

CISCO *Live!*

Let's go



The bridge to possible

Design/Deployment & Tuning Of Outdoor Wi-Fi & WGBs

Ian Procyk, Wireless Guy
VE7HHS

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IBOEWN-2000

Agenda

This is an interactive session **so** here are some topics to help guide us...

- Your use cases!
- Considerations when deploying outdoors
- CURWB vs WGB vs AWPP MESH
- Product Capabilities Matrix
- Recent MESH Enhancements
- AFC & Standard Power Operation

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



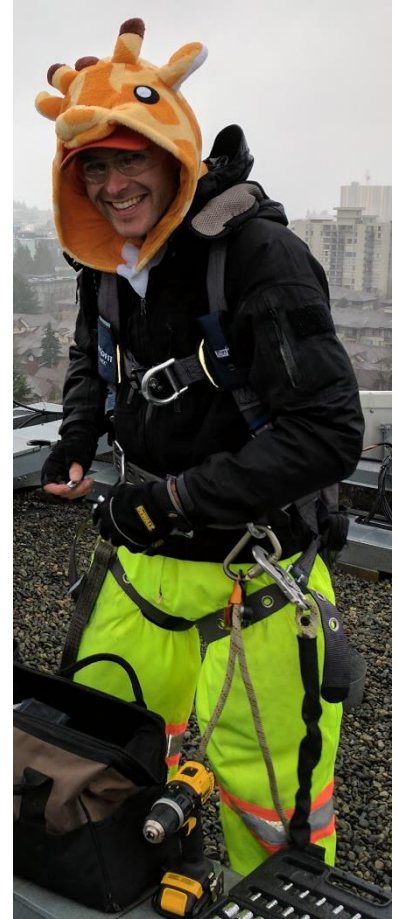
- University of B.C. (WLAN team) 2005-2009
- Canadian Coast Guard (Telecom) 2009-2010
- GBIT Logistics (IT Consultancy) 2010-2011
- Cisco Systems (Wireless Guy) 2011-today

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

Considerations when deploying outdoors

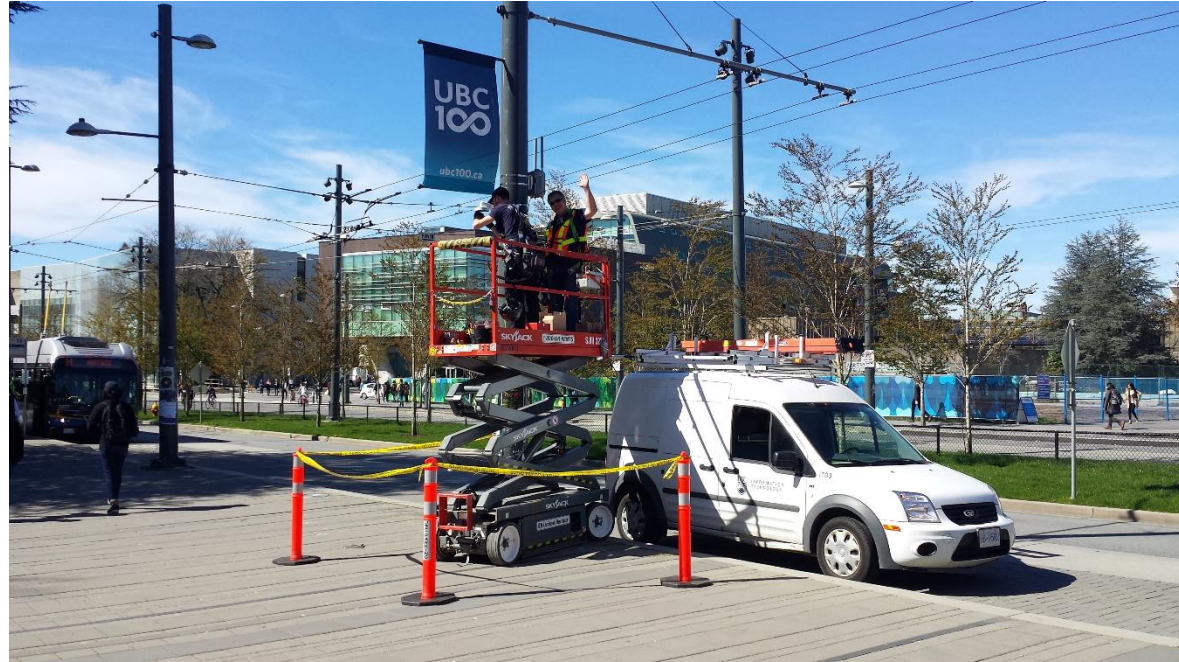
Safety Considerations

- 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.



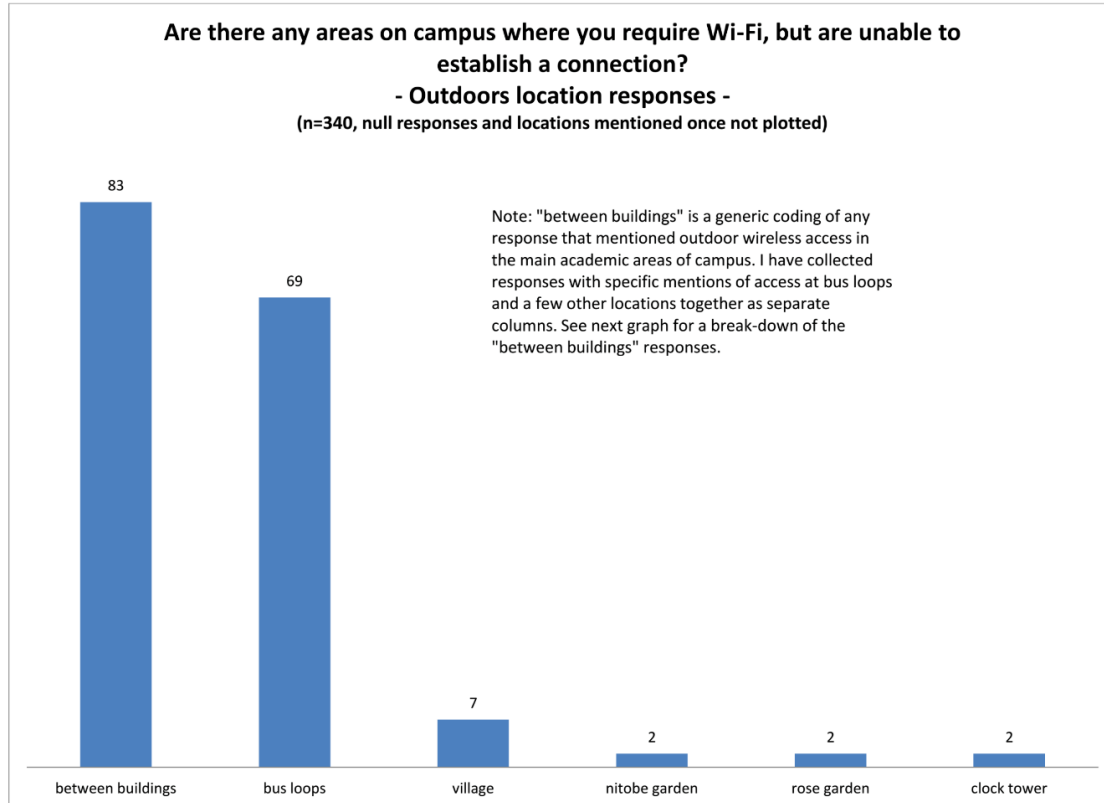
Safety Considerations

- 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.



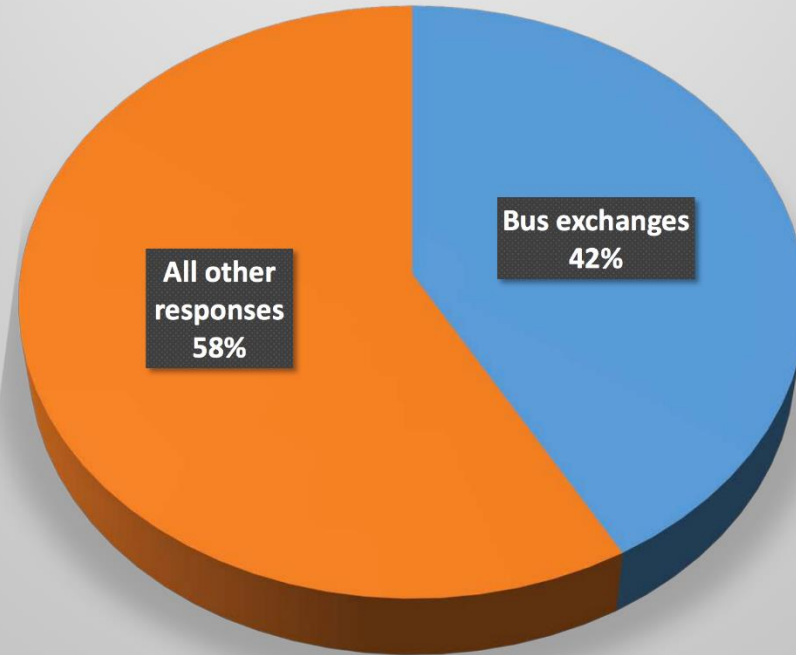


On Campus? Where do I start?



