Cisco Aironet Series 1600/2600/3600 Access Point Deployment Guide, Release 7.5

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www.cisco.com

Abstract

This document covers the Cisco 2600 and 3600 Series Access Points theory of operation and installation as part of a Cisco wireless LAN (WLAN) solution. Subjects related include:

- Choosing the right Access Point
- Differences between AP 3600 and AP 3500
- Differences between AP 3600 and AP 2600
- Introduction of AP 1600 – AP feature comparison
- Hardware details, mounting options, bracket choices and installation considerations
- Antenna options, radiation patterns external antenna deployments
- Understanding spatial streams, MCS rates, and what they mean
- ClientLink 2.0 – what this means for Bring Your Own Device (BYOD)
- Primer 802.11ac and Wave-1 802.11ac module for the AP 3600
- Site Survey considerations
- Look at poor installations, Q&A and useful URLs

Audience

This document is intended for trained and experienced technical personnel familiar with the existing Cisco Wireless Networking Group (WNG) product line and features.

Table of Contents

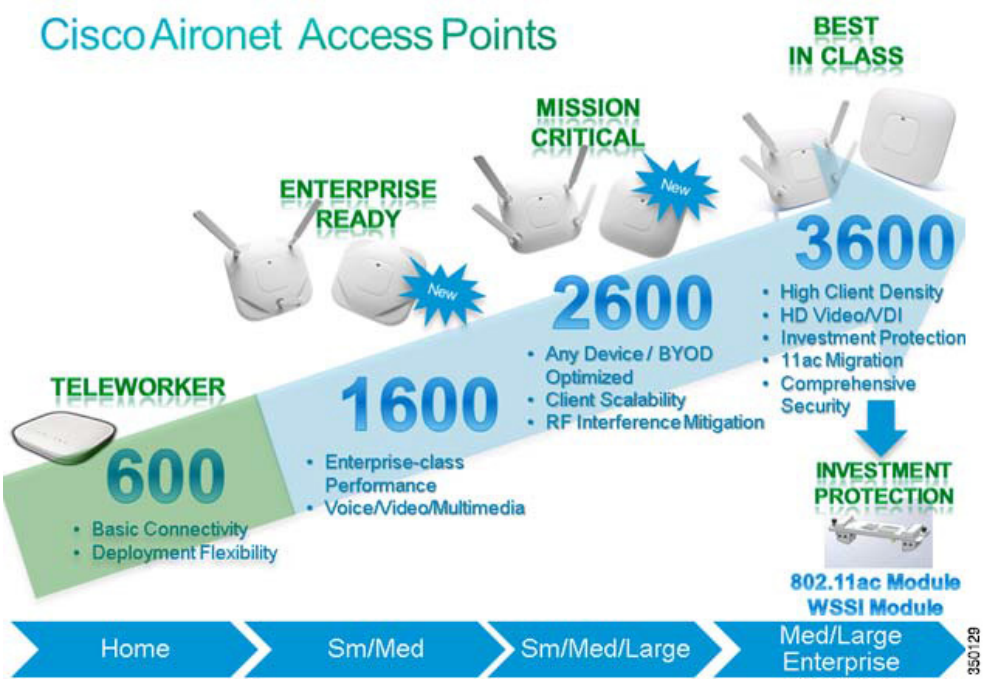
Choosing the Right Access Point

Models

The Cisco 3600 Series Access Point (AP 3600) targets customers requiring support for mission-critical applications. The AP 3600 embodies ClientLink 2.0, an innovative antenna technology comprising four transmit radios and four receive radios called 4X4 Multiple Input Multiple Output (MIMO) and three

spatial stream (3SS) beamforming, together referenced as 4x4:3. ClientLink 2.0 permits speeds up to 450 Mbps via additional Modulation and Coding Scheme (MCS) data rates 16-23, while still maintaining IEEE 802.3af (15.4 Watt) Power over Ethernet (PoE) compliance. More on spatial streams can be found in section 802.11n Primer - Understanding Spatial Streams.

Figure 1 Access Point Portfolio Placement



Access Points are available in two models see Figure 2:

- Internal antennas version labeled “i” that has captured antennas (part of the housing and not removable). The “i” series is designed for indoor Enterprise installations where office aesthetics are a primary concern.
- External antennas version labeled “e” that is more rugged and designed for industrial use in locations such as hospitals, factories, and warehouses, anywhere a need exists for external antennas and/or extended operating temperatures. The “e” version also supports mounting inside NEMA enclosures for use in the most demanding environments.

Figure 2 AP 3600 Models and Eco-packs

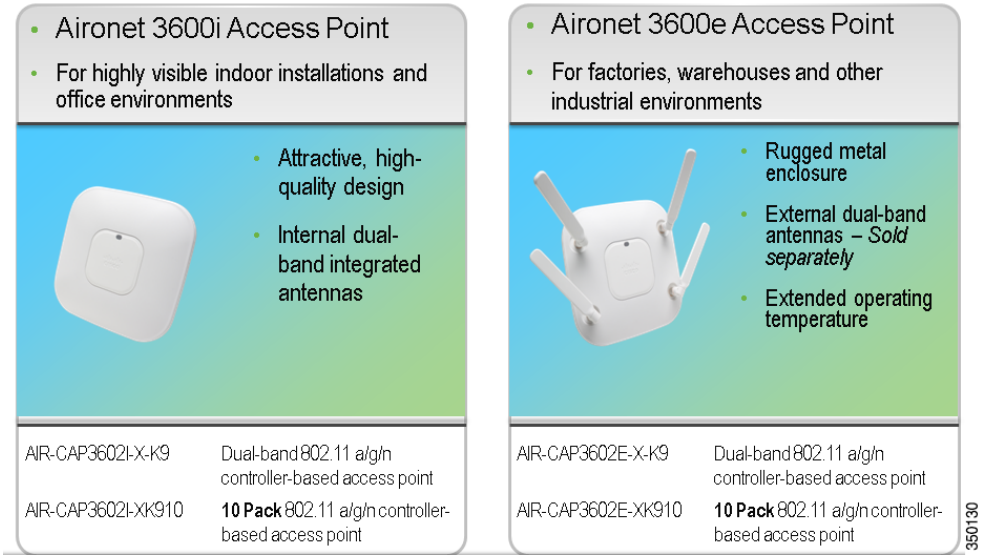


Figure 3 AP 2600 Models and Eco-packs

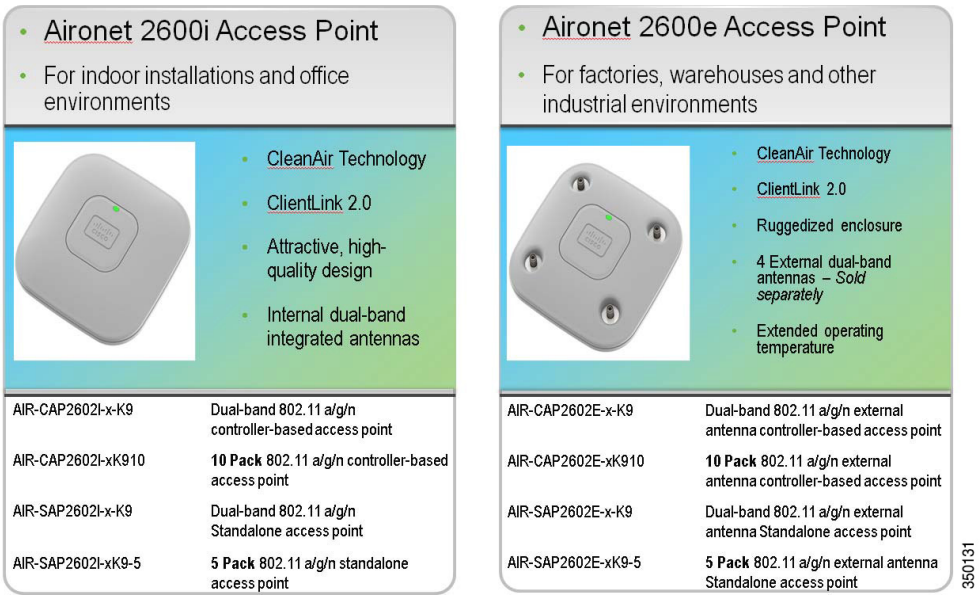
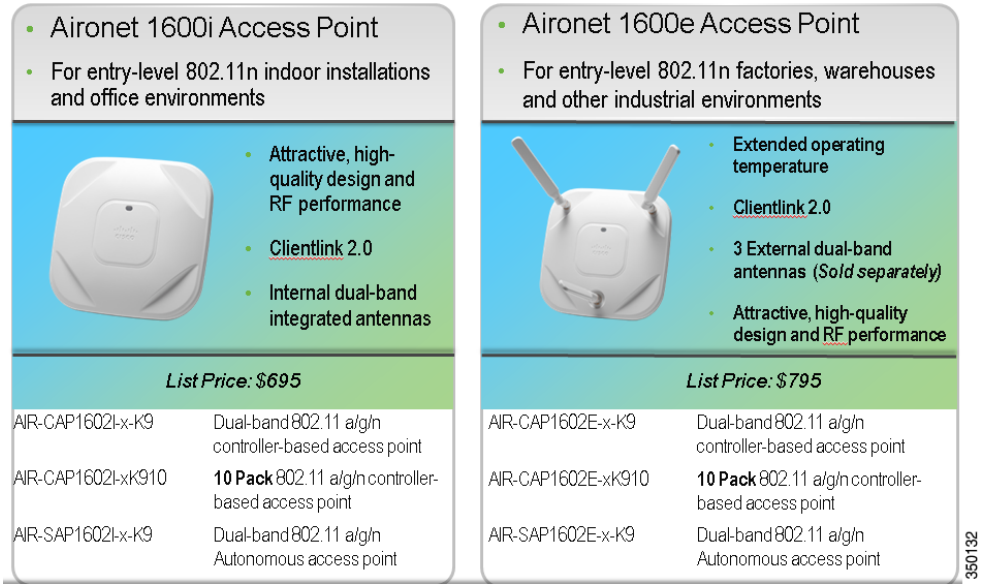


Figure 4 AP 1600 Models and Eco-packs



Differences between the AP 3600 and AP 3500 Access Points

The internal antenna version of AP 3600 and AP 3500 is almost identical in physical appearance with the exception of the LED which is slightly larger and more oval on the AP 3600. The AP 3500 has a square LED (allows for visual identification).

Figure 5 AP 3600 vs AP 3500 LED Appearance

From a side view, the AP 3600 is slightly thicker when compared to the AP 3500. The thicker size allows for additional radio support and printed circuit board area, as well as modularity for future capabilities. While the AP 3600 has a little more depth, this AP is completely backward compatible with the mounting brackets for the existing Cisco Aironet 1040, 1140, 1260 and 3500 Series Access Points.

Figure 6 Side View of AP 3600 (2.11 inches) and AP 3500 (1.84 inches) in height

The AP 3600e (external antenna version) differs in appearance from the AP 3500e, having fewer antenna connector ports primarily due to the dual-band antenna system that is used.

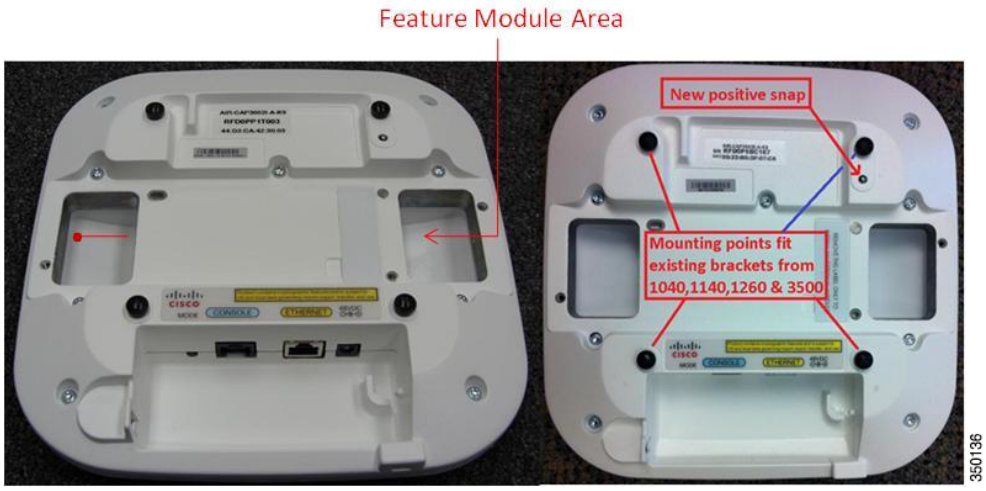
The AP 3500e has separate antennas for each band, 2.4 GHz and 5 GHz, and does not support 3SS technology since it has only two transceivers (transmitter/receiver) and one extra receiver per band enabling operation up to two spatial streams.

The AP 3600e has combined all the antenna ports (dual-band) so that each antenna port can transmit simultaneously on each band; had the antenna ports not been combined, this would have required 8 antennas. The AP 3600 has four transceivers (transmitter/receiver) radio ports per band for a total of eight transceiver, four in each band. This additional radio per band permits beamforming to 3SS clients using ClientLink 2.0 to improve the overall performance of all 802.11n clients with 1, 2 and 3 spatial streams.

Note Beamforming to a 3SS client requires n+1 RF design. To accomplish this, the AP 3600 has an additional radio per band, which improves client performance by using Cisco ClientLink 2.0.

Unlike AP 3500, the newer AP 3600 design supports an additional feature module. The bottom of the AP 3600 unit looks different as it has openings to support the feature module. The openings, while fully sealed, permit the module to have access to the topside of the AP to allow the module antennas (if present in the module being used) to fully function. The unit includes a positive snap “spring loaded BB” so the installer can feel a positive lock when the AP is fully engaged in the bracket (Figure 7).

Figure 7 Bottom of AP 3600 Unit



AP 3600 Feature Module Support

The WSSI (Wireless Security and Spread Spectrum Intelligence) module adds new functionality to the AP to future-proof customers' investment. This module provides a dedicated monitor radio to scan the full spectrum (not just the channel on which the AP is operating). It will offload complete monitoring and security services to the monitor module including CleanAir, WIDS/WIPS, Context-aware Location, Rogue Detection, and Radio Resource Management (RRM). This module allows for full spectrum analysis on all channels on both the 2.4 and 5 GHz bands.

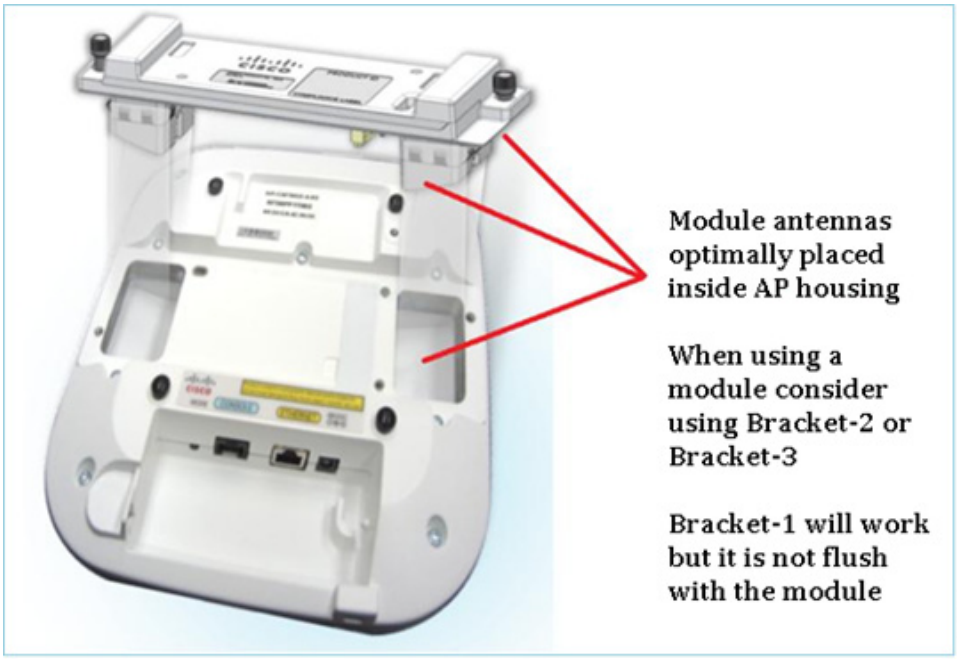
Having the add-on feature module avoids having to deploy a separate, dedicated overlay network for full spectrum monitoring and eliminates the need for an extra cable pull and additional infrastructure costs (Figure 8).

The second available module will provide 802.11ac (wave-1) functionality to the AP 3600. This radio module will operate at 5GHz and allow the AP 3600 to fully support 802.11a/n along with 802.11ac clients. (Wave-1) functionality will support a 1.3 Gbps PHY / ~1 Gbps MAC (throughput) using 3 spatial streams, 80 MHz, 256 QAM. Supporting Explicit Beamforming support per the 802.11ac standard.

Use of the module may require the local power supply, Cisco power injector, .3at PoE+ or the use of Cisco Enhanced PoE, as the module may increase power draw greater than 15.4W.

Note Cisco Enhanced PoE was created by Cisco and is the forerunner to 802.3at PoE+.

Figure 8 Feature Module Slides into Bottom of AP 3600



Differences between the AP 3600 and AP 2600

The AP 3600 has a modular design that offers future protection with the .11ac module, security module and perhaps other modules in the future. AP 3600 is a 4X4:3SS supporting an extra transmitter chain for additional downlink performance for all bands and clients.

The AP 2600 is very similar to the AP 3600 but is a 3X4:3SS so with the AP 2600 - Client Link does not beamform to 3-ss clients, however; it does beamform at legacy and 1 & 2 Spatial Stream rates.

The AP 3600 has slightly higher performance and beamforms to legacy 1, 2, 3 spatial stream rates and .11ac rates when using the optional .11ac module.

Unlike the AP 3600, the AP 2600 Access Point does not support optional modules but it does have a little higher antenna gain in the 2.4 GHz band. A lot of effort has been put in to make sure the coverage area is uniform between different models of Access Points so that if you surveyed for a 3600 Series AP, the AP 2600 can also be substituted without performing another survey.

Figure 9 AP 2600 is same size as AP 3600 but does not support radio modules

Figure 10 Backside of the AP 2600 - mounting hardware and antennas are the same as AP 3600

Introducing Cisco Aironet 1600 Series Access Point

Designed as an entry level Access Point, key feature items include:

- ClientLink 2.0 – a key addition when moving up from the AP's 1040/1140 and 1260 series.
  - Support for 802.11n clients up to 1-SS
  - Supports 802.11a/b/g clients
  - ClientLink 2.0 for 1600 can support (beam-form) up to 32 clients per radio interface
- 3x3:2 architecture for improved performance vs. 2x2:2 AP 1040
  - Comparable for better throughput performance vs. AP 1140 & 1260
- External antenna model for entry-level / mid-market
- Can support up to 128 clients per radio for a total of 256 clients
- LED color change different from previous Access Points (see Getting Started Guide: Cisco Aironet 1600 Series Access Points)
- Support for Clean Air Express – Basic Spectrum Analysis coming via software upgrade

Cisco Clean Air Express

Cisco CleanAir Express technology is enabled on the advanced silicon design of the Cisco's Second Generation entry-level Access Point, the Cisco Aironet® 1600. With Clean Air Express the Aironet 1600 Access Point has the ability to effectively detect RF interference, identify the source, locate it on a map, and then make automatic adjustments to optimize wireless coverage. With Clean Air Express technology, organizations have a basic spectrum analysis capability to support their wireless networks while simplifying ongoing operations.

Figure 11 Comparison of CleanAir features

Spectrum Intelligence			
	CleanAir Express*	CleanAir	CleanAir with WSSI
Access Point	AP-1600*	AP-2600 or AP-3600	AP-3600 with WSSI Module
Detection	•	•	•
Classification	•	•	•
Mitigation	•	•	•
Location	•	•	•
Performance Optimized		•	•
Top Impacts and Severity List		•	•
Alert Correlation		•	•
Air Quality Index		•	•
Zone of Impact		•	•
Off Channel Scanning			•
Proactive Intelligent Channel Switching			•

** Will be available via software upgrade*

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Figure 12 Comparison 3600, 2600 and 1600 series Access Points.

