GNSS Best Practices for AFC and AP Location Deployments

Document History

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- Initial version

GNSS Deployment Best Practices

The use of 6-GHz Standard Power requires Automated Frequency Coordination (AFC). AFC provides a coordinated channel and power to a Standard Power-mode network to ensure that Wi-Fi services do not interfere with incumbent services in the 6GHz space. For more information about AFC, see the Automated Frequency Coordination guide for cloud and on-premises deployments.

As per FCC regulations, access points (APs) operating at Standard Power must automatically obtain geolocation coordinates using an external or internal Global Navigation Satellite System (GNSS) module. The AP's location is obtained automatically through the CW-ACC-GPS1, a GNSS module that attaches to the USB port of any Cisco Wi-Fi 6E AP.

Once installed, position the AP on the floor of a building near a window with a clear line of sight to the sky. Within 10 minutes, the GNSS module acquires a satellite signal and shares the AP's location with the Cisco Catalyst 9800 Series Wireless Controllers or the Cisco Meraki dashboard. When connected to an external antenna, the module acquires satellite signals of up to 32 satellites which is then used to compute GPS location, constellation, orientation, and time.

Figure 1: CW-ANT-GPS1-M-00-NS Antenna: Different Views

The key requirements for operational stability when planning a site deployment for 6 GHz Standard Power are GNSS signal health and satellite distribution. GNSS signal health and quality varies greatly depending on the GNSS module's location within a floorplan. Before Standard Power operation is enabled within a floorplan, it is crucial to identify installation points within a building where the module receives a stable GPS reception. It is

important to determine the placement and quantity of GNSS modules for a floor plan to ensure stable Standard Power operation.

This guide provides a comprehensive approach to deploying GNSS modules for AFC and AP location services, with a focus on optimizing GNSS module performance. The goal is to ensure reliable and stable satellite signal reception by identifying optimal locations and implementing necessary adjustments in the field.

Firmware Requirements

- Cisco Catalyst 9800 Series Wireless Controllers running Cisco IOS XE 17.14.1 or a later release
- Cisco Meraki networks running MR 30.7+ or a later release

Supported APs

- Cisco Meraki MR57
- Cisco Catalyst C9163
- Cisco Wireless 9136 Series
- Cisco Wireless 9162 Series
- Cisco Wireless 9164 Series
- Cisco Wireless 9166 Series
- Cisco Wireless 9176 Series
- Cisco Wireless 9178 Series

Installation

Identify potential locations in a floor plan that provide the best signal health and stability for GNSS modules. The number and signal strength of satellites that the GNSS module can detect over a 24-hour period is a key metric for evaluating ideal GNSS installation points.

Geolocation Propagation

Figure 1. Wired and Wireless Geolocation Propagation Techniques

To conduct a preliminary GNSS site survey, it is recommended to have at least four modules to scope the proposed placement of APs on a floorplan, and the signal quality each module receives. If at least one AP nearby has a valid GPS signal, other neighboring APs can leverage the same GPS coordinates with a relative

measure of uncertainty. This process is known as geolocation propagation. It can be accomplished either through wired proximity on the same Layer 2 switch stack or through shared RF neighborship up to a calculated distance of up to 400 meters from an AP with a valid GPS signal.

Wireless propagation allows neighboring APs to see an AP with GNSS reception as its neighbor by hearing beacon frames and NDP messages transmitted on any band/ radio. For best results, the stronger the RF neighborship, the more consistent the results are likely to be. If the neighborship is weak and close to the noise floor, then the deployment is likely prone to gaps in neighborhood. They would also be susceptible to other variables at any given time that can hinder performance or limit geolocation propagation from working properly.

Target an RF neighborship of an RSSI of at least -75 dBm or better on any one of the 2.4 GHz, 5 GHz, or 6 GHz bands and an SNR of 15-20 or better for optimal and consistent results. Results will vary from one wireless environment to the next.

For GNSS APs to share their location via wired propagation, they need to be seen as neighbors in the CDP or LLDP table confirming that they are connected to the Layer 2 network. This neighborhood relation will give a wired distance between APs.

