
cisco Live!
ALL IN

The bridge to possible

Outdoor Wireless

A prospective from the field on Design | Build | Maintenance

Ian Procyk, Sr. Technical Solutions Architect
@VE7HHS & iprocyk@cisco.com

BRKEWN-2832

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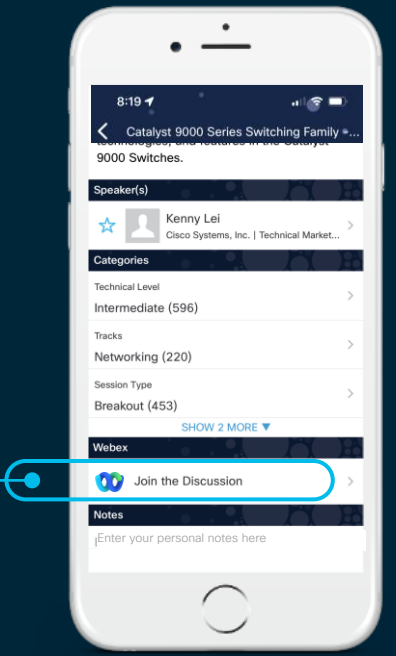
Webex spaces will be moderated by the speaker until June 17, 2022.



https://ciscolive.ciscoevents.com/ciscolivebot/#BRKEWN-2832

Agenda

- Fluid MESH (CURWB) vs 802.11 MESH
- Considerations when deploying outdoors
- 6GHz Outdoors?
- What makes the 9124AX(I,D,E) Different?
- Recent MESH Enhancements
- FAQ Rapid Fire

Special Thanks:

UBC Wireless Team

Geoff Armstrong **VE7KA**
Matt Dodge **VA7ROH**
Devin Kettle

Pason Systems

Niall Sexton
Jared Feniak

Your Speaker – Ian Procyk (iprocyk@cisco.com)

- University of B.C. (WLAN team) 2005-2009
- Canadian Coast Guard (Telecom) 2009-2010
- GBIT Logistics (IT Consultancy) 2010-2011
- Cisco Systems (Wireless Guy) 2011-today

- Ham Radio – Licensed 1997 - **VE7HHS**
- Help run a WISP for EMCOMM (BCWARN.net)
- Support many amateur radio clubs / repeater sites

Let's Address Something Off the Top...

VS

Cisco Ultra Reliable Wireless Backhaul
CURWB

Catalyst Wireless
802.11 MESH

Introducing Cisco Catalyst IW9167 Series

One hardware, two wireless technologies

Industrial and outdoor
Wi-Fi 6E access point

OR

Cisco Ultra-Reliable
Wireless Backhaul

Improved data rate: up to 7.8Gpbs
Improved availability: up to 99.999%

- IP67, shock/vibration, extreme temperatures
- Cisco secure
- Flexible and sustainable

Tri-radio
2.4 GHz, 5GHz, 5/6GHz

4x4
4 spatial streams

Multigigabit
RJ45, M12 or SFP+

PoE and DC power

GNSS, BLE, Scanning Radio

Learn more, see product and demo at the WoS

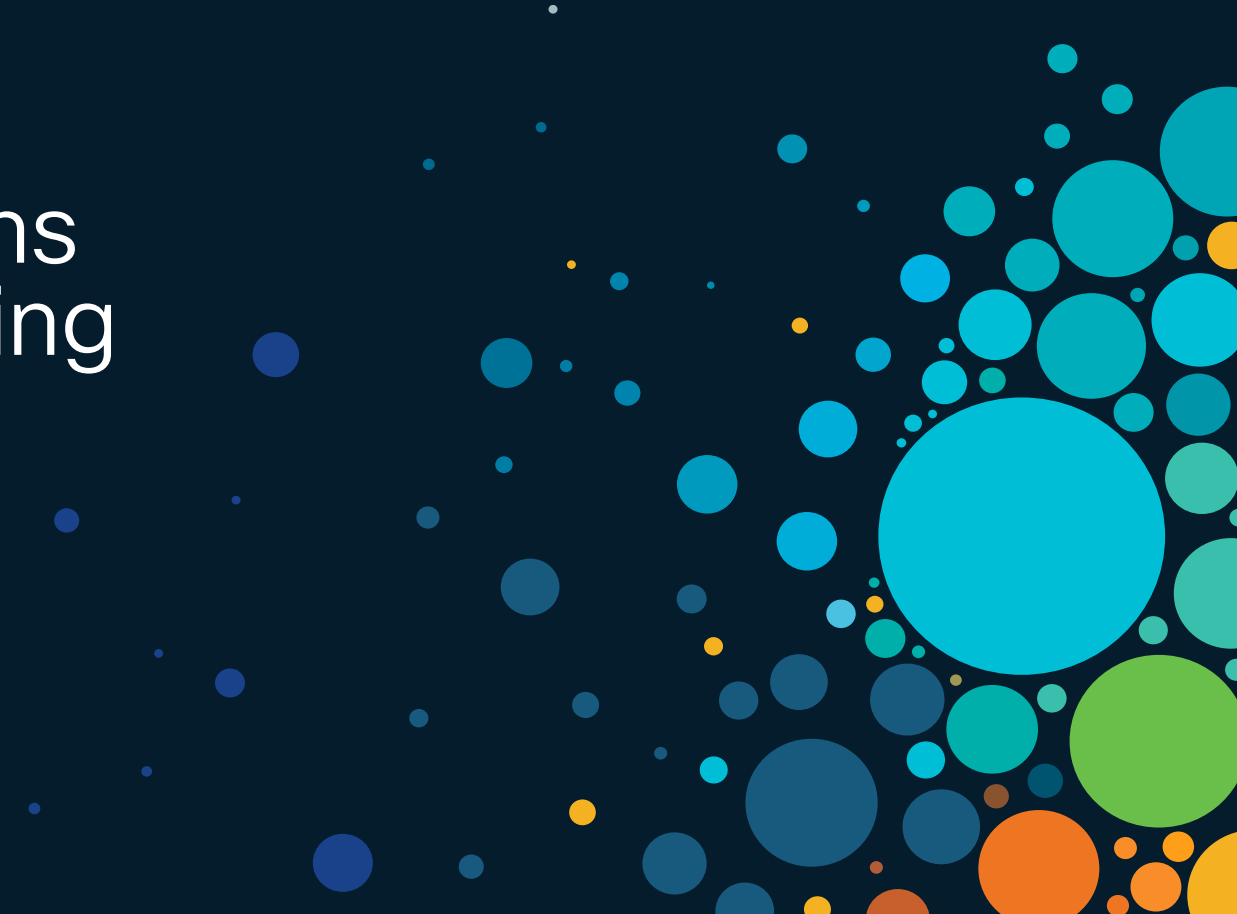
Consider CURWB on IW9167 IF:

- You are looking for a dedicated P2P or P2MP backhaul solution
- You don’t want a WLC involved
- Your application requires high speed mobility and or seamless handoff
- Environmental (vibration, extended temp) are important

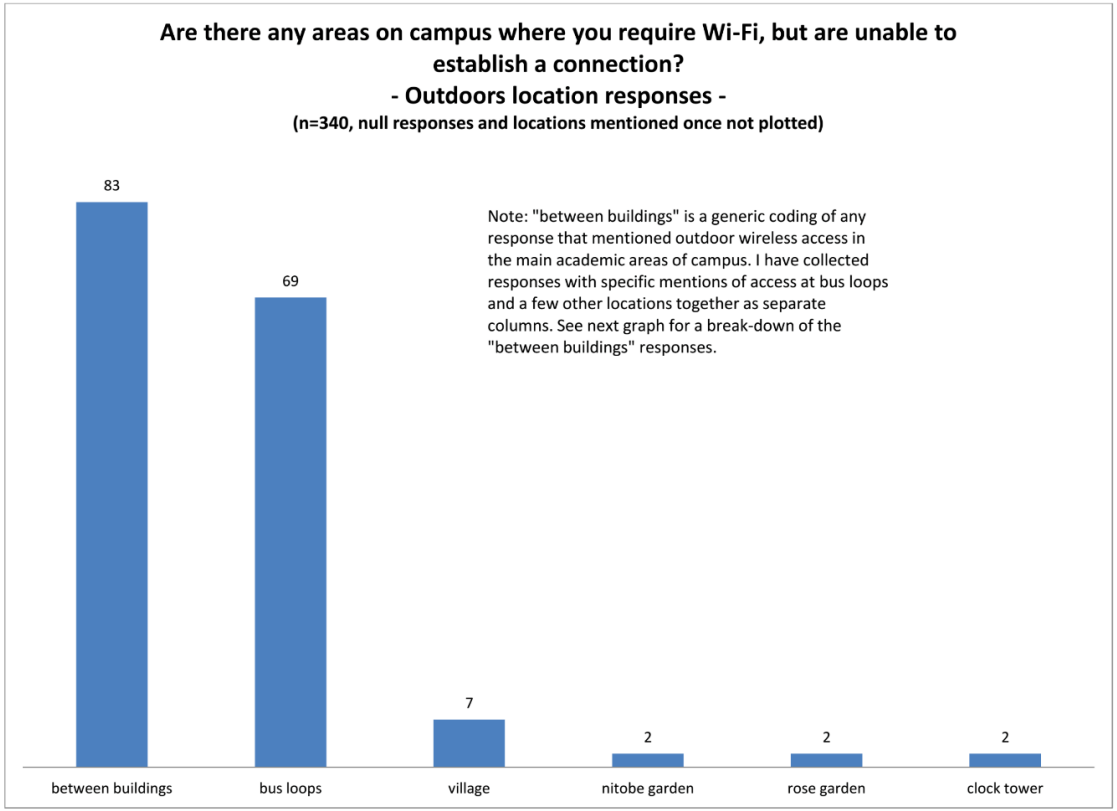
Consider Catalyst Wireless MESH IF:

- You need to provide Wi-Fi & Backhaul in the same area (one box)
- You already have a WLC
- You are ok with “fixed portable” MESH operation

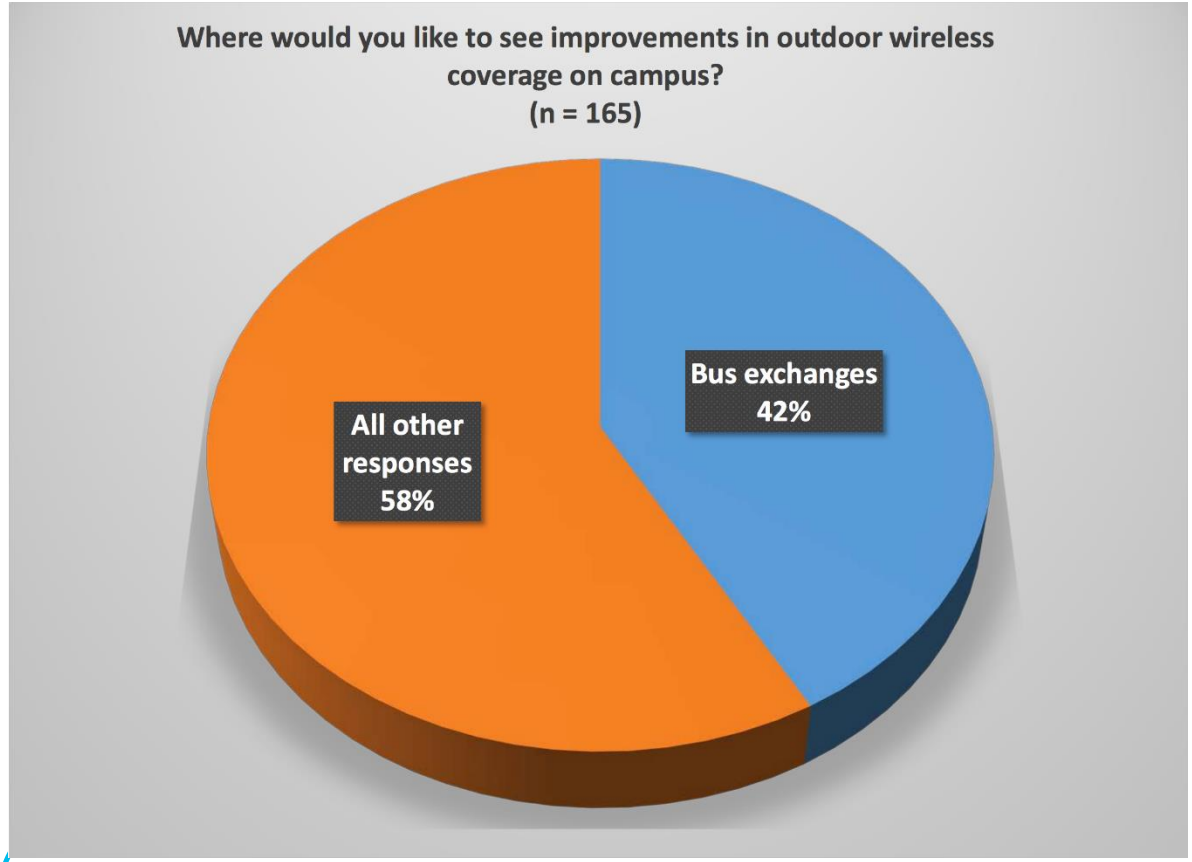
Considerations when deploying outdoors



On Campus? Where do I start?

