MG Cellular Best Practices

Optimizing 5G

How to determine coverage?

Checking Coverage Maps

Many Service Providers offer coverage maps on their websites or mobile apps for users to use. These maps show areas where their 4G/5G services are available. Some Service Providers also show coverage on their coverage maps by location or at a specific address. These maps are a convenient way to get an initial understanding of the capabilities and limitations of the network in their area.

Some websites for reference are : https://www.verizon.com/coverage-map ,

https://www.t-mobile.com/coverage/coverage-map , https://www.fcc.gov/BroadbandData/Mo...aps/mobile-map

Field Testing

Field testing involves physically testing the network coverage and performance in various locations using mobile devices. Field testing provides real-world insights into network coverage and performance, allowing you to validate coverage maps and identify areas with weak or no coverage. Consider testing indoors and outdoors, as well as areas with potential obstructions such as buildings or natural terrain features. Check signal strength, data speeds, and overall network performance. Conduct speed tests using apps or websites designed for measuring internet speed. These tests measure the download and upload speeds of the network connection. Run multiple tests in each location to account for variability and fluctuations in network performance.

Check with Network Providers

Contact the network provider directly to inquire about coverage in specific areas. They may provide detailed information based on their network infrastructure and planned expansions.

What carrier should I choose?

There are several factors to help you determine what carriers to choose.

Coverage

Check here to see how to assess the coverage provided by each carrier in your area

Device Compatibility

Different carriers may use varying network technologies and frequency bands for their 4G and 5G deployments. It's essential to ensure that your device supports the specific network technology and frequency bands used by the carrier you intend to subscribe to. Devices are equipped with radio modems that support specific LTE and 5G frequency bands. These bands determine which frequencies the device can communicate on and affect its compatibility with the carrier's network. Make sure to check the LTE and 5G bands supported by your device and compare them with the bands deployed by the carrier.

Network Performance

Evaluate the network performance in terms of speed, reliability, and latency. Conduct speed tests using your mobile device in different locations to compare the download and upload speeds observed for each carrier.

Data Plans and Pricing

Review the available data plans and pricing structures offered by each carrier. Compare features such as data caps, speeds, pricing tiers, and any additional fees or charges.

By carefully evaluating these factors, you can choose the best carrier for your FWA device that offers reliable internet connectivity, suitable data plans, responsive customer support, and value-added services.

What determines throughput?

Here are several factors that help in determining throughput.

Signal Strength

The signal strength between the device and the nearest cell tower significantly affects throughput. It is measured in decibels (dBm) or signal bars on the device's interface. Higher signal strength values indicate a stronger signal, while lower values indicate a weaker signal.

Several factors can affect signal strength.

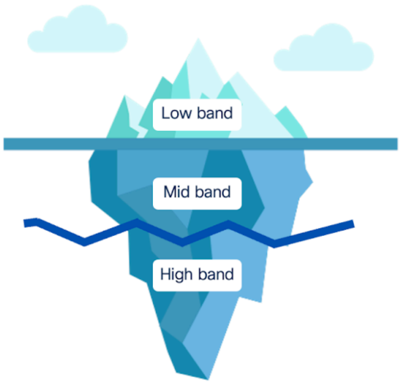
- **Distance from cell tower**: The closer the device is to the cell tower the stronger the signal strength tends to be. Signal strength decreases as the distance between the device and the tower decreases.
- **Interference and Obstructions**: Interference from neighboring towers or environmental factors can degrade signal strength. Structures like buildings, trees, natural terrain, and various obstacles can weaken or obstruct radio signals, resulting in a decrease in signal strength. Clear line-of-sight between the device and the cell tower is ideal for optimal signal strength.
- **Weather conditions**: Conditions like rain and snow can affect signal strength and signal propagation. These can cause temporary degradation of signal quality and affect throughput.

Frequency Bands

The choice of spectrum and frequency bands directly influences the performance, coverage, and capabilities of FWA services. The device uses different frequency bands which have different characteristics like coverage range and capacity.

Here is how it affects throughput.