Figure 2. Geolocation Propagation Operation across an Indoor Floorplan

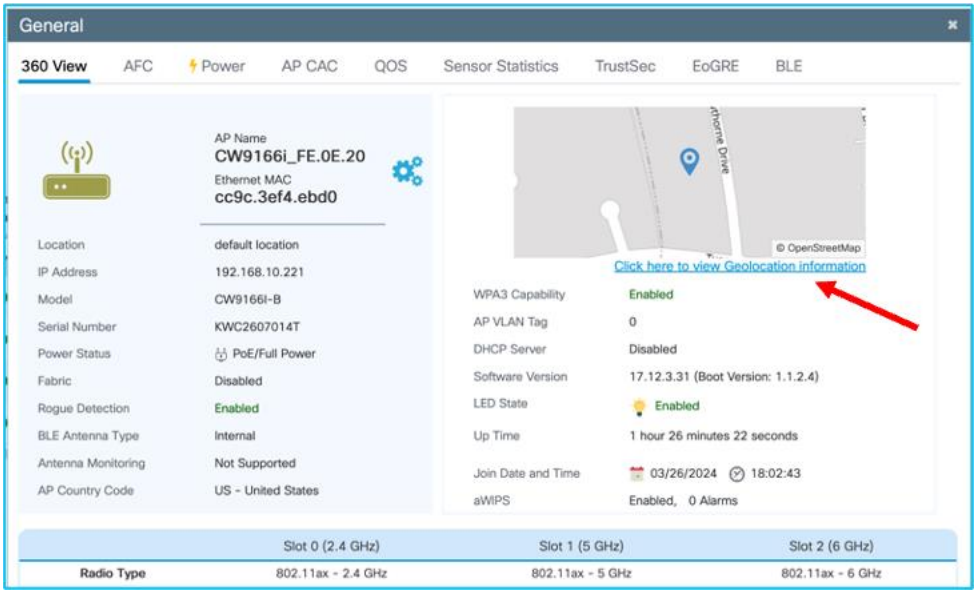
GPS Signal Lock

For the GNSS module to obtain a GPS signal, the AP must be powered on or the USB port must be enabled. The USB port is enabled either in the AP join profile on the wireless controller or in the port profile on the Meraki dashboard. After 10 minutes, the GNSS module attempts to retrieve a satellite signal and the LED on the side of the module blinks green. Once a GPS signal is achieved, the LED transitions to solid green.

For the GNSS module to achieve a stable GPS lock, the module must be in sight of at least 4 satellites. However, for greater location accuracy, it is advised to have a reception of 6-8 satellites at any given time. If an AP's internal or external GPS module acquires a signal, then the location type indicates "GNSS". If the AP uses either wired or wireless geolocation propagation techniques obtain location from a neighboring GNSS AP, then its location type will be "Derived".

Figure 3. GNSS Module: LED status

For Cisco Catalyst 9800 Series Wireless Controller-based deployments, the AP's **Location Type** can be found either under **General > 360 View > Click here to view Geolocation Information > AP Geolocation Information** or under **Edit AP > Geolocation**.



