Yarn Mesh Relay

Planning & Deployment Guide

For Yarn Mesh customers

1. Document Control

Definitions:

Term	Definition
2.4GHz ISM	2.4GHz (unlicensed) Industrial, Scientific, Medical radio spectrum
802.15.4	IEEE 802.15.4 Wireless Mesh Network standard
ASL	(metres) Above Sea Level
IMS	FTP’s Integrated Management System (cloud software platform)
IP	Internet Protocol (key protocol for internet communications)
IPv6	Internet Protocol version 6 (replaces/extends IPv4 IP addressing)
LoS	Line of Sight
LTE	Long Term Evolution (3G/4G/5G mobile standards)
RF	Radio Frequency (communications)

Revision History

Version	Date Issued	Author	Authoriser	Description
0.1	10/05/2023	Jonathan Clark		First draft
0.2	14/05/2023	Jonathan Clark		First release for review
0.3	17/07/2023	Jonathan Clark		Second release for review
0.4	10/10/2023	Jonathan Clark		Third release for review
1.0	12/10/2023	Acea Quigg		Approved for release

Level 1
293 Durham St,
CBD
Christchurch, 8013

support@ftpsolutions.co.nz
03 409 0883
http://ftpsolutions.co.nz

1.1. Table of Contents

2. Introduction

Yarn Mesh is a low-powered 802.15.4 sensor connected mesh, optimised for interconnecting devices and users over wide areas and difficult terrain, designed and delivered by the Team at FTP. Yarn uses publicly available 2.4GHz ISM spectrum, with a planning radius of roughly 1-3km in sub-optimal conditions. If required, 6km+ links are possible in good conditions with good line-of-site; all with a compact omni-directional antennae.

Yarn enables solar and battery powered devices to stream real-time telemetry from the field or farm, especially in remote environments.

Yarn overcomes the limitations of common point-to-point communications systems such as LTE (3G/4G/5G), NB-IoT, LoRa and SigFox by creating IPv6 enabled mesh communications links that **extend connectivity up, down, over, and beyond**. Each new sensor/device extends the mesh's coverage. Therefore, Yarn's mesh topology is ideally suited to enabling communication across hilly, mountainous, and complex terrain environments where other communications solutions fail, are unavailable or cost prohibitive.

Yarn is accelerated by AI/ML through machine vision. Nodes/sensors can recognise and categorise events and then take action, all without needing cloud/server backed processing. This leaves the network free from large, frequent file transfers for off-network processing. Quiet networks use less power, which means smaller batteries, solar panels, and overall costs.

The AI/ML algorithms can be updated over the air too, along with sensor, radio, camera, or device firmware; that means less frequent trips into the field for maintenance, giving you and your team more time to focus energy on extracting the most from your operations.

3. Yarn Mesh Network Planning

Deploying a Yarn Mesh network starts with good network planning. FTP's IMS Wireless Manager is purpose built for planning, monitoring, and managing Yarn Mesh wireless networks. The RF Planning module of Wireless Manager is used to plan and model installation locations and network coverage for Yarn Mesh node placement prior to physical deployment.

When planning a Yarn Mesh network, it is important to have a good understanding of the area and devices that require coverage, the use-case/s drive placement and planning for the Yarn Mesh Gateway and Yarn Mesh Relays. We refer to the Gateways and Relays as the 'network infrastructure'.

In a Yarn Mesh network all devices share the same radio interface properties, however Yarn Mesh implements dynamic roles for devices based on live network metrics.

3.1. Yarn Mesh Architecture

Yarn Mesh networks consist of three different node types:

- Gateway
- Relay
- End Device

Yarn Mesh consists of a common radio air interface, meaning all nodes are equipped with the ability to communicate in the same manner, however different nodes can perform different network roles. Network roles are assigned dynamically by the network, typically a nodes role is not visible to a network user.

