



Cisco Aironet 1600/2600/3600 Series Access Point Deployment Guide



Abstract

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

- AP 1600, 2600, and 3600
- Differences between the AP 3600 and the AP 3500
- Differences between the AP 3600 and the AP 2600
- Introduction of the AP 1600 and AP feature comparison
- Hardware details, mounting options, bracket choices, and installation considerations
- Antenna options, radiation patterns, and external antenna deployments
- Spatial streams and MCS rates
- ClientLink 2.0 and Bring Your Own Device (BYOD)
- Site survey considerations
- Inappropriate installations, Questions and Answers, 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.

Revision History

Document Number:	EDCS-1188900 (replaces EDCS-1130881)
Document Author:	Frederick Niehaus (fredn)
Author's Organization:	WNG (WNBU) TME
Document Date / Version:	12/12/12 version 3.0

Table of Contents

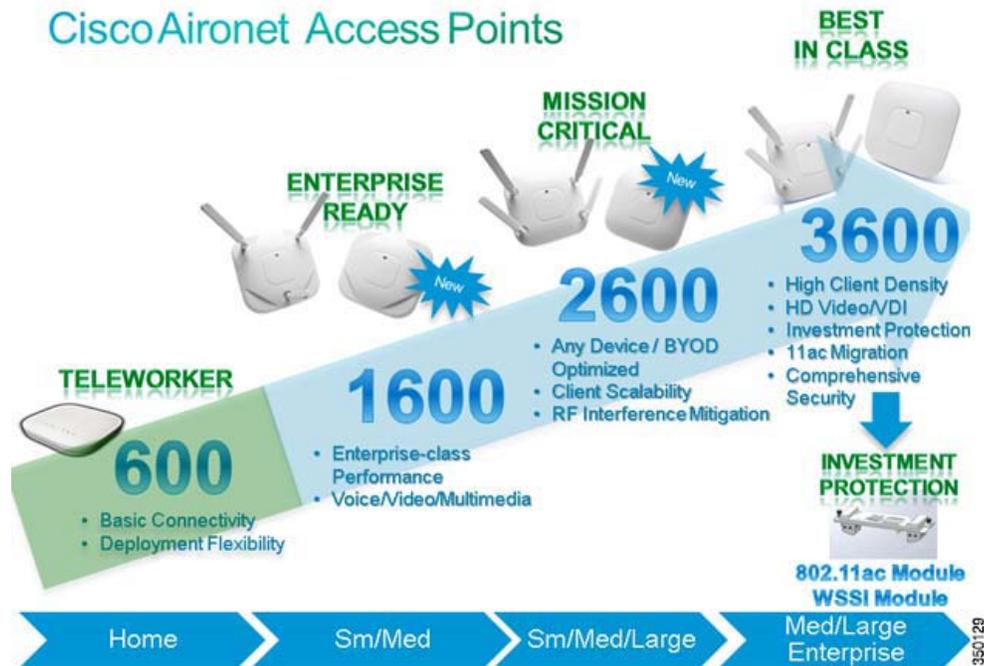
- [Revision History](#)
- [Cisco Aironet Series Access Points](#)
- [Cisco Aironet Series Access Points](#)
 - [Internal and External Antennas](#)
 - [3600 Series](#)
- [Feature Modules for the 3600 Series](#)

- Comparison of the 3600 and 3500 Series
 - Comparison of the 3600 and 2600 Series
 - Introduction to the 1600 Series
 - Key Features
 - Cisco CleanAir Express for AP 1600
 -
- Hardware and Mounting Options
 - Brackets and Clips
 - Channel Rail Adapters
 - Installation in Ceiling Tiles
 - Installation on Walls
 - Color
- Unique Installations
 - Clean Rooms
 - Above Ceiling Tiles
 - Stadium and Harsh Environments
 - Areas with High Vibration
 - Warehouse and Factory
 - Ethernet Cable Recommendation
 - Antenna Cable Recommendation
 - Access Point Spacing Recommendations
 - IDF Closets (Telecommunications or Other Electrical Equipment)
 - Very High Altitudes
 - Common or Distributed Antenna System (DAS)
 - Elevators
- External Antenna Options and Patterns
 - AP 1600/2600 and AP 3600e
 - AP 3600i, AP 2600i, and AP 1600i
- External Antenna Deployments
- 802.11n, Spatial Streams, and Beamforming
 - Clients That Support Three Spatial Streams
 - Beamforming in ClientLink 1.0 and 2.0
- Site Survey Considerations
- General Guidelines
- Examples of Improper Installations
- Questions and Answers
- Useful URLs

Cisco Aironet Series Access Points

Cisco Aironet 3600, 2600, 1600, and 600 Series Access Points (APs) provide highly secure and reliable wireless connections for both indoor and outdoor environments. Figure 1 illustrates the product portfolio, which ranges from the entry-level 600 Series for basic connectivity to the 3600 Series for best-in-class performance.

Figure 1 Access Point Portfolio Placement



Internal and External Antennas

The 3600, 2600, and 1600 Series offer models with internal or external antennas. Figure 2, Figure 3, and Figure 4

describe the internal and external antenna models for each series.

- APs with internal antennas have an “i” (for example, AP 3600i) in the model number. They have captured antennas, which are part of the housing and not removable, and are designed for indoor enterprise installations where office aesthetics are a primary concern.
- APs with external antennas have an “e” (for example, AP 3600e) in the model number. They are more rugged and are designed for industrial use in locations such as hospitals, factories, warehouses, and other locations where there is a need for external antennas or extended operating temperatures. The external antenna models also support mounting inside NEMA enclosures for use in the most demanding environments.

Figure 2 AP 3600 Models and Eco-Packs

<ul style="list-style-type: none"> • Aironet 3600i Access Point • For highly visible indoor installations and office environments 	<ul style="list-style-type: none"> • Aironet 3600e Access Point • For factories, warehouses and other industrial environments
 <ul style="list-style-type: none"> • Attractive, high-quality design • Internal dual-band integrated antennas 	 <ul style="list-style-type: none"> • Rugged metal enclosure • External dual-band antennas – <i>Sold separately</i> • Extended operating temperature
<p>AIR-CAP3602I-X-K9 Dual-band 802.11 a/g/n controller-based access point</p> <p>AIR-CAP3602I-XK910 10 Pack 802.11 a/g/n controller-based access point</p>	<p>AIR-CAP3602E-X-K9 Dual-band 802.11 a/g/n controller-based access point</p> <p>AIR-CAP3602E-XK910 10 Pack 802.11 a/g/n controller-based access point</p>

350130

Figure 3 AP 2600 Models and Eco-Packs

<ul style="list-style-type: none"> • <u>Aironet</u> 2600i Access Point • For indoor installations and office environments 	<ul style="list-style-type: none"> • <u>Aironet</u> 2600e Access Point • For factories, warehouses and other industrial environments
 <ul style="list-style-type: none"> • <u>CleanAir</u> Technology • ClientLink 2.0 • Attractive, high-quality design • Internal dual-band integrated antennas 	 <ul style="list-style-type: none"> • <u>CleanAir</u> Technology • ClientLink 2.0 • Ruggedized enclosure • 4 External dual-band antennas – <i>Sold separately</i> • Extended operating temperature
<p>AIR-CAP2602I-x-K9 Dual-band 802.11 a/g/n controller-based access point</p> <p>AIR-CAP2602I-xK910 10 Pack 802.11 a/g/n controller-based access point</p> <p>AIR-SAP2602I-x-K9 Dual-band 802.11 a/g/n Standalone access point</p> <p>AIR-SAP2602I-xK9-5 5 Pack 802.11 a/g/n standalone access point</p>	<p>AIR-CAP2602E-x-K9 Dual-band 802.11 a/g/n external antenna controller-based access point</p> <p>AIR-CAP2602E-xK910 10 Pack 802.11 a/g/n external antenna controller-based access point</p> <p>AIR-SAP2602E-x-K9 Dual-band 802.11 a/g/n external antenna Standalone access point</p> <p>AIR-SAP2602E-xK9-5 5 Pack 802.11 a/g/n external antenna Standalone access point</p>

350131

Figure 4 AP 1600 Models and Eco-Packs

Aironet 1600i Access Point		Aironet 1600e Access Point	
<ul style="list-style-type: none"> For entry-level 802.11n indoor installations and office environments 		<ul style="list-style-type: none"> For entry-level 802.11n factories, warehouses and other industrial environments 	
 <ul style="list-style-type: none"> Attractive, high-quality design and RF performance Clientlink 2.0 Internal dual-band integrated antennas 		 <ul style="list-style-type: none"> Extended operating temperature Clientlink 2.0 3 External dual-band antennas (Sold separately) Attractive, high-quality design and RF performance 	
List Price: \$695		List Price: \$795	
AIR-CAP1602I-x-K9	Dual-band 802.11 a/g/n controller-based access point	AIR-CAP1602E-x-K9	Dual-band 802.11 a/g/n controller-based access point
AIR-CAP1602I-x-K910	10 Pack 802.11 a/g/n controller-based access point	AIR-CAP1602E-x-K910	10 Pack 802.11 a/g/n controller-based access point
AIR-SAP1602I-x-K9	Dual-band 802.11 a/g/n Autonomous access point	AIR-SAP1602E-x-K9	Dual-band 802.11 a/g/n Autonomous access point

350132

3600 Series

The Cisco 3600 Series Access Point (AP 3600) targets customers who require 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. See the section on [802.11n, Spatial Streams, and Beamforming](#) for more on spatial streams.

Feature Modules for the 3600 Series

The WSSI (Wireless Security and Spread Spectrum Intelligence) module adds new functionality to the AP 3600 to protect customer investment. This optional, add-on module provides a dedicated monitor radio to scan the full spectrum, not just the channel on which the AP operates. It offloads complete monitoring and security services to the monitor module, including CleanAir, WIDS/WIPS, Context-Aware Location, Rogue Detection, and Radio Resource Management (RRM). The WSSI module allows for full spectrum analysis on all channels on both the 2.4 and 5 GHz bands. It avoids the need to deploy a separate, dedicated overlay network for full spectrum monitoring and eliminates the need for an extra cable pull and additional infrastructure costs.

The second available module provides 802.11ac (wave-1) functionality to the AP 3600. This radio module operates at 5GHz and allows the AP 3600 to fully support 802.11a/n along with 802.11ac clients. (Wave-1) functionality supports a 1.3 Gbps PHY / ~1 Gbps MAC (throughput) using three spatial streams, 80 MHz, 256 QAM. It also supports Explicit Beamforming per the 802.11ac standard. Use of the radio module may require a local power supply, Cisco power injector, .3at PoE+, or use of the Cisco Enhanced PoE because the module may draw power greater than 15.4W.

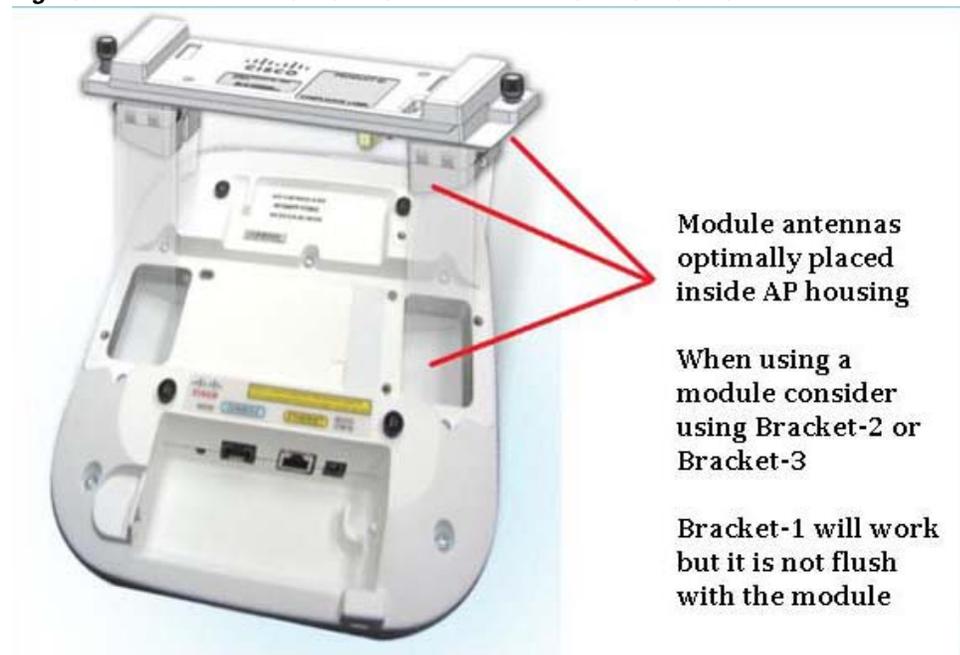


Note

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

Feature modules slide into the bottom of AP 3600, as shown in [Figure 5](#).

