11.7 IAS Advanced Setup

11.7.1 Configuration

Leader

Go to the **Presets>Mesh Settings** page.

Only one node is configured as a **Leader**; the leader node may be the node least likely to lose communications with the network and typically be at the base station, but this will depend on the nature of the system and operating environment.

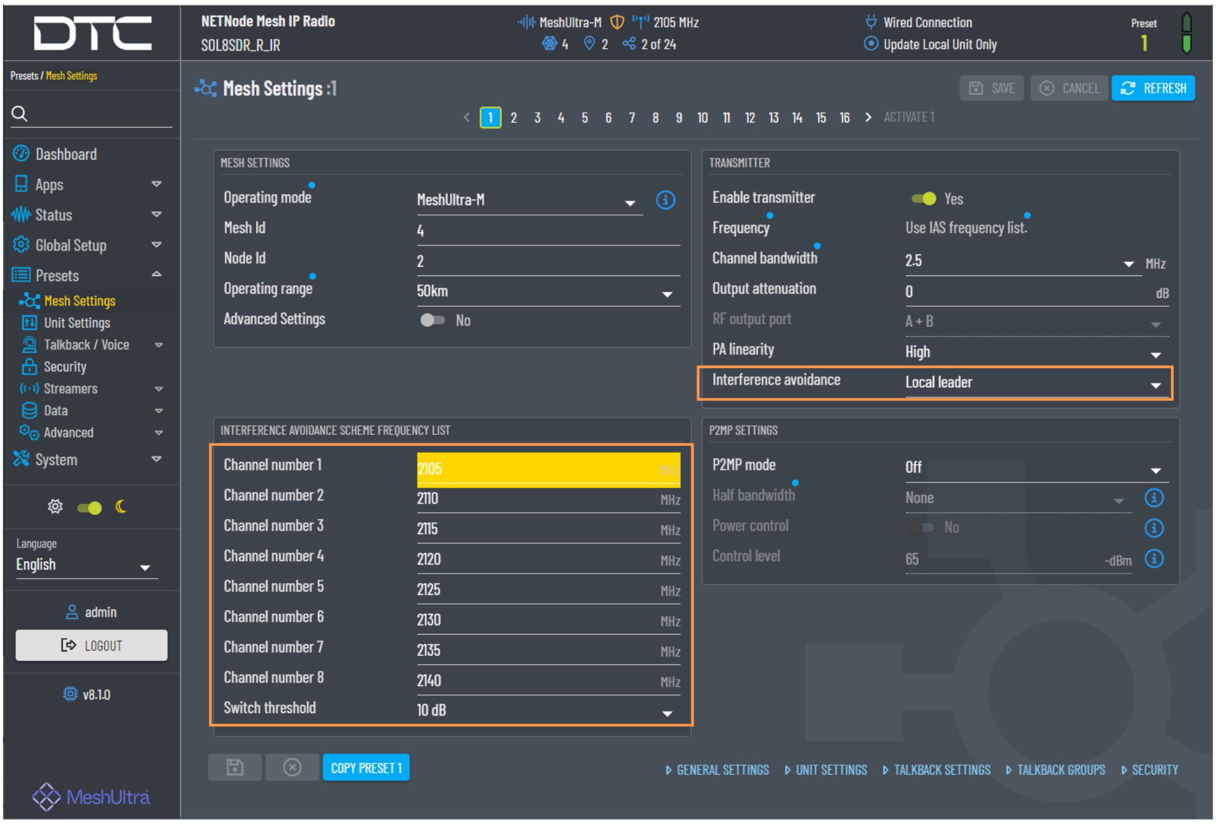
In **Distributed** mode, the node with the lowest Node ID will act as the leader. If you try to select a node which is not the lowest Node ID, an error message will show.

Up to eight channels can be entered in the frequency list and **must be within the band of all nodes in the system**. The active frequency is highlighted. The further apart the frequencies, the better the reduction in interference during a frequency move. The greater number of channel presets that are entered, the longer it will take to re-establish the network as there are more alternate frequencies to scan.

Note: Please read *Section 11.7.3* before setting the frequency list.

Note: It is not necessary for Update All Nodes to be set for IAS to operate.

Note: There are optimum small frequency offsets that improve the performance of the system by reducing the chance of adjacent frequencies triggering false burst detection on the wanted frequency; the optimum offsets can be calculated from frequency delta and bandwidth figures. Please contact DTC Technical Support (*Section 13.2*) for help in selecting offsets, if required.



Switch Threshold

The **Switch Threshold** is the amount of noise reduction (dB) required between the current channel and the best alternative channel before a hop will occur. The higher the number, the less likely a channel change will occur.

Some experimentation may be required to find the optimum switch threshold for the interference environment the radio is operating in.

Note: For NETNode devices, to avoid unnecessary hopping it is recommended to use a value of at least 4dB for sub-band 2 and 10dB for sub-band 1 and 3, see *Section 11.7.3*.

For large networks, the distance between the nodes is worthy of consideration. When units are running at high power and are within a few feet or tens of feet of each other, it is possible that they can self-interfere during frequency hops. The user can experiment by increasing the switch threshold to optimize the speed of the hop against the propensity of the network to accidentally hop due to self-interference. For networks above 40 nodes, the user may wish to experiment with thresholds up to 20dB. The strength of the typical interference/jamming is also a consideration.

When testing IAS, it is more realistic to test with the interference >20 feet from the Mesh network.

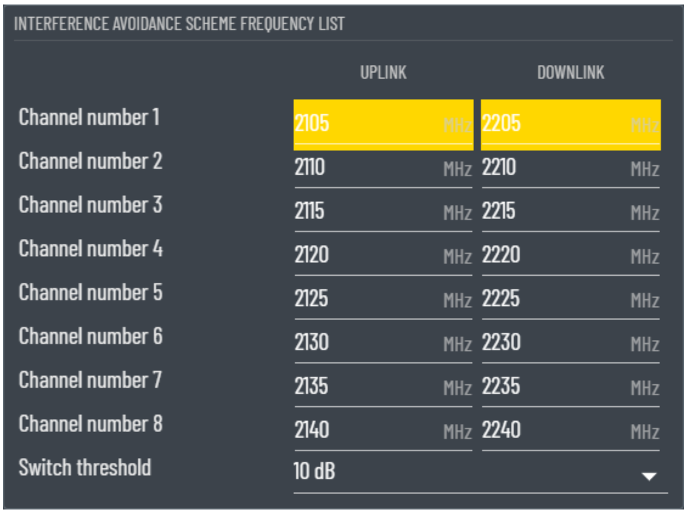
Followers

All other nodes in the Mesh network will become **Followers** when the leader is configured and will enter the IAS scheme automatically. Nodes wishing to enter the system must be on the correct frequency and Mesh settings. The follower node frequency list will match the leader but will be greyed out.

11.7.2 P2MP Interference Avoidance

Interference Avoidance can also be applied to a point-to-multipoint network, see *Section 11.6* for P2MP setup.

Configuration is the same as explained above in *Section 11.7.1* but alternatives are required for the uplink and downlink frequencies.



11.7.3 Frequency Settings

Channel Selection

For **SDR-MESH**, the selection of alternate channel frequencies (1-8) has no constraints and can be set within the bandwidth of the product variant.

For **NETNode**, the selection of alternate channel frequencies has additional constraints due to the enhanced band filtering architecture. All alternate channel frequencies (1-8) must be within the same operating sub-band and constrained within the range defined in *Table 11-2*.

Frequency Variant	Sub-band 1	Sub-band 2	Sub-band 3
320-470MHz	320-446.375MHz within a 20MHz range	446.5-449.5MHz unrestricted	449.625-470MHZ within a 20MHz range
1200-1700MHz (hardware rev. <4.0)	1200-1409.875MHz within a 75MHz range	1410-1460MHz unrestricted	1460.125-1700MHz within a 75MHz range
1200-1700MHz (hardware rev. ≥4.0)	1200-1349.875MHz within a 75MHz range	1350-1440MHz unrestricted	1440.125-1700MHz within a 75MHz range
1650-2400MHz	1650-2199.875MHz within a 75MHz range	2200-2300MHz unrestricted	2300.125-2400MHz within a 75MHz range
1980-2550MHz	1980-2199.875MHz within a 75MHz range	2200-2300MHz unrestricted	2300.125-2550MHz within a 75MHz range
4400-5000MHz	Sub-bands do not apply; select from 4400-5000MHz within a 250MHz range		

Table 11-2 NETNode Frequency Selection Bands

Phase 5 Channel Selection Example

A UHF (320-470MHz) NETNode is configured for IAS, the selected channel frequencies are chosen to lie in Band 1 which requires all channels to be configured within 320-446.375MHz and a 20MHz range. *Table 11-3* shows valid and invalid channel settings.

Channel Number	Valid Settings	Valid Settings	Invalid Settings	Invalid Settings
Channel Num #1	340MHz	341MHz	340MHz	441MHz
Channel Num #2	342.9MHz	342MHz	345MHz	442MHz
Channel Num #3	345.7MHz	343MHz	350MHz	443MHz
Channel Num #4	348.6MHz	344MHz	355MHz	444MHz
Channel Num #5	351.4MHz	345MHz	360MHz	445MHz
Channel Num #6	354.3MHz	346MHz	365MHz	446MHz
Channel Num #7	357.1MHz	347MHz	370MHz	447MHz (out of sub-band)
Channel Num #8	360MHz	348MHz	375MHz	448MHz (out of sub-band)
Total range	20MHz	8MHz	35MHz (exceeded range)	8MHz

Table 11-3 Channel Range Examples

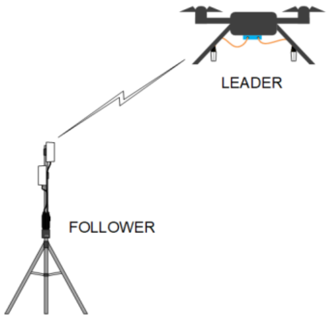
11.7.4 IAS Example Scenarios

Two Node System: Ground to Air

Node 1 is the ground station.

Node 2 is the mission aircraft. The aircraft is the most vulnerable node to interference.

The aircraft is configured as **Local Leader** and the ground station will configure itself as a **Follower**.



If the aircraft Leader node suffers severe interference causing a loss of link, it will select another frequency clear of interference and attempt to start a network.

The ground station Follower node will sweep through the frequency list listening for a network. Once it hears the aircraft node it will reform a network on the new frequency.

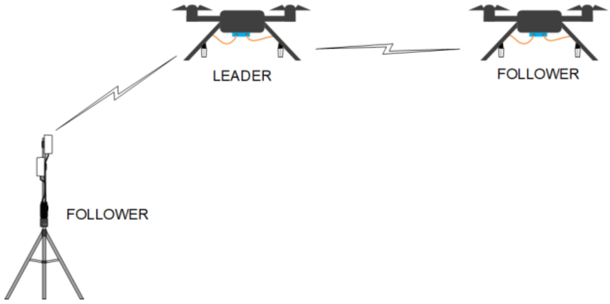
Three Node System: Ground to Air to Air

Node 1 is the ground station.

Node 2 is the repeater aircraft. The repeater node has a direct RF link to the ground station and the mission aircraft.

Node 3 is the mission aircraft. It only has a direct link to the repeater aircraft and is the most vulnerable node to interference.

The repeater aircraft is configured as **Local Leader** and the ground station and mission aircraft will configure themselves as **Followers**.



Should the mission aircraft be lost, a network will still be maintained be between the repeater aircraft and ground station.

If the mission aircraft is subject to sudden high level interference, it will drop off the network as it won't have had the opportunity to communicate the high interference level it is experiencing.

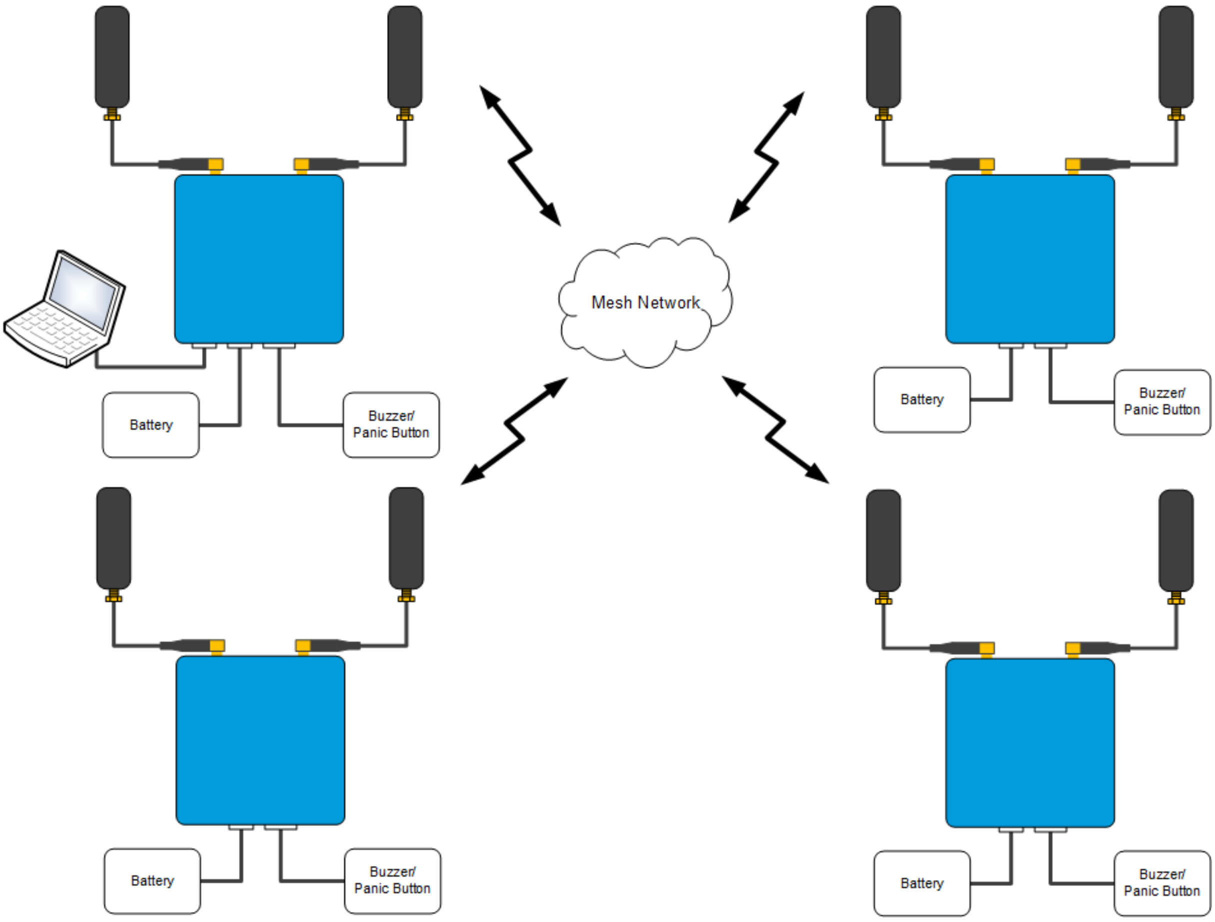
However, it is quite likely the repeater node will detect this on-channel interference, albeit at a lower level, and thus may instigate a frequency change to a clear channel. This would provide an opportunity for the mission node to rejoin the network.