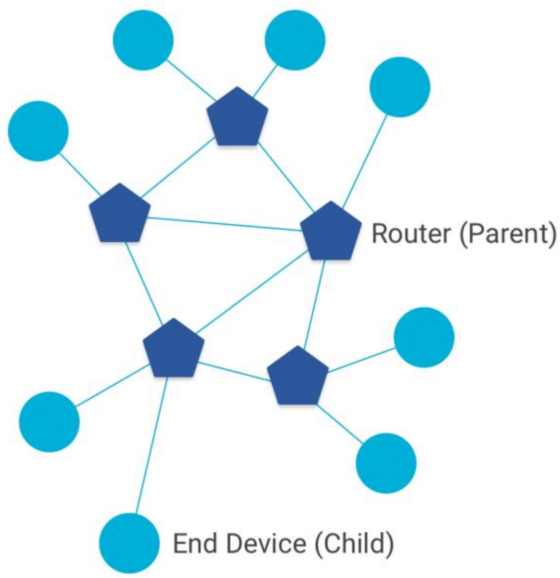


Figure 1 - Example of the dynamic topology of Yarn Mesh network.

In a Yarn Mesh each node has a role, the dynamically assigned role is either:

- Leader
- Router
- Child

In a typical deployment:

- The Leader role is assigned to the Gateway node as it usually the first node established on the network.
- A Router role gets assigned to a Relay device due to a Relay usually being able to see multiple End Devices.
- End Devices can have the Child or Router role. In a network consisting of a smaller number of nodes End Devices are more likely to be assigned the Router role, however in a larger network it is more likely that they will be assigned the Child role.

3.2. Yarn Mesh Gateway

The first and most important node deployed in a Yarn Mesh network is the Gateway. It takes data from the End Devices either directly or via other End Devices and/or Relays and forwards it via the internet to IMS. The Gateway is the bridge between the mesh network and an IP (data) backhaul network, such as carrier 4G LTE or IP satellite connection.

Figure 2 - Yarn Mesh Gateway deployed in the field

3.3. Yarn Mesh Relays

The second most important class of nodes deployed in a Yarn Mesh network are the Relays. A Relay acts like a shortcut for network traffic, reducing the need for the furthest End Devices to convey their traffic through every other End Device in the network chain to get to their data to the Gateway. Relays make Yarn Mesh networks more efficient, more reliable, increase path redundancy and allow more devices to be connected in each network chain.

Another way to think of Relays is like a highway or freeway for network traffic, yes you can get to your destination by taking all the minor backroads to get there, but it much more efficient and faster - especially when there are lots of cars need to get to the same destination - via the highway or freeway.

Yarn Mesh Gateways and Yarn Mesh Relays comprise what we refer to as the 'infrastructure layer' or 'backbone' of the network. These devices are responsible for helping make the network efficient and ensuring End Devices have more than one network path back to the Gateway, this makes Yarn Mesh networks reliable, provides redundancy and ensures they are fault tolerant.

3.4. Yarn Mesh Relay Deployment Planning

The first and most important node deployed in a Yarn Mesh network is the Gateway. It takes data from the End Devices either directly or via other End Devices and/or Relays and forwards it via the internet to IMS. The Gateway is the bridge between the mesh network and an IP (data) backhaul network, such as carrier 4G LTE or IP satellite connection.

Figure 3 - Yarn Mesh Relay deployed in the field

Once the Yarn Gateway is deployed and online in IMS, Relays are the next device type that need to be deployed, prior to deploying any End Devices.

The physical installation location of each Relay is key to achieving the best mesh network coverage and performance. Relays require good line of site either directly back to the Gateway or to the next Relay in the direction of the Gateway. Although not best practice, Relays can connect via an End Device to another Relay or the Gateway, however this is the least preferred option and is not recommended practice.

Relays should be deployed on terrain high points with good line of sight to large areas requiring coverage. Relays should be deployed in open terrain with solar panels facing North with no obstructions or potential obstructions from vegetation or terrain that may impact solar charging. Relays use Monocrystalline solar panels which are best for generating maximum current in full sun, but power generation drops significantly if any shade is cast on any part of the panel.

Relays form the 'backbone' of the mesh network and good line of sight to upstream and downstream peer Relays is key to good network reliability, resiliency, and performance.