- **Range of Frequency**: Higher frequency bands like mmWave offer faster data speeds but require denser infrastructure deployments and line of sight connections limiting the coverage area. Lower-frequency bands like Sub-6 GHz provide broader coverage and better penetration through obstacles, making them suitable for delivering services to a wide range of locations, including rural and suburban areas. While they may not deliver the highest speeds compared to higher-frequency bands, they provide reliable connectivity over longer distances
- **Signal Interference**: Frequency bands at higher frequencies could face increased vulnerability to disruption from various sources like other wireless devices, atmospheric conditions, or electromagnetic sources. This interference has the potential to degrade signal quality, resulting in decreased throughput, especially in densely populated urban areas or regions with elevated levels of electromagnetic activity.
- **Signal Propagation**: Lower-frequency signals propagate more effectively through obstacles, resulting in more consistent throughput over longer distances. Whereas higher frequency signals have shorter wavelengths and are likelier to experience attenuation caused by obstructions such as buildings and foliage. This attenuation has the potential to diminish signal strength and throughput, particularly in environments characterized by dense urban infrastructure or obstructed line-of-sight pathways.



Band category	Channel bandwidth	Coverage distance	Device throughput	Optimal placement
Low	< 25 MHz	Very long	Low	Anywhere
Mid	< 100 MHz	Long	High	Outdoor
High	< 3 GHz	Short	Very high	Outdoor

Antenna placement and Alignment

The following factors show how antenna placement and alignment affect throughput

- **Line of Sight**: Ensuring a clear line of sight between the antenna and the cell tower is essential for achieving optimal throughput. This maximizes the signal reception. Aligning the antenna precisely with the tower's direction minimizes signal divergence and ensures optimal signal strength, further enhancing throughput performance. Obstructions along the signal path can block or weaken radio signals, leading to signal attenuation. Buildings, dense foliage, or hilly terrain can absorb or reflect radio waves, causing signal loss and reducing signal strength. This attenuation can result in lower throughput and slower data transfer speeds.
- **Signal Reception**: The placement and alignment of the antenna dictate its capacity to receive signals from the cell tower or base station. Ensuring the antenna is correctly positioned optimizes signal reception, thereby maximizing both signal strength and throughput. Installing the antenna where it has an unobstructed view of the tower and is free from obstacles such as buildings or foliage enhances signal reception
- **Optimization of antenna**: Various frequency bands might necessitate distinct antenna designs or positioning techniques to enhance throughput. Antennas tailored for higher-frequency bands may demand meticulous alignment and placement owing to their shorter wavelength and high vulnerability to obstruction. Understanding the characteristics of the frequency bands and optimizing the antenna placement is important for maximizing the throughput.

Congestion of Network

This occurs when the demand for network resources exceeds the available capacity, resulting in degraded performance and slower data transfer speeds. Congestion affects throughput in the following ways.

- **Latency**: Due to increased latency and delays in data transmission caused by the overload on network resources can lead to reduced speeds for users to access the network. As data packets encounter congestion points in the network infrastructure, they experience longer queuing times, resulting in slower throughput.
- **Jitter**: Jitter is nothing but time delay in your network connection. This can result in inconsistent performance for time sensitive applications. Network congestion worsens jitter and can cause degraded performance for applications that require low latency.
- **Packet loss**: In congested periods, network devices might discard packets due to buffer overflow or congestion management methods. This packet loss exacerbates reduced throughput and may impair the quality of real-time applications like VoIP or video streaming.

Bands and Frequencies: What do they mean?

Bands refer to specific ranges of frequencies within the electromagnetic spectrum that are allocated for particular purposes or services. Each band has a range of frequencies with unique characteristics like coverage and capacity.

Frequencies are electromagnetic waves which are used to transmit data or information wirelessly. Each band within the electromagnetic spectrum corresponds to a specific range of frequencies.

Different bands have distinct characteristics and are allocated for various types of wireless communication services. Higher frequencies offer higher data speeds but have shorter range whereas lower frequencies have wider coverage with lower speeds.

It is important to understand bands and frequencies for the following reasons

1. Speed: Higher-frequency bands, such as mmWave, can deliver faster data speeds and higher capacity connections, making them suitable for delivering ultra-fast broadband services. However, they may require denser infrastructure deployment and have shorter range compared to lower-frequency bands.
2. Interference
3. Coverage
4. Device Compatibility

LTE has two kinds of data transmission techniques.

1. **FDD (Frequency Division Duplex)**: In this technique separate frequency bands are allocated for Uplink and downlink directions. The transmission here can occur simultaneously which allows for full duplex communication. It is suited for applications like voice calls.
2. **TDD (Time Division Duplex)**: In this technique the uplink and downlink transmission share the same frequency band but are separated in time. The direction of transmission switches between uplink and downlink in predetermined time intervals, enabling two-way communication within the same frequency band. This is more suited for applications like internet browsing or media streaming.