11.8 GPIO Panic Button

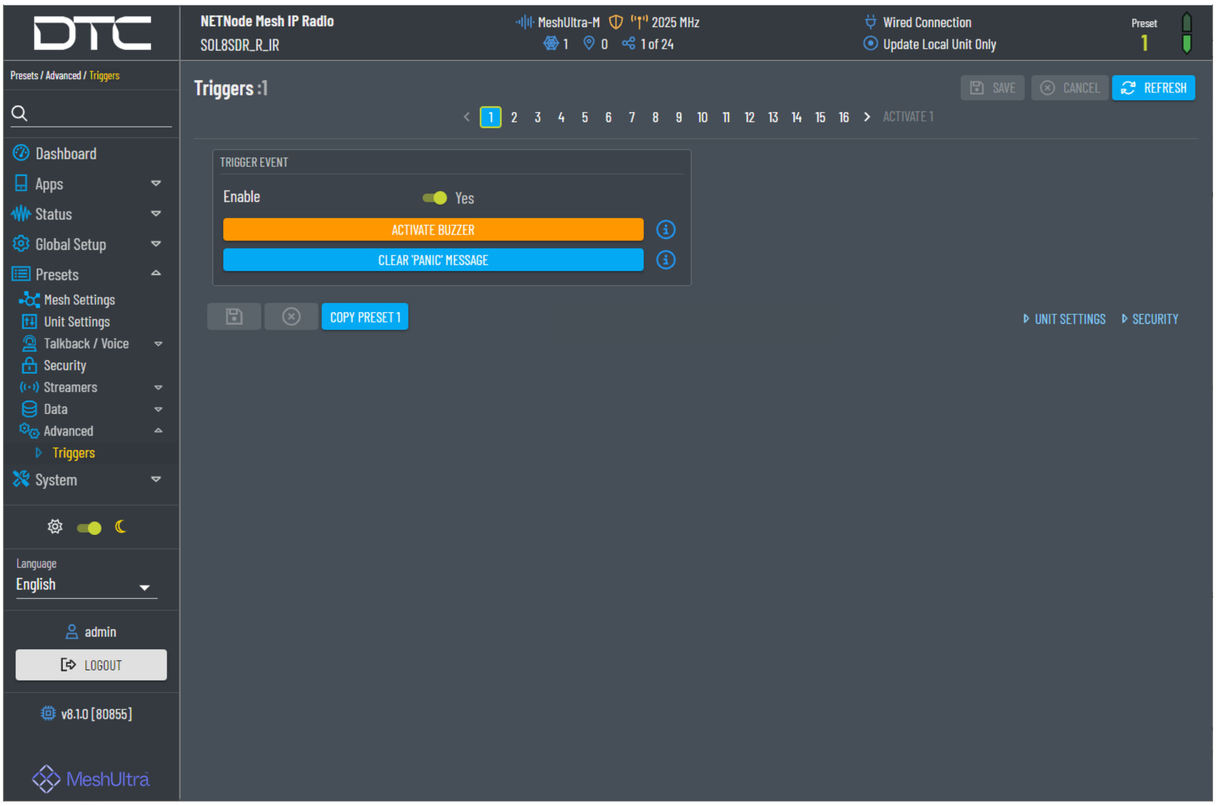
Products with a GPIO port may be fitted with a panic buzzer/panic button. Please refer to the OEM guide for further details.

Pin	Function
1	GPIO0
2	GPIO1
3	0V
4	GPIO2 (panic button)
5	Switched 3V3 Out (buzzer)
6	0V

The following system diagram provides an example set up for several nodes in a Mesh network, each fitted with a buzzer/panic button device.



Each node must have Enable set to **Yes** in the **Presets>Advanced>Triggers** page.



A buzzer device fitted to any node in the network will be activated by clicking **Activate Buzzer**. The buzzer will operate for 4 seconds.

When a panic button is activated, a panic message is displayed in the WUI header showing unit name, time, and Node ID / Mesh ID.

The message can be cleared by clicking **Clear Panic Message**.

11.9 ATAK Integration with Cable to Phone

11.9.1 Introduction

This section explains how to setup a Mesh node with a Samsung S20 Tactical Edition phone with TE Enabler support package and pre-installed ATAK software, over a cabled connection.

11.9.2 Connections

The following diagram provides an example integration of a SOL8SDR-H2 with a Samsung S20 TE phone. However, any Mesh node with a similar USB connection can be used.

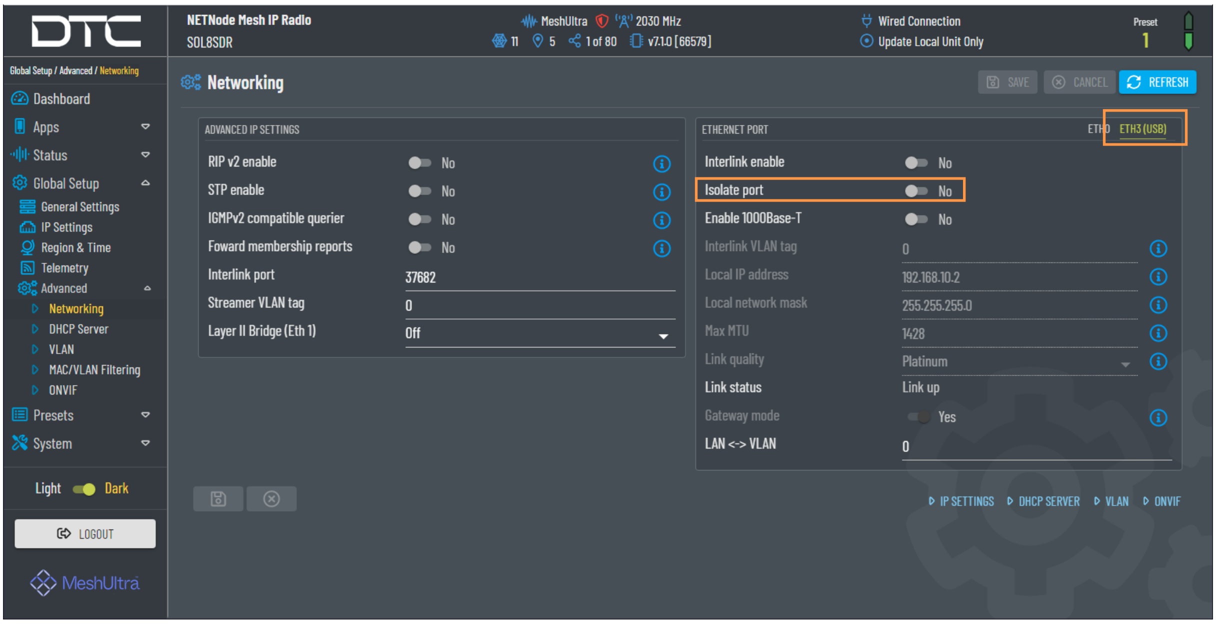
Figure 11-2 ATAK to SDR-H2 Connections

11.9.3 Node Configuration

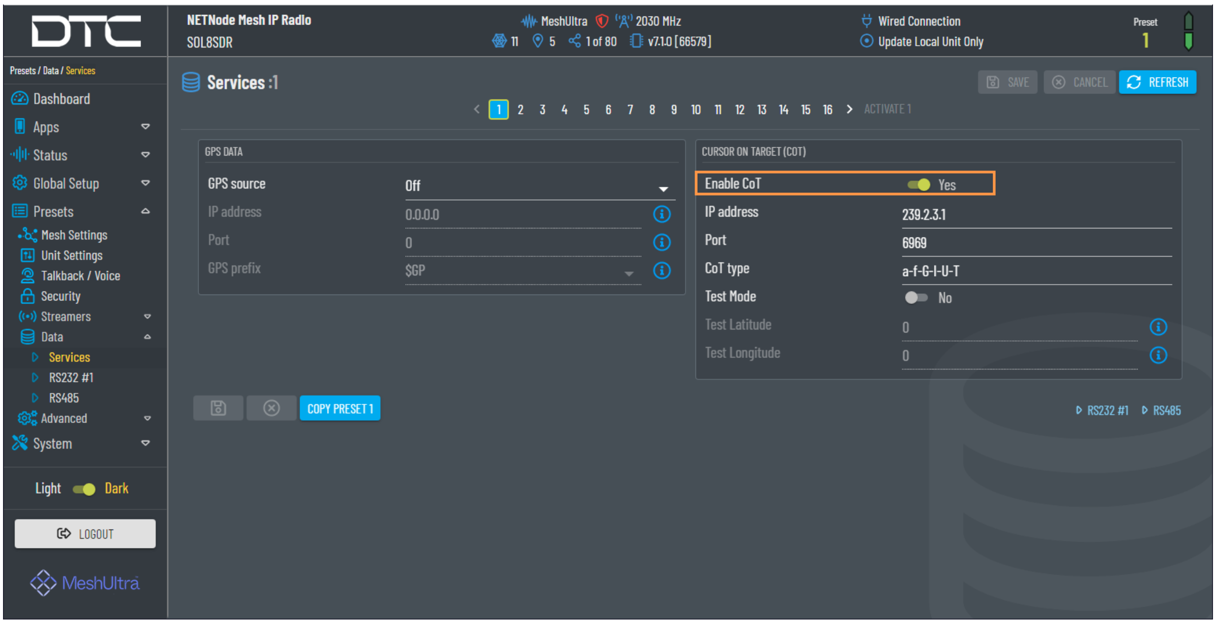
Open the node WUI on the Mesh node and go to the **Global Setup>General Settings** page. Ensure the **USB mode** is set to **Host**.

When the phone is connected to the USB connector of the node, ensure the phone is set for **USB tethering** on connection; it may default to charge.

If the phone has tethered successfully, a **Eth3 (usb)** page will be created in the **Global Setup>Advanced>Networking** page. Ensure that **Isolate Port** is set to **No** to allow the IP data to pass.



Go to the **Presets>Data>Services** page and ensure that **Enable CoT** is set to **Yes**.

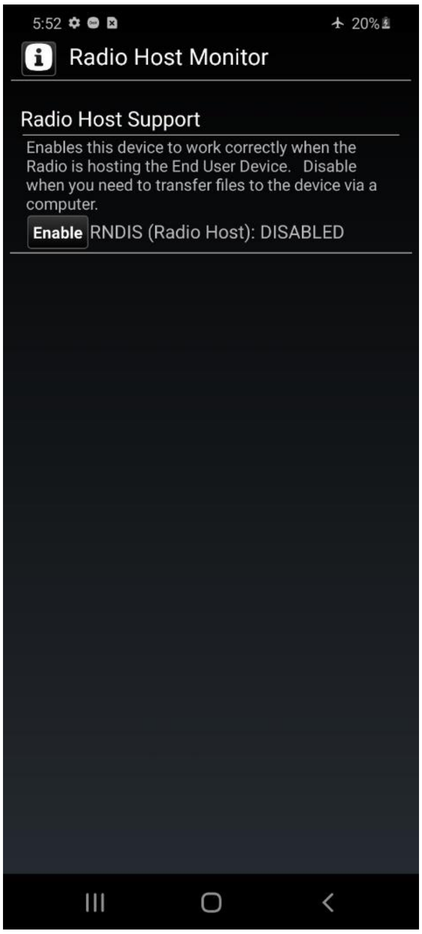


11.9.4 Phone Configuration

The Samsung S20 TE phone will be pre-installed with required TE Enabler applications.

Radio Host Monitor

Open the Radio Host Monitor app and Enable RNDIS.



In the **Change Configuration** settings, set the **Address** to a unique IP address on the same subnet as the node. The **Status** will reconfigure.

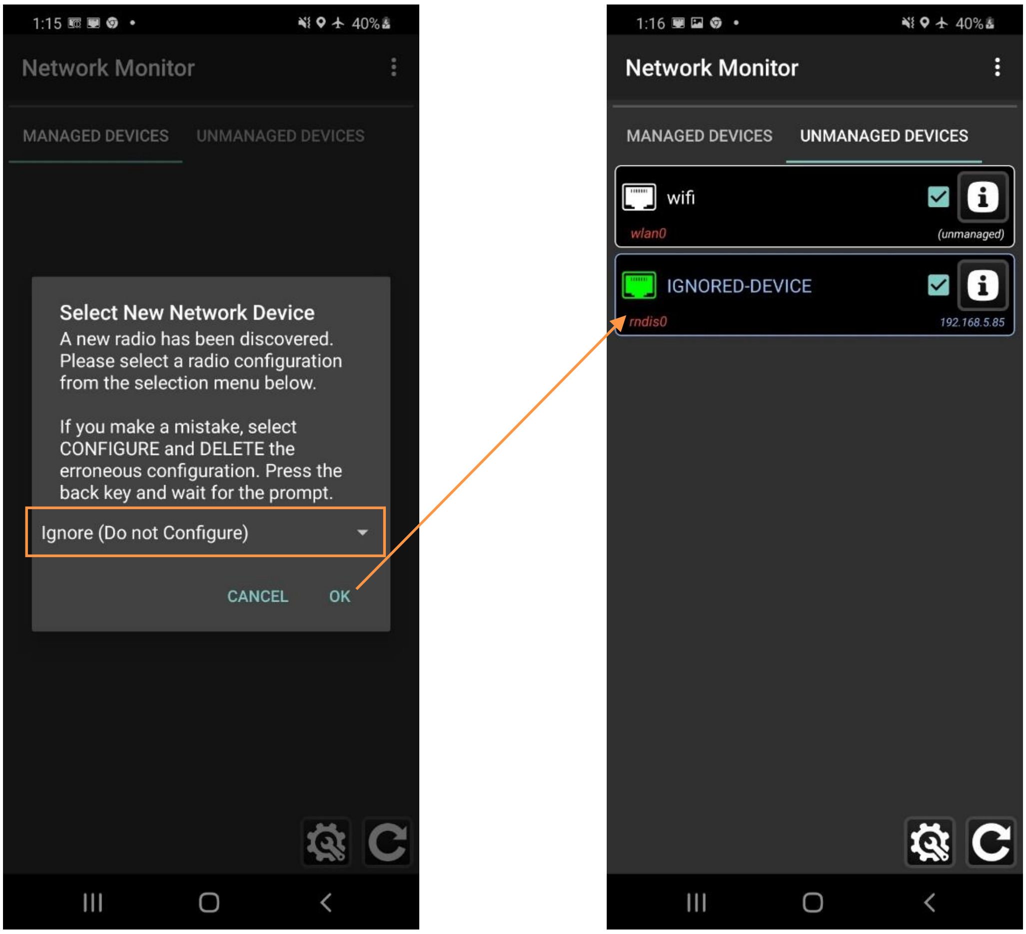
The node and phone will now be connected by IP and a web browser interface to the node can be opened on the phone, if required.