When planning the deployment of Yarn Mesh Relays, it is important to consider proximity - in network hops - to the furthest Yarn Mesh End Nodes that will be deployed via the Relay or Relays and back to the Gateway. A network hop is a connection between a pair of nodes, these can be any combination of Yarn Relays and/or End Node devices. Reducing the maximum number of hops (depth) of the network will result in better performance (throughput). A discreet Yarn Mesh network consisting of all devices that can see a single Gateway via all other devices in that discreet network is known as a chain or network chain. For network performance, minimising hops (connections) between End Nodes and the Gateway is best practice. Relays are a simple and cost-effective method of minimising network hops and increasing network resiliency, throughput and decreasing latency.

Therefore, the key considerations when planning Relay placement are:

- Location, location, location: to determine the optimum location for your network these factors should be considered:
  - Upstream and Downstream Connectivity: Proximity to upstream and downstream Relays or Gateway devices.
  - Mesh Connectivity: Maximising LoS (Line-of-Sight) to as many core Yarn Mesh devices (Relays) as possible, lowering hop count (aka network node depth).
  - Elevation: Placing the Relay at a high point on the terrain can help maximise LoS (Line-of-Sight) to other mesh devices, both Relays and the End Devices you are trying to connect and provide maximum unobstructed sunlight hours for solar charging.

- Sunlight: When planning Relay installation, it is most important for the planning considerations to be based on what the conditions will be in mid-winter when solar gain and solar hours are at their lowest.
- Direction: Each Relay has a small sized solar panel to charge its onboard battery, therefore Relay installation location in the Southern Hemisphere needs to have a good unobstructed North facing aspect for maximum solar gain during winter months.
- Wind: Terrain shielding to place the Relay leeward to prevailing storm fronts should be considered to reduce the potential for maximal wind events (severe storms) to affect Relay installation, especially at high elevations (>500m ASL) or in exposed locations such as coastlines or other known potential extreme wind zones. Due to their small size Relays are designed to withstand all but the most severe wind conditions.

FTP's IMS Wireless Manager provides 3D RF modelling over a 3D terrain model, using this functionality when planning Relay deployment locations is critical to successful deployment and reliable ongoing operation of the Relays and network.

More Relays = More network paths to more devices = More resilient network

A screenshot of the IMS RF Planning module is shown for reference in the image below.