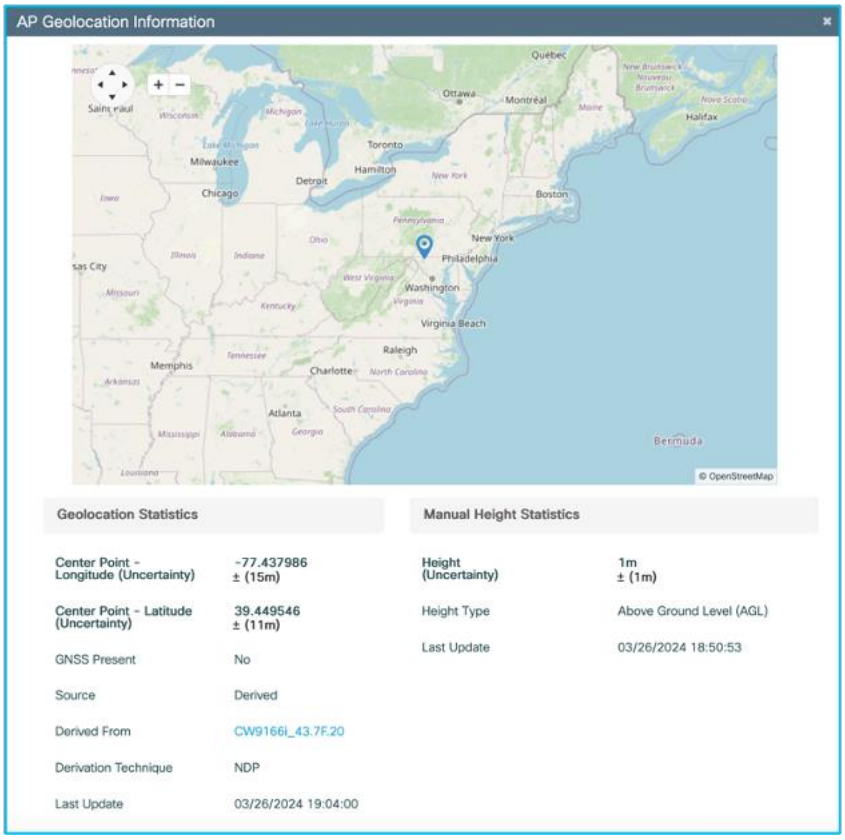


Figure 4. Cisco Catalyst 9800 Series Wireless Controller Dashboard: Geolocation information under the 360 View tab

In the Cisco Meraki dashboard, from the AP's overview page, go to the **AFC** tab. In the **AFC defined AP Location** section, you can find details of the AP's GNSS location such as:

- the **Location Type,**
- its coordinates (latitude and longitude), and
- the level of **Uncertainty** in its positioning.