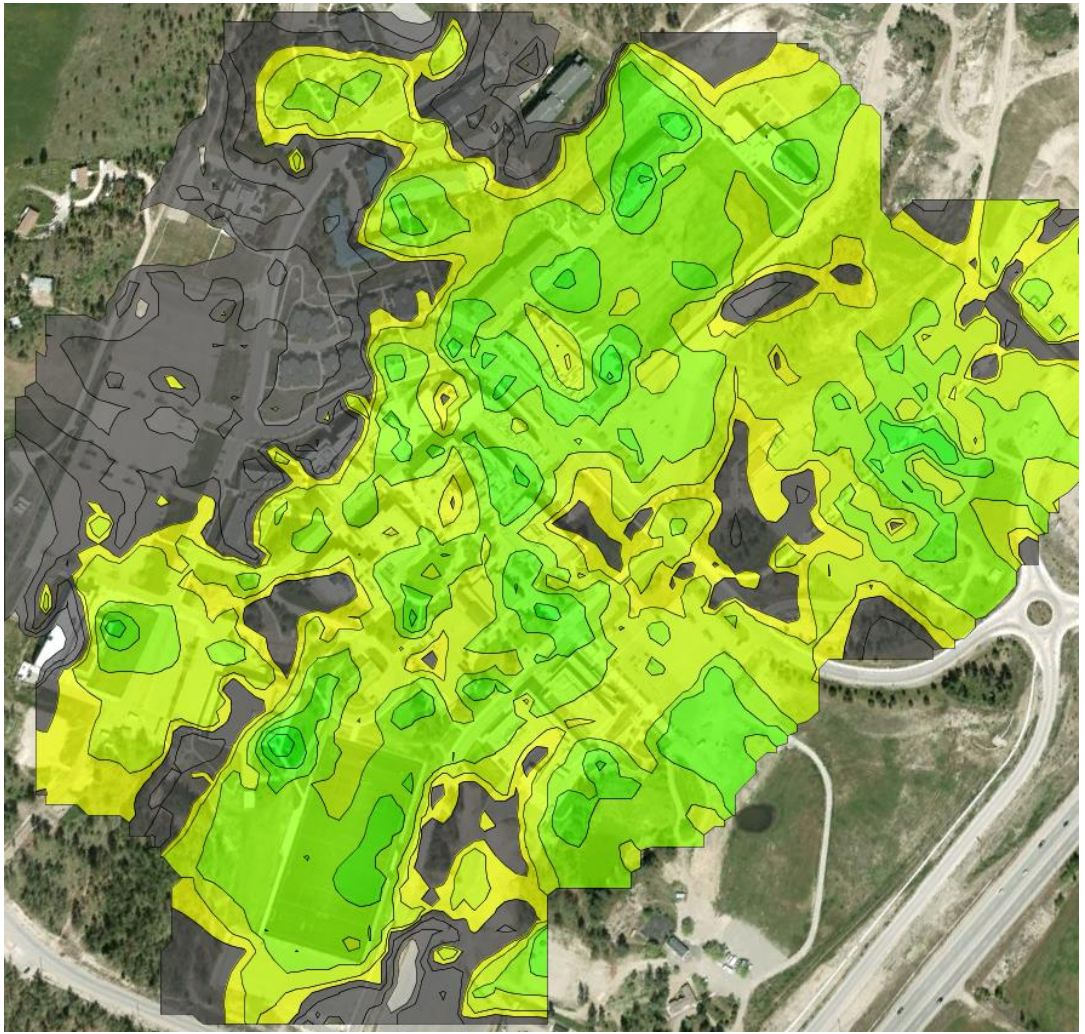


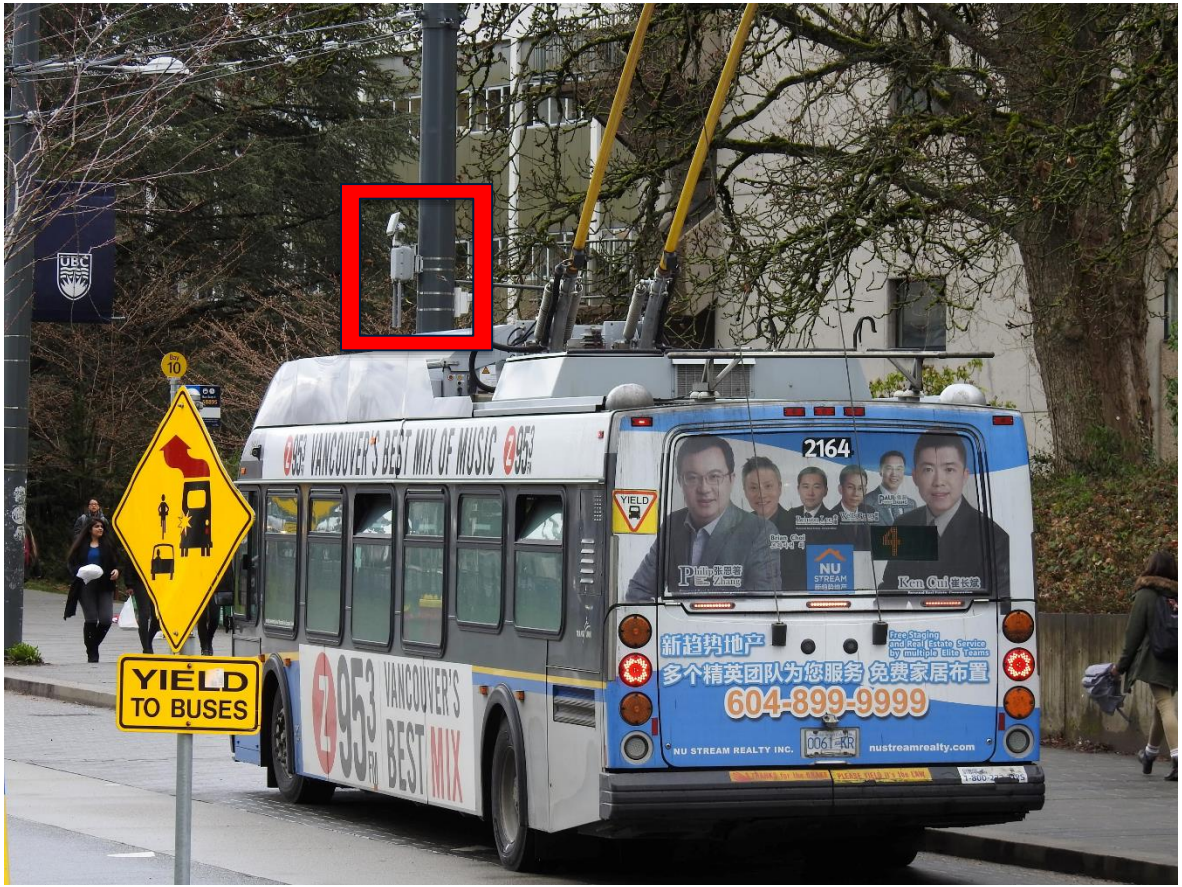
Popular Places

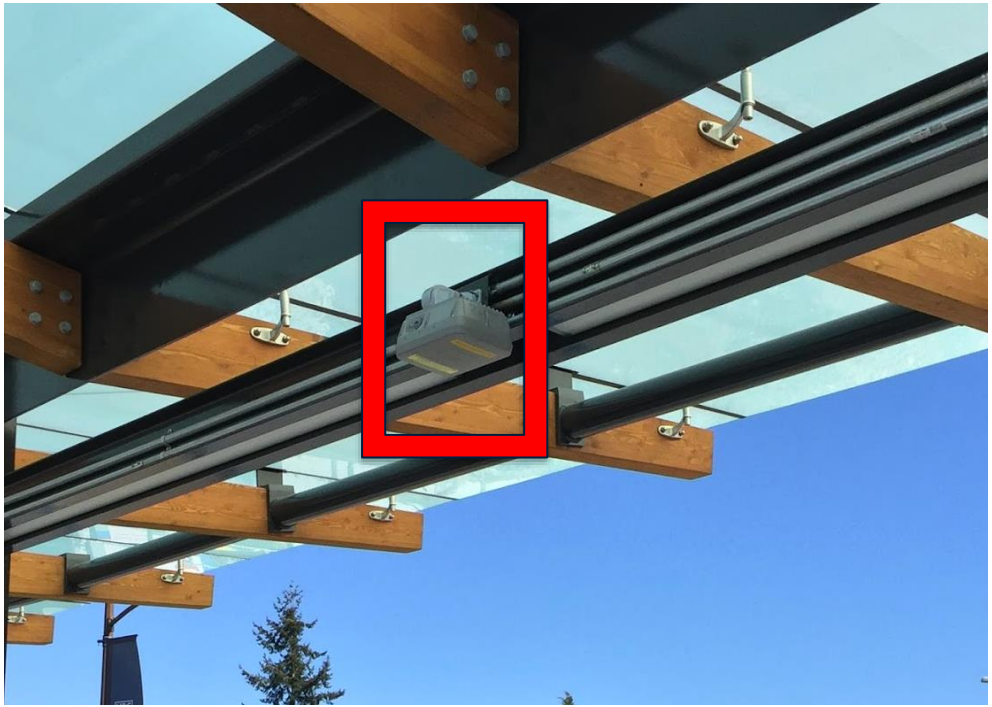


- Site survey path

- 5ghz coverage







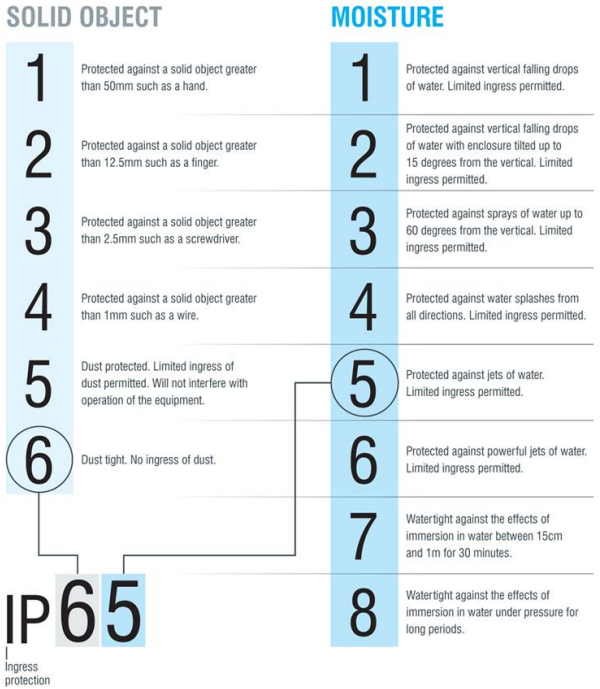
Mesh Backhaul

Blue Light / Emergency Phones

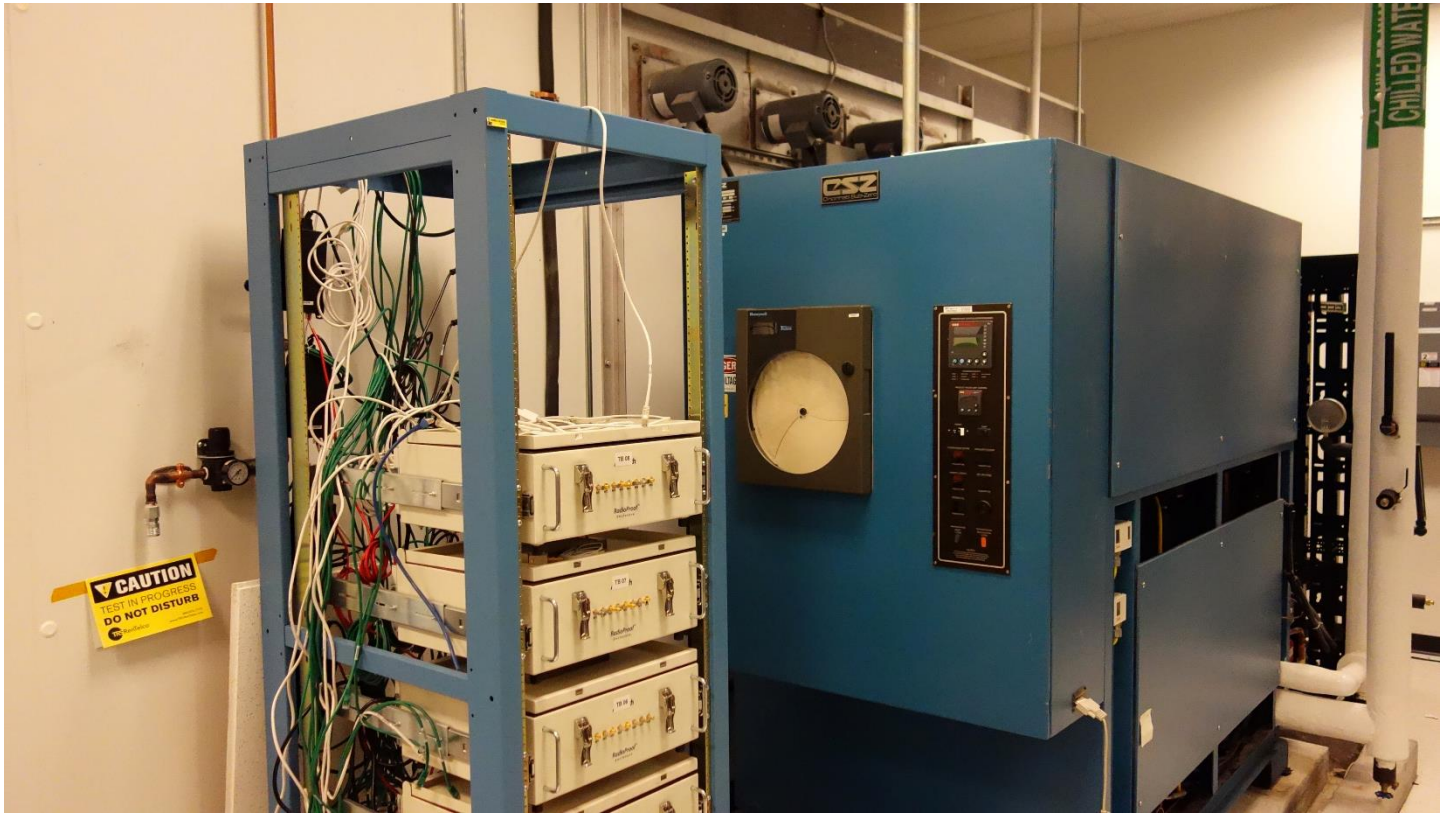
- Retrofit campus blue lights to include APs directly connected to SM fiber.
- Ideal mounting location, close to ground, good line of sight.
- High capacity connection

Why do I need an Outdoor AP?

Image Source:
https://bboxblog.files.wordpress.com/2014/10/ipratings2-copy.jpg



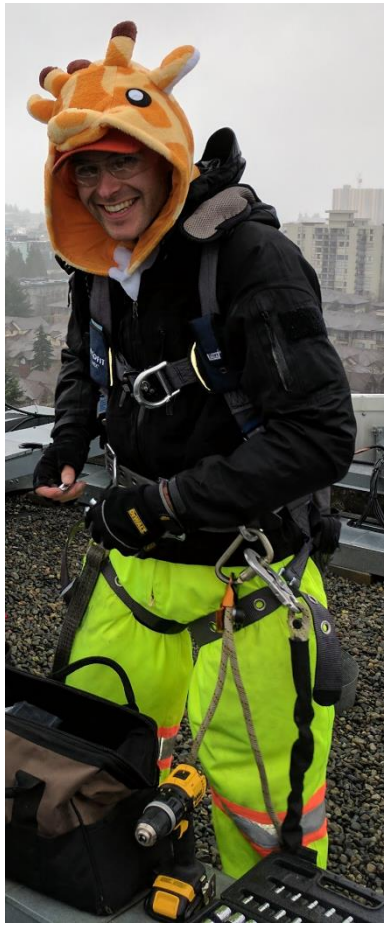
Environmental Testing



Safety Considerations

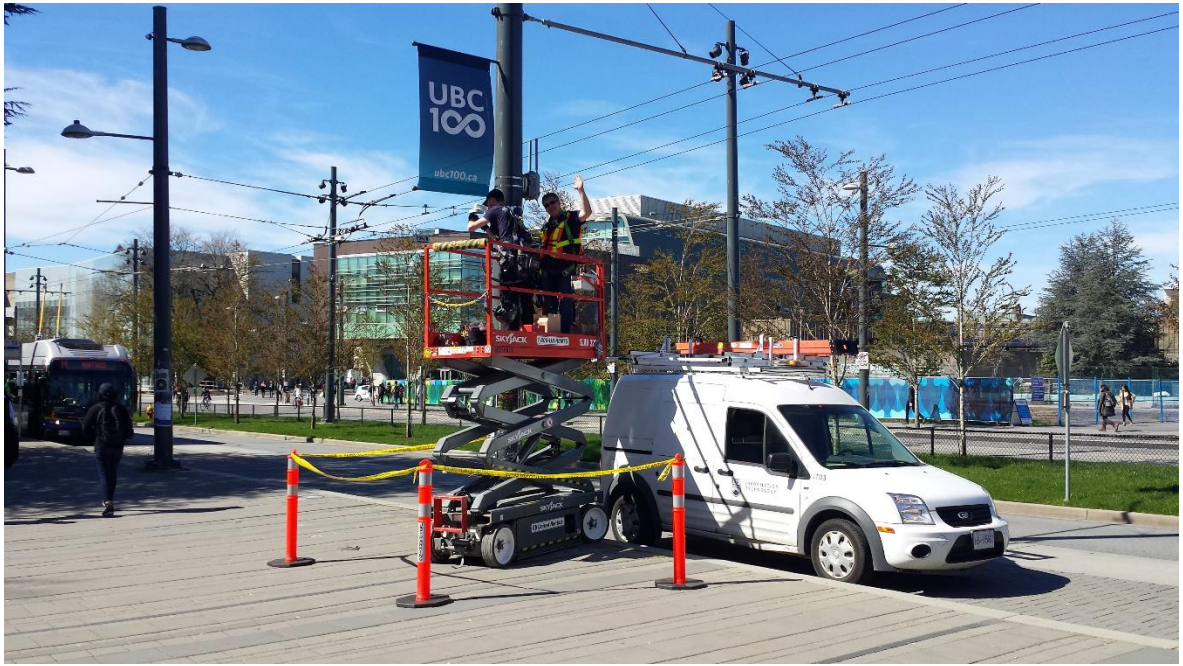
- All staff trained in fall protection

- Current equipment
  -full body harness
  -horizontal lifelines
  -rope grabs
  -hardhats with chinstraps.



Safety Considerations

- Eliminate use of ladders where possible and practical.
- Make sure to isolate work area, especially in public spaces where “stuff” dropping can be of concern.



Safety Considerations

- Staff trained on use of bucket trucks & boom lifts such as JLG's.
- Installations above 30' are very expensive and often impractical in high density areas.

Non Penetrating Roof Mounts (NPRMs)

- Convenient, widely used in the cellular and satellite industry. Obtainable through telecom suppliers.
- No holes required in roof membrane as the supported load is counterweighted with paving bricks.
- Must sit on separate rubber mat to prevent damage to roof membrane. Suggest ½” rubber matt minimum.
- Building code may require seismic bracing of base and or engineering analysis of counterweight.

AP1552 shown with
10 foot mast on
on Wade antenna NPRM

Non Penetrating Roof Mounts (NPRMs)

10x Trylon small ballast NPRMs (36”x36”) shown knocked down on left along side rubber matts. One 36x36 NPRM assembled with 20cm concrete blocks on right.

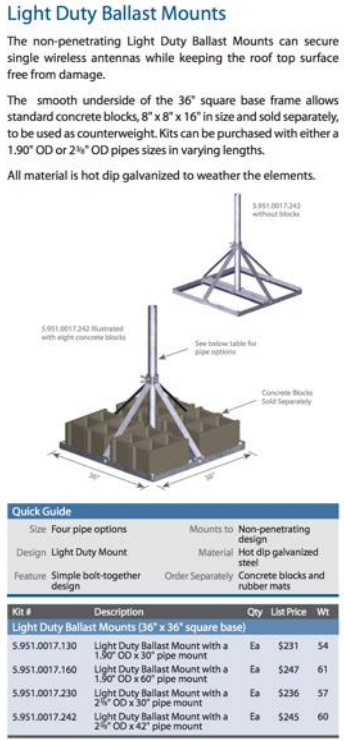
NPRM Suppliers

- Trylon-TSF (based in Ontario) makes some very nice heavy duty NPRMs made from hot dip galvanized steel angle. Easy to assemble, with large hardware and minimum number of parts. Trylon typically sells via partners such as Alliance Corp or Hutton.

  Source:
  http://www.trylon.com/downloads/Roof%20Top%20Structures.pdf

- Wade Antennas sells low-cost alternatives. They are significantly cheaper but take longer to assemble and aren't rated for as much window load. Also caution - sharp edges. SMI Industrial Electronics in Langley is a local Wade reseller.

  Source:
  http://www.wadeantenna.com/ius/resources/Tripods.pdf



Light Duty Ballast Mounts

The non-penetrating Light Duty Ballast Mounts can secure single wireless antennas while keeping the roof top surface free from damage.

The smooth underside of the 36" square base frame allows standard concrete blocks, 8" x 8" x 16" in size and sold separately, to be used as counterweight. Kits can be purchased with either a 1.90" OD or 2⅜" OD pipes sizes in varying lengths.

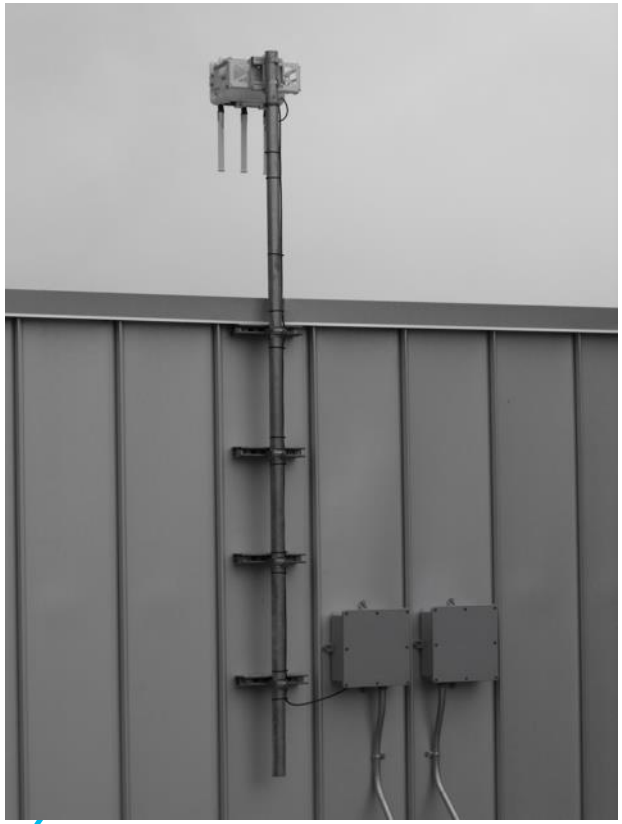
All material is hot dip galvanized to weather the elements.

Quick Guide

Size	Four pipe options	Mounts to	Non-penetrating design
Design	Light Duty Mount	Material	Hot dip galvanized steel
Feature	Simple bolt-together design	Order Separately	Concrete blocks and rubber mats

Kit #	Description	Qty	List Price	Wt
Light Duty Ballast Mounts (36" x 36" square base)				
5.951.0017.130	Light Duty Ballast Mount with a 1.90" OD x 30" pipe mount	Ea	$231	54
5.951.0017.160	Light Duty Ballast Mount with a 1.90" OD x 60" pipe mount	Ea	$247	61
5.951.0017.230	Light Duty Ballast Mount with a 2⅜" OD x 30" pipe mount	Ea	$236	57
5.951.0017.242	Light Duty Ballast Mount with a 2⅜" OD x 42" pipe mount	Ea	$245	60

Wall Mounts
Using: Unistrut & conduit clamps



Wall Mounts

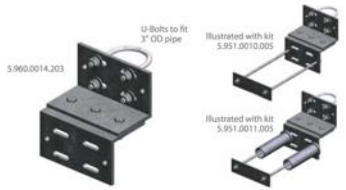
Using: U-Bolts, clip mount with concrete anchors.

Clip Mount Kits

Our Clip Mount Kits are an extension of the adjacent clip angle kits but come standard with an additional reversible bottom angle. For wall mounting applications and sold separately, we have standard bracket options available on page 80 that can connect to concrete walls (5.951.0010.005) or combined concrete/brick walls (5.951.0011.005) up to 16" thick. See page

Kit #	Description	Qty	List Price	Wt
Small Clip Mount Kits				
5.960.0011.200	Small Clip Mount Kit	Ea	$40	6.6
5.960.0011.201	Small Clip Mount Kit fits 2⅜" OD pipe	Ea	$50	7.3
5.960.0011.202	Small Clip Mount Kit fits 3" OD pipe	Ea	$52	7.4
5.960.0011.203	Small Clip Mount Kit fits 3½" OD pipe	Ea	$54	7.4

Note: Two 9/16" holes are spaced on 6" centers.