Network Monitor

Open the Network Monitor app.

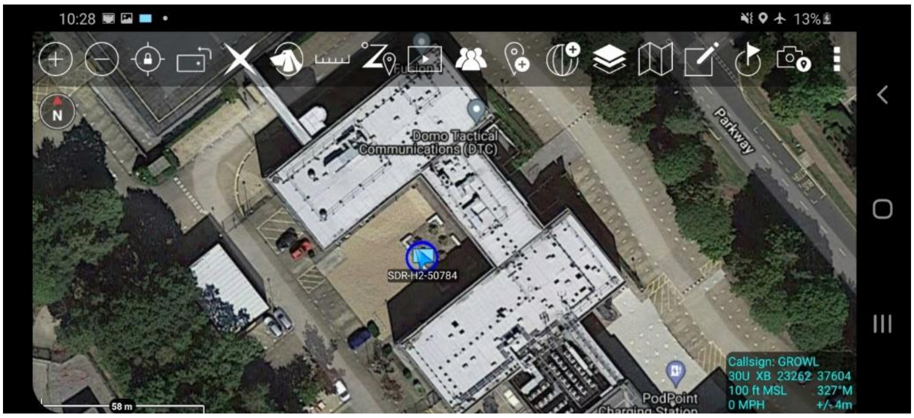
If the phone has detected the node, a **Select New Network Device** dialogue will be present. Change the device to **Ignore (Do not Configure)** and tap OK.

In the **Unmanaged Devices** tab, the connected device will appear green and will show the IP address configured earlier in the Radio Host Monitor.



ATAK

Open the ATAK app. The CoT data from the node will now be appear in the application.



11.10 ATAK Mesh Radio Plugin

11.10.1 Introduction

The ATAK Mesh Radio plugin will allow interaction with the Mesh radio via the ATAK software application. The ATAK installation files and ATAK plugin can be downloaded from DTC's WatchDox facility, see *Section 13.1*.

IMPORTANT: The ATAK plugin variant must match the ATAK version, i.e., the plugin for v4.5.1 cannot be used for ATAK v4.7.0. Only use the DTC supplied ATAK installers to install the full version of the ATAK software.

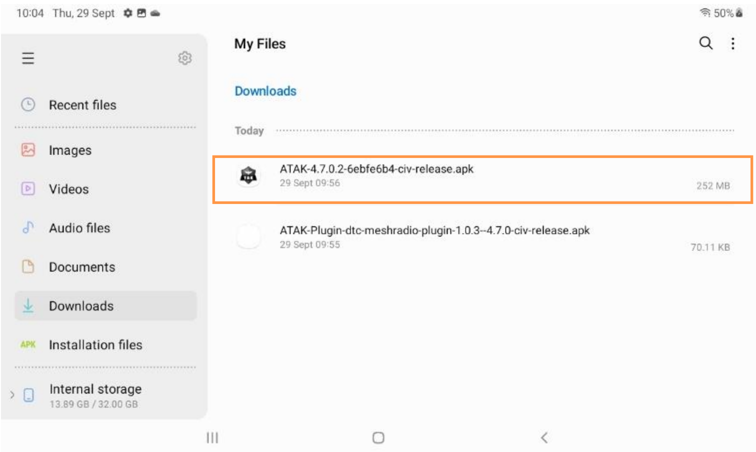
It is recommended that the previous version of ATAK is uninstalled before installing a new version; ensure any residual ATAK files are removed by manually deleting the ATAK folder. Please be aware configuration or saved files will be lost.

11.10.2 Load the ATAK Application

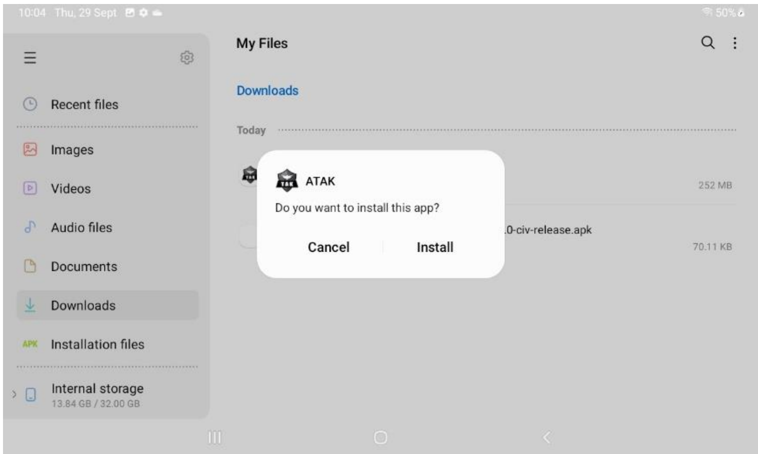
Connect the phone/tablet to a PC and copy the DTC supplied ATAK installation and plugin files to the phone/tablet's download folder. When the transfer is complete, the phone/tablet can be disconnected from the PC.

Note: The following screenshots are representative and may differ depending on the device.

On the phone/tablet, go to the downloads folder and open the ATAK installation file.



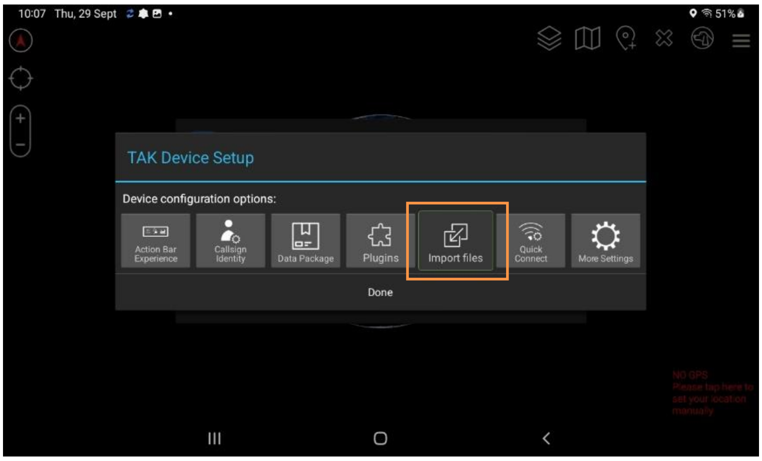
It may be necessary to allow permission to complete the installation.



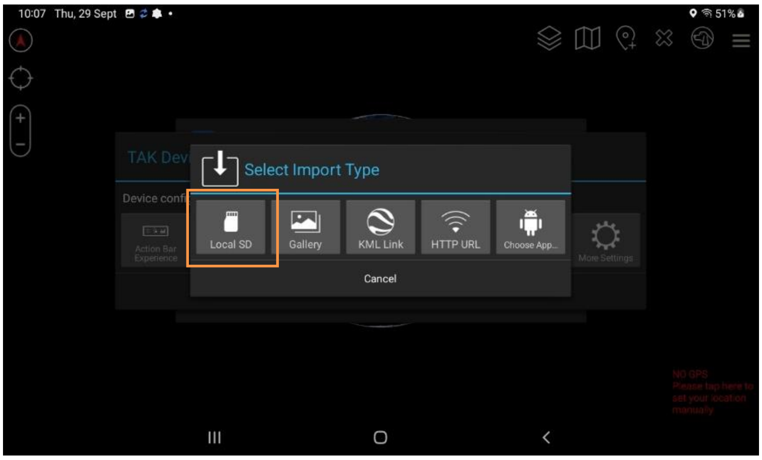
On successful completion of the installation, open the ATAK application. It will be necessary to accept user license agreements and allow phone/tablet permissions to use the application.

When the ATAK application opens, you may be presented with the **Device Setup** screen, this will enable you to install the plugin. Select **Import files**.

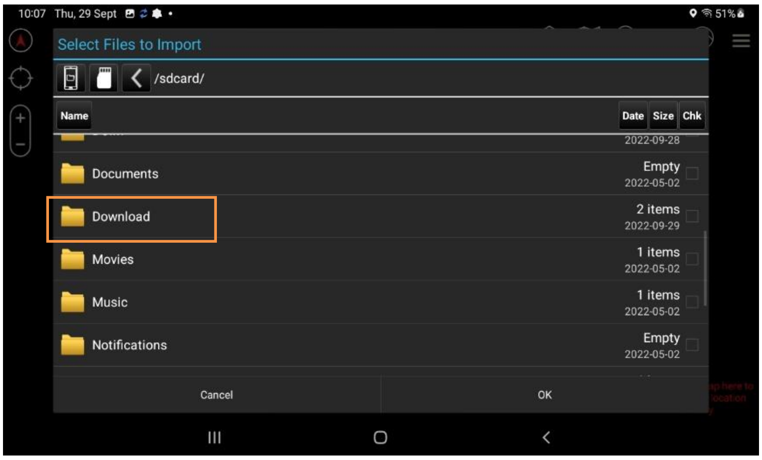
IMPORTANT: The plugin installation may need to be completed twice before it is successfully installed. It can also be initialised from the ATAK **Import** menu.



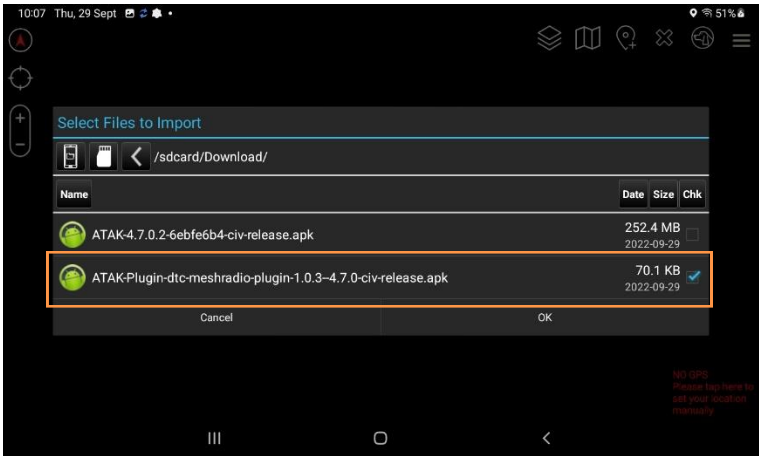
Select **Local SD**.



Open the **Download** directory.



Select the plugin file and click **OK** to start the download. It may be necessary to allow permissions to complete the installation.

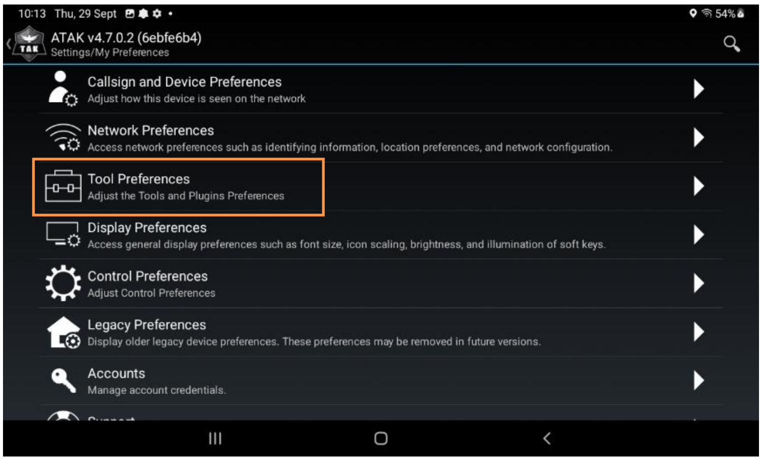


11.10.3 Connect Mesh Radio

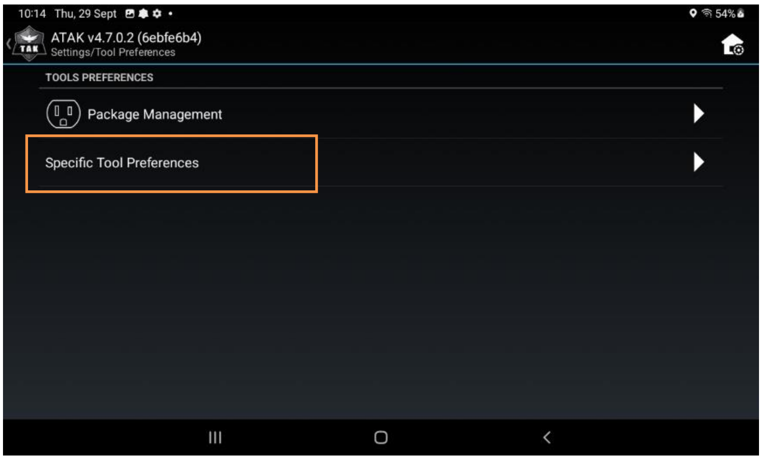
Before proceeding with the ATAK setup, it is essential to establish a Wi-Fi connection from the phone/tablet to the Mesh radio. Ensure a Wi-Fi dongle is attached to the radio and configure the WLAN settings as an access point, see *Section 7.8*. Go to the phone/tablet's Wi-Fi settings and connect to the radio using the configured SSID and pass phrase.

Start the ATAK application and from the main menu select **Settings**.

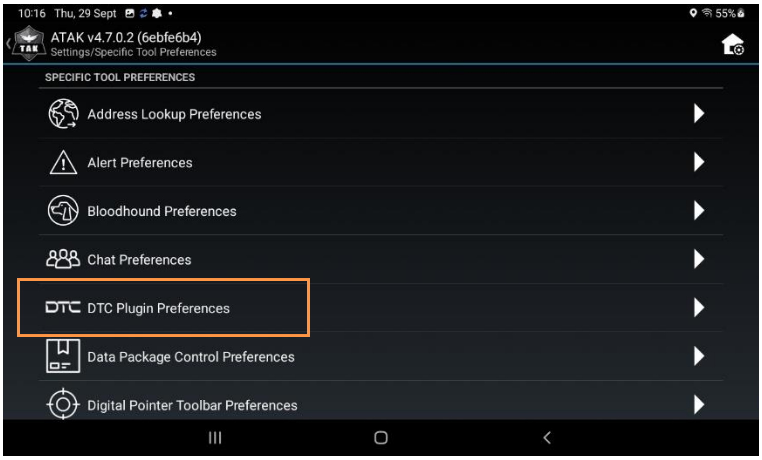
Select **Tool Preferences**.