Popular Places

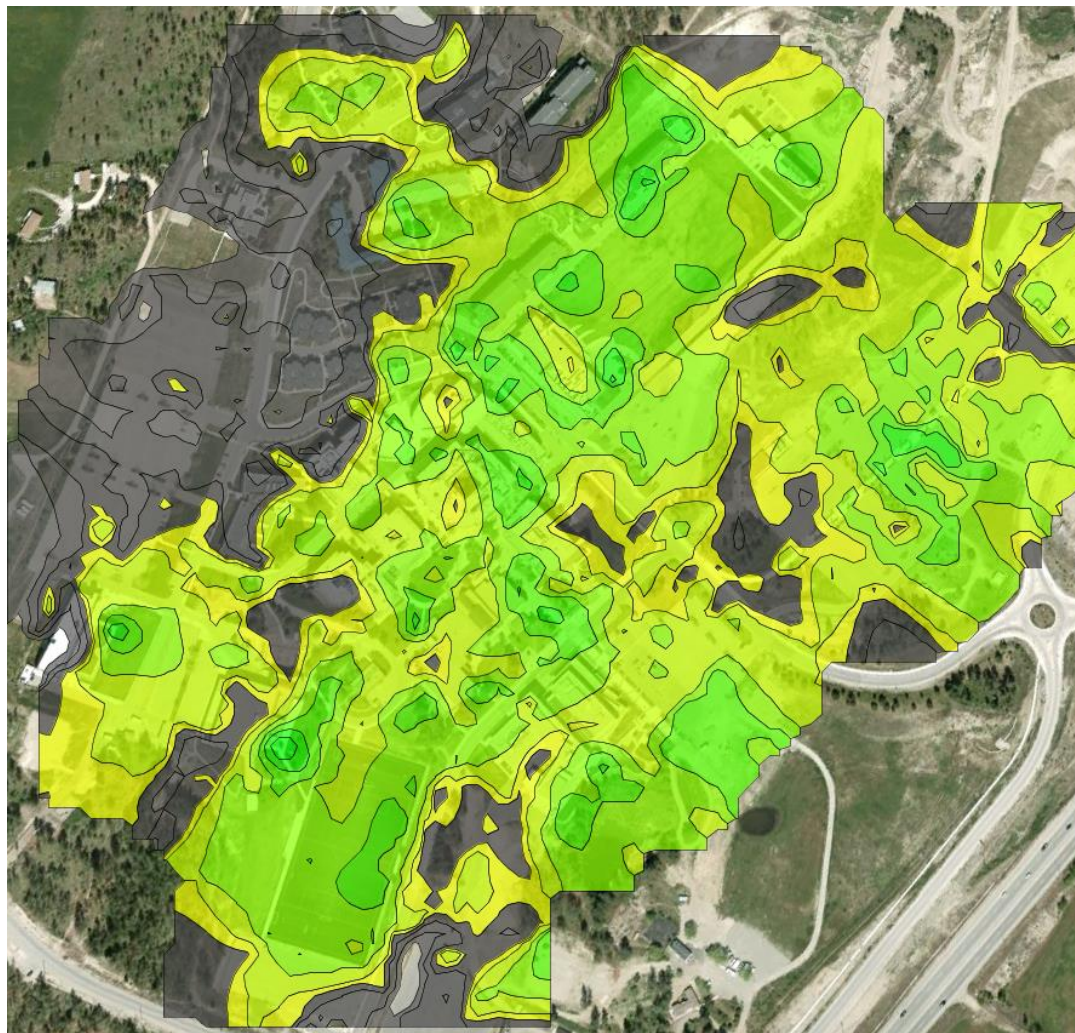
Where would you like to see improvements in outdoor wireless coverage on campus?
(n = 165)



- Site survey path



- 5GHz coverage



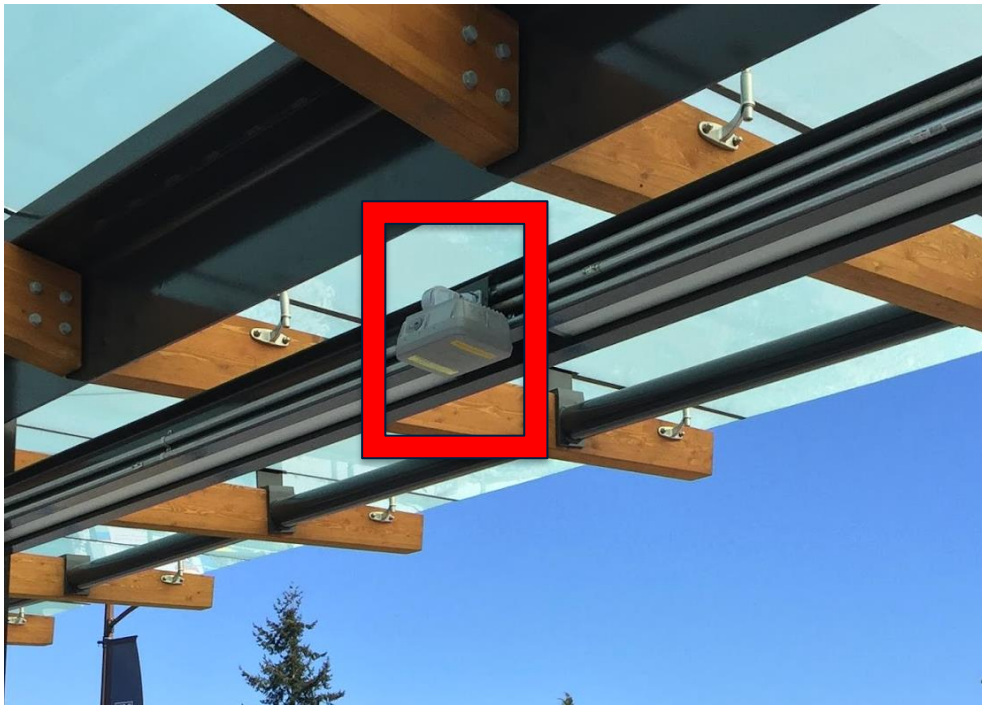






Mesh Backhaul





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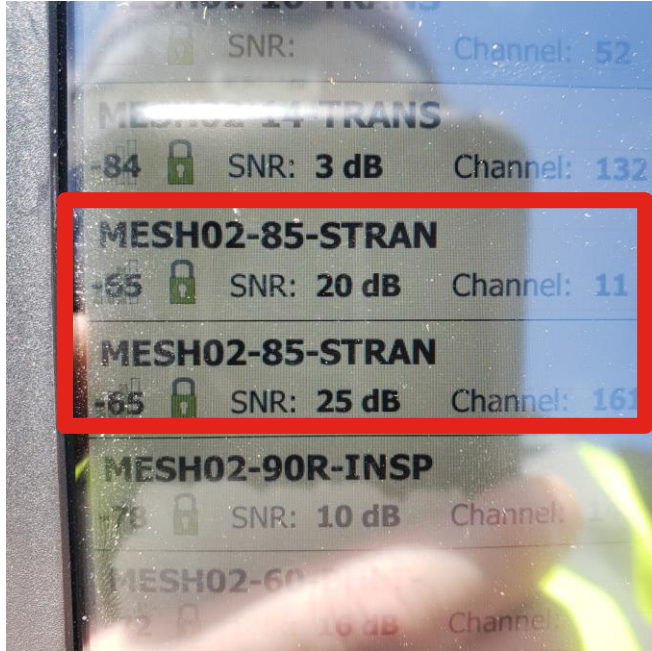


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What About The Roof?



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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



Blue Light / Emergency Phones



No Pathway? Make One...



No Pathway? Make One...



Why do I need an Outdoor AP?