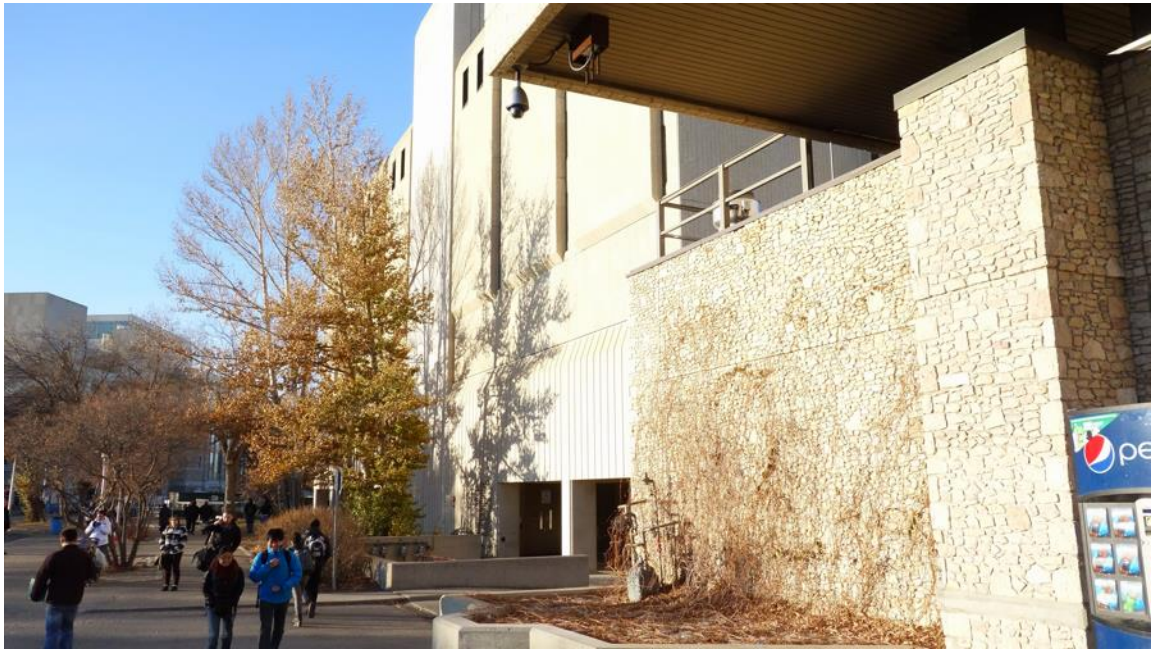


Custom Wall Mount
Fabricated in-house @ University Customer.

Not the most ideal setup (omni antennas against a wall). Aesthetics concerns at this location prevented an alternate location or design.

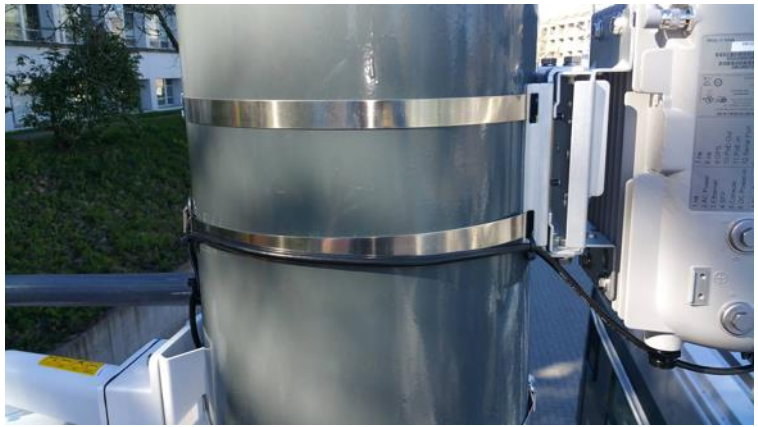
Signal from this AP covers a wide-open field which ends 350 feet away.

Custom Ceiling Mount
Fabricated in-house @ University In Canada



Pole / Pipe Mount

- AP 1572 is shown here using PMK1



AP1572 shown mounted to 8” diameter pole – providing power and connection to CCTV

Ideas for roof penetrations

A hole big enough for a 3” conduit was cored through the roof during renovation.
This hole was then covered over with a pre-cast slab which housed the CAT6 drop.
An elevated conduit pathway was established to AP location using rubber roof blocks obtained from Wesco Distribution (electrical supplier).

An electrical service entrance weather head provides a path for cables in this rooftop application

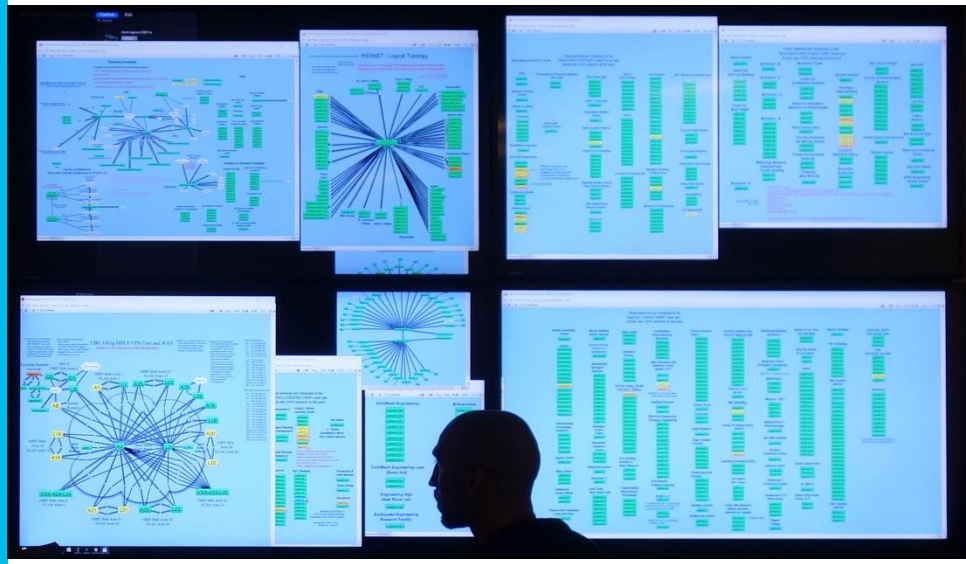
Installation Guides

- A hardware deployment guide is published that accompanies each product Cisco makes.
- These guides are specifically helpful in understanding the various mounting brackets and installation options for each product.
- Grounding, lightning protection, antenna configurations and weatherproofing are also covered.

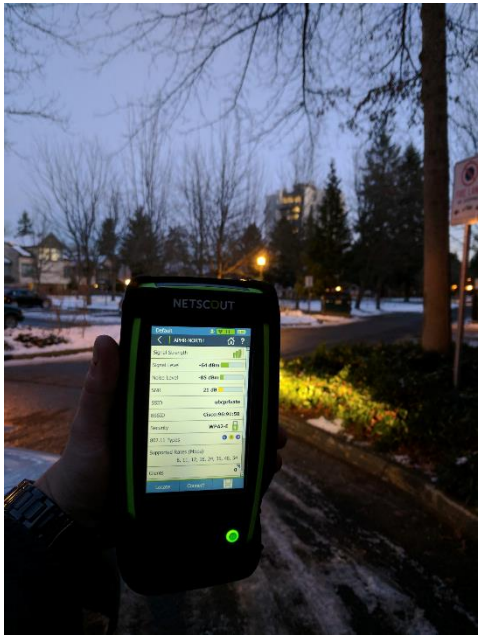
Quick Summary

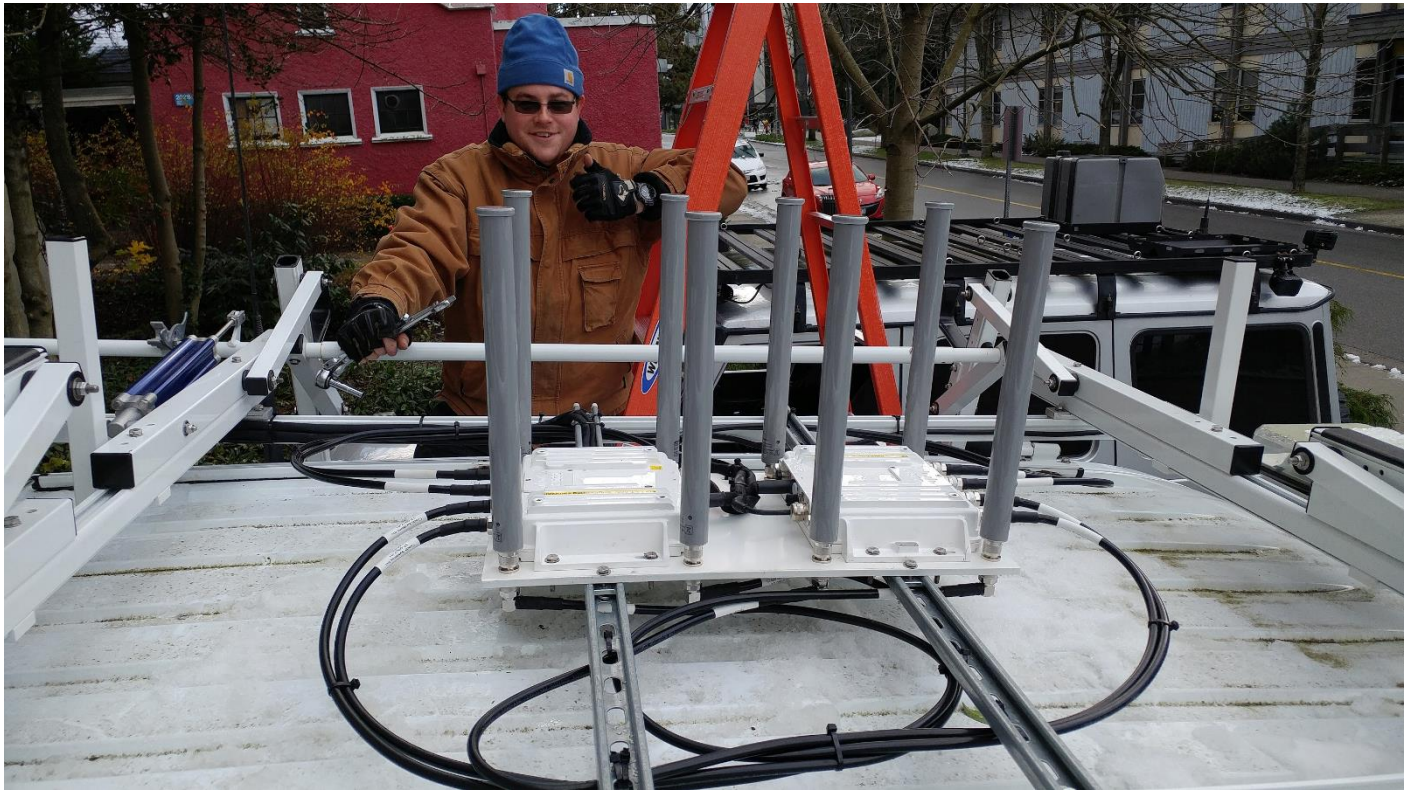
- The cost of deploying an AP outdoors is often **2-4x the cost of the hardware itself**.
- Fall protection training/equipment, engineering approval and pathway (coring etc.) drive installation cost up. As result, it is critical that time be spent up front to identify locations with the most “bang for buck”.
- Higher is not always better – ideal deployment height with Omni’s is often below 40’.
- Look to mount on building corners to maximum coverage areas
- Think about RF coverage like lighting – “where would I hang this light to minimize shadows? “

Looking at the data...

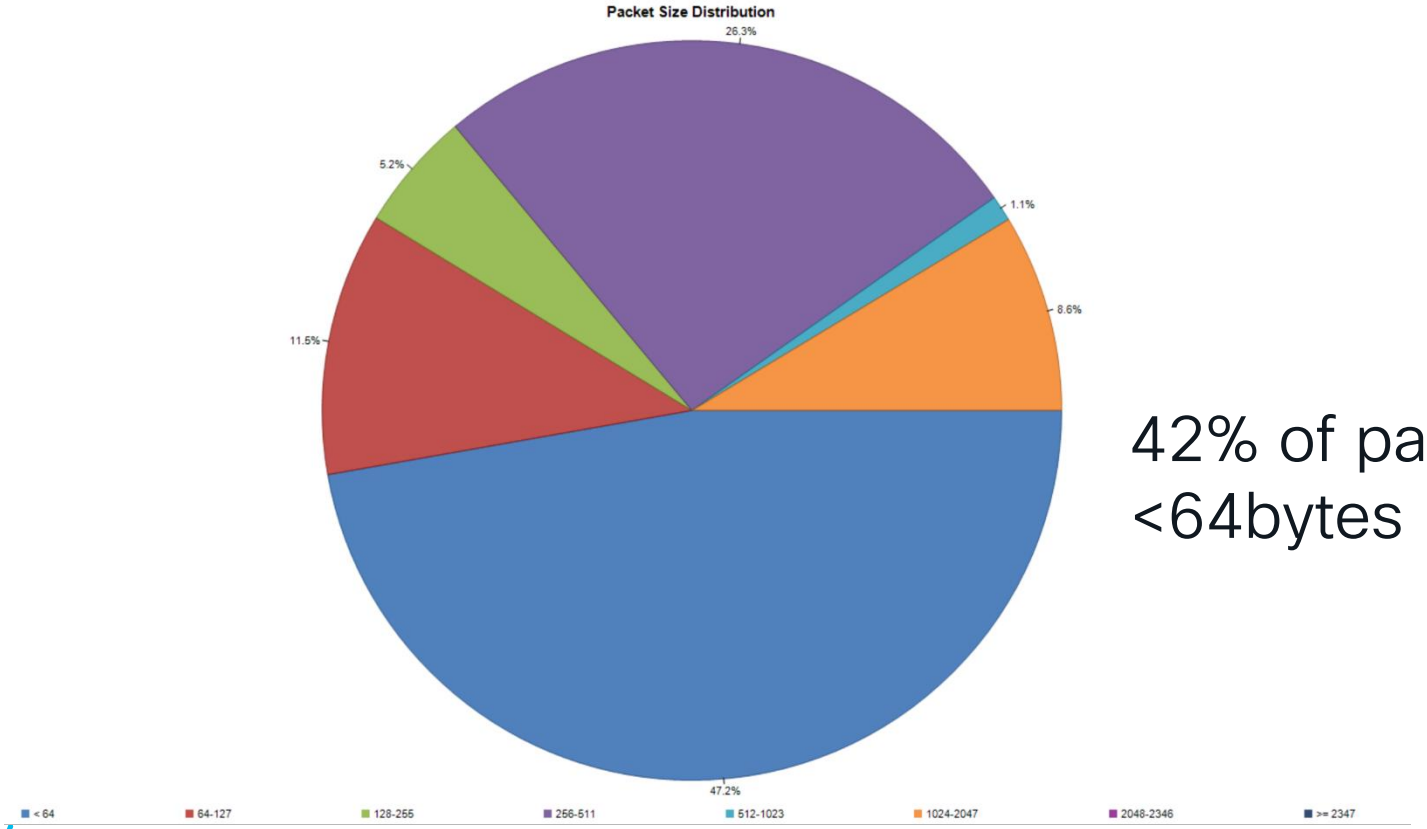


Building an Outdoor Sniffer



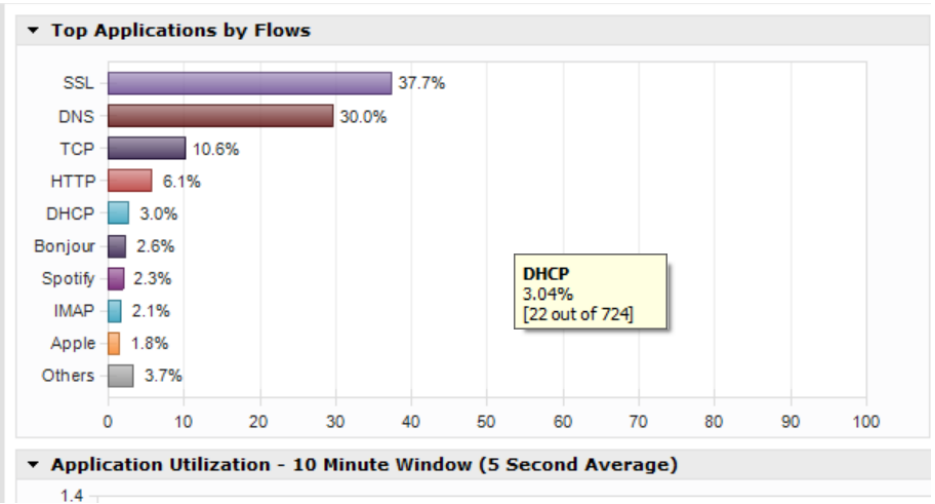


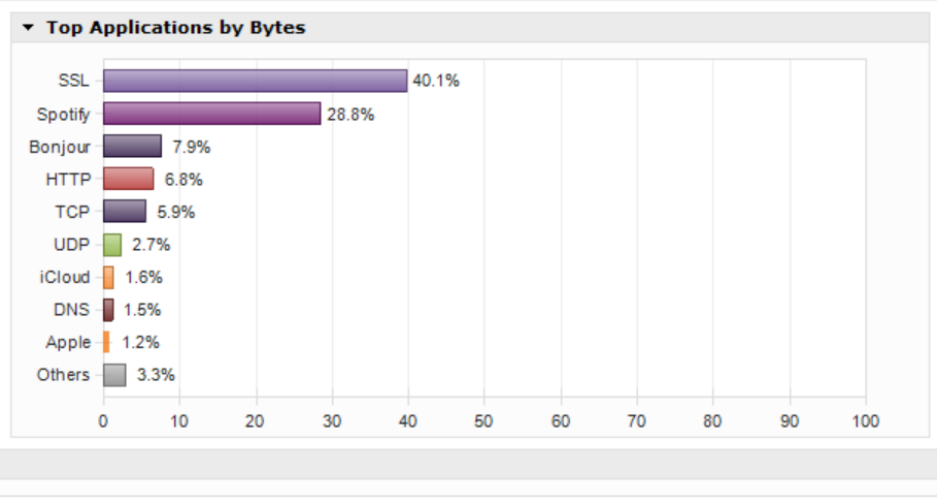
What's in the air?