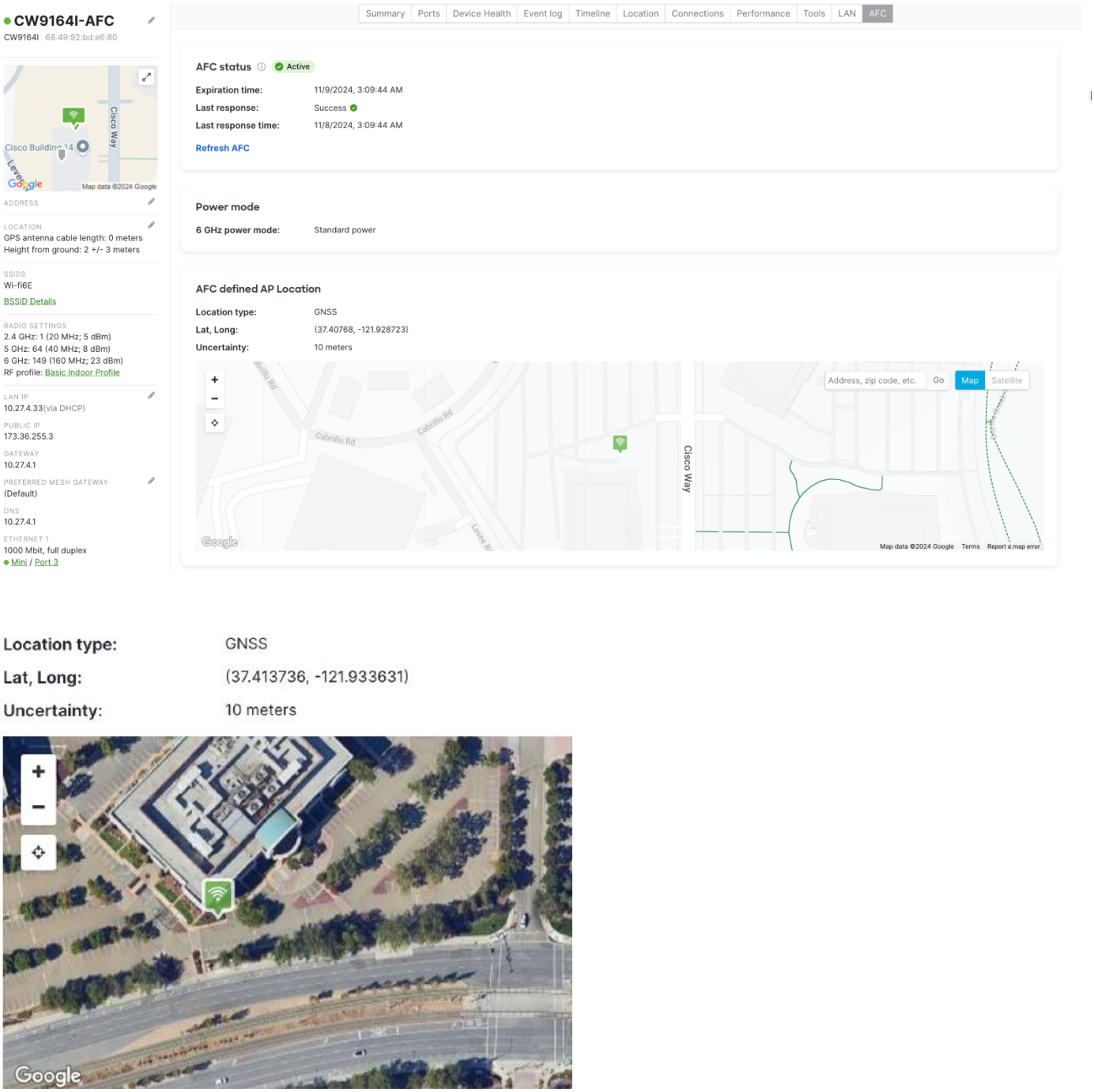


Figure 5. Cisco Meraki dashboard: GNSS location information

Currently, the Meraki dashboard does not report the exact number of satellites the GNSS module sees at any given time. During a preliminary site visit, it is advised to use a handheld GPS receiver to see the expected satellite constellations and relative signal strength the modules will receive at a planned installation point.

After identifying possible installation points, ensure that the GNSS module can maintain a stable GPS lock with at least 6–8 satellites over a 15-minute window. A location that maintains a stable lock with 6 or more satellites during this period is likely to remain stable over 24 hours, ensuring consistent 6-GHz Standard Power operation.

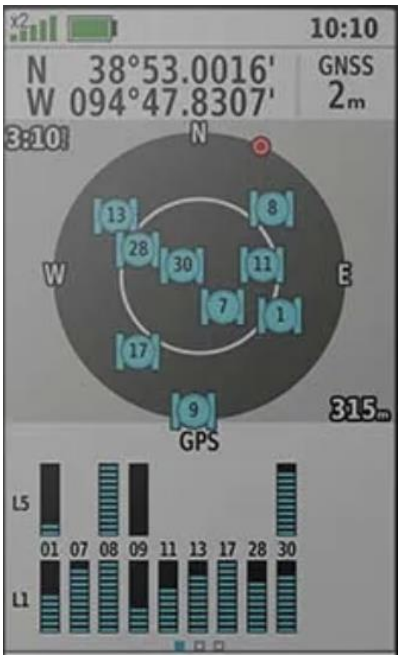


Figure 6. Satellite Constellation Seen on a Handheld GPS Receiver

For controller-based GNSS deployments, run the **show gnss info** command on the AP's CLI to assess the real-time availability and attributes of satellites seen by the AP's GNSS module. This command provides information about the number of satellites the GNSS module is detecting, constellation pattern, position, and signal health.

```
AP9166#sh gnss info

GnssState: Started
ExternalAntenna: true
Fix: 3D-Fix ValidFix: true Time: 2024-08-13 01:13:32
Latitude: 37.4200716 Longitude: -121.91980029999999
HorAcc: 13.329574 hDOP: 1.12
Uncertainty Ellipse:
 Major axis: 23.329574 Minor axis: 23.329574 Orientation: 0
Altitude MSL: 19.666 HAE: -8.506 VertAcc: 26.636
NumSat: 7 RangeRes: 6 GpGstRms: 22.9
pDOP: 2.11 hDOP: 1.12 vDOP: 1.79 nDOP: 0.88 eDOP: 0.7 gDOP: 0 tDOP: 0
LastFixTime: 2024-08-13 01:13:31
SatelliteCount: 14

Const.    SatId CNO   Elev. Azim. Signal  Used  Health  Band  LTO  CBEE
GPS       3     29    74    178   CCLTS   Yes   Good    L1    No   Yes
GPS       4     19    63    334   CCLTS   Yes   Good    L1    No   Yes
GPS       6     11    18    304   CCLTS   No    Good    L1    No   Yes
GPS       7     28    19    235   CCLTS   No    Good    L1    No   Yes
GPS       9     30    33    298   CCLTS   Yes   Good    L1    No   Yes
GPS       26    28    37    67    CCLTS   Yes   Good    L1    No   Yes
GPS       31    29    30    48    CCLTS   Yes   Good    L1    No   Yes
GPS       3     10    74    178   Search  No    Good    L5    No   Yes
GPS       4     28    63    334   Avail   Yes   Good    L5    No   Yes
GPS       6     27    18    304   Avail   Yes   Good    L5    No   Yes
GPS       9     27    33    298   Avail   Yes   Good    L5    No   Yes
GPS       26    17    37    67    Search  No    Good    L5    No   Yes
Galileo   13    30    23    220   CCLTS   Yes   Good    L1    No   No
Galileo   13    26    23    220   CCLTS   Yes   Good    L5    No   No

GNSS_PostProcessor:
Latitude: 37.42007063728407 Longitude: -121.91981663062286
HorAcc: 11.838588 hDOP: 6.803786
Uncertainty Ellipse:
 Major axis: 22.716136 Minor axis: 20.754236 Orientation: 5.0986424
Altitude MSL: 14.361918 HAE: 0 VertAcc: 0

CiscoGNSS:
Latitude: 37.420120317671817 Longitude: -121.9197608062745
HorAcc: 9.128268 hDOP: 1.2097641
Uncertainty Ellipse:
 Major axis: 19.128268 Minor axis: 19.128268 Orientation: 0
Altitude MSL: 5.8647238 HAE: 0 VertAcc: 0

Last Location Acquired:
Latitude: 37.4200716 Longitude: -121.91980029999998
HorAcc: 9.128268 hDOP: 1.07
Uncertainty Ellipse:
 Major axis: 19.128268 Minor axis: 19.128268 Orientation: 0
Altitude MSL: 18.031611 HAE: -10.140052 VertAcc: 10.45725
Derivation Type: GNSS_Receiver
Time: 2024-08-13 01:12:54
```