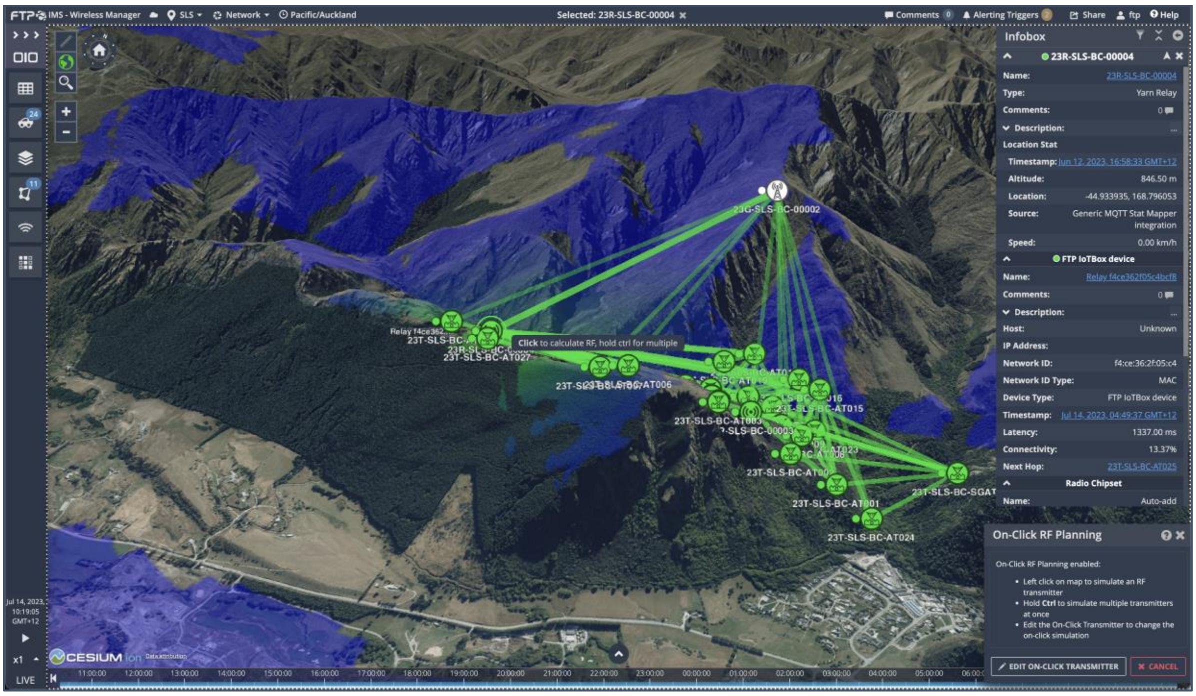


Figure 4 - FTP IMS RF Planning module showing RF coverage provided in the Bush Creek by just one of the deployed Yarn Mesh Relay's, this Relay alone is used to connect 9 out of 25 Yarn Mesh TrapNode connected AT220 Traps.

The image below shows the perspective from the Yarn Mesh Relay (23R-SLS-BC-00004) looking North-West once installed. Any Yarn Mesh node within line-of-sight from this

Relay and coloured in the RF plan can connect directly with this Relay, the Relay in turn can see the Gateway, sending and receiving network traffic as required. The mesh dynamically selects the best path for network traffic.

Figure 5 – Yarn Mesh Relay, Bush Creek, Arrowtown, New Zealand

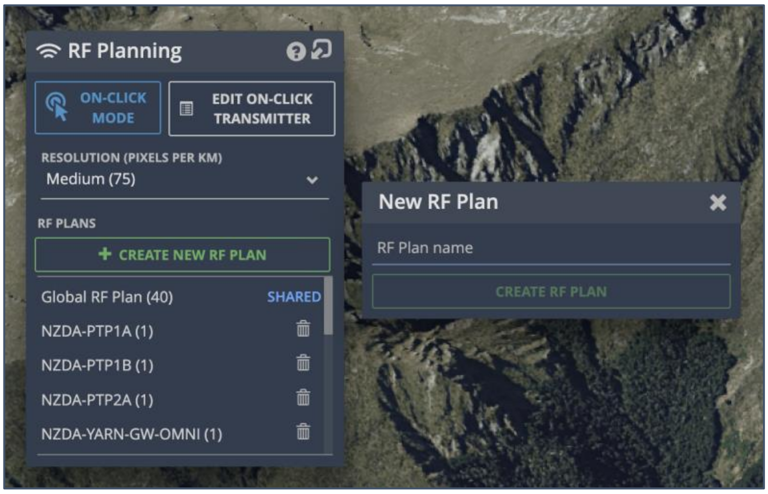
3.4.1. Yarn Mesh Relay Planning Process

Planning Yarn Mesh networks and installation locations for Yarn Mesh Relay deployment is performed through the IMS RF Planning module. Instructions on how to use the IMS RF Planning module can be found here:

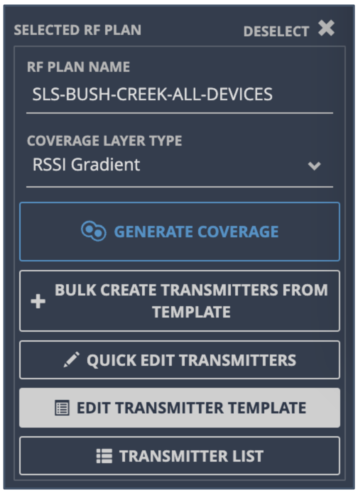
https://ftpsolutions.helpjuice.com/en_AU/ims-quick-start-guide/qsg-rf-planning