42% of packets <64bytes

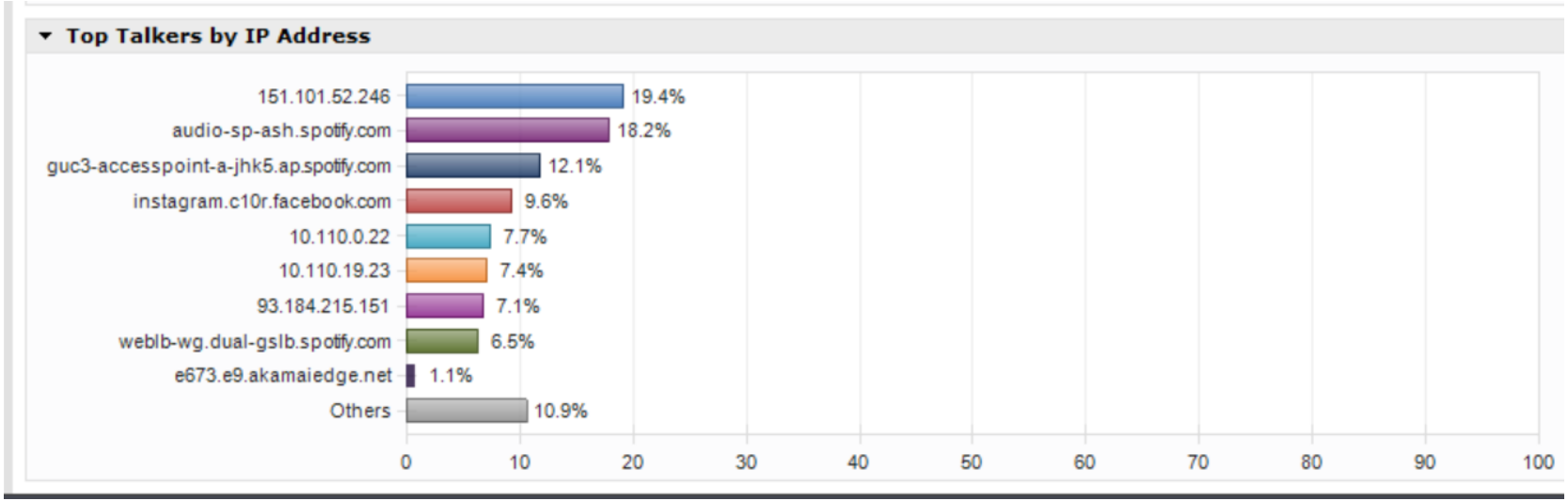
Protocol breakdown





Top Applications

- Near the bookstore (Spotify)



Comparing Indoor vs Outdoor Retry Rate

802.11 Analysis	Packets	Bytes	Value
Average Signal Strength			39.525
Average Signal dBm			-63.133
Average Noise			36.857
Average Noise dBm			-82.469
802.11 Data	19.275%	29.371%	
802.11 Management	18.706%	13.110%	
802.11 Control	34.189%	1.764%	
Local	54.059%	14.988%	
From DS	11.837%	27.[illegible]9%	
To DS	6.231%	2.098%	
DS-DS	0.043%	0.011%	
Retry	7.989%	13.112%	
Encrypted	16.409%	28.367%	
Decryption Errors	0.000%	0.000%	
Order	0.000%	0.000%	
Unprotected Data	1.440%	0.168%	
Minimum Data Rate Packets	0.043%	0.011%	

Indoor

Packets	Bytes	Value
		28.164
		-59.092
		26.725
		-79.848
18.357%	27.699%	
21.168%	23.499%	
34.525%	2.941%	
56.635%	26.600%	
10.397%	24.[illegible]0%	
6.895%	2.999%	
0.123%	0.051%	
19.453%	28.501%	
7.723%	16.337%	
0.000%	0.000%	
0.000%	0.000%	
1.455%	0.324%	
0.167%	0.074%	

Outdoor

Rate & Range Testing - 9124

Base Station:

- 1x 9124AXE-A UNII-3 TX PWR 1
- 2x 14dBi 5114P2M-N Patches
- Tested out to 2.7KM / 1.6miles
- Mast @ 32ft

On Vehicle:

- 1x 9124AXE-A
- 1x 13dBi patch ANT2513P4M-N

Rate & Range Testing – 9124

Rate & Range Testing - 9124

2513+9124 AXE on Vehicle

5114P2M-N x2 +9124 AXE on Mast

Rate & Range Testing – 9124AXE

Base Station:

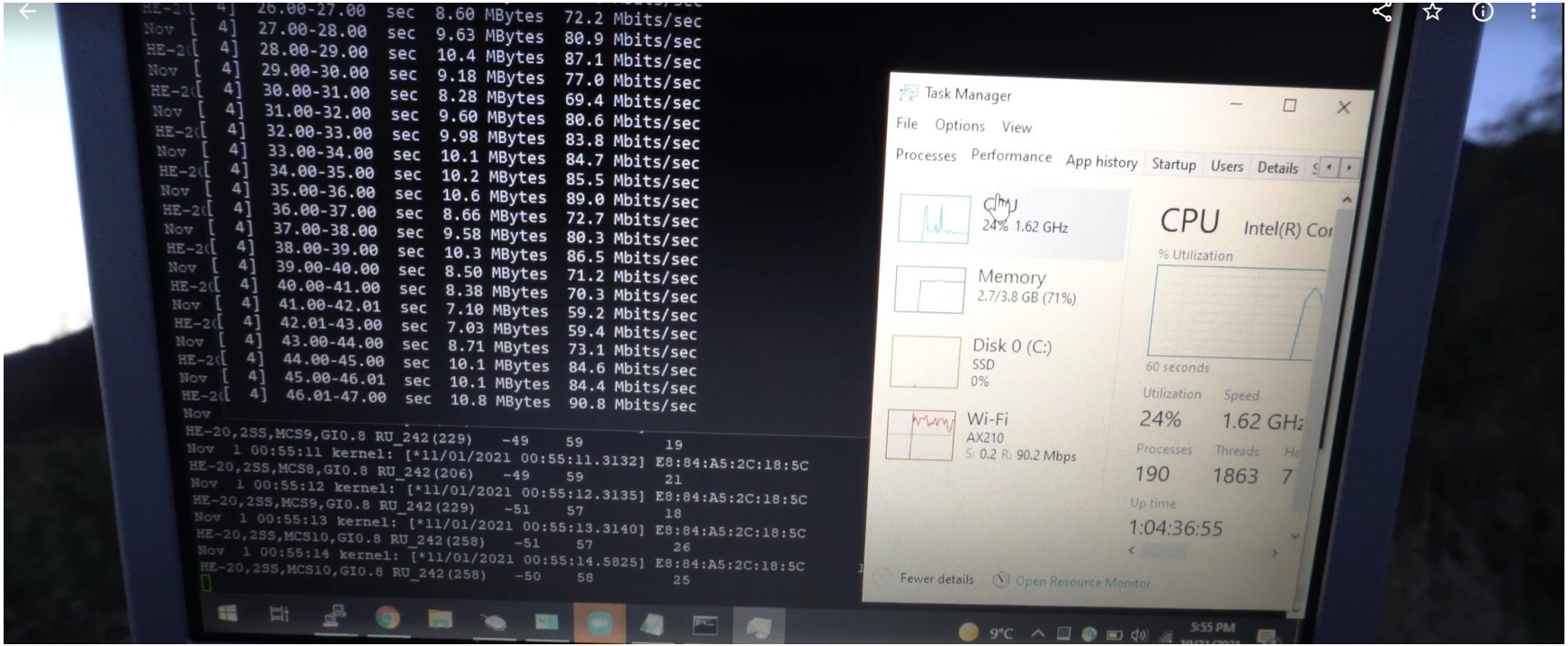
- 1x 9124AXE-A 2.4GHz TX PWR 1
- 4x 4/7dBi 2547 Omni's
- Tested out 800'
- Mast @ 32ft

Client:

- Panasonic Toughbook CF-30MK2
- 1x Intel AX210 2SS

Rate & Range Testing – 9124AXE /w Laptop @ 800ft

Rate & Range Testing – 9124AXE /w Laptop @ 800ft



Rate & Range Testing @ 800ft on 2.4GHz - 9124

6GHz Outdoors?

6E Regulatory Steps – FCC / USA Got things rolling...

Media Contact:
Neil Grace, (202) 418-0506
neil.grace@fcc.gov

For Immediate Release

FCC PROPOSES MORE SPECTRUM FOR UNLICENSED USE

WASHINGTON, October 23, 2018—The Federal Communications Commission today proposed to make up to 1200 megahertz of spectrum available for use by unlicensed devices in the 6 GHz band (5.925-7.125 GHz). Unlicensed devices that employ Wi-Fi and other unlicensed standards have become indispensable for providing low-cost wireless connectivity in countless products used by American consumers.

https://docs.fcc.gov/public/attachments/DOC-354692A1.pdf

6E Client Device Requirements – FCC

Federal Communications Commission
Office of Engineering and Technology
Laboratory Division Publication

February 4 2021

Part 15 Subpart E U-NII 6 GHz
General Guidance Bands 5, 6, 7, 8

There are seven equipment classes[6] that are applicable to a Form-731 for Part 15 Subpart E for 6 GHz U-NII device certifications, as illustrated in Figure 1:

1. 6ID: 15E 6 GHz Low-power indoor access point.
2. 6PP: 15E 6 GHz Subordinate indoor device. These devices are under control of a Low-power indoor access point (P1[7]).
3. 6XD: 15E 6 GHz Low-power Indoor client. These devices are under control of a low-power indoor access point (P1).
4. 6CD[2]: 15E 6 GHz Dual client. These devices are under control of either a low-power indoor access point (6ID) (P1) or Standard power access point (P2[7]).
5. 6SD*: 15E 6 GHz Standard power access point. These devices are managed by the Automatic Frequency Coordination (AFC) system.
6. 6FX*: 15E 6 GHz Standard client. These devices are under control of a Standard power access point (P2).
7. 6FC*: 15E 6 GHz Fixed client. These devices are associated with a standard power access point (P2).

* Applications only accepted in Phase 2.

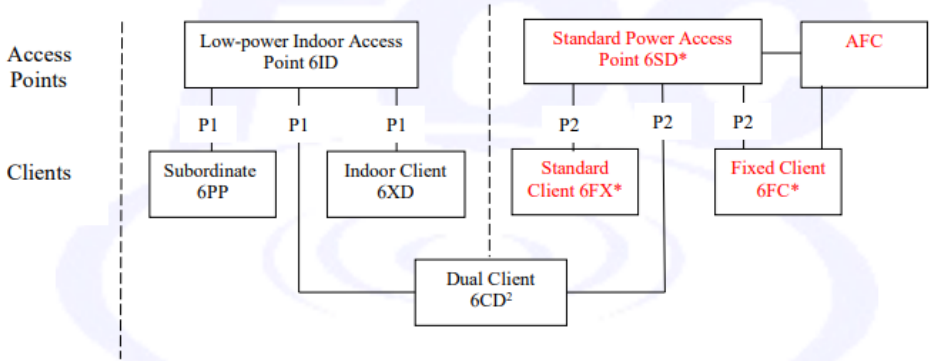


Figure 1 – Part 15 Subpart E Equipment Classes

A low-power indoor access point …

1. These devices may operate as a: bridge, peer-to-peer connection, connector between the wired and wireless segments of the network, or a relay between wireless network segments.
2. These devices are limited to indoor locations, have an integrated antenna, and cannot use a weatherized enclosure.
3. Low-power indoor access points devices are prohibited on oil platforms, cars, trains, boats, and aircraft, except large aircraft while flying above 10,000 feet.
4. Low-power indoor access points must be powered by a wired connection and not by battery power [7].
5. Low-power indoor access points may use battery backup only during power outages.

Incumbent Users – Utilities / SCADA

Background

The FCC's Report and Order (R&O) to open the 6 GHz band of spectrum to unlicensed usage went into effect in July 2020.

The R&O allows two types of unlicensed operations -- low powered indoor use and outdoor use protected with an automated frequency coordination (AFC) technology.

A broad coalition of incumbent license holders filed extensive comments raising concerns about interference to operations that could result from opening the band to unlicensed users and requesting further testing and protections from the FCC. Those concerns and comments were not addressed, leading APPA and others in the electric sector to file legal challenges.

In April 2021, investor-owned utility Southern Company and the Electric Power Research Institute (EPRI) acquired 6 GHz devices available on the market to conduct real world testing on impacts to electric utilities.

They operated them near a Southern Company microwave link operating between Fortson and Columbus, Ga., using the FCC thresholds for reportable interference. The tests showed that, even at low powered indoor use, the unlicensed devices would "cause harmful interference to licensed fixed microwave systems" greater than the FCC's acceptable levels. This report was filed and presented to FCC staff.

AMERICAN PUBLIC POWER ASSOCIATION

APPA was joined in the filings by:

- The Utilities Technology Council
- American Gas Association
- Edison Electric Institute
- American Petroleum Institute
- American Water Works Association
- National Rural Electric Cooperative Association
- International Association of Fire Chiefs
- The Association of American Railroads
- APCO International
- Nuclear Energy Institute and
- The National Public Safety Telecommunications Council.

https://www.publicpower.org/periodical/article/appa-other-groups-seek-fcc-rulemaking-6-ghz-low-power-indoor-devices

AT&T vs. FCC on 6GHz in December 2021

United States Court of Appeals
FOR THE DISTRICT OF COLUMBIA CIRCUIT

Argued September 17, 2021 Decided December 28, 2021

No. 20-1190

AT&T SERVICES, INC.,
PETITIONER

v.

FEDERAL COMMUNICATIONS COMMISSION AND UNITED STATES OF AMERICA,
RESPONDENTS

APPLE INC., ET AL.,
INTERVENORS

Consolidated with 20-1216, 20-1272, 20-1274, 20-1281, 20-1284

On Petitions for Review of an Order
of the Federal Communications Commission

Jonathan E. Nuechterlein argued the causes for petitioners Joint Issues. *Mark Reddish* argued the causes for petitioner APCO. With them on the joint briefs were *Jeffrey S. Cohen*, *C. Frederick Beckner III*, *Rick Kaplan*, *Jerianne Timmerman*, *Craig A. Gilley*, *Mitchell Y. Mirviss*, *Elizabeth C. Rinehart*, and *Russell P. Hanser*. *Michele Farquhar*, *Brett Kilbourne*, *Jay*

Thread

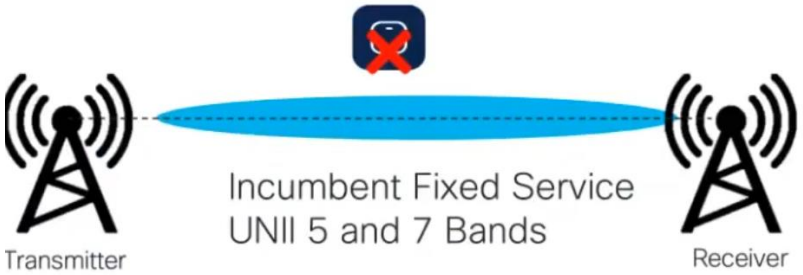
Jessica Rosenworcel
@JRosenworcel

Big news! Today the DC Circuit unanimously upheld the FCC's decision to free up the 6 GHz band for more unlicensed use. This decision = more Wi-Fi in more places and it matters because it comes at a time when being connected is more important than ever. cadc.uscourts.gov/internet/opini...

11:42 AM · Dec 28, 2021 · Twitter Web App

https://www.cadc.uscourts.gov/internet/opinions.nsf/7658F4CE919568A7852587B900589344/%24file/20-1190-1928330.pdf

Client-Side Behavior – AFC Example



Specified Search

State = California
County = SANTA CLARA
Frequency Upper Band >= 6425
Frequency Assigned <= 5925

Matches 1- 10 (of 109)

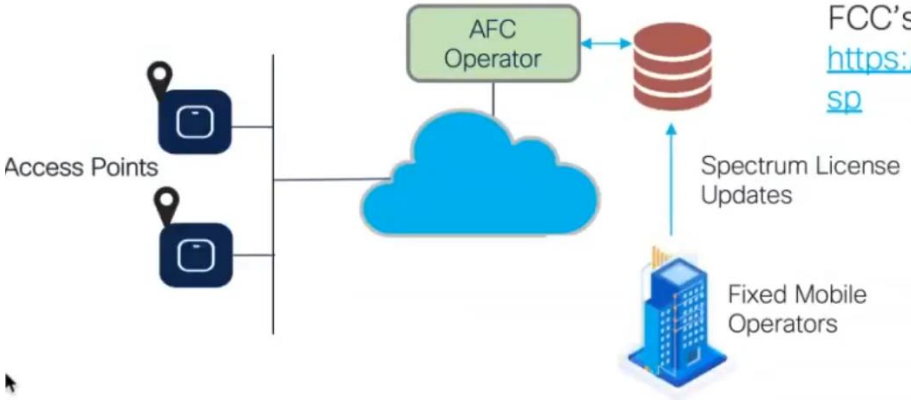
Pending Application(s)
Termination Pending
Lease

Page 1 2 3 4 5 6 7 8 9 10 NEXT »

	Call Sign/Lease ID	Name	FRN	Radio Service	Status	Expiration Date
1	KDJ61	Pacific Gas and Electric Company	0029560497	MG	Active	05/31/2030
2	KHO66	SANTA CLARA, COUNTY OF	0001539824	MW	Active	01/17/2031
3	KMD36	SANTA CLARA, COUNTY OF	0001539824	MW	Active	09/15/2028
4	KMJ74	Pacific Gas and Electric Company	0029560497	MG	Active	11/28/2021
5	KMJ93	AT&T COMMUNICATIONS OF CALIFORNIA INC	0003301702	CF	Canceled	02/01/2010
6	KMR49	Pacific Gas and Electric Company	0029560497	MG	Active	12/24/2027
7	KMW56	PACIFIC BELL	0001551530	CF	Canceled	08/01/2000
8	KMY77	SOUTHERN CALIFORNIA EDISON COMPANY	0001535608	CF	Active	11/19/2021
9	KMZ79	AT&T COMMUNICATIONS OF CALIFORNIA INC		CF	Canceled	02/01/2000
10	KND27	SOUTHERN CALIFORNIA EDISON COMPANY	0001535608	CF	Active	01/18/2022

Call Sign/Lease ID | Name | FRN | Radio Service | Status | Expiration Date

Page 1 2 3 4 5 6 7 8 9 10 NEXT »



FCC's Universal Licensing System:
https://wireless2.fcc.gov/UlsApp/UlsSearch/searchGeographic.jsp

Automated Frequency Coordination (AFC):
Central database of frequencies, which are available in the AP's same geographical location, and where the AP does not risk to interfere with other systems (e.g. fixed satellites)

Where Does the 9124 Fit in?

How are the models different?

9124AX(I,D,E)

Old Family Photos...

1572IC

AP-IOS

Note: 1572IC has integrated cable modem and is powered via coax. Typically for cable operators only!

1572EAC

AP-IOS

With GPS!

GPS RX built in, external antenna optional. Cool feature for mining operators or people who move RAPs/MAPs.