Figure 5 Back View of the AP 3600 with Feature Module



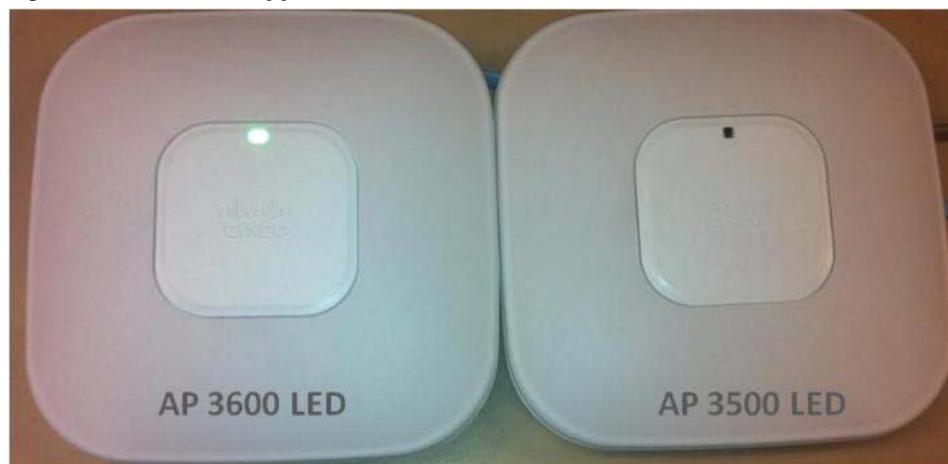
Note

Please refer to the [Installing the Module](#) section of the [Installing the Cisco Aironet 3600 Series Access Point 802.11ac Radio Module](#) guide for more details.

Comparison of the 3600 and 3500 Series

The AP 3600i (internal antenna model) and the Cisco 3500 Series Access Point (AP 3500) are almost identical in physical appearance. To easily distinguish them, note that the LED for the AP 3500 is square, while the AP 3600i has an LED that is slightly larger and more oval. (See [Figure 6](#).)

Figure 6 LED Appearance in the AP 3600i and the AP 3500



From a side view, the AP 3600i is slightly thicker (2.11”) than the AP 3500 (1.84”), as shown in [Figure 7](#). The thicker size allows for additional radio support and printed circuit board area, as well as feature modules for future capabilities. While the AP 3600i has a little more depth, it is completely backward compatible with the mounting brackets for the existing Cisco Aironet 1040 Series Access Point (AP 1040), 1140 Series Access Point (AP 1140), 1260 Series Access Point (AP 1260), and the AP 3500.

Figure 7 Side View of the AP 3600i and the AP 3500



The external antenna models (the AP 3600e and the AP 3500e) differ in appearance because the AP 3600e has fewer antenna connector ports, primarily due to the dual-band antenna system.

The AP 3600e has combined all the antenna ports (dual-band) so that each antenna port can transmit simultaneously on each band; if the antenna ports were not combined, this would have required eight antennas. The AP 3600 has four transceivers (transmitter/receiver) radio ports per band for a total of eight transceivers, 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 one, two, and three spatial streams.



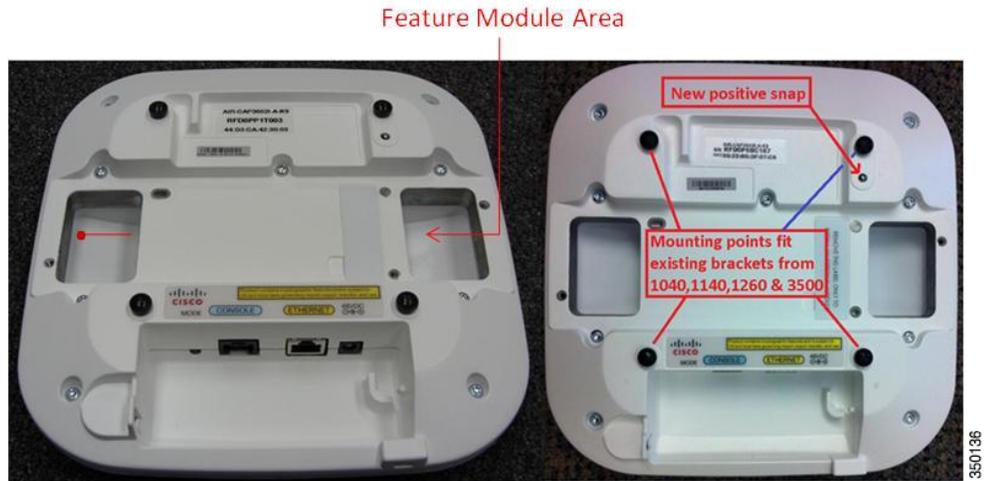
Note

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

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.

Unlike the AP 3500, the newer AP 3600 design supports an optional, add-on feature module. The bottom of the AP 3600 has openings to support the feature module, as shown in [Figure 8](#). The openings, while fully sealed, permit the module to have access to the top of the AP, which allows the module antennas (if present) 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 8 Bottom View of the AP 3600 with Support for a Feature Module



Comparison of the 3600 and 2600 Series

The AP 3600 has a modular design that offers future protection with optional .11ac and security modules. The AP 2600 does not support optional modules. However, the AP 2600 does have a slightly higher antenna gain in the 2.4 GHz band.

The AP3600 and the AP2600 are the same size, but it is easy to identify each one by noting whether the Cisco logo has an embossed frame (AP 3600) or not (AP 2600). (See [Figure 9](#).)

Figure 9 Front View of the AP2600 and the AP 3600



The AP 2600 from the front is identical to The AP 3600 except the logo has an embossed frame around it.

This allows you to identify it visually as an AP 2600



350137



The AP 2600 from the front is identical to The AP 3600 except the logo has an embossed frame around it.

This allows you to identify it visually as an AP 2600



350137

The AP 2600 is a 3X4:3SS, so ClientLink does not beamform to 3SS clients; however, it does beamform at legacy, one, and two spatial stream rates. The AP 3600 is a 4X4:3SS, supporting an extra transmitter chain for additional downlink performance for all bands and clients. The AP 3600 has slightly higher performance and beamforms to legacy, one, two, and three spatial stream rates and .11ac rates when using the optional .11ac module.

The two series use the same mounting hardware and antennas. See [Figure 10](#) for a back view.

Figure 10 Back View of the AP 2600



Because of these similarities, there is no need to repeat a site survey for the AP 2600 if a survey exists for the AP 3600.

Introduction to the 1600 Series

The Cisco Aironet 1600 Series Access Point (AP1600), shown in [Figure 11](#), is a second generation, entry-level AP.

Figure 11 **AP 1600**



Key Features

Significant features include:

- ClientLink 2.0
 - Adds a key function when upgrading from the AP 1040/1140 and the AP 1260
 - Supports 802.11n clients up to 1-SS
 - Supports 802.11a/b/g clients
 - Supports (beam-form) up to 32 clients per radio interface
- 3x3:2 architecture
 - Better performance than the 2x2:2 AP 1040
 - Better throughput performance than the AP 1140 and the AP 1260
- External antenna model for entry-level and mid-level market
- Up to 128 clients per radio for a total of 256 clients
- Different LED color change compared to earlier access points
- CleanAir Express – Basic Spectrum Analysis available in version 8.0 and later

Cisco CleanAir Express for AP 1600

Cisco CleanAir Express technology is enabled on the advanced silicon design of the AP 1600. With CleanAir Express, the AP 1600 has the ability to effectively detect RF interference, identify the source, locate it on a map, and make automatic adjustments to optimize wireless coverage. With CleanAir Express technology, organizations have a basic spectrum analysis capability to support their wireless networks while simplifying ongoing operations. (See [Table 1](#).)

Table 1 Comparison of CleanAir Features in the 1600/2600/3600 Series

Spectrum Intelligence			
	CleanAir Express¹	CleanAir	CleanAir with WSSI
Access Point	AP 1600 ¹	AP 2600 or AP 3600	AP 3600 with WSSI Module
Detection	Yes	Yes	Yes
Classification	Yes	Yes	Yes
Mitigation	Yes	Yes	Yes
Location	Yes	Yes	Yes
Performance Optimized		Yes	Yes
Top Impacts and Severity List		Yes	Yes
Alert Correlation		Yes	Yes
Air Quality Index		Yes	Yes
Zone of Impact		Yes	Yes
Off Channel Scanning			Yes
Proactive Intelligent Channel Switching			Yes

1. Available with 8.0 and higher versions of software.

Identifying the differences between CleanAir and CleanAir Express as it applies to the Cisco Aironet 1600 Series Access Point:

- CleanAir Express is currently available and requires controller code 8.0 or later. CleanAir Express is a fully functional version of Cisco Systems CleanAir.
- The main difference with CleanAir Express is that the Cisco Aironet 1600 Series Access Point (sometimes referred to as the 1K series) has less dedicated memory for local CleanAir operations and so the 1600 Series needs to off-load portions of the Spectrum Intelligence (SI) functions on the 1K series to host memory.
- The Cisco 2K and 3K series have higher memory and processes the SI functions locally.
- The AP 1600 contains the Cisco custom silicon CleanAir hardware chip and therefore can recognize all the interferers that the 2K and 3K series Access Point can recognize.
- The core differences or limitations with CleanAir Express centers around the limitation of core memory and processing power within the AP 1600. For this reason, the AP 1600 can only track 3 devices per radio interface, where the 2K and 3K series can track 10 devices per radio.
- When scanning in monitor mode, 2K and 3K series Access Points can scan processing spectrum in 40 MHz segments and therefore those Access Points can spend less time in the scan cycle looking for interferers (11.4%) compared to the AP 1600 (1K series) that must process the spectrum looking at a smaller 20 MHz segment at a time and therefore the scan cycle is a bit longer at 22.8%.
- If the scan cycle is longer, then the detection time for other monitoring functions such as wIPS, rogues, and so on is extended.

Comparison of Indoor Access Points

A comparison of the indoor access points for the 3600/2600/1600/600 Series is shown in [Figure 12](#).

Figure 12 Comparison of the 3600/2600/1600/600 Series

Cisco Aironet Indoor Access Point Comparison Matrix

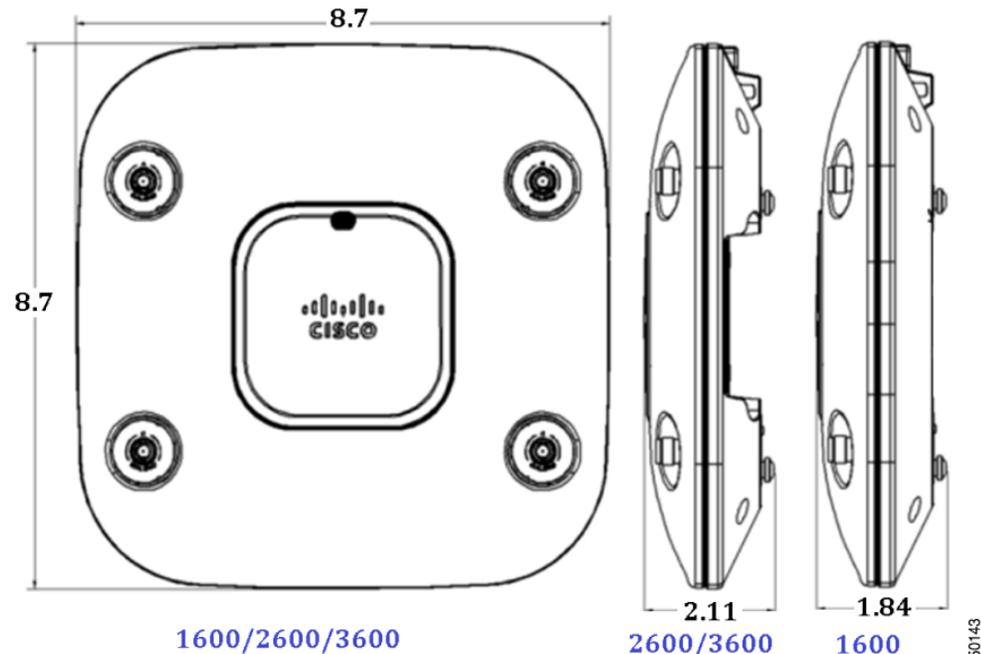
	3600 Series	2600 Series	1600 Series	600 Series
Max Data Rate	1.3 Gbps	450 Mbps	300 Mbps	300 Mbps
Radio Design MIMO:Spatial Stream	11n: 4x4:3 11ac: 3x3:3	3X4:3	3X3:2	2X3:2
CleanAir	Clean Air	Clean Air	Clean Air Express	
ClientLink (No. of Clients **)	ClientLink 2.0 (128) EBF for 802.11ac	ClientLink 2.0 (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 802.3af 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

350142

Hardware and Mounting Options

The AP 1600, 2600, and 3600 have the same mounting options and share similar dimensions, as shown in [Figure 13](#). There are slight cosmetic differences; for example, there are three antennas on the AP 1600.