Image Source:

<https://bboxblog.files.wordpress.com/2014/10/ipratings2-copy.jpg>

SOLID OBJECT

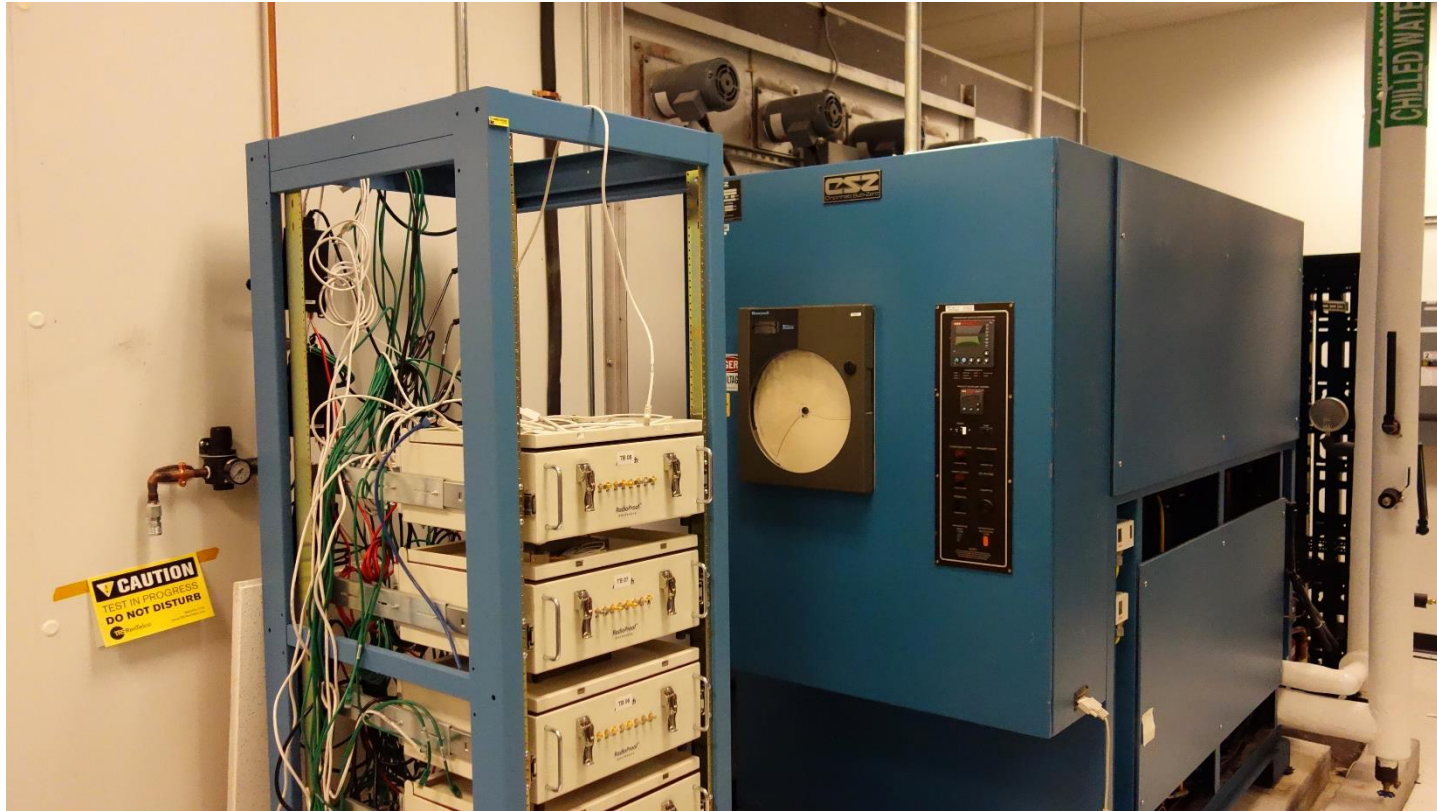
1	Protected against a solid object greater than 50mm such as a hand.
2	Protected against a solid object greater than 12.5mm such as a finger.
3	Protected against a solid object greater than 2.5mm such as a screwdriver.
4	Protected against a solid object greater than 1mm such as a wire.
5	Dust protected. Limited ingress of dust permitted. Will not interfere with operation of the equipment.
6	Dust tight. No ingress of dust.

MOISTURE

1	Protected against vertical falling drops of water. Limited ingress permitted.
2	Protected against vertical falling drops of water with enclosure tilted up to 15 degrees from the vertical. Limited ingress permitted.
3	Protected against sprays of water up to 60 degrees from the vertical. Limited ingress permitted.
4	Protected against water splashes from all directions. Limited ingress permitted.
5	Protected against jets of water. Limited ingress permitted.
6	Protected against powerful jets of water. Limited ingress permitted.
7	Watertight against the effects of immersion in water between 15cm and 1m for 30 minutes.
8	Watertight against the effects of immersion in water under pressure for long periods.

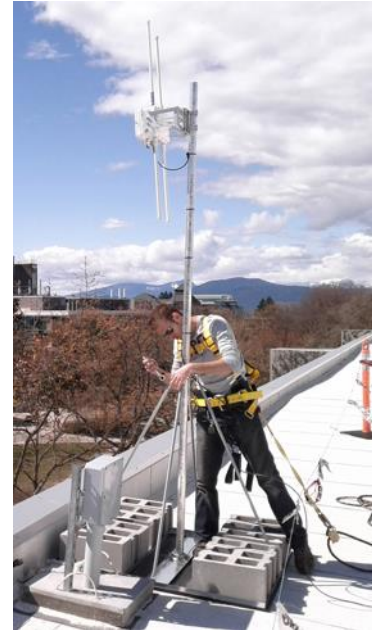
IP65
Ingress protection

Environmental Testing



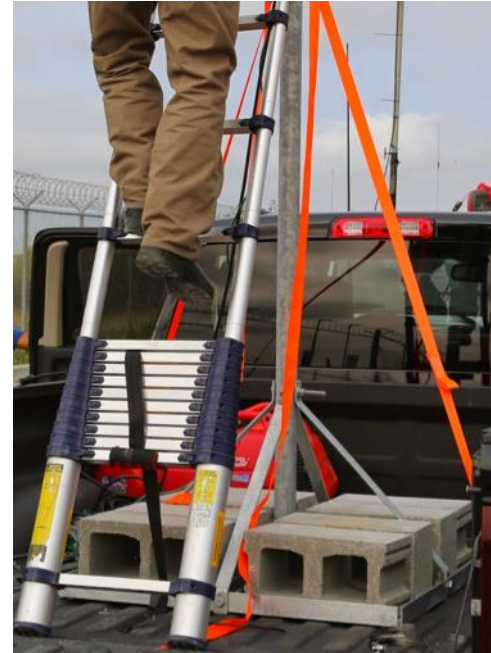
Non-Penetrating Roof Mounts (NPRMs)

- 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 1/2" rubber mat minimum.
- Building code may require seismic bracing of base and or engineering analysis of counterweight.



AP1552 shown with
10 foot mast on
Wade antenna NPRM

Non Penetrating Roof Mounts (NPRMs)



10x Tylon small ballast NPRMs (36"x36") shown knocked down on left along side rubber mats. 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:

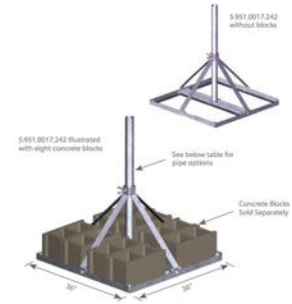
<http://www.wadeantenna.com/ius/resources/Tripods.pdf>

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 2 1/4" 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 2 1/4" OD x 30" pipe mount	Ea	\$236	57
5.951.0017.242	Light Duty Ballast Mount with a 2 1/4" OD x 42" pipe mount	Ea	\$245	60

Wall Mounts

Using: Unistrut & conduit clamps



Wall Mounts

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



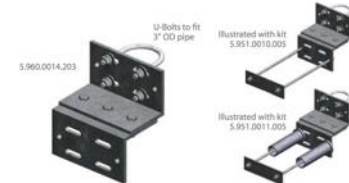
Clip Mount Kits

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 fits 2 3/8" OD pipe	Ea	\$40	6.6
5.960.0011.201	Small Clip Mount Kit fits 2 3/8" 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 3 1/2" 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



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

Hardware Installation Guides

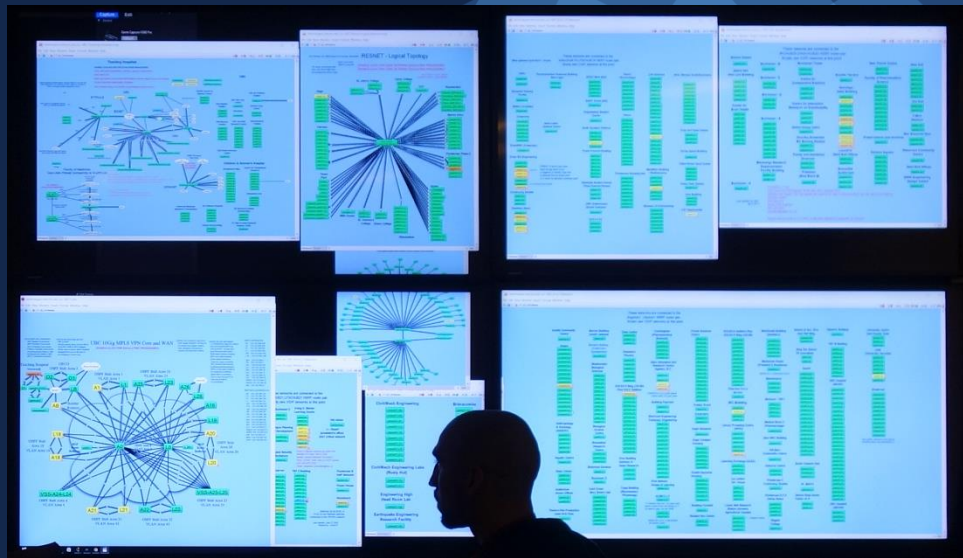
- A hardware deployment guide is published that accompanies each product Cisco makes.
- These guides are specifically helpful in understanding the various mounting brackets and installation options for each product.
- Grounding, lightning protection, antenna configurations and weatherproofing are also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



