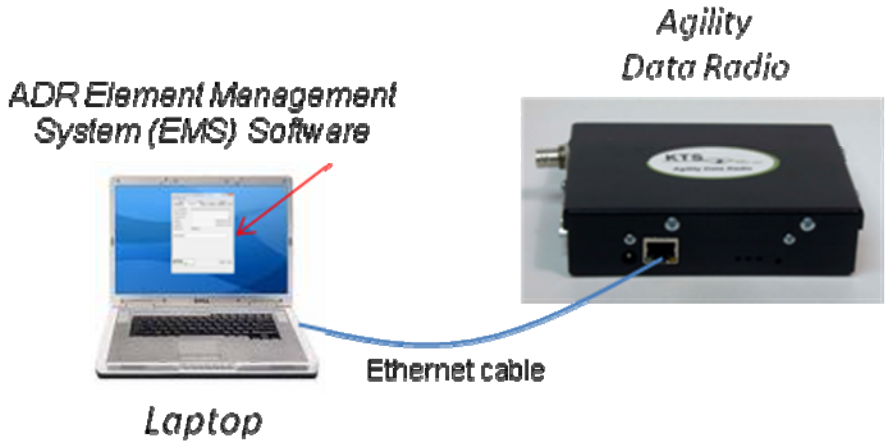


Figure 2: AWR/EMS Connection

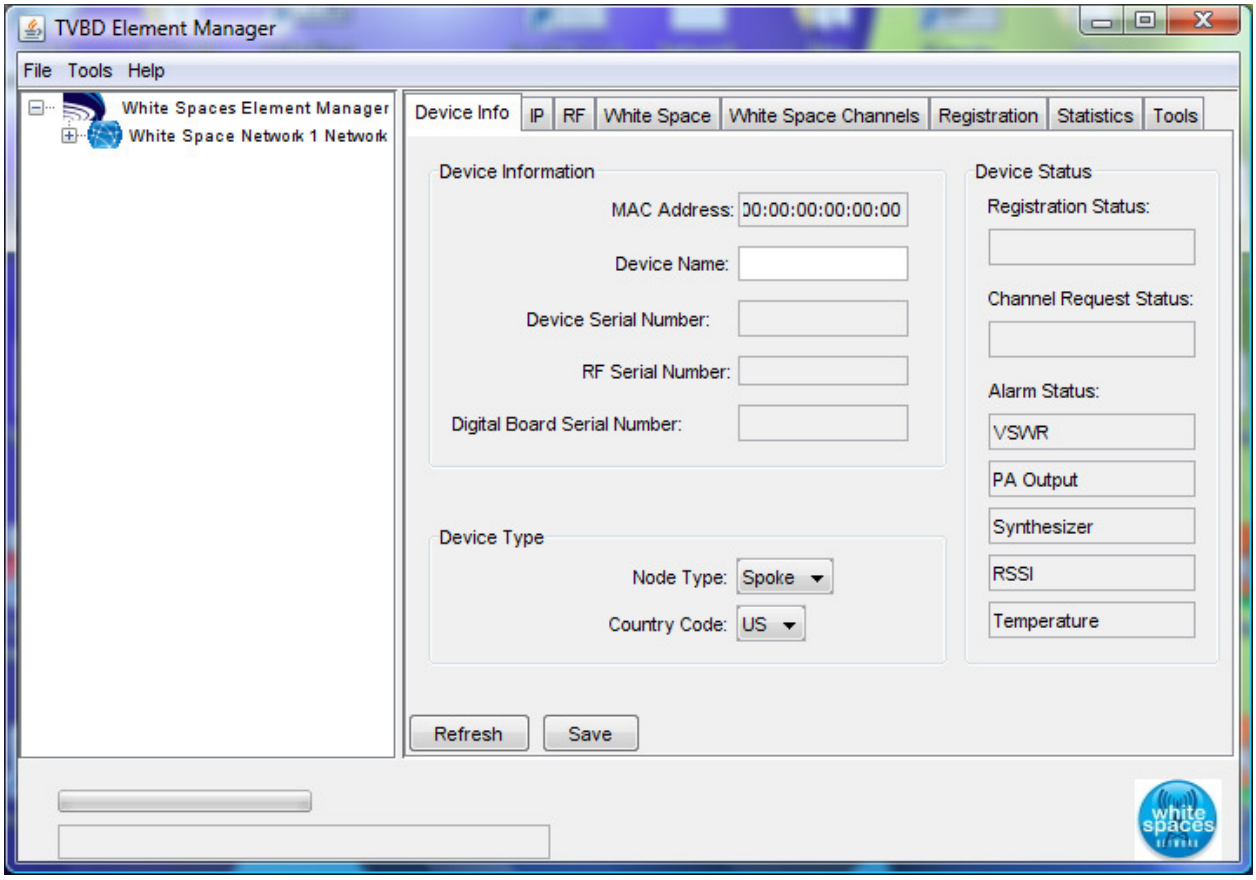


Figure 3: TVBD EMS Main Screen

Position	Color	Function
1	Green	Power On
2	Red	Summary Fault
3	Green/Amber	RF Activity (Amber = TX; Green=RX)

Table 1: LED Definitions

Contents

Operational and Safety Notices

RF Exposure

The radio described in this manual transmits RF energy. The concentrated energy from the antenna may pose a health hazard. All antennas used with this radio must be installed to provide a minimum separation from all persons of 90 cm (36 inches). The above separation distance must be maintained at all times. More information can be obtained from the FCC at the following website:

http://www.fcc.gov/Bureaus/Engineering_Technology/Documents/bulletins/oet65/oet65.pdf

FCC Part 15 Notice

NOTE: This equipment operates under an experimental license.

Equipment operation currently conforms to the rules for TV band devices, pursuant to Part 15 of the FCC Rules. These rules are designed to provide reasonable protection against harmful interference. 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 manufacturer, dealer or an experienced radio/ TV technician for help.

Safety

This product is specifically intended for professional installation. It is advisable to use the device only in the normal operating position as described in this guide.

WARNING: This device transmits radio frequency (RF) energy. To comply with FCC RF exposure requirements, antennas must be installed and operated with a minimum separation distance of 90 cm from all persons.

WARNING: 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.

WARNING: 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

WARNING: To eliminate risk of electric shock, DO NOT connect/disconnect cables while units are energized.

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

WARNING: Installation of antennas near power lines is dangerous, and contacting power lines can be lethal. Select the installation site with safety, as well as 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.

1.0 Product Description

The Agility White Space Radio (AWR) shown in Figure 1.1 below is designed to provide a reliable wireless connection for digital communication in selected TV bands in the 174 – 216 MHz (VHF) or 470 - 698 MHz (UHF) frequency ranges.

Figure 1.1: Agility White Space Radio (AWR)

The AWR is operated under the control of a FCC-approved TVBD database such as the one provided by Spectrum Bridge, Inc. Its frequency, power level and many other transmit parameters cannot be set by the operator. This is done to make sure the AWR does not interfere with other 'incumbent' users in the TV bands.

The unit is housed in an aluminum enclosure which is not weather-tight. Two printed circuit boards are included: RF and Digital. The RF board is provided in one of two configurations as outlined below:

VHF Band: 174 to 216 MHz

UHF Band: 470 to 698 MHz

These RF cards provide a common differential baseband I/Q interface to the Digital board. The RF board includes transmit, receive, synthesizer and control sections. The transmit section includes an Intermediate Power Amplifier (IPA), Power Amplifier (PA), Variable Attenuator and Forward and Reverse Power Detectors. The PA provides up to 1 Watt (30 dBm) of RF output power at the antenna connector, assuming a 6 dBi antenna gain or less. This transmit power is reduced dB for dB for antennas with higher gain than 6 dBi. The Variable Attenuator is used by the Automatic Transmit Power Control (ATPC) system processor to set and maintain the proper transmitted RF power level. A closed-loop process is used with the Forward Power Detector to maintain the desired output level under all conditions. The Reverse Power Detector is used to detect impedance mismatches which may occur with an antenna or cable failure.

The receive section of the RF board includes a Tunable Bandpass Filter (TBPF), Low Noise Amplifier (LNA) and Variable Attenuator. The TBPF is centered by the control processor about the radio's operating frequency and has a 20 MHz passband. The LNA provides gain and a noise figure of about 4 dB. An Automatic Gain Control (AGC) loop is managed by the control processor using the Variable Attenuator. A constant level is maintained into the Digital board.

The synthesizer section includes a 20 MHz Frequency Reference which is a Temperature-Compensated Crystal Oscillator (TCXO) with Stratum 3 frequency stability. This reference is multiplied up to the desired operating frequency within the Synthesizer. The output is applied to the Digital Up and Downconverters. This provides direct modulation and demodulation of the baseband, modulated signal.

The control section includes a processor with on-board memory, analog to digital converters and general purpose I/O. It also includes a serial port which is used to communicate with the processor on the Digital board. The processor manages the transmit power control and receive AGC loops. It also programs the synthesizer to tune to the operating frequency. The memory contains the processor code along with critical calibration tables which are generated during manufacturing. These tables provide accurate transmit power setting across the band, receive power estimation and tunable filter control.

The Digital board provides the user ports, message routing and radio management functions. The radio provides a standard RJ45 Ethernet port for connection to user devices.

2.0 Applications

The most common application for the AWR is a ‘star’ network where a single hub site communicates to a collection or remote or ‘spoke’ sites as shown in Figure 2.1.

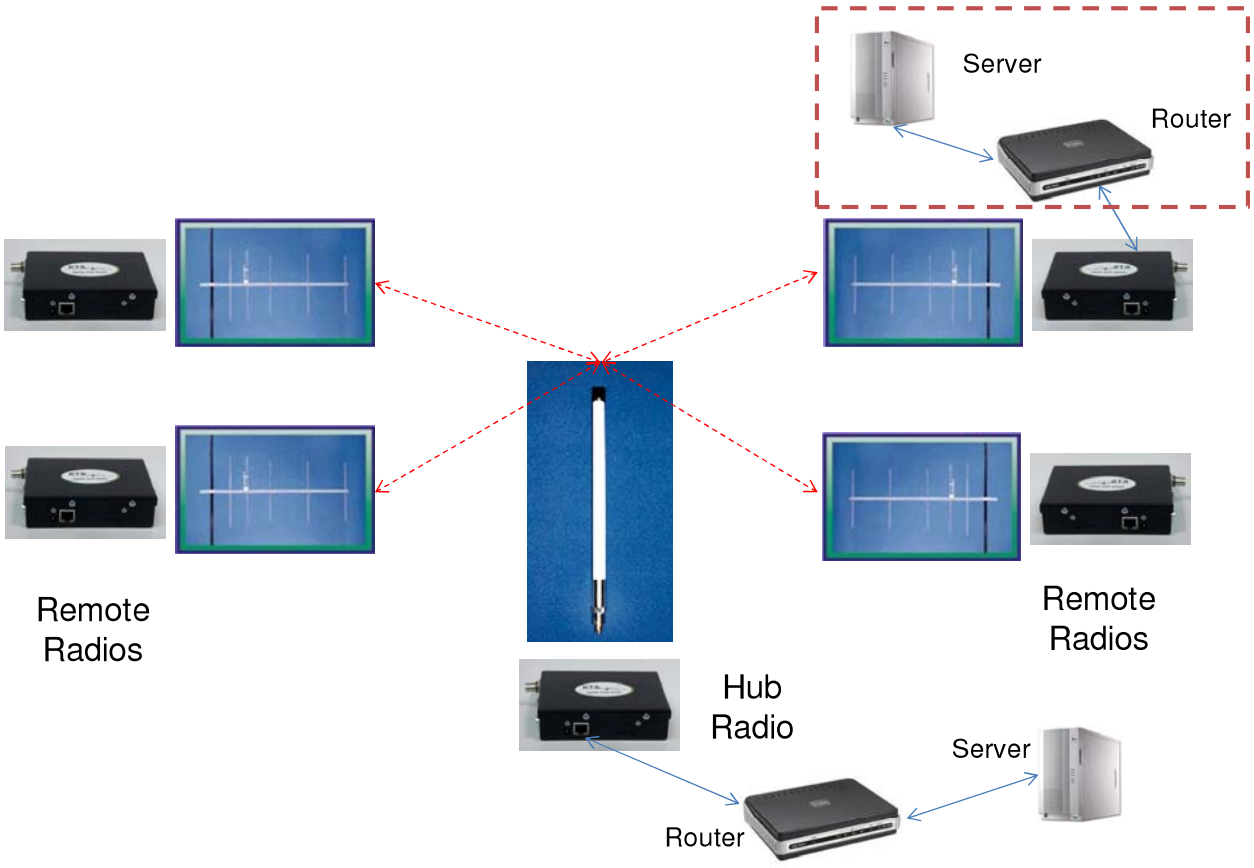


Figure 2.1: Star Network Configuration

The Hub AWR is typically connected to an omnidirectional antenna via a length of coaxial cable. The signal transmitted by the Hub AWR is then transmitted in a 360-degree pattern to all remote sites within a range supported by the configured transmitted power. Each remote site

AWR is typically connected to a directional antenna via a length of coaxial cable. These antennas are 'pointed' toward the Hub to achieve maximum gain.