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

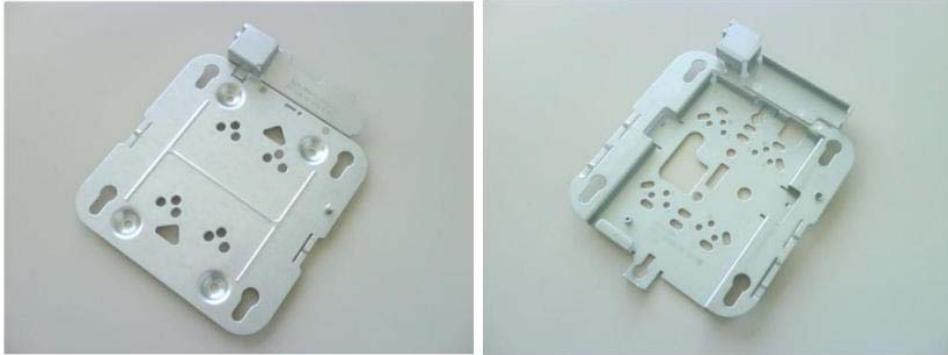


Brackets and Clips

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. When ordering, the customer may choose either a low-profile or a universal bracket; both are shown in [Figure 14](#). Each bracket is a zero-dollar (\$0) option at the time of configuration.

If the customer does not choose a bracket, the default is the low-profile AIR-AP-BRACKET-1, which is the most popular bracket for ceiling installations. For the AP 3600, Cisco recommends using the universal bracket, part number AIR-AP-BRACKET-2.

Figure 14 *Access Point Bracket Choices*



AIR-AP-BRACKET-1
AP Bracket: Low-Profile

AIR-AP-BRACKET-2
AP Bracket: Universal

350144

If the AP needs to be mounted directly to a ceiling on the gridwork, AIR-AP-BRACKET-1 mounts flush and has the lowest profile. Since some ceiling tiles are recessed, two different styles of ceiling clips, recessed and flush rails, are available to mount the bracket to the ceiling gridwork. (See [Figure 15](#)).

Figure 15 *Recessed and Flushed Ceiling Grid Clips*



AIR-AP-T-RAIL-R
Ceiling Grid Clip (Recessed)

AIR-AP-T-RAIL-F
Ceiling Grid Clip (Flush)

350078

If the AP needs to be mounted to an electrical box, to another type of wiring fixture, inside a NEMA enclosure or on a wall, the 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.

Channel Rail Adapters

When mounting APs to ceiling channel rails, such as those shown in [Figure 16](#), use the optional channel adapter. The AIR-CHNL-ADAPTER comes in a two-pack, slides onto the channel rails, and attaches to the ceiling grid clips described above. [Figure 17](#) and [Figure 18](#) show the channel rails, channel adapter, ceiling grid clip, and finished installation.

Figure 16 Channel Rails

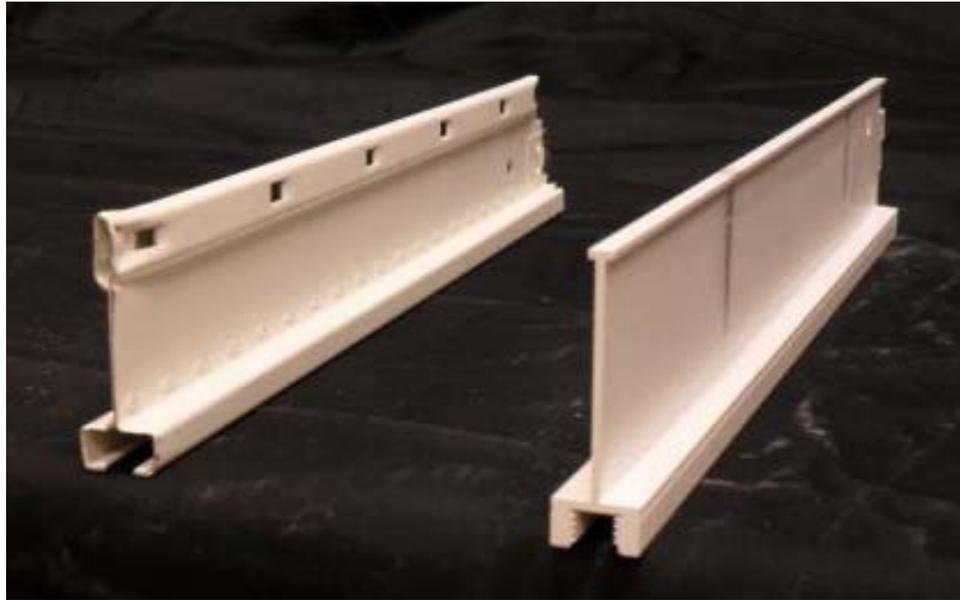


Figure 17 AIR-CHNL-ADAPTER (left); Channel Rails (right)

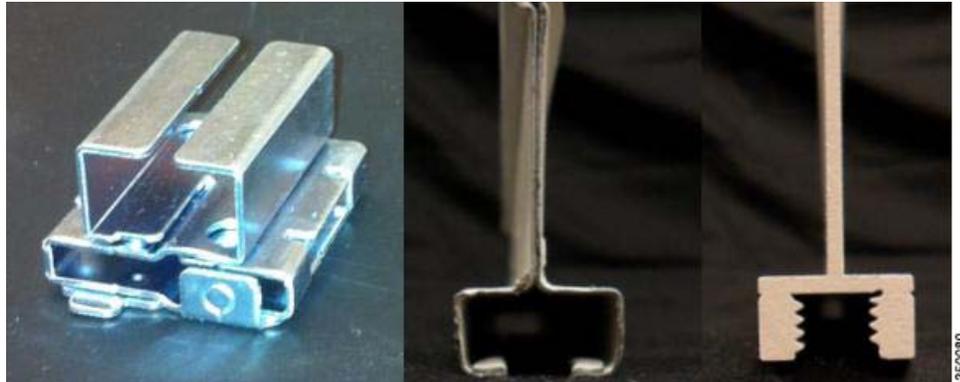


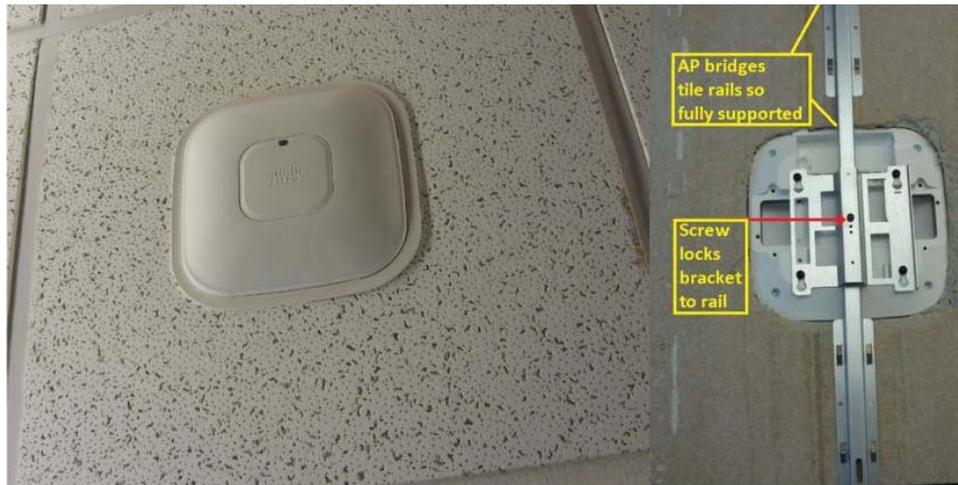
Figure 18 AIR-CHNL-ADAPTER and Ceiling Grid Clip (left); Finished Installation (right)



Installation in Ceiling Tiles

Many hospitals and other carpeted enterprise environments prefer a more streamlined look and wish to install the AP directly into the tile. In this case, use the optional Cisco AIR-AP-BRACKET-3, as shown in [Figure 19](#).

Figure 19 Optional AIR-AP-BRACKET-3 for Installation of APs into Ceiling Tiles



Use the “beauty ring” as a template to cut the tile. Cisco does not offer custom cut tiles but the tiles are easy to cut with a carpet knife or electric tool such as the Dremel™ or Rotozip™ rotary cutting tool.

A metal rail that extends the length of the tile supports the AP above the ceiling if the tile becomes wet or otherwise fails. A mechanical set screw pulls the AP tight to the ceiling and locks it into the bracket. Additionally, a Kensington style lock can be used for physical security of the AP, but, once installed, it is difficult to remove the AP without removing the tile since the AP does not slide out from the front side of the tile.



Note

This bracket fits the AP 1040, 1140, 1260, 1600, 2600, 3500, and 3600.

Installation on Walls

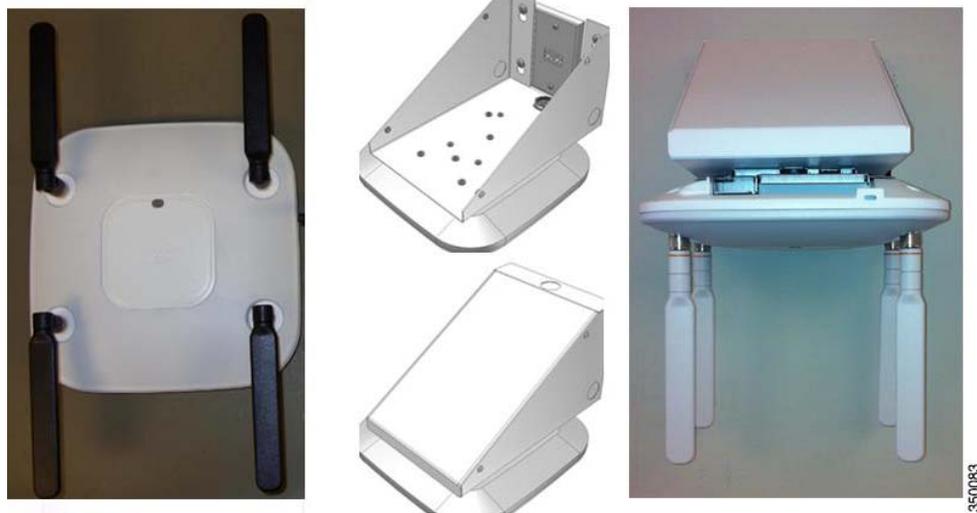
Walls can be a physical obstacle to the wireless signal and may compromise 360 degree coverage. If the wall is an outside wall or if the goal is to send the signal in a 180-degree pattern rather than a 360-degree pattern, a directional antenna (often referred to as a patch antenna) used with the AP 3600e may be a better choice.

Avoid wall-mounting APs with internal antennas such as the AP 3600i. The internal antenna model is designed to mount to a ceiling to provide 360-degree coverage. If wall-mounted in a non-horizontal orientation, the signal may penetrate floors and ceilings. This causes unintended coverage and may result in additional, needless roaming access when, for example, a user with Wi-Fi phone walks on an adjacent floor.

Instead of wall-mounting APs with internal antennas, you can:

- Use the AP 3600e with dipoles or patch antennas.
- Use an optional wall mount bracket, such as the Oberon P/N 1029-00, that puts the AP 3600i or the AP 3500e into a horizontal orientation. (See [Figure 20](#).) Use this Oberon bracket unless you have a hotspot, kiosk, or small venue scenario and roaming is not an issue.

Figure 20 *Vertical (Up/Down) Antennas on a Wall-Mounted AP (Left); Oberon Wall Mount Bracket (Center, Right)*



Color

To change the color of an AP, use colored vinyl tape or purchase a colored plastic cover from Oberon (see Figure 21). The Oberon cover can also be used to hide the Cisco logo or hide the LED. Do not paint the AP, since that voids the warranty.

Figure 21 *Oberon Skin*



If the environment requires an AP color change or you have a requirement to remove the Cisco logo or LED you have options

www.oberonwireless.com

Phone (814) 867-2312

PART NUMBERS:
1140/3500i/3600i-SKIN
3600e-SKIN
1260/3500e-SKIN

Specifications:

- Fabricated from textured ABS plastic
- The skin is virtually transparent to access point radio frequency signals
- Attaches to access point with Velcro tabs (included)
- Standard color is black
- Skins are paintable
- Custom colors are available on request. Please contact your Oberon representative

350084

Unique Installations

Clean Rooms

Many hospitals and factories have requirements to wipe down or gently spray the environment with a chemical (often diluted material that has cleaning and disinfectant properties). The AP 3600 is ideal for these types of applications because it is designed with a purpose built Wi-Fi chipset with enterprise and industrial class components. This design enables the AP enclosure to have a Plenum rating and to be ventless. (See Figure 22.)

Figure 22 *AP 3600 Industrial Class Components*



AP has an RF conductive rubber gasket

350085


Note

The AP 2600 is 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 to protect and secure the AP. (See [Figure 23](#).)

