



# MESHMERIZE

## Tunnel Construction Connectivity Solution

### Summary

Reliable communication is crucial within tunnel environments, ensuring seamless interactions between workers, machines, and all other elements in the tunnel. The complex nature of tunnel construction demands a robust and adaptable connectivity solution.

Traditional connectivity falters amidst constant excavation and machinery movement, creating a need for a reliable solution without compromising performance.

Meshmerize addresses the challenges by offering a resilient mesh network with low-latency and self-healing features.

During construction, it ensures uninterrupted connectivity, enhancing safety and efficiency. Its functionality extends beyond the construction phase, continuing to work effortlessly in the completed tunnel.

### Key Solution Benefits

- **EXCELLENT RELIABILITY THROUGH MULTI-PATH ROUTING**  
No single point of failure, all devices are APs.
- **BEST-IN-CLASS AFFORDABILITY**  
Without compromising reliability.
- **UNPARALLELED FLEXIBILITY IN SETUP AND DEPLOYMENT**  
Choose your own hardware and set it up yourself using a step-by-step guide.
- **TRULY WIRELESS NETWORK COVERAGE EXPANSION**  
Seamless network expansion - no extra cables needed.
- **RESILIENT NETWORK BACKUP**  
Reliable partner in mission critical operations.
- **HIVE - NETWORK MANAGEMENT**  
Automating deployment and network operation with cloud-based Hive management.

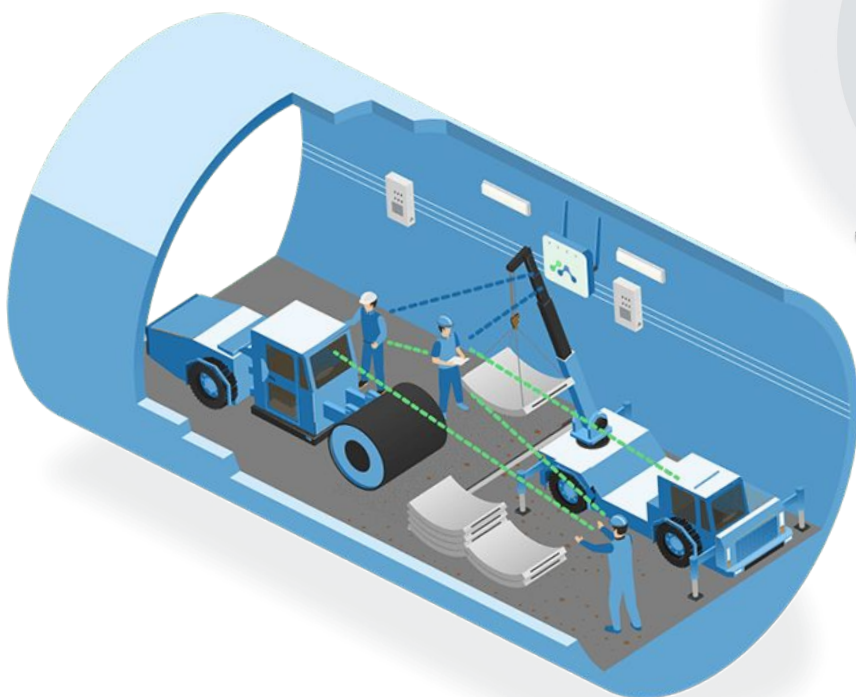
## How does it work?

Meshmerize easily overcomes challenges present in tunnel communication. By using multi-path routing, Meshmerize is relaying messages through all nodes, forming redundant communication paths to proactively prevent a loss of communication in case of a single link failure. Instead of relying on single wireless links,

Meshmerize uses a decentralized device-to-device communication to strengthen the network from the inside. This enables Meshmerize to expand the network without expensive cabling installations by simply connecting all devices directly and wirelessly, eliminating radio shadows in the tunnel.

## Hardware selection

Implementing Meshmerize in tunnel communication offers flexibility in hardware selection, allowing customers to choose from a selection of devices that suit their specific needs.





## Static hardware recommendations

The primary devices are installed as static hardware throughout the tunnel to provide comprehensive network coverage. They are strategically positioned every few hundred meters, taking into consideration factors like bends and obstacles. To enhance signal strength and reach, the devices are equipped with directional antennas, ensuring focused and efficient connectivity.