1562E

1540

1562I

AP-COS for All three

Catalyst 9124AX Outdoor Access Point

C9124AXI(D) Integrated Omni & Directional

Powered by Cisco RF ASIC

9124AXI, 9124AXD

- 4x4 + 4x4 in both 2.4 and 5 GHz
- MU-MIMO, OFDMA
- Cisco RF ASIC for next-gen Cisco CleanAir®
- Integrated BLE/IoT radio
- 2.5G mGig Wired uplink + 1G SFP+ 1Gbe with 802.3af power out – 15.4 watts
- 30 dBm Transmit Power(Same as 1572)
- 1024 QAM, data rate of 2.5 Gbps

C9124AX External Antennas

Powered by Cisco RF ASIC

9124AXE

- Dual Radio Mode: 4x4 + 4x4 in both 2.4 and 5 GHz
- Tri-Radio Mode: 2x2 + 2x2 + 2x2 in 2.4 Ghz, 5Ghz(Slot 1) & 5 Ghz(Slot 2)
- MU-MIMO, OFDMA
- Cisco RF ASIC for next-gen Cisco CleanAir
- Integrated BLE/IoT radio
- 2.5G mGig Wired uplink + 1G SFP + 1Gbe (802.3af power out-15.4 watts)
- 29 dBm Transmit Power
- Enhance Surge Protection & Lightning arrester for Ethernet ports and DC Input
- -E SKU: Six N-type connectors: Three ports support Self-Identifying Antenna (SIA)

Cisco Outdoor AP Dimensions

9124AXE: 10.2 x 9.2 x 3.2 in. (25.9 x 23.3 x 8.1 cm)

9124AXI/D: 10.2 x 9.2 x 3.2 in. (25.9 x 23.3 x 8.1 cm)

1542I/D: 7.9 x 5.9 x 2.4 in. (20 x 15 x 6.1 cm)

1562I: 9.0 x 6.8 x 3.9 in. (22.9 x 17.1 x 9.8 cm)

1562D: 9.0 x 6.8 x 4.3 in. (22.9 x 17.1 x 10.9 cm)

1562E: 9.0 x 6.8 x 3.9 in. (22.9 x 17.1 x 9.8 cm)

1572EAC/1572EC: 11.8 x 7.9 x 6.3 in. (30.0 x 20.1 x 16.0 cm)

1572IC: 11.8 x 7.9 x 7.9 in. (30.0 x 20.1 x 20.1 cm)

Catalyst 9124AXI/D – Ports / Plugs / Etc.

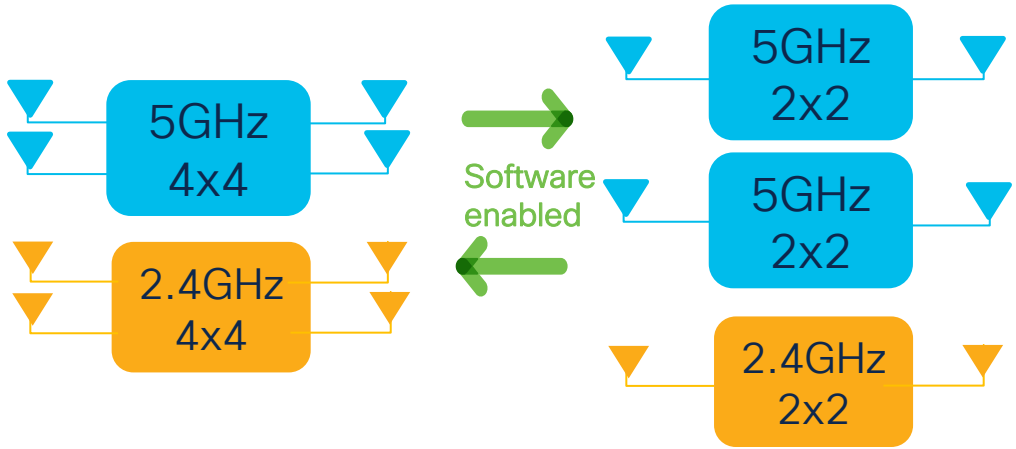
FAQ:

Q1: Can the AP be powered by an injector but use the SFP port for backhaul?

A1: YES.

C9124AXE – Radio Mode

Mode	2.4 Ghz (Slot 0)	5 Ghz (Slot 1)	5 Ghz (Slot 2)
Dual Radio	4x4	4x4	Down
Tri-Radio	2x2	2x2	2x2



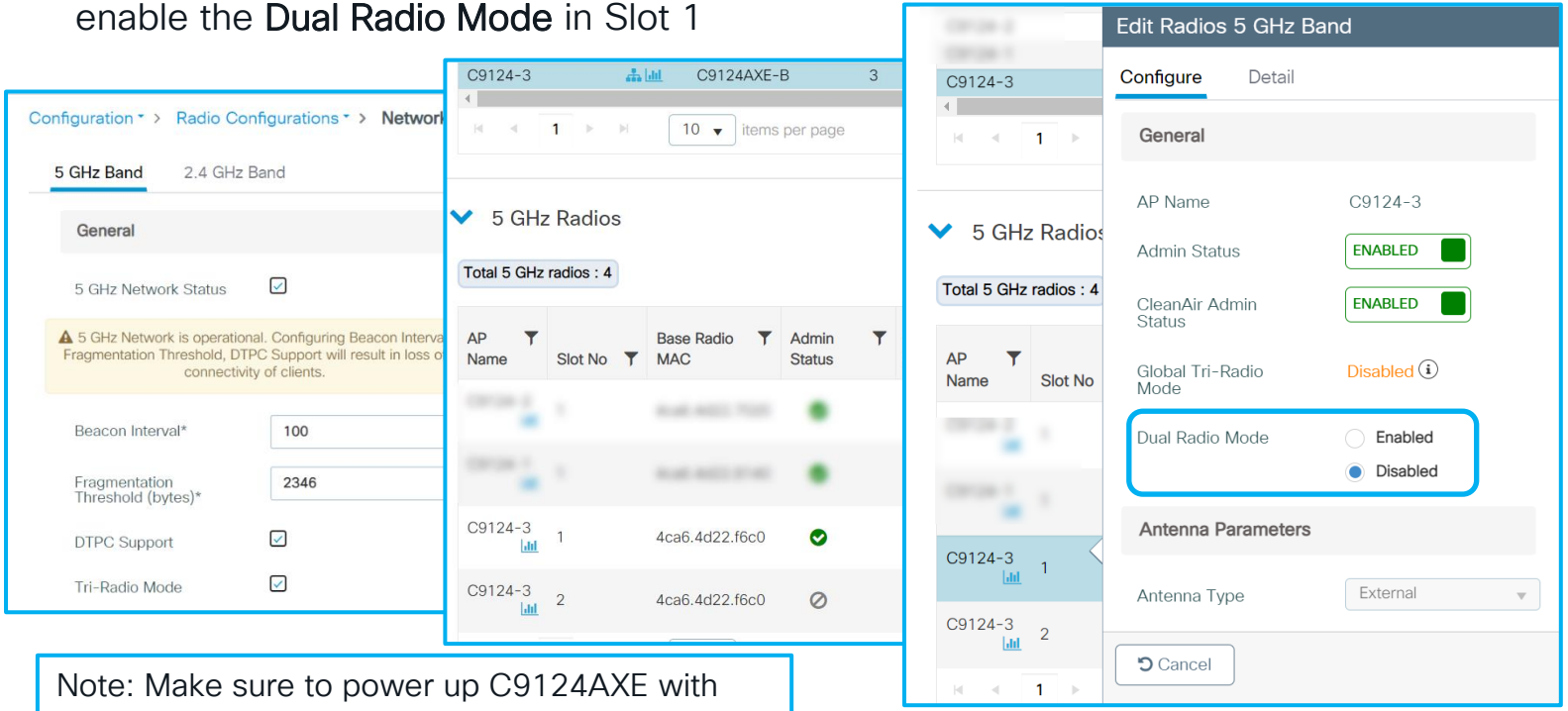
Note: To enable Tri-Radio Mode, C9124AXE should be powered up by 802.3bt/UPOE/DC

Catalyst 9124AXE – RF Port Mapping

Mode	Ports Used For 2.4 Slot 0	Ports Used For 5GHz Slot 1	Ports Used for 5GHz Slot 2
2.4GHz 1ss 5GHz 1ss 5GHz 1ss	1	3	5
2.4GHz 2ss 5GHz 2ss 5GHz 2ss	1,2	3,4	5&6
2.4GHz 4ss 5GHz 4ss 5GHz 2ss	1,2,3,4	1,2,3,4	5&6

Catalyst 9124AXE – Tri-Radio Mode

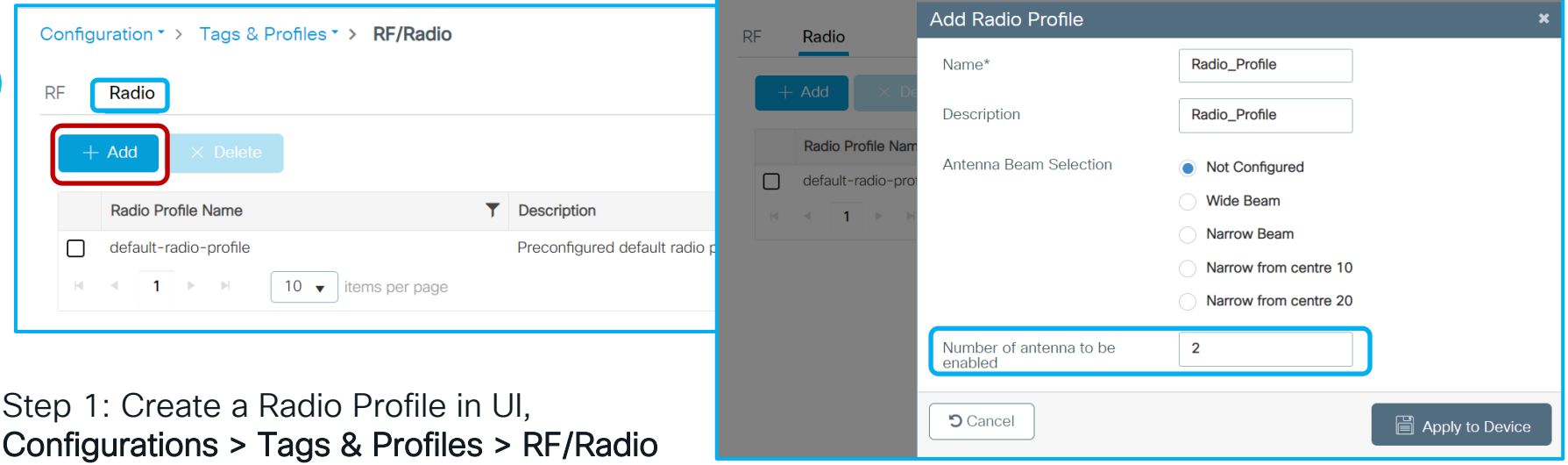
- To enable Tri-Radio globally in UI, **Configuration > Radio Configurations > Network(5ghz)**
- In Access Point(**Configuration > Wireless > Access Points**), Expand the **5 Ghz Radios** and enable the **Dual Radio Mode** in Slot 1



Note: Make sure to power up C9124AXE with 60W source to operate in Tri-Radio Mode

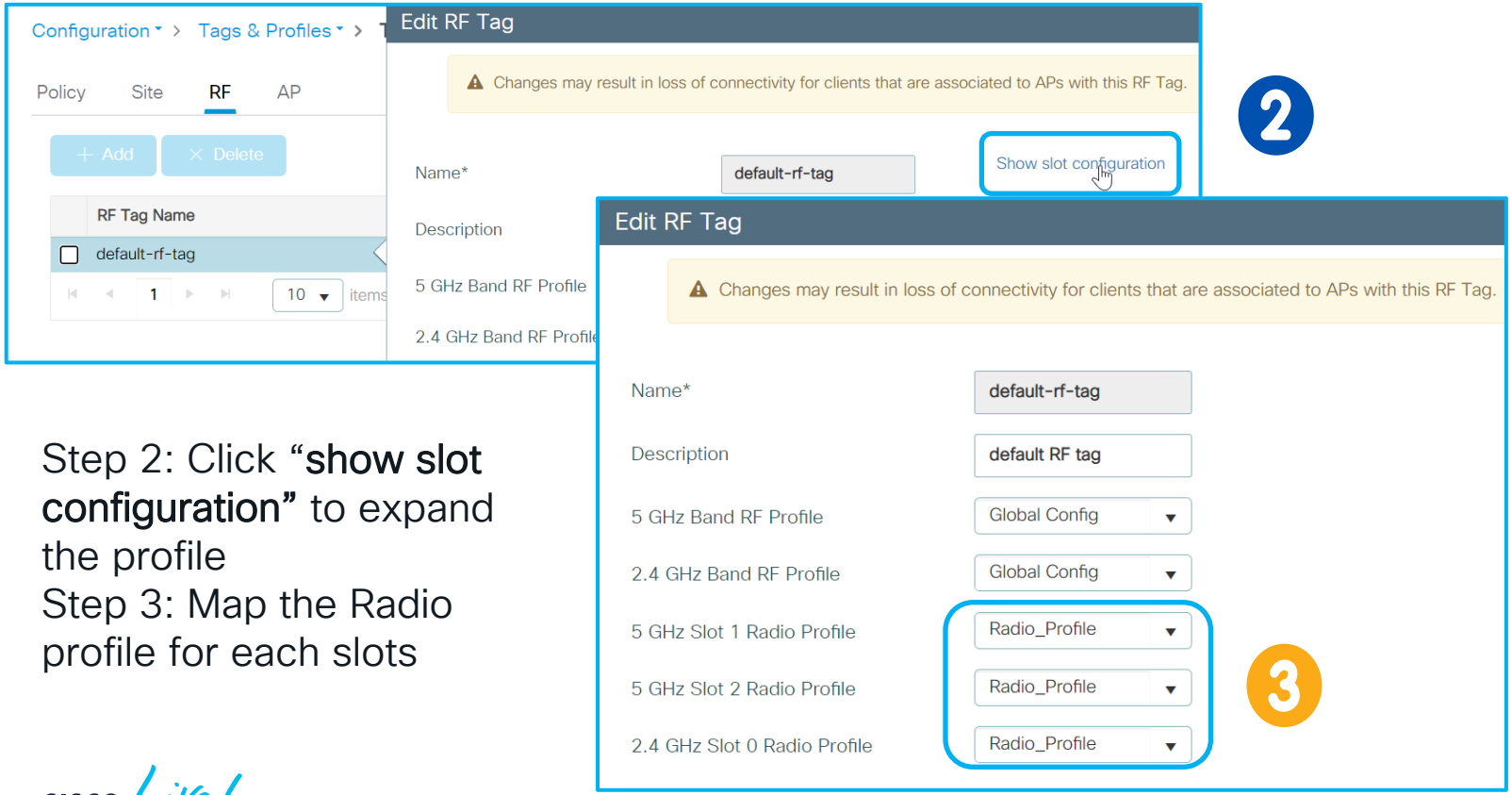
Catalyst 9124AX Series – Radio Profile

- In Cisco IOS-XE 17.6.1 SW, Catalyst 9124AX APs can operate in 1x1, 2x2 & 4x4 only
- With the introduction of Antenna Selection, Administrator can choose the mode manually and allowing the Access Point to choose the Antenna to be used



Step 1: Create a Radio Profile in UI,
Configurations > Tags & Profiles > RF/Radio

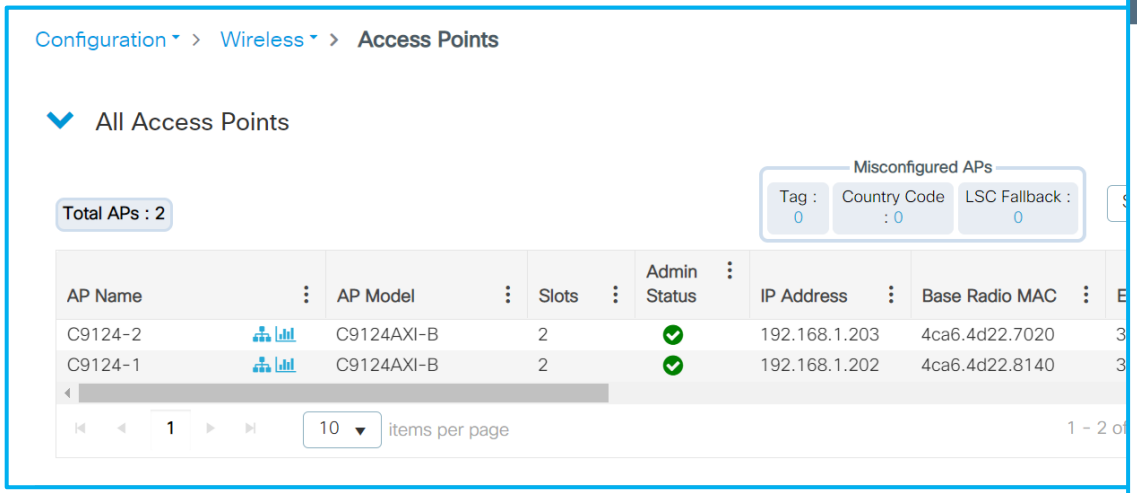
Catalyst 9124AX – Radio Profile

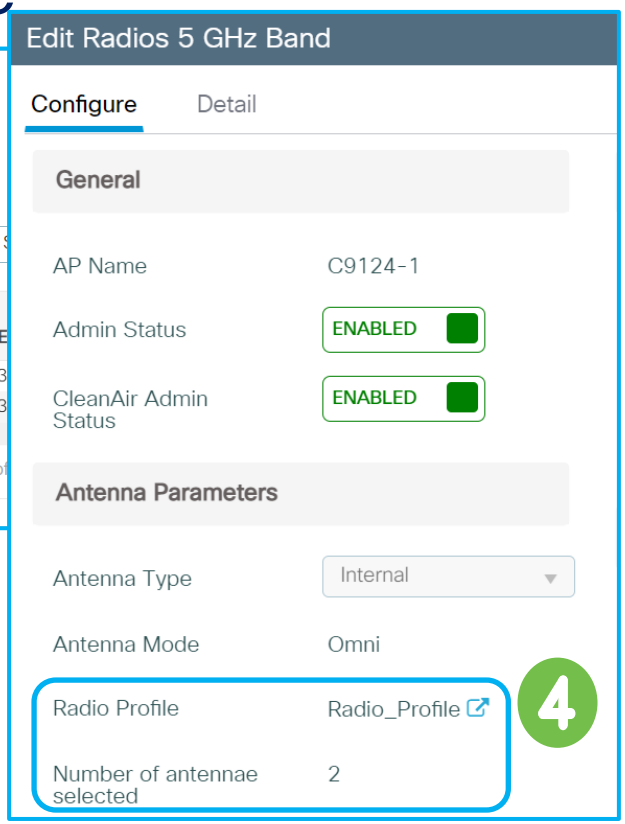


Step 2: Click “**show slot configuration**” to expand the profile

Step 3: Map the Radio profile for each slots

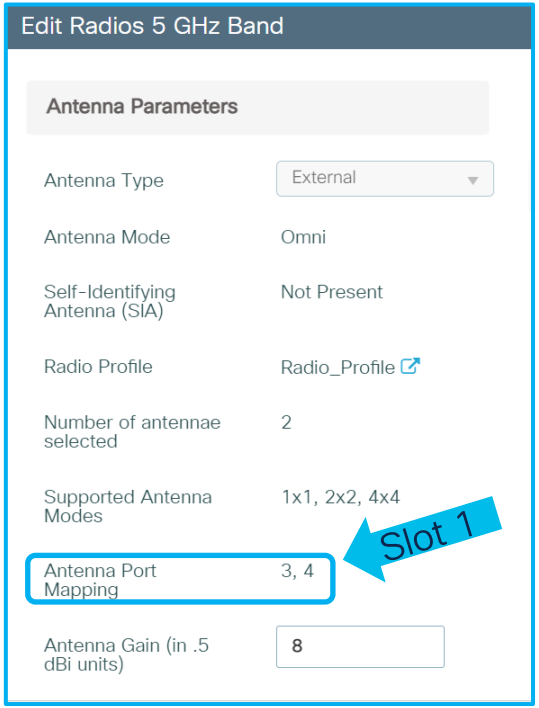
Catalyst 9124AX – Radio Profile





Step 4: Check the **Radio Profile** & **Number of Antennae selected** in the Access Point slots

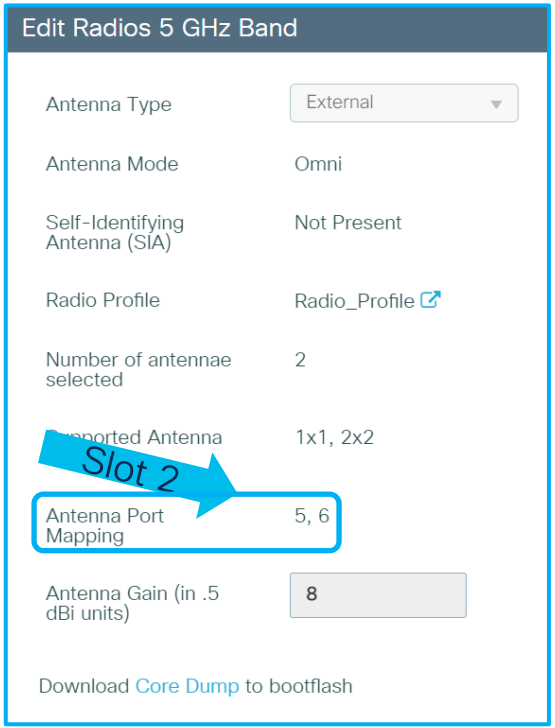
Catalyst 9124AXE – Radio Profile



Step 5 & 6: Antenna Port Mapping is also displayed in respective radio slots

5

6



Catalyst 9124AXI/D: Antenna Configuration

- Catalyst 9124AXI/D APs support 4 Antenna Paths in both 5 Ghz and 2.4 GHz. A separate internal Antenna for IoT and pair of Antenna for AUX. Below table explains the different Antenna modes supported in C9124I/D.

