Yarn Mesh Gateway

Planning & Deployment Guide

Extend connectivity up, down, over, and beyond

Prepared by:

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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
APN	Access Point Name (mobile LTE APN)
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)
NFC	Near Field Communication
RCT	Radio Communications Tower (for Yarn Mesh Gateway)
RF	Radio Frequency (communications)

Revision History

Version	Date Issued	Author	Authoriser	Description
0.1	23/05/2023	Jonathan Clark		First draft
0.2	29/05/2023	Jonathan Clark		First release for review
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Document Sign off

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2 Yarn Mesh 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.

2.1 Yarn Mesh Use-Case Overview

Yarn Mesh has been designed from the ground-up to support communications in remote and complex terrain environments, such as large farms, wilderness areas, mines, ports and large civil construction projects.

Yarn Mesh enables data-driven environmental management by enabling people, organisations and projects to connect data from sensors and devices across large geographic areas, quickly and cost effectively.

Yarn Mesh provides a secure, ubiquitous, low-power communications network that can support a large range of sensors, devices, and use-cases.

In an environmental management context, the ubiquity of the Yarn mesh means that a network deployed to connect both automated self-resetting and manually reset traps can also enable the interconnectivity of things like:

- Water quality and flow via in-river sensors and the Yarn IoTBox
- Birdsong through birdcall monitoring devices via Yarn IoTBox
- Wildlife and Predator behaviour tracking via Yarn TracBeacon
- Invertebrate counts via the Yarn TrapBox
- Personnel health, safety and task location awareness via Yarn TracTag
- Situational awareness of operational vehicles such as ATV's and utility vehicles including location, speed and engine telemetry via Yarn OBDBox.
- Weather data via compact 3rd party field deployable weather stations for detailed hyper-local climatic information.

Regarding Environmental Management, FTP's Yarn Mesh is intended but not limited to supporting use-cases across a range of areas. A high-level summary of these areas (sectors) and their Yarn Mesh technology use-cases is listed in the table below.

Yarn Mesh use-cases in Environmental Management		
Industry	Sectors	Use Cases
Environment	Predator Control	• Trap telemetry from the field • 'Smart' trap integration • 'Manual' trap integration • Live capture trap support • Trail cameras • Personnel location • Field messaging • Image classification • Passive tracking • Audio classification • Active tracking

		• Trap control
	Water Management	• Flow/Level/Quality monitoring
	Soil Management	• Nutrient leaching and runoff monitoring
	GHGs & Carbon	• Monitoring GHG levels and flux
	Health & Safety	• In-field workers, worker safety
	Situational Awareness	• In-field workers, worker safety, operations, vehicles

In a farm management context, the ubiquity of the Yarn mesh means that a network deployed to connect soil probes and monitor irrigation can also enable the interconnectivity of things like:

- Personnel health, safety and task location awareness via Yarn TracTag
- Situational awareness of operational vehicles such as ATV's and utility vehicles including location, speed and engine telemetry via Yarn OBDBox.
- Weather data via compact 3rd party field deployable weather stations for detailed hyper-local climatic information.

Regarding Farm Management, FTP's Yarn Mesh is intended but not limited to supporting use-cases across a range of industry sectors. A high-level summary of these industry sectors and their use-cases is listed in the table below.

Yarn Mesh use-cases in Farm Management		
Industry	**Industry Sectors**	**Use Cases**
Agriculture	Farm Management	• Personnel location • Field messaging • Irrigation • Task Management • Livestock containment
	Water Management	• Flow/Level/Quality monitoring
	Soil Management	• Nutrient leaching and runoff monitoring
	GHGs & Carbon	• Monitoring GHG levels and flux
	Health & Safety	• In-field workers, worker safety
	Situational Awareness	• In-field workers, worker safety, operations, vehicles

3 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.