User devices are connected to the Ethernet RJ45 connector of the AWR. The point-to-multipoint network shown in Figure 2.1 interconnects the Hub AWR with all remote AWRs over the air. Media Access Control (MAC) software within the AWR allows all the radios to share the wireless spectrum on a non-interfering basis.

It is assumed that the user traffic is IP. The Hub AWR performs the polling of all remote AWRs. This happens automatically and transparently to the user devices connected to the Ethernet ports. This MAC is referred to as Poll/Select. When a remote AWR receives an IP message over the Ethernet port it is routed through a Learning Bridge in the AWR. If this bridge determines it should be transmitted over the air, the AWR buffers the message until the next poll is received from the Hub AWR and transmits the message.

3.0 Specifications

Electrical

Frequency bands	
VHF Band	174 to 216 MHz
UHF Band	470 to 698 MHz
RF Transmit Power	17 to 30 dBm
Noise Figure	4 dB
Spurious & Harmonic Emissions	FCC Part 15 compliant*
Blocking/Selectivity	60 dB, typical
Data Rates	1.5 or 3.1 Mb/s
Channel Bandwidth	6 MHz
Modulation	2-FSK, SOQPSK
Frequency Selection	100 kHz steps
Operating mode	Burst, Time-division duplexing

Mechanical

Dimensions	4” x 5” x 1.4”
Enclosure material	AL, Black powder coating
Weight (wall mount)	400 g
Mounting (ordered separately)	L-DIN, Flat-DIN or wall mount (with optional integral (fan)

Environmental

Operating Temperature Range	-30 to 55^0 C
Operating Humidity	Up to 95%, non-condensing

Power

Input Voltage	+9 to 14 VDC
Consumption	
Transmit	1.5 A
Receive	0.5 A
Idle	0.1 A

* FCC Part 15 certification pending.

Specifications are subject to change without notice.

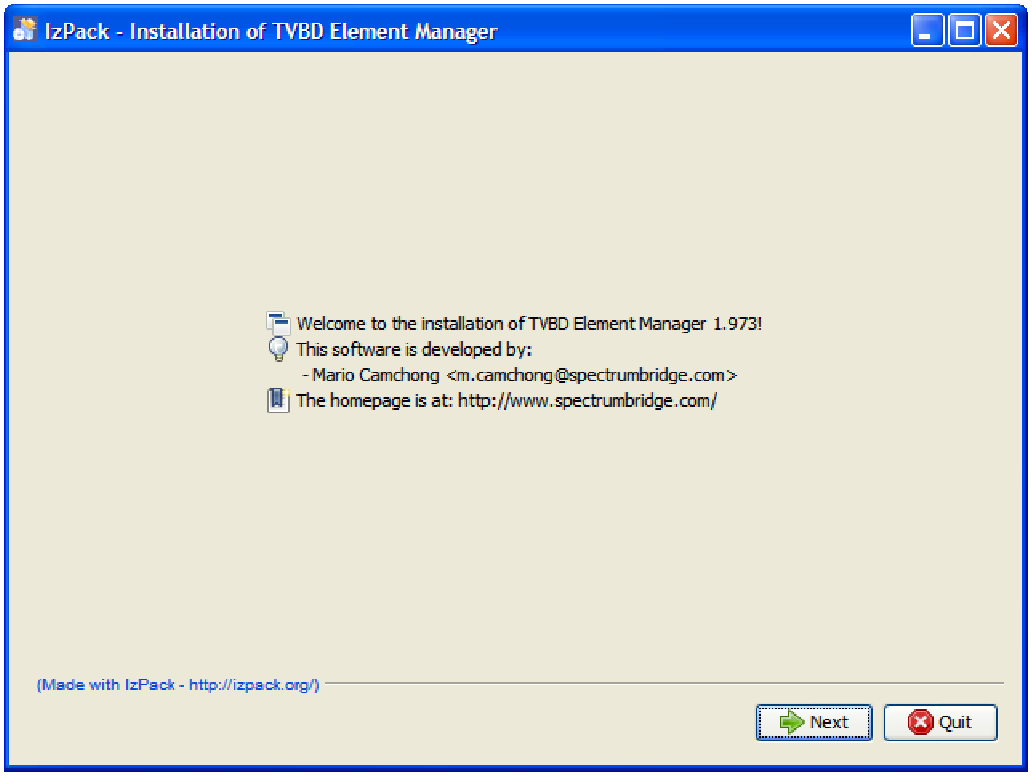
4.0 TVBD Element Management System

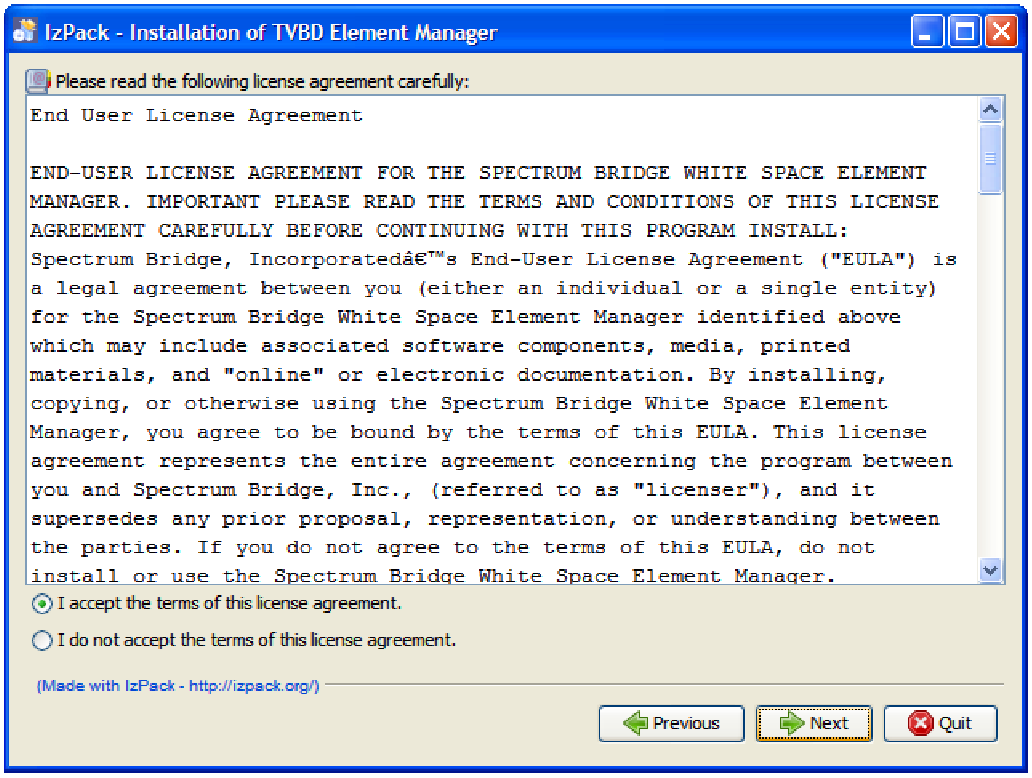
Most networks require some level of network management and a White Space Network is no exception. This document will describe the use of the KTS Wireless TVBD White Space Element Management System (EMS). This tool is used during radio deployment and also to manage the network once it is fully operational.

EMS Application Installation

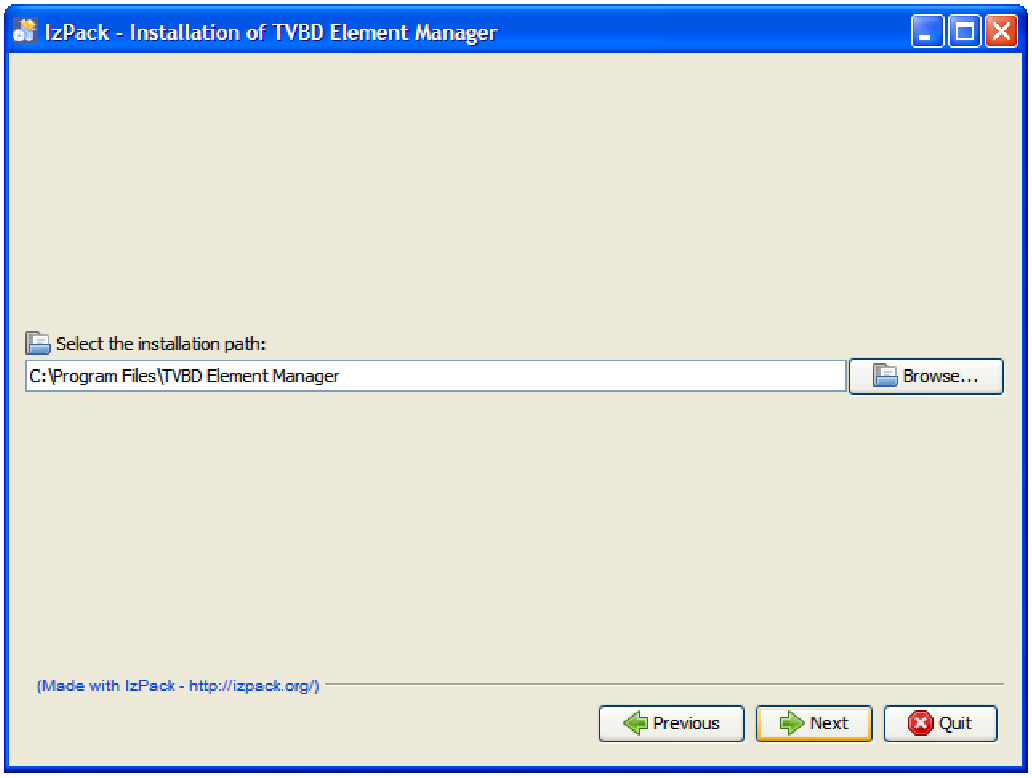
The EMS Application is a Java based application. The application requires a Windows XP (32-bit) or newer operating system, but will also run in Linux. The minimum Java Runtime Environment is 5.0.

The included CD contains a software directory with a file called TVBD_Installer.jar. Double click on the file to launch the installer. The following installation program will be displayed. Select Next to continue installation of the Element Manager Program.

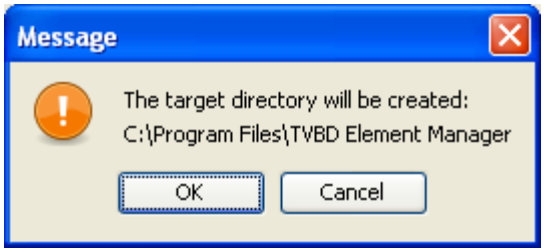




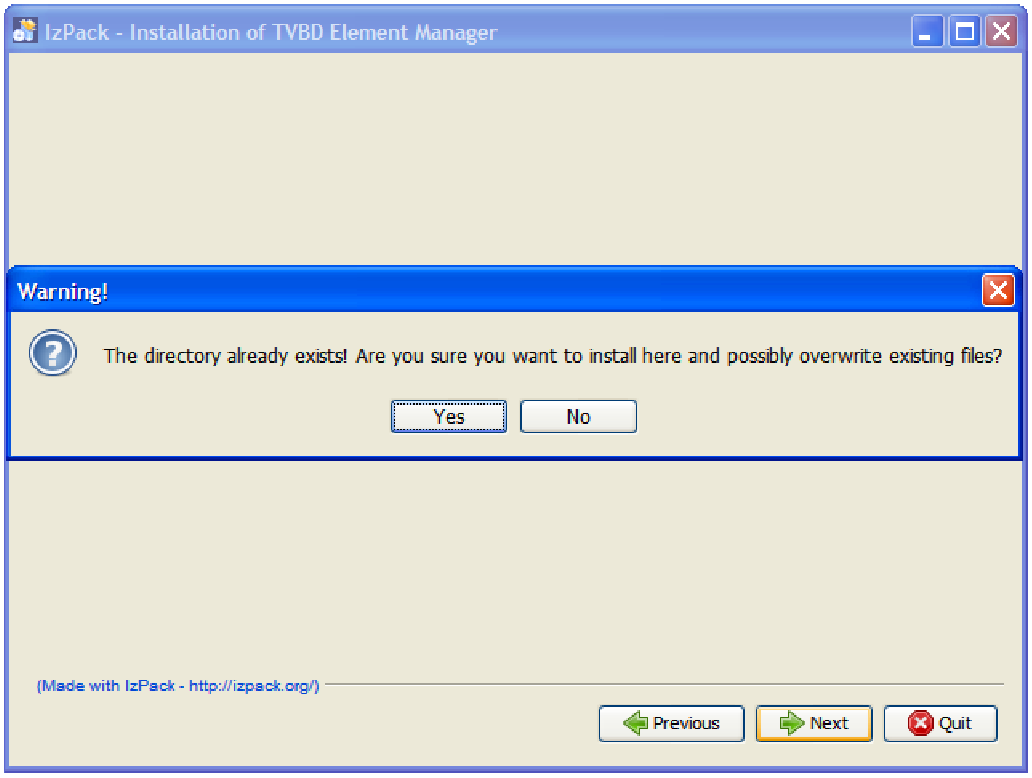
To continue the installation, select the “I accept…” radio button and then Next.