Check this link for different LTE frequency bands.

5G has the following kinds of frequency ranges-

1. **FR1**: FR1 refers to the frequency range used for the deployment of 5G in sub-6 GHz spectrum bands. Most initial 5G rollouts have employed FR1 spectrum bands because they are readily available and compatible with current network infrastructure.
2. **FR2**: FR2 refers to the frequency range used for the deployment of 5G in millimeter-wave (mmWave) spectrum bands. It includes frequency bands above 24 gigahertz (GHz), such as bands in the 24 GHz, 28 GHz, and 39 GHz ranges. It provides high-speed, high-capacity connections primarily in urban environments.

Check this link for some of the 5G NR frequency bands.

In the context of FWA and 5G there are two bands that are highly relevant. They are Sub 6 Ghz bands and mmWave bands. Sub6 Ghz bands typically operate below 6GHz and include frequencies used for both 4G LTE and 5G deployments. Sub-6 GHz bands offer broad coverage and better penetration through obstacles like buildings. mmWave bands operate at frequencies above 24 GHz. This facilitates ultra-fast data speeds and high-capacity connections, ideal for providing multi-gigabit-per-second (Gbps) speeds in densely populated urban areas. Nonetheless, mmWave signals suffer from shorter range and increased susceptibility to obstruction, necessitating denser infrastructure deployment and line-of-sight connections.

MG Deployment Best Practices

Which MG Should I be using?

There are many things to consider when deciding which MG best fits your deployment. Can I get a good signal? Will I need to deploy outside? Will Omni antenna work for me or will I need something more directional?

The table below has some basic information that we recommend you keep in mind.

MG21/21E	MG41/41E	MG51/51E	MG52/52E
• Basic Failover Connectivity • Basic 4G • 300 Mbps/50 Mbps (d/u) • 1 x 1 Gbps LAN port • PoE or DC-powered • 1 SIM	• Advanced Failover + Basic Primary Connectivity • Advanced 4G LTE • 1.2 Gbps/150 Mbps (d/u) • 2 x 1 Gbps LAN ports • PoE or DC-powered • 2 SIMs	• Advanced Primary Connectivity • 5G NSA sub-6 • 2 Gbps/300 Mbps (d/u) • 2 x 2.5 mGig LAN ports • PoE or DC-powered • 2 SIMs	• Advanced Primary 5G Connectivity • 5G SA sub-6 GHz • 2 Gbps/300 Mbps (d/u) • 2 x 2.5 mGig LAN ports • PoE or DC-powered • 2 SIMs • eSIM (Coming Soon)

You can use the MG Sizing Guide for more detailed information.

MG Sizing Guide: https://meraki.cisco.com/product-col...gateways/?file

NAT Mode vs Passthrough Mode: What's right for me?

Before deploying your MG, one of the first things you will need to do is determine which mode you would like your MG to operate in **NAT Mode** or **Passthrough**. See below for more information about these modes

NAT Mode

This is the default mode the MG will be deployed in. In this mode, the MG will act as a layer 3 gateway for the subnets under the Subnet Configuration section. Client traffic to the Internet is translated (NATed) so that its source IP becomes the uplink IP of the cellular gateway. In this mode, the MG will act as a DHCP server and assign addresses to devices connected to its LAN ports.

Passthrough Mode

Putting your MG in Passthrough mode disables the Layer 3 NAT Functionality of the device. The MG will instead forward the IP Address provided by the carrier to a device connected behind it. This deployment mode works best when directly connected to a single device (See Directly Connected to an MX below). For more information about Passthrough Mode, see the following MG IP Passthrough document.

MG IP Passthrough: https://documentation.meraki.com/MG/General_Configuration/MG_IP_Passthrough

Deployment Topologies

In this section, We'll cover some common use cases and how an MG can be deployed and configured to work in each scenario.