Key device specifications	
EnGenius ECW160	Acksys RuggedAir100
The recommend hardware choice for this purpose is the EnGenius ECW160, a dual-radio dual-band Wi-Fi access point. Its IP67-rated weatherproof and dust proof housing withstands harsh environments making it the perfect choice for the tunnel construction environment.	A suitable alternative access point is the Acksys RuggedAir100 Wi-Fi access point, client, repeater & mesh point designed for industrial applications in harsh environments. It offers a ruggedized IP66 waterproof, shock and vibrations proof enclosure, an extended operating temperature range, and industrial standard M12 connectors for more demanding deployments.
Qualcomm 717 MHz Quad-Core CPU ARM Cortex A7	Qualcomm Atheros QCA9558 SoC
Power-over-Ethernet: 802.3af/at or Proprietary 54V IEEE 802.11e Compliant Source Active Ethernet (PoE)	Dual insulated redundant input +9VDC to +48VDC, M12 connector 4-pole A-coded & PoE 802.3af (15.4W), mode A/endspan compatible
Dual-Radio Concurrent 2.4GHz & 5GHz 2x2 802.11ac/a/b/g/n	Single-radio 2.4GHz 2x2 802.11a/b/g/n
Operating: -4°~140°F/-20°C~60°C, Storage: -40F°~176°F/-40°C~80°C temperature range	Operating: -40°C to +70°C temperature range



## Mobile node recommendations

In addition to the static hardware installations, Meshmerize offers options for equipping mobile nodes, such as vehicles, with hardware to further enhance connectivity in tunnel construction sites. These mobile devices can be equipped with different hardware options to establish additional connections, improving both reliability and coverage in the most challenging and inaccessible areas of the tunnel.

Key device specifications	
Doodle Labs Smart Radio	PCTEL Industrial IoT Access Point
The Doodle Labs Smart Radio is an easy-to-carry, easy-to-use Mesh Rider Radio designed to be worn by personnel in order to connect individuals to a mesh network. Its built-in Wi-Fi hot spot makes it easy to connect any internet-enabled device to the same mesh network. It is the perfect choice for a lightweight Access Point to be carried by construction personnel.	PCTEL's AP-WiFi-1200 Industrial IoT Access Point is ideal for demanding industrial and outdoor applications. Housed in a compact, easy-to-deploy enclosure and offering external antenna connectors, it can be used in a wide variety of applications and environments, tunnel construction sites being one of them.
Qualcomm Atheros QCA9533	Dual-radio 2.4 and 5 GHz
6V - 24V, USB-PD Compliant	4 external WiFi antenna ports
Dual-band 802.11n, 2x2	Power-over-Ethernet (PoE) - PoE, 802.3at Type 1 Class 3
Operating: -40°C to +85°C (industrial), -10°C to +65°C (commercial) temperature range	Operating: -40°C to +65°C IP67

More information on the Meshmerize-enabled devices can be found on the individual [device pages](#).

# Mesh Performance

Depending on the choice of hardware, the Meshmerize tunnel communication connectivity solution provides reliable network coverage and failover ability in case of a fiber breakage.

	Minimum / Average / Maximum expected Throughput		
	1 hop	2 hops	3+ hops
<b>EnGenius ECW160</b>	15 / 58 / 68 Mbit/s	7 / 15 / 25 Mbit/s	2 / 4 / 7 Mbit/s
<b>Acksys RuggedAir100</b>	20 / 34 / 40 Mbit/s	6 / 10 / 15 Mbit/s	2 / 4 / 7 Mbit/s

	Minimum / Average / Maximum expected Latency		
	1 hop	2 hops	3+ hops
<b>EnGenius ECW160</b>	4 / 9 / 76 ms	4 / 16 / 140 ms	8 / 23 / 376 ms
<b>Acksys RuggedAir100</b>	2 / 3 / 6 ms	3 / 5 / 10 ms	5 / 6 / 9 ms

The performance figures mentioned above are based on the assumption of accurate setup and configuration. They were obtained through measurements in the 2.4GHz band with 20MHz channel width. The actual measured numbers can vary due to a range of factors that are beyond the control of the Meshmerize software, including wireless environment, hardware selection, antenna positioning, and other. Meshmerize does not warrant for specific wireless or network performance aspects such as data throughput, packet loss, or scalability in arbitrary deployments, as these elements are affected by the aforementioned factors.