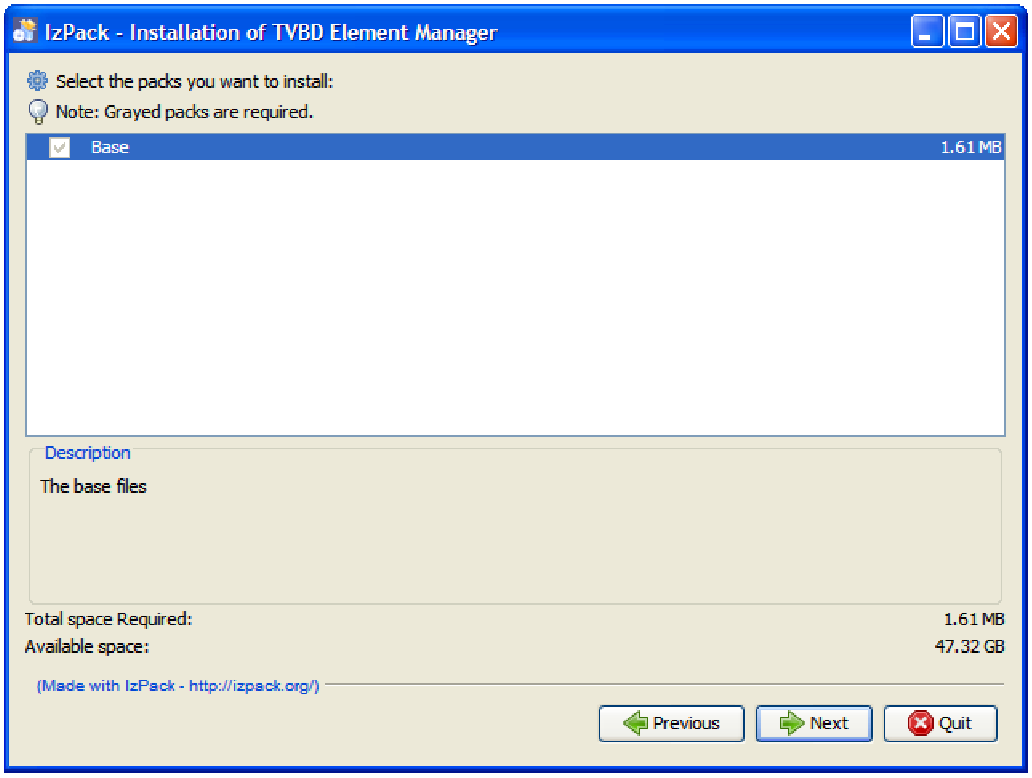
The file installation path is displayed. Click Next to continue.



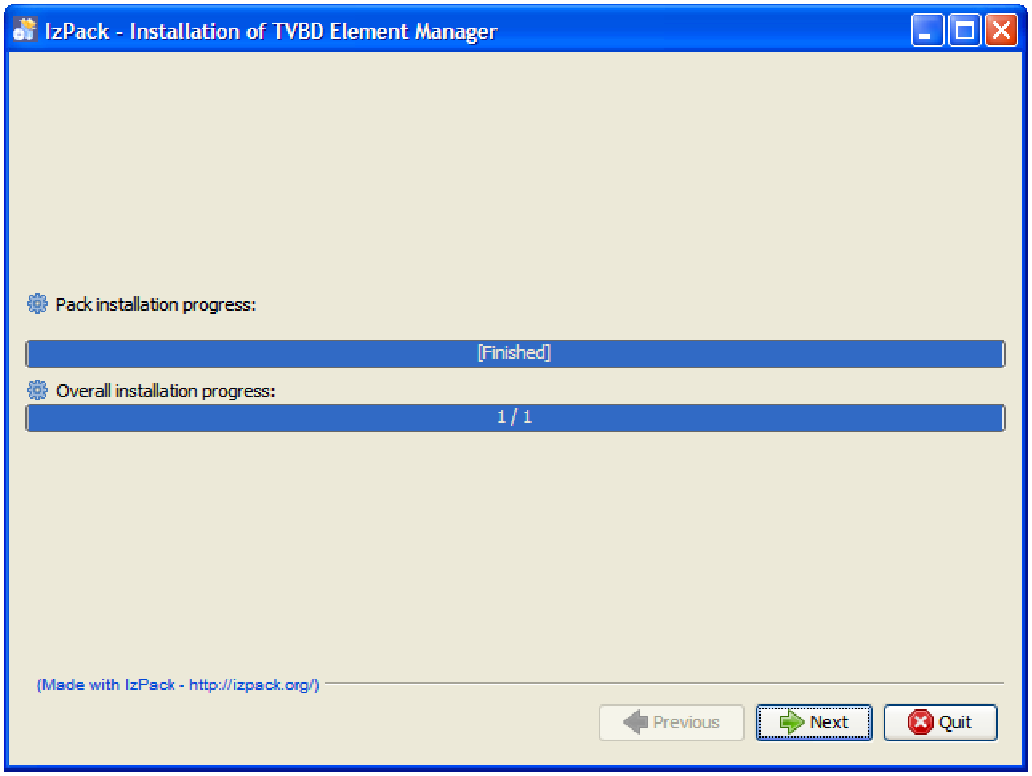
'The target directory will be created' message is displayed if this is the first installation of the EMS application. Select OK to continue the installation.



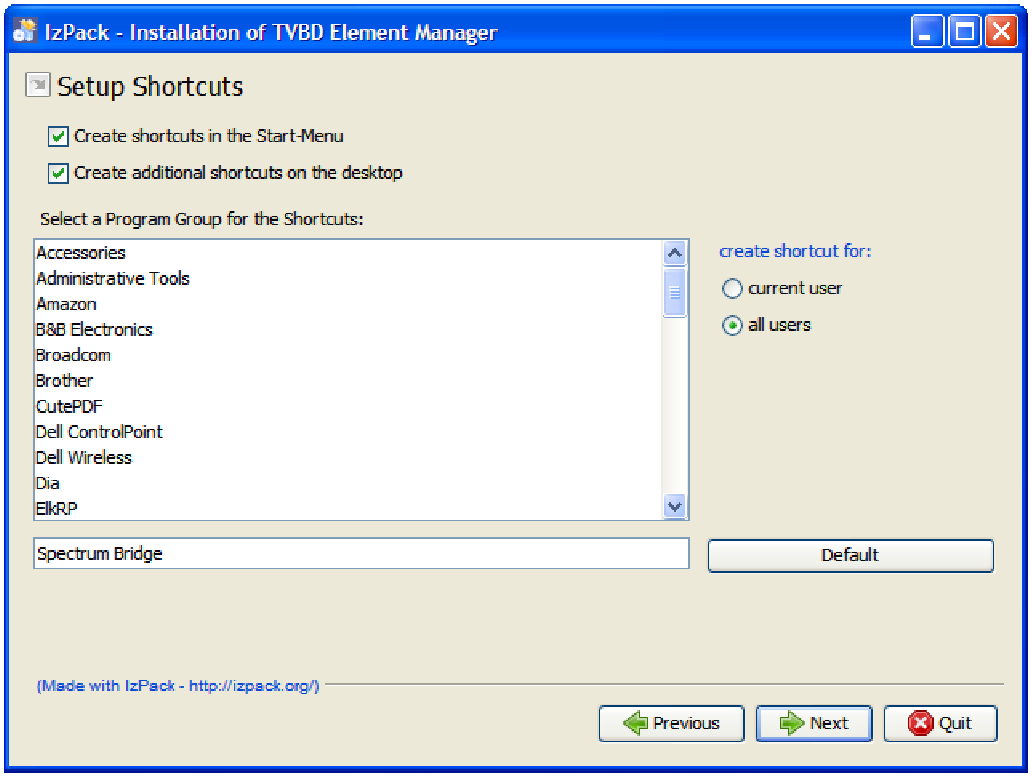
'The directory already exists' message is displayed when the EMS application is being reinstalled or updated. Select 'Yes', and then select Next to continue the installation.



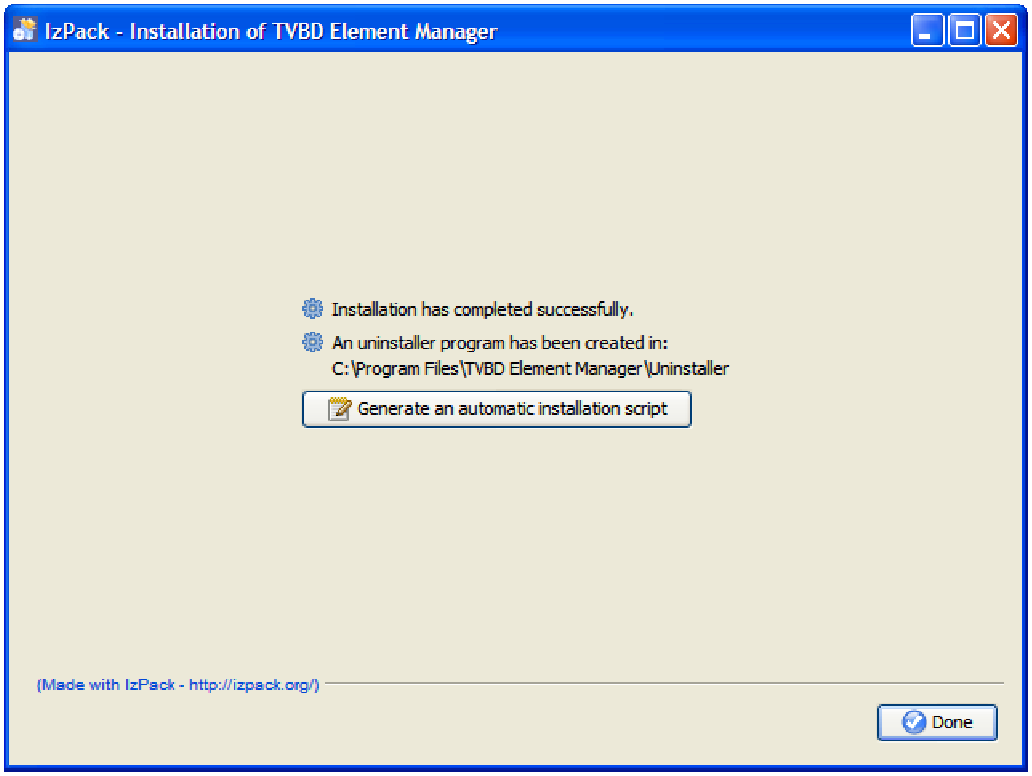
Select Next to continue the installation.



Select Next to continue the installation.