Cisco Aironet Indoor Access Point Comparison Matrix

	3600 Series	2600 Series	1600 Series	600 Series
Max Data Rate	1.3 Gbps	450 Mbps	300 Mbps	300 Mbps
Radio Design MIMO:Spatial Stream	11n: 4x4:3 11ac: 3x3:3	3X4:3	3X3:2	2X3:2
CleanAir	Clean Air	Clean Air	Clean Air Express	
ClientLink (No. of Clients **)	ClientLink 2.0 (128) EBF for 802.11ac	ClientLink 2.0 (128)	ClientLink 2.0 (32)	
Max Clients (Per Radio)	200	200	128	15 (total wireless)
BandSelect	✔	✔	✔	
VideoStream	✔	✔	✔	
Rogue AP Detection	✔	✔	✔	
Adaptive wIPS	✔	✔	✔	
OfficeExtend	✔	✔	✔	✔
FlexConnect	✔	✔	✔	
Wireless Mesh	✔	✔	✔	
Autonomous	✔	✔	✔	
Power	11n: 802.3af 11ac: Enhanced PoE, AC Adapter 802.3at or UPoE	802.3af AC Adapter	802.3af AC Adapter	100 to 240 VAC, 50-60 Hz AC Adapter
Wi-Fi Standards	802.11 a/b/g/n/ac	802.11 a/b/g/n	802.11 a/b/g/n	802.11 a/b/g/n

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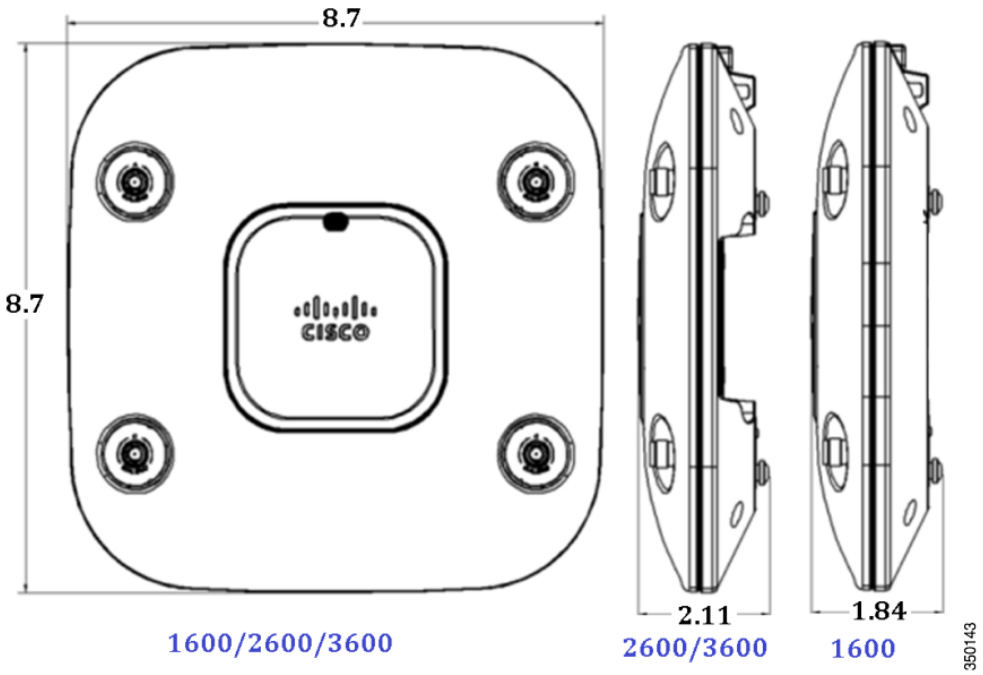
Access Point Physical Hardware and Mounting Options

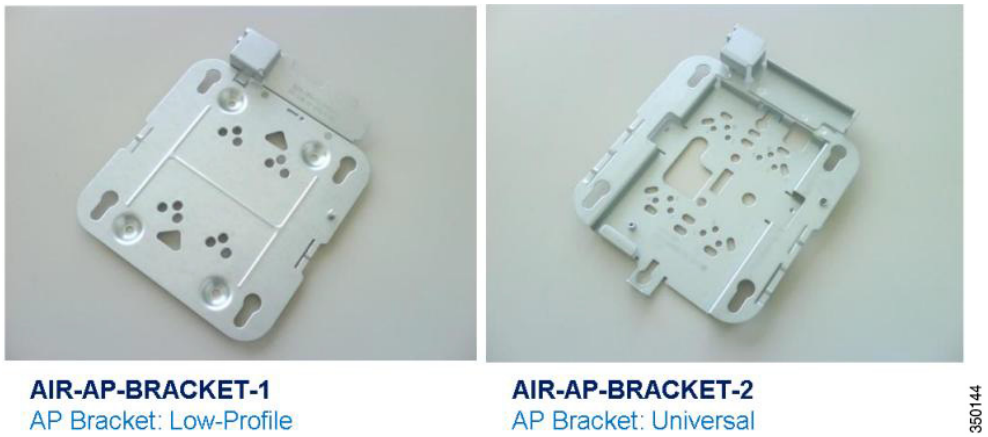
AP 1600, 2600 and 3600 have the same physical dimensions and mounting options with slightly different cosmetic differences example (3 antennas on 1600) but share similar dimensions as shown in Figure 13.

Figure 13 Mechanical Drawing of the AP 2600 and the AP 3600



There are many different installation options available depending upon the requirements of the customer. Brackets are available from Cisco as well as third-party companies. During the ordering process, the customer may choose one of two brackets (but not both). Each bracket is a zero-dollar ($0) option at the time of configuration. If the customer does not choose a bracket, the selection default is AIR-AP-BRACKET-1 which is the most popular for ceiling installations. The other choice is a universal bracket that carries part number AIR-AP-BRACKET-2 (Figure 14).

Figure 14 Access Point Bracket Choices



Note While using AP 3600 module, we recommend AIR-AP-Bracket-2.

If the AP will be mounted directly to a ceiling on the gridwork, then AIR-AP-BRACKET-1 mounts flush and has the lowest profile. However, if the AP will be mounted to an electrical box or other wiring fixture, or inside a NEMA enclosure or perhaps wall mounted, then AIR-AP-BRACKET-2 is a better choice. The extra space in the bracket allows for wiring, and the extra holes line up with many popular electrical boxes. When mounting the bracket to the ceiling gridwork, some ceiling tiles are recessed. For this reason, two different styles of ceiling clips, recessed and flush rails, are available (Figure 15).

Figure 15 Recessed and Flushed Ceiling Grid Clips

Note Different clips are available for attaching to ceiling grid work

Channel Rail Adapters - Cisco Part Number AIR-CHNL-ADAPTER

When mounting APs to ceiling channel rails such as the ones shown in Figure 16, an optional channel adapter is used: AIR-CHNL-ADAPTER. It comes in a two-pack and attaches to the ceiling grid clip above. Refer to Figure 17 and Figure 18.

Figure 16 Example of Channel Rails

Figure 17 AIR-CHNL-ADAPTER (left) Slides onto the Rails

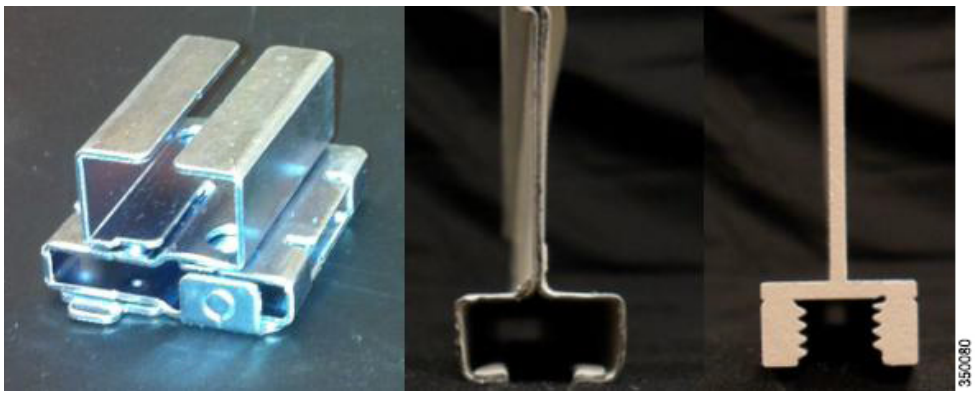
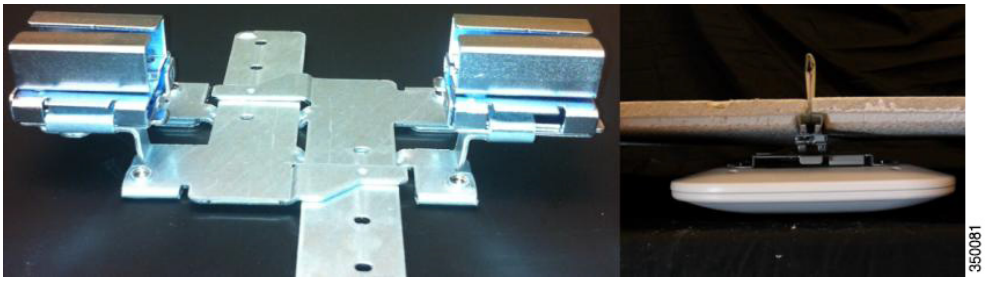


Figure 18 AIR-CHNL-ADAPTER Mounted to Rail Clip (left) and Finished Installation (right)



Mounting an AP Directly into the Tile Using Optional AIR-AP-BRACKET-3

Many hospitals and other carpeted Enterprise environments prefer a more streamlined look and wish to install the AP directly into the tile. This can be done using the optional Cisco AIR-AP-BRACKET-3 (Figure 19).

When using this bracket, the “beauty ring” is used as the template to cut the tile which can be cut using a carpet knife or electric tool such as a rotary cutting tool, e.g., Dremel™ or Rotozip™. Cisco does not offer custom cut tiles as there are simply too many different styles and the tiles are easy to cut.

The AP is fully supported above the tile with a metal rail that extends the length of the tile. This supports the AP should the tile become wet or otherwise fail. A mechanical set screw pulls the AP tight to the ceiling and locks it into the bracket. Additionally, physical security of the AP can be maintained by the use of a Kensington style lock, but once installed it is difficult to remove the AP without removing the tile as the AP will not slide out from the front side of the tile.

Figure 19 Optional AIR-AP-BRACKET-3 used to install the AP directly into the tile

Note This bracket will fit the AP 1040, 1140, 1260, 1600, 2600, 3500 and 3600 Series Access Points.

Wall-mounting the AP

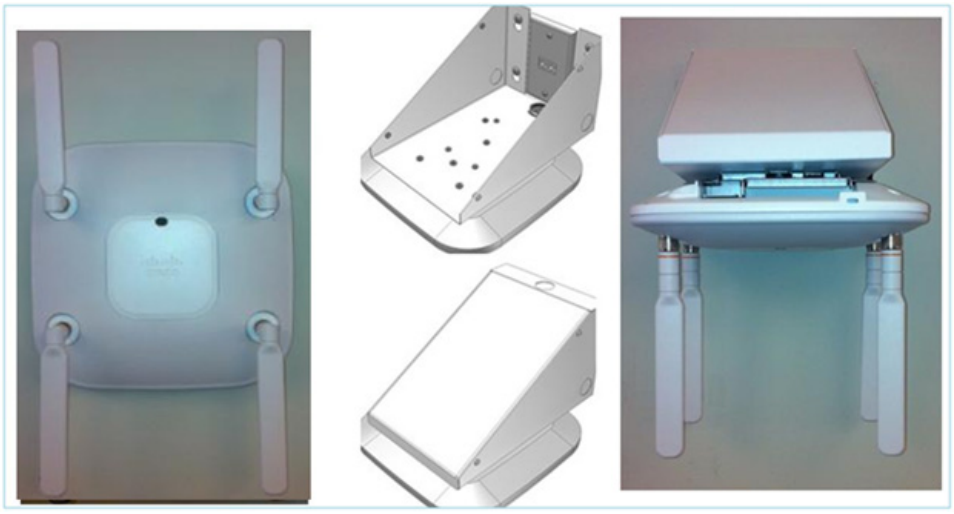
When wall mounting is desired, the installer should understand that walls can be a physical obstacle to the wireless signal; therefore, maintaining 360 degree coverage may be compromised by the wall. If the wall is an outside wall and/or the goal is to send the signal in a 180-degree pattern instead, a directional antenna often referred to as a “patch” antenna may be a better choice assuming the AP 3600e is used.

Avoid wall-mounting APs with internal antennas such as the AP 3600i unless you use the optional Oberon right-angle mount (Figure 20). The internal antenna model was designed to mount to a ceiling to provide 360-degree coverage. If wall-mounted in a non-ceiling orientation the signal may penetrate the floor above and below causing unintended coverage that could result in additional, needless roaming access when a mobility client, e.g., user with Wi-Fi phone, walks by on an adjacent floor.

Instead, use the AP 3600e (with dipoles or patch antennas), or use an optional wall mount that puts the AP 3600i or AP 3500e into a ceiling type orientation when mounted to a wall.

Note APs with internal antennas such as the AP 3600i that are wall-mounted should use the Oberon mounting bracket unless roaming is not an issue, e.g., hotspot, kiosk, or small venue scenario.

Figure 20 Wall-mounting APs antennas should be vertical (up/down) or use the Oberon right-angle mounting structure - ideal for AP 3600i. Oberon P/N 1029-00)



Changing the Color of an AP

If there is a desire to change the color of an AP, rather than painting the AP which would void the warranty, consider using colored vinyl tape or using a colored plastic cover from Oberon (Figure 21).

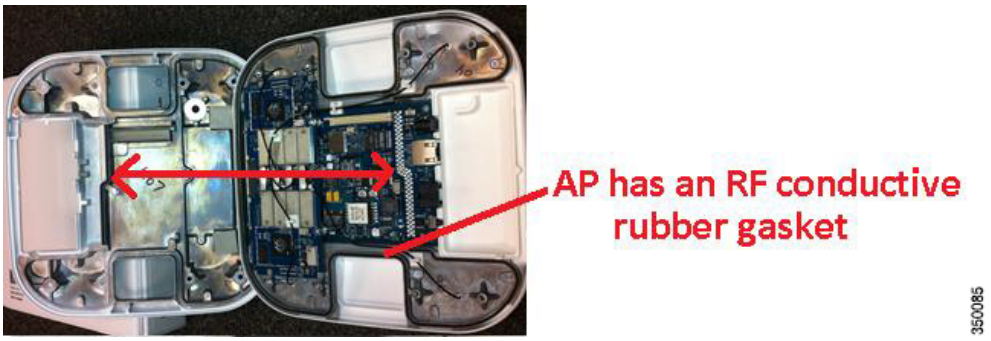
Figure 21 Third-party option for changing AP color, adding custom Logo, or hiding the LED

Unique Installations

Clean Rooms (Healthcare)

Many hospitals and factories have requirements to wipe down or gently spray the environment with a chemical (often diluted material that has cleaning / disinfectant properties). The Cisco AP 3600 is designed with a purpose guild Wi-Fi chipset with Enterprise and industrial class components (Figure 22). This enables the AP enclosure to have a Plenum rating and is vent-less, so the unit is ideal for these types of applications.

Figure 22 Inside of the AP 3600 - (no vents or fans, everything is industrial quality)



Note AP 2600 is also made of a similar construction and design for clean room deployments.

If the clean room environment requires metal ceilings or areas where tile is not practical, a metal enclosure from Oberon can be used (Figure 23).

Figure 23 Oberon Metal Enclosure protects and secures the AP in Clean Room Areas

Above Ceiling Tiles

The AP 2600 and 3600 are rated for installation in the Plenum area (UL-2043). Many customers prefer to locate the AP so that nothing can be visible on the ceiling. In some cases this is preferred for aesthetic reasons, so customers may install the AP above a drop ceiling. This also may be preferred in high theft areas such as classrooms or in areas where policy dictates that nothing can be visible on the ceiling.

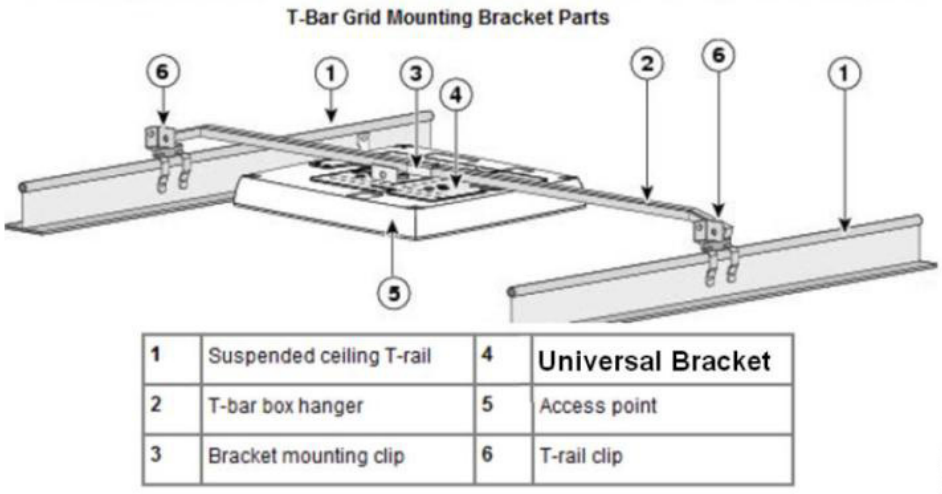
When this is a hard requirement, optional T-Bar hangar accessories from third-party companies such Erico and Cooper can be used (Figure 24). The Erico Caddy 512a or the Cooper B-Line BA50a or similar T-Bar Grid T-Bar hangars can be used.

For more information see:

www.erico.com

www.cooperindustries.com

Figure 24 Example of how to hang an AP above the ceiling tiles



1	Suspended ceiling T-rail	4	Universal Bracket
2	T-bar box hanger	5	Access point
3	Bracket mounting clip	6	T-rail clip

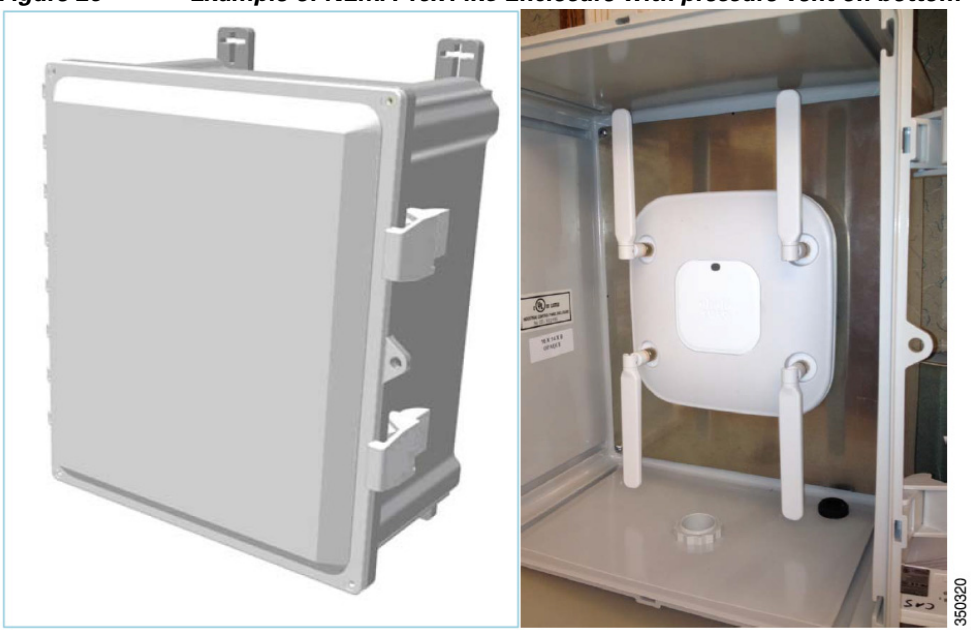
Note Installing APs above the ceiling tiles should only be done when mounting below the ceiling is not an option. The tiles must not be conductive; such installations can certainly degrade advanced RF features such as voice and location, so verify coverage and performance. Always try to mount the AP as close to the inside middle of the tile as possible, and avoid areas with obstructions (Figure 25).

Figure 25 Installing AP above ceiling tiles: Pick an area clear of obstructions, avoid ceiling clutter

Stadium/Harsh Environments

Customers wishing to install the AP in harsh environments where it may be exposed to weather, such as sporting areas, stadiums, open garden areas or warehouse freezers, may wish to use a NEMA type enclosure.