Figure 23 **Oberon Metal Enclosure**

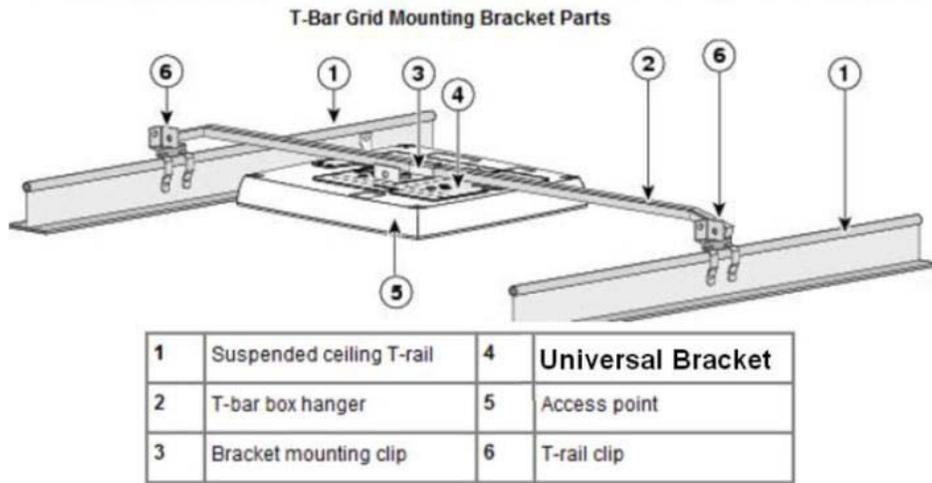


Above Ceiling Tiles

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

T-Bar hangar accessories, such as The Erico Caddy 512a or the Cooper B-Line BA50a, can be used for such installations. (See [Figure 24](#).)

Figure 24 Installation of an AP Above Ceiling Tiles



350087



Note

Install APs above the ceiling tiles only when mounting below the ceiling is not an option. “Above ceiling tiles” installations can certainly degrade advanced RF features such as voice and location, so verify coverage and performance and ensure the tiles are not conductive. Mount the AP as close to the inside middle of the tile as possible, and avoid areas with obstructions and clutter. (See [Figure 25](#).)

Figure 25 Placement of an AP Installation Above Ceiling Tiles



350088

Stadium and Harsh Environments

Customers may wish to use a NEMA type enclosure to install an AP in harsh environments where the AP may be exposed to weather, such as sporting areas, stadiums, open garden areas or warehouse freezers. There are several third-party sources for NEMA type enclosures.

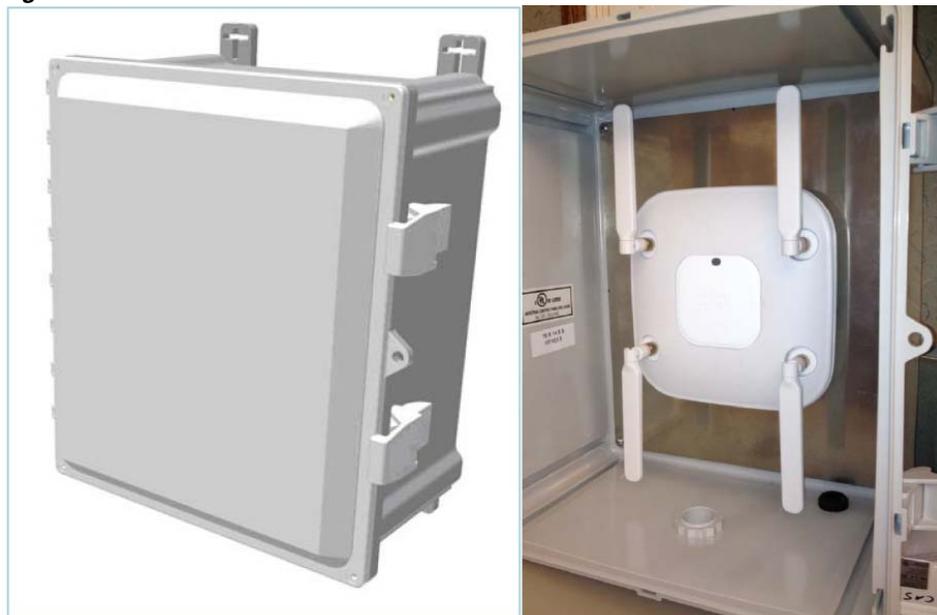


Note

Some APs may not be certified for outdoor deployments in a NEMA enclosure. For example, in some areas of the world, regulatory agencies may permit AP outdoor NEMA enclosures if the AP is indoors (such as a freezer or garden area) but may prohibit use of those NEMA enclosures outdoors. This seems to vary with weather radar compliance, UNII-1 compliance, and so forth. Check with your local Cisco account team or the communications regulatory agency for your area.

Cables should exit from the bottom of the NEMA type enclosure so that rain and moisture do not run down the cable into the enclosure. 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 26](#).)

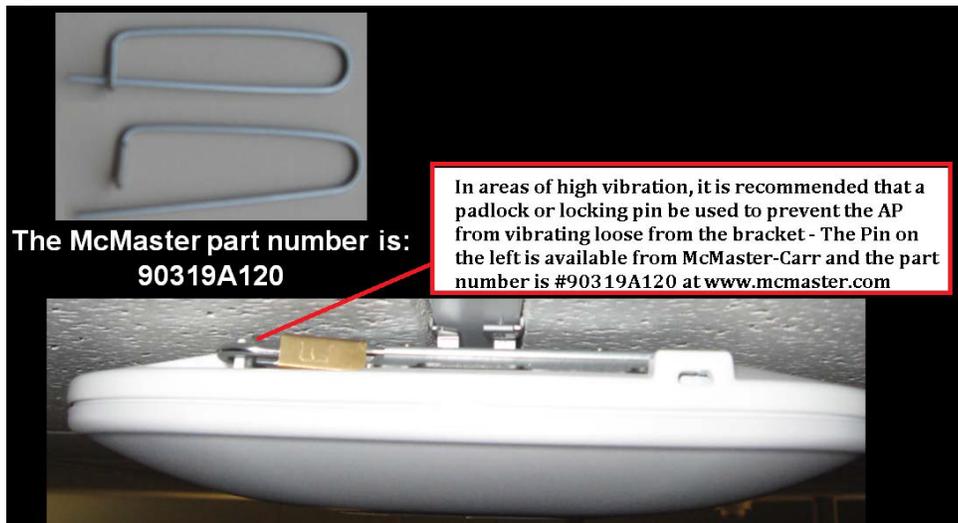
Figure 26 NEMA 16 x 14 x 8 Enclosure with Pressure Vent on Bottom



Areas with High Vibration

If the access point is installed with a “side arm” type mount or is installed in locations where there may be high vibration, use a padlock or metal pin to secure the AP so it does not loosen or fall off the bracket. (See [Figure 27](#).) McMaster offers a suitable pin (P/N 90319A120). Avoid use of plastic ties, which deteriorate over time.

Figure 27 *Metal Pins or Padlocks for Areas of High Vibration*



Warehouse and Factory

Warehouse installations are often difficult because of the very high ceilings and the clutter of the material in storage. As part of your site survey, always check the coverage when the warehouse is fully stocked, since the material in storage can change the RF coverage and interfere with uniform coverage.

For aisles, use directional (patch) antennas on the wall and shoot down the aisles. You can also use low-gain omni-directional antennas (such as dipoles) on the ceiling or units with integrated antennas; high gain omni-directional antennas tend to have more nulls. (See [Figure 49](#).)

The higher the AP is mounted, the farther the signal must travel. Use pipe and electrical box mounting techniques to lower the AP (external and internal antenna models) so that it is closer to users. (See [Figure 28](#).)

Figure 28 AP Placement in Warehouse



To mount an AP at the end of a pipe or electrical conduit box, use the universal bracket Cisco AIR-APBRACKET- 2, because it mates to the holes of most electrical boxes. (See [Figure 29](#).) Conduit and adapters are available at most electrical or home repair centers.

Figure 29 *Installation of an AP onto an Electrical Conduit Box*



Ethernet Cable Recommendation

While the AP 1600/2600 and the AP 3600 work well with CAT-5e for new cable installations, Cisco recommends that customers use CAT6a because CAT6a cable is required by the 10GE standard.

Antenna Cable Recommendation

Keep antenna cable runs as short as possible. Cisco offers low loss (LL) and ultra low loss (ULL) cables, which have the same characteristics as Times Microwave LMR-400 and LMR-600.



Note

When drilling holes for cable, allow for the size of connector drill bit, which is typically 5/8". (See [Figure 30](#).)

Figure 30 *Cable Installation, with Allowance for Connector*



Cisco cables carry the part number AIR-CAB (Aironet Cable) and then a length. For example, a 20' 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 use outdoors or in manufacturing areas.

Access Point Spacing Recommendations

If you have a Wi-Fi device such as an AP and want to use another AP in the vicinity on a different channel, space the APs approximately six feet (two meters) apart. 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. Avoid clustering the APs or the antennas from different APs together, since this could degrade performance.

If you have other devices that transmit, move or separate the devices as far apart as reasonable. (This is especially important if they operate in the same frequency ranges; for example, frequency hopping legacy APs or other devices may operate just below or above the 2.4 and 5 GHz band.) Then, check for interference. Test both types of devices at the same time under heavy utilization (load), then characterize each system independently to see whether 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 information.

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 electrical wiring or Ethernet in the near field (6-15 inches) of the antenna, and try not to install the AP in an electrical closet. If you remote antenna cables from such a closet, you may be required to use Plenum rated cable, so refer to local fire and safety regulations. Remember that the best place for the AP is as close to the users as practical.

For more information on interference, see

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

Very High Altitudes

While not defined in the specification sheet for the AP 2600 and the AP 3600, these APs 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 were monitored for continual operation passing traffic, with constant ping testing throughout the operational altitude test.

Common or Distributed Antenna System (DAS)

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



Note

Cisco does not certify, endorse or provide RF support for Wi-Fi deployments over any DAS.

The DAS vendor and systems integrator are solely responsible for the support of the DAS products, adequate RF coverage, and 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.

The DAS vendor and systems integrator are also responsible for understanding that the deployed DAS system meets the requirements of all of the customer 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 do provide support for non-RF related issues in Cisco products according to the customer support agreement with Cisco Systems.

For more information, see the following URL:

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

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. Elevator coverage can be a challenge, but it is often possible, especially if the elevator only serves a few floors.

In high rise elevators, roaming issues are more problematic because the client cycles through a large number of APs rather quickly. Some companies put a patch antenna on the floor inside the shaft and a patch antenna on the bottom of the elevator car, while other companies use leaky coaxial cable along the side of the shaft.

When installing any Wi-Fi equipment inside elevator cars or shafts, follow local regulations. Some installations may be prohibited because of safety reasons, while other installations may be prohibited by the building owner or local fire department. Only elevator repair persons or experienced contractors should perform this type of work.

External Antenna Options and Patterns

AP 1600/2600 and AP 3600e

The following dual-band, dual-resonant antennas are available for use with the AP 1600e*/2600e and the AP 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



The AP 1600 requires only three dipole antennas, not four. For ceiling, wall or patch mounts, simply leave the fourth antenna lead unused.

Do not use single-band antennas unless you choose to disable the other radio band in the AP.

For details on all 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

You can also 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 (see [Figure 31](#) and [Figure 32](#)) and the AIR-ANT2566P4W-R dual-band patch antenna (see [Figure 33](#) and [Figure 34](#)). Other antennas include the AIR-ANT2524V4C-R (see [Figure 35](#) and [Figure 36](#)) and the AIRANT2544V4M-R (see [Figure 37](#) and [Figure 38](#)).