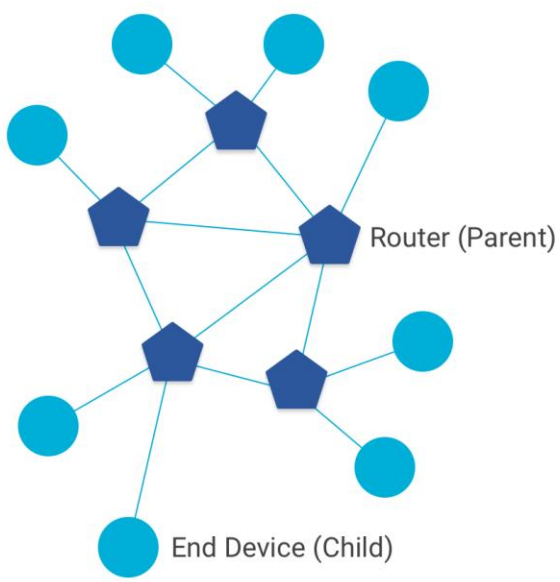


Figure 1 - Example of the dynamic topology of Yarn Mesh network.

In a Yarn Mesh network 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 Gateway Deployment Planning

The physical location of the Gateway is paramount, it should be placed centrally to decrease the number of hops that are required for a path to root from any node. It should have good line of site to primary Relays or End Devices that provide the ‘backbone’ of the mesh network and good line of site to the nearest cellular tower if using a cellular as the backhaul medium. It is possible to use other forms of backhaul including satellite or ethernet IP connectivity. In all scenarios a TCP/IP connection is required to backhaul data from End Devices - over the mesh - via the Gateway to the Internet and on to IMS.

Figure 3 - Yarn Mesh Gateway deployed at around 1200m altitude, mounted on an Yarn Mesh Radio Comms Tower (RCT).

When planning a Yarn Mesh Gateway deployment, it is important to consider proximity - in network hops - to the furthest Yarn Mesh End Nodes that will be deployed. 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. Therefore, the key considerations when planning Gateway placement are:

- Location, location, location: to determine the optimum location for your network these factors should be considered:
    - Backhaul Connectivity: Proximity to carrier IP LTE coverage (if using an LTE (4G/5G) uplink for the backhaul data service).
    - 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 Gateway at a high point on the terrain can help maximise LoS (Line-of-Sight) to other mesh devices, provide direct LoS to cellular services and provide maximum unobstructed sunlight hours for solar charging.
    - Sunlight: When planning a Gateway 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 Gateway requires a medium sized solar panel to charge its onboard batteries, therefore Gateway 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 Gateway leeward to prevailing storm fronts can and should be used to reduce the potential for maximal wind events (severe storms) to affect Gateway installation, especially at high elevations (>500m ASL) or in exposed locations such as coastlines or other known potential high-wind zones.

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

No (available) Gateway = No (available) Network

The IMS RF Planning module is shown for reference in the image below.