Figure 26 Example of NEMA 16x14x8 Enclosure with pressure vent on bottom



Third-party sources for NEMA type enclosures include:

www.oberonwireless.com

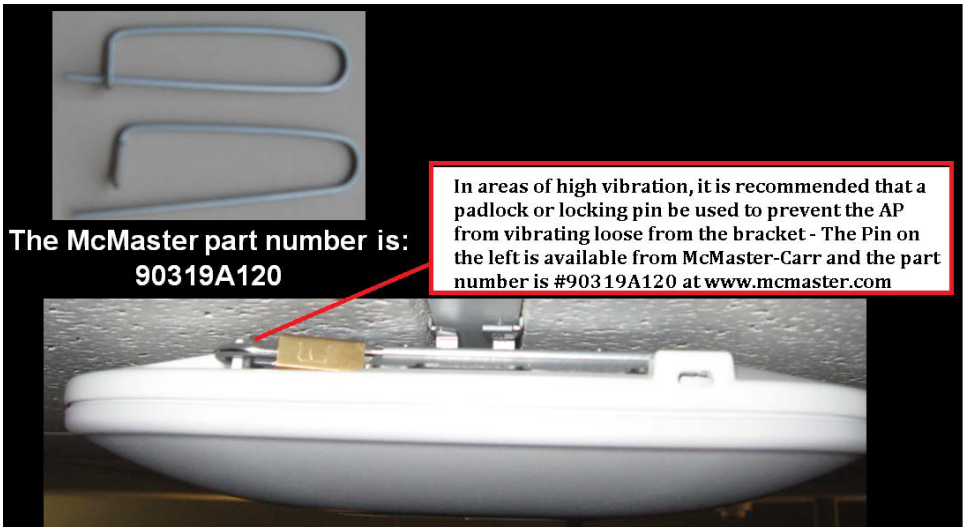
http://www.terra-wave.com/

When using a NEMA type enclosure, try to have the cables exit out of the bottom of the enclosure so that rain and moisture do not run down the cable into the enclosure. Also, the color of the enclosure may affect the heat rating; for example, a black enclosure gets much hotter in the sun than a white one. You may also want to use a pressure vent to prevent moisture accumulation. See Figure 27.

Areas with High Vibration

If the Access Point is installed using a “side arm” type mount or other mounting locations where there is a likelihood of high vibration, it is recommended that a padlock or metal pin be used to prevent the AP from vibrating loose from the bracket.

Figure 27 A metal pin or padlock will not deteriorate over time so it is better than a plastic tie



Warehouse and Factory

Warehouse installations are often difficult because of the very high ceilings and the clutter of the material being warehoused. When performing a coverage check (site survey) always check the coverage at “full stock” levels as the material being warehoused can change the RF coverage creating loss of uniform coverage. Also, try to position the APs as close to the users perhaps lowering the antennas when possible or practical to do so. If the AP is 30 feet in the air, that is 30 feet farther the signal has to go, “best case”. When configuring coverage for aisles, try to use directional (Patch) antennas on the wall and shoot down the aisles; or use low-gain Omni-directional antennas on the ceiling (such as dipoles) or units with integrated antennas as high gain omnidirectional antennas tend to have more nulls. See Figure 49.

Another option is to mount the AP lower using pipe and electrical box mounting techniques. Refer to the example shown in Figure 28.

Figure 28 AP Placement in Warehouse Environment

Note External dipole “e” series or internal antenna “I” series version could be used

When mounting an AP at the end of a pipe or electrical conduit box, use the universal bracket Cisco AIR-AP-BRACKET-2, as it will mate to the holes of most electrical boxes (Figure 29). Conduit and adapters can be purchased at most electrical or home repair centers.

Figure 29 Mounting an AP onto an Electrical Conduit Box (ceiling T-Bar or conduit)

Ethernet Cable Recommendation

While the AP 1600/2600 and 3600 will work fine with CAT-5e for new cable installations, it is recommended that customers use CAT6a as this is the cabling required by the 10GE standard.

Antenna Cable Recommendation

Whenever practical/possible, please keep antenna cable runs as short as possible. Cisco offers low loss (LL) and ultralow loss (ULL) cables, which have the same characteristics as Times Microwave LMR-400 and LMR-600.

Cisco cables carry the part number AIR-CAB (Aironet Cable) and then a length. For example, a 20 Ft length of LL cable with RP-TNC connector is Cisco AIR-CAB-020LL-R. These heavy black cables are not Plenum rated and are primarily for outdoor use or manufacturing areas.

Figure 30 When drilling holes for cable allow for size of connector (typically 5/8 inch) drill bit.

Access Point Spacing Recommendations

If you have a Wi-Fi device such as an AP and you are going to use another AP in the vicinity on a different channel, it is recommended that you space each AP apart by approximately 6 Ft (2 meters). Avoid clustering the APs or the antennas from different APs together, as this could cause degradation in performance. This recommended distance is based on the assumption that both devices operate in the unlicensed band and do not transmit RF energy more than 23 dB - that is, 200 mW. If higher power is used, space farther apart.

Should you have other devices that transmit, especially if they operate in the same frequency ranges, for example, frequency hopping legacy APs or other devices that operate close in frequency to those of the AP (think below or above the 2.4 and 5 GHz band), you should consider moving or separating the devices as far apart as can reasonably be done. After you have done this, check for interference by testing both devices at the same time under heavy utilization (load) and then characterize each system independently to see how much, if any, degradation exists.

Warning **In order to comply with FCC, EU, and EFTA RF exposure limits, antennas should be located at a minimum of 7.9 inches (20 cm) or more from the body of all persons. See the installation guide under declaration of conformity for more on this (http://www.cisco.com/en/US/docs/wireless/access_point/3600/quick/guide/ap3600getstart.html).**

Installations in IDF Closets (Telecommunications or other Electrical Equipment)

When installing APs near other electrical or telecommunications equipment, keep all wiring and metal away from the antennas and avoid placing the antennas near electrical lines. Do not route wiring electrical or Ethernet in the near field (6-15 inches) from the antenna. Try to refrain from installing the AP in the electrical closet, as the best place for the AP is as close to the users as possible/practical. If you remote antenna cables from such a closet, you may be required to use Plenum rated cable (see local fire/safety regulations for more on this).

Below are a few URLs for understanding interference:

http://www.cisco.com/en/US/prod/collateral/wireless/ps9391/ps9393/ps9394/prod_white_paper0900aecd807395a9_ns736_Networking_Solutions_White_Paper.html

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/white_paper_c11-609300.html

Installations at Very High Altitudes

While not defined in the specification sheet for the AP 2600 and AP 3600, these Access Points passed functional checks after a Non-Operational altitude test of 25C @ 15,000 Ft was performed. Additionally, they fully passed a functional test during an operational altitude test of 40C @ 9,843 Ft.

All units in the test group were connected to at least one WLAN client and monitored for continual operation passing traffic, and performing constant ping testing throughout the operational altitude test.

Installations Using a Common or Distributed Antenna System (DAS)

Due to the dual-band nature of the antenna system on the AP 2600 and AP 3600, along with key features such as ClientLink 2.0 beamforming, it is not recommended for deployments on Distributed Antenna Systems commonly referred to as DAS.

Customers wishing to integrate a Wi-Fi over DAS solution should understand that Cisco does not certify, endorse or provide RF support for Wi-Fi deployments over ANY Distributed Antenna System.

The DAS vendor and/or systems integrator is solely responsible for the support of the DAS products and for providing adequate RF coverage and supporting any RF-related issues. This support includes, but is not exclusive to location accuracy, RF coverage, roaming issues related to RF, multipath issues, and scalability.

Additionally, the DAS vendor and/or systems integrator is responsible for understanding that the deployed DAS system meets the requirements of all of the customer's Wi-Fi devices and applications over the DAS system; this statement includes, but is not exclusive to, all Voice over WLAN (VoWLAN) and medical devices.

While Cisco Technical Assistance Center (TAC) and Cisco field teams do not provide support for RF issues that arise in a Cisco WLAN used over a DAS, they will provide support for non-RF related issues in Cisco products per the customer's support agreement with Cisco Systems.

For more on this see the following URL:

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps6973/positioning_statement_c07-565470_ps10092_Products_Data_Sheet.html

Installations Inside and Around Elevators

Elevator coverage can sometimes be accomplished by placing APs in the near field of the elevator, typically on each floor near the elevator door. Since elevators often have metal doors and the shafts are often concrete or contain other materials that degrade Wi-Fi coverage, it is important to check the coverage inside the elevator. While such coverage can be challenging it is often do-able, especially if the elevator is only a few floors.

High rise elevators are more challenging since roaming issues are problematic as the client is cycling through a large number of APs rather quickly. Some companies that do in-elevator advertising have put a patch antenna on the floor inside the shaft and a patch antenna on the bottom of the elevator car, while other companies have used leaky coaxial cable running on the side of the shaft.

When installing any Wi-Fi equipment inside the elevator cars or shafts, local regulations need to be followed as many times such installations are prohibited either for safety reasons or because the building owner or local fire department may prohibit same. Also, it is dangerous and only elevator repair persons or contractors experienced with this kind of work should be in those areas.

External Antenna Options and Patterns

For use with AP 1600/2600 and 3600e Access Points

The following antennas are available for use with the AP 1600e*/2600e and 3600e

AIR-ANT2524DB-R – Dual-band (Black) dipole (4 required) – 2/4 dBi Dipole

AIR-ANT2524DW-R – Dual-band (White) dipole (4 required) – 2/4 dBi Dipole

AIR-ANT2524DG-R – Dual-band (Grey) dipole (4 required) – 2/4 dBi Dipole

AIR-ANT2524V4C-R – Dual-band Omni-directional (1 required) – 2/4 dBi Ceiling mount Omni use

AIR-ANT2544V4M-R– Dual-band Omni-directional (1 required) – 4/4 dBi Wall mount Omni use

AIR-ANT2566P4W-R– Dual band directional (1 required) – 6 dBi Patch wall mount use

Note These are all dual-band, dual-resonant antennas. Do not use single-band antennas on this product unless you choose to disable the other radio band within the AP. Also, in the case of the AP 1600 only three dipole antennas are required (not four) if using the ceiling, wall or patch mount simply leave the 4th antenna lead unused.

For additional information on Cisco antennas, see the Cisco Antenna Reference Guide at this URL:

http://www.cisco.com/en/US/prod/collateral/wireless/ps7183/ps469/product_data_sheet09186a008008883b.html

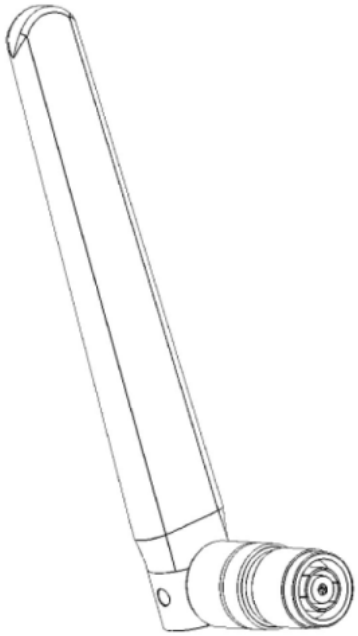
The antenna reference guide will have details for all Cisco antennas; you can also find individual datasheets at this URL: http://www.cisco.com/en/US/products/hw/wireless/ps469/index.html

The two most popular external antennas for the AP 3600e are the AIR-ANT2524Dx-R dual-band dipole antenna (Figure 31 and Figure 32) and the AIR-ANT2566P4W-R dual-band patch antenna (Figure 33 and Figure 34).

Figure 31 Specifications for the AIR-ANT2524Dx-R Dual-band Dipole Antenna

Technical Specifications

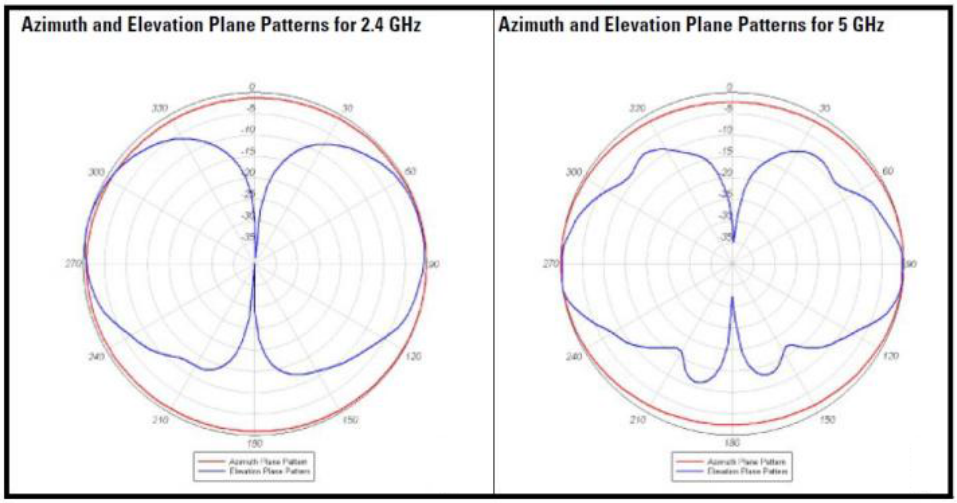
Parameter	Specification
Antenna type	Dual-band dipole
Operating frequency range	2400 to 2500 MHz
	5150 to 5850 MHz
Nominal input impedance	50Ω
VSWR	Less than 2:1
Peak Gain @ 2.4. GHz	2 dBi
Peak Gain @ 5 GHz	4 dBi
Elevation plane 3dB beamwidth @2.4 GHz	63 degrees
Elevation plane 3dB beamwidth @ 5 GHz	39 degrees
Connector type	RP-TNC plug
Antenna length	6.63 in. (168.5 mm)
Antenna width	0.83 in (21 mm)
Radome length	4.88 in. (124 mm)
Weight	1.3 oz
Operating temperature	–20°C to 60°C (–4° to 140°F)
Storage temperature	–40°C to 85°C (–40°F to 185°F)
Environment	Indoor, office



AIR-ANT2524Dx-R Series Dual-band Dipole

350095

Figure 32 Radiation Pattern for the AIR-ANT2524Dx-R Dual-band Dipole Antenna



350096

Figure 33 Specifications for the AIR-ANT2566P4W-R Dual-band Patch Antenna

Antenna type	4-element dual-band MIMO
Operating frequency range	2400 to 2484 MHz
	5150–5850 MHz
VSWR	2:1 or less
Gain	6 dBi in both bands
Polarization	Linear, vertical
Azimuth Plane 3-dB Beamwidth	2.4 GHz band: 105°
	5 GHz band: 125°
Elevation Plane 3-dB Beamwidth	2.4 GHz band: 70°
	5 GHz band: 60°
Length	6.3 in. (16 cm)
Width	11 in. (27.9 cm)
Depth	1.2 in. (3.05 cm)
Weight	1.4 lbs
Cable length and type	3 ft. (91.4 cm) plenum rated
Connector	RP-TNC
Environment	Indoor/outdoor
Operating temperature range	-22° to 158° F
	-30° to 70° C

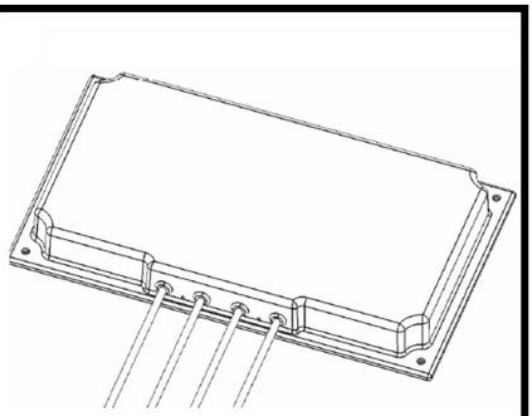


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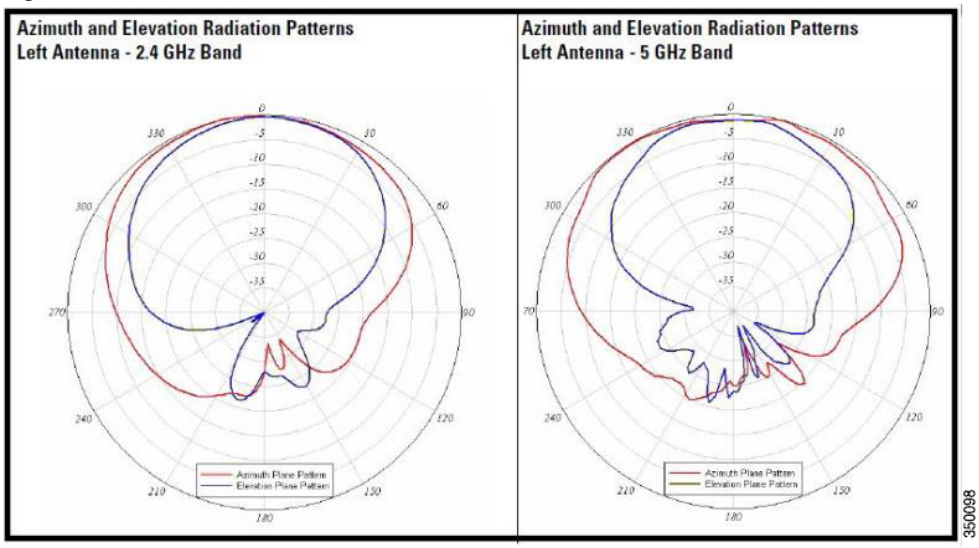
Figure 34 Radiation Pattern for the AIR-ANT2566P4W-R Dual-band Patch Antenna



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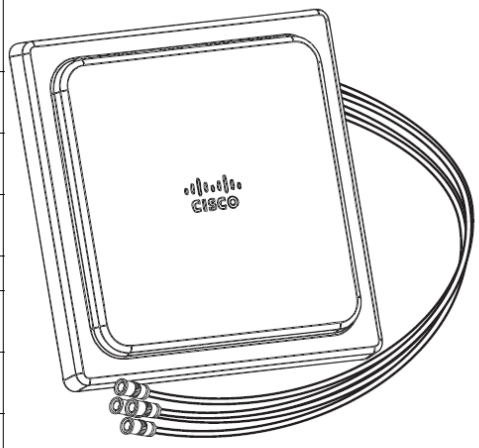
Assuming the antenna is mounted on a wall, the Azimuth (in RED) is the signal going forward from the antenna, the elevation in Blue is “up/down” pattern.