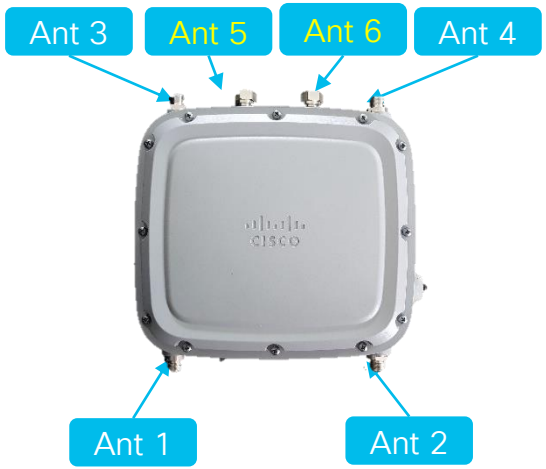
	5Ghz Radio				2.4Ghz Radio				IoT	CW	
Mode	Path-0 Ant-1	Path-1 Ant-2	Path-2 Ant-3	Path-3 Ant-4	Path-0 Ant-1	Path-1 Ant-2	Path-2 Ant-3	Path-3 Ant-4	Path-0	Path-0	Path-1
1x1	Y	-	-	-	Y	-	-	-	Y	Y	Y
2x2	Y	Y	-	-	Y	Y	-	-	-	-	-
4x4	Y	Y	Y	Y	Y	Y	Y	Y	-	-	-
2x2(160)	Y	Y	-	-	-	-	-	-	-	-	-
4x4(160)	Y	Y	Y	Y	-	-	-	-	-	-	-

Catalyst 9124AXE: Dual Radio Antenna Configuration

- The -E SKU supports one to six antenna configurations
- -E SKU IoT radio has internal dedicated Antenna, and the Aux radio will share the same antennas with serving radios through splitters

Catalyst® 9124AXE Dual-Radio Antenna Configurations:

	5Ghz Radio 1 (Primary)				5Ghz Radio 2 (Secondary)		2.4Ghz Radio				IoT
Mode	Path-0 Ant-3	Path-1 Ant-4	Path-2 Ant-1	Path-3 Ant-2	Path-0 Ant-5	Path-1 Ant-6	Path-0 Ant-1	Path-1 Ant-2	Path-2 Ant-3	Path-3 Ant-4	Path-0
1x1 (20/40/80)	Y	-	-	-	-	-	Y	-	-	-	Y
2x2 (20/40/80)	Y	Y	-	-	-	-	Y	Y	-	-	Y
4x4 (20/40/80)	Y	Y	Y	Y	-	-	Y	Y	Y	Y	Y



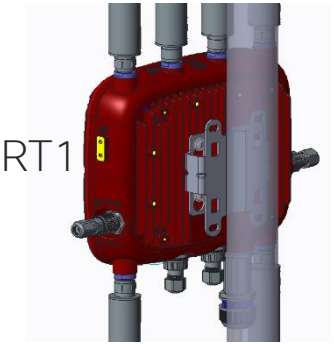
Catalyst 9124AXE: Tri-Radio Antenna Configuration

Catalyst® 9124AXE Tri-Radio Antenna Configurations: Channel Bandwidth <=80 Mhz

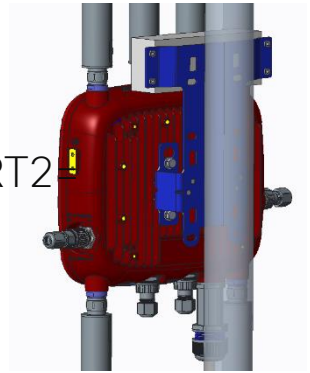
	5Ghz Radio 1 (Primary)				5Ghz Radio 2 (Secondary)		2.4Ghz Radio				IoT
Mode	Path-0 Ant-3	Path-1 Ant-4	Path-2 Ant-1	Path-3 Ant-2	Path-0 Ant-5	Path-1 Ant-6	Path-0 Ant-1	Path-1 Ant-2	Path-2 Ant-3	Path-3 Ant-4	Path-0
1x1 (20/40/80)	Y	-	-	-	Y	-	Y	-	-	-	Y
2x2 (20/40/80)	Y	Y	-	-	Y	Y	Y	Y	-	-	Y

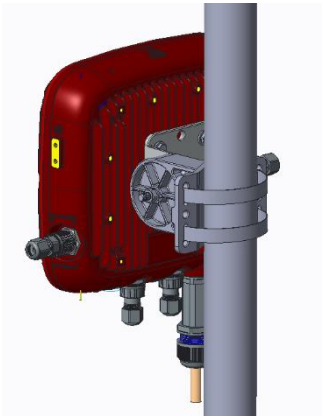
Catalyst 9124AX Series: Mounting Brackets

AIR-MNT-VERT1

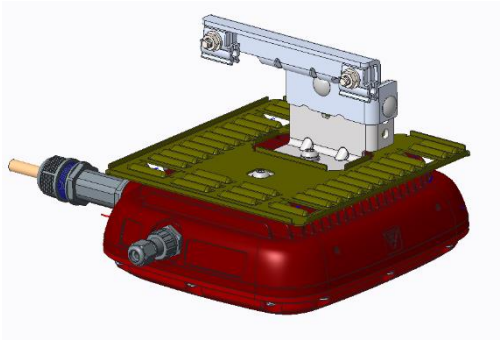


AIR-MNT-VERT2

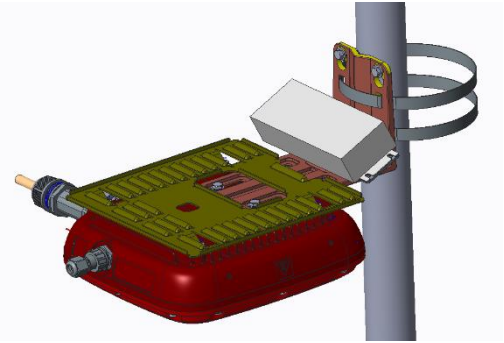




AIR-MNT-ART1=



AIR-MNT-STRAND1=



AIR-MNT-HORZ1= & AIR-MNT-HORZ1-PSU

Catalyst 9124AX Series: Re-usable Mounting kits

Mounting kit - Reusable	9124AXI	9124AXD	9124AXE
AIR-ACC1530-PMK1=	✗	✓	✓
AIR-ACC1530-PMK2=	✗	✓	✓

AIR-ACC1530-PMK1=
Fixed vertical mount

AIR-ACC1530-PMK2=
Tilting mount

Catalyst 9124AXE: Antenna options

- Antennas (most of them) used in AP1562E can be re-used in C9124AXE access points. In addition, support for the new SIA Antenna(highlighted below) is also available in same band and gain

Product ID	Description	Gain
AIR-ANT2547V-N	Omnidirectional dual band (2.4/5 GHz)	2.4 Ghz: 4 dBi 5 Ghz: 7 dBi
AIR-ANT2547VG-N/**AIR-ANT2547VG-NS**	Omnidirectional dual band (2.4/5 GHz)	2.4 Ghz: 4 dBi 5 Ghz: 7 dBi
AIR-ANT2568VG-N/**AIR-ANT2568VG-NS**	Omnidirectional dual band (2.4/5 GHz)	2.4 Ghz: 6 dBi 5 Ghz: 8 dBi
AIR-ANT2588P3M-N=	3-port wall/pole mount directional (wide)	2.4 Ghz: 8 dBi 5 Ghz: 8 dBi
AIR-ANT2588P4M-NS=	4-port wall/pole mount directional (wide)	2.4 Ghz: 8 dBi 5 Ghz: 8 dBi
AIR-ANT2513P4M-N/**AIR-ANT2513P4M-NS=**	4-port wall/pole mount directional (narrow)	2.4 Ghz: 13 dBi 5 Ghz: 13 dBi
AIR-ANT2450V-N=	Omnidirectional (2.4 GHz)	2.4 Ghz: 5 dBi
AIR-ANT2480V-N=	Omnidirectional (2.4 GHz)	2.4 Ghz: 8 dBi
AIR-ANT2413P2M-N=/**AIR-ANT2413P2M-NS=**	2-port directional (2.4 GHz)	2.4 Ghz: 13 dBi
AIR-ANT5180V-N=	Omnidirectional (5 GHz)	5 Ghz: 8 dBi
AIR-ANT5114P2M-N=/**AIR-ANT5114P2M-NS=**	2-port directional (5 GHz)	5 Ghz: 14 dBi

- Support Self-Identifying Antennas (AP ANT ports 1, 3, 5) in Antennas:
  AIR-ANT2547VG-NS, AIR-ANT2568VG-NS, AIR-ANT2413P2M-NS=, AIR-ANT5114P2M-NS=, AIR-ANT2568VG-NS, AIR-ANT2513P4M-NS=

Recent MESH Enhancements

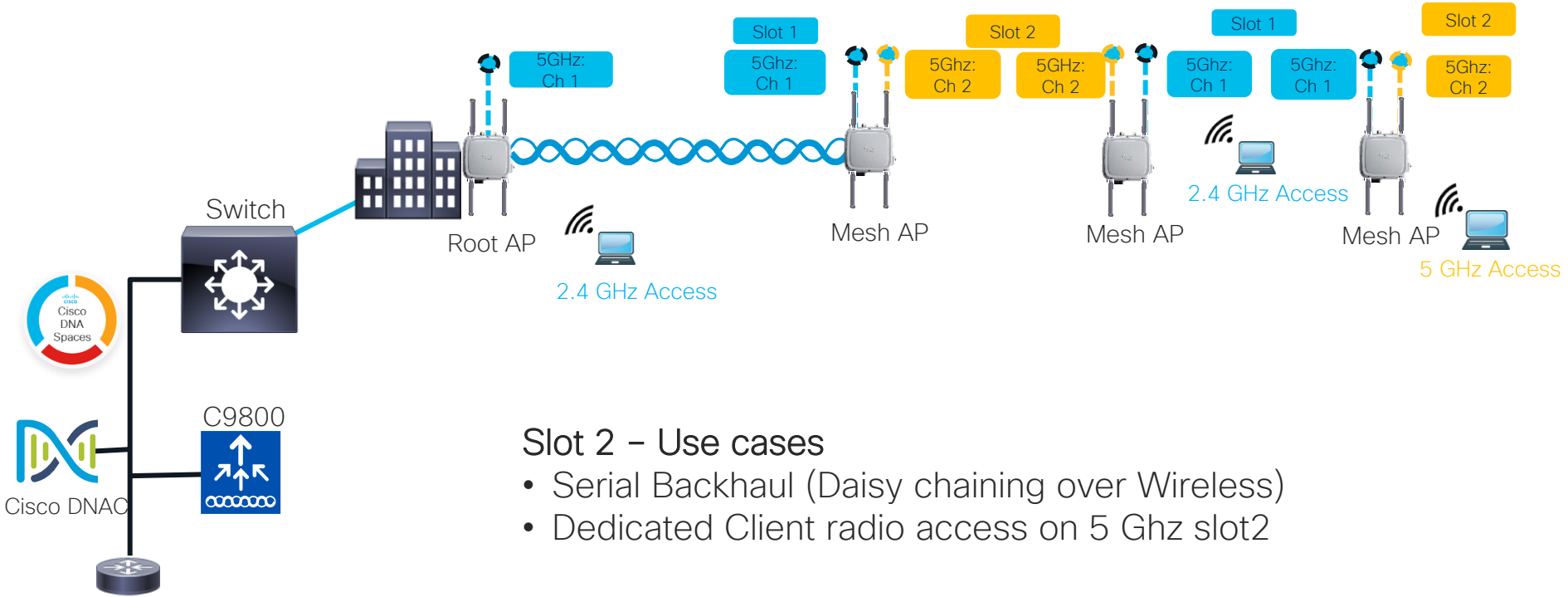
Problem: Bandwidth drops the deeper my MESH gets

Problem: Every time I “hop” through a MESH node, my bandwidth half's and my latency doubles. This sucks. How can I fix this?

Solution: Use an AP with 2x 5GHz slots that supports “Serial Backhaul”

Serial Backhaul enables the use of different channels on different backhauls, which helps in reducing interferences and maximizes the throughput. Intention is that in units with 3rd and 4th radio, two of the radios are reserved for backhaul.

Solution Overview – Mesh Serial Backhaul



Slot 2 – Use cases

- Serial Backhaul (Daisy chaining over Wireless)
- Dedicated Client radio access on 5 Ghz slot2

Configurations – Serial Backhaul

Config

```
C9800(config)#wireless profile radio mesh-downlink
C9800(config)#mesh backhaul
C9800(config)#[no] mesh designated downlink

C9800(config)#wireless tag rf map-tag
C9800(config)#dot11 5ghz slot2 radio-profile mesh-downlink

Associate the RF Tag to the Access Point
```

Verify

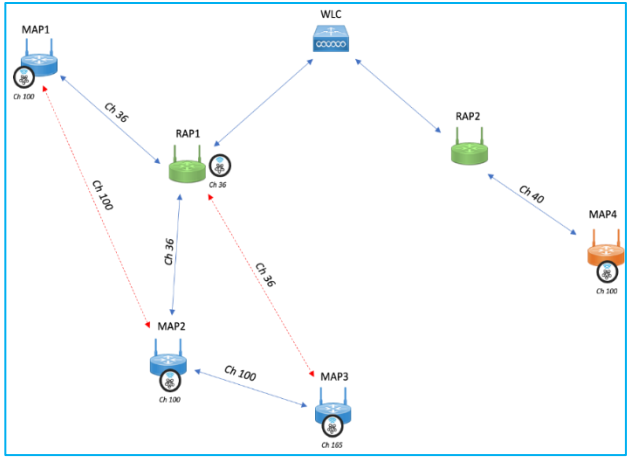
```
C9800# show wireless profile radio detailed <profile>
Radio Profile name: <profile>
Description:
Beam-Selection: Not configured
Mesh
  Backhaul: <true/false>
  Designated downlink: <true/false>
```

- ✓ Executed in CLI radio profile config mode
- ✓ Enables/Disables the serial backhaul feature
- ✓ Once configured following warning is printed:

  "Warning! Designated downlink supported only on slot2 of mesh APs, associate in the rf tag accordingly"

Mesh Config – Serial Backhaul

```
C9800# # show mesh config
AP Specific Configuration:
AP Role: Mesh AP
Backhaul Mode: 802.11a
Internal DHCP Running Status: Disabled
Strict Wired Uplink: Disabled
Background Scanning: Disabled
Strict Matching BGN: Disabled
Convergence Method: Standard Convergence, CCN mode: Disabled
Ethernet Bridging BPDU Allow: Disabled
Daisy Chain Mode: Disabled
.....
Preferred Parent: 00:00:00:00:00:00
CAPWAP Join Mode: Not configured
Daisychain STP Redundancy: Disabled
Bridge Group Name:
Mesh Block Child State: Allowed
Serial backhaul: Enabled
Radio config:
 Slot0:          [        backhaul:Enabled        supported_downlink:Disabled
designated_downlink:Disabled ]
  Slot1:         [        backhaul:Enabled        supported_downlink:Enabled
designated_downlink:Disabled ]
  Slot2:         [        backhaul:Enabled        supported_downlink:Enabled
designated_downlink:Enabled ]
```



Channel Assignment – Initial Phase – Serial Backhaul

Design	❑ Uplink and Downlink channels shall be different ❑ All 5G radios shall respect a frequency guard between their operating channel (HW dependent, for example Ithaca (AP9124) 100Mhz) ❑ DFS channels shall be supported
RAP	❑ Uplink is Wired. The RAP uses the channel given by WLC
MAP	❑ The MAP connects to a Parent as first step. Once uplink is ready, then the MAP will select the best channel to be used. Different from Uplink, that respects frequency guard of the platform.