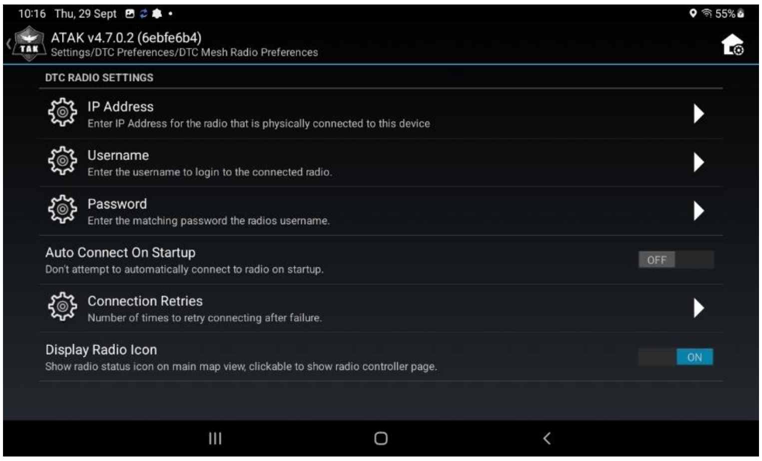
Select **Specific Tool Preferences**.



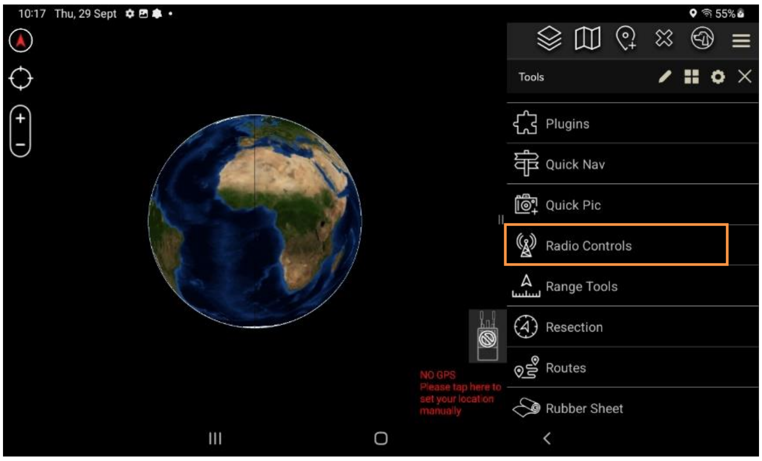
Select **DTC Plugin Preferences**.



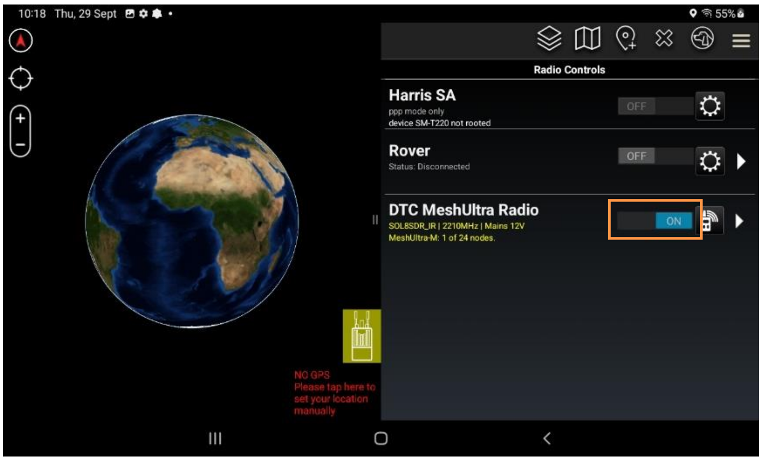
Enter the **IP Address** of the Mesh radio, the **Username** (admin or blank if default), and the **Password** (Eastwood if default).



Return to the ATAK main menu, select **Radio Controls**.



Switch the Mesh radio **On**; the radio icon should turn amber or green, see *Table 11-4*.



The radio icon can have the following states.

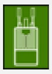
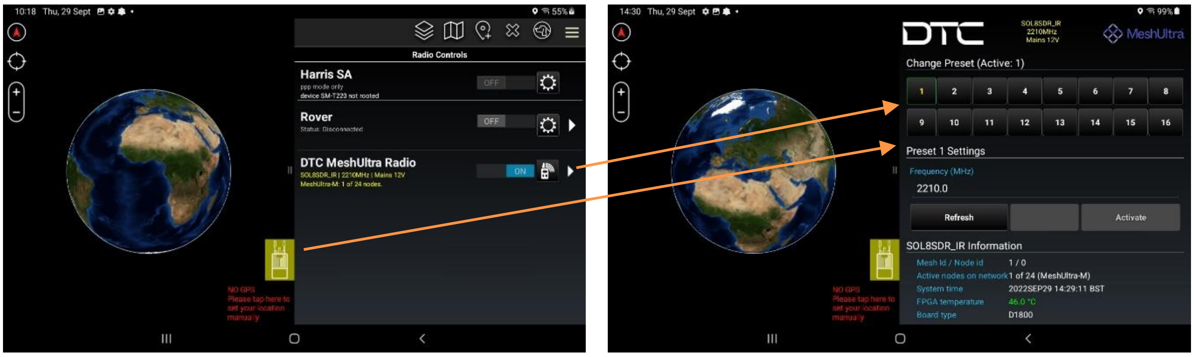
Icon	State
	Off
	Attempting to connect
	Connected to radio although no Mesh formed
	Connected to radio and Mesh formed with other radios

Table 11-4: Radio Colour Codes

11.10.4 ATAK Plugin Operation

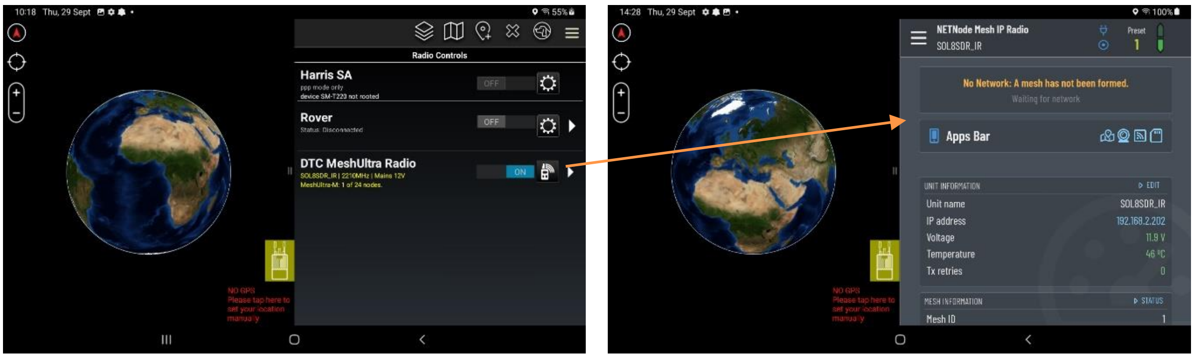
The Mesh radio dashboard allows you to change the preset and frequency settings, it also provides status and device connection information. Scroll down to see all features.

The dashboard can be accessed from the radio icon or from the forward arrow icon in the Radio Controls page.



It is possible to open a web browser connection to the node for full web interface control.

In the Radio Controls page, select the radio icon in the Mesh radio connection. It may be necessary to re-enter the Mesh radio user credentials to open the WUI.



11.11 USB Device Connection to Tablet

11.11.1 Introduction

The following examples were tested using a tablet with a USB-C port via a USB On-the-Go adaptor (to ensure the tablet is configured as a host).

The node must be configured as a USB device and have a USB-C or USB-micro connector.

Note: Nodes with USB-A (f) connectivity cannot be used in this scenario as this is always a host.

11.11.2 System Diagram

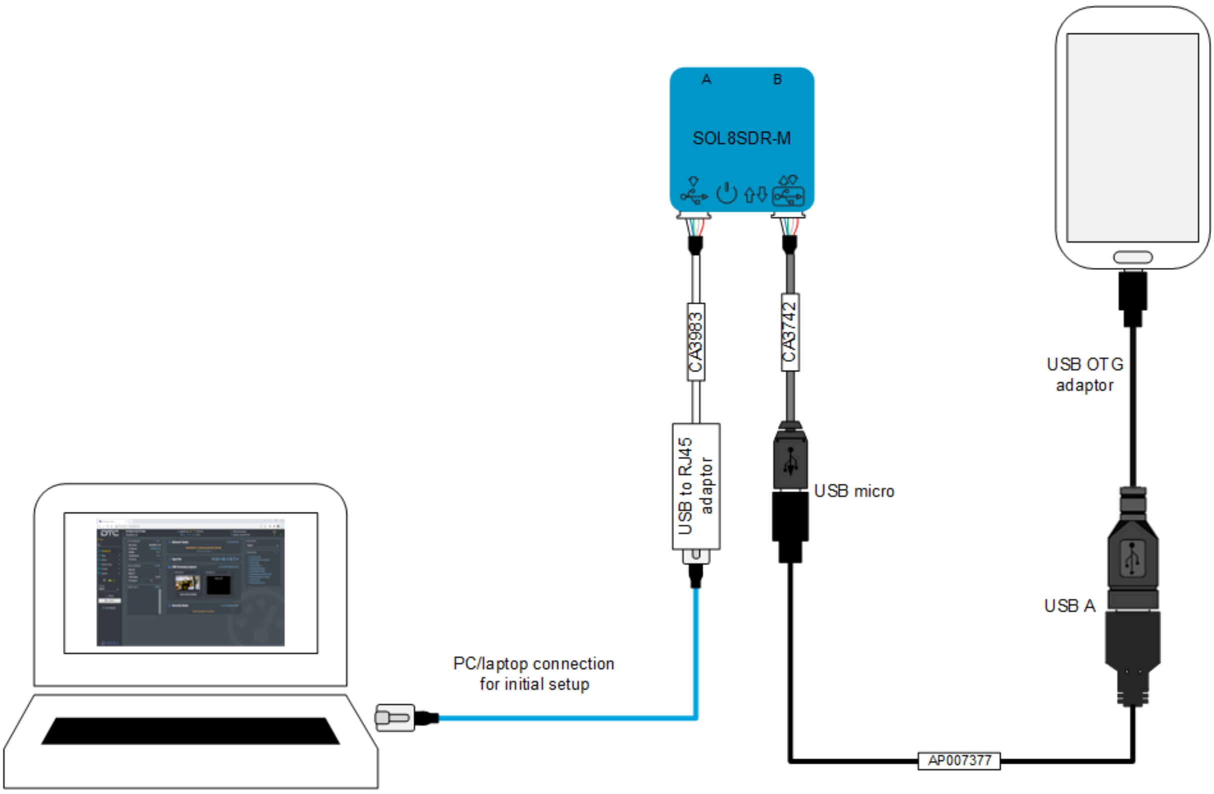


Figure 11-3: SDR-M Connection to Tablet

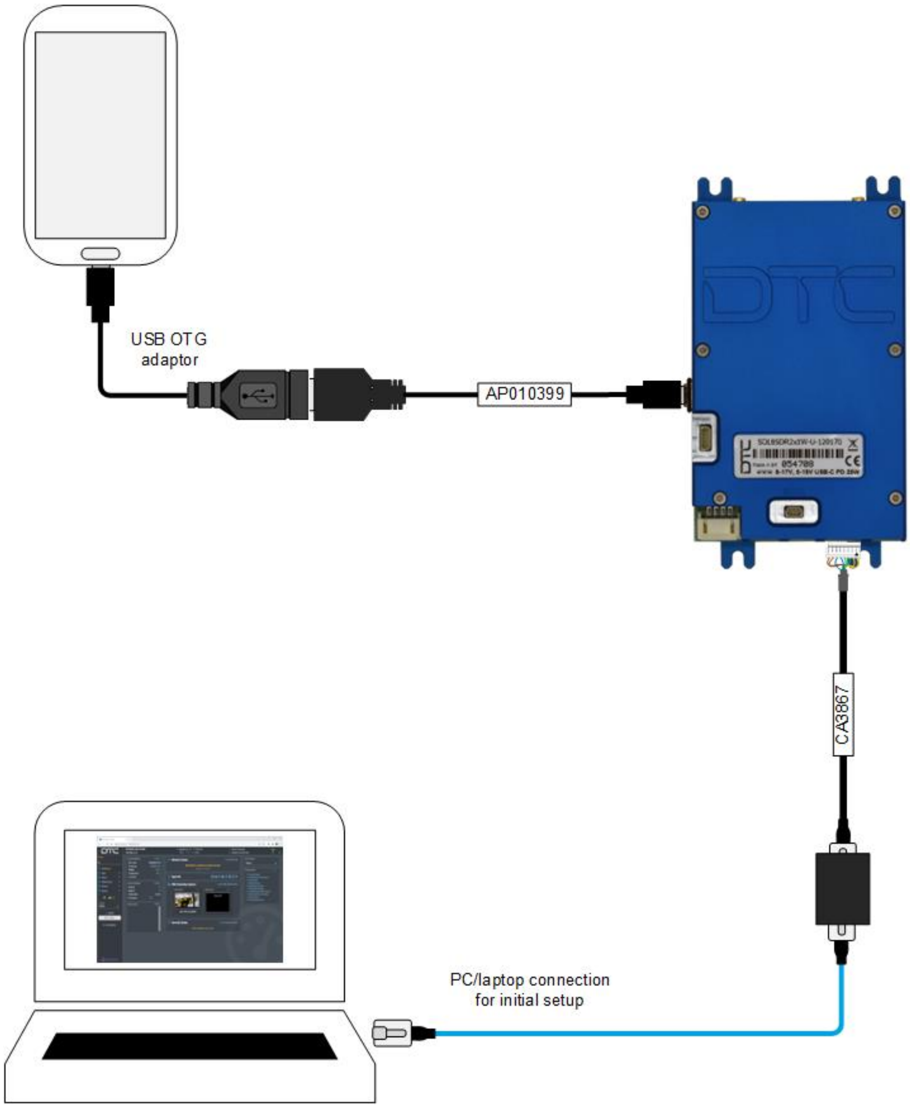
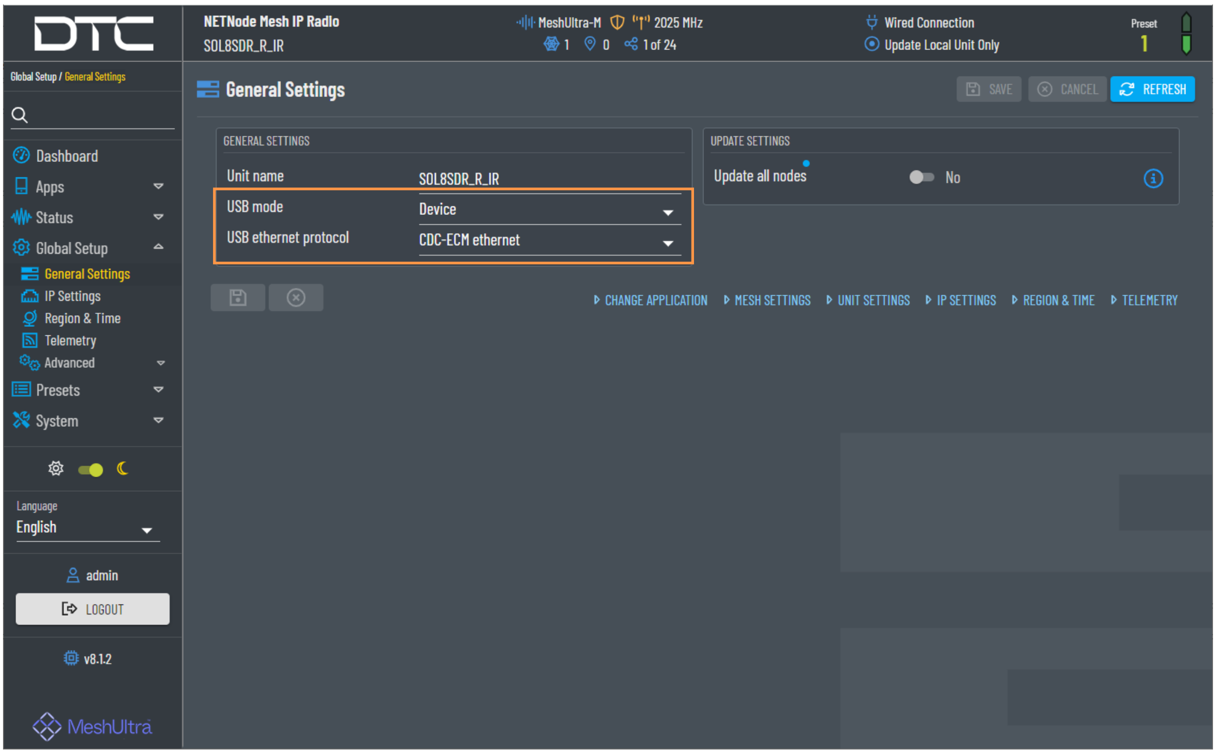