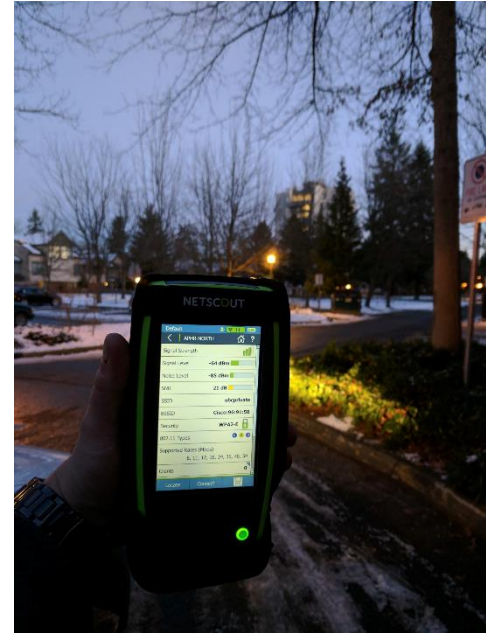
Quick Summary

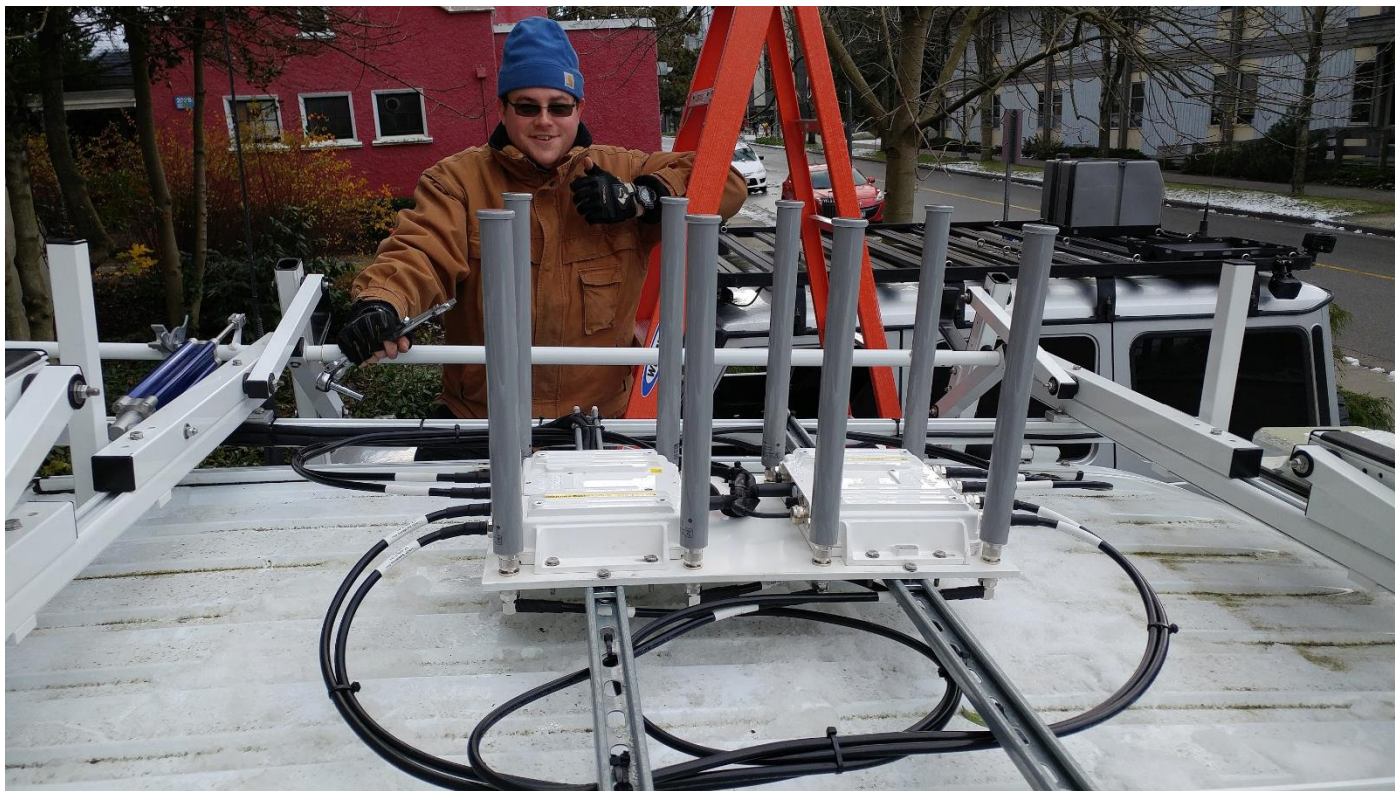
- The cost of deploying an AP outdoors is often **2-4x the cost of the hardware itself**.
- Fall protection training/equipment, engineering approval and pathway (coring etc.) drive installation cost up. As result, it is critical that time be spent up front to identify locations with the most “bang for 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...

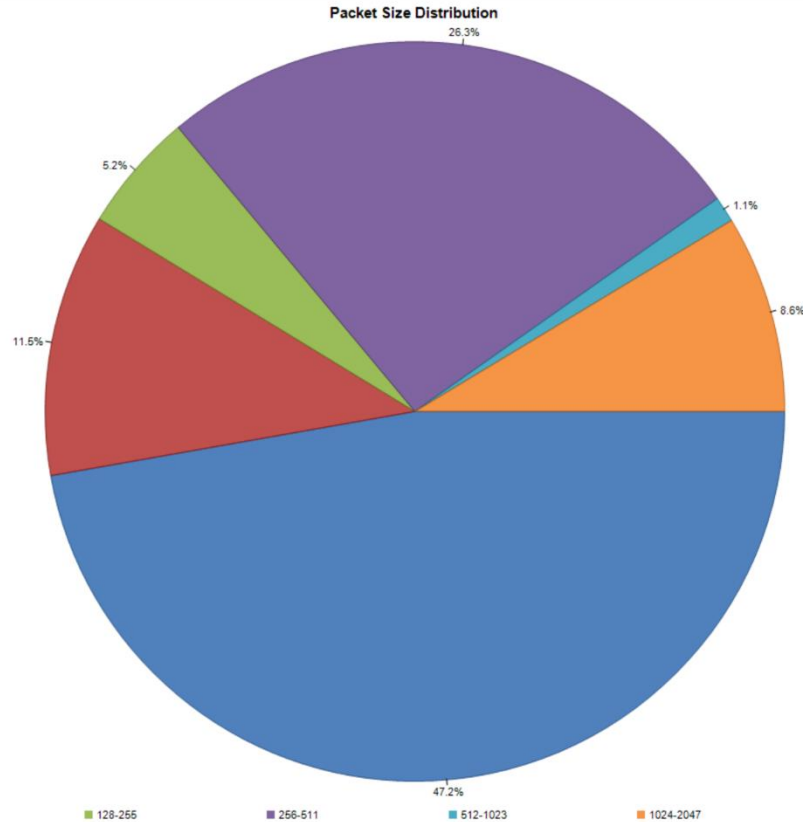


Building an Outdoor Sniffer





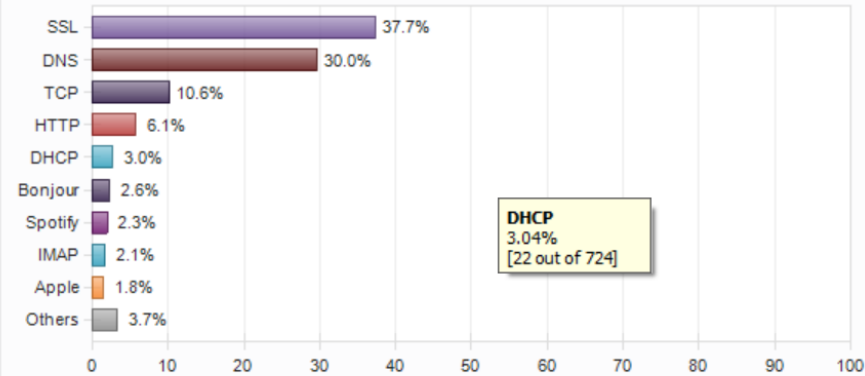
What's in the air?