1. In IMS, create an RF Plan in IMS to model and visualise Yarn Mesh deployment coverage in 3D.

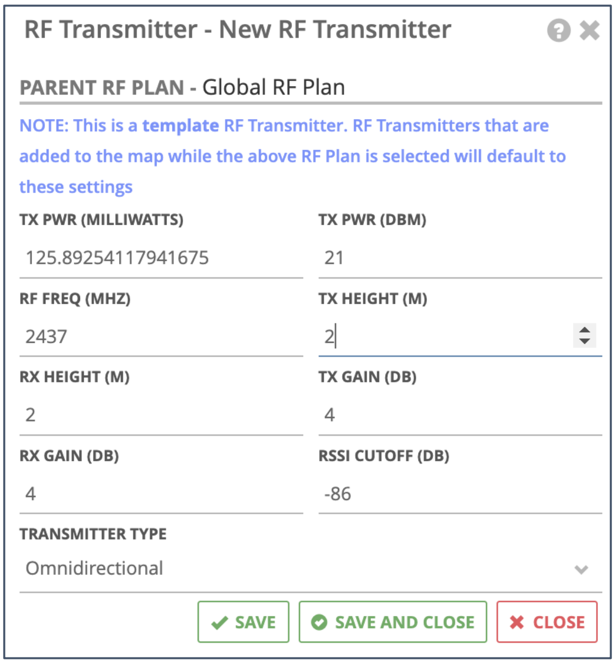
    a. Create new RF Plan

        i. 

    b. Select the newly created RF Plan.

        i. 

    c. Edit the RF Transmitter Template using the following RF settings.

i. 

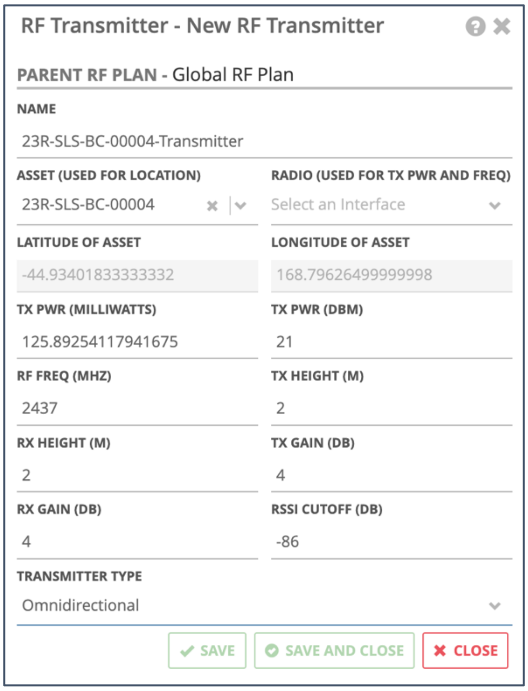
ii. RX and TX height can be set to 2m for Relays.

d. Create Transmitters

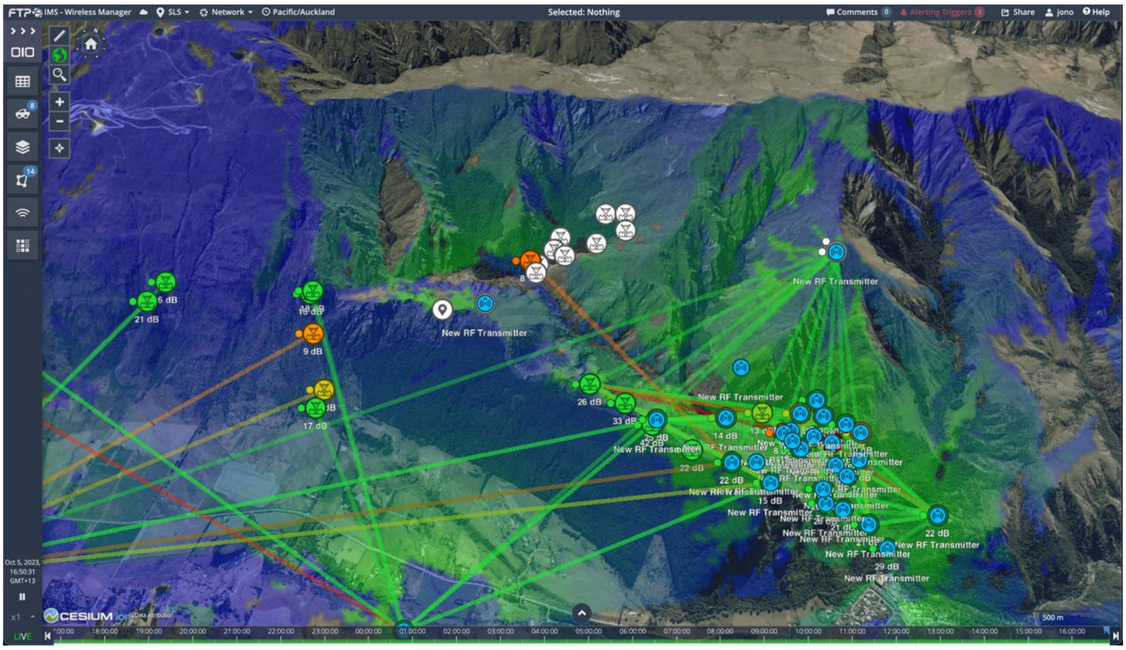
i. Click Quick Edit Transmitters to create new transmitters.