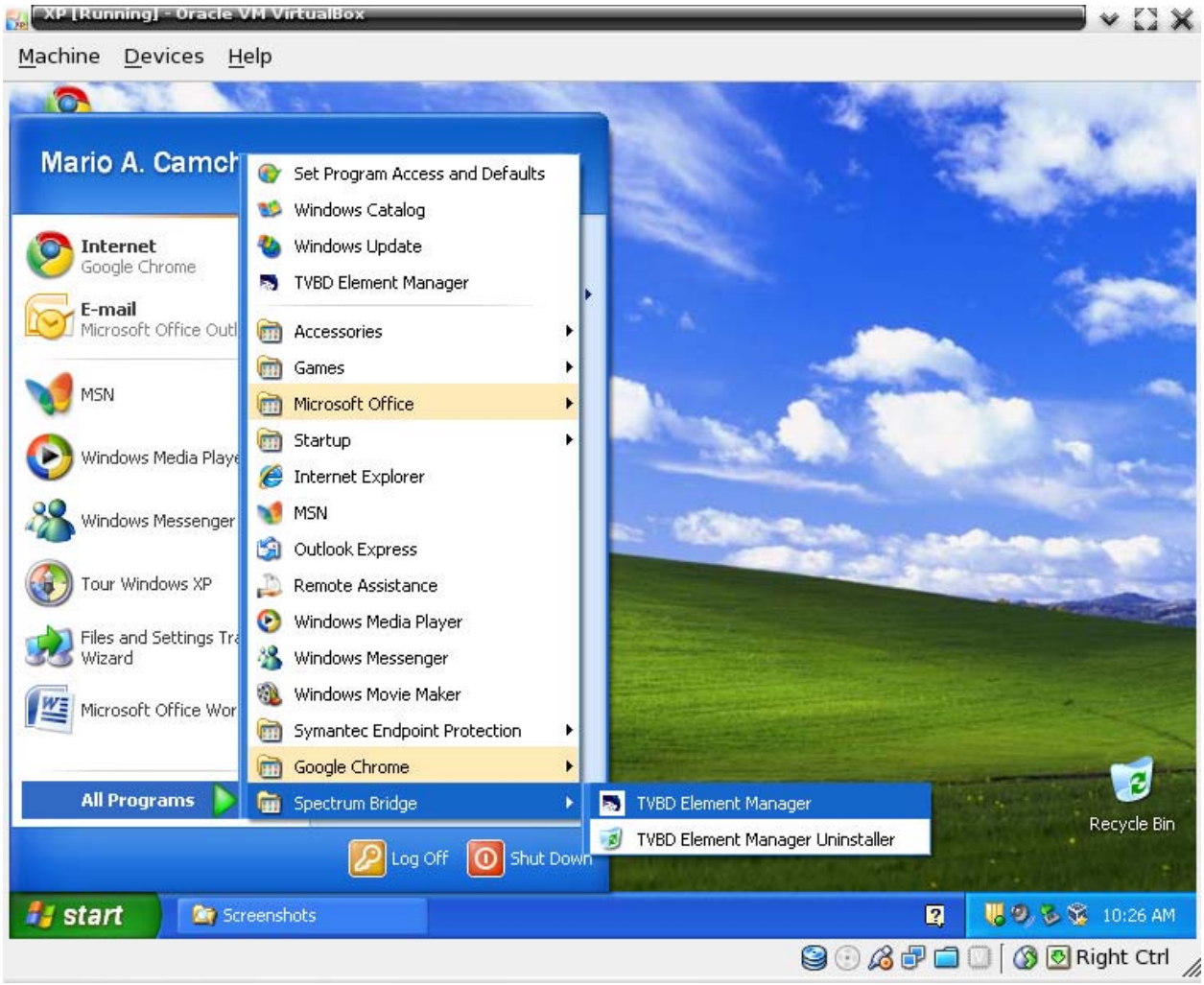


Modify the Shortcut preferences as desired and select Next to continue.



Select Done to complete the installation process.

Once the EMS application has been installed, it can be launched by clicking on the TVBD Element Manager entry in the Start Menu, or from the icon installed on the desktop.



EMS Application User Guide

The TVBD White Space Element Manager is designed show one or more networks and their nodes on the left panel and specific details about a selected node on the right panel. Clicking on the circle next to the network's name expands the tree view to show its hubs. Clicking the circle to the left of the hub expands the branch to show the spokes associated with that hub. When the user clicks on a node name, the application displays information about that node on the right panel. To change the name or IP of a node click on the node, then select Tools -> Edit Node. Note: You cannot remove the words Network, Hub or Spoke.

Each tab on the right panel groups specific features of the radio. Clicking the Refresh button on the bottom refreshes the information about the node and clicking the Save button pushes changes (any change done to a field) to the node. Most fields in the application can be edited and saved by clicking the Save button at the bottom of the window unless the fields are grayed out.

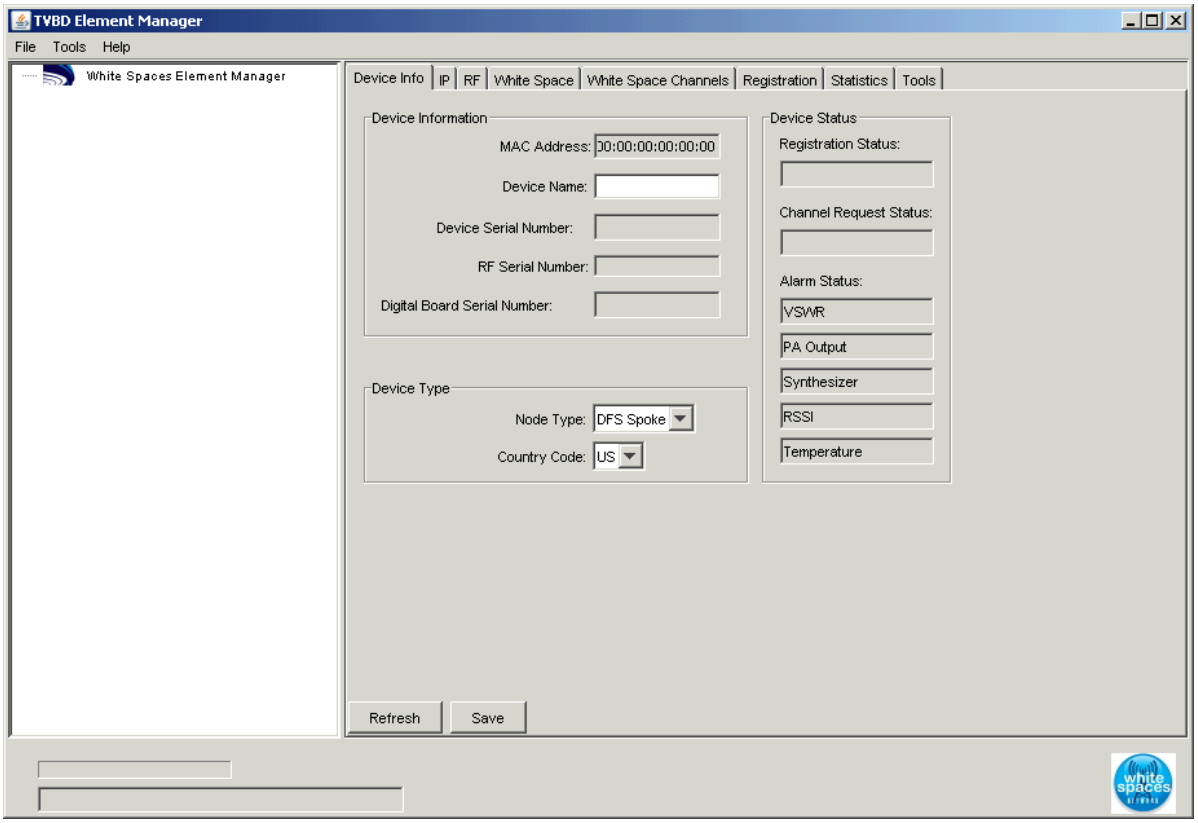


Figure 1 - Main EMS Window

A screenshot of each TV Band Devices Element Manager window is provided in order to make the descriptions of the manager more meaningful.

Adding a Network

When the EMS application for the first time, the application will not have any network elements in the left panel and the installer must 'build' a network tree by first adding a Network name. To add a Network to the White Spaces Element Manager, click on Tools -> Add Network.

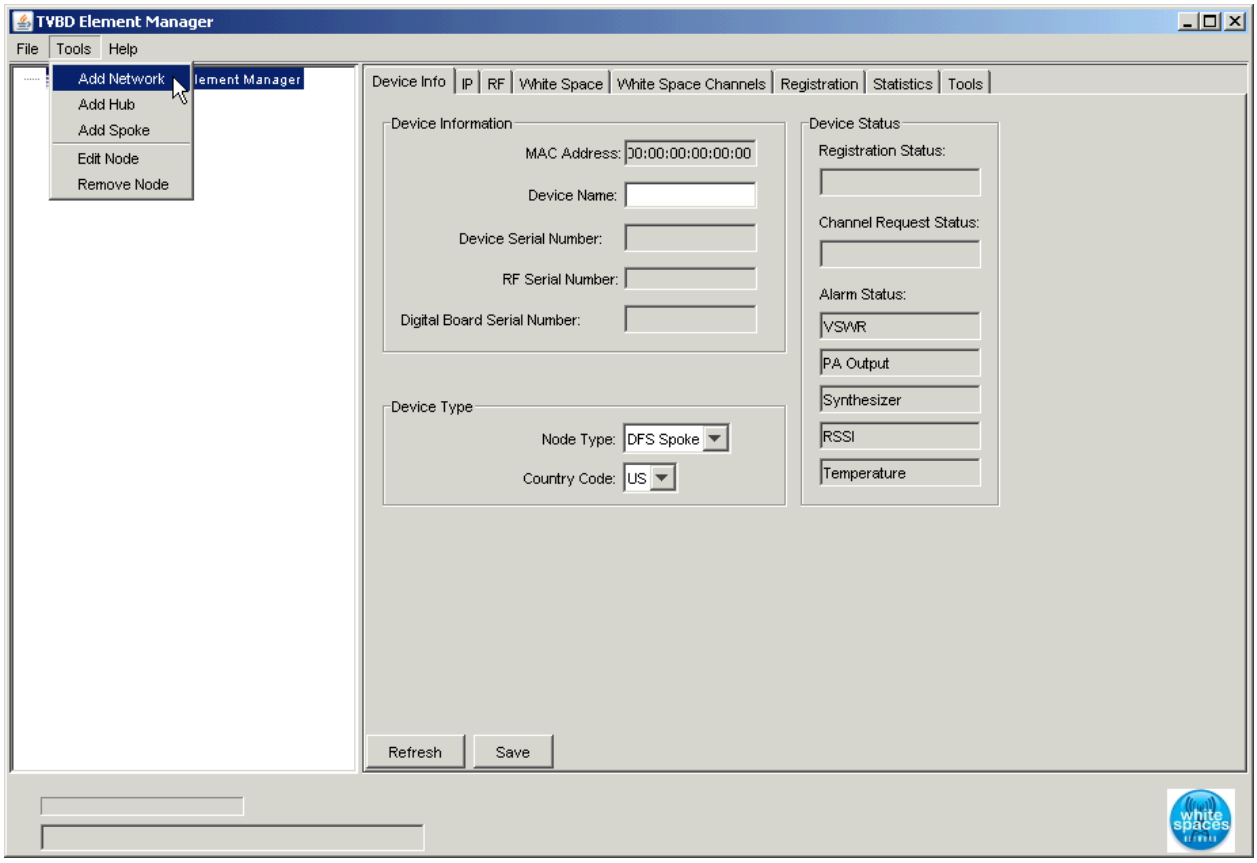


Figure 2 - Adding a Network

A window will be displayed to enter a network a name as shown below. Note: You do not need to add the word “Network” to the name as the application will add this automatically. Multiple networks can be added to the Element Manager. Once the name has been entered, click the OK button.

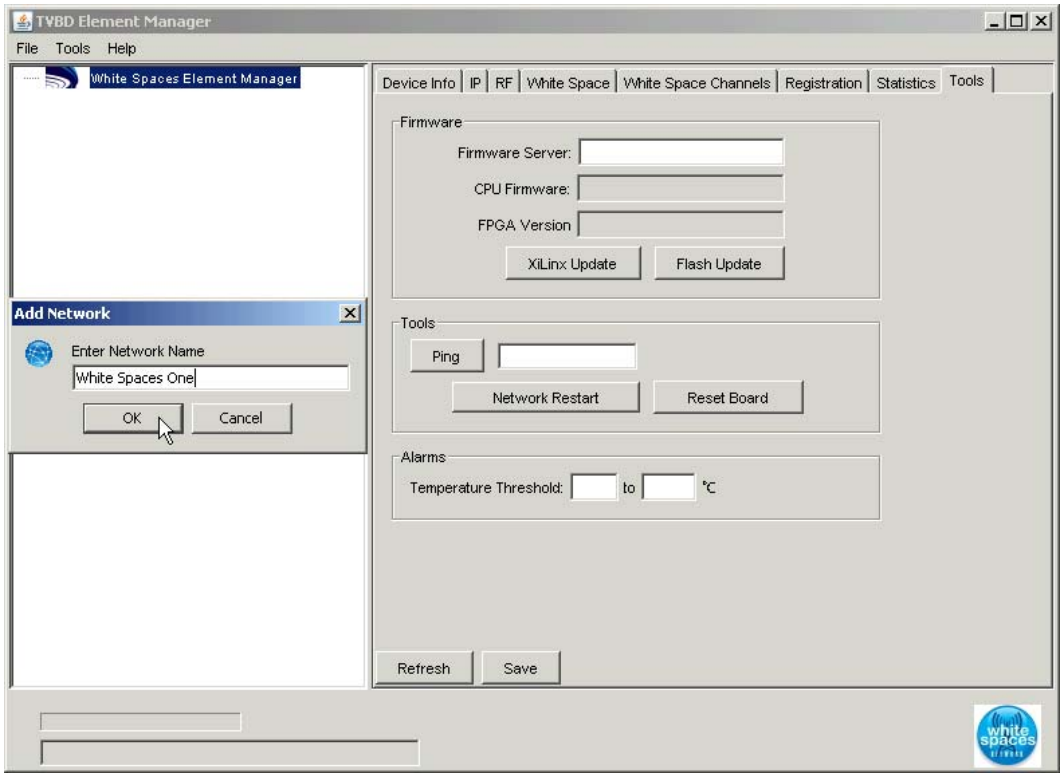


Figure 3 - Entering the Network Name

The newly created network will show up as a new branch under the White Spaces Element Manager (the root of the tree).