42% of packets
<64bytes

Protocol breakdown

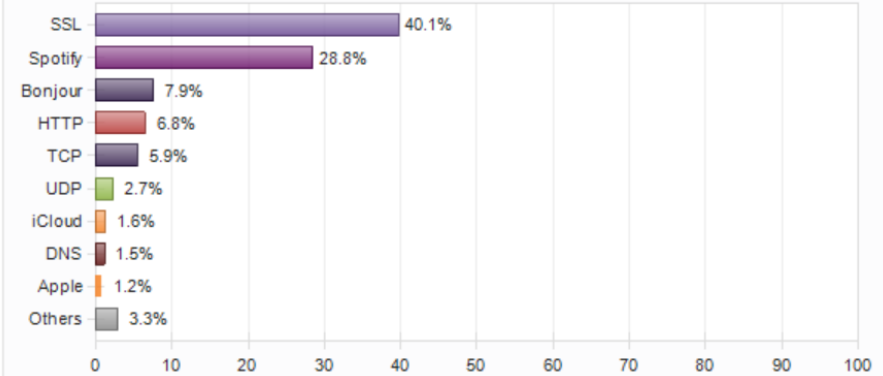
▼ Top Applications by Flows



▼ Application Utilization - 10 Minute Window (5 Second Average)

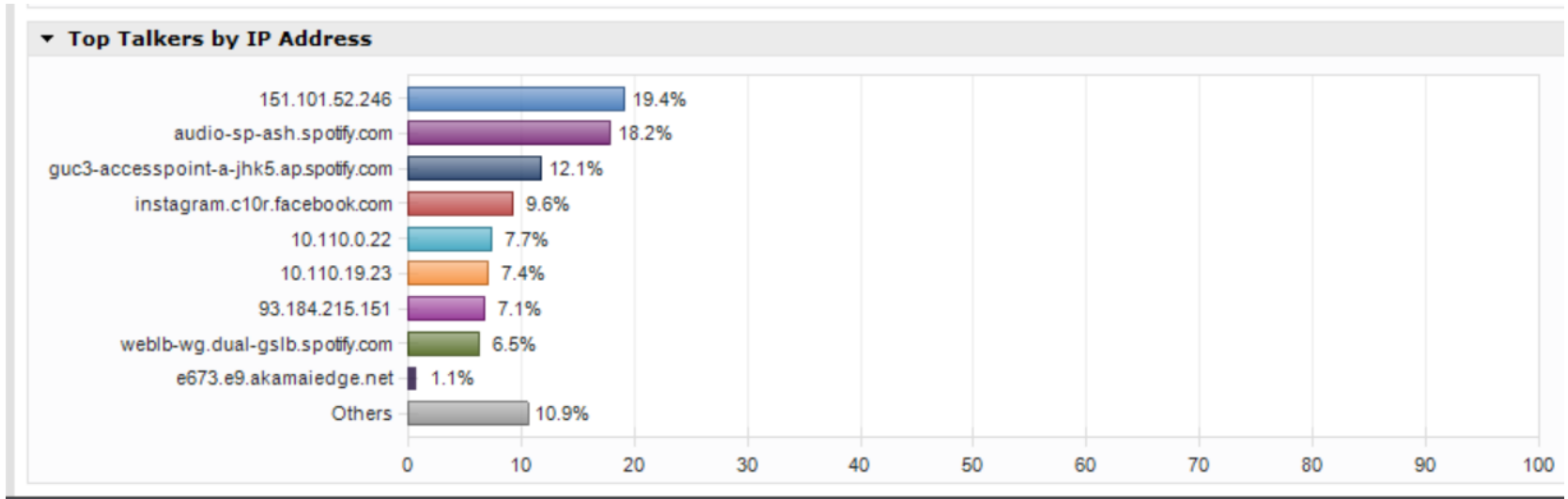
1.4

▼ Top Applications by Bytes



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%	27.749%	
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%	24.790%	
	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

WGB Info

The WGB Feature Matrix

Feature	Cisco Wave 1 APs	Cisco Wave 2 and 11AX APs
802.11r	Supported	Supported
QOS	Supported	Supported
UWGB mode	Supported	Supported on Wave 2 APs Not supported on 11AX APs
IGMP Snooping or Multicast	Supported	Supported
802.11w	Supported	Supported
PI support (without SNMP)	Supported	Not supported
IPv6	Supported	Supported
VLAN	Supported	Supported
802.11i (WPAv2)	Supported	Supported
Broadcast tagging/replicate	Supported	Supported
Unified VLAN client	Implicitly supported (No CLI required)	Supported
WGB client	Supported	Supported
802.1x – PEAP, EAP-FAST, EAP-TLS	Supported	Supported
NTP	Supported	Supported
Wired client support on all LAN ports	Supported in Wired-0 and Wired-1 interfaces	Supported in all Wired-0, 1 and LAN ports 1, 2, and 3
Second radio wireless client support	Supported	Supported on Cisco 11AX APs only.

IOS Based WGBs?

The screenshot shows a Cisco TechNote page. At the top left is the Cisco logo. To its right are navigation links: 'Products and Services', 'Solutions', 'Support', and 'Learn'. Below the navigation is a breadcrumb trail: '... / Cisco Industrial Wireless 3700 Series / Troubleshooting TechNotes /'. The main title of the document is 'WGB Roaming: Internal Details and Configuration'. Below the title is a utility bar with icons for 'Save', 'Translations', and 'Print'. Underneath the utility bar, it says 'Updated: August 26, 2011' and 'Document ID: 113198'. On the right side of this section, there is a link for 'Bias-Free Language'. Below this is a 'Contents' section with a horizontal line. The contents list includes: 'Introduction', 'Prerequisites' (with sub-items: 'Requirements', 'Components Used', 'Conventions'), 'What is a Work Group Bridge?', 'Usage Scenarios', 'Roaming' (with sub-item: 'Elements of Roaming'), and 'Configuration Guide - Security policies' (with sub-items: 'Configuring WPA2-PSK', 'Configuring WPA2 with 802.1x', 'Configuring WPA2 with CCKM').

RSSI Monitoring

WGB can implement a pro-active signal scan for the current parent and start a new roaming process when the signal falls below an expected level.

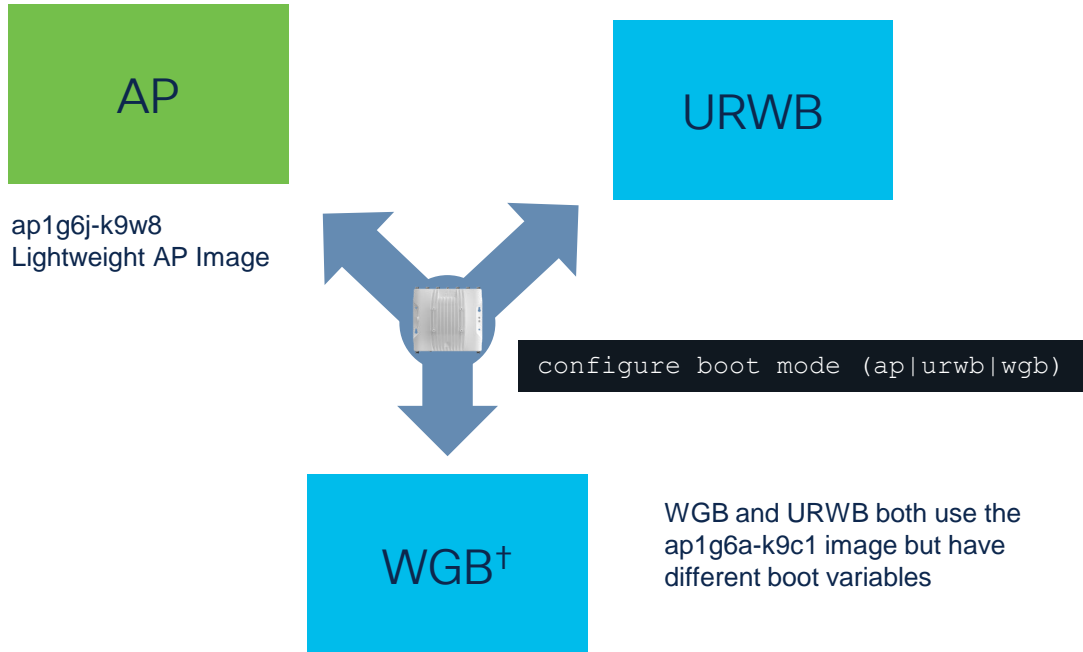
This process takes two parameters:

- A timer, which wakes up the check process every X seconds
- RSSI level, which is used to start a roaming process if the current signal is below it.