Figure 11-4: SDR2x1W-UC Connection to Tablet

11.11.3 Node Configuration

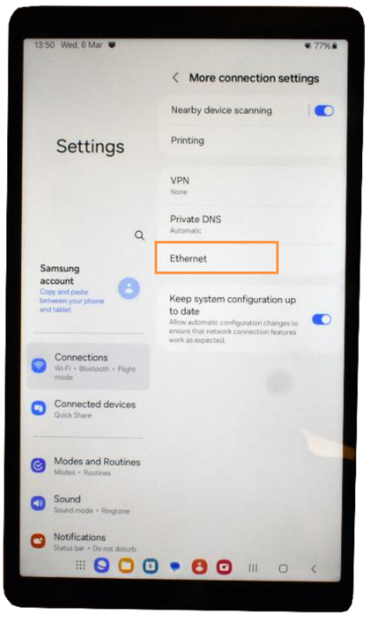
Open the node WUI on the Mesh node and go to the **Global Setup>General Settings** page. Ensure the USB mode is set to **Device** and the USB Ethernet protocol is set to **CDC_ECM Ethernet**.



11.11.4 Tablet

When the node is connected to the tablet via USB as shown in Figure 11-3 and Figure 11-4, the Connection Settings on the table device should show **Ethernet** in bold black (i.e., not greyed out).

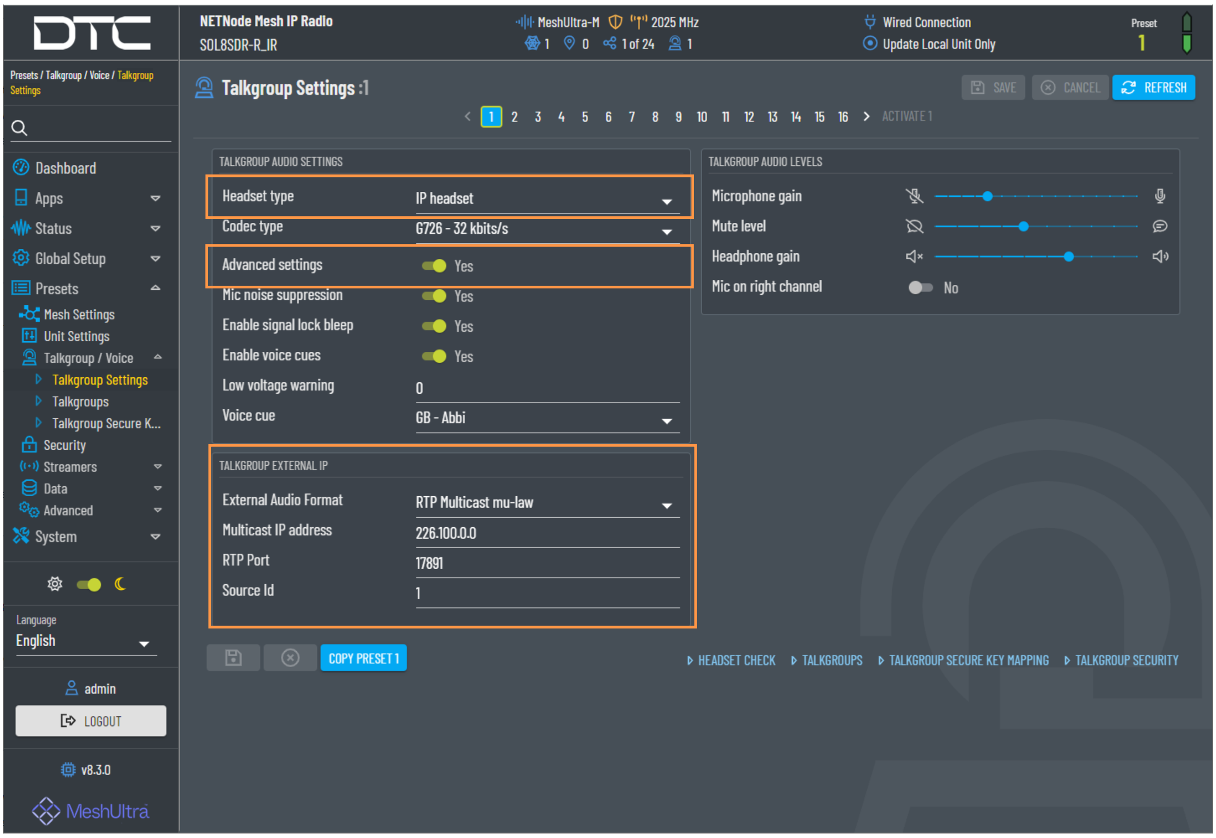
If the system is not connected to an DHCP server, it may be necessary to fix IP addresses on the tablet and node.



11.12 IP Headset Protocol

11.12.1 Overview

Go to the **Presets>Talkgroup Settings** page, select **IP headset** as the headset type and **Advanced settings** is set to **Yes**. The **Talkgroup External IP** settings will show.



When the radio receives and decodes talkgroup audio packets, it will re-encode them according to the **External Audio Format** selection. The G711 encoded audio will then be encapsulated in an RTP packet and sent to the specified **Multicast IP address** and **RTP port**.

When the radio receives RTP packets on the specified Multicast IP address and RTP port containing encapsulated G711 audio of the selected external audio format it will:

1. Decode the received G711 audio.
2. Encode it in the selected codec type.
3. Send audio packets to the selected Talkgroup.

11.12.2 G711 Codec

G711 is a PCM codec format which encodes audio at a sampling rate of 8kHz, 8 bits per sample. It can use one of two logarithmic companding algorithms, µ law and A law. The IP Mesh radios support both algorithms when IP headset is enabled. The algorithm is selected under External audio format.

11.12.3 RTP Packet Details

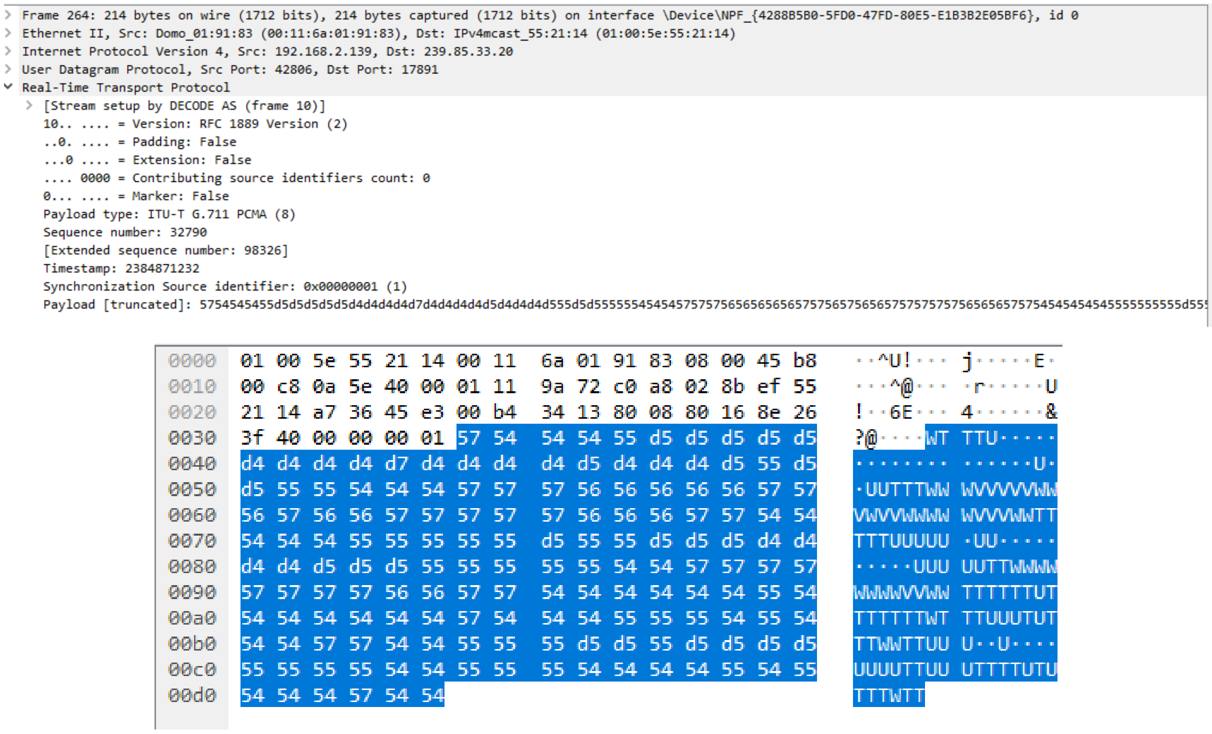
An RTP (Real-time Transport Protocol) packet consists of a 12-byte header and a payload. These packets are sent as UDP.

The radio sends the RTP packets with a 160-byte payload. This payload contains 160 G711 encoded samples.

The RTP packet header contains the following fields:

Field	Length (bits)	Description
Version	2	RFC 1889 version (always 10 binary).
Padding	1	Whether there are any extra padding bytes at the end of the RTP packet (in the case if this protocol always 0).
Extension	1	Whether there are any extension fields between the 12-byte header and the payloads (in the case of this protocol always 0).
Contributing source ID count	4	The number of contributing source identifiers that can follow the SSRC (in the case where this would be greater than 0, that number of 32-bit IDs would follow the SSRC and thus extend the RTP payload length. For this protocol though, the value is always 0).
Marker	1	Signalling used for application specific reasons to indicate some special significance of the packet (for this protocol always 0).
Payload type	7	Value 0 (µ law) or 8 (A law).
Sequence number	16	Increments by 1 with each RTP packet sent.
Timestamp	32	Increments by number of samples in packet payload. **Note**: From software version 8.3.0 onwards, the timestamp increments correctly with each packet sent by a value of 160. Prior to version 8.3.0 the timestamps increment by 320.
SSRC	32	Identifier for the sender (for packets sent out by the radio, this will be the Session ID value from the control page).

An example of a captured packet sent by the radio and captured by Wireshark is shown below.



11.12.4 IP Headset Protocol Specific Details

The radio will send out an RTP packet for each 20ms of audio input it decodes.

RTP packets will only be sent when it receives and decodes talkgroup packets and not at any other time. Therefore, a continuous stream of RTP packets should not be expected.

When sending RTP packets to the radio, consideration should be taken to implement either push-to-talk or an input volume sensitivity level. This will then avoid sending packets continuously.

11.12.5 Using GStreamer Pipelines

GStreamer pipelines can be used to receive and send IP headset protocol RTP packets. An example command line pipeline can run from a command prompt with the following command:

gst-launch-1.0 udpsrc uri=udp://239.85.33.20:17891 caps=application/x-rtp,media=audio,encoding-name=PCMA ! rtppcmadepay ! queue ! alawdec ! queue ! audioconvert ! audioresample ! autoaudiosink

This pipeline makes the following assumptions:

- **External Audio Format** is set to RTP multicast a-law
- **Multicast IP address** is set to 239.85.33.20
- **RTP port** is set to 17891

12. Appendix A: Reference Material

12.1 Domo Video Download Tool

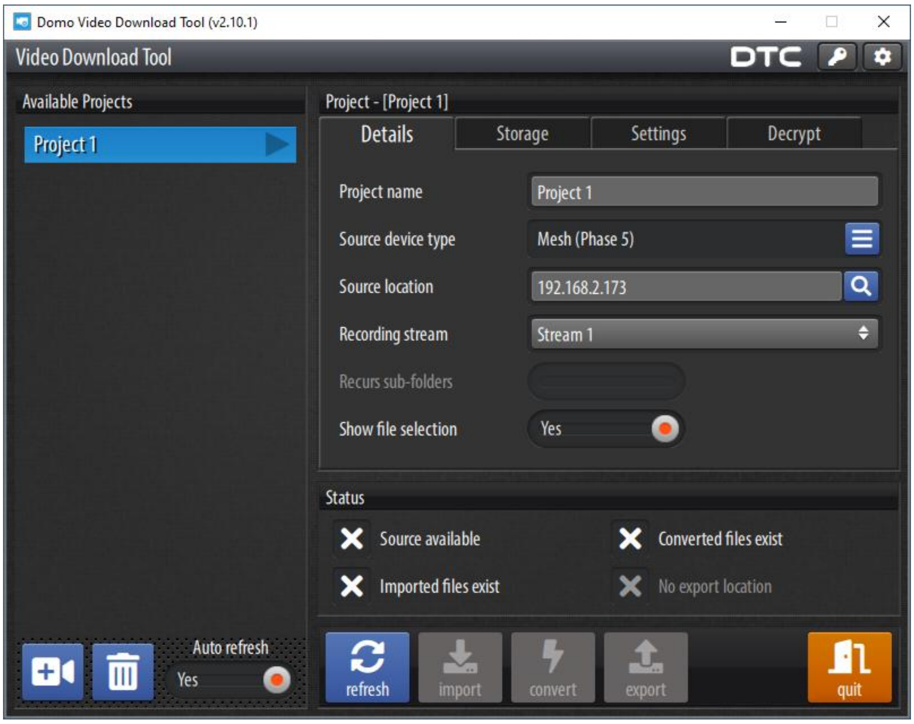
12.1.1 Introduction

Domo Video Download Tool (DVDT) is a software application that can be used to download and convert files from DTC products into a merged stream without the need for 3rd party software. It is also able to process any raw stream data from any network or folder location.

The application is available for download from WatchDox, see *Section 13.1*.