Figure 35 Specifications for the AIR-ANT2524V4C-R Dual-band Omni Antenna

Antenna type	4-Element, Dual-band, Low Profile Omni
Operating frequency ranges	2400–2484 MHz 5150–5850 MHz
VSWR	2:1 or less in both bands
Peak gain	2.4-GHz band: 2 dBi 5-GHz band: 4 dBi
Polarization	Linear
Azimuth plane 3 dB beamwidth	Omnidirectional
Elevation plane 3 dB beamwidth	2.4-GHz band: 69° 5-GHz band: 60°
Length	7.25 in (18.4 cm)
Width	7.25 in (18.4 cm)
Depth	1 in (2.5 cm)
Weight	1.3 lb (0.59 kg)
Cable	3 ft (91.4 cm) plenum rated, UV stable
Connector	RP-TNC
Environment	Indoor
Temperature range	32°F to 133°F (0°C to 56°C)



350099

Figure 36 Radiation Pattern for the AIR-ANT2524V4C-R Dual-band Omni Antenna

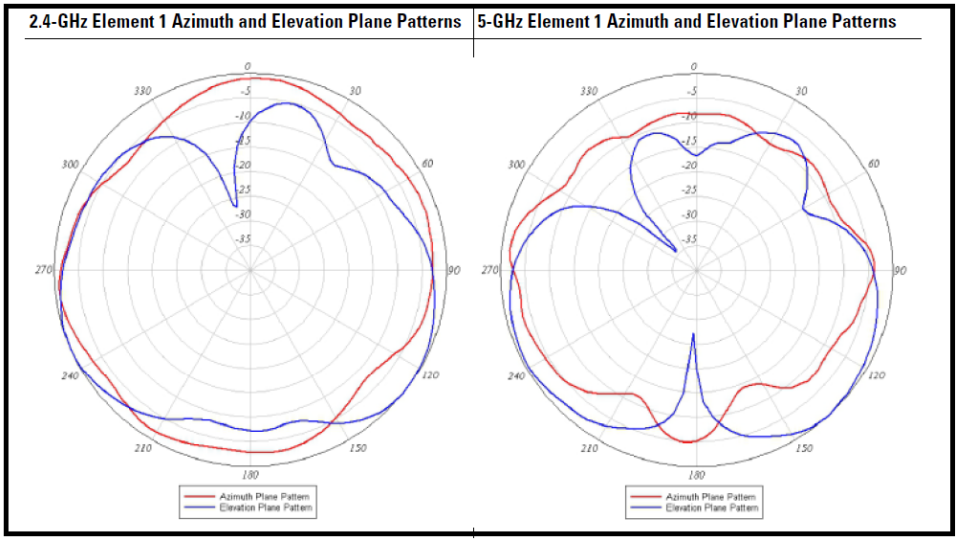


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Figure 37 Specifications for the AIR-ANT2544V4M-R Dual-band Omni Antenna

Antenna type	4-element MIMO omnidirectional
Operating frequency range	2400-2484 MHz
	5150-5850 MHz
Nominal input impedance	50Ω
VSWR	2:1 or less
Peak gain	2.4-GHz band: 4 dBi
	5-GHz band: 4 dBi
Polarization	Linear, vertical
Azimuth plane (3 dB beamwidth)	Ominidirectional
Elevation plane (3 dB beamwidth	2.4-GHz band: 60°
	5-GHz band: 33°
Length	8.6 in (21.8 cm)
Diameter	6.3 in (16 cm)
Weight	Antenna: 1.48 lb. (671.5 g);
Cable	3-ft. (91.4 cm) plenum
Connector	RP-TNC
Environment	Indoor/outdoor
Temperature range	-22° F to 158° F (-30° C to 70° C)

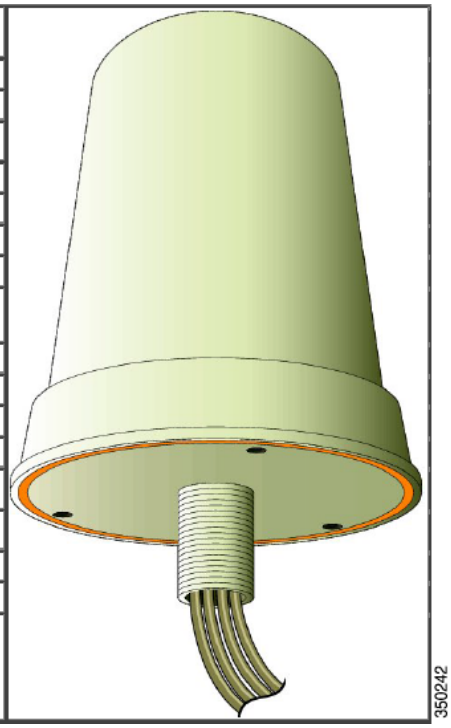
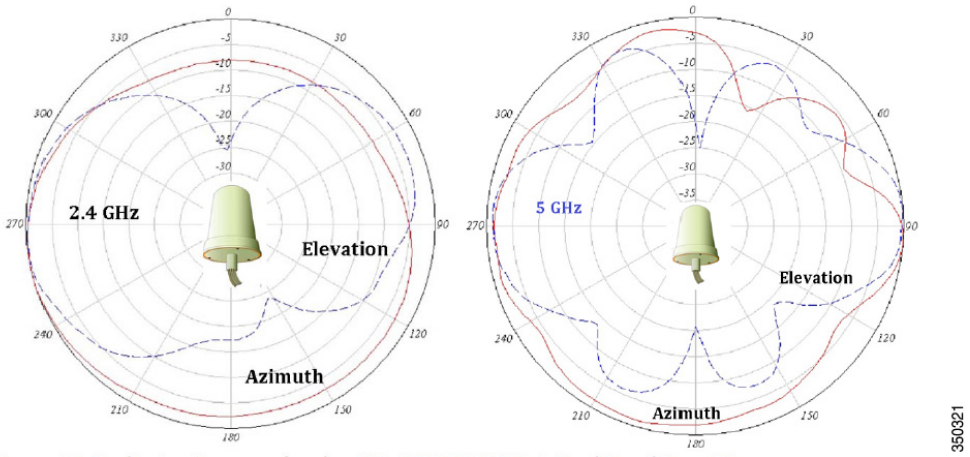


Figure 38 Radiation Patterns for the AIR-ANT2544V4M-R Dual-band Omni Antenna



Note For larger patterns, see the individual specification sheet for this antenna.

AP 3600i, AP 2600i, and AP 1600i

Antenna patterns for the AP 3600i integrated antenna model are shown in Figure 39 and Figure 40.

Antenna patterns for the AP 2600i integrated antenna model are shown in Figure 41 and Figure 42.

Antenna patterns for the AP 1600i integrated antenna model are shown in Figure 43c and Figure 44.

Figure 39 Radiation Patterns for the AP 3600i @ 2.4 GHz

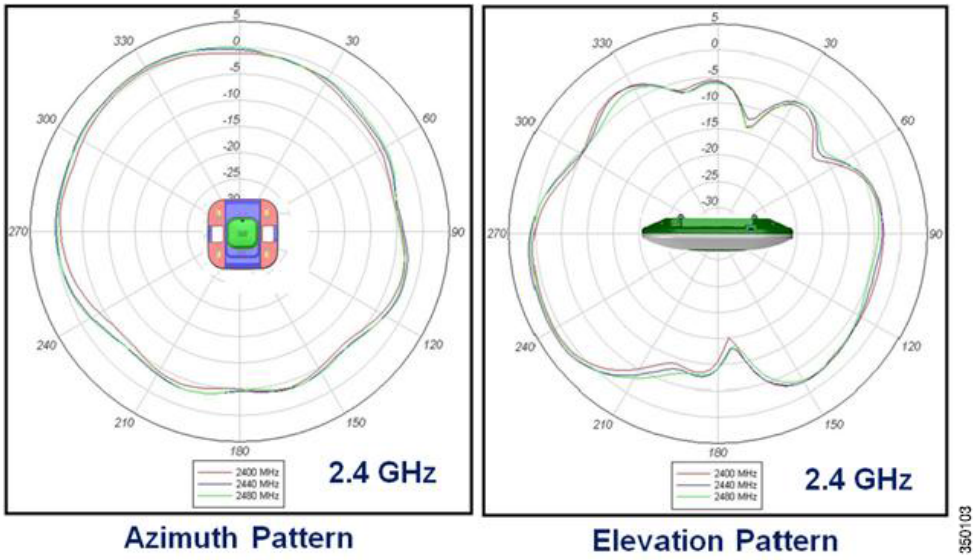


Figure 40 Radiation Patterns for the AP 3600i @ 5 GHz

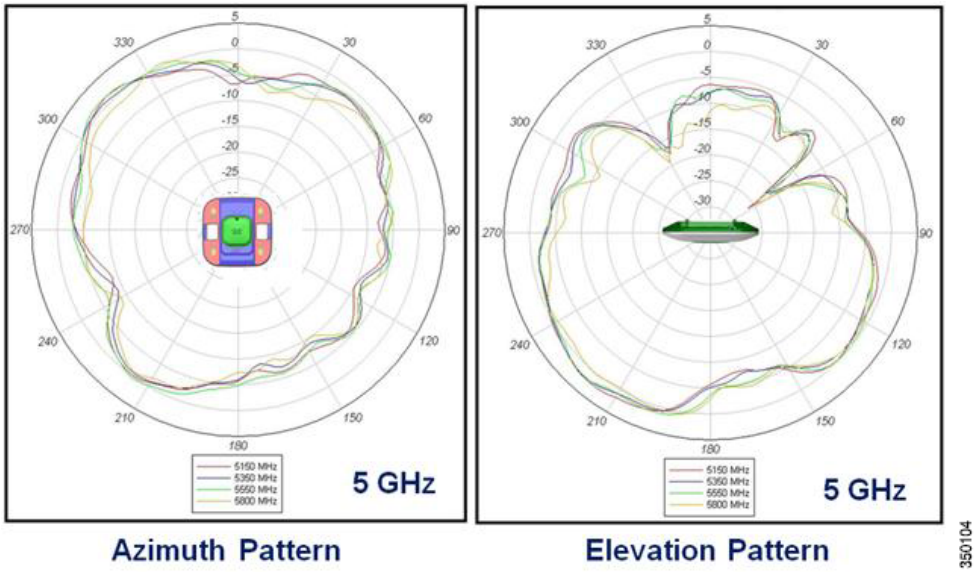


Figure 41 Radiation Patterns for the AP 2600i @ 2.4 GHz

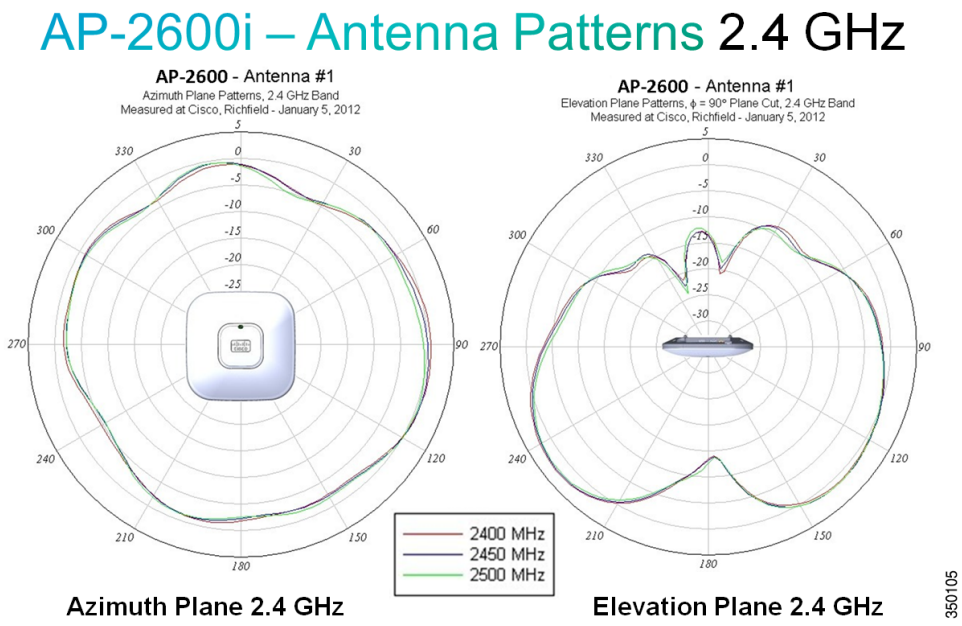


Figure 42 Radiation Patterns for the AP 2600i @ 5 GHz

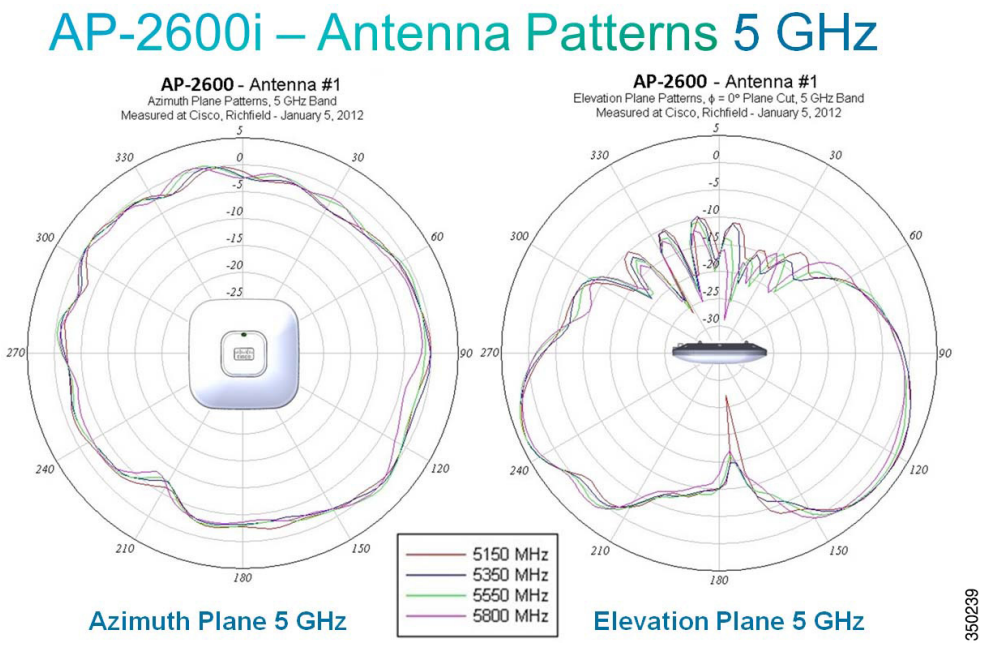


Figure 43 Radiation Patterns for the AP 1600i @ 2.4 GHz

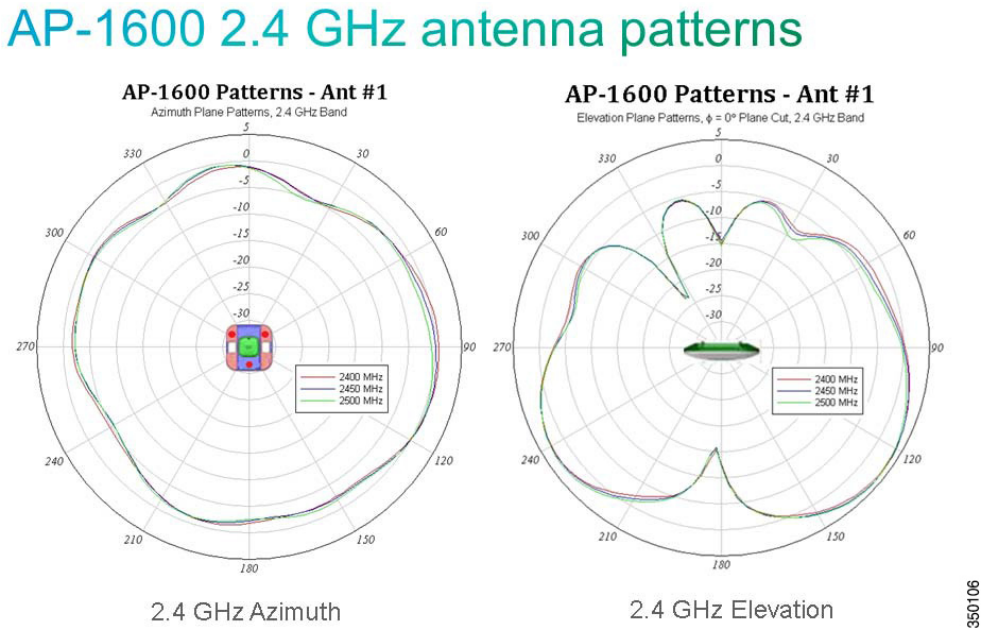
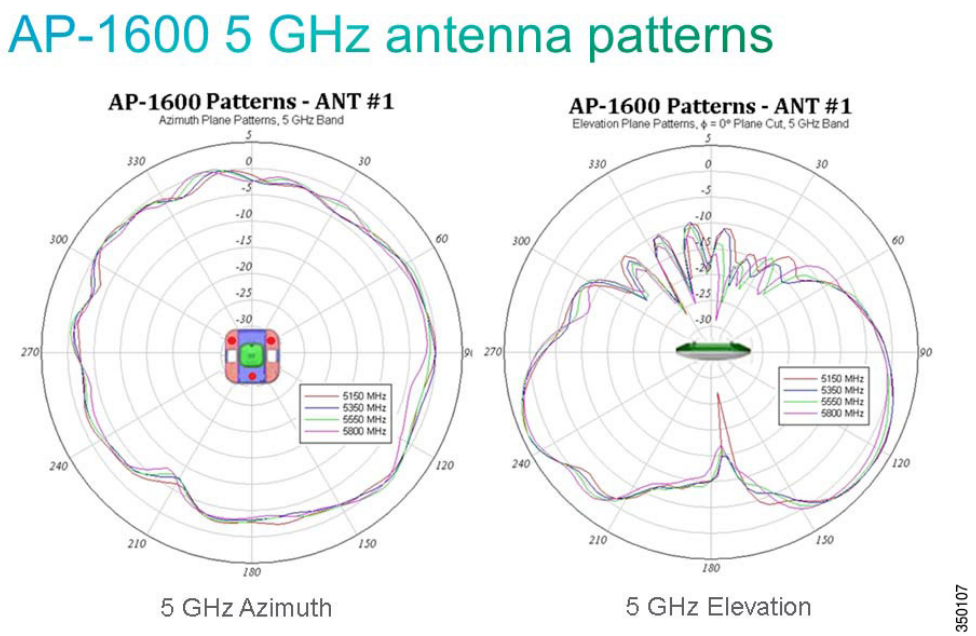


Figure 44 Radiation Patterns for the AP 1600i @ 5 GHz



Understanding External Antenna Deployments

All Cisco antenna connectors are labeled “A” “B” “C” and so on… “A” has a higher priority than “B” or “C/D” so if the Access Point supports say 3 or 4 antennas and you only have 2 antennas, you would use them on ports “A” and “B” (short term until you could install the additional antennas).

While it is not recommended that you use less antennas – the product (in a pinch) would support 802.11a/b/g clients or single spatial stream N clients using only one or two antennas however there is a significant performance hit and you would lose Client Link functionality – Should you do this, you would also want to configure the Access Point in software to not use the other antennas.

Note The AP 1600 has three antenna ports (not configurable as it is an entry level AP). The AP 2600/3600 has four configurable antenna ports - one extra transceiver (receiver/transmitter per band).

When using a MIMO (dual-radiating element antennas) such as:

AIR-ANT2524V4C-R – Dual-band Omni-directional – 2/4 dBi Ceiling mount Omni use

AIR-ANT2544V4M-R– Dual-band Omni-directional – 4/4 dBi Wall mount Omni use

AIR-ANT2566P4W-R– Dual band directional – 6 dBi Patch wall mount use

It is not critical which antenna lead goes onto which antenna port on the Access Point so long as all the antenna ports on the AP are connected to the antennas. In the case of the Patch antenna AIR-ANT2566P4W-R, since the elements are spaced physically apart (side by side) in the plastic housing, there is a slight improvement if you use the outer two elements on the Patch on ports “A” and “B” but again it is only a small improvement and not critical and that is why we do not label them.

Figure 45 6 dBi patch antenna – while not critical, ideally port "A" and "B" would be on the ends.