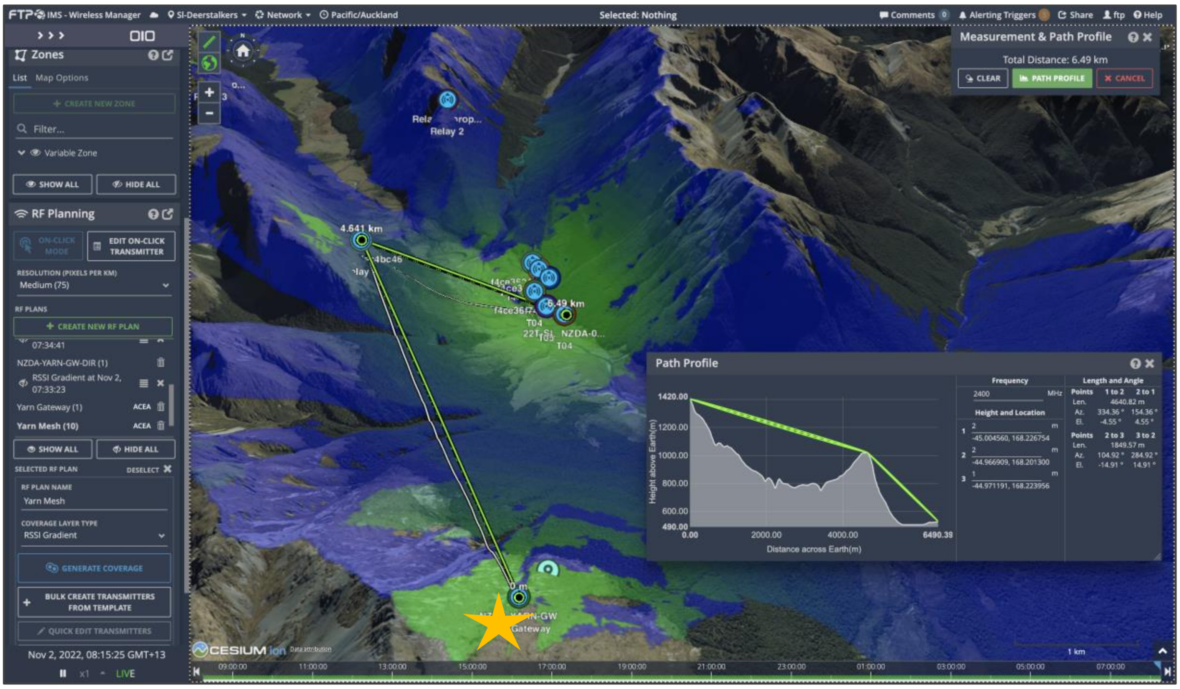


Figure 4 - FTP IMS RF Planning module showing RF coverage provided in the Greenstone Valley and Steele Creek by 1 x Yarn Mesh Gateway, 1 x Yarn Mesh Relay and 6 x Yarn Mesh AT220 Traps.

The image below shows the perspective from the Yarn Mesh Gateway once installed. Any Yarn Mesh node within line-of-sight from this Gateway and coloured in the RF plan should have the option of direct connectivity, the mesh will dynamically select the best path for network traffic.

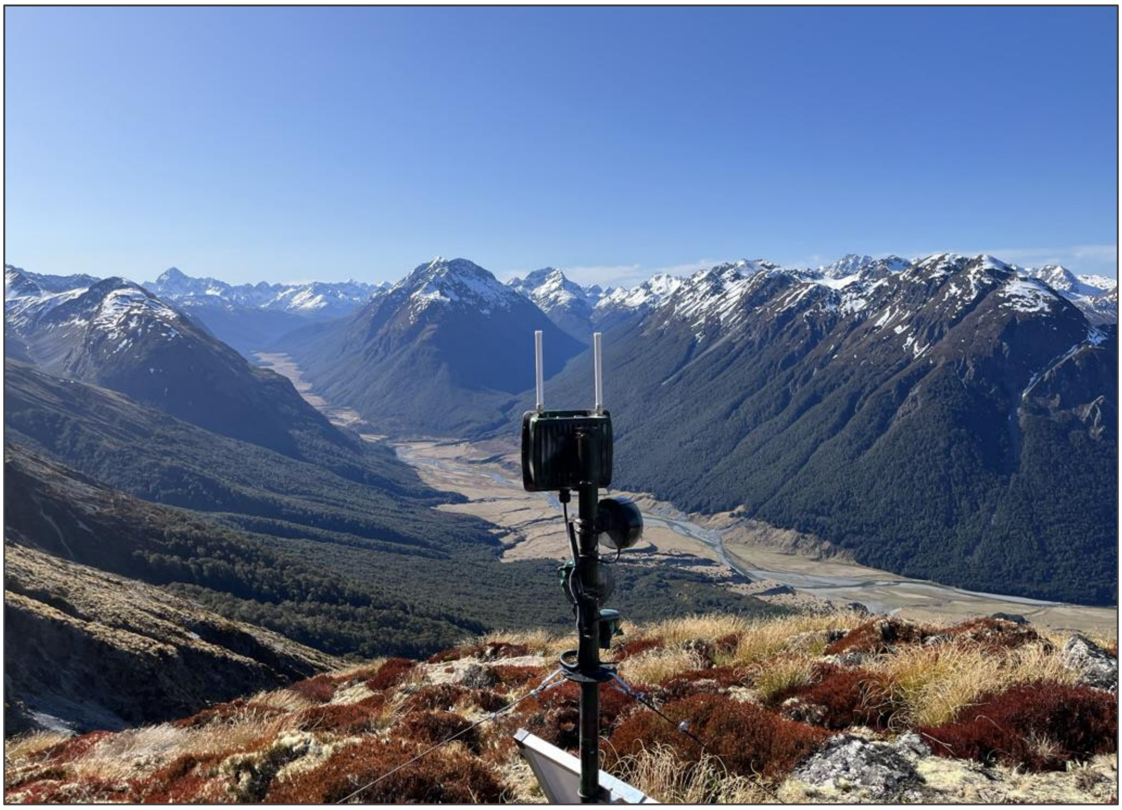
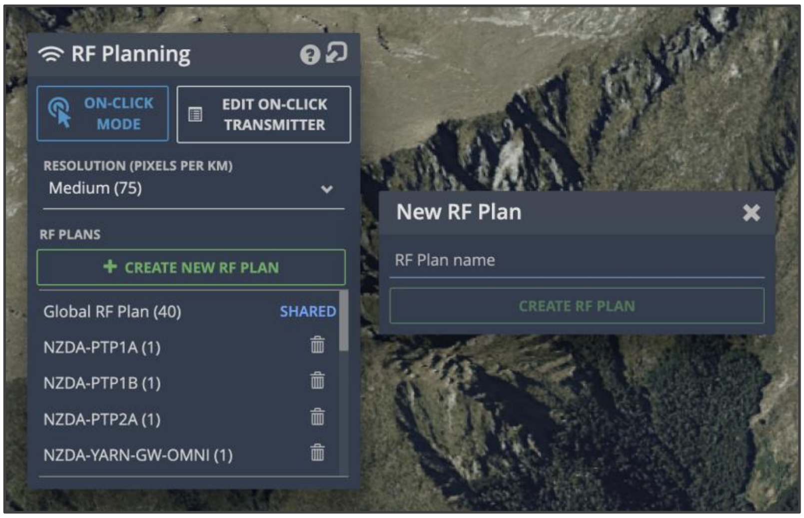