Channel Assignment – Serial Backhaul

Radio Assignment	❑ No per-AP configuration, Uplink and Downlink radios are statically assigned as radio profiles. (e.g., radio 1 => Uplink, radio 2 => Downlink). Provides a control over field deployment on radio selection for uplink and downlink and connect antennas accordingly
Client Access	❑ Basic client access will be offered on 2.4 Ghz radio and 5 Ghz radio (not used by serial backhaul) ❑ Universal client access will be available only on the downlink backhaul radio
Role of WLC	❑ WLC provides configuration knob to enable/disable this feature. WLC does check if the AP supports serial backhaul feature by looking at AP capabilities

Channel Assignment – Events – Serial Backhaul

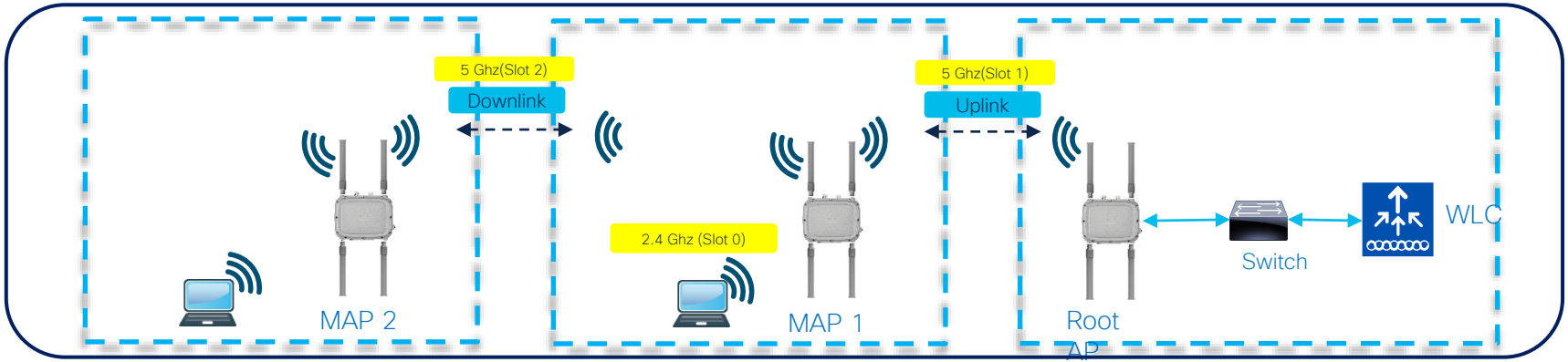
Radar

- Each mesh node shall perform radar detection on DFS channel. In non-serial-backhaul mesh networks WLC receives DFS event and assigned a new channel to RAP.
- When a serial backhaul detects a radar event on its downlink channel, it sends this radar event to WLC, then the AP will select a new channel (by using FreqGuardFx({Channel list – { uplink-channel – DFS_radar_channel} })

Roaming

- When MAP roams to a new parent, it follows the initialization procedure:
  - ✓ Select the best downlink channel
  - ✓ Notify children of the change (CCA)

Mesh – Designated Downlink



- Mesh Serial Backhaul(SBH) allows us to maximize throughput over multiple mesh hops
- Allows network segregation.
- Enables us to use different channels on different backhauls, which helps in avoiding localized link interferences
- In above deployment, Slot 1 is used for Uplink, Slot 0 is for Client Access and Slot 2 is the designated Downlink

Problem: I need faster Uplink Loss Detection

Problem: In current Cisco IOS-XE Mesh design, if the RAP uplink is down, the entire sector loses connectivity. The customer must implement alternate way to detect failures and steer the MAP forcefully towards another parent (Implementing manual tear down)

Solution: RAP uplink detection is made simple, and the teardown is automatically triggered from the RAP upon backhaul failure.

- Reduce detection time for RAP uplink backhaul failure by pinging the gateway at frequent interval to monitor the uplink
- Introduce Latency check as another criteria: Gateway link check to confirm whether the latency is within the threshold
- When RAP loses uplink, it should stop serving clients (disconnect client and do not broadcast SSID)

Solution Overview – Mesh Forced Roam

What?	❑ Detects the Uplink failure on Root AP (RAP) in the Mesh Sector
How?	❑ Periodic Ping Test to Gateway at frequent intervals ❑ Latency check of Ping Test
Action	❑ When there are Ping Failures (Configured Retries) or Ping Latency is higher than the configured threshold, the RAP triggers a de-auth in the MAP ❑ MAP roams to next available parent and resumes service

Forced Roam – Configurations

Base Config	❑ All these configurations are part of IOS-XE Mesh profile
Configurable options	❑ Ping Interval – At what interval should the Ping to GW be sent ❑ Ping Retries – Acceptable number of failures to conclude Uplink down ❑ Ping Latency – Latency threshold to take decisions
Fallback	❑ Option to configure the wait time – Allow RAP backhaul to stabilize ❑ Configure time during which RAP should not accept MAPs

Forced Roam – Configurations

Config

```
C9800(config)#wireless profile mesh default-mesh-profile
C9800(config-wireless-mesh-profile)#fast-teardown
C9800(config-wireless-mesh-profile-fast-teardown)#
```

Verify

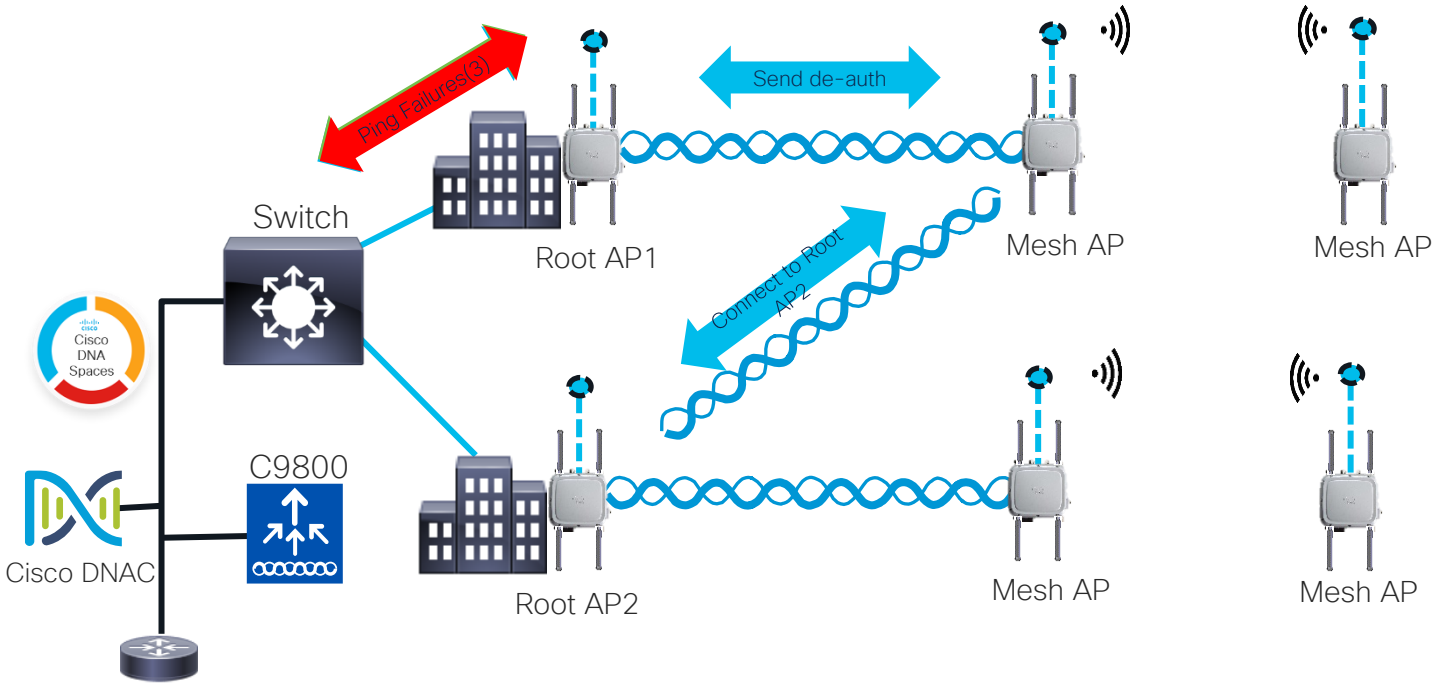
```
C9800#show wireless profile mesh detailed default-mesh-profile
Mesh Profile Name              : default-mesh-profile
-----------------------------------------------------
Description                    : Default multi bssid profile
Bridge Group Name              : unconfigured
.....
Fast Teardown                  : ENABLED
  Number of Retries                : 4
  Interval in sec                  : 1
  Latency Threshold in msec        : 10
  Latency Exceeded Threshold in sec : 8
  Uplink Recovery Interval in sec   : 60

C9800#
```

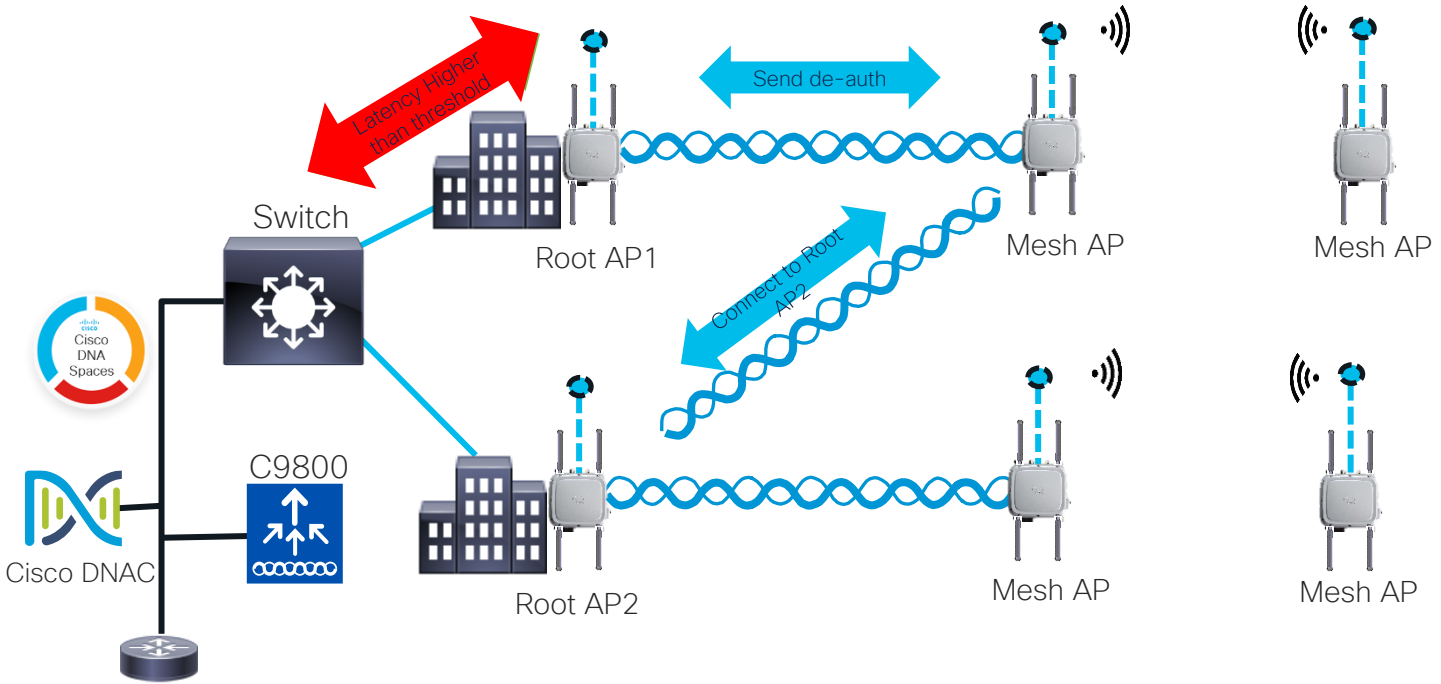
Options

- **interval** : Retry interval
- **latency-exceeded-threshold** : Interval in which at least one ping must succeed in less than threshold time
- **latency-threshold** : Ping latency threshold
- **Retries** : Number of retries until gateway is considered unreachable
- **uplink-recovery-interval** : Time during which RAP uplink must be stable to accept child connections

Forced Roam – Gateway Down



Forced Roam – Latency High



F.A.Q
Rapid Fire

FAQ-1

- MESH data rates do not decrease linearly with each hop but if they did and we use 20Mhz channels with a data rate of 234Mbps the actual backhaul how would the data rates between the root MAPS work out?

  - After 1st hop Mesh AP = 117Mbps
  - After 2nd hop Mesh AP = 58.5Mbps
  - After 3rd hop Mesh AP = 29.25Mbps
  - After 4th hop Mesh AP = 14.63Mbps

- How is this different if I use a dual 5GHz design?
- For the 9124 using .11ax does that increase the bandwidth per hop vs 11ac?

FAQ-2

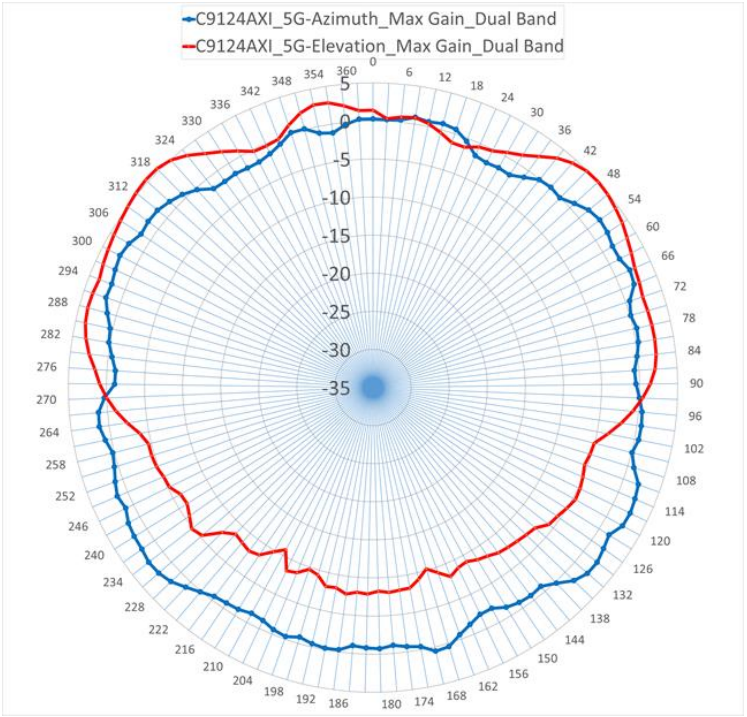
- If a client uses up all the 4th hop bandwidth, how does it affect hops before it and the bandwidth they can use?
- How quick is the failover to a secondary RAP for a MAP? Do you lose pings or is it not really noticed? Does the client associated to the MAP notice the failover?
- What antennas can I use? What is supported?
- When will DNAC support outdoor MAPS?
- Can I power my 9124 via PoE but use the SFP port for backhaul?

FAQ-3

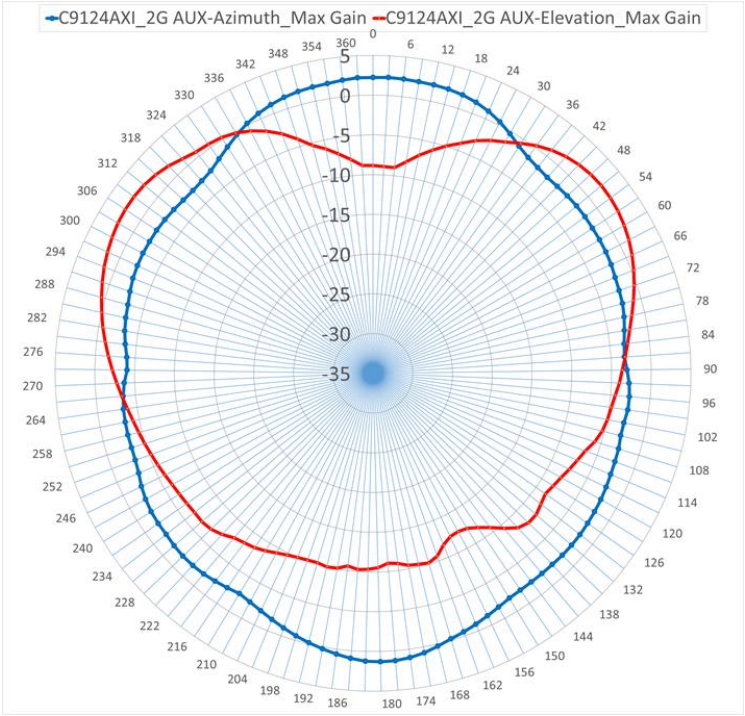
- Is the coverage of the 9124 the same as it's predecessors?
- Is a Solar Shield Required?
- Are lightening arrestors required?
- Does the 9124 support WGB mode?
- How many MESH hops can I have?
- Can the 9124 interop with older MESH APs?
- When should I use VLAN transparent in Ethernet Bridging?
- What code version should I be using if I want the best performance?

Additional Resources

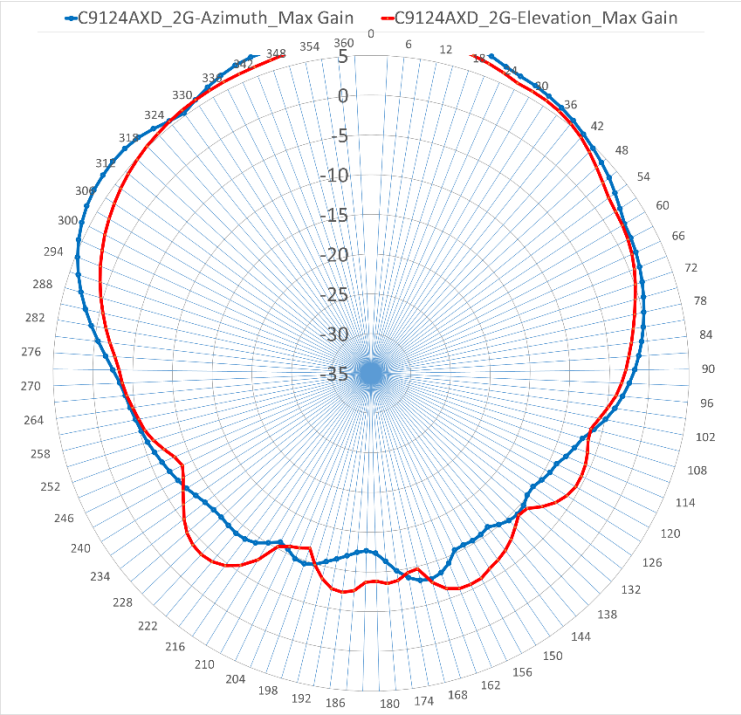
Catalyst 9124AXI: Dual-band 5 GHz azimuth/elevation



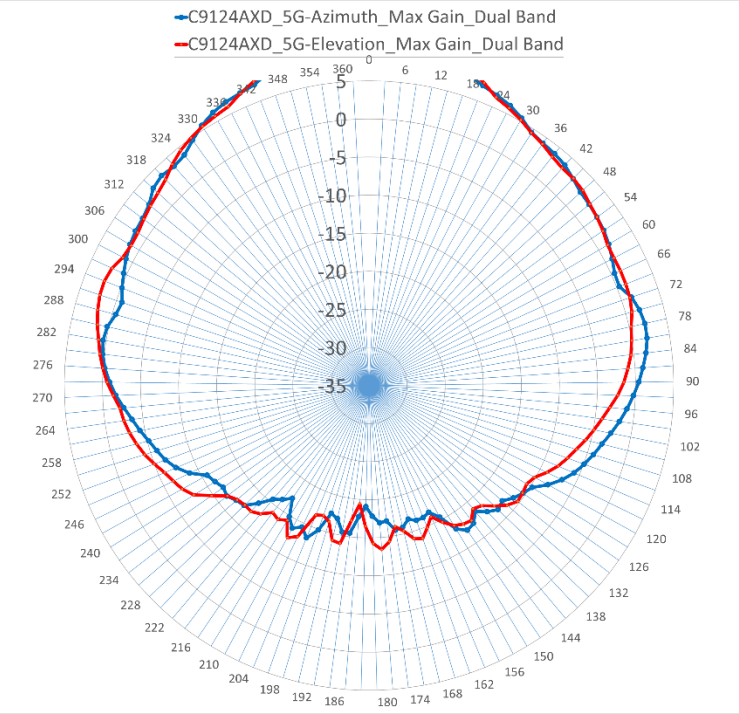
Catalyst 9124AXI: 2 GHz Aux azimuth/elevation