ii. Click on the location on the Map where you want to place the RF transmitter to model.

e. Associate Transmitter with Asset.

i. 

f. Generate Coverage to show modelled coverage area.

i. 

ii. Assets coloured white have not been deployed yet; RF planning shows the coverage a new Relay would provide if installed on the ridge opposite the new gully area.

iii. Coverage for existing Assets can be visualised alongside planned coverage for new Assets. Visibility of existing Assets can be switched on and off to aid RF planning as required.

g. Modify Asset (Gateway, Relay, TrapNode etc) location and count according to coverage needs.

h. Generate Coverage again and validate.

3.5. Yarn Mesh End-Devices

Yarn Mesh End-Device nodes are the interfaces between sensors or hardware devices in the field that you care about monitoring or getting data from.

Yarn Mesh End-Device nodes send the data generated by sensors or devices at the 'edge' of the mesh over the network. In many cases Yarn Mesh End-Devices interpret and process the data generated by a sensor or device before sending it across the mesh. End-Devices are also capable of receiving a command or taking an action based on the data values being read from the sensor or connected device.

For Environmental Management predator control purposes an End-Device could be one of the following Yarn Mesh devices:

- TrapNode
- WaveLink (personal locator & messenger)
- IntelliCam (trail camera)

For Farm Management purposes an End-Device could be one of the following Yarn Mesh devices:

- IoTBox
- WaveLink (personal locator & messenger)
- FuelNode
- TankNode
- OBDBox

Planning and deployment information for Yarn Mesh End-Devices is covered in the Planning and Deployment Guide for each device respectively.

4. Network Deployment

Yarn Mesh and IMS enable environmental management and predator control projects to deploy and manage trapping networks and environmental monitoring devices across one or many landscape-scale areas. Initial deployment can consist of a few devices and scale to more than a few hundred devices in each 'network chain'. A 'network chain' is a set of Yarn Mesh connected devices connected to a single Yarn Gateway, in the case of a predator control project this would largely consist of TrapNodes connecting traps or monitoring bait station devices and Yarn Relays. Yarn Relays are typically used on high points in the landscape to provide network coverage to large areas, this provides connection resiliency and redundancy for devices, providing greater autonomy for field workers as to where they place trap and detection devices on the ground.

4.1. Relay Deployment

The Yarn Mesh Relay comes in a weatherproof enclosure. Inside the Relay enclosure is the Relay PCB containing RF electronics and power management circuitry with a lithium-battery. The Relay PCB has a single u-FL socket into which a u-FL to N-Type RF antenna connector is connected, the N-type connector is mounted in the lid of the Relay enclosure, the Yarn Mesh Antenna is screwed into this N-type connectors prior to the Yarn Mesh Relay being powered on. Attachment of the supplied antenna prior to powering on the Relay is crucial to avoiding irreparable damage to the sensitive RF Power Amplifier circuitry.

Caution: Do not power on the Yarn Mesh Relay without attaching the supplied antenna first! Doing so will result in irreparable damage to the electronics.

Figure 6 – Side view of the Yarn Mesh Relay enclosure, showing solar panel, solar panel mounting arms, main Relay enclosure body and RF antenna. Note: solar panel cable connection to Relay solar input plug.