Figure 7. AP CLI: Output of show GNSS info command

In the **SatelliteCount** subsection of the command output, the current count of satellites visible to the GNSS module along with the satellite constellation is listed.

```
SatelliteCount: 14

Const.    SatId CNO   Elev. Azim. Signal  Used  Health  Band  LTO  CBEE
GPS       3     29    74    178   CCLTS   Yes   Good    L1    No   Yes
GPS       4     19    63    334   CCLTS   Yes   Good    L1    No   Yes
GPS       6     11    18    304   CCLTS   No    Good    L1    No   Yes
GPS       7     28    19    235   CCLTS   No    Good    L1    No   Yes
GPS       9     30    33    298   CCLTS   Yes   Good    L1    No   Yes
GPS       26    28    37    67    CCLTS   Yes   Good    L1    No   Yes
GPS       31    29    30    48    CCLTS   Yes   Good    L1    No   Yes
GPS       3     10    74    178   Search  No    Good    L5    No   Yes
GPS       4     28    63    334   Avail   Yes   Good    L5    No   Yes
GPS       6     27    18    304   Avail   Yes   Good    L5    No   Yes
GPS       9     27    33    298   Avail   Yes   Good    L5    No   Yes
GPS       26    17    37    67    Search  No    Good    L5    No   Yes
Galileo   13    30    23    220   CCLTS   Yes   Good    L1    No   No
Galileo   13    26    23    220   CCLTS   Yes   Good    L5    No   No
```

Figure 8. show gnss info command: Satellite constellation seen in the command output

The **GNSS_Post Processor** output is the collective readings of reported satellites by the GNSS module. These readings are aggregated to determine the precise location of the GNSS module along with a measured level of uncertainty.

```
GNSS_PostProcessor:
Latitude: 37.42007063728407 Longitude: -121.91981663062286
HorAcc: 11.838588 hDOP: 6.803786
Uncertainty Ellipse:
 Major axis: 22.716136 Minor axis: 20.754236 Orientation: 5.0986424
Altitude MSL: 14.361918 HAE: 0 VertAcc: 0
```

Figure 9. show gnss info command: GNSS_Post Processor output

The **CiscoGNSS** shows the satellite measurements calculated by the Cisco GNSS Processor. This is obtained by fine tuning the GNSS Post Processor output over 24 hours.

```
CiscoGNSS:
Latitude: 37.420120317671817 Longitude: -121.9197608062745
HorAcc: 9.128268 hDOP: 1.2097641
Uncertainty Ellipse:
 Major axis: 19.128268 Minor axis: 19.128268 Orientation: 0
Altitude MSL: 5.8647238 HAE: 0 VertAcc: 0
```

Figure 10. show gnss info command: Computed location of GNSS processor

GNSS Signal Considerations

If the number of satellite constellations visible is less than four, then the GNSS module will experience unstable satellite reception. If more than four satellites are seen in a constellation but no GNSS signal is received, then this can be due to poor signal health. Reposition the AP within the floor plan to improve the GNSS module's line of sight to the sky.

Note: Satellite distribution plays a critical role in the AFC location process. Better accuracy is achieved when satellites are widely distributed rather than clustered together. While satellite distribution cannot be influenced, the satellite lock can be improved by installing the GNSS module with a wider view of the sky.