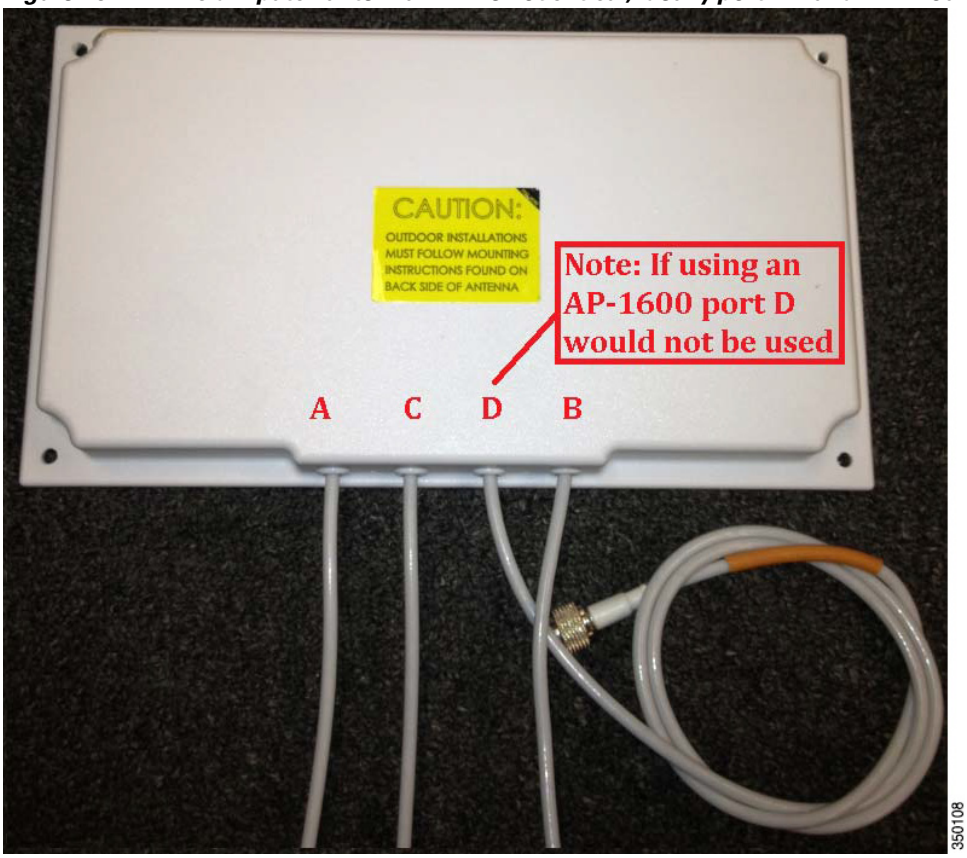


Figure 46 AP 1600 Note port "A" is spaced furthest from "B" and "C" for best diversity

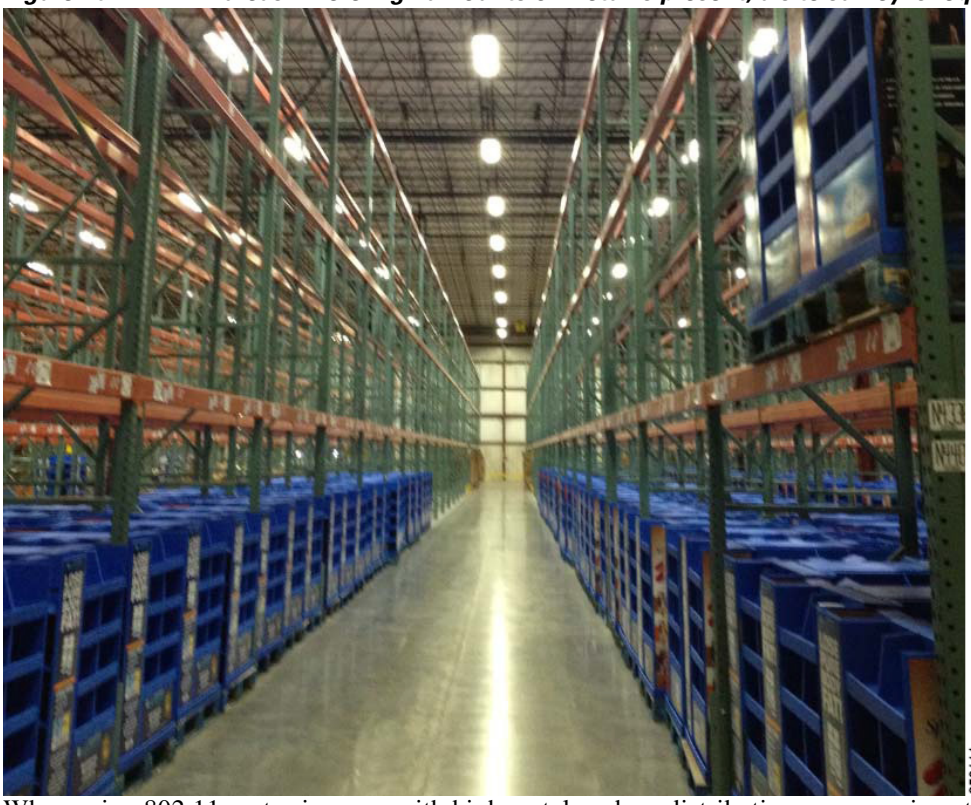
Remember the best antenna placement is the one where the antenna is physically closest to the actual users. If you are mounting multiple single package dual band antennas externally such as dipoles, spacing is not critical but try to space as far apart as practical (with “A” and “B” the furthest apart).

Figure 47 Antenna Placement

Note Avoid spacing antennas further than 10 Ft (antennas should be in same RF coverage area)

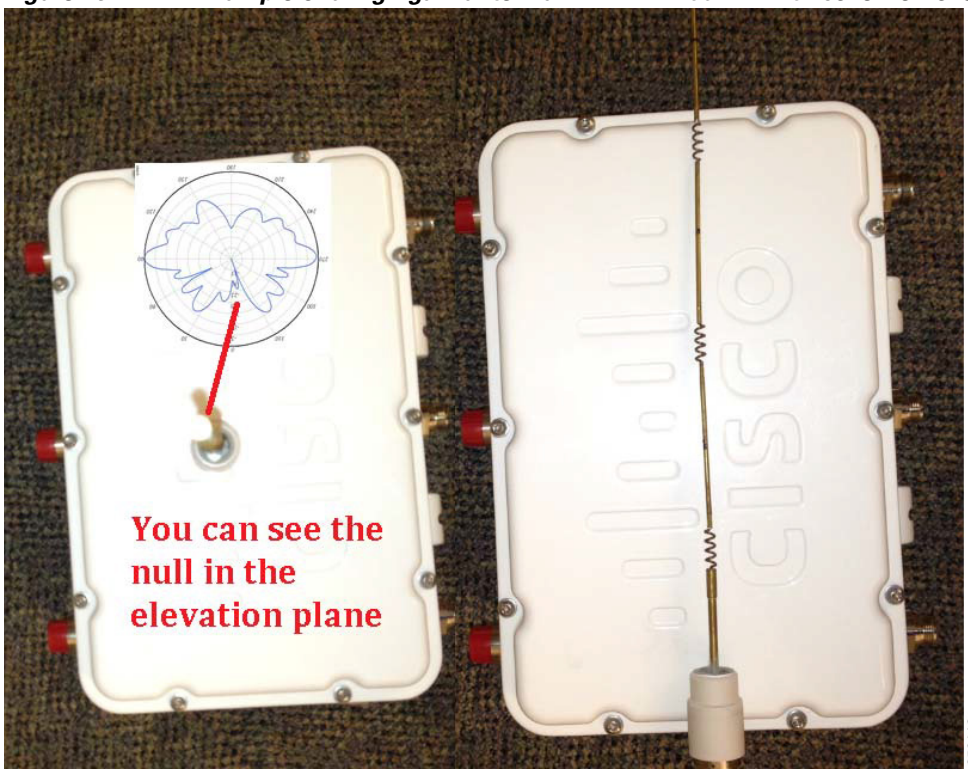
Note Avoid using single band (single radiating element antennas) like those used with earlier 3500 series Access Point products as they are not fully compatible with the newer 1600/2600 and 3600 Series Access Points. Antennas for the 1260 and 3500 series are single radiating element antennas made for each individual band. The 3600, 2600 and 1600 use dual band - dual radiating element antennas and are branded with an orange marking see Figure 45 and Figure 46.

Figure 48 In areas where high amounts of metal is present, a site survey is required



When using 802.11n rates in areas with high metal such as distribution areas or airport hangars, sometimes lower gain antennas (on the ceiling) can perform better as lower gain antennas tend to radiate the signal in all directions increasing the chance that multi-path will enhance the signal. Of course if you have a clear shot, a patch antenna at the end of an aisle at roughly the same height or just above the (WLAN client) is preferred.

Figure 49 Example of a high gain antenna AIR-ANT2480V-N with cover removed



A high gain antenna may have a null or dead spot directly underneath it as the antenna element is often much longer with less metal surface area available to conduct the radio wave if you are located directly underneath it, however; the further away you are from the antenna the more surface is available and so the better it performs.

802.11n Primer - Understanding Spatial Streams

For a video on understanding the fundamentals of Spatial Streams see the following URL:

http://www.cisco.com/en/US/netsol/ns767/index.html

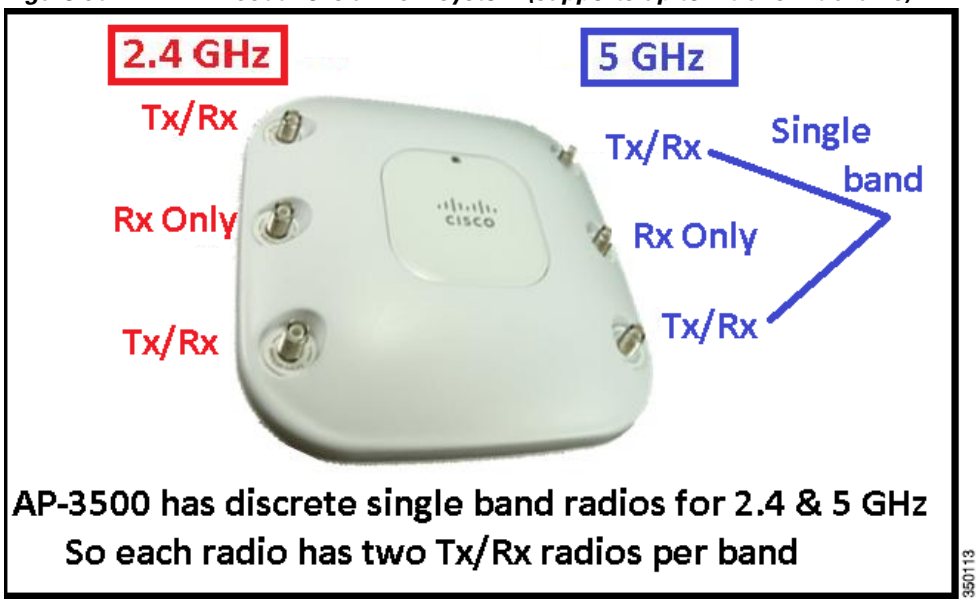
MIMO, which refers to a radio system that has multiple separate receive and transmit paths, is at the heart of 802.11n. MIMO systems are described using the number of transmitters and receivers in the system. For example, "two by one" or 2x1 refers to a system with two transmitters and one receiver (Figure 50).

Spatial streams, the act of transmitting information out of more than one antenna port concurrently, requires that the AP have at least two or more transmitters and support elements of 802.11n, e.g., support of multiple spatial streams.

In the 802.11a/b/g days data rates were actual Mbps rates like 2, 11, 54 Mbps etc., and was done with one transmitter. In the case of the AP 3500 series it has two transmitters per band so it supports 802.11n data rates up to 300 Mbps using two spatial streams.

With 802.11n the different rates are called Modulation and Coding Scheme (MCS) index value, and the value also defines how many streams are used. The AP 3500 supported up to 300 Mbps (MCS rate 15 configured with a bonded channel and short guard interval (GI). Refer to Figure 51. The MCS values correspond to actual data rates.

Figure 50 AP 3500i/e is a 2x3:2 system (supports up to 2 transmit chains)



Note 2x3:2 means two transmitters, three receivers supporting two spatial streams.

Figure 51 Modulation and Coding Scheme: 2SS Bonded Channel Supports up to 300 Mbps

				Signal BW =20 MHz		40 MHz	
MCS	Coding	Modulation	Streams	GI = 800 nS	GI =400 nS	GI = 800 nS	GI =400 nS
MCS0	1/2	BPSK	1	6.5	7.2	13.5	15
MCS1	1/2	QPSK	1	13	14.4	27	30
MCS2	3/4	QPSK	1	19.5	21.7	40.5	45
MCS3	1/2	16-QAM	1	26	28.9	54	60
MCS4	3/4	16-QAM	1	39	43.3	81	90
MCS5	2/3	64-QAM	1	52	57.8	108	120
MCS6	3/4	64-QAM	1	58.5	65	131.5	135
MCS7	5/6	64-QAM	1	65	72.2	135	150
MCS8	1/2	BPSK	2	13	14.4	27	30
MCS9	1/2	QPSK	2	26	28.9	54	60
MCS10	3/4	QPSK	2	39	43.3	81	90
MCS11	1/2	16-QAM	2	52	57.8	108	120
MCS12	3/4	16-QAM	2	78	86.7	162	180
MCS13	2/3	64-QAM	2	104	115.6	216	240
MCS14	3/4	64-QAM	2	117	130	243	270
MCS15	5/6	64-QAM	2	130	144.4	270	300

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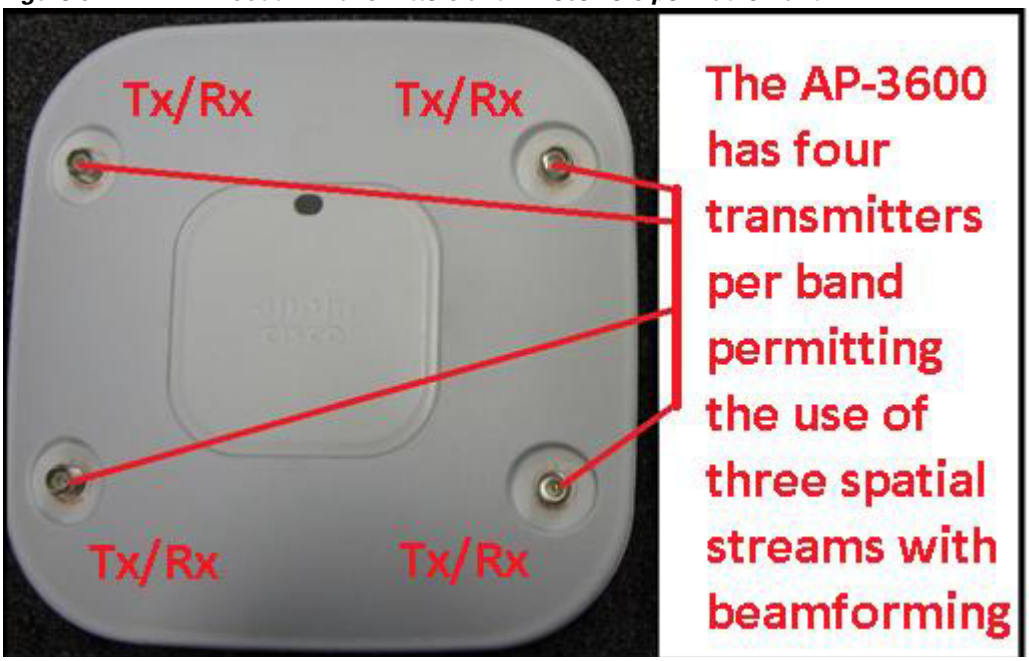
Unlike the AP 3500, the newer AP 3600 supports 3SS with twice as many transmitters (4 per band) enabling faster data rates of up to 450 Mbps. Note that there is an extra radio for redundancy and enhanced performance (upstream and downstream) and the AP 3600 can also beamform to 3SS clients as well. The AP 2600 is similar but the extra or redundant radio is for upstream as it is a receive only so it is unable to beamform to 3-ss clients but can beamform at the other non-3ss rates.

Using a dual-band design the AP 3600 has a total of 8 transceivers (transmitter/receivers) using only 4 antennas (Figure 52). Four radios are used in each band, 2.4 GHz and 5 GHz.

Figure 52 AP 3600: 4 Transmitters and 4 Receivers per Radio Band



The AP 2600 while similar to the AP 3600 is slightly different as it is a 3x4:3 meaning, the AP 2600 also has 4 antennas to help on the receive (upstream signal) but it only uses three transmitters on the downstream side.

The yellow sections of the MCS chart in Figure 53 depict the faster data rates supported by the AP 3600. The AP 3600 supports 802.11a/b/g rates as well as 802.11n rates of MCS values 0-23.

Figure 53 AP 2600/3600 supports up to 450 Mbps (MCS rates 0-23) AP 1600 (MCS rates 0-15)

				Signal BW =20 MHz		40 MHz	
MCS	Coding	Modulation	Streams	GI = 800 nS	GI =400 nS	GI = 800 nS	GI =400 nS
MCS0	1/2	BPSK	1	6.5	7.2	13.5	15
MCS1	1/2	QPSK	1	13	14.4	27	30
MCS2	3/4	QPSK	1	19.5	21.7	40.5	45
MCS3	1/2	16-QAM	1	26	28.9	54	60
MCS4	3/4	16-QAM	1	39	43.3	81	90
MCS5	2/3	64-QAM	1	52	57.8	108	120
MCS6	3/4	64-QAM	1	58.5	65	131.5	135
MCS7	5/6	64-QAM	1	65	72.2	135	150
MCS8	1/2	BPSK	2	13	14.4	27	30
MCS9	1/2	QPSK	2	26	28.9	54	60
MCS10	3/4	QPSK	2	39	43.3	81	90
MCS11	1/2	16-QAM	2	52	57.8	108	120
MCS12	3/4	16-QAM	2	78	86.7	162	180
MCS13	2/3	64-QAM	2	104	115.6	216	240
MCS14	3/4	64-QAM	2	117	130	243	270
MCS15	5/6	64-QAM	2	130	144.4	270	300
MCS16	1/2	BPSK	3	19.5	21.7	40.5	45
MCS17	1/2	QPSK	3	39	43.3	81	90
MCS18	3/4	QPSK	3	58.5	65	121.5	135
MCS19	1/2	16-QAM	3	78	86.7	162	180
MCS20	3/4	16-QAM	3	117	130	243	270
MCS21	2/3	64-QAM	3	156	173.3	324	360
MCS22	3/4	64-QAM	3	175.5	195	364.5	405
MCS23	5/6	64-QAM	3	195	216.7	405	450

3 Spatial Stream MCS Rates

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These additional MCS rates permit more choices for the client supporting 3SS when making rate-shifting decisions as the rate-shifting algorithm maintains the best overall throughput connection.

Clients That Support Three Spatial Streams

Clients with 3SS support are starting to become commonplace. As the new 802.11ac specification starts to get traction, many newer client adapters will have the newer chipsets and support 3SS as a subset to 802.11ac. Additionally, unlike many of our competitors the Cisco AP 1600/2600 and 3600 fully supports all the DFS channels for more usable channels in the 5 GHz range. More clients, especially 802.11ac clients, will start to emerge supporting these newer channels in 802.11n modes as well.

Currently the most popular 3SS client is the Apple 2011 MacBook Pro, as it is based upon the Broadcom BCM4331 chipset and a small USB adapter by Trendnet, "TEW 684UB", based on the Ralink chipset.

Additionally, the Intel 5300 and 6300 has supported 3SS for a long time. Perhaps because of the different hardware platforms this card is installed in, testers have observed good throughput on many notebooks (+320 Mbps) and reduced throughput on other notebooks such as 240 Mbps. If you experience low throughput using the Intel card, one suggestion might be to try a MacBook Pro or Trendnet adapter, and if they perform well try another notebook with the Intel card or perhaps open a case with Intel or the laptop manufacturer for a possible remedy. During the AP 3600 beta trials we observed differences in performance with different notebooks using the Intel 6300 card.

Note Sometimes it can be difficult to reliably maintain a 3SS link as it is easy for the client to rate-shift out of the 3SS mode. The client plays an important role in the ability to maintain a 3SS link, so it can vary with the quality of the client being used and the test environment.

The AP 3600 with its extra radio per band can use the extra redundant radio to beamform (thanks to ClientLink 2.0) and uses this to maintain the advantage of 3SS links. Cisco ClientLink 2.0 can also improve the overall performance of 802.11n clients using 1, 2 and 3 spatial streams and legacy .11a/g clients.

Understanding Beamforming – ClientLink 1.0 and 2.0

ClientLink 1.0 was first introduced with the AP 1250 and AP 1140 series Access Points; it is a method of creating a stronger signal on the downlink side for 802.11a/g clients by hearing the clients on the uplink and then adjusting the transmitter timing so the signal appears much stronger at the client end.

This feature used to be user configurable; however, starting with 7.2 code stream it is now on by default and is not user configurable as there is no benefit to disabling it.

The AP 3600 fully supports ClientLink 1.0 for 802.11a/g clients but has a greater advantage as it also supports all 802.11n clients including 1, 2 and 3 spatial stream clients. This capability is called ClientLink 2.0. There is a distinct advantage with ClientLink 2.0 over the 802.11n enhanced beamforming specification, as ClientLink 2.0 works with ALL clients today and does not require any client sounding or support (Figure 54).

Figure 54 ClientLink 2.0

	802.11n (EBF) Enhanced Beam Forming	Client Link 2.0 (CVBF)
WLAN Client		Cisco Vector Beam Forming
Works for Multiple Spatial Stream HT Clients	Not yet	All
Works for 1 SS HT Clients	Not yet	All
Works for Legacy Clients (11 a/g)	None	All
General Requirements/Dependencies		
Requires Client Cooperation/Support	Yes	No
Requires Use of Channel Time for Sounding	Yes	No
Can be Used w/ Clients Currently on Market	No	All 11a/g/n

350115

With beamforming technology, changing the timing of two transmitters creates a stronger signal for the receiver, e.g, a client device. This is referred to as constructive interference. Sometimes, however, the opposite happens and the signals cancel each other out. This is called destructive interference. Refer to Figure 55.