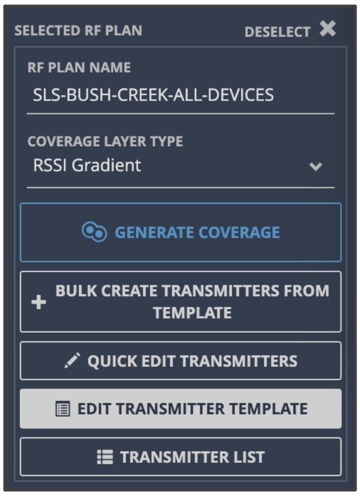
Figure 5 – Yarn Mesh Gateway, Greenstone Valley, New Zealand

3.3.1 Yarn Mesh Gateway Planning Process

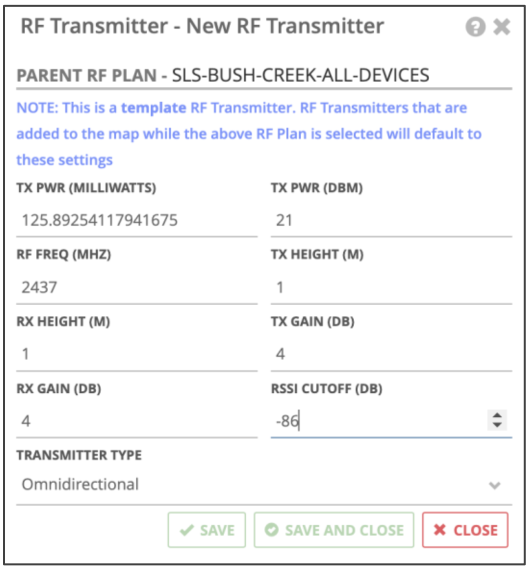
Planning Yarn Mesh networks and installation locations for Yarn Mesh Relay deployment is performed through the IMS RF Planning module. Instructions on how to use the IMS RF Planning module can be found here:

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 Transmitter Template with the following settings.

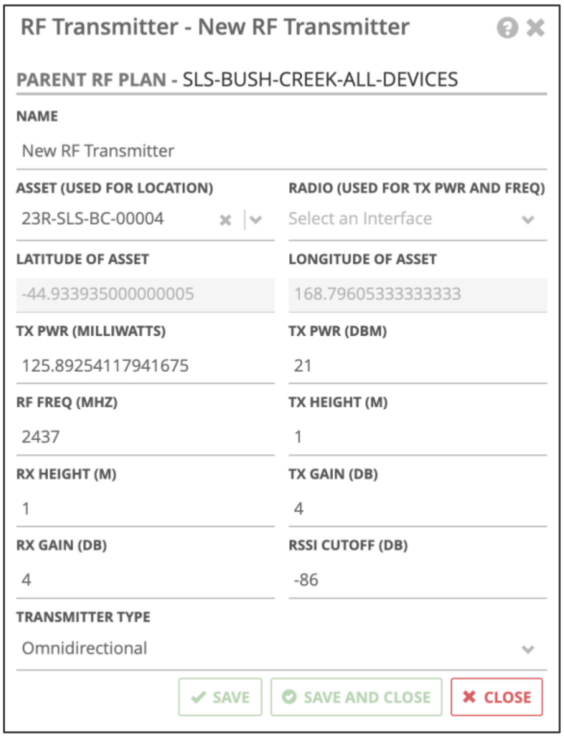
i. 