Deployment Modes

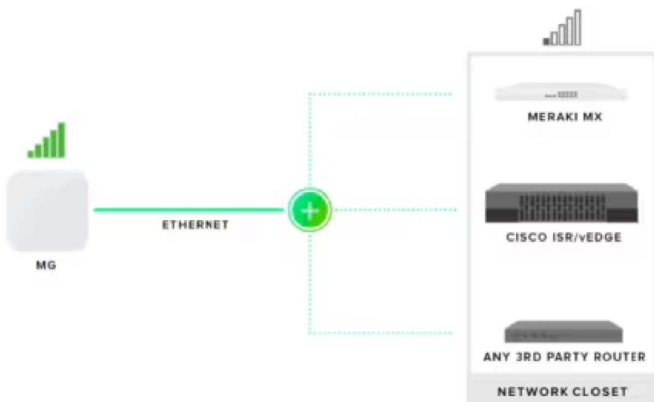
NAT Mode

NAT Mode is the default deployment mode for the MG. If that is how you choose to deploy the MG, you just need to ensure the MX WAN port you connect to is configured to get an IP Address from DHCP.

Passthrough Mode

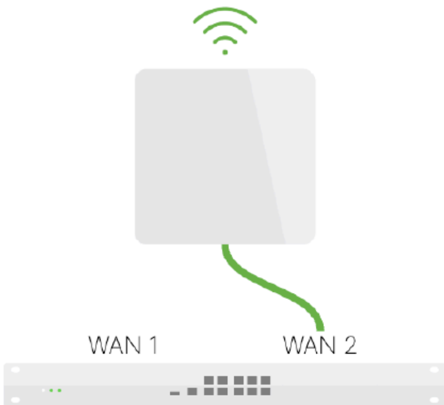
If you choose to deploy in Passthrough Mode, you may need to manually configure an IP Address on your MX's WAN interface. Also, when enabling Passthrough mode, Port 2 on your MG will be disabled. Ensure you connect your Device to Port 1.

Below you will see additional topologies that can be accomplished by connecting your MG directly to a Meraki MX. While we'll be using a combination of MG and MX for these examples, it is important to keep in mind that the MG makes use of Ethernet to hand off the cellular connection. This allows it to be used in tandem with not only Meraki MX, but also any Cisco ISR/vEdge, or 3rd party Routing and SD-WAN Device.

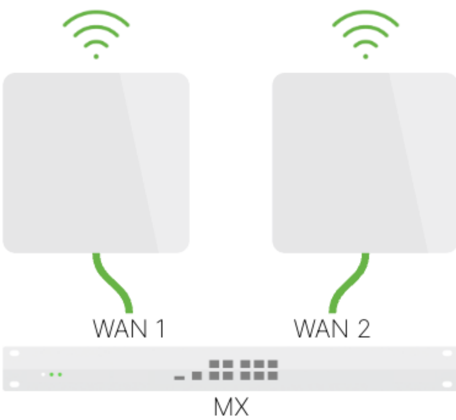


Directly connected to an MX

In this scenario, you are installing the MG as a Failover/Primary uplink to an MX. If the MX is capable of providing PoE from its WAN interface, you can connect directly to the interface. If it is not capable of providing PoE, you could install a PoE injector (MA-INJ-4) between the MX and MG, or power the MG with a Power Adapter (MA-PWR-30W).



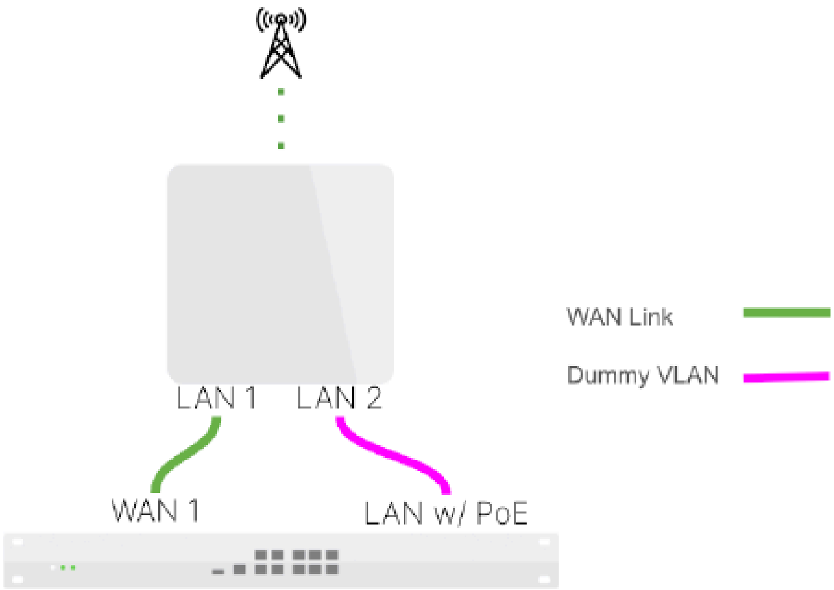
Single MG, MX
MG can be single or dual SIM