Adding Hub to the Network

A hub can be added to the network by first selecting the appropriate network name and then clicking on Tools -> Add Hub as shown below:

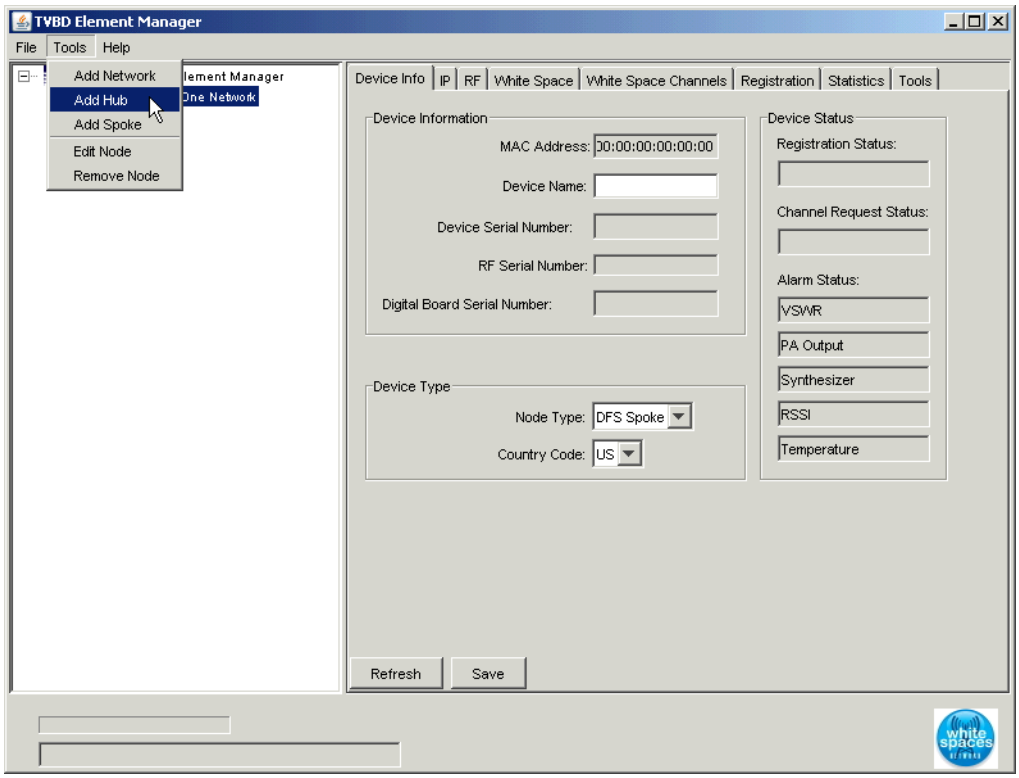


Figure 4 - Adding a Hub

A window will be displayed to enter a name for the new Hub. Note: You do not need to add the word “Hub” to the name as the application will add this automatically.

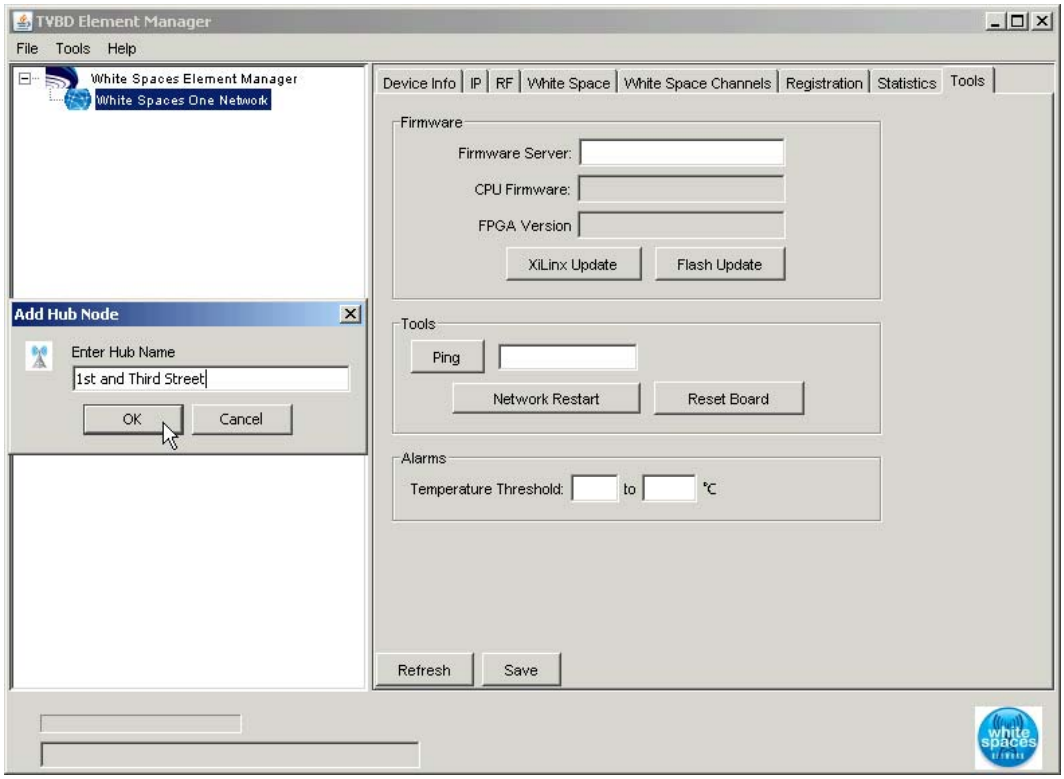


Figure 5 - Entering the Hub Name

When the Hub name has been entered, select the OK button. Another popup window will be displayed to enter the IP address for the Hub. Select OK to finish adding the new Hub.

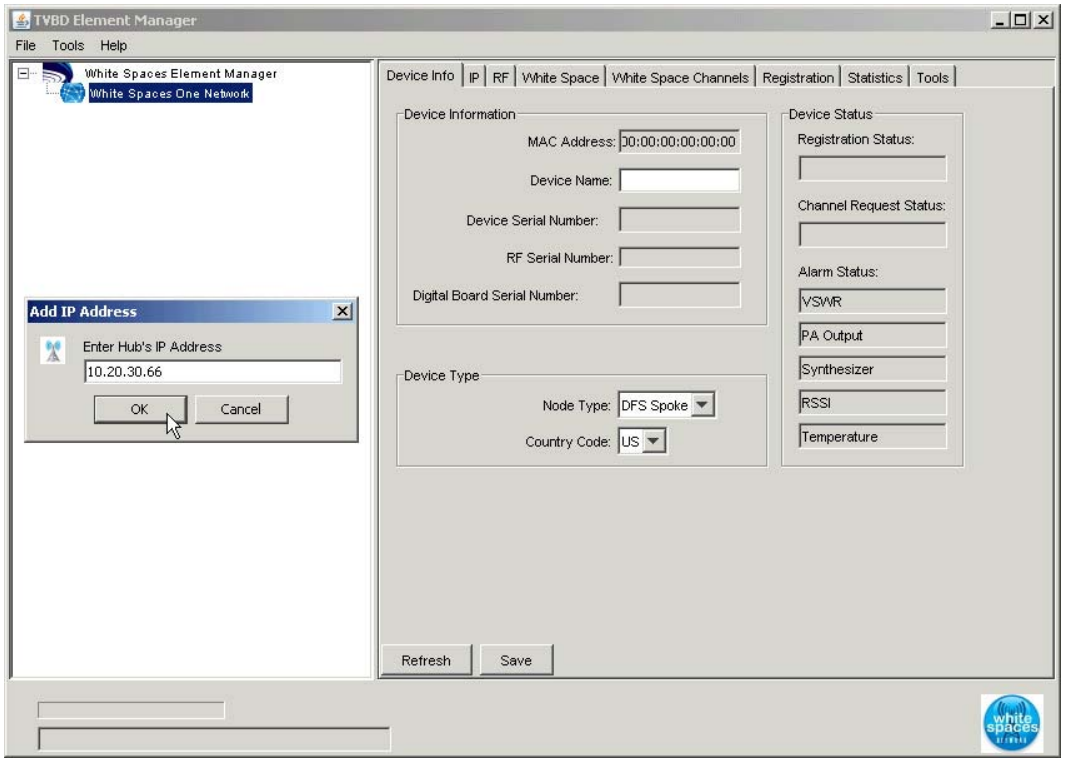


Figure 6 - Entering the Hub IP Address

Once the hub has been added, it will appear under the selected network as a new branch.

Note: The network IP address scheme will be defined by the Network Manager or Installer. The IP addresses displayed in the screen examples are for reference only.

Adding a Spoke to a Hub

A spoke can be added by selecting the appropriate hub, and then clicking on Tools -> Add Spoke. Complete the process by follow the screens just like when adding a hub.

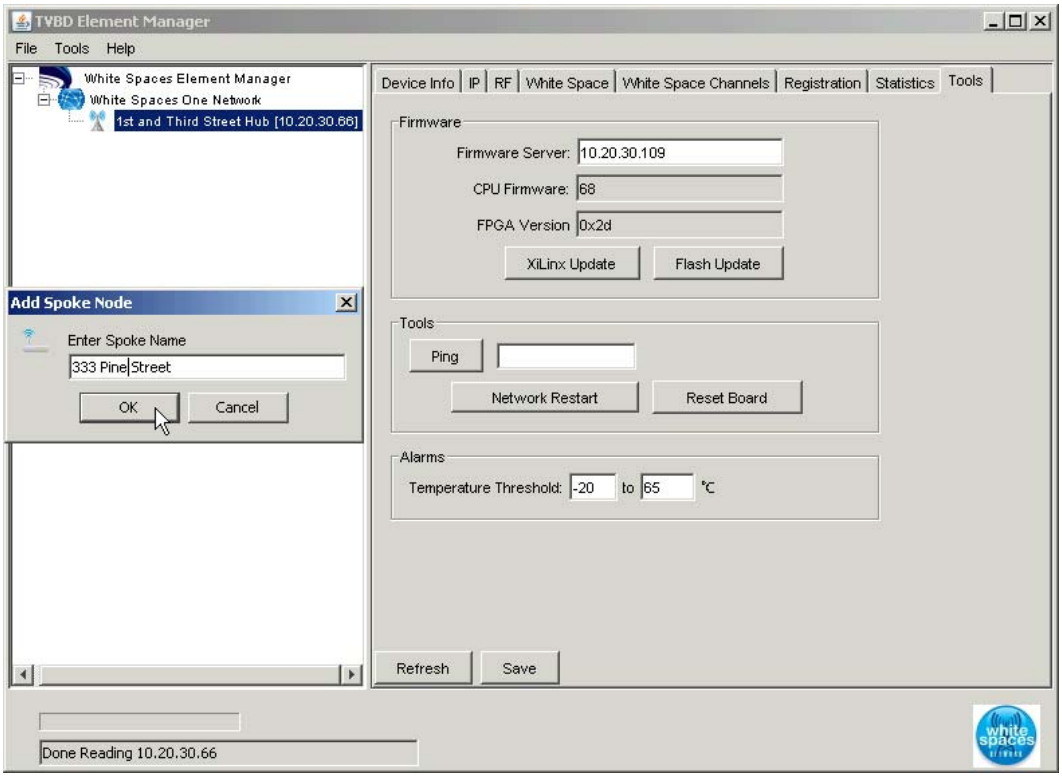


Figure 7 - Entering the Spoke Name

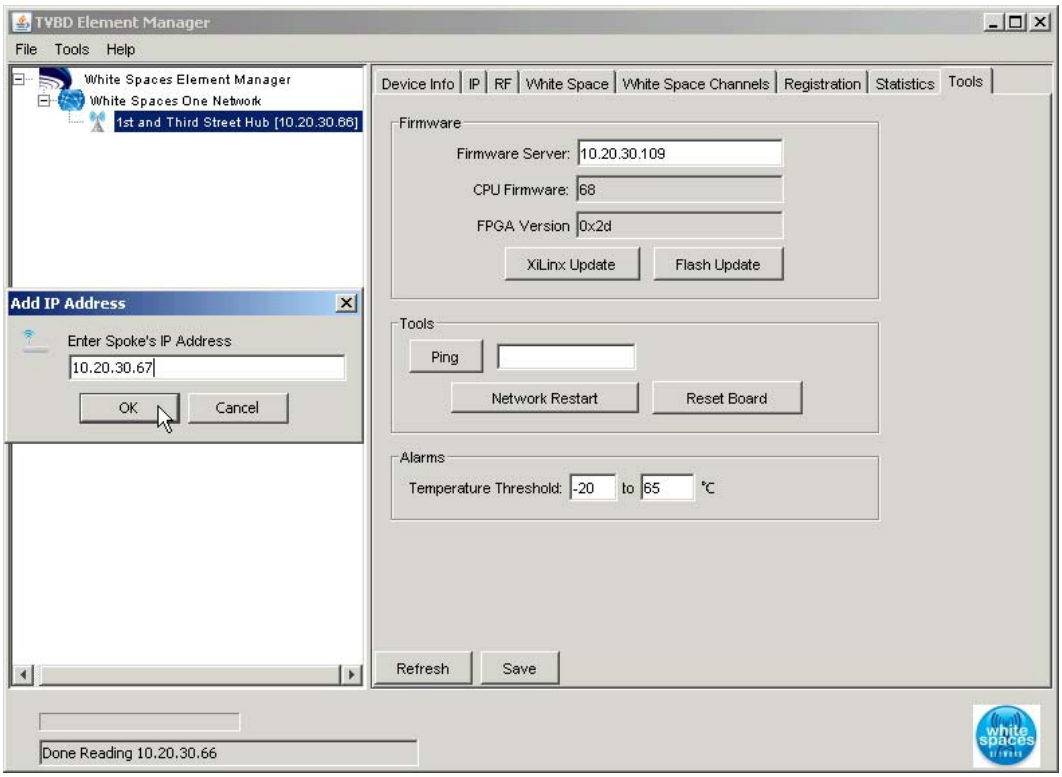


Figure 8 - Entering the Spoke IP Address

Deleting a Node

A node can be deleted at any time by selecting it and then clicking Tools -> Remove Node. Please note that this feature can remove a complete network including branches within this network. The same applies to deleting a hub node, which will remove all spokes that talk to that node.