Figure 55 Beamforming (constructive and destructive interference)

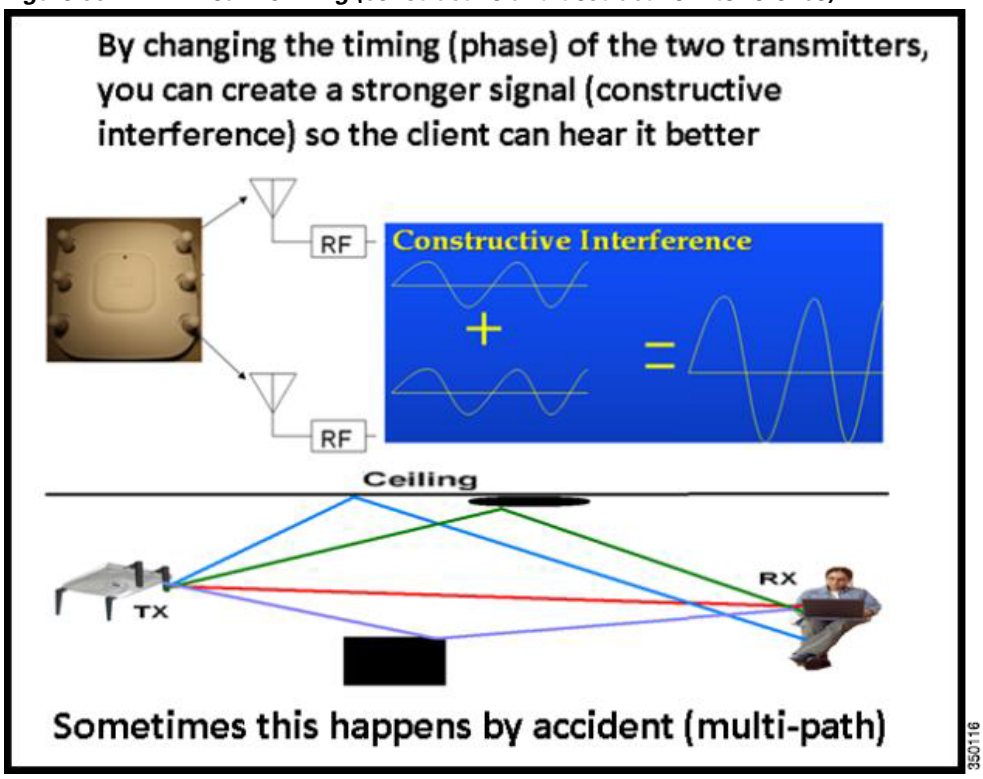

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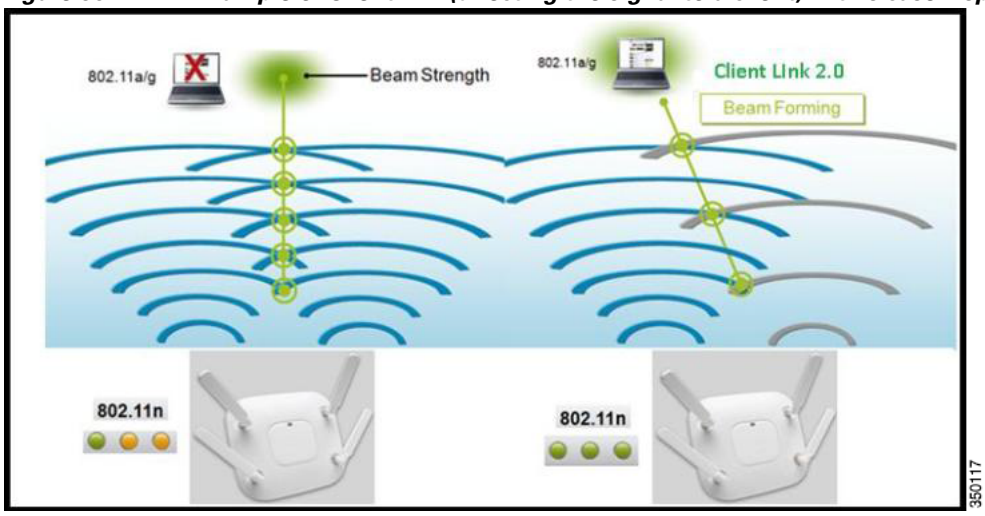
Figure 56 provides a visual comparison of ClientLink 1.0, using 1 spatial stream, and ClientLink 2.0, using 3 spatial streams. Unlike the AP 3500, the AP 3600 provides multiple spatial streams using four transceivers for even greater performance. AP 3600 can beamform to all 802.11a/g and 802.11n 1, 2 and 3 spatial stream clients. The signal is x3 as each stream is beamformed.

Figure 56 Example of ClientLink (directing the signal to a client, in this case 1 spatial stream)



Note In order to beamform to clients using 3 spatial streams, since 3 transmitters are used in the transmissions the AP needs at least one additional radio to beamform. The AP 3600 has 4 radios pre band and can beamform to clients using 3 spatial streams.

To summarize, ClientLink 2.0 takes the received signals heard from the client on the uplink, calculates how the multipath signal looked from those streams, and then on the reciprocal side (transmit downlink) figures out the optimal way using all four radios to best form the signal (transmit beamforming) to enable the client to best decode (receive the signal on the downlink) with the least amount of retries.

ClientLink 2.0 with AP 3600 enables beamforming to all 802.11n clients, including 3SS clients, and can do so for up to 128 clients at a time. Note AP 1600 supports less clients (32) and does not support 3-ss. ClientLink 1.0 support a maximum of 15 clients at a time. ClientLink 2.0 significantly improves throughput and coverage up to 60% on the downlink side for a much better 802.11n client connectivity and enhancing the Bring Your Own Device (BYOD) experience.

For more information on Cisco ClientLink 2.0 refer to the following URL:

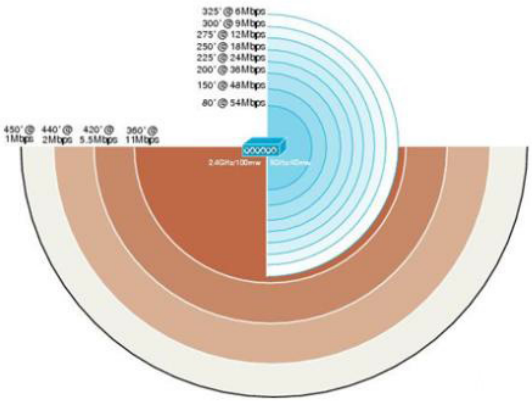
http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps11983/at_a_glance_c45-691984.pdf

Site Survey Considerations

While ClientLink dynamically beamforms and helps to maintain a robust signal which results in fewer retries, it was not designed to change the cell range. ClientLink creates a better connection experience, not larger cell size.

For this reason, when conducting a survey it is important to keep in mind that the AP 3600 cell sizes are generally the same or very similar to other Cisco Access Points. Figure 57 depicts typical ranges in the 1-54 Mbps range. While it is always recommended to survey with the equipment you intend to deploy, a previous survey done with say an AP 3500 – would not be invalid for an AP 3600 deployment. Figure 58 and Figure 59 provide examples of the modulation types and signal-to-noise ratio (SNR).

Figure 57 AP 3600 Site Survey Ranges (typical cell sizes have not changed; AP 3500 and AP 3600 cell sizes are the same



Assuming 10% PER

Speed	Required SNR	AP Sensitivity
1	0	-91
2	3	-91
5.5	6	-91
6	2	-87
11	9	-88
12	6	-86
24	11	-85
36	13	-85
48	17	-78
54	19	-77

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Figure 58 Site Survey Sensitivity and SNR

MCS Index 1/2/3 spatial stream	Modulation	Minimum Sensitivity 20 MHz	Required SNR (dB)
0/8/16	BPSK 1/2	-82	1
1/9/17	QPSK 1/2	-79	4
2/10/18	QPSK 3/4	-77	6.5
3/11/19	16 QAM 1/2	-74	9.75
4/12/20	16 QAM 3/4	-70	13
5/13/21	64 QAM 2/3	-66	17.25
6/14/22	64 QAM 3/4	-65	18.75
7/15/23	64 QAM 5/6	-64	19.75

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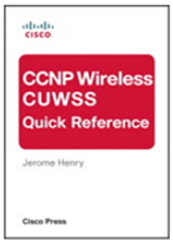
Note The SNR for 3SS is 28 dB, per IEEE, but Cisco RF engineers recommend 30-32 dB for best performance.

Figure 59 Site Survey Sensitivity and SNR



CCNP Wireless CUWSS Quick Reference (eBook)

By Jerome Henry.
Published by Cisco Press.
Series: Quick Reference Sheets.

Published: Sep 9, 2010
Copyright 2011
Dimensions:
Pages: 96
Edition: 1st

While you may see this in print, the values seem a bit conservative to us

The AP-3600 can do better than this but some customers might use these values as it is a Cisco Press reference.

RSSI/SNR Guidlines				
Data Rate				
20\40 MHz	2.4 GHz Min RSSI	2.4 GHz Min SNR	5 GHz Min RSSI	5 GHz Min SNR
14.4\30	-82	11	-79	14
28.9\60	-79	14	-76	17
43.3\90	-77	16	-74	19
57.8\120	-74	19	-71	22
86.7\180	-70	23	-67	26
115.6\240	-66	27	-63	30
130\270	-65	28	-62	31
144.4\300	-64	29	-61	32

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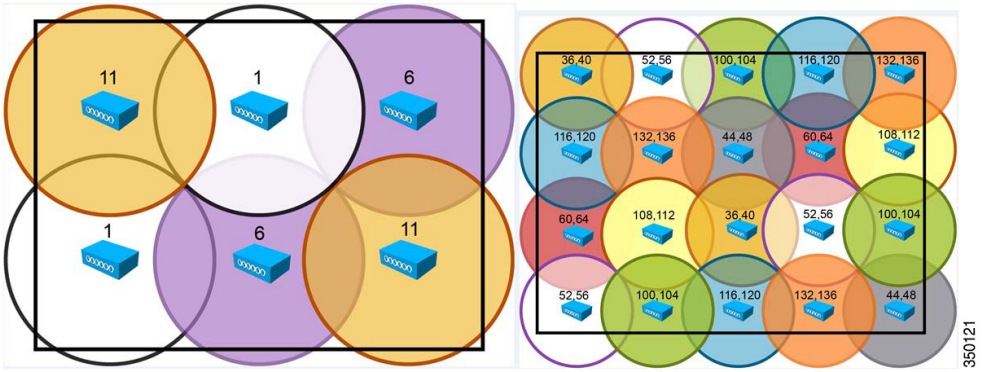
General Considerations Regarding Access Points

Following are some guidelines to remember regarding all access points.

1. Always try to mount the AP as close to the users as possible for best performance. Be aware of the environment; for example, hospitals have metal doors, coverage can change when the doors close, old buildings can have metal grid work in the plaster or asbestos. Avoid mounting the AP or antennas near metal objects, as doing so can change the coverage area.
2. When using the 2.4 GHz frequency, the same 1, 6 & 11 channel scheme is used as is the 5 GHz channel scheme (Figure 60). Avoid putting all of the APs on the same channel, and reuse channels as you can. See our other deployment guides for more on this topic.

Figure 60 Example of Channel Usage in 2.4 and 5 GHz (Two Channels used if 40 MHz)



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3. Try to determine which clients are going to be used and check the coverage using those clients. For example, a PDA or Wi-Fi phone might not have the same range as a notebook or tablet.

Tip Verify coverage using the worst performing clients that you intend to deploy.

4. If you require 3 spatial stream coverage for the fastest throughput, and/or you are looking for the best BYOD experience, the Cisco Aironet 3600 and 2600 Series Access Points with ClientLink 2.0 will perform better than the AP 3500. The AP 3600 can beamform to 802.11n clients, so it is important to understand the data requirements if you are mixing Cisco Aironet 1260, 3500 and 3600 Series Access Points in the same areas.
5. While site surveys are generally recommended, if the design is done at half power and Cisco RRM is in place, sometimes a limited site survey (coverage check) is adequate for smaller venues. If this is a very challenging environment such as train connectivity, Gas & Oil verticals, large hospitals, etc., Cisco has an Advanced Services team that can be contracted to help you get up to speed or perform your installation. See your Cisco account team for more information.
6. Cisco AP 3600 was introduced in the 7.1.91 or higher code stream and is supported by the following: Cisco 2500, 7500, 5508 and WiSM2 Series Controllers and WCS 7.0.220 or higher and NCS 1.1 or higher. The AP 1600 and 2600 was introduced in the 7.4 release.
7. The rule of thumb coverage plan is: 1 AP per 5,000 square feet for data and 1 per 3,000 square feet for voice and location services.
8. Some clients (especially older ones) do not support the UNII-2 extended client channels 100-140, so if you have lots of older clients you may want to disable them in the DCA channel list.

Note More and more clients support these channels all the time, as will the newer 802.11ac clients.

802.11ac Primer – How is it different from 802.11n?

802.11ac is backwards compatible with 802.11n but is coming in “Waves” which are different features and functionality. New features and functionality often require new hardware, or as in the case of the AP 3600 the ability to introduce new hardware within the base unit. An Access Point that is not modular typically requires a complete hardware replacement. The AP 3600 utilizes a dual core processor with one core supporting new hardware via the feature module option. The first release of 802.11ac (Wave-1) brings the following features over 802.11n

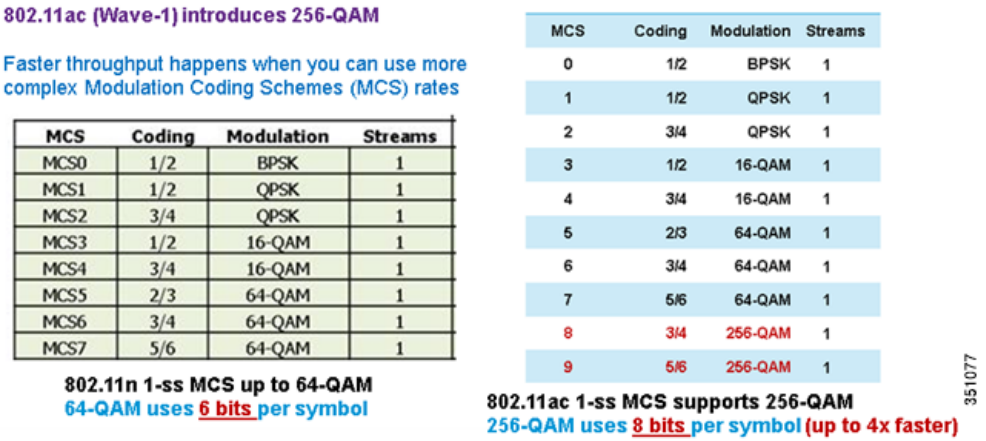
802.11ac Wave-1 features include:

- Faster PHY rate 1.3 Gbps over the typical 450 Mbps of 802.11n
- Introduction of faster modulation 256 QAM over the 64 QAM of 802.11n – This creates many new data rates similar to 802.11n but in many cases faster rates with single stream and multiple stream devices
- Ability to bond 80 MHz channels versus 40 MHz bonding of 802.11n – This can greatly enhance the throughput of devices that only support 1 spatial stream by extending the usable bandwidth of the device (often portable battery operated devices lacking multiple radios) spatial streams.
- Explicit Compressed Beam Forming – This is similar to what was proposed in 802.11n and is a method whereas the client can take advantage of sounding mechanisms to essentially tell the Access Point how to better beam form the signal back to the client. This functionality only works with 802.11ac clients and is supported with the Cisco Wave-1 module but this does not negate the value of Cisco Client Link which is still used by the primary 802.11n radios as Client Link benefits all 802.11a,g, and n clients.
- With regard to Cisco products, the 802.11ac module is a 5 GHz only as 802.11ac does not scale well in 2.4 GHz due to the limited channels and bandwidth limitations (it is not practical to bond channels in 2.4 GHz) in an enterprise deployment and non-standard “turbo modes” don’t scale.

802.11ac Wave-2 features include: (Note this paper concentrates on Wave-1) as Wave-2 is still in flux.

- Everything supported in Wave-1
- Multi-user MIMO <Multiple Input Multiple Output> client enhancement
- Bonding up to 160 MHz
- Faster Ethernet uplinks exceeding GbE

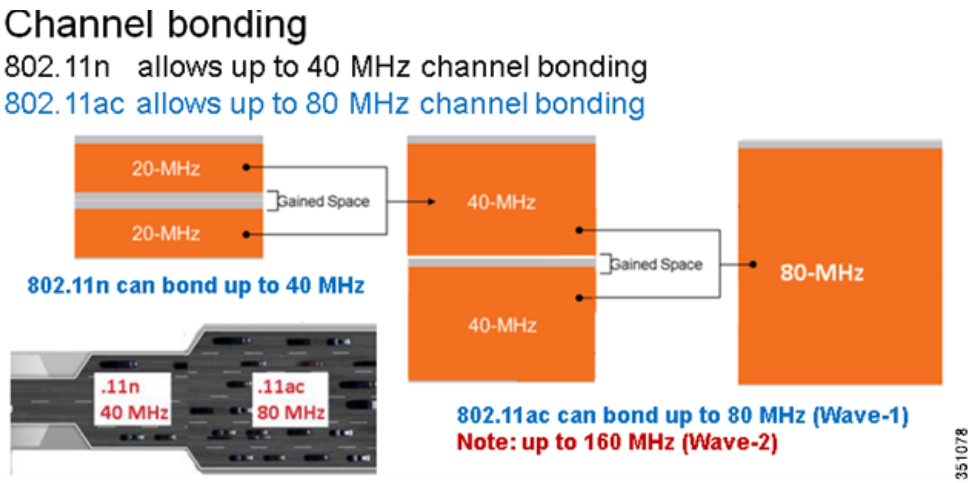
Figure 61 1 Spatial Stream MCS rates for 801.11n (left) and 1 Spatial Stream MCS rates for 802.11ac



MCS	Coding	Modulation	Streams
MCS0	1/2	BPSK	1
MCS1	1/2	QPSK	1
MCS2	3/4	QPSK	1
MCS3	1/2	16-QAM	1
MCS4	3/4	16-QAM	1
MCS5	2/3	64-QAM	1
MCS6	3/4	64-QAM	1
MCS7	5/6	64-QAM	1

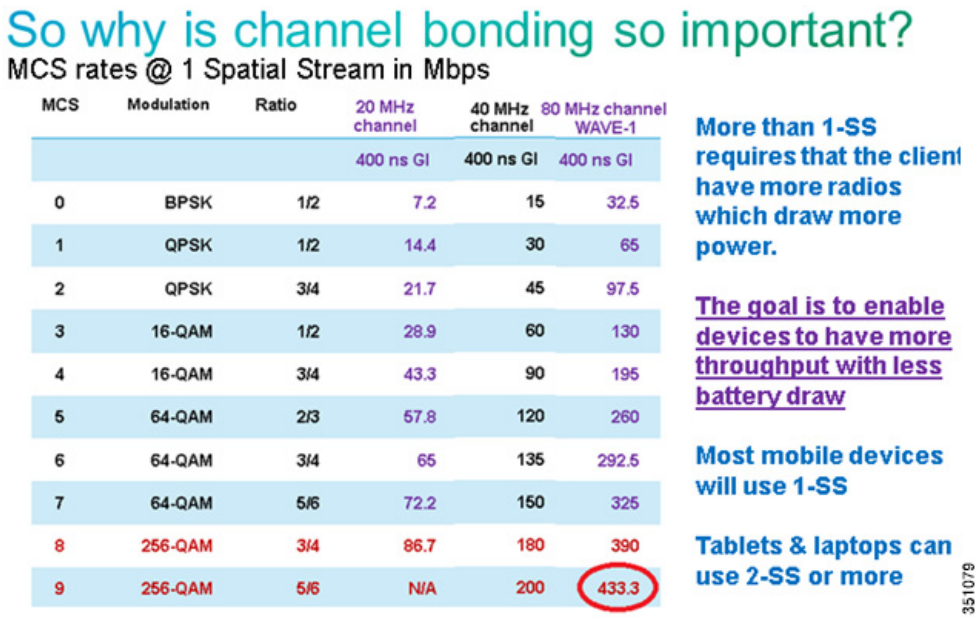
MCS	Coding	Modulation	Streams
0	1/2	BPSK	1
1	1/2	QPSK	1
2	3/4	QPSK	1
3	1/2	16-QAM	1
4	3/4	16-QAM	1
5	2/3	64-QAM	1
6	3/4	64-QAM	1
7	5/6	64-QAM	1
8	3/4	256-QAM	1
9	5/6	256-QAM	1

Figure 62 Channel bonding allows more usable bandwidth (similar to a multi-lane highway)



So the net take-away is that 802.11ac permits faster speeds – allowing clients to take advantage of the additional bandwidth and complex modulation for over-all performance enhancement while maintaining backward compatibility with 802.11n and 802.11a/g systems already in place.