Dual MG, Single MX
MGs can be single or dual SIM

PoE Provided via LAN Port

While the above options work with an MX that can provide PoE via its WAN interface, there are some models that do not have this ability such as the MX75. However, these models often include LAN ports that have PoE. If configured with a Dummy VLAN (VLAN that is not in use on your network), you can connect one of the LAN ports of your MG to this PoE port to provide power, and connect the other MG port to the MX's WAN interface to provide connectivity.



Single MG, MX with PoE from LAN

MG with HA Pair

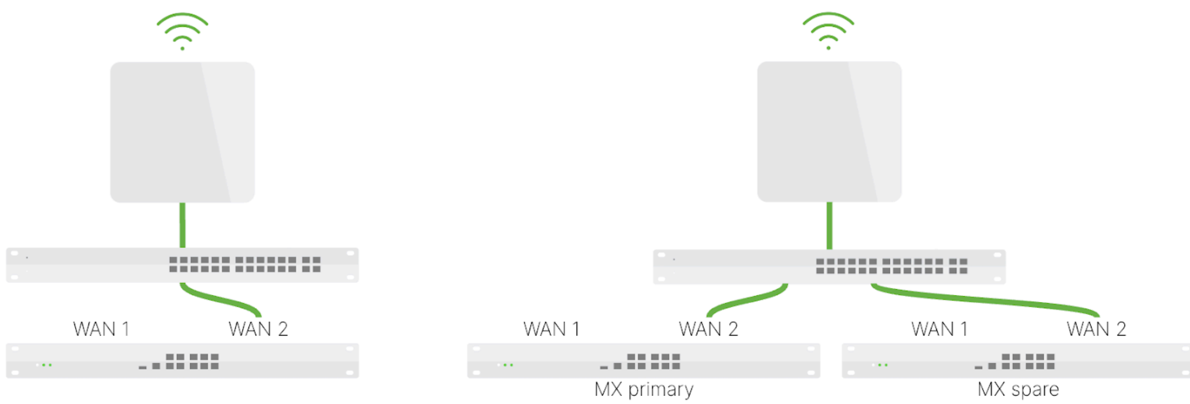
MG's can be directly connected to HA pairs without any additional configuration. Connect the MG's directly to WAN 2 for a backup cellular connection on both MX's.

Dual MG with HA Pair

Dual MG, MX HA
MGs can be single or dual SIM

MG's with Breakout Switches

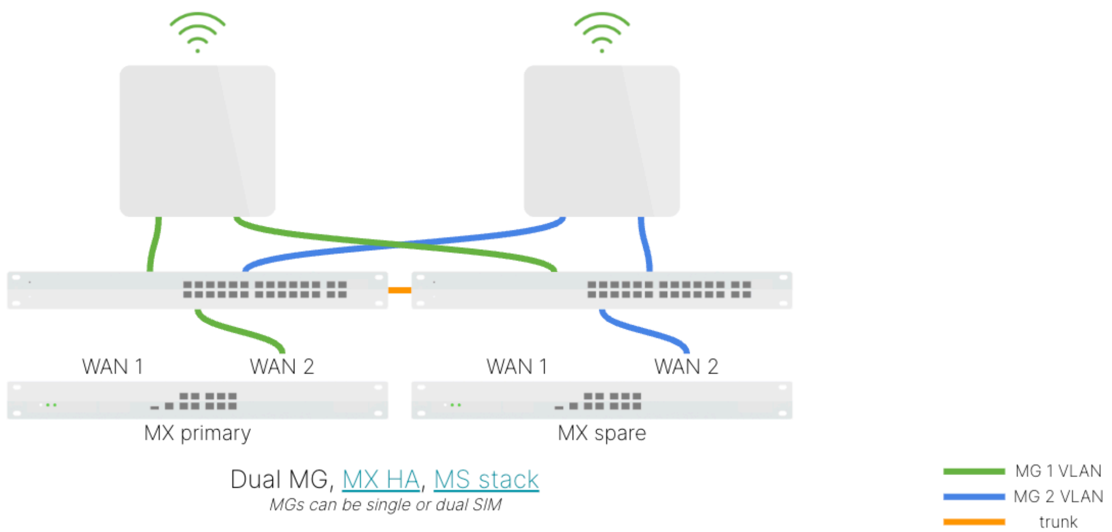
Using breakout switches between your MX and MG allows you to connect more than 2 devices to the MG. Deploying your MG in NAT Mode is required for this deployment.