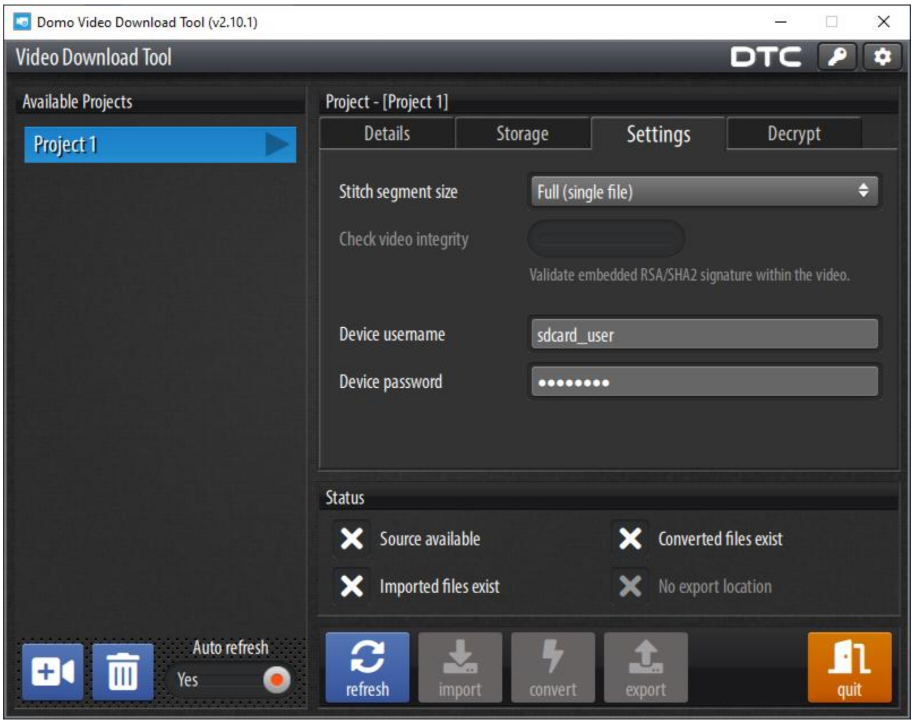
Ensure the device is powered and connected by Ethernet. Open DVDT from the desktop shortcut.

12.1.2 Details Tab



Setting	Description
Project name	Enter a new project name, if required.
Source device type	Click the hamburger  and select the device type from the list presented. This will be either Mesh (Phase 5), or Solo8 SDR, or Mesh USB Capture (for MeshUltra MP4 recordings).
Source location	Enter the IP address of the device or click search  to select from a list of all networked devices.
Recording stream	Select the stream source that you want to download files from.
	Create a new project by clicking .

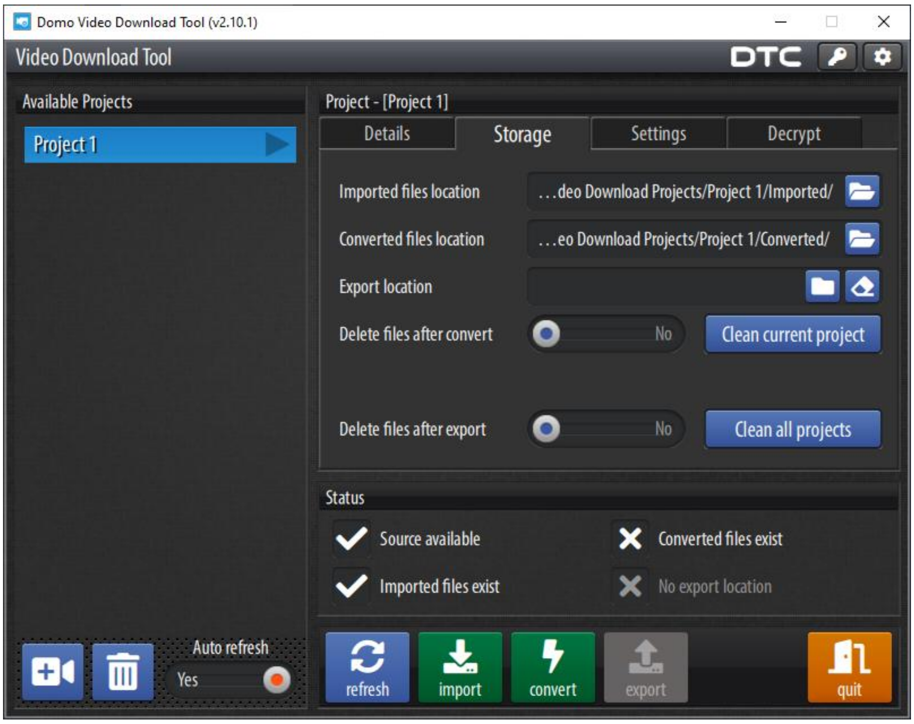
12.1.3 Settings Tab

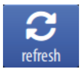
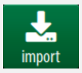


Setting	Description
Stitch segment size	Select the segment size for the converted files. If one file is required choose **Full (single file)**. If segmented files are required choose your option from 5 to 60 minutes strings.
Device username	The device username for Mesh recordings is **sdcard_user**.
Device password	The device password for Mesh recordings is **Eastwood**.

12.1.4 Import and Convert/Storage Tab

Note: Import and Convert can be processed from any tab.



Setting	Description
	Click **Refresh** to update the status of the applied settings. Import will turn green when all settings are correct, allowing import of data.
	Click **Import** to import unprocessed recordings. Import must be green to import data. Import will open a window which will allow you to select which recordings to import. **Note**: If there is a problem, check the physical connection or device username and password in the Settings tab.
	Click **Convert** to convert the imported files into a stream. Convert must be green to convert data.
Imported files location Converted files location	Click  to open the project folder for imported or converted files. The project location can be changed by opening settings  in the top-right corner of the application.

12.2 Working with FTP

Note: The preferred method to upgrade the software and licenses is via the web browser, see *Section 9.3.1*.

An FTP client application can be used to upload recorded files and upgrade your software and license.

12.2.1 Open the FTP application

Open the preferred 3rd party FTP client application on the PC (in this example we have used FileZilla). Refer to *Figure 12-1*.

1. Enter the IP address of the SDR in the Host window of the application.
2. Enter the username as **sdcard_user**.
3. Enter the password as **Eastwood**.
4. Click on Quickconnect.

12.2.2 Transfer Files

5. Browse to the **stream** folder on the node (Remote site).
6. Browse to the destination folder you wish to copy files to (Local site).
7. Drag and drop the selected files to the destination folder.

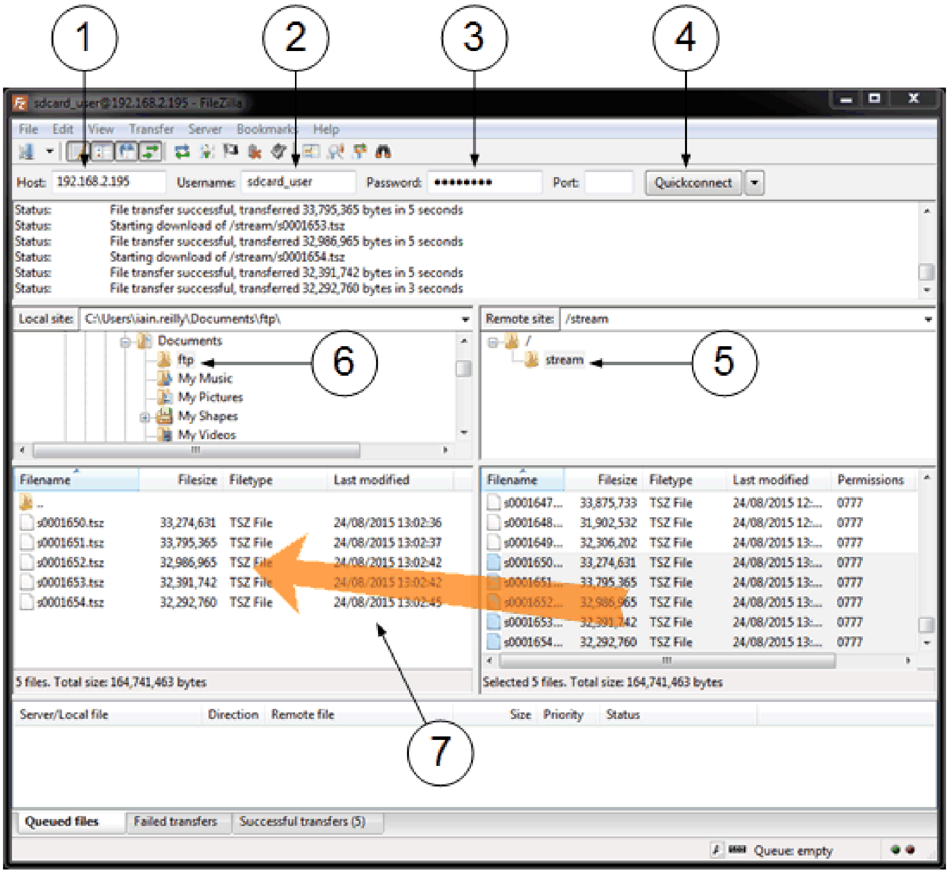


Figure 12-1 FTP Application

12.2.3 Upgrade the Software

1. Complete *Section 12.2.1* above to open the FTP application and connect.
2. Browse to the location of the upgrade file (Local site). The upgrade file will be something like **d1740_upgrade.tar.zz** (the file name will depend on the internal PCB).
3. Browse to the root directory of the node (Remote site) i.e., the directory marked ***/***.
4. Drag and drop the upgrade file into the root directory of the node.
5. The upgrade will start automatically.
6. The upgrade may take up to 15 minutes depending on how many parts of the code need to be upgraded.
7. The node will reboot on successful completion of the upgrade.

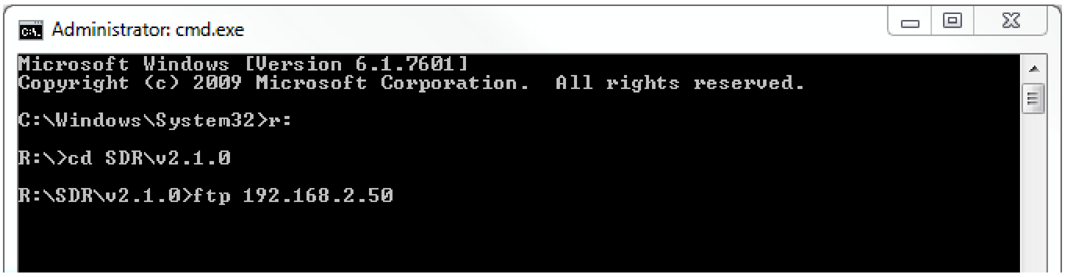
12.2.4 Upgrade the License

1. Complete *Section 12.2.1* above to open the FTP application and connect.
2. Browse to the location of the license file (Local site). The license file will be something like: **AK000774-5380c66037bf6a56-89158.lic**.
3. Browse to the root directory of the node (Remote site) i.e., the directory marked ***/***.
4. Drag and drop the license file into the root directory of the node.
5. Rename the file to be: **d1740.lic** (the file name will depend on the internal PCB).
6. Click Server>Disconnect. DO NOT POWER DOWN.
7. Open web browser and go to the **System>Tools** page and click the **Reboot Unit** button. **DO NOT** carry out a hard power cycle.
8. The node will refresh with the new license.

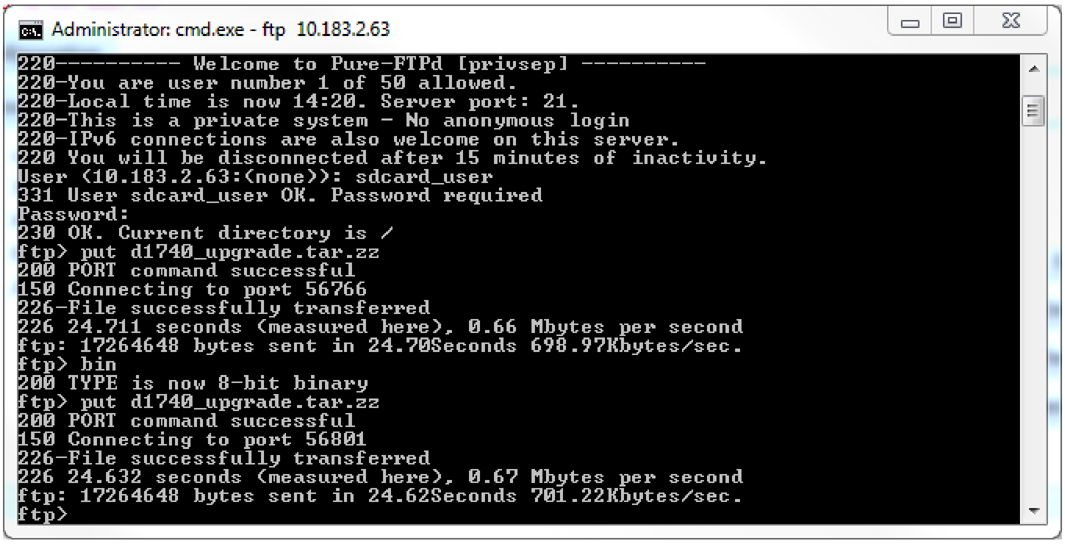
12.2.5 Command Prompt FTP Upgrade

As an alternative upgrade to above, an FTP upgrade can be done using a command prompt.

1. Open a command prompt and go to the directory of the upgrade file.
2. Enter ftp xxx.xxx.xxx.xxx, where xxx.xxxx.xxx.xxx is the IP address of the node.



3. When prompted for a username type **sdcard_user** and enter.
4. When prompted for a password type **Eastwood** and enter.
5. Type **bin** and enter.
6. Type **put d1740_upgrade.tar.zz** (the file name will depend on the internal PCB) and press enter.



7. The unit will automatically power cycle to trigger the upgrade.
8. When the unit has finished rebooting and the IP connection has re-established, confirm that the unit has been upgraded from the **Information** page of the web browser.

CAUTION: Do not power off at any stage of the upgrade process. The upgrade will take longer depending on how many files need to be updated.

12.3 Recommended Video Encoder Settings

12.3.1 Overview

The node can offer transmission bitrates from 150kbps^{-1} to almost 30Mbps^{-1}. The DTC product uniquely offers this wide data rate range in the marketplace. When a user chooses a lower bitrate link, they will achieve much greater range than standard achieved by an 8MHz bandwidth link. Range increases of 2 to 5 times are possible.

DTC encoding products provide the user with a wide range of settings so that a user can trade-off increased image resolution vs. frame rate vs. latency for any chosen COFDM link mode.

DTC video encoders offer both **Standard Delay** and **Low Delay** settings. **Standard Delay** provides between 0.5 to 1 second delay for bitrates above 1Mbps and slightly longer delays as the bitrate is reduced. **Low Delay** typically reduces the end-to-end delay by a factor of 4 to 8.