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

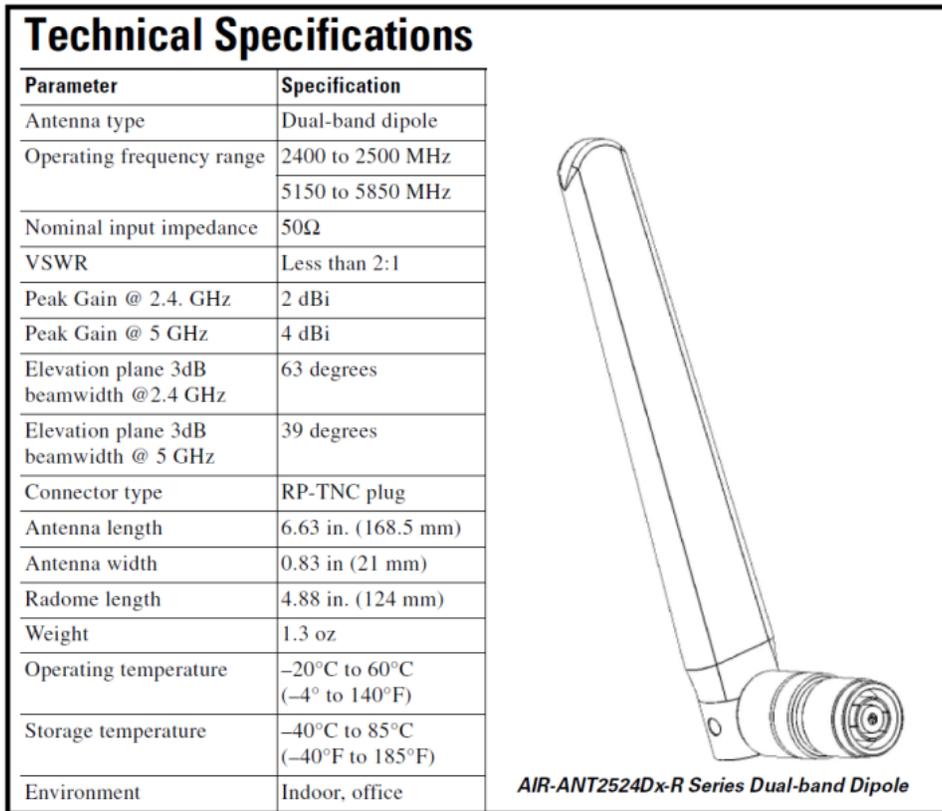


Figure 32 Radiation Pattern for the AIR-ANT2524Dx-R Dual-Band Dipole Antenna

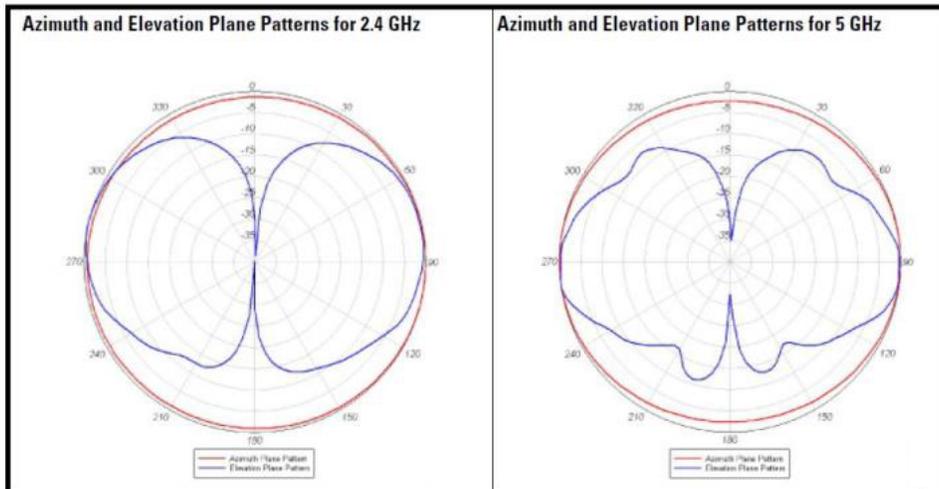


Figure 33 Specifications for the AIR-ANT2566P4W-R Dual-Band Patch Antenna

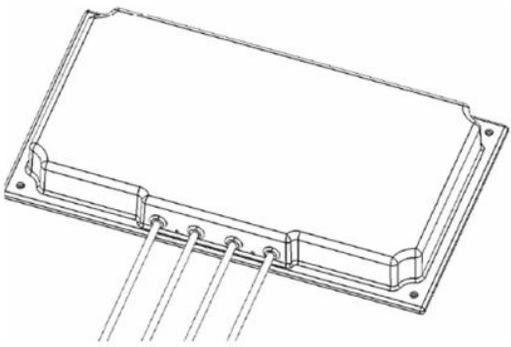
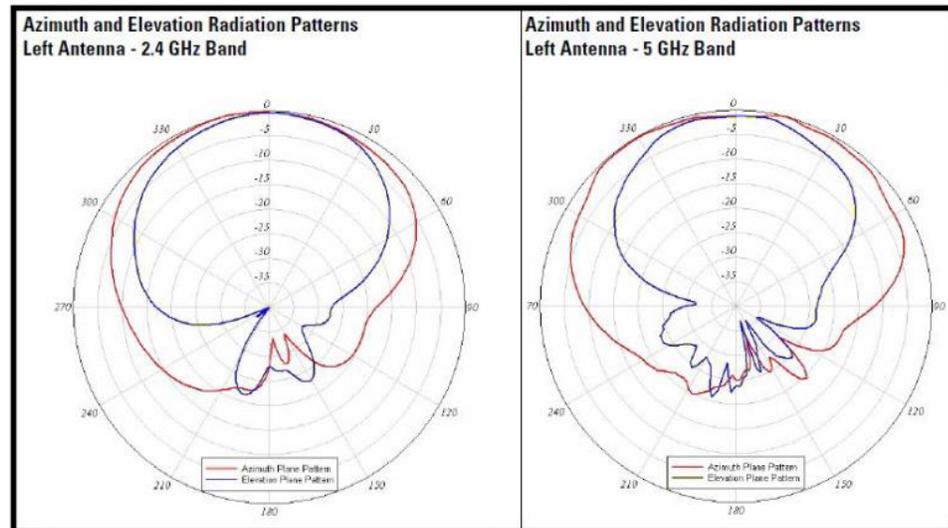
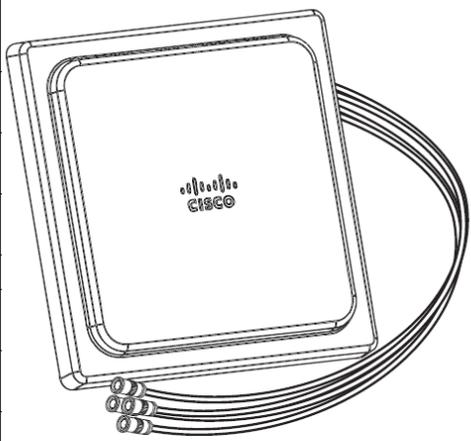
Antenna type	4-element dual-band MIMO	 <p>AIR-ANT2566P4W-R 4 Element Dual-Band Patch (indoor / outdoor use)</p>
Operating frequency range	2400 to 2484 MHz 5150–5850 MHz	
VSWR	2:1 or less	
Gain	6 dBi in both bands	
Polarization	Linear, vertical	
Azimuth Plane 3-dB Beamwidth	2.4 GHz band: 105° 5 GHz band: 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	350097
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	

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

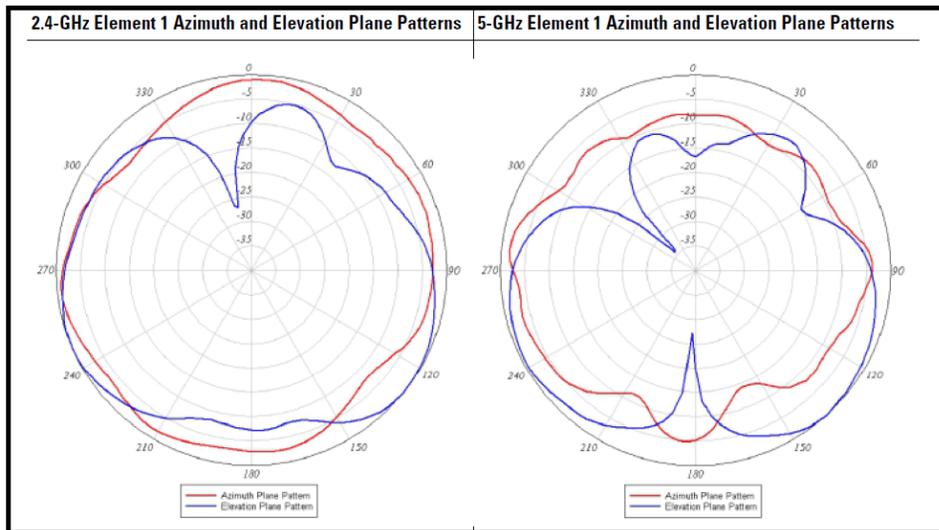
If the antenna is mounted on a wall, the azimuth (in red) is the signal going forward from the antenna, and the elevation (in blue) is the up/down pattern.

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



350100

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

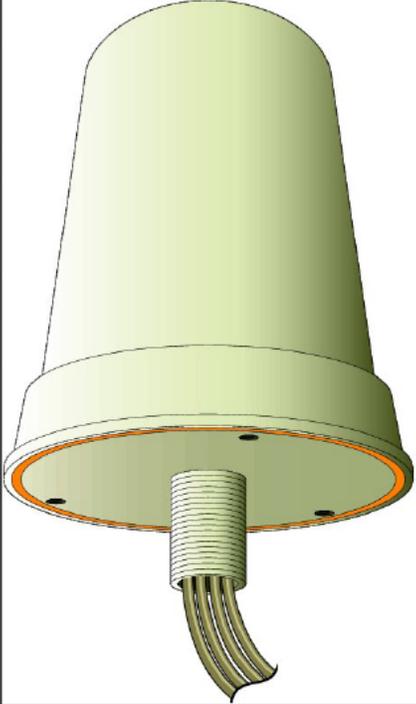
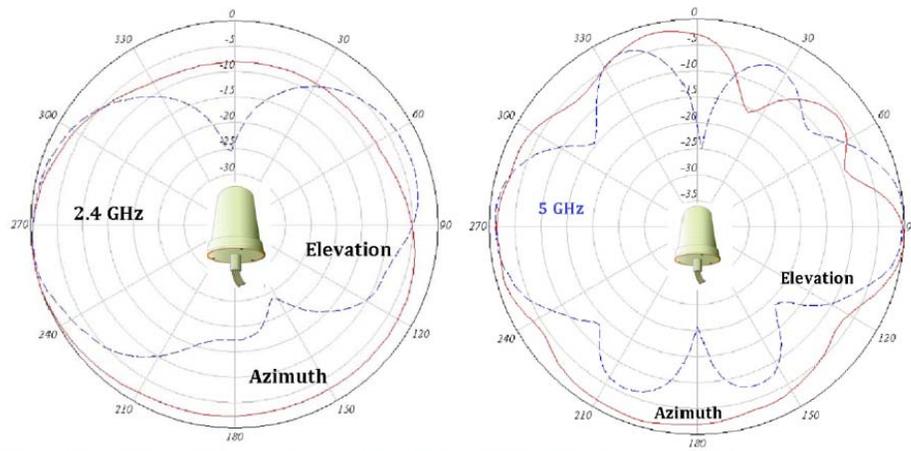
Antenna type	4-element MIMO omnidirectional	
Operating frequency range	2400-2484 MHz	
	5150-5850 MHz	
Nominal input impedance	50Ω	
VSWR	2:1 or less	
Peak gain	2.4-GHz band: 4 dBi	
	5-GHz band: 4 dBi	
Polarization	Linear, vertical	
Azimuth plane (3 dB beamwidth)	Ominidirectional	
Elevation plane (3 dB 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

Figure 39 and Figure 40 show the radiation patterns for the AP 3600i (internal antenna model).

Figure 41 and Figure 42 show the radiation patterns for the AP 2600i (internal antenna model).

Figure 43 and Figure 44 show the radiation patterns for the AP 1600i (internal antenna model).