For example:

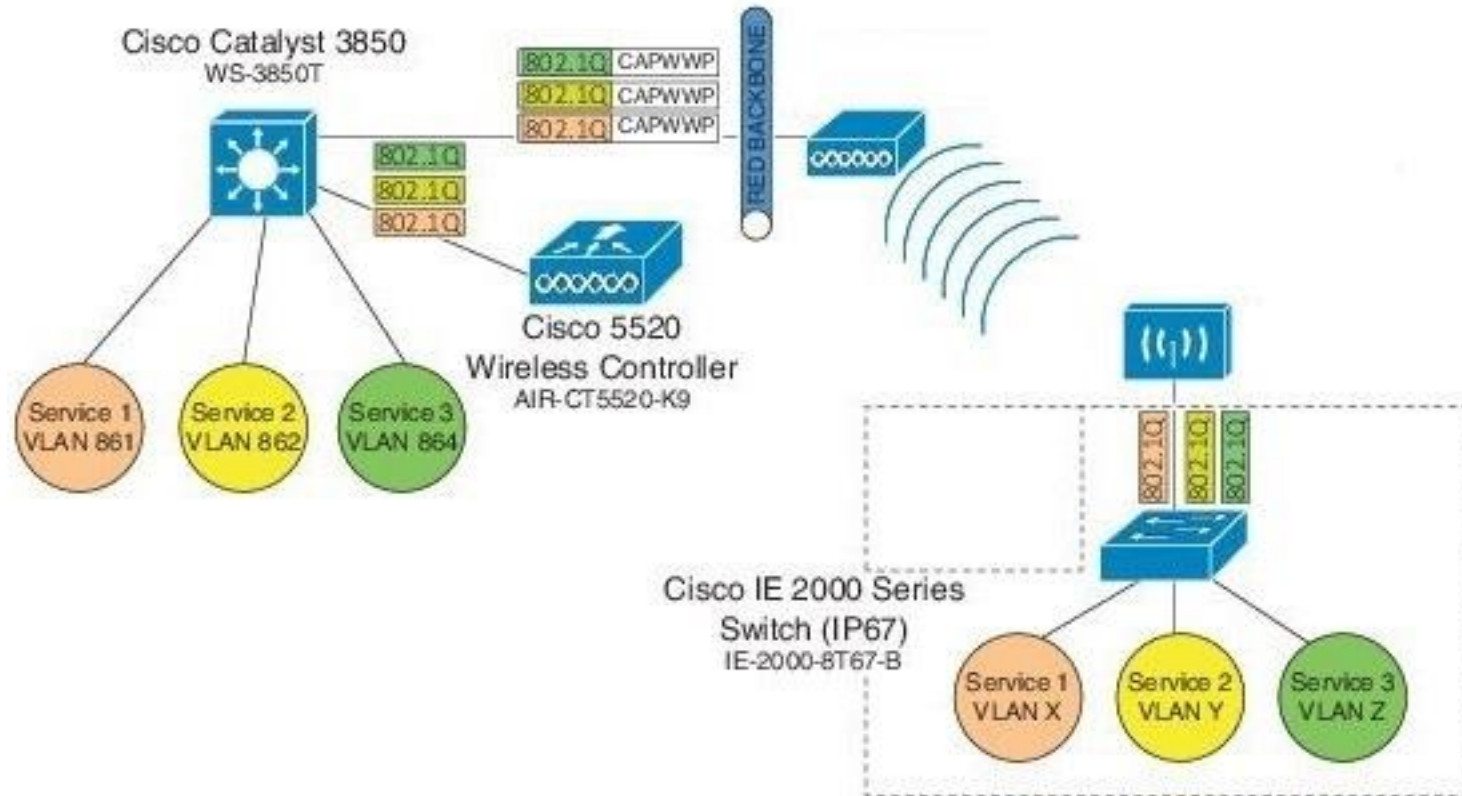
in d0 mobile station period 4 threshold 75

Switching Modes



- Switching modes will factory default and reboot the AP
- Both software images are loaded at factory but updated separately thereafter.
- Licensing for AP and URWB are both SLP based.

WGB Multi VLAN L2 via IAPP



Rate & Range Setting Expectations...

Pinecone
Burke
Provincial
Park

Minnekhada
Regional Park

Pitt-Addington
Marsh

4.5km 2.8 mi

Google

Rate & Range Testing - 9124





Rate & Range Testing - 9124



2513+9124 AXE on Vehicle



5114P2M-N x2 +9124 AXE on Mast

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



SNR vs Link Distance

2SS 20MHz CH149 AP: 14dBi Vehicle: 13dBi



Distance (miles)	SNR (dB)
50 (0.03)	70
200 (.125)	58
300 (.186)	48
500 (.300)	44
700 (.430)	39
800 (.490)	37
900 (.559)	36
1000 (.621)	35
1200 (.745)	32
1500 (.932)	26
1700 (1.05)	24
2000 (1.24)	23
2200 (1.36)	21
2300 (1.42)	19
2500 (1.55)	17
2700 (1.67)	Link drop

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:

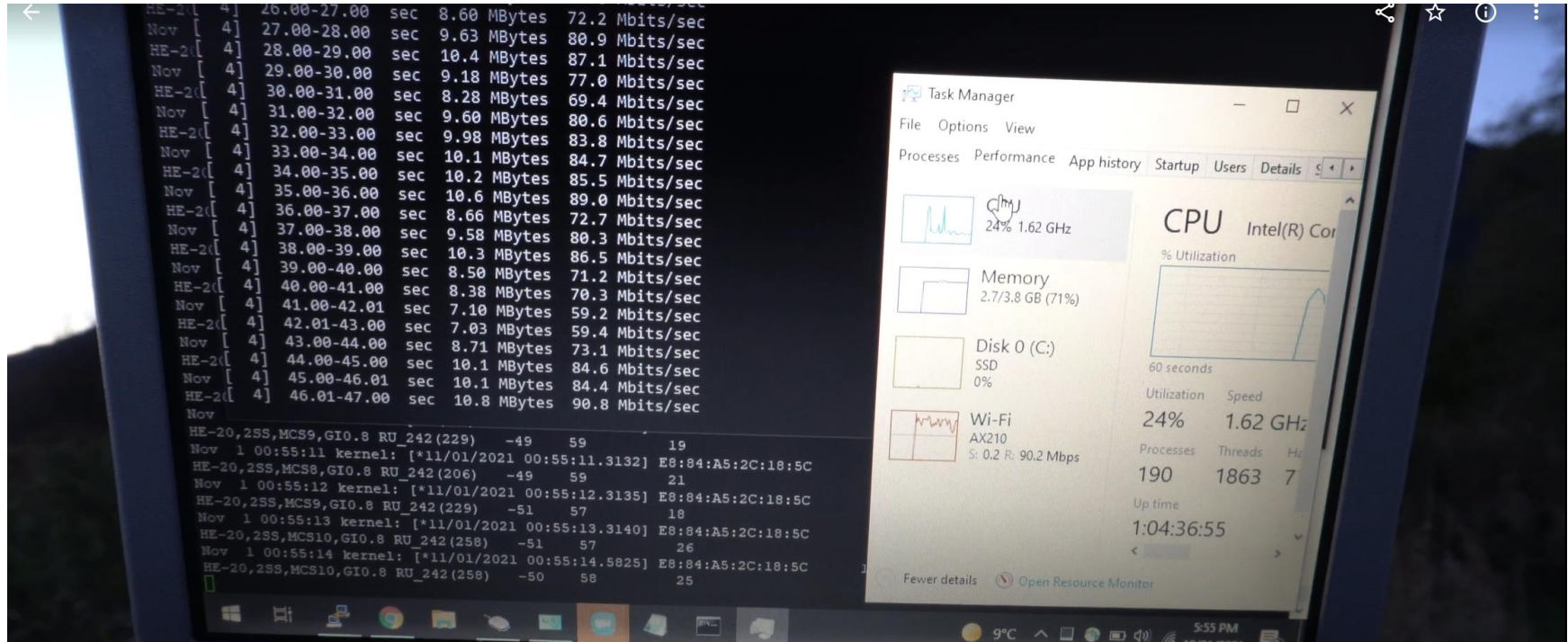
- Panasonic Toughbook CF-30MK2
- 1x Intel AX210 2SS