If there is a deviation in the measured service quality compared to the provided numbers, it is important to ensure that the setup adheres to our recommendations. If performance issues persist, [Meshmerize Support](#) should be contacted for further assistance.

# Deploying Meshmerize

## Software

Deploying Meshmerize devices involves initial steps of installing Meshmerize and setting up a default configuration. Depending on the chosen hardware, Meshmerize may come pre-installed, requiring only activation. If Meshmerize is not included in the factory firmware, installation instructions specific to the device can be found on the device's respective page. At this stage, all Meshmerize instances will be unlicensed.

For assistance, the [Meshmerize Quick Start Guide](#) provides detailed instructions on get started with the first Meshmerize installation, connecting to devices, setting up Meshmerize, installing a license, and customizing configurations.

## Configuration

For optimal wireless network performance, adapting the wireless configuration of the devices to suit the specific deployment environment is necessary. This is to ensure that the network avoids unwanted external interference.

Configuration of the mesh network should be done to operate on a Wi-Fi channel that is isolated for the specific deployment. Additional networks transmitting on the same frequency will drain available resources and reduce the overall network performance of the wireless installation.

### Meshmerize - Quick Start Guide

User guide for first steps after successful installing MeshmerizeOS

#### Meshmerize - Quick Start Guide

This guide leads you through the necessary steps to successfully deploy and test the Meshmerize mesh network. The primary goal is to ping multiple devices from your computer.

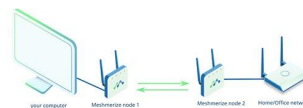
To achieve this, the guide will walk you through the following key steps in detail:

1. Meshmerize out-of-the-box Test
2. Connect to your Meshmerize device
3. Install the Meshmerize license
4. Set up a simple connection between two Meshmerize devices
5. Short introduction on how to configure Meshmerize and general network settings.

Please note that these steps assume that you have already installed MeshmerizeOS on your devices. If you want to know how to install Meshmerize, go to the [respective device's guide installation section](#).

#### Quick out-of-the-box test

Let's start with a quick out-of-the-box demonstration of Meshmerize by connecting your computer to the internet. This requires at least two Meshmerize-enabled devices and a running DHCP server, for instance from your home or office router that you already use. Power on both Meshmerize devices (nodes) and connect the LAN port of your first node with one of the Ethernet ports of your office/home network. Next, connect the LAN port of the second node to your computer. Your setup should look as depicted in the graphic.



Your computer will automatically establish a connection using the DHCP server of your office network to join the network. You should now be connected to the internet through the Meshmerize network, and you can freely move around while enjoying seamless connectivity. To test your internet connectivity, you can use your preferred terminal to `ping meshmerize.net`. Optionally, you can turn on a third Meshmerize device (or more) and place it slightly at a distance to enjoy the range extension of your network.

Voilà! You have a self-healing mesh network.

For more details on how to mesh nodes without a DHCP server for 30 minutes after powering up the device, please refer to the Meshmerize Wiki.

## Support

For inquiries related to open questions or specific requirements and configurations, the [Meshmerize Wiki Documentation](#) or [Meshmerize Support](#) can be referenced for assistance.

# Introducing Hive

Hive is a comprehensive network management tool which allows network monitoring, configuring and control. It is available as a cloud-hosted service, as well as a self-hosted variant if internet access is not possible at the site. Consulting the [Getting Started Guide](#) is advised for detailed steps on how to connect devices to Hive.

Hive enables the execution of a suite of provided actions to configure and customize device settings across the deployment, tailored to each device's role in the network. This ensures proper configuration for all devices fine-tuned for the AS/RS use case, eliminating manual configuration with individual device handling.



## BIRD'S EYE VIEW OF THE NETWORK

Visualize and accurately position all nodes, both static and mobile, on a map or floor plan.



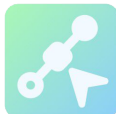
## MANAGE DEVICES IN BULK, WITH EASE

Effortlessly modify configurations across multiple devices.



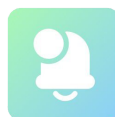
## PERFORMANCE BASED TROUBLESHOOTING

Proactively identify and resolve network issues.



## HASSLE-FREE NODE PROVISIONING

Conveniently add, remove or relocate nodes.



## ALERTS AND NOTIFICATIONS

Receive real-time alerts on network state changes for quick issue resolution.



## API INTEGRATIONS

Integrates the network nodes into your other tools using RESTful API calls.