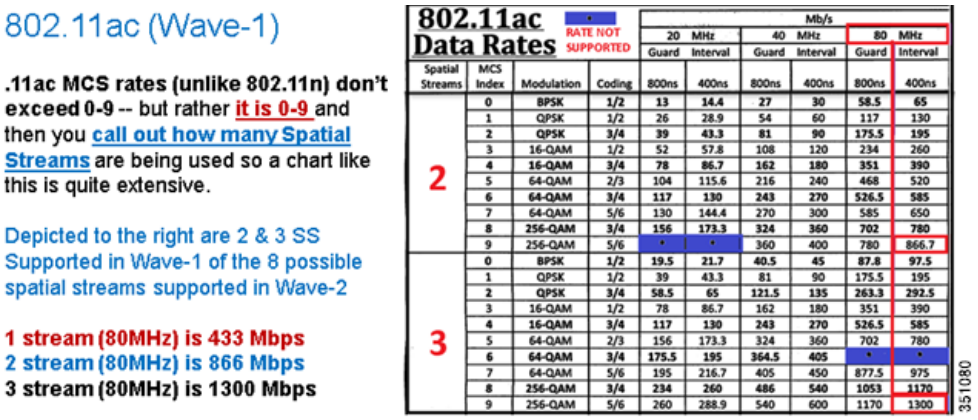
Figure 63 Faster speeds with newer MCS rates and bonding – up to 433 Mbps on 1 stream.



MCS	Modulation	Ratio	20 MHz channel	40 MHz channel	80 MHz channel WAVE-1
			400 ns GI	400 ns GI	400 ns GI
0	BPSK	1/2	7.2	15	32.5
1	QPSK	1/2	14.4	30	65
2	QPSK	3/4	21.7	45	97.5
3	16-QAM	1/2	28.9	60	130
4	16-QAM	3/4	43.3	90	195
5	64-QAM	2/3	57.8	120	260
6	64-QAM	3/4	65	135	292.5
7	64-QAM	5/6	72.2	150	325
8	256-QAM	3/4	86.7	180	390
9	256-QAM	5/6	N/A	200	433.3

Even faster speeds occur when you can use multiple spatial streams, many newer smart phones may likely support only 1 spatial stream, but higher end tablets and notebooks will typically support 2 or more spatial streams. Let's look at speeds when using 2 and 3 spatial streams.

Figure 64 Typical Wave-1 data rates @ 2 and 3 spatial streams



Spatial Streams	MCS Index	Modulation	Coding	20 MHz 800ns	20 MHz 400ns	40 MHz 800ns	40 MHz 400ns	80 MHz 800ns	80 MHz 400ns
2	0	BPSK	1/2	13	14.4	27	30	58.5	65
	1	QPSK	1/2	26	28.9	54	60	117	130
	2	QPSK	3/4	39	43.3	81	90	175.5	195
	3	16-QAM	1/2	52	57.8	108	120	234	260
	4	16-QAM	3/4	78	86.7	162	180	351	390
	5	64-QAM	2/3	104	115.6	216	240	468	520
	6	64-QAM	3/4	117	130	243	270	526.5	585
	7	64-QAM	5/6	130	144.4	270	300	585	650
	8	256-QAM	3/4	156	173.3	324	360	702	780
	9	256-QAM	5/6	•	•	360	400	780	866.7
3	0	BPSK	1/2	19.5	21.7	40.5	45	87.8	97.5
	1	QPSK	1/2	39	43.3	81	90	175.5	195
	2	QPSK	3/4	58.5	65	121.5	135	263.3	292.5
	3	16-QAM	1/2	78	86.7	162	180	351	390
	4	16-QAM	3/4	117	130	243	270	526.5	585
	5	64-QAM	2/3	156	173.3	324	360	702	780
	6	64-QAM	3/4	175.5	195	364.5	405	•	•
	7	64-QAM	5/6	195	216.7	405	450	877.5	975
	8	256-QAM	3/4	234	260	486	540	1053	1170
	9	256-QAM	5/6	260	288.9	540	600	1170	1300

Understanding 802.11ac and the option module

AP 3600 Radio Module Cisco Part Number (AIR-RM3000AC-x-K9=)

Independent radio module providing 802.11ac support (Wave-1) support within the AP 3600

Features include:

- Complements existing 5 GHz 802.11n radio by providing an independent 802.11ac overlay
- Permits faster throughput for 802.11ac clients by permitting channel bonding up to 80 MHz
- Enhanced denser modulation 256 quadrature amplitude modulation (QAM) up from .11n's 64 QAM
- 3x3 antenna design
- Support for 1, 2, and 3 spatial streams
- SU-MIMO --- Single User Multiple Input Multiple Output
- Explicit Beam Forming
- 1.3 Gbps PHY (Approximately 1 Gbps MAC)

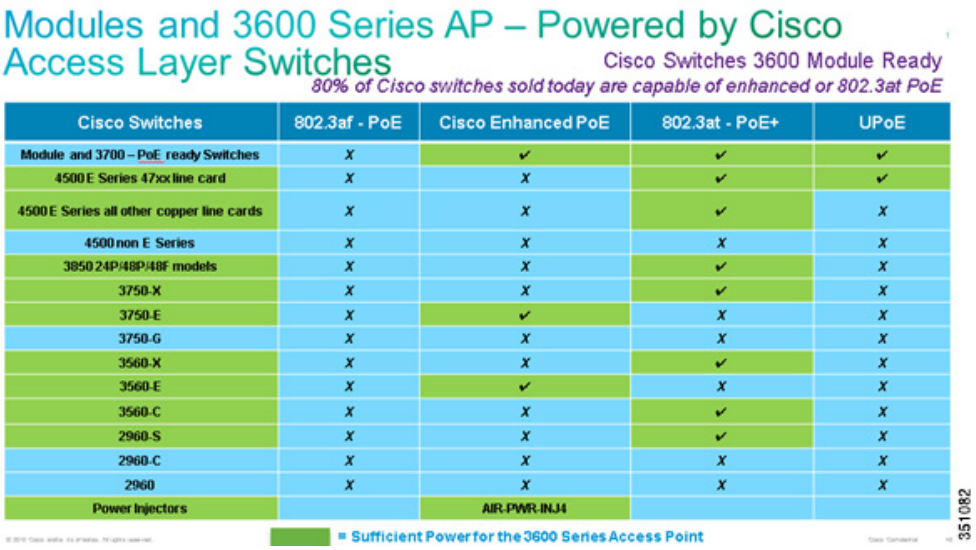
Module details and specifications can be found at the following URL:
http://www.cisco.com/en/US/prod/collateral/modules/ps12859/ps13128/data_sheet_c78-727794.html

Radio Module Operational Overview

With the module installed, the AP 3600 operates three active radios 2.4 GHz and 5 GHz integrated radios (slots 0 and 1) as well as the 802.11ac 5 GHz module which shows up as (slot 2). This additional radio module takes the overall power draw of the Access Point to 18 Watts. If the power being supplied is

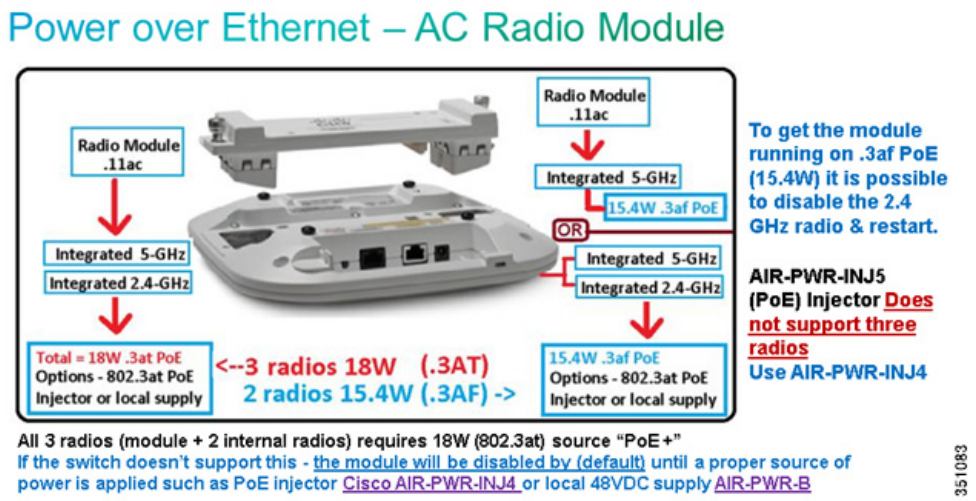
limited (for example 15.4W 802.3af power) the Access Point will come up with the radio module disabled until a suitable source of power is available such as enhanced PoE, 802.3at PoE+, Power Injector for or the Local Power Supply AIR-PWR-B is used.

Figure 65 Switches that support the AP 3600



Should the installer/administrator determine a need to power the module from a 15.4 Watt power source (perhaps it is a high density installation where there is plenty of 2.4 coverage) or the AP is being used to augment areas with 802.11ac where 2.4 coverage is already present – if so, the internal 2.4 GHz radio can be disabled allowing the AP 3600 with 802.11ac module to come up with full power and full functionality. We feel this is a significantly better approach allowing installers to perform full functionality site surveys @ 15.4W (802.11af) rather than compromising RF power and shutting down Spatial Streams and other ports.

Figure 66 Module powering options for low power 802.3af (15.4 Watts)



Because the module antennas are internal, the module radiates much like an AP 3600i would as there are no RF connectors on the module, so the antennas "appear" as they would on the internal models.

Figure 67 Top covers removed from AP and module to show how antennas are mounted

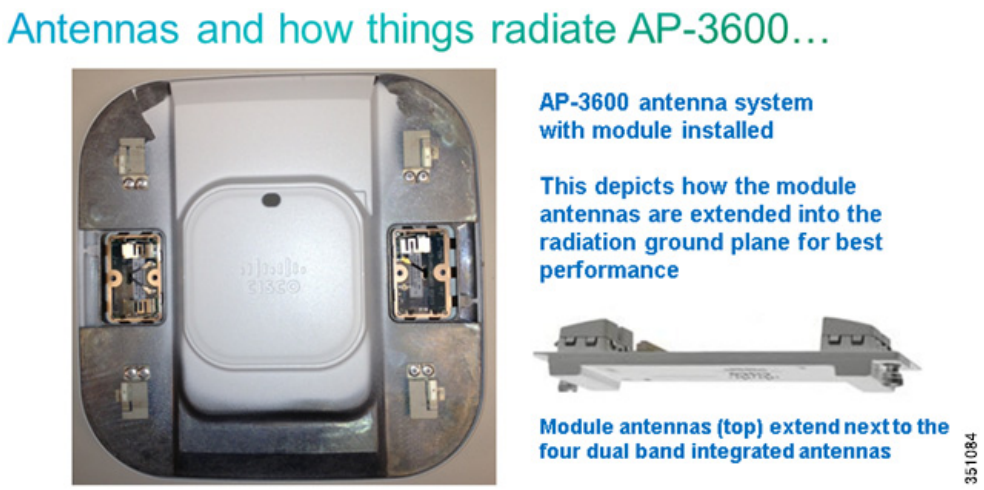
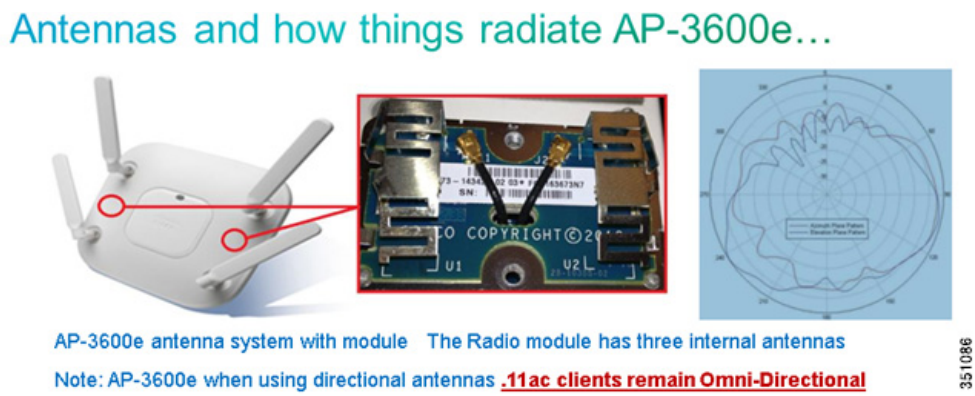


Figure 68 Coverage is optimized for ceiling placement and radiates omni-directionally

If the AP is not mounted on the ceiling but rather on a wall, this may acceptable for smaller deployments such as hotspots, kiosks, transportation or smaller coverage areas but in an enterprise deployment it could cause excessive roams as the signal (think of the diagram above turned on its side) signal can radiate on the floor above and below rather than downward in a uniform 360 pattern. See Figure 20.

If the module is installed in an AP 3600e (with external antennas) the 802.11ac module will still behave as described in Figure 68 and if the dipole antennas are used, the AP will continue to provide an omni-directional coverage pattern. If a patch or other directional or high gain antenna is used, it can create a condition where you have two different coverage patterns. Since both the 5 GHz module radio and the internal 5 GHz 802.11n radio both work together as one “blended” radio it is best to keep cells uniform by using dipoles or by verifying coverage is acceptable for your intended application.

Figure 69 Module antennas are internal to the Access Point and radiate omni-directionally



Because the 5 GHz module operates in the same frequency band as the internal 5 GHz 802.11n radio, both radios have been purposefully designed to work in tandem (think of it as a blended radio) where both radios work as one radio maintaining proper isolation and performance. Unlike the competition, this allows the 802.11ac client to be serviced by the module while legacy a/g and 802.11n clients are serviced by the integrated radios taking full advantage of Client Link 2.0 to beam form without having to try and bounce clients around based on signal strength.

Given the AP has a dual core processor with one core managing the module, similar to the "master/slave" approach that was used with IDE hard drives, the module always takes its direction from the "master" radio, in this case the integrated 802.11n radio. So when performing power and frequency selection for example selecting 80 MHz (802.11ac) channel bonding, the integrate radio and not the module radio sets the "anchor" point where the frequency starts with the module performing the overlay extending the 80 MHz over the existing channel selected by the integrated "master" radio (802.11n radio). Both the integrated radio and the module also share the same SSIDs.

This virtual radio approach requires both radios to be enabled so you cannot disable the integrated 5 GHz radio and just run the .11ac radio module.

Currently in the US, there are 22 (20 MHz) channels, 9 (40 MHz) channels, and 4 (80 MHz) channels. 802.11ac (Wave-2) supports 160 MHz channels but there is only 1 channel available today, this is likely going to get better as the Federal Communications Commission and other regulatory bodies realize the need for more unlicensed spectrum and are actively working to free up more spectrum.

Let's take a look at the frequencies available and how the channel bonding would work.

Figure 70 Current channel allocation plan US Theater.

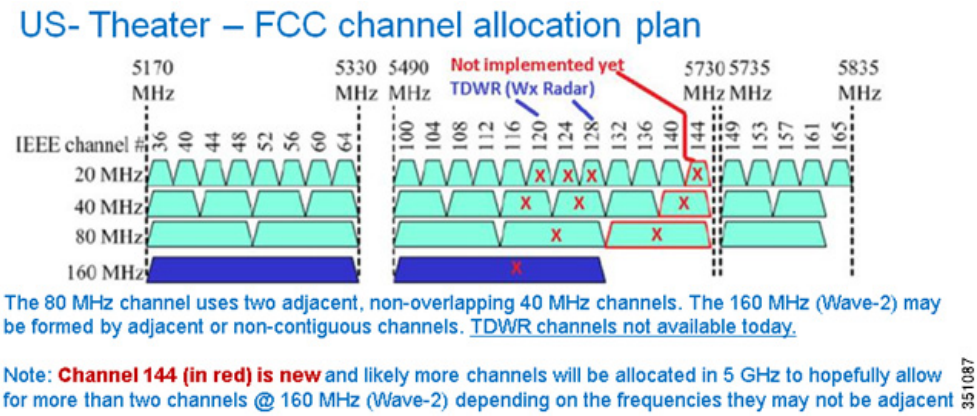
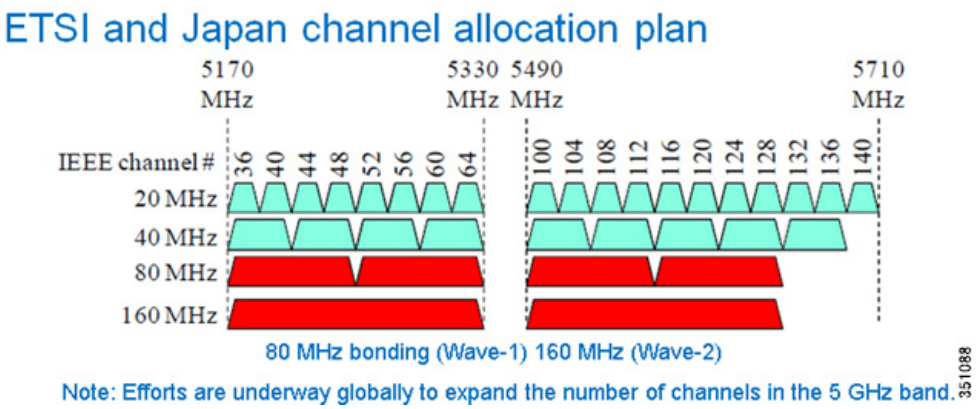


Figure 71 Current channel allocation plan ETSI Theater.



What's in the future as far as spectrum allocation?

- In the US there are currently 22/10/5/1 channels with bandwidth 20/40/80/160MHz channels
- With opening up of 5.35-5.47GHz & 5.85-5.925GHz, the number of channels increases to 34/16/8/3
- If the industry manages to take back the TDWR channels, the number of increases to 37/18/9/4

So as time progresses we should see additional channels becoming available.

Client Band Steering

In order to optimize client performance, 802.11ac clients are able to take advantage of ECBF – Explicit Compressed Beam-Forming a IEEE 802.11ac standardized method of Beam-forming (similar in some ways to Cisco's Client Link) but slightly different as the .11ac client needs to send "sounding information" to the AP and then the AP uses that sounding information (from the client) to best send the signal back to the client using (beam-forming).

Note ECBF only works with 802.11ac clients, Cisco Client Link continues to be used with non-802.11ac clients to improve the overall performance of 802.11n and legacy clients resulting in an improved performance with all clients rather than just 802.11ac clients. This helps maintain solid connections to the AP without having to bounce clients off of the AP using other methods such as signal strength causing needless roaming with the client is not actually engaged in passing traffic.

Note if is it a significant advantage to allow the module to service the 802.11ac clients while the integrated radio services the non-802.11ac clients. Should the 802.11ac client require something the module radio does not support (for example, Cisco Client Extensions "CCX elements" the 802.11ac module will push the client to the integrated radio to service that request.

802.11ac Client Recommendations

At the time of this writing, 802.11ac clients are just now starting to get integrated into smart phones. Devices like Samsung's Galaxy S4, ZTE's Grand Memo and the HTC One phone are early to market 802.11ac devices. It is expected that integrated notebooks and tablets (those devices often supporting 2 and 3 spatial streams) will start to emerge later in the calendar year.

Right now USB adapters and “Workgroup Bridge” like media adapters are available – Here is a partial list, keep in mind new products are being released all the time.

USB clients available today

ASUS Model USB-AC53

D-Link Model DWA-182

Belkin Model F9L1106

Netgear A6200

Buffalo Model WI-U2-866D

Edimax Model EW-7822UAC

Linksys AE6000

PCI - Desktop clients

ASUS Model PCE-AC66

WGB - Like

TRENDnet Model TEW-800MB

Buffalo Model WLI-TX4-1300H

Linksys Model WUMC710

Linksys Model AC1300*

Note The Linksys Model AC1300 is a 3 spatial stream WGB like device with good performance.