4.1.1. Relay Deployment Requirements

4.1.1.1. Yarn Mesh Relay Hardware Required

- Yarn Mesh Relay
  - Parts List
    - 1 x Relay
    - 2 x solar panel brackets (left & right brackets)
    - 1 x 10W solar panel with connector
    - 2 x M8 x 15mm bolts (included in Relay enclosure)
    - 2 x M3 x 12mm self-tapping screws (included)

4.1.1.2. 3rd Party Hardware/Software Required

- Waratah (aka Y-post or Star picket)
  - 1 x Waratah (dimensions 42mm D x 40mm W x 1800mm+ Long)
  - Waratahs come in a several different cross-sectional dimensions, the Yarn Mesh Relay uses the largest commonly available size of 42mm D x 40mm W.
  - In New Zealand Mitre10 supplies the JobMate Y-post brand which adheres to these dimensions.
- Sunseeker application
  - Download & buy Sunseeker 3D mobile application to deployment mobile from Google Play Store: https://play.google.com/store/apps/details?id=com.ajnaware.sunseeker

4.1.1.3. Tools Required

- 1 x 13mm ring spanner
- 1 x Phillips #1 screwdriver
- 1 x 2.5mm flathead screwdriver
- 1 x sledgehammer (large) OR a star post driver

4.1.2. Relay Deployment Process

1. Locate installation site:
    a. Using Lat/Long coordinates from planned Relay location in IMS, enter coordinates into a handheld GPS or smartphone with suitable mapping application.
        i. With cellular coverage, IMS and the IMS Locate feature can be used to find the planned Gateway installation location.
    b. Once at installation location coordinates scope immediate area for best 'Line-of-Site' (LoS) to other key Yarn Relays locations if applicable.
        i. Find exact location that provides best LoS to other key Yarn Mesh devices.
        ii. Ensure location has good visibility to clear sky (sun) to the North[1] and is positioned for maximum sun hours during winter. Use SunSeeker 3D mobile application to help determine sun hours during winter.

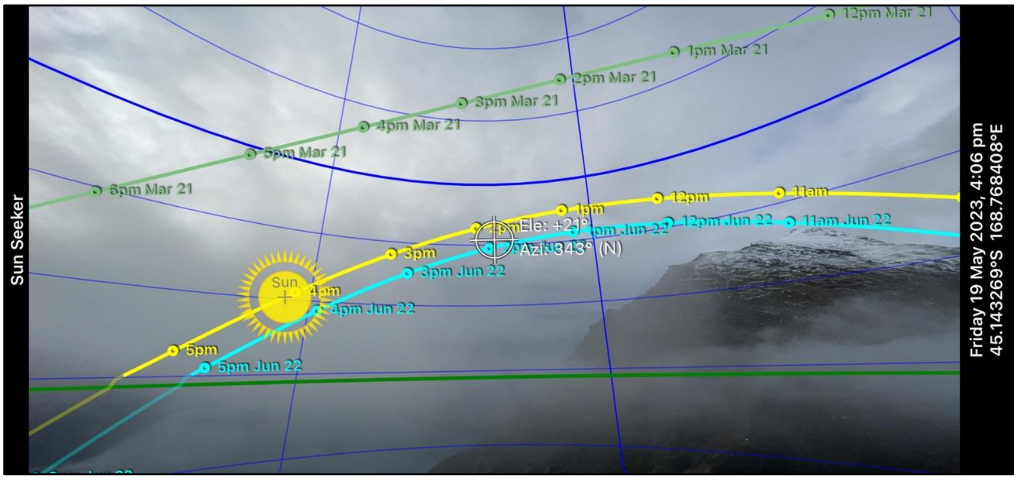


Figure 7 - Sunseeker 3D augmented reality mobile application. 3D mode visualised the location of the sun at different times of the year throughout the day. The turquoise line is the sun path on the shortest day of the year, the yellow line is today, green line is the sun path on the equinox.

        iii. Look at options to use surrounding terrain for wind shielding from prevailing storm fronts (e.g., Southernly or Nor-Westerly exposure are the typical directions for prevailing storms with high-winds in New Zealand). This is to reduce wind-loading on the solar panel during very high wind events. Be careful not to let positioning for wind

[1] If in the Southern hemisphere. North hemisphere installations require solar panel orientation to the South.

shielding affect radio LoS.

iv. Before finalising exact install location, check ground is both soft enough to drive Waratah to depth (˜750mm+) and firm enough to hold it securely in the ground even in storms with high-winds[2] (e.g., 120km/hr plus winds). Test ground conditions for suitability by using sledgehammer to drive the Waratah in a several points around identified Relay installation site.