12.3.2 Recommended Single SD Video Settings

Table 12-1 details settings for a **single** standard definition (**SD**) video input in NTSC or PAL format.

Bandwidth	Bitrate	SD Video NTSC/PAL Low Delay	SD Video NTSC/PAL Standard Delay
8MHz	6Mbps	Full resolution	Full resolution
2.5MHz	4.8Mbps	Full resolution	Full resolution
2.5MHz	2.4Mbps	3/4 horizontal Full frame rate	Full resolution

Table 12-1 Typical Single SD Video Settings

12.3.3 Recommended Single HD Video Settings

Table 12-2 details some settings for a **single** high definition (**HD**) video input.

Note: **Res H** refers to the horizontal resolution setting on the video encoder. **Res V** refers to the vertical resolution setting on the video encoder.

Frame refers to the frame rate: 1/2 frame would be 15 video frames per second on a 1080P30 mode, or 30 frames per second on a 720p60 encoded image. The DTC encoder frame rates of 1/4, 1/8 and even 1/24 can be selected.

Bandwidth	Bitrate	Standard Delay		Low Delay	
		HD Video 720p	HD Video 1080p30	HD Video 720p	HD Video 1080p30
8MHz	8Mbps	Full Res H Full Res V Full Frame	Full Res H Full Res V Full Frame	3/4 Res H Full Res V Full Frame	3/4 Res H Full Res V Full Frame
8MHz	6Mbps	3/4 Res H Full Res V Full Frame	3/4 Res H Full Res V Full Frame	2/3 Res H Full Res V Full Frame	2/3 Res H Full Res V Full Frame
2.5MHz	4.8Mbps	3/4 Res H Full Res V Full Frame	3/4 Res H Full Res V Full Frame	2/3 Res H Full Res V Full Frame	2/3 Res H Full Res V Full Frame
2.5MHz	2.4Mbps	1/2 Res H Full Res V Full Frame	1/2 Res H Full Res V Full Frame	1/2 Res H 1/2 Res V Full Frame	1/2 Res H 1/2 Res V Full Frame
2.5MHz	1.2Mbps	1/2 Res H 1/2 Res V 1/2 Frame	1/2 Res H 1/2 Res V 1/2 Frame	N/A	N/A

Table 12-2 Typical Single HD Video Settings

12.3.4 Image Resolution vs Frame Rate

It is also possible to enhance image resolution by reducing the frame rate. *Table 12-3* should be compared with *Table 12-2* to illustrate how this can be achieved.

Bandwidth	**Bitrate**	**Standard Delay**	
		HD Video 720p	**HD Video 1080p30**
8MHz	6Mbps	Full Res H Full Res V 1/2 Frame	Full Res H Full Res V 1/2 Frame
2.5MHz	4.8Mbps	Full Res H Full Res V 1/2 Frame	Full Res H Full Res V 1/2 Frame
2.5MHz	2.4Mbps	2/3 Res H Full Res V 1/2 Frame	2/3 Res H Full Res V 1/2 Frame
2.5MHz	1.2Mbps	1/2 Res H Full Res V 1/4 Frame	1/2 Res H Full Res V 1/4 Frame

Table 12-3 Alternative Resolution and Frame Rate Settings

12.3.5 Recommended Dual HD Video Settings

Table 12-4 details some settings for a **dual** high definition (**HD**) video input when the encoder has two HD signals connected.

Bandwidth	**Bitrate**	**Standard Delay**		**Low Delay**	
		HD Video 720p	**HD Video 1080p30**	**HD Video 720p**	**HD Video 1080p30**
8MHz	9Mbps	Full Res H Full Res V 1/2 Frame	Full Res H Full Res V 1/2 Frame	1/2 Res H Full Res V Full Frame	1/2 Res H Full Res V Full Frame
8MHz	8Mbps	1/2 Res H Full Res V Full Frame	1/2 Res H Full Res V Full Frame	1/2 Res H 1/2 Res V Full Frame	1/2 Res H 1/2 Res V Full Frame
8MHz	6Mbps	1/2 Res H Full Res V 1/2 Frame	1/2 Res H Full Res V 1/2 Frame	1/4 Res H 1/2 Res V Full Frame	1/4 Res H 1/2 Res V Full Frame
2.5MHz	4.8Mbps	1/2 Res H Full Res V 1/2 Frame	1/2 Res H Full Res V 1/2 Frame	1/4 Res H 1/2 Res V Full Frame	1/4 Res H 1/2 Res V Full Frame
2.5MHz	2.4Mbps	1/2 Res H 1/2 Res V 1/4 Frame	1/2 Res H 1/2 Res V 1/4 Frame	1/4 Res H 1/4 Res V Full Frame	1/4 Res H 1/4 Res V Full Frame

Table 12-4 Typical Dual HD Video Settings

12.4 Latency

The following latency results have been recorded with 6 high-quality video streams over a 13 node Mesh system using UDP as a transmission protocol:

- Video with full MP3 audio decoding, latency measured at 428ms. Further testing revealed that decoding video only, a latency of 198ms was achieved.
- Relaying will add around 10ms per hop.
- Reduced bandwidth, poor radio conditions and strained link budgets will increase latency.

12.5 Data Rates

12.5.1 Single Mesh Mode

Signal Quality	Bandwidth (MHz) with Data Rates (Mbps)										
	1.25	1.5	1.75	2.5	3	3.5	5	6	7	8	10
5	1.7	2.11	2.46	3.4	4.15	4.75	6.68	8.28	9.61	11.1	13.97
4	1.35	1.62	1.93	2.66	3.04	4.18	5.25	6.08	7.48	8.49	13.4
3	0.83	0.98	1.89	1.75	2.25	2.94	3.52	4.29	5.45	5.85	6.86
2	0.6	0.74	1.12	1.2	1.77	2.38	2.41	3.09	3.93	3.96	4.5
1	0.44	0.55	0.84	0.85	1.19	1.72	1.8	2.34	2.56	2.71	3.35

12.5.2 MIMO/Reduced MIMO Mode Data Rates and Sensitivity

		MiMo Mesh data capacity (Mbps) for each channel bandwidth and SQT value														
SQT Value	SNR Threshold / dB	Bandwidth (MHz)														
		1.25	1.5	1.75	2.5	3	3.5	5	6	7	8	10	12	14	16	20
6	23.1	5.6	6.7	7.9	11.2	13.5	15.7	22.4	26.9	31.4	35.9	44.9	53.3	61.7	70.2	87
5	17.1	4.0	4.8	5.6	8.0	9.6	11.2	16.0	19.2	22.4	25.6	32.0	38.0	44.0	50.0	62.0
4	14.1	3.1	3.7	4.3	6.2	7.4	8.6	12.3	14.8	17.2	19.7	24.6	29.2	33.8	38.4	47.6
3	11.1	2.0	2.4	2.8	4.0	4.8	5.6	8.0	9.6	11.2	12.8	16.0	19.0	22.0	25.0	31.0
2	8.1	1.5	1.8	2.2	3.1	3.7	4.3	6.2	7.4	8.6	9.8	12.3	14.6	16.9	19.2	23.8
1	5.1	0.8	0.9	1.1	1.5	1.8	2.2	3.1	3.7	4.3	4.9	6.2	7.4	8.5	9.7	12.0

		Reduced MiMo Mesh data capacity (Mbps) for each channel bandwidth and SQT value														
SQT Value	SNR Threshold / dB	Bandwidth (MHz)														
		1.25	1.5	1.75	2.5	3	3.5	5	6	7	8	10	12	14	16	20
6	23.1	3.0	3.6	4.2	6.0	7.2	8.3	11.9	14.3	16.7	19.1	23.9	27.5	31.2	34.8	44
5	17.1	2.1	2.6	3.0	4.3	5.1	6.0	8.5	10.2	11.9	13.6	17.0	19.6	22.2	24.8	30.0
4	14.1	1.6	2.0	2.3	3.3	3.9	4.6	6.5	7.8	9.2	10.5	13.1	15.0	17.0	19.0	23.8
3	11.1	1.1	1.3	1.5	2.1	2.6	3.0	4.3	5.1	6.0	6.8	8.5	9.8	11.1	12.4	15.5
2	8.1	0.8	1.0	1.1	1.6	2.0	2.3	3.3	3.9	4.6	5.2	6.5	7.5	8.5	9.5	11.5
1	5.1	0.4	0.5	0.6	0.8	1.0	1.1	1.6	2.0	2.3	2.6	3.3	3.8	4.3	4.8	5.8

		MiMo, Reduced MiMo and Standard Mesh Sensitivity (dBm) for each channel bandwidth and SQT value														
SQT Value	SNR Threshold / dB	Bandwidth (MHz)														
		1.25	1.5	1.75	2.5	3	3.5	5	6	7	8	10	12	14	16	20
6	23.1	-85.9	-85.1	-84.5	-82.9	-82.1	-81.5	-79.9	-79.1	-78.4	-77.9	-76.9	-76.1	-75.4	-74.9	-73.9
5	17.1	-91.9	-91.1	-90.5	-88.9	-88.1	-87.5	-85.9	-85.1	-84.4	-83.9	-82.9	-82.1	-81.4	-80.9	-79.9
4	14.1	-94.9	-94.1	-93.5	-91.9	-91.1	-90.5	-88.9	-88.1	-87.4	-86.9	-85.9	-85.1	-84.4	-83.9	-82.9
3	11.1	-97.9	-97.1	-96.5	-94.9	-94.1	-93.5	-91.9	-91.1	-90.4	-89.9	-88.9	-88.1	-87.4	-86.9	-85.9
2	8.1	-100.9	-100.1	-99.5	-97.9	-97.1	-96.5	-94.9	-94.1	-93.4	-92.9	-91.9	-91.1	-90.4	-89.9	-88.9
1	5.1	-103.9	-103.1	-102.5	-100.9	-100.1	-99.5	-97.9	-97.1	-96.4	-95.9	-94.9	-94.1	-93.4	-92.9	-91.9

12.6 Iperf Testing

12.6.1 Introduction

Iperf is a commonly used tool that can measure the data throughput of an IP network. The latest version of iperf can be downloaded from the following website:

https://iperf.fr/iperf-download.php

Note: Before running iperf, it will be necessary to allow the executable through the PC's Firewall.

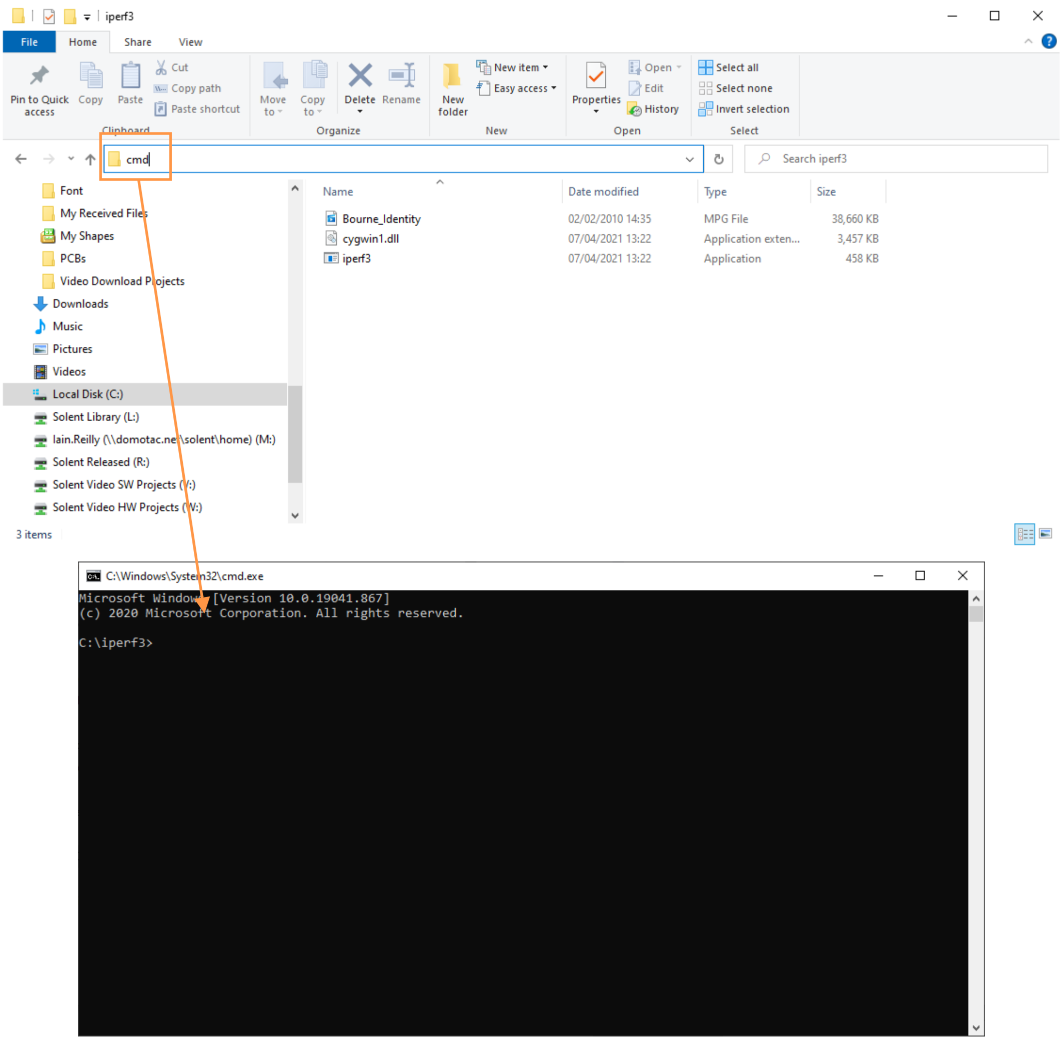
Mesh nodes from v6.4.0 onwards have an iperf server running on them, this will enable a user to connect to a Mesh network and analyse the IP data throughput to any node.

12.6.2 Example

The following provides an example iperf operation.

Open a command prompt and change the directory to the iperf executable and data files.

An easy way to do this is to open File Explorer, browse to the required directory, type cmd in the address bar and press enter.



Place a data file to pass to the node in the iperf directory. In our example we are using an MPEG file.