Some early observations

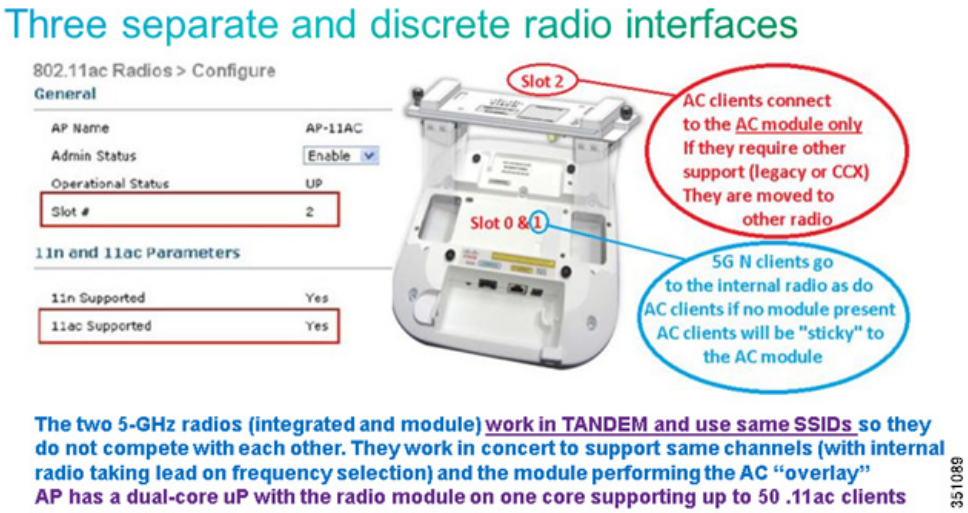
USB clients can appear to be a bit slow (performance) depending on drivers, USB port version, etc. We have also seen some clients that have trouble maintaining an 80 MHz bandwidth in the DFS (Dynamic Frequency Selection) bands. Also, we have observed one USB client that did not work well from a client band steering perspective (meaning we try to send the 802.11ac client to the 802.11ac module) but the client keeps attempting to associate to the integrated 802.11n radio. These are all early client issues and we are actively working with the manufacturers to resolve these early issues and will likely happen with firmware or driver updates.

Radio Interfaces and Understanding Client Associations

As previously mentioned; the Access Point with module has three radio interfaces “slots 0-2” and shares the same RF power characteristics and SSID’s. This permits the both radios to function as a “virtual” or blended radio therefore (RRM controls both the integrated radio and the module radio).

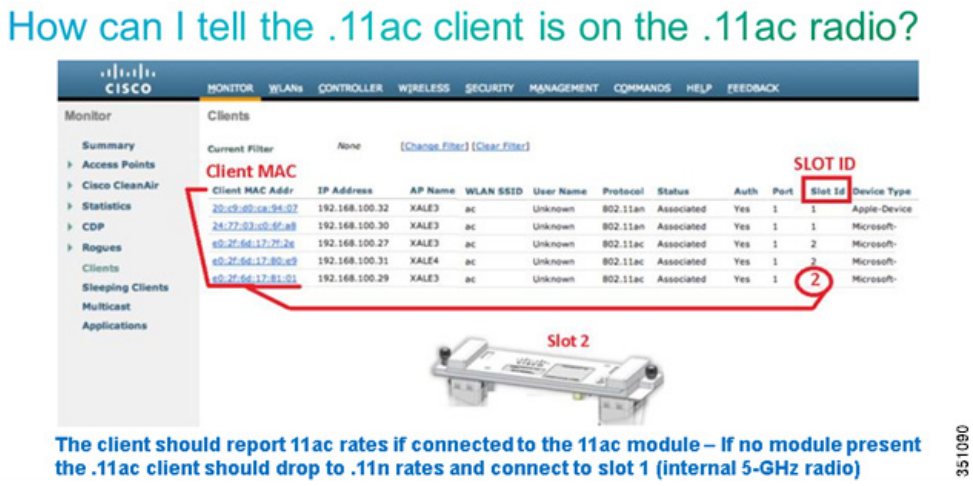
Given there is no “greenfield” 802.11ac mode, RRM, Rogue AP detection and SI (Spectrum Intelligence) all continue to function normally.

Figure 72 Understanding RF radio interfaces



Since 802.11ac is fairly new, having a dedicated module handling the VHT (Very High Throughput) requests makes it easy to see which clients are connected at 802.11ac rates and which 802.11ac clients are actually connecting at 802.11n rates. This is accomplished by observing the SLOT ID.

Figure 73 Understanding client associations



Troubleshooting the module (basics)

Common issues arise because:

- Module isn't screwed down tightly
- Not enough PoE power (requires 802.3at) 18W
- Not configured correctly
- Not understanding the radios operate "together" so you need to configure the radio in slot 1 (5 GHz internal) first

- Not understanding SSID's for both 5 GHz need to be the same and all .11ac clients are sent to the .11ac module

Figure 74 Both thumbscrews need to be tight or power is not applied

Things to look for if the module is not found

- Console will report "module radio found and ok"
- Also console CDP message for Power "Power ok – HIGH POWER inline power source"
- Perhaps remove module – verify AP ok then reinstall
- Module should show up as "slot-2"
- If you suspect PoE (try AIR-PWRB or AIR-PWR-INJ4)
- Module not designed to work with AIR-PWR-INJ5

Some caveats regarding clients connecting to the module

- 802.11ac clients need same type of security as 802.11n to connect
  - WPA/WPA2 with AES or Open
  - CCKM is not supported on this release
- The module radio supports 50 clients in hardware
- 8 keys for multicast traffic one per SSID – 8 keys for 8 SSIDs max on 11ac radio
- 42 keys for the client unicast traffic
- If more than 42 clients are associated, clients will be connected, but throughput for some clients will degrade since encryption/decryption is done in software

Features not supported in the module

MFP – Management Frame Protection

CCX – Cisco Compatible Extensions (Integrated 5 GHz radio handles these requests)

IAPP (used to connect WGBs and their clients) -> no WGB support. Note: You can connect a WGB in WGBu (universal) mode, because it essentially behaves like a standard client, but no WGBC support. Also not supported are SE-Connect, Mesh, Monitor and Autonomous modes

A Quick Look at a few "Non-Optimal" Installations

The pictures below present examples of installations that are not recommended. It is very difficult to provide good Wi-Fi service with a poor installation. Always try to avoid metal and clutter.

Figure 75 Example of an AP installation near metal and clutter (try to avoid metal and clutter)

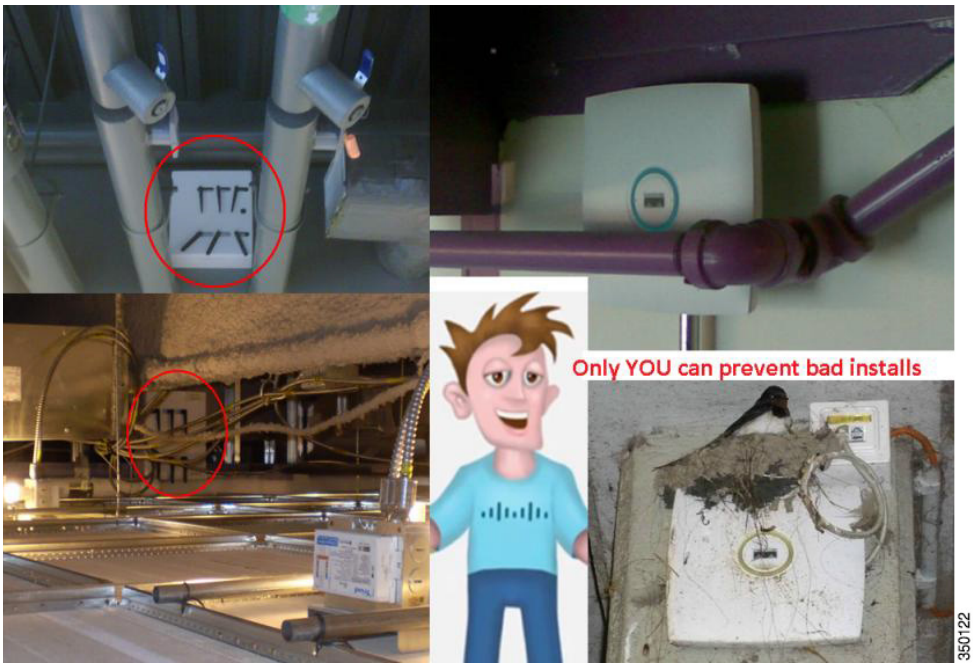


Figure 76 Patch antenna against a metal fence

Figure 77 Example of an AP Installation near metal and clutter (again try to avoid metal and clutter)

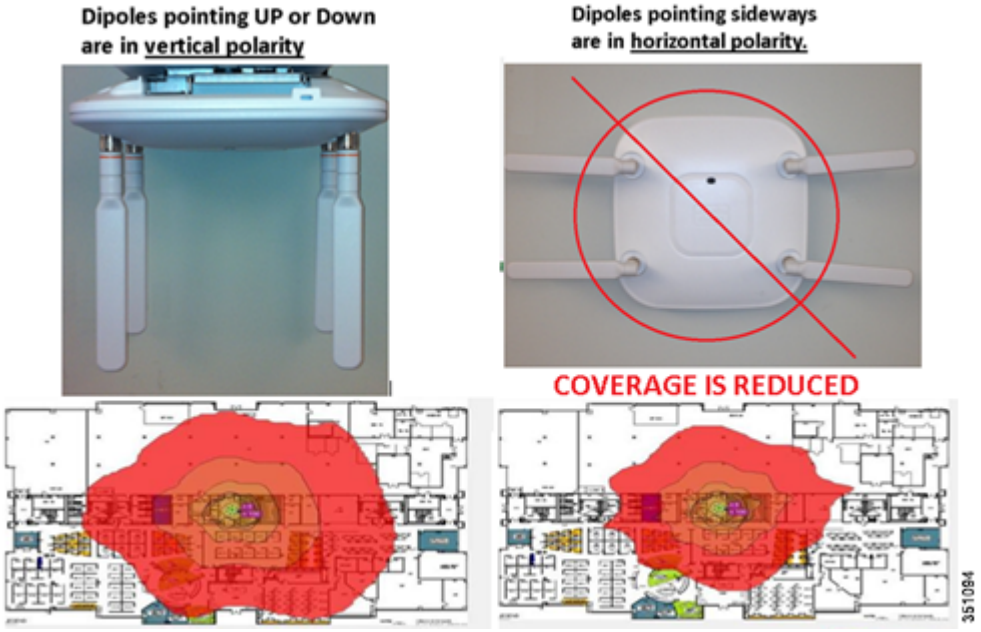
Figure 78 Example of a poor installation - Access Point needs to be level and not swing or move about

Use common sense when mounting devices, AP should be level and secured so that it does not sway or move - Keep the Access Point away from metal objects and try to locate it as close to the users as possible or practical to do understanding aesthetics etc.

Figure 79 Example of a poor installation – Access Point is too high & buried in conductive foil

Remember the best place for an Access Point is as close to the users as possible – Avoid metal or conductive objects in the near field (they cause the radio waves to become directional and increases nulls (dead spots). If you must mount the AP in a high ceiling, look at directional antennas to direct (angle down) the signal to the intended target area and always mount dipoles in the correct orientation.

Figure 80 When using dipole antennas observe the correct orientation (vertical polarity)



Tip When mounting antennas outside, always mount with the WIRES DOWN and never obstruct or put weather proofing material over the drain holes.

Figure 81 Always mount antennas outdoors with leads DOWN (indoors does not matter)

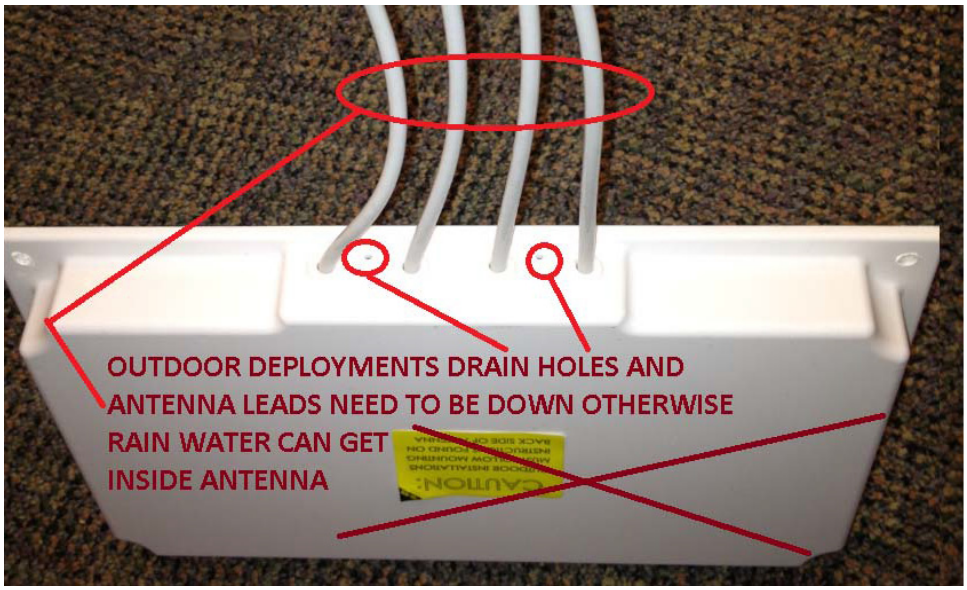


Figure 82 If antenna connectors are exposed to weather – Coax-Seal should be used but if present, do not cover antenna drain holes.

Misc. Questions and Answers

Q. Which AP is best for manufacturing and warehouse areas?

A. Generally speaking the AP 2600e or 3600e would be my first choice as these external antenna models have the highest operating temperature range -20 to 55C. The AP 1600 can also be used but has a slightly lower operating temperature -20 to 50C. If temperature is not a concern then the internal antenna "I" series 1600, 2600 and 3600 may be used.

Q. What if I am in a country where the regulatory agency may not approve the AP to be used outdoors because of UNII-1 band restrictions or I wish to use higher gain antennas?

A. Consider deploying the Cisco Mesh products (1550 series) or look for Access Points ending in "P" for professional install, such as the 3502P series or our outdoor bridging products.

Q. Which AP is best for high density deployments?

A. Both the 2600 and 3600 have virtually identical AP density for coverage based design. Capacity-based designed (smaller-cells) will yield a slightly higher average cell capacity with the 3600 using 3-spatial stream devices and of course an even higher density when using the optional 802.11ac module.

Q. Cisco has a newer Power Injector (AIR-PWR-INJ5) how is this different from the (AIR-PWR-INJ4)?

A. The newer AIR-PWR-INJ5 is a low cost injector for use with the AP 1600 and AP 2600 Series Products. It is an 802.3af (15.4W injector) the AIR-PWR-INJ4 is a more power injector designed to work with the AP 3600 when optional modules are used. The AIR-PWR-INJ5 can be used with the AP 3600 but not if the optional module is used.

Q. Can industrial wireless motion or smoke detectors cause WLAN interference?

A. Yes, some products like United Technologies DD475 and Optex MX-50 operate in the 2.4 GHz band as do other wireless "chimes", cameras and other industrial equipment from other manufacturers.

Q. How much power in Watts does the AP 3600 draw when an option module is used?

A. 18 Watts – AP 3600 draws slightly more than 802.3af (15.4W) with the module installed. Powering options include 802.3at PoE+, local Power Supply AIR-PWR-B or injector AIR-PWR-INJ4. If performing Surveys or 2.4 GHz support is not needed, that radio may be disabled allowing the module to have full power and functionality using 802.3af (15.4 Watts)

Q. What is the Ethernet requirement for 802.11ac (Wave-1)?

A. A single GbE cable is fine for Wave-1. While it is true 802.11ac (Wave-2) will exceed GbE speeds, there is no need or requirement for cabling greater then GbE for 802.11ac Wave-1. Installers wishing to future proof new installations should consider pulling CAT-6a cables <at least 1> and either another CAT6a or a CAT5e cable (this allows you to fall back to 2 GbE ports) for some iterations of Wave-2 and/or support 10GbE should this emerge as the method. 10GbE has some challenges such as PoE standardization – Again for the foreseeable future a single GbE is all that is needed.

Q. Is it true that 802.11ac is coming in "waves" and that new hardware is required for each "wave"?

A. The first iteration of 802.11ac (Wave-1) is available today, and both Wave-1 and Wave-2 requires new hardware to take advantage of the new features in each "wave" or iteration. Fortunately, with a modular AP approach like the AP 3600, upgrading to Wave-1 today is easy. Also unlike the competition, both the AP 3600 and newer Cisco Access Points in the future with modular support will make upgrading to Wave-2 a painless process without having to perform a complete rip and replace.

Q. With the 802.11ac Module installed in the AP3600, will all 3 radios be active?

A. Yes. All 3 radios will be active

The 2.4 GHz radio continues to support legacy b/g clients as well as n clients. The two 5 GHz radios (integrated + module) will work in tandem so they are not competing with each other but working in concert to support the same channels. For instance:

- The 802.11ac module adopts an 80 MHz wide channel on 100-104-108-112
- The 802.11a/n integrated radio operates on Channels 100-104 and a 40 MHz wide channel for 802.11n clients, and 802.11a clients communicate with the integrated radio via Channel 100 and a 20 MHz wide channel

The AP3600 with the new 802.11ac module installed, will provide concurrent support for both the 2.4 and 5 GHz bands and support for 802.11 a, b, g, n and new 802.11ac clients.

Note On the 5 GHz side, it is possible to have a 20 MHz wide 11ac channel and a 40 MHz wide 11n channel, the only requirement is that the primary channel should be the same for both slots and is determined by the primary channel setting on the integrated 11n radio.

Q. Can both 5 GHz radios (integrated and 802.11ac module) be on different channels?

A. No. The two 5 GHz radios will work together on the same channels, which allows the 5 GHz radios to not compete with each other and allows us to maximize the number of clients supported per radio. The primary (integrated .11n radio) will take the lead with the module radio “extending” or bonding from the primary channel set on the integrated radio.

Q. Any other thoughts when installing wireless Access Points?

A. When doing wireless installations, keep the following guidelines in mind:

- It is all about placing the AP as reasonably close to the actual users as possible,
- Making sure you have coverage, (to a known requirement) and compensating for nulls or dead spots regardless of what product you choose to deploy - This is called a site survey.
- Installations should be done based on lessons learned from the site survey – the better the survey the less likely connectivity problems will occur.
- Cisco has an advanced services team that can perform WLAN surveys or help with the wireless design if a partner is not available or able to do same.
- When possible, use Cisco brand antennas listed in this paper (with the orange band)
- Use common sense - don’t mount antennas against metal objects. Similar to a light bulb, antennas work best when there are no obstructions in the path.
- AP 1600, 2600 and 3600 are not weatherproof and has an IP rating of 40.

URL Links and Other Resources

AP 3600 datasheet

http://www.cisco.com/en/US/products/ps11983/index.html

AP and controller datasheets

http://www.cisco.com/en/US/products/hw/wireless/index.html

Cisco antenna reference guide

http://www.cisco.com/en/US/prod/collateral/wireless/ps7183/ps469/product_data_sheet09186a008008883b.html

Why buy Cisco brand antennas

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/white_paper_c11-671769.pdf

Understanding antenna patterns and their meanings

http://www.cisco.com/en/US/prod/collateral/wireless/ps7183/ps469/prod_white_paper0900aecd806a1a3e.html

Cisco Guest Access Deployment Guide

http://www.cisco.com/en/US/docs/wireless/technology/guest_access/technical/reference/4.1/GAccess_41.html

Cisco Schools WLAN Deployment Guide

http://www.cisco.com/en/US/docs/solutions/Verticals/Education/SRA_Schools/schoolSRA_wlan_sba.pdf

The Apple Bonjour / Apple TV Deployment Guide

http://www.cisco.com/en/US/products/hw/wireless/ps4570/products_tech_note09186a0080bb1d7c.shtml

Optimizing Enterprise Video Over Wireless LAN

http://www.cisco.com/en/US/prod/collateral/wireless/ps6302/ps8322/ps10315/ps10325/white_paper_c11-577721.html

Cisco 7925 IP Phone deployment guide

http://www.cisco.com/en/US/docs/voice_ip_comm/cuipph/7925g/7_0/english/deployment/guide/7925dply.pdf

Cisco Mobility Services Engine – WLAN location deployment guide

http://www.cisco.com/en/US/products/ps9742/products_tech_note09186a00809d1529.shtml

WLAN Design Guide for High Density Client Environments in Higher Education

http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps10981/design_guide_c07-693245.pdf

Mobility Design Guides

http://www.cisco.com/en/US/netsol/ns820/networking_solutions_program_home.html

Software support and downloads

http://www.cisco.com/tac