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



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



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

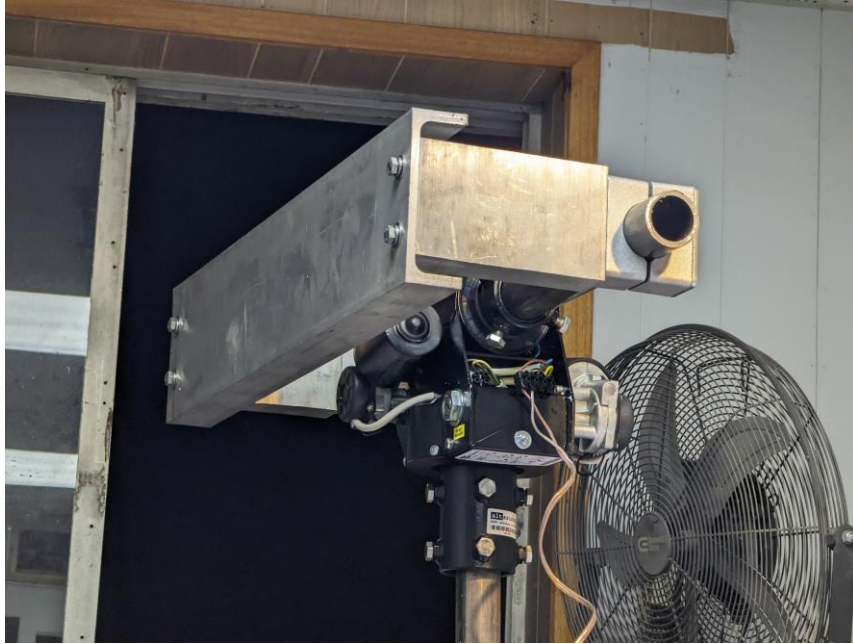


Building a P2P Test Jig

Building a Pan/Tilt Antenna Positioner



Building a Pan/Tilt Antenna Positioner



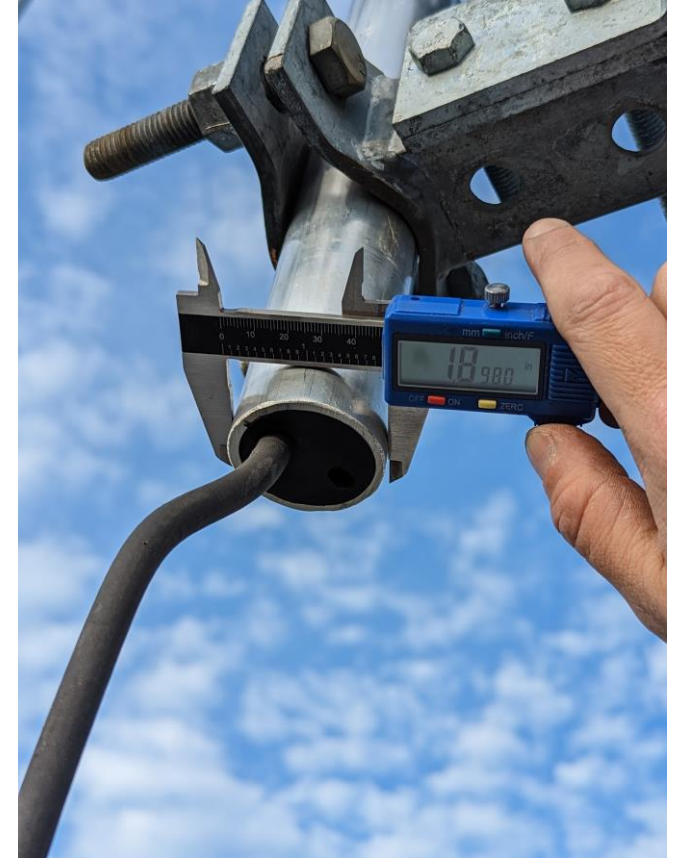
Building a Pan/Tilt Antenna Positioner





CH CAMPS HAUSEF

Building a Pan/Tilt Antenna Positioner



Building a Pan/Tilt Antenna Positioner



Building a Pan/Tilt Antenna Positioner



Building a Pan/Tilt Antenna Positioner



Building a Pan/Tilt Antenna Positioner



IW9167 CURWB Link Distance Testing

Running Some Tests @ 5KM From Mesh Gateway





Cisco URWB IW9167EH - 5.22.22 x +

Not secure | <https://44.135.209.182>

MOTU Mixer | CFARS | T1 BANDSWITCH | T2 BANDSWITCH | T2 ROTATOR | T3 ROTATOR | 208VAC | TRAILER | docs.ve7scc.org | video.ve7scc.org UI3 | Amateur Search | A... | Google

- basic routes
- allowlist / blocklist
- multicast
- snmp
- radius
- ntp
- i2tp configuration
- vlan settings
- Fluidity
- misc settings
- smart license

MANAGEMENT SETTINGS

- remote access
- firmware upgrade
- status
- configuration settings
- reset factory default
- reboot
- logout

Average Signal

Last 30 Average Signal Strength Samples

Current: -84.09m (14.9%)

Close

SPID MO-01 ver. 1.20

M1: 105
M2: 5

Send

STOP

MODE: NORMAL
A1: 105.0 E2: 5.0

OUTS 1 2 3 4 5 6
STATE

fade

MO-01 parameters ORBITRON Options

Motors

Ports

EI map

Download

Motor configuration

Template: 1:AZ, 2:EL

Show azimuth: NORMAL

Use short way: OFF

Use EI map: OFF

Const EI map: OFF

Mouse control:

Motor	State	Type	Kind	Input	Min angle	Max angle
Motor 1	ON	DIGITAL	AZIMUTH	MECHANIC	-180°	+168°
Motor 2	ON	DIGITAL	ELEVATION	MECHANIC	-15°	+195°

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1208 AM
2022-10-24

6GHz Outdoors?

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



Media Contact:

Neil Grace, (202) 418-0506

neil.grace@fcc.gov

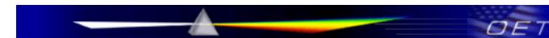
For Immediate Release

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



There are seven equipment classes⁶ 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 (P1⁷).
3. 6XD: 15E 6 GHz Low-power Indoor client. These devices are under control of a low-power indoor access point (P1).
4. 6CD²: 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 (P2⁷).
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.

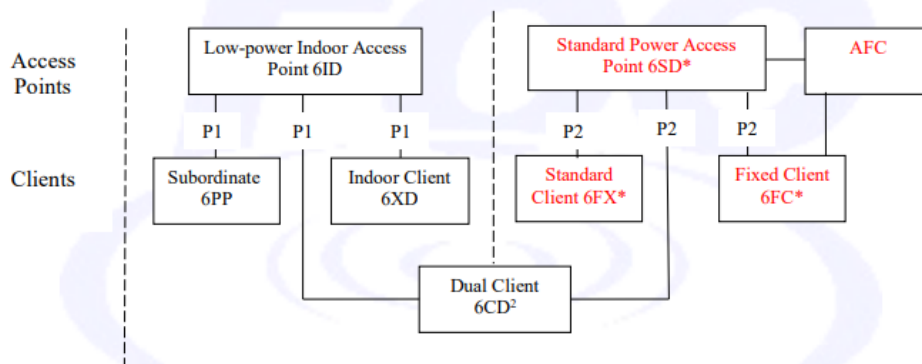


Figure 1 – Part 15 Subpart E Equipment Classes

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.



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*,
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



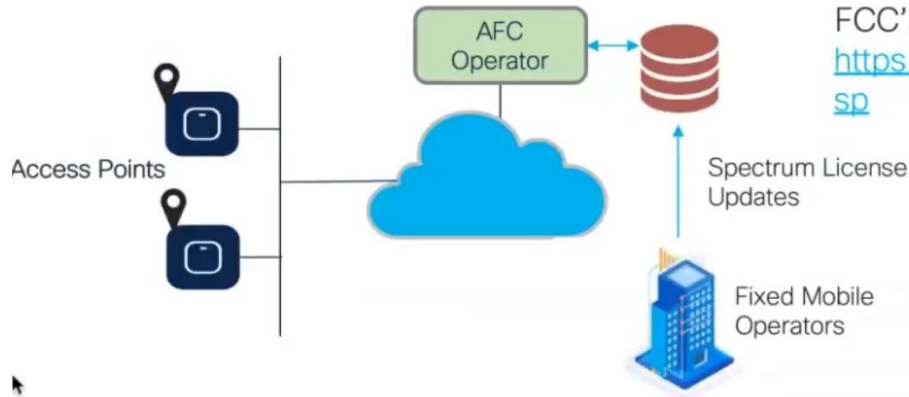
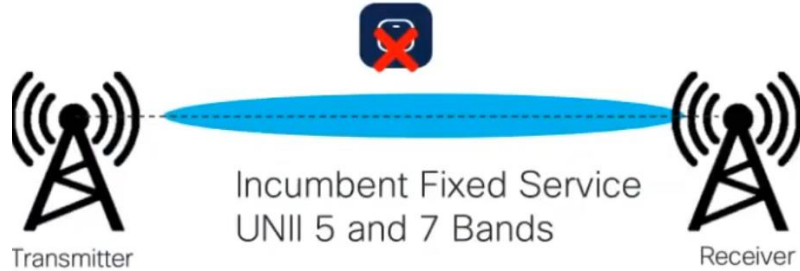
Jessica Rosenworcel ✓
@JRosenworcel

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...](https://www.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 >= 8425
 Frequency Assigned <= 8925

Hatches 1- 10 (of 109)

Page 1 2 3 4 5 6 7 8 9 10

Call Sign/Lease ID	Name	FIRN	Radio Service	Status	Expiration Date
KT01	Pacific Gas and Electric Company	0029560497	MG	Active	05/31/2030
KIS06	SANTA CLARA, COUNTY OF	0001539824	FW	Active	01/17/2031
KM036	SANTA CLARA, COUNTY OF	0001539824	FW	Active	06/15/2028
KM124	Pacific Gas and Electric Company	0029560497	MG	Active	11/26/2021
KM193	AT&T COMMUNICATIONS OF CALIFORNIA INC	0003301702	CF	Cancelled	02/01/2010
KM849	Pacific Gas and Electric Company	0029560497	MG	Active	12/24/2027
KM956	PACIFIC BELL	0001551530	CF	Cancelled	06/01/2000
KM172	SOUTHERN CALIFORNIA EDISON COMPANY	0001532608	CF	Active	11/19/2021
KM279	AT&T COMMUNICATIONS OF CALIFORNIA INC		CF	Cancelled	02/01/2000
KM327	SOUTHERN CALIFORNIA EDISON COMPANY	0001532608	CF	Active	01/18/2022