Saving the Network Configuration

The whole network layout can be saved by clicking File -> Save Network. Once the network is saved, every time the application is launched, it will remember the network configuration. The only way to reset this is by deleting all network nodes and clicking File -> Save Network. A message in the status bar will indicate a successful action.

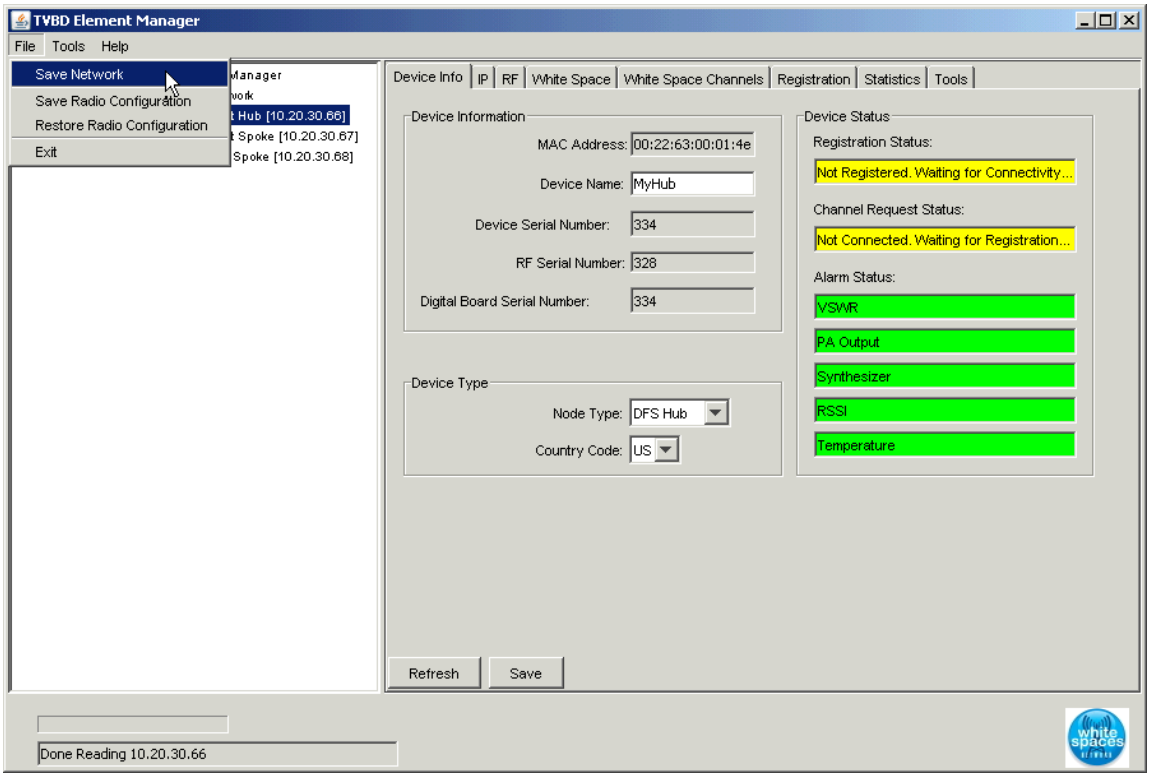


Figure 9 - Saving the Network Configuration

Save Radio Configuration

Saving a device configuration acts as a backup for a single device. This feature is particularly useful when doing firmware upgrades to the devices. To save a radio configuration, select the device to be backed up and click File -> Save Radio Configuration. Note that this is only possible when selecting a hub or a spoke. A message in the status bar will indicate if the backup has been successful.

Restore Radio Configuration

To restore a backed up radio configuration, select the device to be restored and click File -> Restore Radio Configuration. A message in the status bar will indicate if the restore has been successful.

Device Info Tab

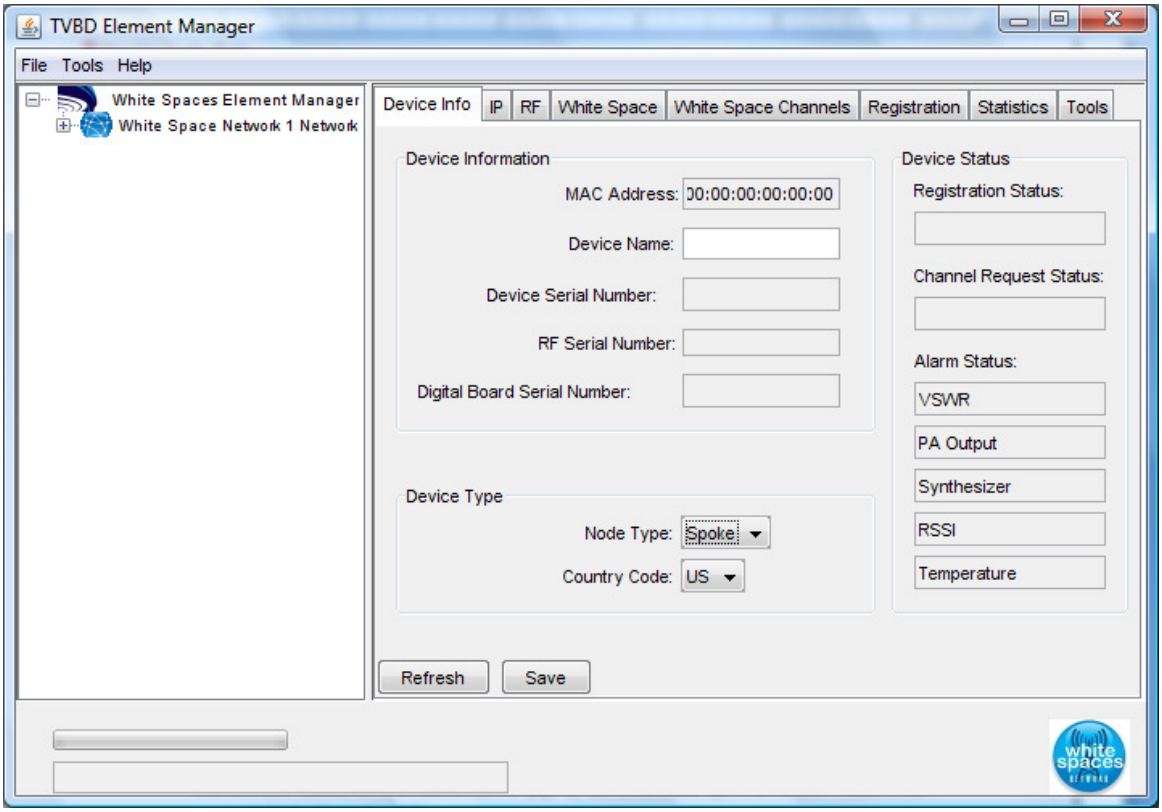


Figure 10 - Device Info Tab

The Device Info tab shows information about the radio that makes it unique.

- The MAC Address is a non-editable field populated with its MAC address.
- The Device Name is the radio name (up to 15 characters). This could match the name selected on the left pane.
- The RF Serial Number is a non-editable field populated with the serial number of the radio.
- The CPU Firmware is a non-editable field populated with the current version of the radio firmware.

- The FPGA Version is a non-editable field populated with the current version of the FPGA firmware.
- The Temperature is a non-editable field populated with the current temperature of the radio reported in degrees Celsius.
- The Alarm is a non-editable field that indicates if there is an operational problem on the radio.
- The Node Type specifies if the radio is a Hub or a Spoke (Remote).
- Country Code is a drop-down list of Countries. US should be selected.

Only the Device Name, Node Type and Country Code fields can be edited and saved to the radio by clicking the Save button at the bottom of the window.

IP Tab

The TVBD Radios have two network stacks: one for the Ethernet interface and one for the wireless interface. This IP tab takes care of the Ethernet IP network configuration.

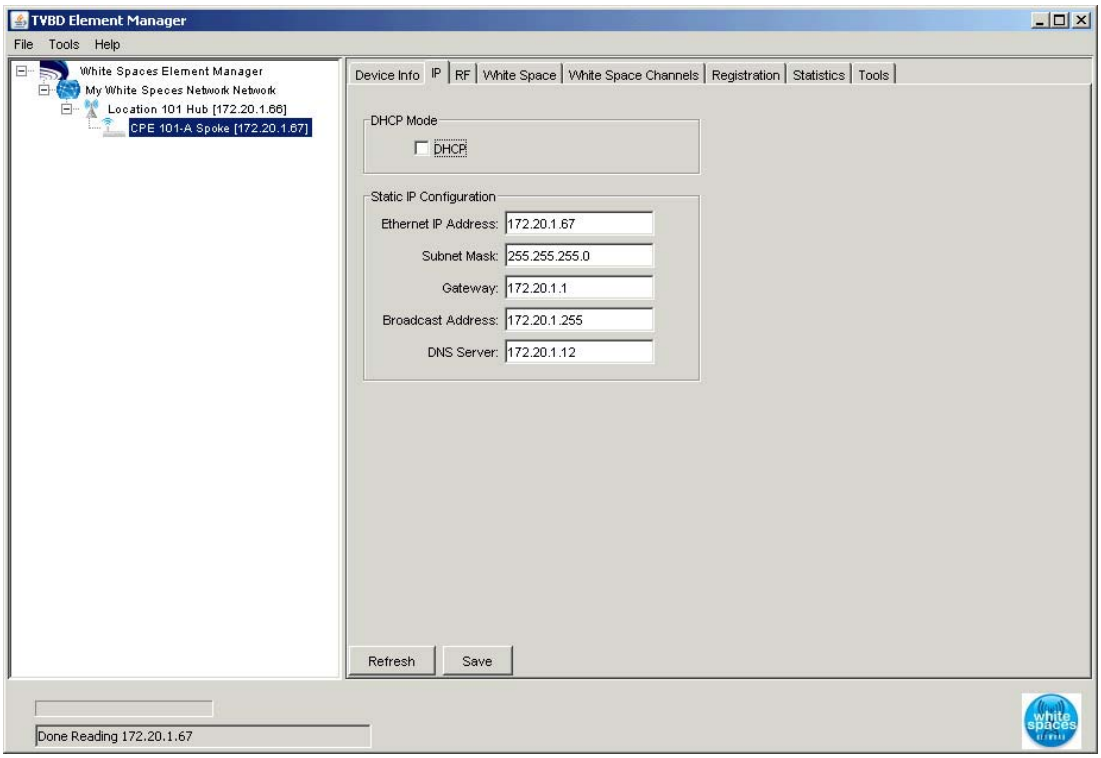


Figure 11 - IP Tab

DHCP Mode

- DHCP Mode Checkbox can be used to enable DHCP mode. The DHCP checkbox tells the device to get an IP network configuration from a DHCP server instead of the

statically configured information. Note that in DHCP mode, the radio doesn't update the Firmware Server or the White Space Server addresses.

The Static IP Configuration

- Ethernet IP address displays the IP address used to communicate to the device when DHCP is not enabled.
- The Subnet Mask, Gateway, Broadcast Address and DNS Server address fields are also displayed and are part of the Static IP Ethernet network configuration when DHCP mode is not enabled.