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

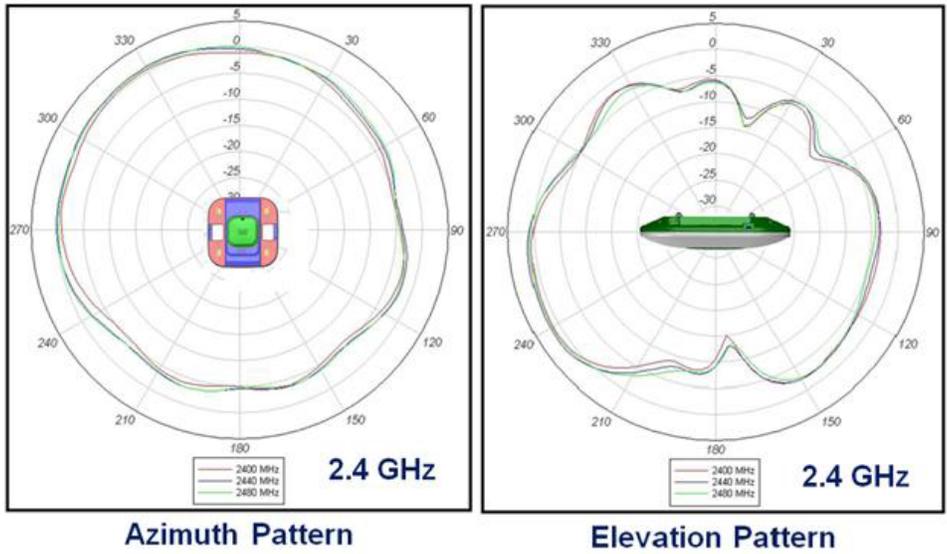


Figure 40 Radiation Patterns for the AP 3600i @ 5 GHz

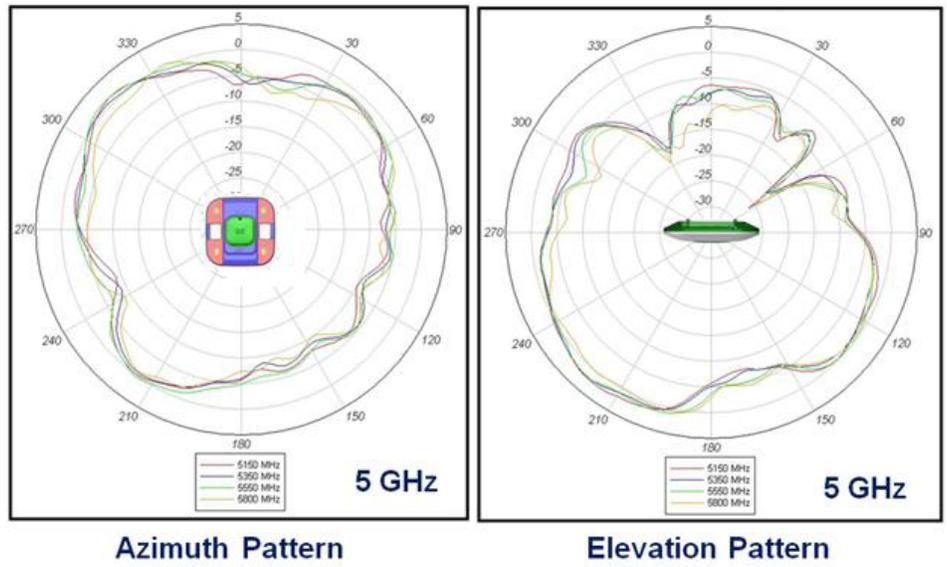
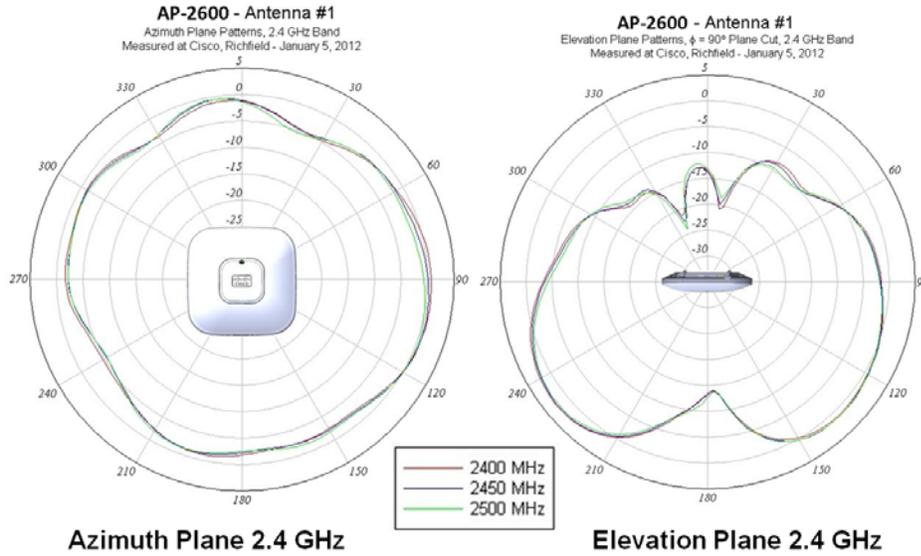


Figure 41 Radiation Patterns for the AP 2600i @ 2.4 GHz

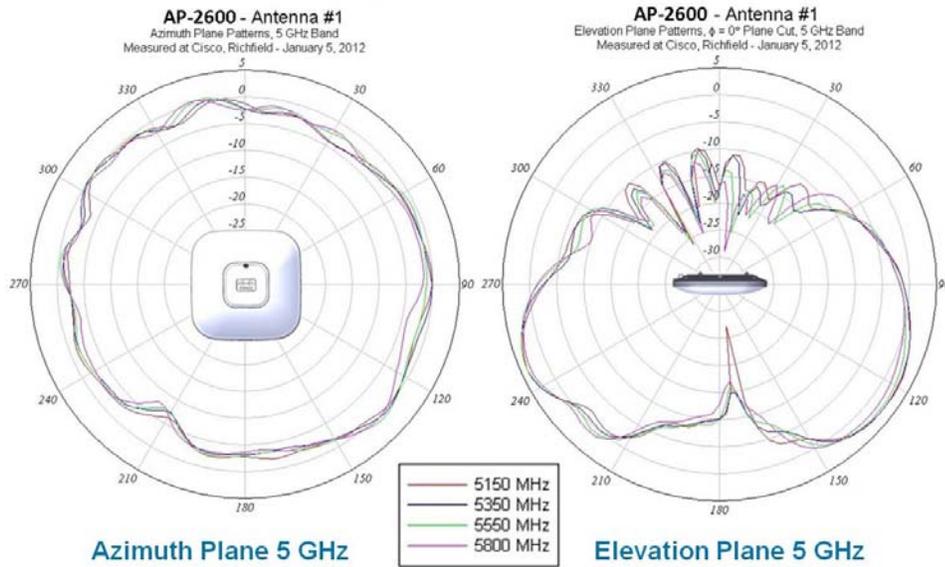
AP-2600i – Antenna Patterns 2.4 GHz



350105

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

AP-2600i – Antenna Patterns 5 GHz



350239

Figure 43 *Radiation Patterns for the AP 1600i @ 2.4 GHz*
AP-1600 2.4 GHz antenna patterns

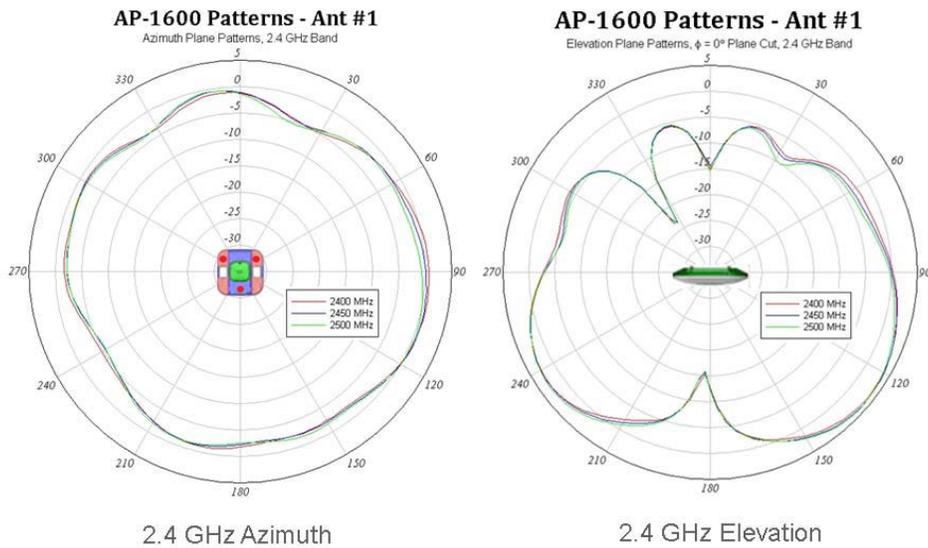
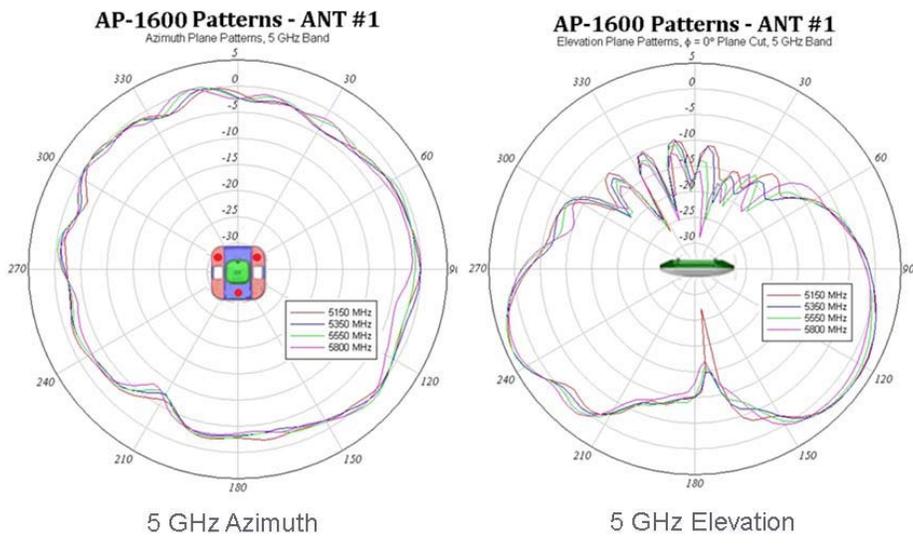


Figure 44 *Radiation Patterns for the AP 1600i @ 5 GHz*
AP-1600 5 GHz antenna patterns



External Antenna Deployments

All Cisco antenna connectors are labeled A, B, C, and so on. A has a higher priority than B, C, or D; therefore, if the access point supports say three or four antennas and you only have two antennas, use ports A and B until you could install the additional antennas.

It is possible to support 802.11a/b/g clients or single spatial stream N clients with only one or two antennas. Cisco does not recommend this because there is a significant degradation of performance, and ClientLink functionality is lost. If you choose to use fewer antennas, configure the access point in software to not use the other antennas.

**Note**

The entry-level AP 1600 has three antenna ports that are not configurable. The AP 2600/3600 has four configurable antenna ports, with one extra transceiver (receiver/transmitter) per band.

MIMOs (dual-radiating element antennas) include:

AIR-ANT2524V4C-R – Dual-band omnidirectional – 2/4 dBi ceiling mount omni use

AIR-ANT2544V4M-R – Dual-band omnidirectional – 4/4 dBi wall mount omni use

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

For MIMOs, it is not critical which antenna lead goes into which antenna port on the access point, as long as all the antenna ports on the AP are connected to the antennas. The patch antenna AIRANT2566P4W-R has the elements spaced side by side in the plastic housing, so there is a slight improvement if you use the outer two elements on the patch on ports A and B (see [Figure 45](#)), but this is not critical. On the AP 1600, port A is spaced furthest from B and C for best diversity, as shown in [Figure 46](#).

Figure 45 6 dBi Patch Antenna



350108

Figure 46 Port Spacing on the AP 1600



350109

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. Try to space the antennas as far apart as practical (with A and B the furthest apart), but no further than 10' apart, since antennas should be in same RF coverage area. (See [Figure 47](#).)

Figure 47 **Antenna Placement**



Note

Avoid using single-band (single-radiating element antennas) like those used with the earlier AP 3500, because they are not fully compatible with the newer AP 1600/2600 and AP 3600. Antennas for the AP 1260 and the AP 3500 are single-radiating element antennas made for each individual band. The AP 3600, 2600, and 1600 use dual-band, dual-radiating element antennas and are branded with an orange marking. (See [Figure 45](#) and [Figure 46](#).)

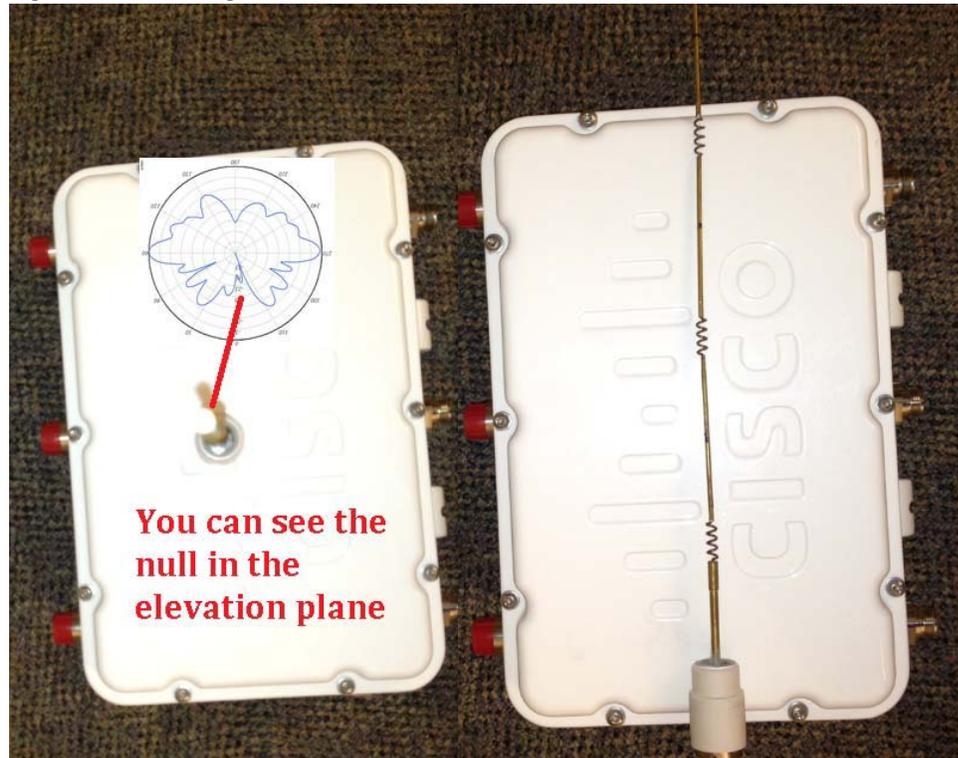
When using 802.11n rates in areas with high metal, such as distribution areas or airport hangars, lower gain antennas on the ceiling may perform better because they tend to radiate the signal in all directions and increase the chance that multi-path will enhance the signal. If you have a clear path, a patch antenna at the end of an aisle at roughly the same height or just above the (WLAN client) is preferred. (See [Figure 48](#).) Be sure to do a site survey.

Figure 48 *Importance of Site Survey in Areas with High Amounts of Metal*



A high gain antenna may have a null or dead spot directly below it because the antenna element is often much longer and has less metal surface area available to conduct the radio wave if you are directly underneath it. (See [Figure 49](#).) The further away you are from the antenna, the more surface is available, and the better it performs.