Highly Available MG Design through the use of MX HA Pair and Breakout Switches

For the most highly available deployment, a pair of breakout switches can be used to connect dual MG's to an MX HA Pair. This deployment will require some configuration of the breakout switches:

- A VLAN for Cellular Uplink
- A Trunk port configured between the switches



Placement and Mounting

In this section, we'll cover recommendations on determining the best location to mount your MG.

Internal Placement

Having your MG inside of a building is a common and valid practice. However, one must keep signal in mind, as some building materials can significantly impact received signal.

If you intend to keep your MG inside of a building there are a few things we recommend:

- Use a smartphone to determine where the best signal is in your building. Install the SIM you intend to use for the MG into a smartphone and walk around the building. Keep an eye on the signal.
- Watch out for metal! Most metals have a very significant negative impact on cellular signals. With an average signal loss of -32 dB to -50 dB. If possible, try to install the MG in a location that does not have materials like metal or concrete on all sides.

External Placement

All MG models are IP67-rated, so an outside placement is the best option to get the highest quality signal possible. Here are some recommendations for out-of-doors placements:

- **Keep it covered!** While all MG's are IP67 rated, direct exposure to the elements can and will deteriorate the MG when given enough time. We recommend mounting the MG in locations mostly protected from direct wind, rain, and sunlight.
- **Location Location Location!** While an outdoor mount may provide the best signal, the location of the mount can still have a significant impact on performance. We recommend that you mount the MG in an elevated position and orient toward the closest known cell tower. If possible, try to give the MG line of sight of said tower, but in the event that it's not visible, ensure that there is nothing directly in the way.
- **Power!** You'll need to make sure the MG has a reliable power source. Most deployments will have an ethernet cable run to the location that provides both PoE and a network connection. If PoE isn't an option, the AC Adapter (MA-PWR-30W) can be used in tandem with a weatherproof electrical outlet.

What type of antenna should I be using?

When using an MG Model with External Antenna you have multiple options for antenna you can pick from. See the table below for options:

MG21E	Patch - MA-ANT-C1-B Dipole - MA-ANT-C1-A
MG41E	Patch - MA-ANT-DUAL-C1 Dipole - MA-ANT-C2-A
MG51E	Patch - MA-ANT-DUAL-C1 Dipole - MA-ANT-C2-A
MG52E	Patch - Coming soon Dipole - MA-ANT-C2-B

Patch vs Dipole: What's the difference?

Dipole antennas are the default, catch-all, best all-around option when it comes to MG Antenna's. They are going to broadcast a signal in all directions with the maximum allowable gain without exceeding the EIRP for Local Regulatory domains.

Patch antennas fit a specific use case because they are directional. If you know the direction of the nearest tower, mounting a Patch antenna up high (on the side of a building or a pole) and pointing it that direction can give you much better results than a Dipole. However, because they are so directional, you will only get better performance if the orientation is correct.

For more detailed information about the differences between Dipole and Patch antenna, see the documents linked below:

MG41E and MG51E Cellular Patch Antenna Datasheet: https://documentation.meraki.com/MG/MG41E%2F%2FMG51E_Cellular_Patch_Antenna_Datasheet

MG41E and MG51E Cellular Dipole Antenna Datasheet: https://documentation.meraki.com/MG/MG_Cellular_Dipole_Antenna_Datasheet/MG41E_and_MG51E_Cellular_Dipole_Antenna_Datasheet

MG21E Cellular Patch Antenna Datasheet: https://documentation.meraki.com/MG/MG_Cellular_Patch_Antenna_Datasheet

MG21E Cellular Dipole Antenna Datasheet: https://documentation.meraki.com/MG/MG_Cellular_Dipole_Antenna_Datasheet

Using 3rd Party Antenna

The use of 3rd Party antennas are not supported. It's up to the user to use based on their own discretion; the Meraki team will not be able to support additional questions for the 3rd party antennas. The antenna port is designed to detect the official MG smart dipole antennas and smart patch antenna. The Cisco Meraki antennas are designed for the maximum allowable gain without exceeding the EIRP for local regulatory domains on their supported bands.