All fields on this tab can be saved by clicking the Save button on the bottom right corner. Changing the Ethernet Address will prompt the user to reboot the device

RF Tab

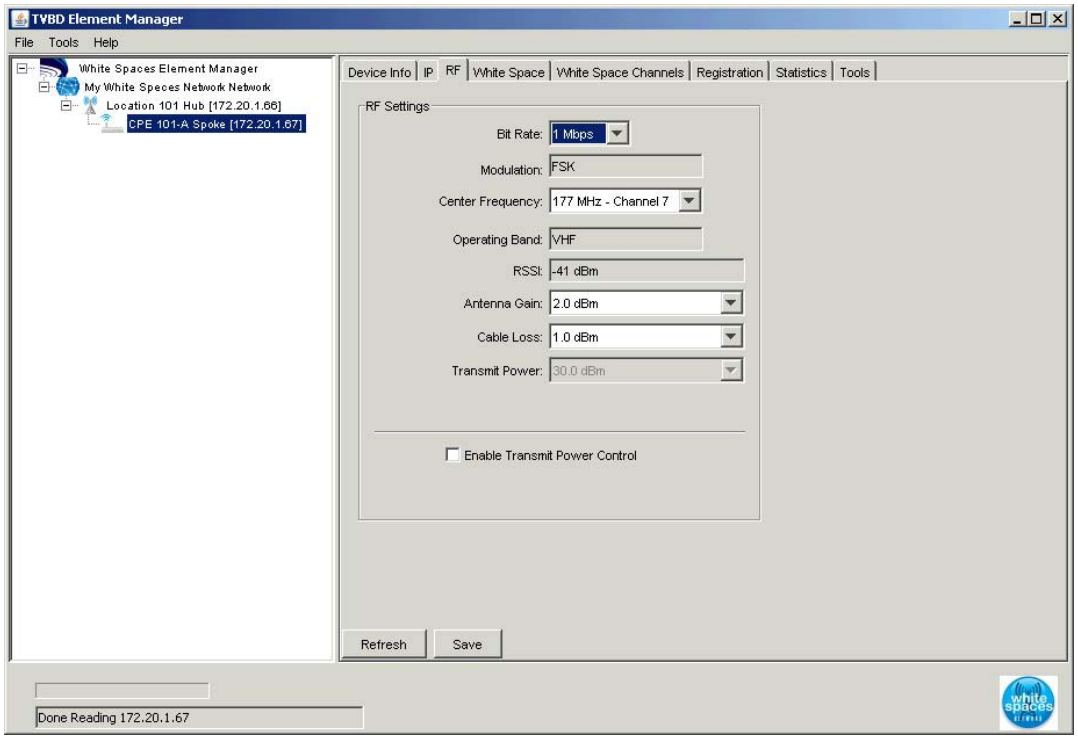


Figure 12 – RF Tab

The RF tab allows for configuration of the radio.

- The Bit Rate is set accordingly in the dropdown box. Values range from 50 kbps to 2 Mbps.
- The Modulation is a non-editable field populated with the modulation used by the radio.
- The Center Frequency is the operating frequency of the radio. The corresponding TV channel is associated to the frequency.
- The Operating Band is a non-editable field populated with the RF board type (VHF or UHF).
- The RSSI is a non-editable field populated with the RSSI as a relative value.
- Antenna Gain is a dropdown box to input the antenna gain in ½ dBm increments.
- Cable Loss is a dropdown box to input the cable loss in ½ dBm increments.
- The Transmit Power is the power level set in dBm. The none-editable box displays the power level in increments of ½ dBm from 17.0 dBm to 32.0 dBm.
- Enable Transmit Power Control checkbox allows dynamic power control.

White Space Tab

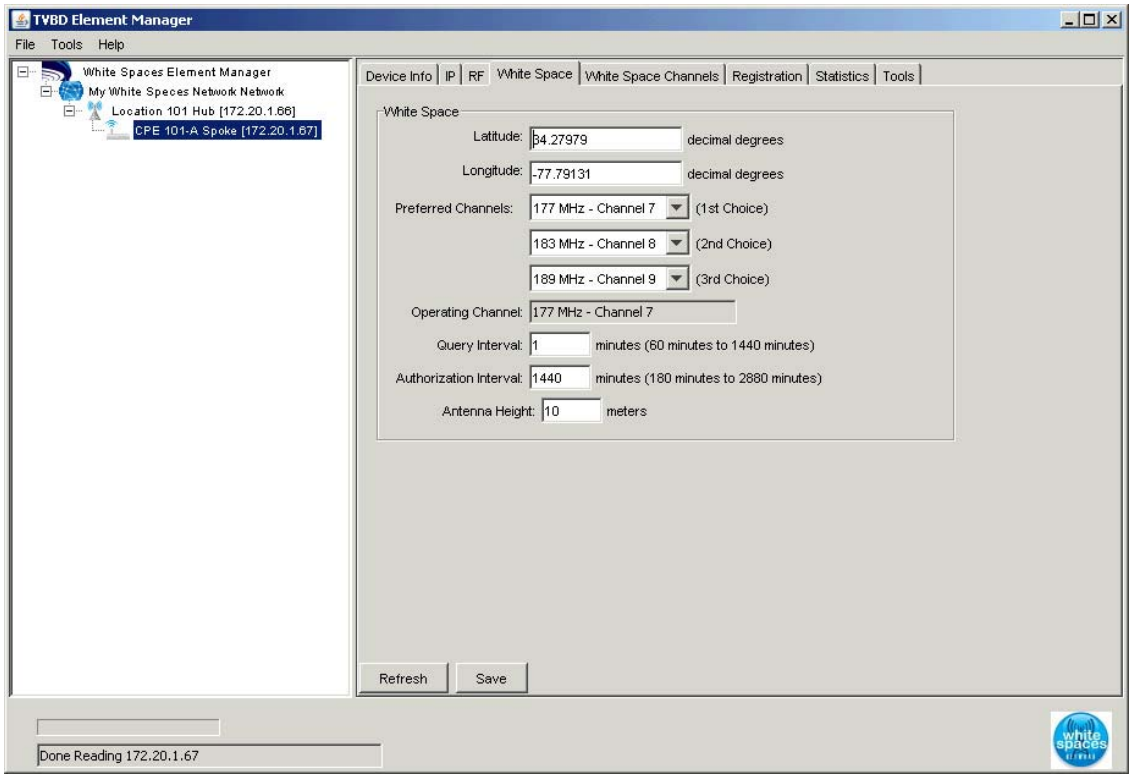


Figure 13 - White Space Tab

The White Space tab allows for configuration of the radio.

- The coordinates (Latitude and Longitude) are NAD27 decimal coordinates with a maximum of 5 decimal places. The location of the radio must be entered here and is used by the White Space database to return a channel map.
- Preferred Channels: The user can pick 3 channels where it would like the network to operate. If the 1st choice is not available from the channel map sent from the TV Bands Database, the radio will try to use the 2nd choice and so on. If the 3rd choice isn't available either, the device will pick a channel of its own.
- The Operating Channel is a non-editable field which displays the operating frequency and TV channel of the radio.
- The Query Interval field is used to set the time in minutes to register the device with a White Space Database.
- The Authorization Interval field is used to set the time in minutes to disable the radio if there is no connectivity to a White Space Database.

- Antenna Height is used to enter the height of the antenna in meters.

White Space Channels Tab

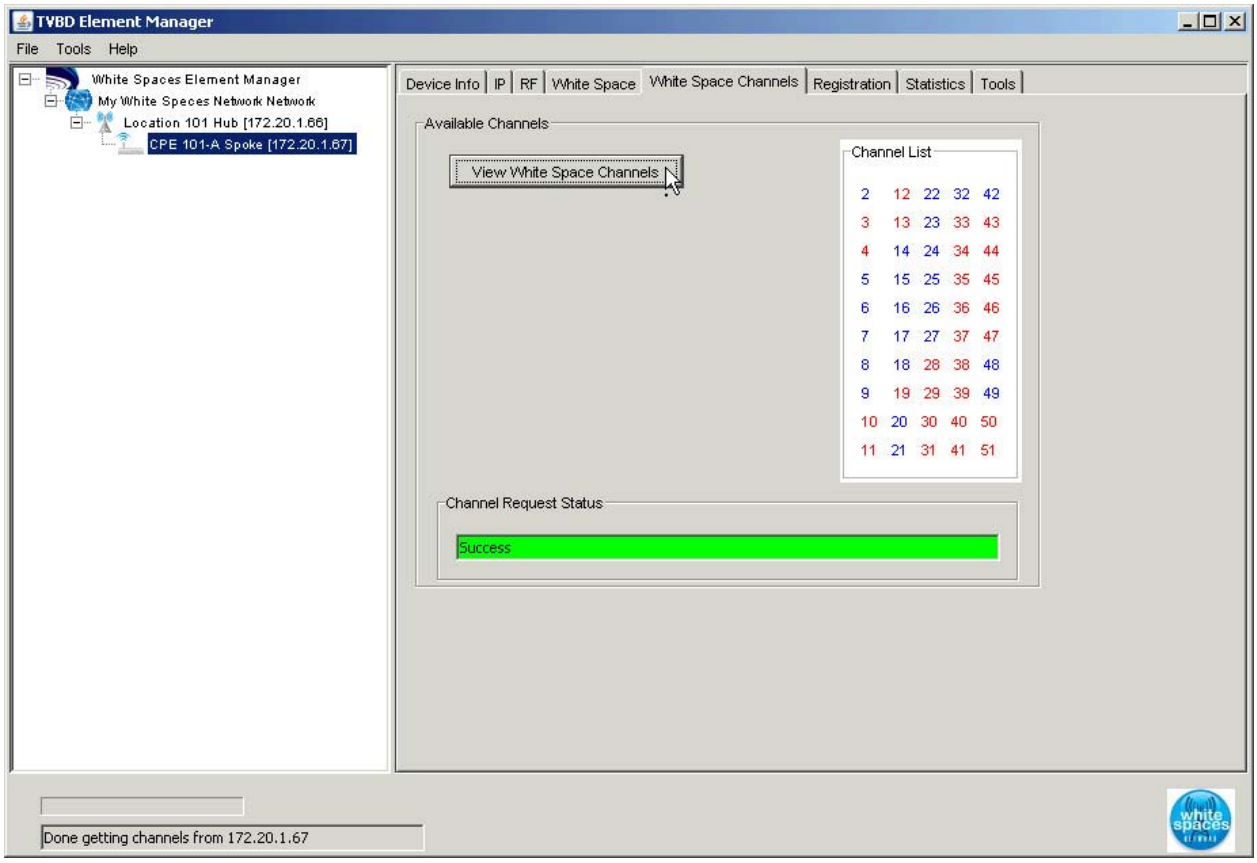


Figure 14 - White Space Channels Tab

The White Space Channels tab is used to display the channel list returned by the TV Bands Database for the specific geographic coordinates entered and saved within the device through the White Space tab.

The TV Bands Database is the server with which the radio communicates to register and get a list of available channels for operation.

Registration Tab

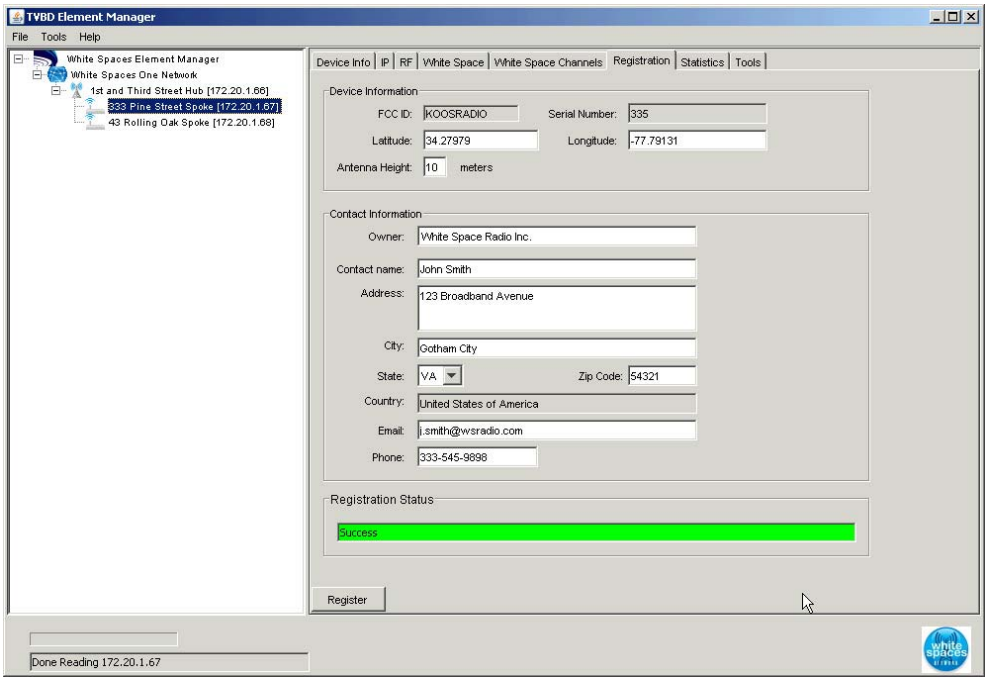


Figure 15 - Registration Tab

The registration tab contains a tool to register the device with the White Space TV Bands Database Service.