Figure 49 High Gain Antenna (AIR-ANT2480V-N) with Cover Removed



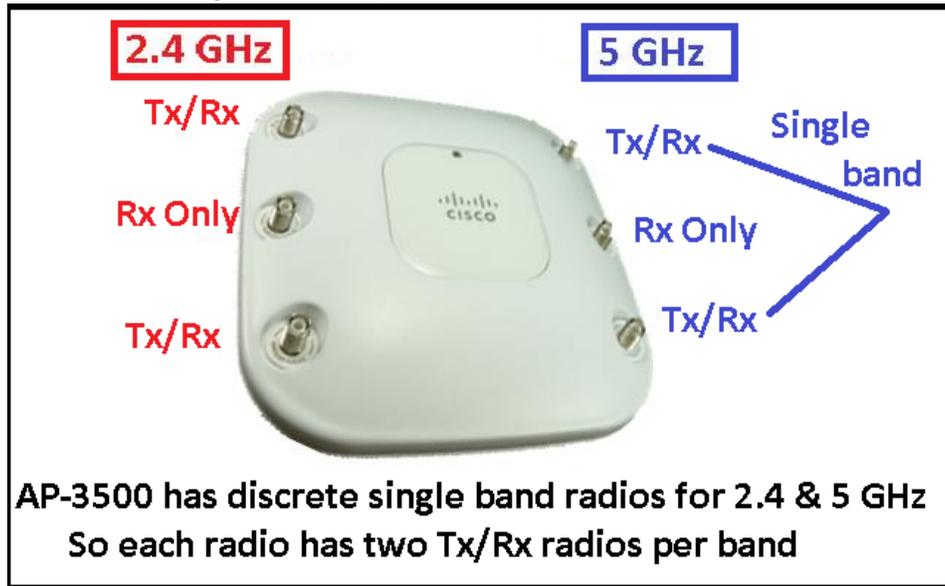
802.11n, Spatial Streams, and Beamforming

For a video on 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 by 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. (See [Figure 50](#).)

Figure 50 AP 3500i/e – 2x3:2 System (Two Transmitters, Three Receivers, Supporting Two Spatial Streams)



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 (for example, support of multiple spatial streams).

With 802.11a/b/g, data rates were actual Mbps rates like 2, 11, and 54 Mbps and were done with one transmitter. The AP 3500 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 the Modulation and Coding Scheme (MCS) index value, and the value 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). (See [Figure 51](#).) The MCS values correspond to actual data rates.



Note

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

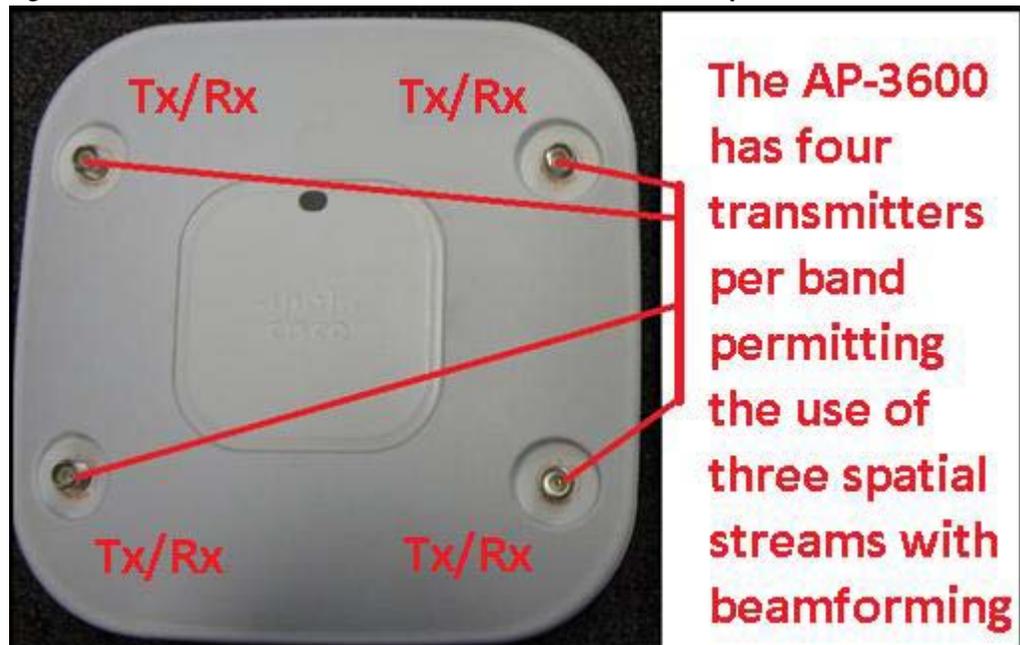
Figure 51 MCS: Two Spatial Stream Bonded Channel Supports up to 300 Mbps

MCS	Coding	Modulation	Streams	Signal BW =20 MHz		40 MHz	
				GI = 800 nS	GI =400 nS	GI = 800 nS	GI =400 nS
				MCS0	1/2	BPSK	1
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

350240

Unlike the AP 3500, the newer AP 3600 supports 3SS with twice as many transmitters (four per band), which enables faster data rates of up to 450 Mbps. There is an extra radio for redundancy and enhanced performance both upstream and downstream. The AP 3600 can also beamform to 3SS clients. The AP 2600 is similar, but the redundant radio is for upstream (as it is a receive only); the redundant radio is unable to beamform to 3SS clients but can beamform at the other non-3SS rates.

The dual-band design of the AP 3600 offers a total of eight transceivers (transmitter/receivers) using only four antennas. (See [Figure 52](#)) Four radios are used in each band, 2.4 GHz and 5 GHz.

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

350241

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

The yellow sections of the MCS chart (see 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)

MCS	Coding	Modulation	Streams	Signal BW = 20 MHz		40 MHz	
				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

350114

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

Clients That Support Three Spatial Streams

Clients with 3SS support are now more common. As the new 802.11ac specification becomes more accepted, many newer client adapters will have the newer chipsets and support 3SS as a subset to 802.11ac. Unlike many competitors, the AP 1600/2600 and the AP 3600 fully support all the DFS channels for more usable channels in the 5 GHz range. More clients, especially 802.11ac clients, will start to emerge and support these newer channels in 802.11n modes.

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

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

**Note**

Sometimes it can be difficult to reliably maintain a 3SS link, since it is easy for the client to rate-shift out of the 3SS mode. The ability to maintain a 3SS link varies with the quality of the client 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. ClientLink 2.0 can also improve the overall performance of 802.11n clients using one, two, and three spatial streams and legacy .11a/g clients.

Beamforming in ClientLink 1.0 and 2.0

ClientLink 1.0 was first introduced with the AP 1250 and the AP 1140; it is a method to create 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 was previously user configurable. However, starting with 7.2 code stream, it is now on by default and is not user configurable because 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, for it also supports all 802.11n clients including one, two, and three 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, because ClientLink 2.0 works with all clients today and does not require any client sounding or support. (See [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 (for example, a client device). This is referred to as constructive interference. If the opposite happens, and the signals cancel each other out, it is called destructive interference. (See [Figure 55](#).)

Figure 55 Beamforming, Constructive Interference, and Destructive Interference

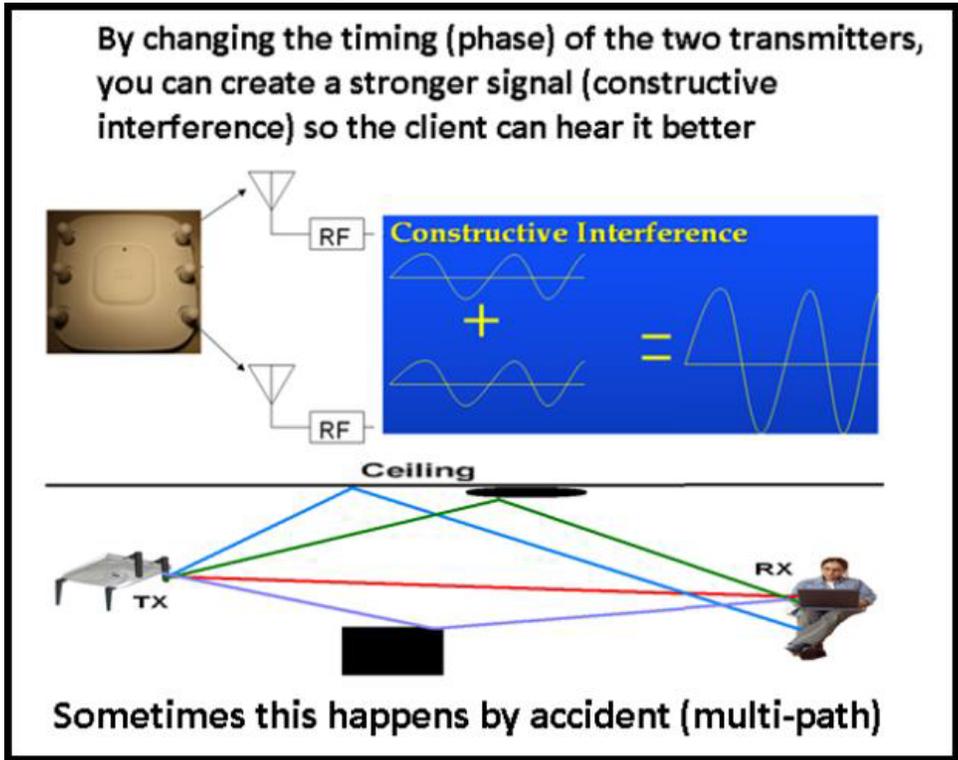
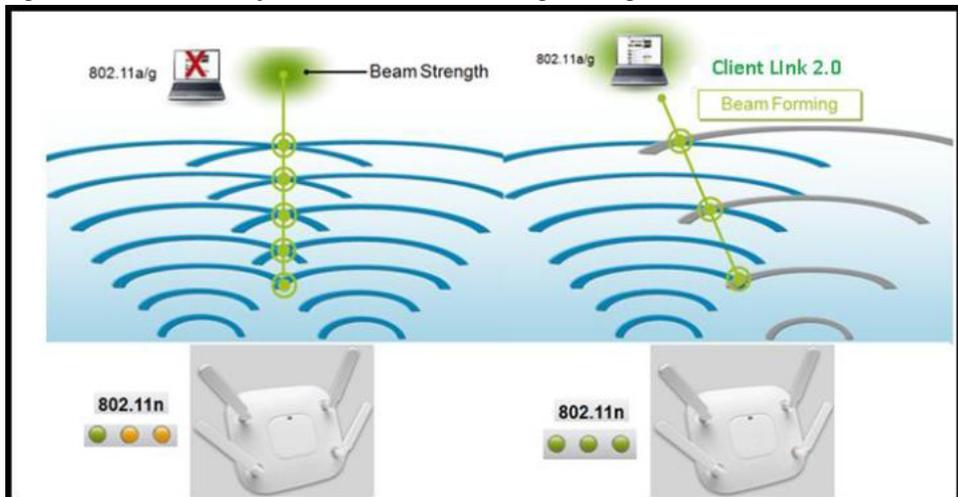


Figure 56 provides a visual comparison of ClientLink 1.0, using one spatial stream, and ClientLink 2.0, using three spatial streams. Unlike the AP 3500, the AP 3600 provides multiple spatial streams using four transceivers for even greater performance. The AP 3600 can beamform to all 802.11a/g and 802.11n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

Figure 56 Example of ClientLink Directing the Signal to a Client



**Note**

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

To summarize, ClientLink 2.0 takes the received signals heard from the client on the uplink and calculates how the multipath signal looked from those streams. Then, on the reciprocal side (transmit downlink), ClientLink 2.0 uses all four radios to figure out the optimal way to 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 an AP 3600 enables beamforming to all 802.11n clients, including 3SS clients, and can do so for up to 128 clients at a time. The AP 1600 supports fewer clients (32) and does not support 3SS. ClientLink 1.0 supported a maximum of 15 clients at a time. ClientLink 2.0 significantly improves throughput and coverage up to 60% on the downlink side for much better 802.11n client connectivity and for 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 a larger cell size.