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.

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

h. Generate Coverage again and validate.

2. Check cellular coverage using to telecommunications carrier network coverage maps.

   a. Once the general installation location is identified in IMS, it is necessary to identify whether the Gateway can be connected via a cellular IP data (3G/4G LTE) service as the preferred means of backhaul IP connectivity or whether it will need connectivity via a satellite IP backhaul service such as Starlink.

   Mobile Network Coverage Maps:

   - Spark: https://www.spark.co.nz/shop/mobile/network/
   - One (Vodafone): https://one.nz/network/coverage/
   - 2 Degrees: https://www.2degrees.nz/coverage/

   b. If using a carrier other than Spark, please let FTP know via a support call or email so the Mobile Network APN settings can be updated on the Gateway before pre-deployment testing.

      i. LTE Backhaul (3G/4G) network tests will fail if another mobile network providers SIM card is installed in the Gateway if these settings are not updated first.

3.4 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.

3.5 Yarn Mesh End Devices

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

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
- PLM (SafeBeacon)
- IntelliCam
- TrailCam

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

- IoTBox
- PLM (SafeBeacon)
- FuelNode
- TankNode
- OBDBox.

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 geographical areas. Initial deployment can consist of a few devices and scale to 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 Gateway Deployment

The Yarn Mesh Gateway comes in a weatherproof, insulated and heated enclosure. Inside the Gateway enclosure is a pair of large lithium-battery packs, heater plates, the Yarn Mesh Gateway electronics with inbuilt LTE modem and RJ45 network adaptor. A SIM card tray for a Micro SIM (mid-sized SIM card) is built-in to the side of the Yarn Gateway PCB for insertion of mobile carrier SIM card as the primary means of backhaul IP connectivity. Two u-FL to N-Type RF antenna connectors are installed in the lid of the Gateway enclosure, the Yarn Mesh Antenna and LTE Antennas are screwed into these N-type connectors prior to the Yarn Mesh Gateway being powered on, attachment of the supplied antennas prior to powering on the Gateway is crucial to avoiding irreparable damage to the sensitive RF Power Amplifier circuitry.

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

The LTE antenna is longer than the Yarn Mesh Antenna, it is critical that the correct antenna type is installed on each N-type connector. The label on the front of the Gateway designates which antenna goes on which side.