When conducting the preliminary site assessment, it is important to consider potential sources of interference in the environment. Transmit and receive radio signals are susceptible to RF obstructions and common sources of interference that can reduce or reflect satellite signals the GNSS module is able to receive.

Select install locations away from metal obstructions such as heating and air-conditioning ducts, large ceiling trusses, building superstructures, and major power cabling runs.

For indoor GNSS deployments, building glass with UV filtering film will completely block the GPS signal from reaching the module. In such cases where the signal is significantly degraded, you can improve GNSS reception by attaching the CW-ANT-GPS1-M-00 external antenna to the GNSS module.

CW-ANT-GPS1-M00 Overview

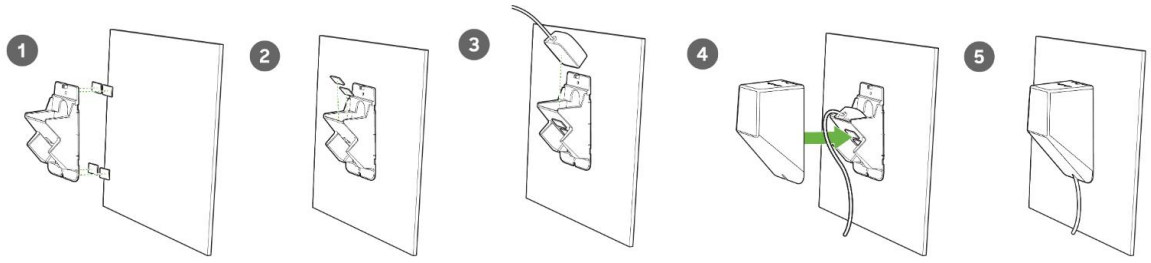


Figure 11. Mounting the CW-ANT-GPS1-M00

The CW-ANT-GPS1-M-00 external antenna is designed for use with the CW-ACC-GPS1 accessory module. It should be mounted clear of any obstructions to the sides of the radiating elements. Generally, the higher an antenna is above the floor, the better it performs. If possible, find a mounting place directly above your wireless device to ensure the lead-in cable is as short as possible.

Connect the antenna to the AP using the MMCX connector and the provided 32.80-ft. (10 m) plenum cable.

GNSS modules located around 13 meters inside a carpeted building register an average satellite count of 3. This limited signal reception results in the GNSS module being unable to maintain a stable GPS lock. To extend the module's reception range in such scenarios, use the CW-ANT-GPS1-M00 external antenna. Once the external antenna is securely attached to the GNSS port located on the left side of the CW-ACC-GPS1, the GNSS module should be able to receive a greater number of satellite constellations, allowing for stable GPS reception.

Signal reception is immediately improved when the antenna is attached to the GNSS module, as the antenna receivers provide stronger GNSS reception than the module alone. Note that the antenna can be routed up to 10 meters to a secondary installation point away from the AP to clear line of sight to the sky.