Note: Each TVBD must be "***Enrolled***" before it can access the White Space Database. During the device enrollment process the client must provide the Manufacturer Name, location information, contact information, the FCC ID, Model and Serial Number for each device to be enrolled using the following link: http://demo.spectrumbridge.com/products-services/whitespaces/DeviceEnrollment.aspx.

- FCC ID: This field is automatically populated by the radio.
- Serial Number: This field is automatically populated by the radio.
- Latitude: This field is automatically populated with the configuration from the White Space tab.
- Longitude: This field is automatically populated with the configuration from the White Space tab.
- Owner: The name of the individual or business that owns the device.
- Contact name: Name of the contact person responsible for the device's operation.
- Address: Address of the contact person.
- Email: Email address of the contact person.

- Phone: Phone number of the contact person.

To register the device, click on the Register button.

Statistics Tab

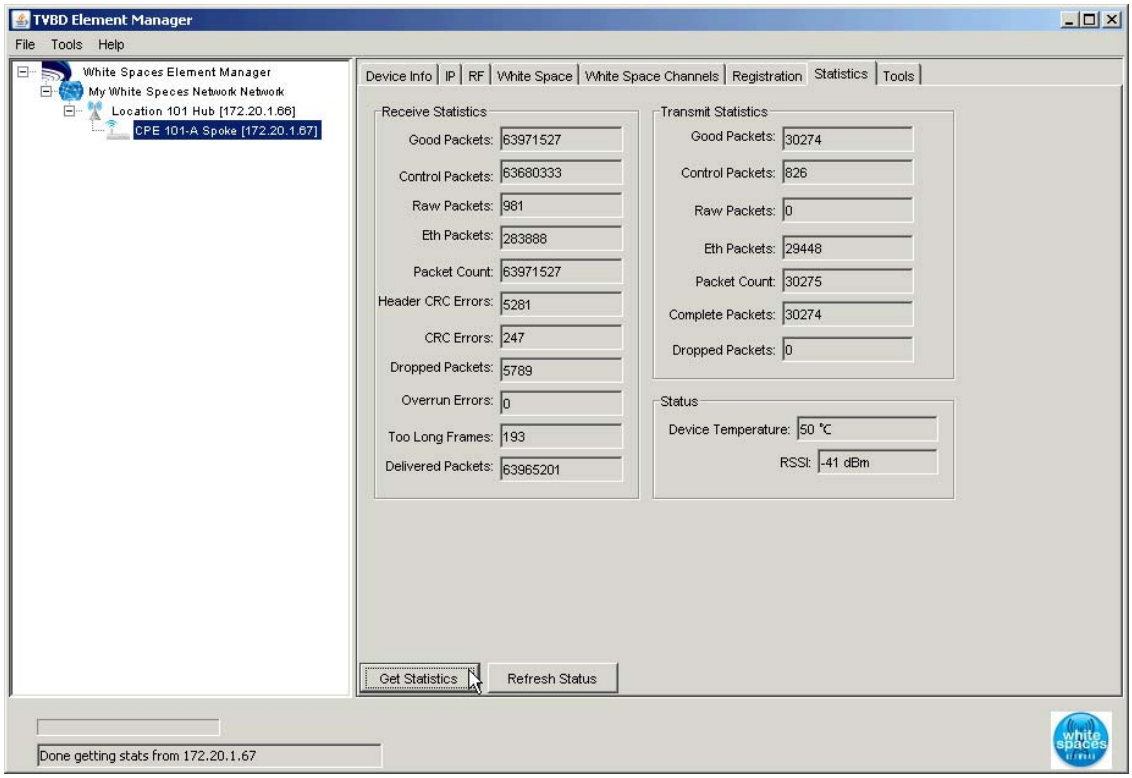


Figure 16 - Statistics Tab

Receive Statistics displays receive packet information handled by the MAC. None of the fields in this tab are editable, but can be polled by clicking the Get Statics button.

- The Good Packets field displays the count of good received packets.
- The Control Packets field displays the count of received control packets.
- The Raw Packets field displays the count of received Raw packets.
- The Eth Packets field displays the count of received Ethernet packets.
- The Packet Count field displays the total amount of packets received.
- The Header CRC Errors field displays the count of received header CRC errors.
- The CRC Errors field displays the count of received CRC errors.
- The Dropped Packets field displays the count of received packets that were dropped.

- The Overrun Errors field displays the count of received overrun errors.
- The Too Long Frames field displays the count of received too long frames.
- The Delivered Packets field displays the count of successfully delivered packets.

Transmit Statistics displays transmit packet information handled by the MAC. None of the fields in this tab are editable, but can be polled by clicking the Get Statistics button.

- The Good Packets field displays the count of good transmitted packets.
- The Control Packets field displays the count of transmitted control packets.
- The Raw Packets field displays the count of transmitted Raw packets.
- The Eth Packets field displays the count of transmitted Ethernet packets.
- The Packet Count field displays the total amount of data packets transmitted.
- The Complete Packets field displays the total transmitted packet count including control packets and data packets (without dropped packets).
- The Dropped Packets field displays the count of transmitted packets that were dropped.

Status displays the Device Temperature and RSSI from the radio. None of the fields in the Status are editable, but can be polled by clicking the Get Statistics button.

Tools Tab

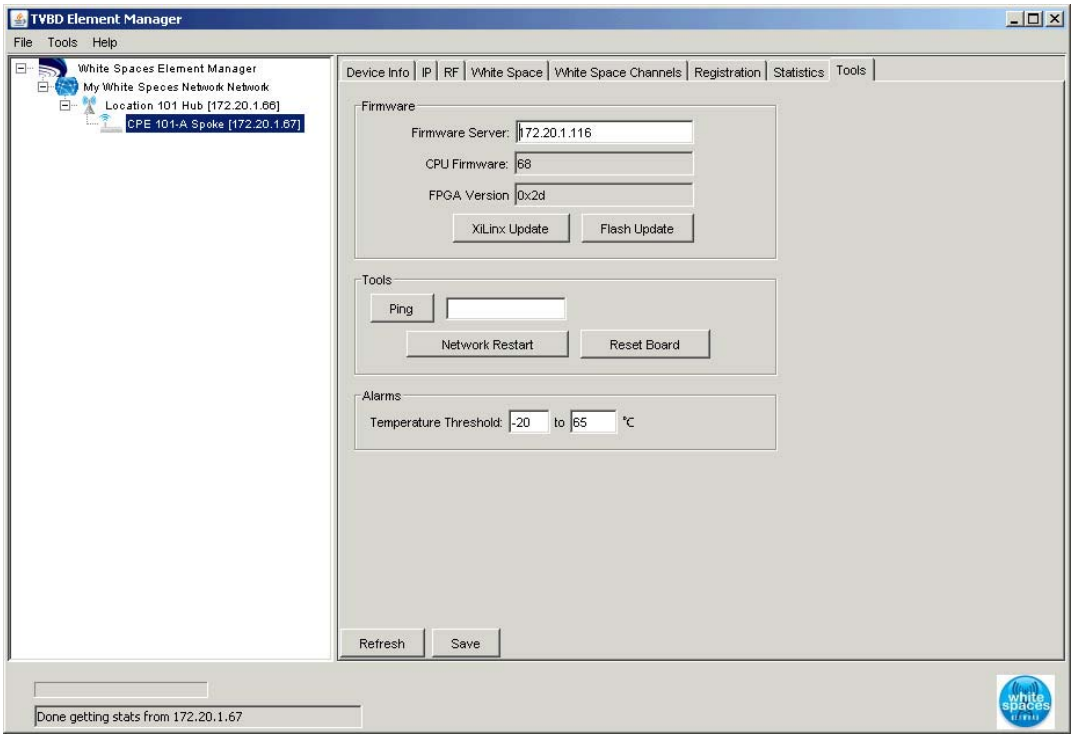


Figure 17 - Tools Tab

The Tools tab contains actions for the radio.

- Firmware Server is the IP address of the device used as the firmware server.
- CPU Firmware displays current version of firmware running on the digital board.
- The Flash Update button will update the CPU firmware using the Firmware server address.
- FPGA Version displays the current version of the FPGA firmware
- The XiLinx Update button will update the FPGA firmware using the Firmware Server address.
- Tools: If pressed, the Ping button will ping the IP address in the text field if reachable.
- The Network Restart button will re-initialize the network stack.
- The Reset Board button will reboot the whole device (digital and radio board).

- Alarms: Temperature Threshold fields allow for a minimum and maximum operating temperature to be set in degrees Celsius. If the radio operates beyond these thresholds, an alarm will be triggered.

The mentioned buttons will take action immediately once pressed.

5.0 Upgrading Software

The software in the AWR can be upgraded in the field to support new features or correct any problems. This can be done locally through the Ethernet port and remotely over the air. The radio has two types of software which can be field-upgraded (CPU and FPGA). The CPU code controls the higher-level functionality within the radio including the MAC, networking layers, network management and user interfaces. The FPGA code supports the Physical layer.

Software upgrades for both the CPU and FPGA code are provided periodically by KTS wireless. Users are notified when these become available. Some upgrades may be mandatory to resolve problems while others may be optional if they include new features. Release notes will be available for each new version outlining the changes. Some new releases may require additional fees and/or licensing agreements.

The tools tab is used to change the software within the AWR.

Tools Tab

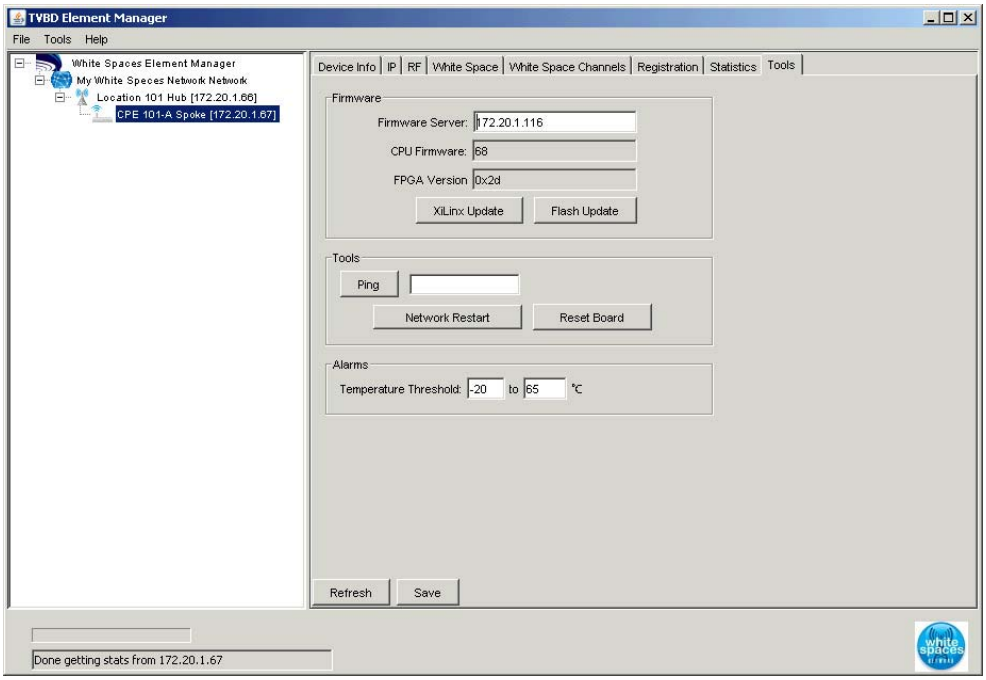


Figure 18 - Tools Tab

The Tools tab contains actions for the radio.

- Firmware Server is the IP address of the device used as the firmware server.
- CPU Firmware displays current version of firmware running on the digital board.
- The Flash Update button will update the CPU firmware using the Firmware server address.
- FPGA Version displays the current version of the FPGA firmware
- The XiLinx Update button will update the FPGA firmware using the Firmware Server address.
- Tools: If pressed, the Ping button will ping the IP address in the text field if reachable.
- The Network Restart button will re-initialize the network stack.
- The Reset Board button will reboot the whole device (digital and radio board).
- Alarms: Temperature Threshold fields allow for a minimum and maximum operating temperature to be set in degrees Celsius. If the radio operates beyond these thresholds, an alarm will be triggered.

The mentioned buttons will take action immediately once pressed.