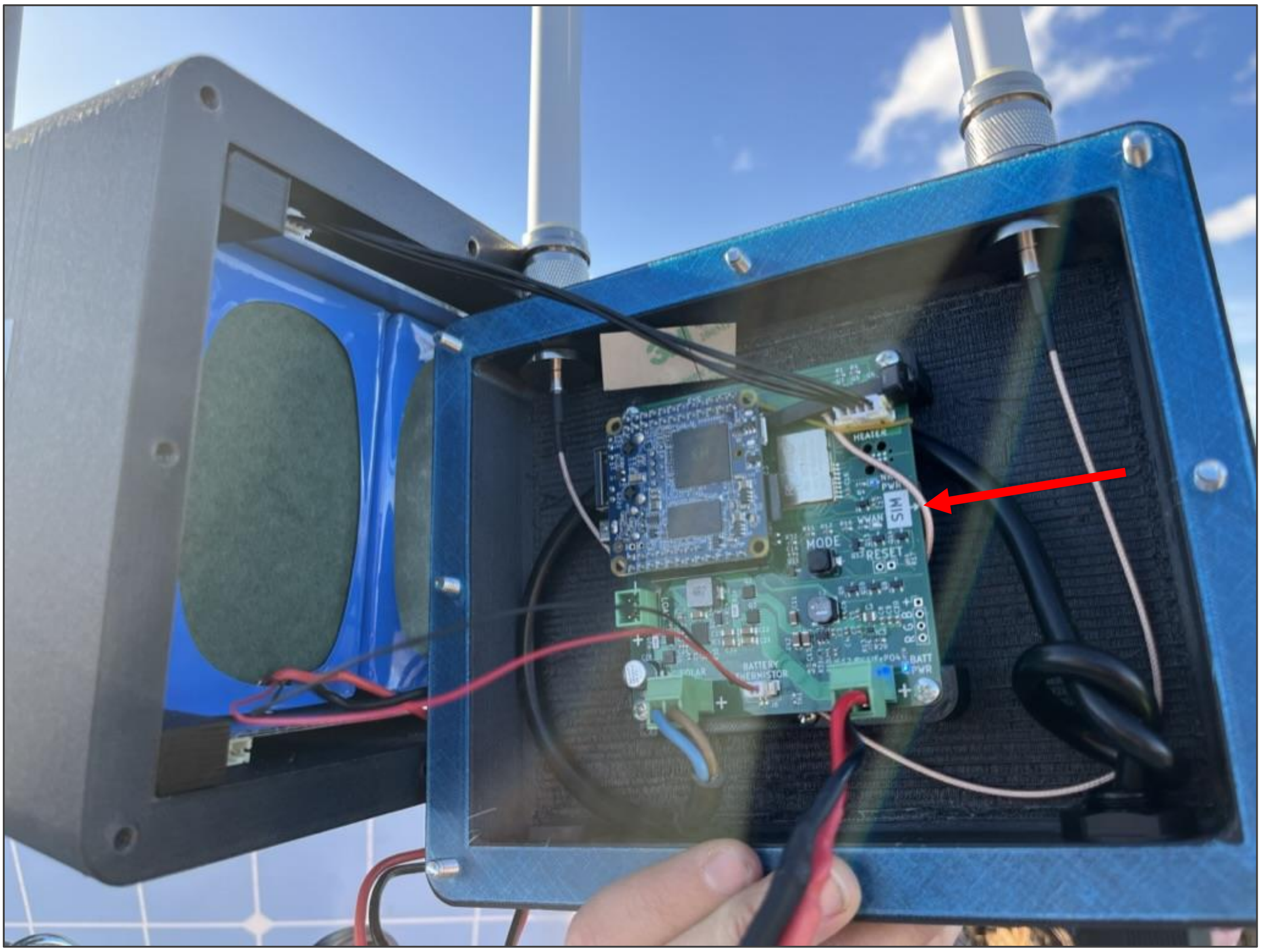


Figure 6 - Inside the Yarn Mesh Gateway enclosure, showing PCB, batteries and antenna RF fly leads. Note red arrow above: Cellular SIM tray is underneath right-hand side of PCB and marked SIM on the board.

4.1.1 Gateway Deployment Requirements

4.1.1.1 Yarn Mesh Gateway Hardware Required

- Yarn Mesh Gateway
- Yarn Mesh Communications Tower
  - Parts List
    - 1 x main antenna tower
    - 2 x solar panel brackets (small top bracket, large bottom bracket)
    - 1 x Gateway mounting bracket

- 5 x 75 x 45mm U-bolts (galvanised)
- 3 x steel carabiners (plated)
- 3 x guy wires (galvanised wire rope)
- 6 x 5mm wire rope grips (galvanised)
- 3 x fence strainers
- 3 x M8x40 bolts with washers & nyloc nuts (galvanised)

4.1.1.2 3rd Party Hardware/Software Required

- LTE (4G/5G) SIM card
- Guy wire anchors:
  - 3 x Waratahs (aka Y-post or Star pickets) (min 800mm, max 1200mm long)
  - 1-2 x Waratahs as spares, may be required to provide further ground anchor for guy wire in direction of prevailing wind.
- Ground stakes:
  - 2 x 30mm galvanised steel tube (˜1000mm long)
- 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

- 13mm ring spanner x 2
- 10mm ring spanner
- 300mm (12 inch) adjustable crescent
- 6mm hex (allen) key
- 4mm hex (allen) key
- ¼ inch drive socket driver
- 10mm ¼ inch drive socket
- 13mm ¼ inch drive socket

- Sledgehammer (large)

4.1.2 Gateway Deployment Process

1. Locate installation site:
   a. Using Lat/Long coordinates from planned Gateway 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. Ensure installation side has good cellular coverage.
      i. Site should have a minimum of two bars coverage your installation mobile phone.
   c. 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.