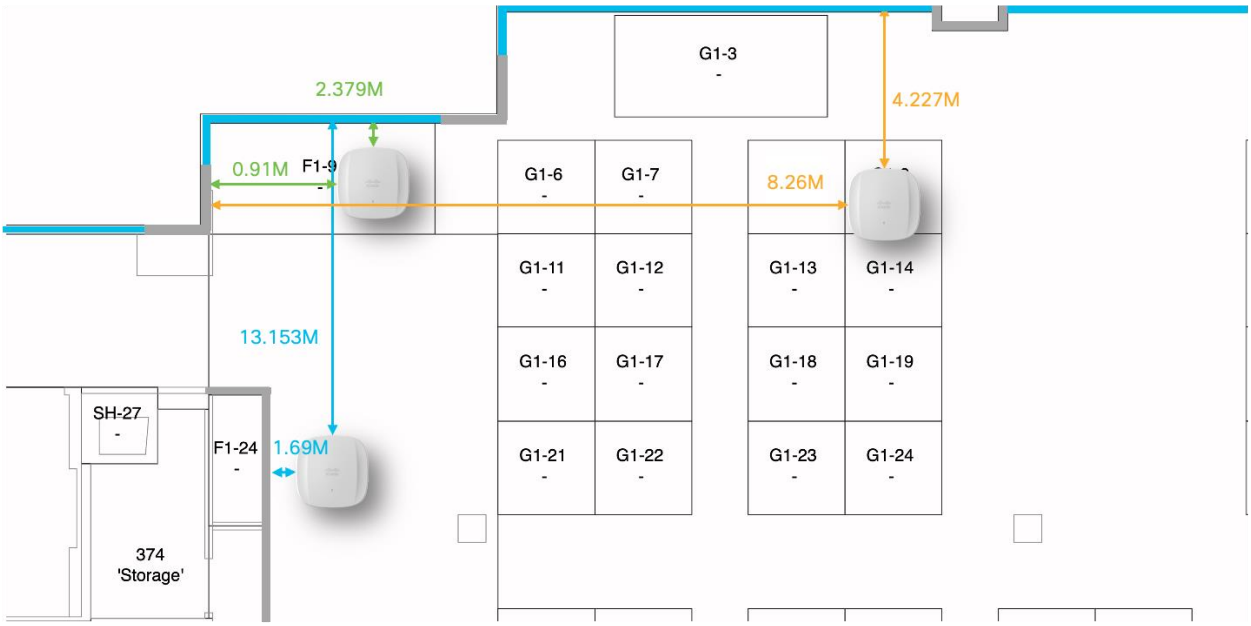
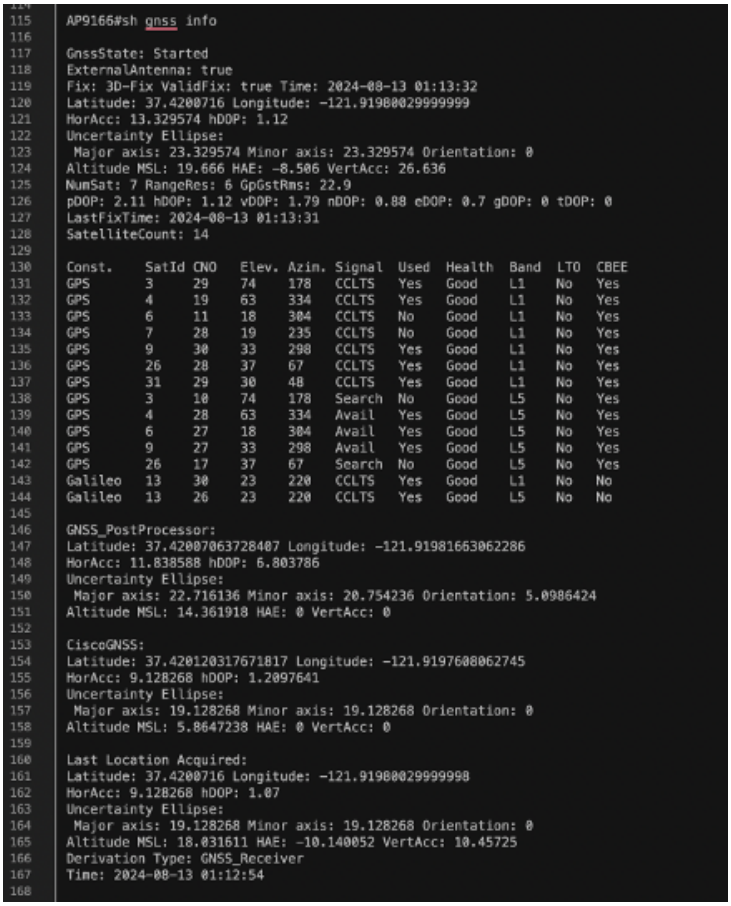


Figure 12. GNSS module positioned ~13 meters within a carpeted office space.

The output of the **show gnss info** in the figures below highlights the enhanced signal reception the GNSS module can achieve with an attached **CW-ANT-GPS1-M00** external antenna.

```
AP9166#show gnss info

GnssState: Started
ExternalAntenna: false
Fix: No-Fix ValidFix: false Time: 2024-08-08 18:38:39
Latitude: 0 Longitude: 0
HorAcc: 3530033.6 hDOP: 99
Uncertainty Ellipse:
 Major axis: 3530033.6 Minor axis: 3530033.6 Orientation: 0
Altitude MSL: -12 HAE: 0 VertAcc: 160000
NumSat: 0 RangeRes: 0 GpGstRms: 0
pDOP: 140 hDOP: 99 vDOP: 99 nDOP: 99 eDOP: 99 gDOP: 0 tDOP: 0
LastFixTime:
SatelliteCount: 3

Const.    SatId CNO   Elev. Azim. Signal  Used  Health  Band  LTO  CBEE
GPS       27    22    -128  -1    CCLTS   No    Good    L1    No   Yes
Galileo   21    23    -128  -1    CCLTS   No    NoInfo  L1    No   No
Galileo   21    9     -128  -1    Search  No    NoInfo  L5    No   No

GNSS_PostProcessor: N/A

CiscoGNSS: N/A

Last Location Acquired: N/A
```