For this reason, during a site 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 Cisco always recommends that you survey with the equipment you intend to deploy, an earlier survey done with an AP 3500, for example, 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 Unchanged; AP 3500 and AP 3600 Cell Sizes Unchanged)

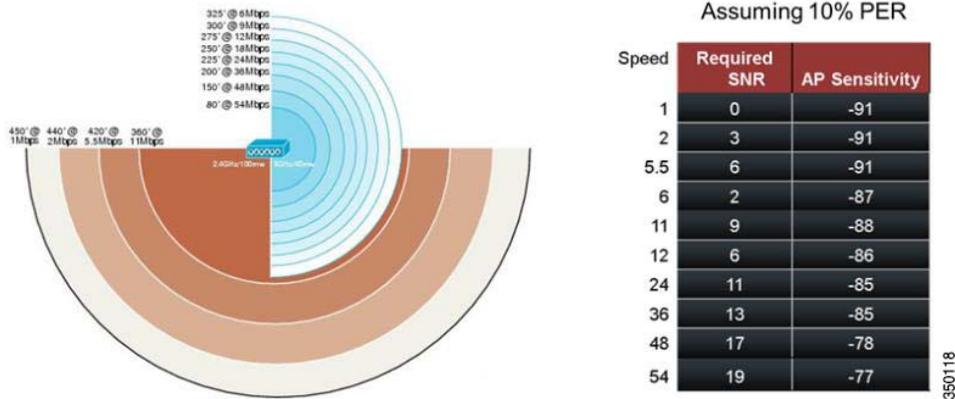


Figure 58 Site Survey Sensitivity and SNR

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

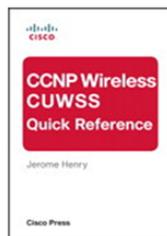
350119


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, RSSI/SNR Guidelines, 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

RSSI/SNR Guidelines				
Data Rate	2.4 GHz Min RSSI	2.4 GHz Min SNR	5 GHz Min RSSI	5 GHz Min SNR
20\40 MHz				
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

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.

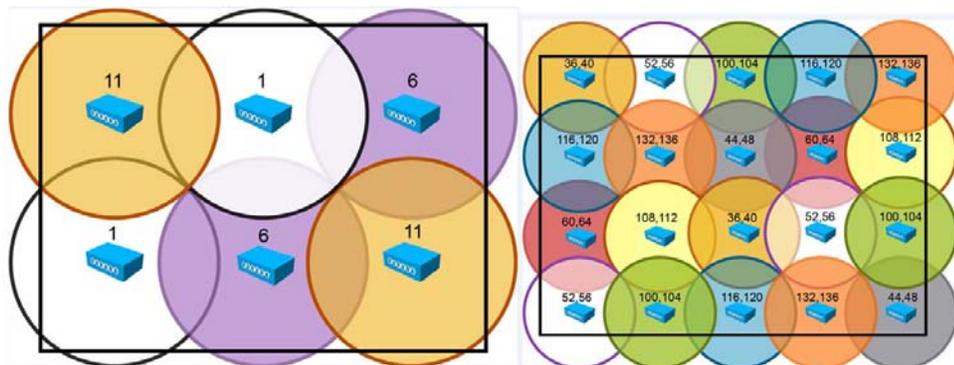
350120

General Guidelines

Following are general guidelines for all access points.

- Always try to mount the AP as close to the users as possible for best performance. Be aware of the environment. For example, if hospitals have metal doors, coverage can change when the doors close. Old buildings can have metal grid work hidden under plaster or asbestos. Avoid mounting the AP or antennas near metal objects, since that may affect the coverage area.
- When using the 2.4 GHz frequency, the same one, six, and eleven channel scheme is used as in the 5 GHz channel scheme. (See Figure 60.) Avoid putting all APs on the same channel, and reuse channels if possible. See other Cisco 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)



350121

- Try to determine which clients will 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.

- If you require three spatial stream coverage for the fastest throughput or if you want the best BYOD experience, the AP 3600 and the AP 2600 with ClientLink 2.0 outperform the AP 3500. The AP 3600 can beamform to 802.11n clients, so it is important to understand the data requirements if you mix the AP 1260, 3500, and 3600 in the same areas.
- While site surveys are generally recommended, if the design is done at half power and Cisco RRM is in place, a limited site survey may be adequate for smaller venues. In very challenging environments such as train connectivity, Gas & Oil verticals, large hospitals, and so forth, you can contract with the Cisco Advanced Services team to help or to perform your installation. Contact your Cisco account team for more information.
- The 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, WCS 7.0.220 or higher, and NCS 1.1 or higher. The AP 1600 and the AP 2600 were introduced in the 7.4 release.
- The rule of thumb coverage plan is: one AP per 5,000 square feet for data and one AP per 3,000 square feet for voice and location services.
- Some clients (especially older ones) do not support the UNII-2 extended client channels 100- 140; therefore, if you have older clients, you may want to disable them in the DCA channel list.

**Note**

The newer 802.11ac clients support these channels, and more clients are starting to support these channels all the time.

Examples of Improper Installations

It is very difficult to provide good Wi-Fi service with an improper installation, so use common sense when mounting devices:

- Keep the AP away from clutter and metal objects. (See [Figure 61](#) and [Figure 62](#).)
- The AP should be level and secure so that it does not sway or move. (See [Figure 63](#).)
- Try to locate the AP as close to the users as possible.

Figure 61 *Improper Installation: AP near Metal and Clutter*

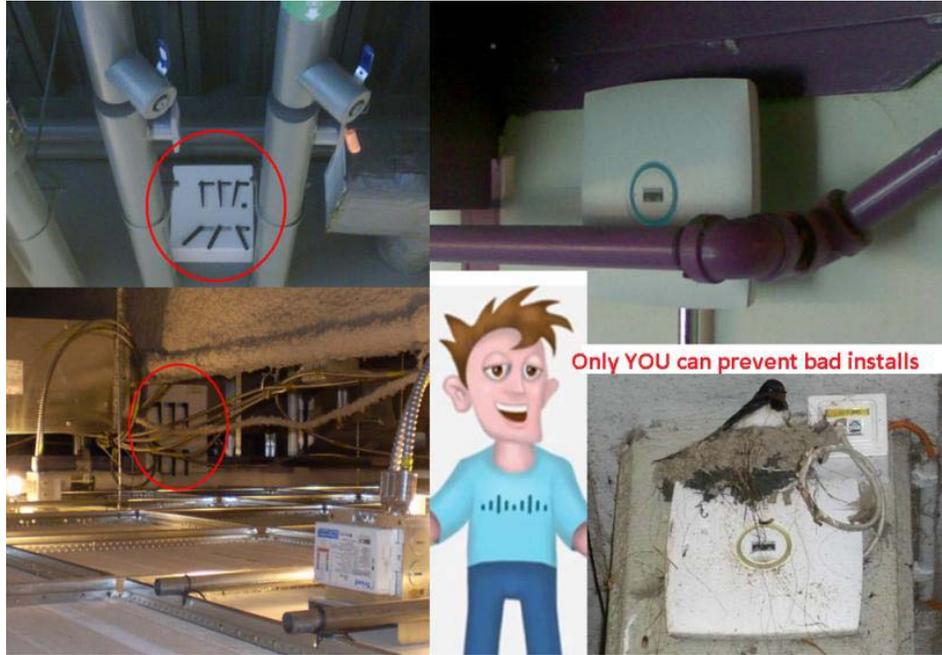


Figure 62 *Improper Installation — Antennas Against Metal*

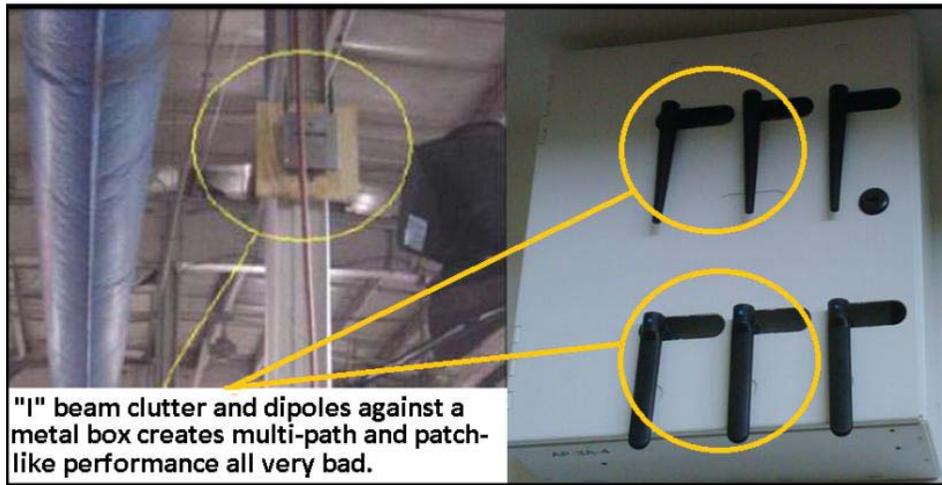
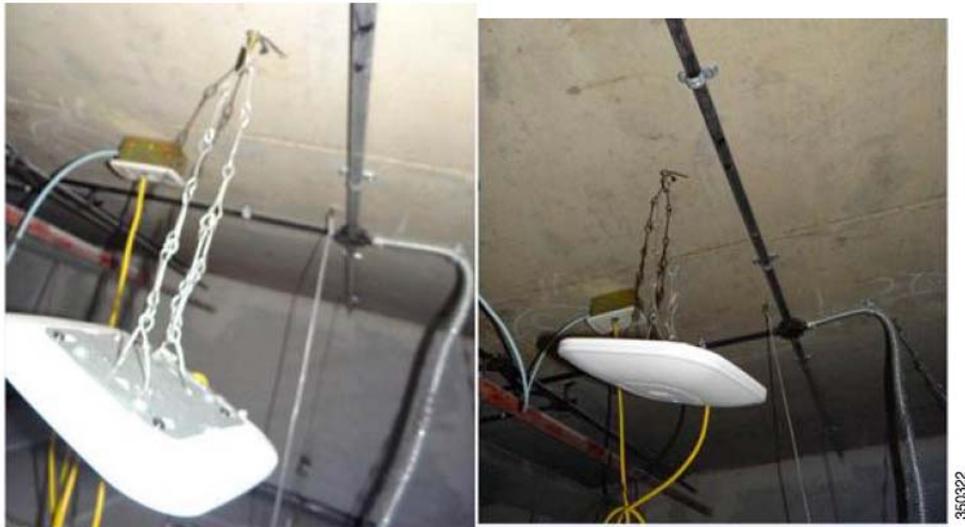


Figure 63 *Improper Installation – AP not Level or Stable*



Tip: When mounting antennas outside, always mount with the antenna leads and drain holes down so that rainwater does not enter the antenna. This approach is not necessary for indoor mounting. (See [Figure 64.](#)) Use Coax-Seal to protect against weather exposure but do not obstruct the drain holes. (See [Figure 65.](#))

Figure 64 AP Mount with Antenna Leads and Drain Holes Down



350126

Figure 65 Sealant

COAX-SEAL®
The Original Connector Sealant!

Seals connections from moisture & corrosion

A must for Wi-Fi – satellite dishes – microwave work – radar and HAM radio • Forms and seals around odd-shaped and difficult fittings • Stays flexible for years • Adheres to polyvinyl and vinyl outer coax jackets • Allows for quick disconnection of fittings • Effective at temperatures from -30° to +180°F (-35° to +82°C)

UNIVERSAL ELECTRONICS, INC. Phone: 828-293-2222
Email: sales@CoaxSeal.com
P.O. Box 2648, Cullowhee, NC 28723

For larger quantities visit us at: **www.CoaxSeal.com**

WRAP
MOLD

To apply - diagonally wrap a strip of Coax-Seal over a clean, dry connection making sure to overlap as you apply. Mold to form a smooth surface and to force out air.

**EFFECTIVE
LONG LASTING
INEXPENSIVE**

350127

Questions and Answers

- Q.** Which AP is best for manufacturing and warehouse areas?
- A.** In general, the AP 2600e or the AP 3600e is the first choice because these external antenna models have the highest operating temperature range -20 to 55°C. The AP 1600 can also be used but has a slightly lower operating temperature -20 to 50°C. If temperature is not a concern, use an internal antenna model (AP 1600i, 2600i, and 3600i).
- 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? What if I wish to use higher gain antennas?

- A.** Consider the Cisco Mesh products (1550 Series) or look for access points ending in “P” (for professional install), such as the 3502P Series or Cisco outdoor bridging products.
- Q.** Which AP is best for high-density deployments?
- A.** Both the AP 2600 and the AP 3600 have virtually identical AP density for coverage-based design. Capacity-based design (smaller cells) yields a slightly higher average cell capacity with the AP 3600 when using 3SS devices and yields 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 an 802.3af (15.4W injector). It is a low cost injector for use with the AP1600 and the AP 2600 and can also be used with the AP 3600 without the optional module. The AIRPWR-INJ4 is a more powerful injector designed to work with the AP 3600 with optional modules.
- Q.** Can industrial wireless motion or smoke detectors cause WLAN interference?
- A.** Yes, some products such as United Technologies DD475 and Optex MX-50 operate in the 2.4 GHz band as do other wireless chimes, cameras, and industrial equipment from other manufacturers.
- Q.** Any other thoughts when installing wireless access points?
- A.** When deploying wireless installations, keep the following guidelines in mind:
- Place the AP as reasonably close to the actual users as possible.
 - Make sure you have coverage (to a known requirement), and compensate for nulls or dead spots, regardless of what product you choose to deploy. Conduct a site survey.
 - Base the installations 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 Cisco partner is not available or able to do same.
 - When possible, use the Cisco brand antennas listed in this guide. They have orange bands.
 - Do not mount antennas against metal objects. Antennas work best when there are no obstructions in the path.
 - The AP 1600, 2600, and 3600 are not weatherproof and have an IP rating of 40.

Useful URLs

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

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>