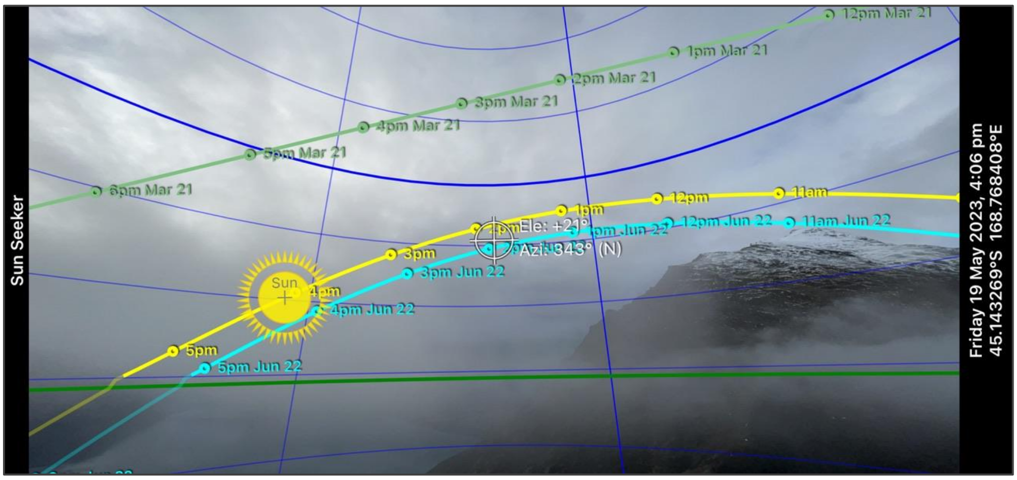


Figure 7 - Sunseeker 3D augmented reality mobile application. 3D mode visualised the location of the sun at different times of the year throughout the day. The

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

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 shielding affect radio LoS.

Figure 8 - Selecting the specific Gateway installation location.

iv. Before finalising exact install location, check ground is both soft enough to drive Waratahs and ground-stakes to depth (˜800mm+) and firm enough to hold them 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 a Waratah in a several points around identified Radio Communications Tower install site.

2. Install Radio Comms Tower

   a. Drive centre ground-stake (30mm Galv Tube) into ground using sledgehammer. at central point of install site exactly where the tower will be installed.

   b. Slide Radio Comms Tower over centre ground stake.

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

c. Drive cross-stake (30mm galv tube) through diagonal tube a the bottom of the RCT. The cross-stake is to prevent rotation of the RCT and help secure it from lifting.

3. Mount Solar Panel to Radio Comms Tower pole.

a. If the solar panel is not mounted to the two mounting brackets, bolt each bracket to the solar panel. It may be necessary to drill 5mm mounting holes first. Use M5 x 20mm Allen head cap screws with washers and nyloc nuts.

Figure 9 - Mounting solar panel brackets to the solar panel for the Radio Comms Tower.

b. Use the supplied U-bolts to fix the solar panel brackets to the RCT pole. Position solar panel to the North (+/-10 degrees). Make sure that the guy wires when installed will not run across the face of the solar panel – any shading or shadow on the face of the solar panel even if minor, will compromise its performance.

Figure 10 - RCT showing solar panel mount U-bolts and guy wire carabiners.