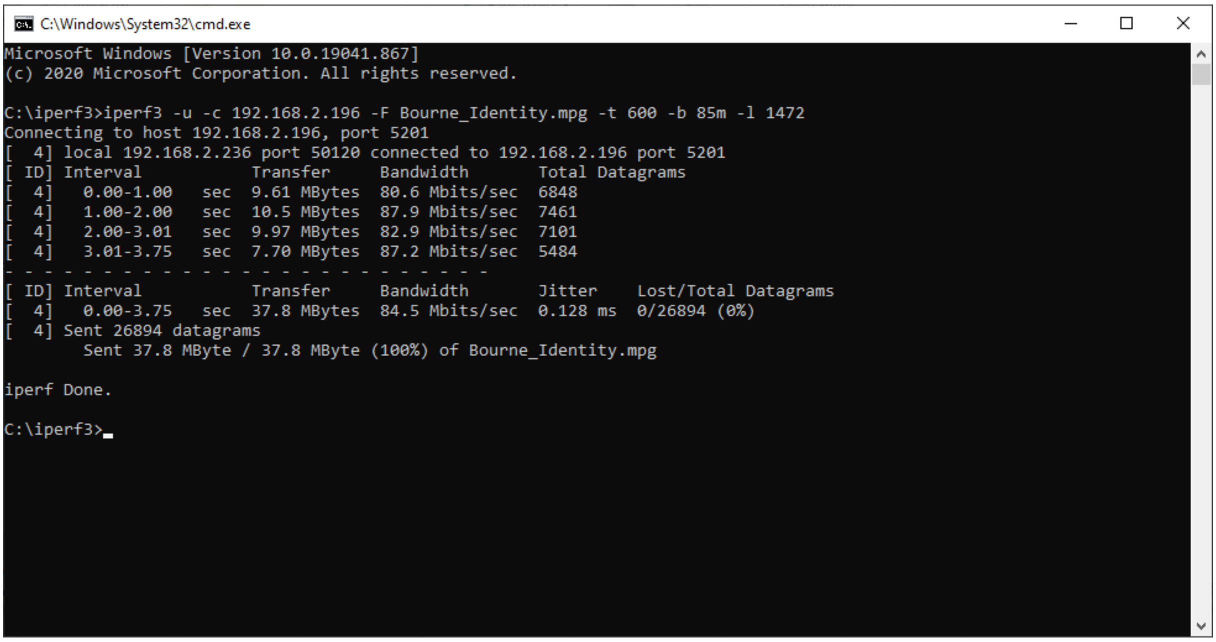
In the command prompt, type the script:

iperf3 -u -c 192.168.2.196 -F Bourne_Identity.mpg -t 600 -b 85m -l 1472

Where:

- **iperf3**: run the iperf executable
- **-u**: use UDP packets
- **-c 192.168.2.196**: run iperf in client mode to the server (Mesh node) IP address
- **-F Bourne_Identity.mpg**: denotes file name
- **-t 600**: maximum time to transmit in seconds
- **-b 85m -l 1472**: target bandwidth in bits/s with maximum packet length in bytes

Data will be returned from the Mesh node providing throughput details.



12.7 Co-Locating Mesh Systems

12.7.1 Introduction

This guide provides installation recommendations for co-locating mesh systems that are operating on different mesh IDs or channel frequencies but are within the same band. To achieve optimum performance in this scenario the installation must achieve sufficient isolation between each system.

12.7.2 Frequency Spacing

The minimum frequency separation should be 4 times the channel bandwidth (CHBW) i.e., 2.5MHz CHBW should be spaced minimum 10MHz apart, a 5MHz CHBW should be spaced minimum 20MHz apart.

At this spacing the channel filters within the receivers are approaching optimum performance and the transmitter spectral regrowth (adjacent channel power) has diminished to a low level. Increasing the spacing to 6 channels will yield a further 3-5dB improvement.

At this offset the aim is to limit the power entering the receiver to <-35dBm. Assuming 2Watts (+33dBm) of transmit power, then >68dB of isolation must be achieved.

This can be achieved by any combination of the following:

- Spatial separation
- Utilising the front to back ratio of directional antennas (if suitable to application)
- Adding external channel filters

12.7.3 Spatial Separation

The free space path loss at modest separations provides significant isolation and will contribute most of the required isolation in many applications. *Table 12-5* shows the free space path loss at several common operating frequencies over a range of separations.

Distance	Path Loss (dB) at Frequency (GHz):				
(metres)	1.3	2.3	3.3	4.7	5.7
0.5	29	34	37	40	42
1	35	40	43	46	48
2	41	46	49	52	54
5	49	54	57	60	62
10	55	60	63	66	68
15	58	63	66	69	71
20	61	66	69	72	74
30	64	69	72	75	77
50	69	74	77	80	82
70	72	77	80	83	84
100	75	80	83	86	88
200	81	86	89	92	94

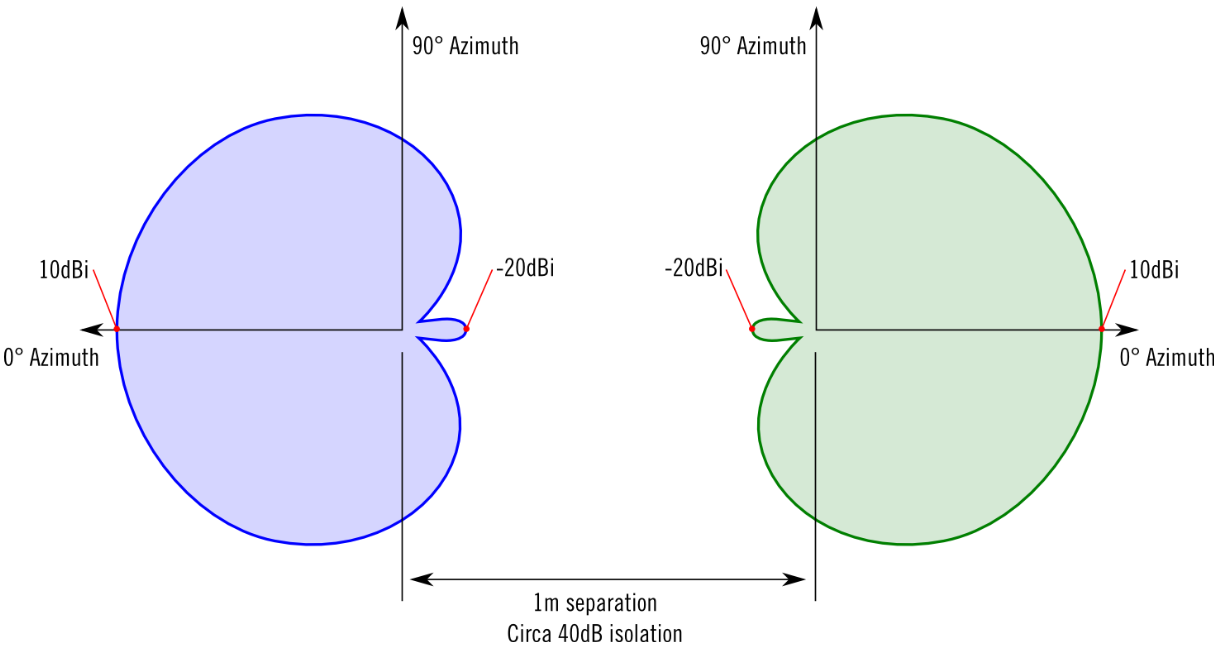
Table 12-5 Free Space Path Loss

Taking an example using DTC's standard 1.14-1.4GHz 4.5dBi OMNI antennas the isolation when horizontally spaced 1m apart was 28dB which is within 2dB of the calculated isolation (taking 35dB from *Table 12-5* -2 x 4.5dBi antenna gain = 26dB).

12.7.4 Directional Antenna Front to Back Isolation

If sector antennas are suitable for the application, then the front to back gain ratio can be utilised to increase isolation. The total isolation is dependent on the antenna, the relative siting angle of the antennas and the spatial separation.

For example, two directional antennas could be positioned back-to-back 1m apart as shown below.



A 1m separation @ 2.3GHz yields 40dB of isolation.

A typical directional antenna achieves 10dBi gain on the front face and -20dBi on the rear face. This yields a further 40dB of isolation between the antennas when placed back-to-back.

Total isolation is 40dB + 20dB +20dB = 80dB

12.7.5 External Channel Filters

If the application does not allow sufficient spatial separation or the use of directional antennas, then channel filters can be placed on each port of the mesh unit. The channel filter will need to provide sufficient rejection at the opposing Mesh frequency. The total rejection will be a combination of spatial separation and the channel filter rejection.

The cost/complexity of the channel filter increases as the frequency separation reduces. If the application permits a large frequency separation, then the channel filter implementation becomes simpler.

12.7.6 Verifying Installation has Sufficient Isolation

It is simple to check that sufficient isolation exists between each Mesh system.

1. Power one mesh system up and establish a link with a remote note.
1. Monitor the receiver SNR (signal-to-noise ratio) and check the link is error free.
2. Power up the 2nd co-located mesh system and establish a link with a remote node.
3. Re-analyse the SNR and error rate on the first mesh system. If the SNR has dropped or the link is no longer error free, then there is not enough isolation between the mesh systems. Power the 2nd system down and confirm that the SNR is restored.

12.8 Encryption

12.8.1 Introduction

This section of the document describes the transport IP packet interaction with standard AES block cipher algorithms (encryption and decryption).

Only one form of AES encryption is described, CBC Mode; this is as specified in the FIPS140-2 documentation.

It will identify:

- AES key sizes that are supported
- Initialization vectors that are used
- The methods of cipher chaining
- How residual bytes are processed
- Key management
- AES power-up tests
- Conditional tests

The details of the standard AES block cipher algorithm and the AES round key generation are left to the AES specification.

12.8.2 FIPS140-2 Accreditation

The SOLSDR NETNode security module resides within the SOLSDR and NETNode IP Mesh Phase 5 product families onwards. It provides FIPS140-2 compliant AES128 and AES256 encryption and decryption functions and includes two modes of operation both software only and hardware accelerated.

https://csrc.nist.gov/projects/cryptographic-algorithm-validation-program/details?product=11953

https://csrc.nist.gov/projects/cryptographic-algorithm-validation-program/details?product=11954

12.8.3 Support for the AES Block Cipher

Each block of data to be AES block ciphered is 128-bit (16 byte) and will be block ciphered according to the AES standard [2].

AES capable products will support two out of the three KEY lengths and the round key generation for these key lengths is per the AES standard [2].

- 128-bit (16 byte) keys
- 256-bit (32 byte) keys

12.8.4 Encryption Overview

When scrambling an IP data stream, the scrambling occurs at the IP packet level [1]. Only one form of AES encryption is supported.

- **CBC Mode**: AES encryption occurs at the packet level. It is a Cipher Block Chaining (CBC) of a variable length payload data algorithm. Most data is passed through a standard AES block cipher in 16 byte blocks. Payload sizes that are not exact multiples of the AES 16-byte block size result in residue bytes of 15 or less. Residue bytes are processed using the Cipher Text Stealing method [3], adapted for a CBC flow.

The implementation is not expected to change keys or key sizes, seamlessly, on a packet by packet-by-packet basis without data loss. Key entry and key size selection would normally be done when setting up a link.

The descrambling implementation of this architecture will be able to learn of the AES mode used on the IP data distributed over the radio network.

Although the token is not encrypted, only the signal quality table information may be decoded. JSON data will not include the status packet for a Node which does not match the encryption key.

GPS data is encrypted.

12.8.5 References

1. RFC 791 Internet Protocol.
2. FIPS 197 Nov 26, 2001: Advanced Scrambling Standard (AES).
3. Bruce Schneier: Applied Cryptography Second Edition, Wiley & Sons 1996.

12.8.6 Determining the Scrambling Mode

There are six selectable modes for data encryption.

- **CLEAR**: No encryption is applied to the IP data. It is assumed the user is providing external encryption or does not require encryption.
- **DES**: If appropriately licenced, a node can support single DES encryption operation. This mode can be disallowed for any nodes operating to FIPs standards.
- **AES128**: All IP data is encrypted using the supplied AES128 key. Received data is processed and decrypted with the same key. Received unencrypted data is also allowed to be processed by the Node.
- **AES128+**: All IP data is encrypted using the supplied AES128 key. Received data is ONLY processed and decrypted with the same key. Received unencrypted data is NOT allowed to be processed by the Node. Therefore, all data in the IP Mesh MUST be transmitted with the same AES128 key to be distributed through the network.
- **AES256**: All IP data is encrypted using the supplied AES256 key. Received data is processed and decrypted with the same key. Received unencrypted data is also allowed to be processed by the Node.
- **AES256+**: All IP data is encrypted using the supplied AES256 key. Received data is ONLY processed and decrypted with the same key. Received unencrypted data is NOT allowed to be processed by the Node. Therefore, all data in the IP Mesh MUST be transmitted with the same AES256 key to be distributed through the network.

12.9 dBm to Watts Conversion

It will be useful to know the equivalent dBm to watts power conversion when adding attenuation to the modulator RF output.

SDRs without internal amplifiers have a maximum RF output of 20dBm (100mW) per TX port.

2x1W variants have a maximum RF output of 30dBm (1W) per TX port.

2x2W variants have a maximum RF output of 33dBm (2W) per TX port.

2x5W variants have a maximum RF output of 37dBm (5W) per TX port.

When calculating, do not convert the equivalent watt value until after the sum has been done:

i.e., 33dBm-3dBm = 30dBm

dBm	Watts
0	1.0mW
1	1.3mW
2	1.6mW
3	2.0mW
4	2.5mW
5	3.2mW
6	4mW
7	5mW
8	6mW
9	8mW
10	10mW
11	13mW
12	16mW
13	20mW
14	25mW
15	32mW
16	40mW
17	50mW
18	63mW

dBm	Watts
19	79mW
20	100mW
21	126mW
22	158mW
23	200mW
24	250mW
25	316mW
26	398mW
27	500mW
28	630mW
29	800mW
30	1.0W
31	1.3W
32	1.6W
33	2.0W
34	2.5W
35	3W
36	4W
37	5W

13. Appendix B: After Sales Support

13.1 Documentation and Software

It is DTC's practise to make the majority of our latest user guides and software available to customers online, by using our WatchDox facility. To access this site, please contact your Account Manager or send a request via DTC's support portal https://domotactical.my.site.com/Support/s/login/.

You will be sent a link where you can log in and create your own password followed by a confirmation email. Once you have done this, you can then log in to your account.

13.2 Technical Support

The Technical Support team can be accessed by one of the following:

- **Phone US**: +1 571 563 7077
- **Email US**: us.technical.support@domotactical.com (no restricted content)
- **Phone UK**: +44 1489 884 550
- **Support Portal ROW**: https://domotactical.my.site.com/Support/s/login/ (no restricted content)

13.3 Using the DTC RMA Service

13.3.1 Contact DTC

If there is a problem and our technical support team have been unable to resolve the issue, email dtc.rma@domotactical.com (US) or solent.customerhub@domotactical.com (UK/ROW) to request a Return Material Authorisation (RMA) form.

Note: Alternatively, use the online form at https://www.domotactical.com/support/.

13.3.2 Complete and Return the RMA Form

Complete and return the RMA form including a detailed description of the problem.

When the hub receives the completed form, an RMA number and shipping instructions will be sent.

13.3.3 Pack the Device

Note: Before packing, remove all personal non-DTC kit or media from the device.

Use the original shipping container and packing materials, if possible.

If the original packing materials are not available, wrap the equipment with soft material (e.g., PU/PE form) then put the wrapped equipment into a hard cardboard shipping box.

13.3.4 Mark the Box and Send to DTC

Clearly mark the outside of the shipping box with the RMA number and send the box using your normal process.