Figure 13. Satellite coverage seen from the install location (Figure 12) without an attached external antenna



```
AP9166#sh gnss info

GnssState: Started
ExternalAntenna: true
Fix: 3D-Fix ValidFix: true Time: 2024-08-13 01:13:32
Latitude: 37.4200716 Longitude: -121.91980029999999
HorAcc: 13.329574 hDOP: 1.12
Uncertainty Ellipse:
 Major axis: 23.329574 Minor axis: 23.329574 Orientation: 0
Altitude MSL: 19.666 HAE: -8.506 VertAcc: 26.636
NumSat: 7 RangeRes: 6 GpGstRms: 22.9
pDOP: 2.11 hDOP: 1.12 vDOP: 1.79 nDOP: 0.88 eDOP: 0.7 gDOP: 0 tDOP: 0
LastFixTime: 2024-08-13 01:13:31
SatelliteCount: 14

Const.    SatId CNO   Elev. Azim. Signal  Used  Health  Band  LTO  CBEE
GPS       3     29    74    178   CCLTS   Yes   Good    L1    No   Yes
GPS       4     19    63    334   CCLTS   Yes   Good    L1    No   Yes
GPS       6     11    18    304   CCLTS   No    Good    L1    No   Yes
GPS       7     28    19    235   CCLTS   No    Good    L1    No   Yes
GPS       9     30    33    298   CCLTS   Yes   Good    L1    No   Yes
GPS       26    28    37    67    CCLTS   Yes   Good    L1    No   Yes
GPS       31    29    30    48    CCLTS   Yes   Good    L1    No   Yes
GPS       3     10    74    178   Search  No    Good    L5    No   Yes
GPS       4     28    63    334   Avail   Yes   Good    L5    No   Yes
GPS       6     27    18    304   Avail   Yes   Good    L5    No   Yes
GPS       9     27    33    298   Avail   Yes   Good    L5    No   Yes
GPS       26    17    37    67    Search  No    Good    L5    No   Yes
Galileo   13    30    23    220   CCLTS   Yes   Good    L1    No   No
Galileo   13    26    23    220   CCLTS   Yes   Good    L5    No   No

GNSS_PostProcessor:
Latitude: 37.42007063728407 Longitude: -121.91981663062286
HorAcc: 11.838588 hDOP: 6.803786
Uncertainty Ellipse:
 Major axis: 22.716136 Minor axis: 20.754236 Orientation: 5.0986424
Altitude MSL: 14.361918 HAE: 0 VertAcc: 0

CiscoGNSS:
Latitude: 37.420120317671817 Longitude: -121.9197608062745
HorAcc: 9.128268 hDOP: 1.2097641
Uncertainty Ellipse:
 Major axis: 19.128268 Minor axis: 19.128268 Orientation: 0
Altitude MSL: 5.8647238 HAE: 0 VertAcc: 0

Last Location Acquired:
Latitude: 37.4200716 Longitude: -121.91980029999998
HorAcc: 9.128268 hDOP: 1.07
Uncertainty Ellipse:
 Major axis: 19.128268 Minor axis: 19.128268 Orientation: 0
Altitude MSL: 18.031611 HAE: -10.140052 VertAcc: 10.45725
Derivation Type: GNSS_Receiver
Time: 2024-08-13 01:12:54
```

Figure 14. Satellite coverage seen from the install location (Figure 12) with an attached CW-ANT-GPS1-M00 external antenna

Conclusion

To learn more about monitoring AP location data on the Cisco Catalyst 9800 Wireless controller and Meraki dashboard, see the documents listed in the **References** section. Following these guidelines and best practices will help identify and maintain optimal GNSS module placement, ensuring consistent signal quality and reliability for long-term 6-GHz Standard power operation and AP AnyLocate deployments.

References

- https://www.cisco.com/c/en/us/td/docs/wireless/controller/9800/17-12/config-guide/b_wl_17_12_cg/m_afc.html
- https://documentation.meraki.com/MR/Deployment_Guides/Automatic_Frequency_Coordination
- https://www.cisco.com/c/en/us/products/collateral/wireless/catalyst-9100ax-access-points/ghz-unlicensed-spectrum-reg-wp.html

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