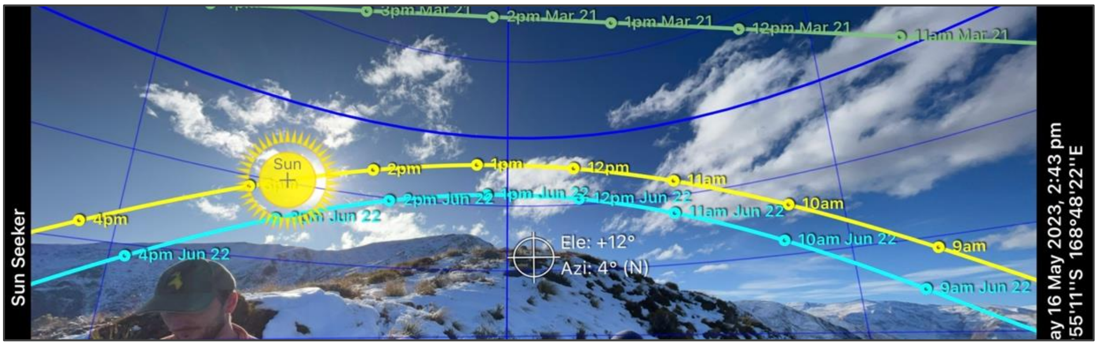


Figure 11 - View from exact heading (angle) and azimuth of solar panel through the Sunseeker 3D augmented reality mobile app. The yellow line is the sun path on this day, the turquoise line shows the sun path of the shortest day of year.

c. In alpine areas especially above 1000m, mount the solar panel up at least 800mm off the ground to ensure that the 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.

d. 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. Install Guy Wires.

a. Position the 3 x guy wires at approximately 120-degree spacings from each other. One guy wire will need to be installed directly opposite the solar panel position, the other two wires need to be installed at a flatter angle to the left and right of the solar panel to ensure they don't interfere with the panels position.

Figure 12 - Yarn Mesh Gateway on a Yarn Mesh Radio Comms Tower showing guy wires.

b. It is necessary to find good ground for each of the guy wire's waratahs. 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.

c. Once installation locations for each waratah have been found, drive each waratah in to the ground with the longest fin facing the RCT pole, with approximately 30-degree back angle (angle away from the pole). Drive each waratah to a minimum of 750mm below ground. Only the highest mounting hole on the waratah should be visible above ground now.

d. Using the supplied M8 x 40mm galvanised bolts, washers and nyloc nuts, securely fasten a fence strainer to the top of each waratah. Tighten each bolt so that the fence strainer is as close as possible to the waratah without squashing it. Squashing the fence strainer can result in it failing in a high-wind event.

e. Feed each guy wire through its respective fence strainer and bend back on itself so the wire is held under the winding tab on the strainer's reel.

f. Using the large adjustable crescent, wind each fence strainer to wind each wire rope on to each fence strainers reel, initially taking most of the slack out of each wire rope.

g. Once the slack from each wire rope is removed, it is important to tighten each of the 3 x strainers a little bit at a time, ensuring that the RCT pole remains in a vertical position to the sky in all directions.

h. Each wire rope needs to be very tight, there should be almost zero movement in the RCT pole when pushed and pulled in any direction once the fence strainers are at the necessary tension. During testing, if there is noticeable movement of the pole when pushed or pulled strongly, go back around each strainer tightening it one increment at a time until any play is removed. Check that the waratahs have not moved in the ground or slogged out the hole they are in – if so, repeat the Step 4 process.

i. If a waratah needs to be reinforced, another waratah can be cross-nailed on a 45-degree angle directly in front of each guy wire waratah – this is a last resort, only use this when the ground conditions do not provide sufficient stability for a single waratah to hold the guy wire under tension.

5. Mount the Gateway enclosure to pole.

   a. Bolt the RCT Gateway Mounting Bracket to the Gateway enclosure using the supplied M8 x 16mm Allen head cap screws. Ensure the screws are tight and secure without overtightening. Overtightening these cap screws risks damaging the internal thread on the Gateway enclosure, damaging this thread will result in a new enclosure body being required.

   b. Connect the supplied U-bolts, washer plates, plain nuts and nyloc nuts to the RCT Gateway Mounting Bracket. Slide Gateway enclosure attached to RCT Gateway Mounting Bracket over the top of the RCT pole. Use the plain nuts to initially position the Gateway as high as possible on the pole. Angle the Gateway so that the LTE (4G) antenna has clear LoS towards the direction of the cellular tower. The LTE antenna is on the left side of the Gateway when looking at the Gateway Lid front on.

   c. Tighten U-bolts plain nuts, test the Gateway cannot rotate on the pole when push with a good amount of force sideways. Tighten U-bolts further until sideways movement is not possible. Now tighten nyloc nuts down over plain nuts, these act as locknuts to prevent the U-bolts coming loose.

6. Check and test Gateway availability.

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