2. Install Waratah

a. It is key to ensure that the long edge of the Waratah (Y) is facing North or facing the direction of maximum solar gain in winter given terrain considerations. Think of the Y shape of the Waratah like and arrow, the tip of the arrow needs to point North or in the direction either side of just North where maximum solar gain is achieved in winter if solar gain is constrained by terrain features. The Sunseeker 3D is key to finding the optimal location and northerly orientation for maximum solar gain in winter and throughout the year.

b. It is necessary to find good ground for the waratah. The ground needs to be sufficiently solid that the waratah will not be pulled out in a high-wind event. Test the ground first by driving a waratah approx. 600mm+ into the ground close to where the best installation location is. This test allows you to check that the waratah can be driven to the minimum embedment depth of 750mm in that area and that the ground has suitable bearing capacity to sustain a high-wind event.

[2] Significant storm events can product winds at elevation in exposed places of over 160km/hr.

c. Drive Waratah into ground using Sledgehammer or Star Post Driver exactly where the Relay will be installed with the Y or arrow of the waratah aligned to the northerly direction identified for maximum solar gain.

d. Ensure Waratah is embedded at least 750mm into the ground.

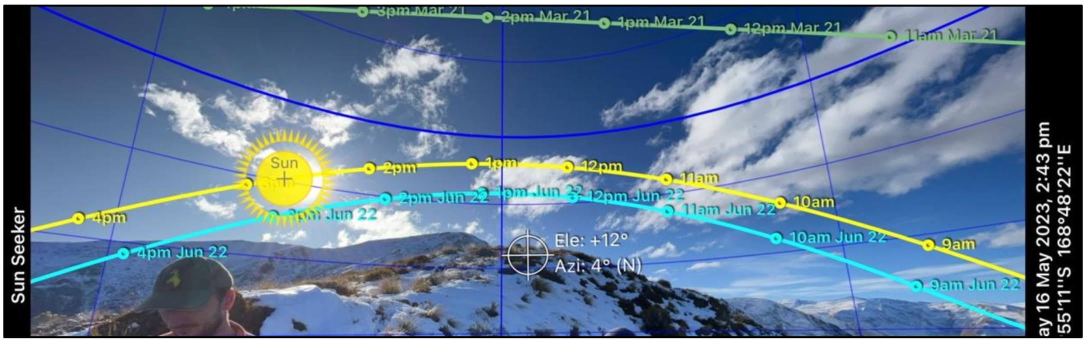
e. Test installation stability by applying moderate to firm pressure by hand in each direction to make sure the Waratah installation is sufficiently strong to hold the Relay in high wind conditions (120km/hr+).

3. Mount Solar Panel to Relay enclosure.

a. If the solar panel is not mounted to the two relay mounting brackets, screw each bracket to the solar panel.

b. Tighten the 2 x bolts on the back of the Relay enclosure with a 13mm ring spanner to secure the Relay enclosure to the Waratah.

c. Solar panel position should now be facing towards the North (+/-15 degrees). Make sure that solar panel is clear of any shading or shadow (from vegetation etc) on the face of the solar panel, even if minor, this will compromise its performance.



d. In alpine areas especially above 1000m, ensure the Relay enclosure with its solar panel is up at least 800mm off the ground, this helps ensure that the Relay and panel does not get buried in snow during a storm or enable wind-blown snow to build up around it. The panel is mounted at a 27deg angle which is steep enough for snow to be unable to adhere to the panel.

e. Use the Sun Seeker app on your installation mobile to position the solar panel to the best position for maximum sun hours during mid-winter. Install position in most circumstances should be no more than +/-15-degrees from due North.

4. Check and test Relay Connectivity

   a. Test to see whether the Relay is available over the internet.

Level 1
293 Durham St,
Christchurch, 8013
New Zealand

support@ftpsolutions.co.nz
03 409 0883
http://ftpsolutions.co.nz