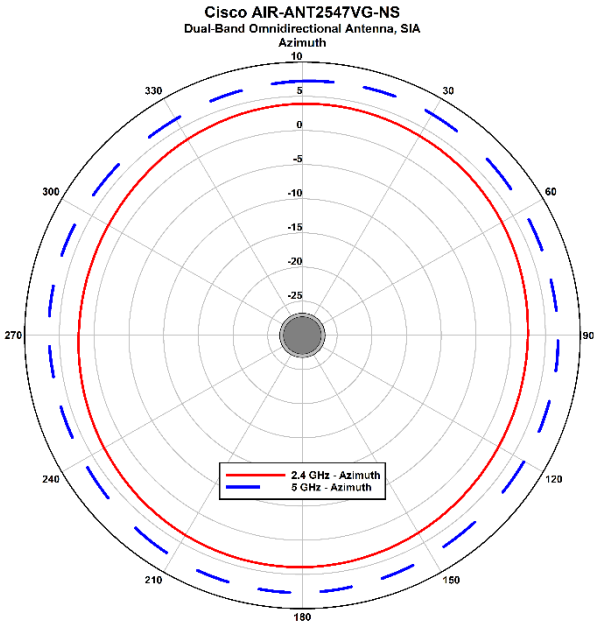
Catalyst 9124AXD: Dual-band 2 GHz azimuth/elevation

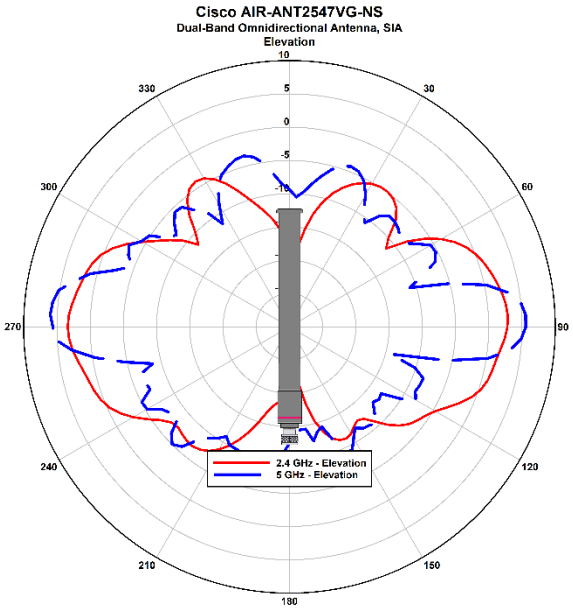


Catalyst 9124AXD: Dual-band 5 GHz azimuth/elevation



Antenna AIR-ANT2547VG-NS





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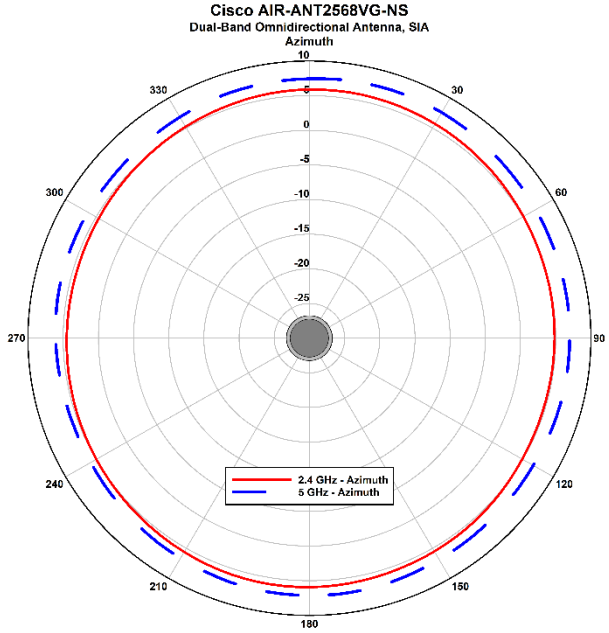
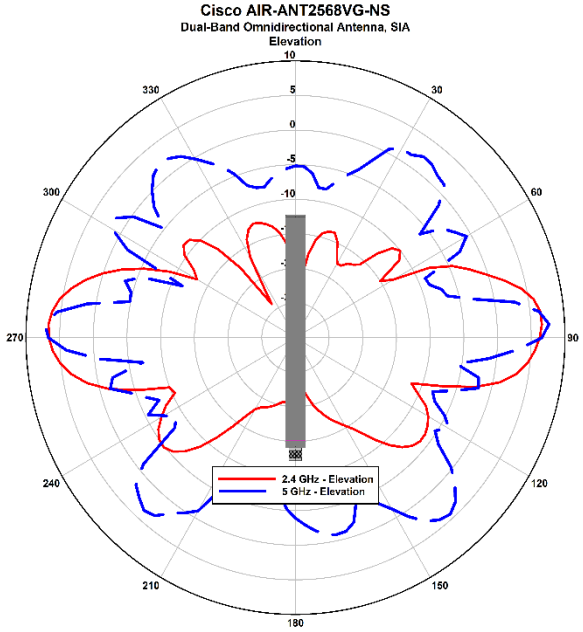
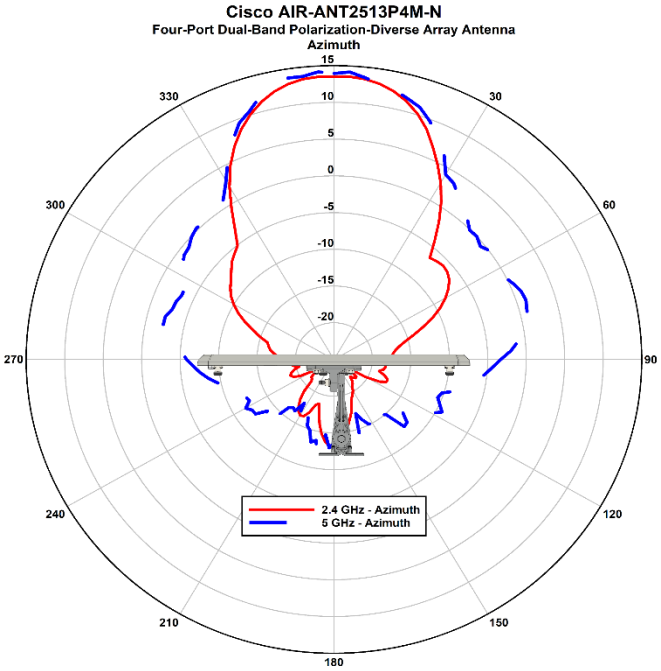
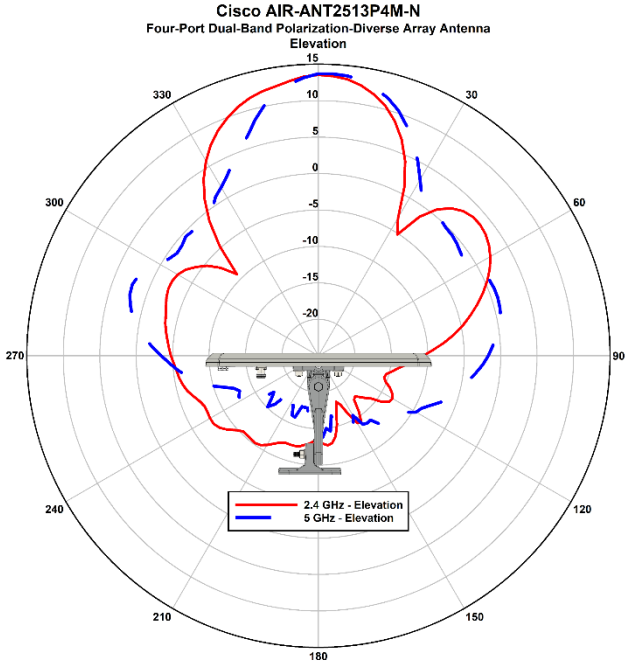




Antenna AIR-ANT2513P4M-N





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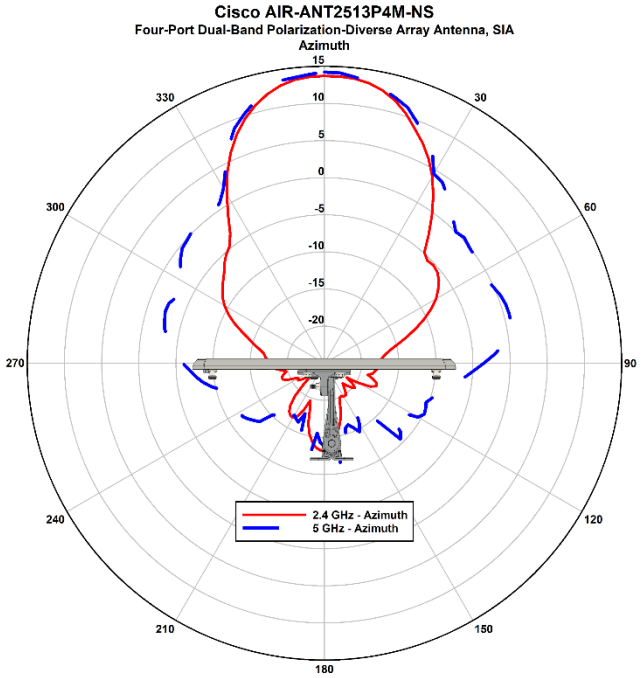
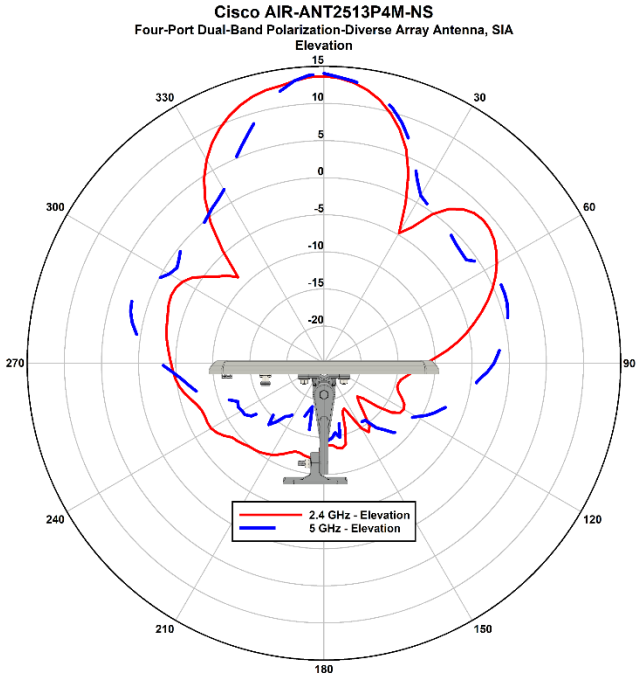
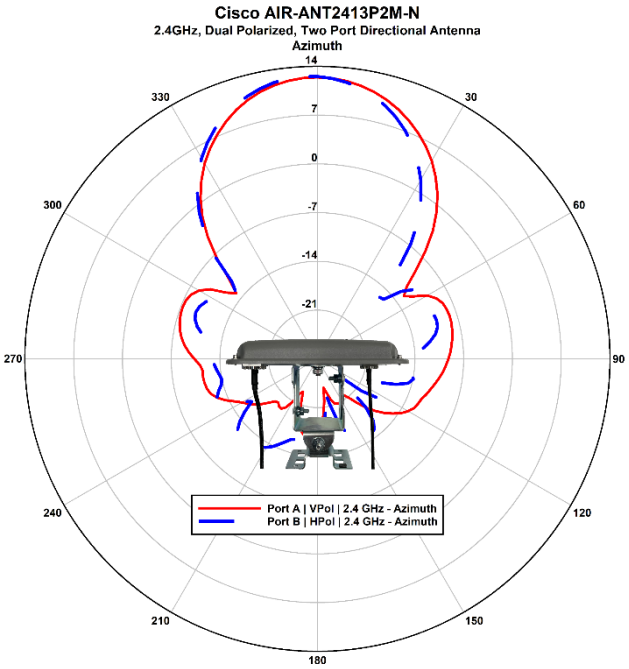
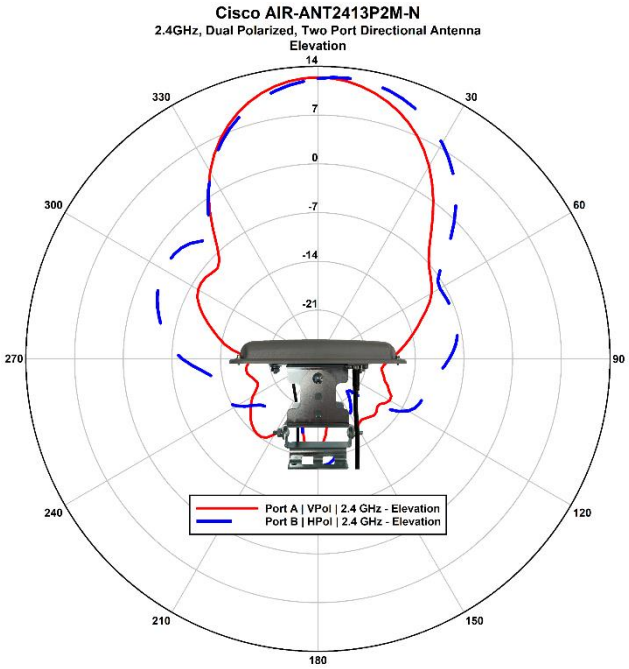




Antenna AIR-ANT2413P2M-N





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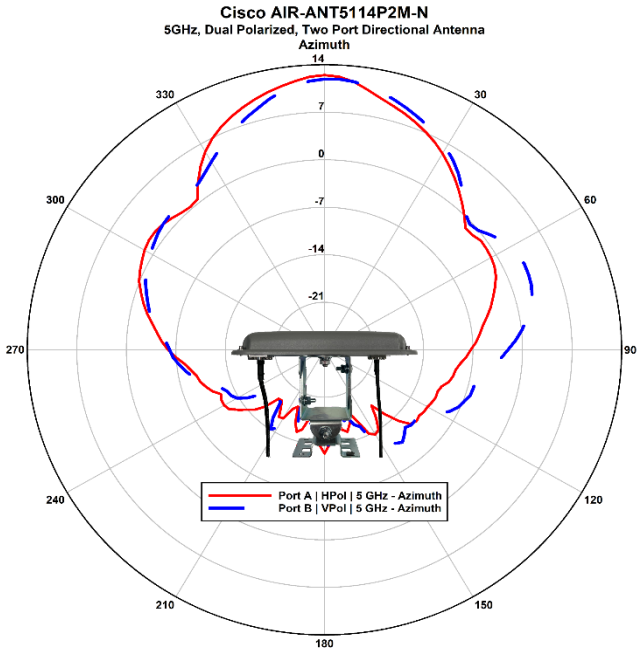

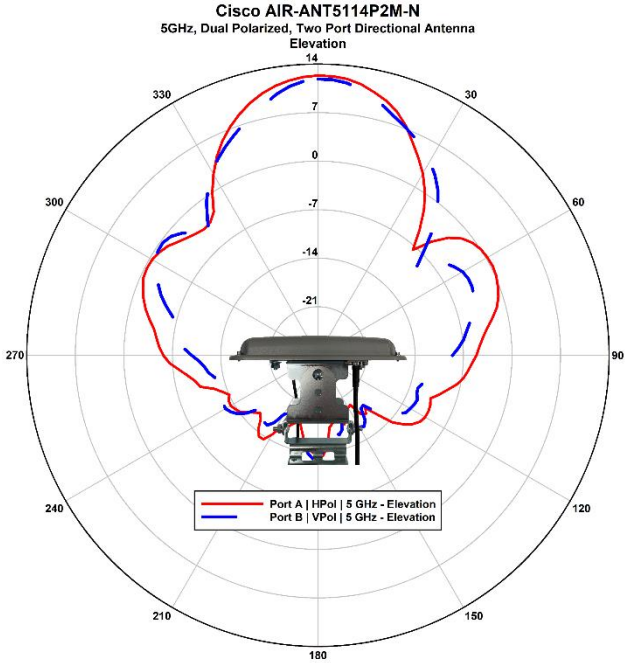

Outdoor AP	1532I	1532E	IW3702	1562I	1562D	1562E	1572EAC
Type	802.11n	802.11n	802.11ac W1	802.11ac W2	802.11ac W2	802.11ac W2	802.11ac W1
Radios	2.4G: 3x3:3 5G: 2x3:2	2.4G: 2x2:2 5G: 2x2:2	2.4G: 4x4:3 5G: 4x4:3	2.4G: 3x3:3 5G: 3x3:3	2.4G: 2x2:2 5G: 2x2:2	2.4G: 2x2:2 5G: 2x2:2	2.4G: 4x4:3 5G: 4x4:3
Clients per radio	100	100	200	200	200	200	200
RF output power	Up to 27/29 dBm	Up to 27/29 dBm	Up to 23 dBm	Up to 29 dBm	Up to 27 dBm	Up to 27 dBm	Up to 30 dBm
ClientLink			n	n	n	n	n
CleanAir			n	n	n	n	n
BandSelect	n	n	n	n	n	n	n
FlexConnect	n	n	n	n	n	n	n
Wireless mesh	n	n	n	n	n	n	n
Antennas	Internal	Flexible Antenna Port (dual band/single band)	Flexible Antenna Port (dual band/single band)	Internal	Internal - Directional	Flexible Antenna Port (dual band/single band)	Flexible Antenna Port (dual band/single band)
Network interface(s)	2 x RJ-45	2 x RJ-45	2 x M12	1 x RJ-45, 1 x SFP	1 x RJ-45, 1 x SFP	1 x RJ-45, 1 x SFP	2x RJ-45, 1 x SFP
SPF Port				n	n	n	n
PoE Power options	PoE+/UPoE	PoE+/UPoE	PoE/PoE+	PoE+/UPoE	PoE+ (802.3at)	PoE+ (802.3at)	UPoE
DC power options	24-57 VDC	24-57 VDC	9.6 to 60 VDC	48 VDC	48 VDC	48 VDC	AC, 10 to 16 VDC
PoE (802.3af) out			n				n
Dimensions	9" x 7" x 4"	10" x 7" x 4"	11.3" x 8.0" x 2.3"	9.0" x 6.8" x 3.9"	9.0" x 6.8" x 4.3"	9.0" x 6.8" x 3.9"	11.8" x 7.9" x 6.3"
Temp Range °C	-30° to 65°	-30° to 65°	-50° to +75° (DC Powered)	-40° to 65°	-40° to 65°	-40° to 65°	-40° to 65°
Weight	5.0 lbs	5.5 lbs	6.7 lbs	5.6 lbs	5.7 lbs	5.6 lbs	13.5 lbs
Rating	IP67	IP67	IP67, Cold, Vibration, Shock, Freefall, Seismic	IP67	IP67	IP67	IP67, NEMA 4X

Sources for Aluminum Pipe / Tube

- If using your own mast for wall mount applications, then Metal Supermarkets is a good source for low volume orders of aluminum pipe and tube.

  Source: https://www.metalsupermarkets.com


Thank You.

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