Call Sign/Lease ID Name FIRN Radio Service Status Expiration Date

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)

Platform Notes

Enterprise Outdoor Access Points

MR78/76/86



- 802.11AX, MU-MIMO, OFDMA
- MR76/78: 2x2 MR86: 4x4
- Integrated Scanning Radio
- Integrated BLE Radio
- Cloud based RF Optimization
- MR76/78: 1G MR86:2.5G (RJ45)
- MR76/78: .3af MR86: .3at
- Integrated L7 Firewall
- Real-time WIDS/WIPS
- Enhanced transmit power and receive sensitivity

C9124



- 802.11AX, MU-MIMO, OFDMA
- 4x4 + 4x4:4
- Cisco RF ASIC next-gen Cisco CleanAir
- IoT ready
- 1x 2.5G mGig/SFP/1Gbe PoE-Out
- PoE-In 802.3af/at/bt/UPOE
- DC power input (24 to 56 VDC)
- 30 dBm Transmit Power(Same as 1572 and higher than 1562)
- Centralized, FlexConnect, Bridge, Flex+Bridge & EWC



CW9163E



- 802.11AX, MU-MIMO, OFDMA
- 2x2(2.4GHz) + 2x2(5GHz) + 2x2(6GHz)*
- Tri-band Scanning Radio with next-gen CleanAirPro
- IoT ready
- 1x 2.5G mGig
- In-built GPS module
- PoE-In 802.3af/at

* 6GHz subject to AFC availability

IoT Wireless portfolio

IW9165D
Wireless Client



Ultra Reliable
Wireless Backhaul



IW9167EH
Wi-Fi 6 & URWB



IW9165E
Wireless Client



IW6300H
HAZLOC Wi-Fi

ESW6300
Embedded Wi-Fi

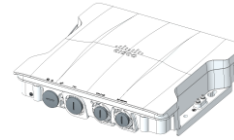
Cisco Catalyst 802.11ax Industrial Wireless Portfolio



IW9165E



IW9165D



IW9167I



IW9167E

Orderable Now

Application	Wireless client for mobile assets	Wireless backhaul for fixed and mobile assets	Outdoor and Industrial Heavy-duty Wireless AP	Wireless backhaul for fixed and mobile assets
Radio	(2) 2x2 802.11ax radios 5GHz, 5/6GHz	(2) 2x2 802.11ax radios 5GHz, 5/6GHz	(3) 4x4 802.11ax radios 2.4GHz, 5GHz, 6GHz	(3) 4x4 802.11ax radios 2.4GHz, 5GHz, 5/6GHz
Antenna	(4) RP-SMA (f)	Internal 15dBi directional plus (2) N-Type (f)	Internal Omnidirectional 5-6 dBi	(8) N-Type (f)
Wireless Mode	WGB or URWB	URWB	WiFi AP	WiFi AP, WGB, or URWB
Ethernet	(1) 2.5Gbps RJ45 (1) 1Gbps RJ45 Optional M12 adapter	(1) 2.5Gbps RJ45 (1) 1Gbps RJ45 Optional M12 adapters	(1) x 5Gbps RJ45 (1) SFP+ Optional M12 adapters	(1) 5Gbps RJ45 (1) SFP+ Optional M12 adapters
Expandability	BLE, GNSS, GPIO	BLE, GNSS	BLE, GNSS	BLE, GNSS
Certifications	IP30, EN50155 -20C to +50C	IP67 -40C to +70C	IP67 -40C to +70C	IP67, EN50155 -50C to +75C

Cisco Catalyst 6E Industrial Wireless Portfolio



IW9165E



IW9165D



IW9167

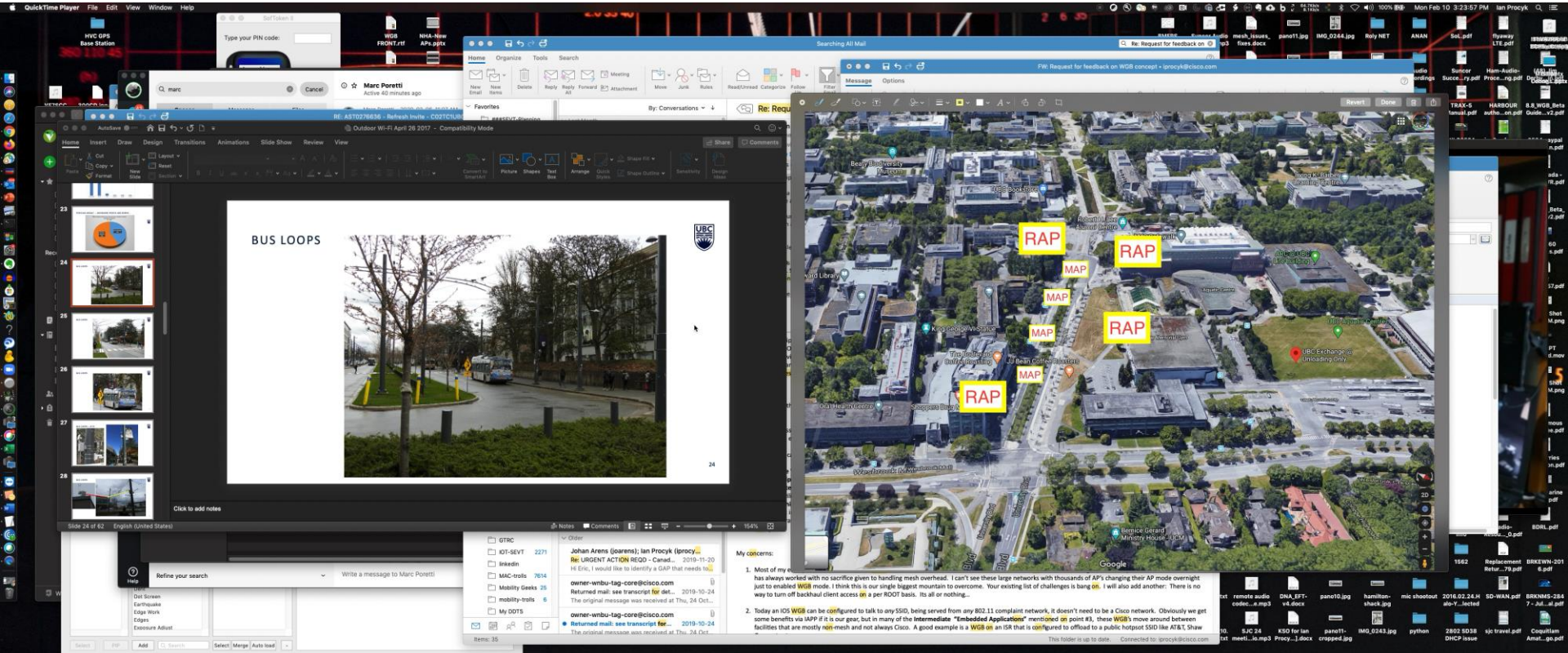
Application	Wireless client for mobile assets	Wireless backhaul for fixed and mobile assets	Wireless backhaul for fixed and mobile assets
Radio	2 x 802.11ax radios (5GHz, 5/6GHz)	2 x 802.11ax radios (5GHz, 5/6GHz)	3 x 802.11ax radios (2.4GHz, 5GHz, 5/6GHz)
Antenna	4 x RP-SMA	Built-in 15dBi directional plus 2 x N-Type (f)	8 x N-Type (f)
Modulation	2x2 MIMO	2x2 MIMO	4x4 MIMO
Wireless Mode	WGB or URWB	URWB	WiFi, WGB, URWB
Ethernet	1 x 2.5Gbps + 1 x 1Gbps RJ45 Optional M12 adapter	1 x 2.5Gbps + 1 x 1Gbps RJ45 Optional M12 adapters	1 x 5Gbps RJ45 + 1 x SFP+ Optional M12 adapters
Expendability	BLE, GNSS, GPIO	BLE, GNSS	BLE, GNSS
Certifications	IP30, EN50155 -20C to +50C	IP67 -50C to +75C	IP67, EN50155 -50C to +75C

MESH



Recent Mesh Enhancements

- On AP boot up - least congested channel scan (17.6)
- Background Scanning on RF-ASIC Aps (9130/9124) (17.9)
- Convergence Improvements (17.6+)
- Serialbackhaul (17.7)
- Backhaul support adjusted down to 5dB SNR (17.9)
- MESH RRM DCA Phase 1 **RAP only** (17.9)
- MESH RRM DCA Phase 2 **Full mesh tree** (17.14) 😊





MESH AP

Backhaul Radio

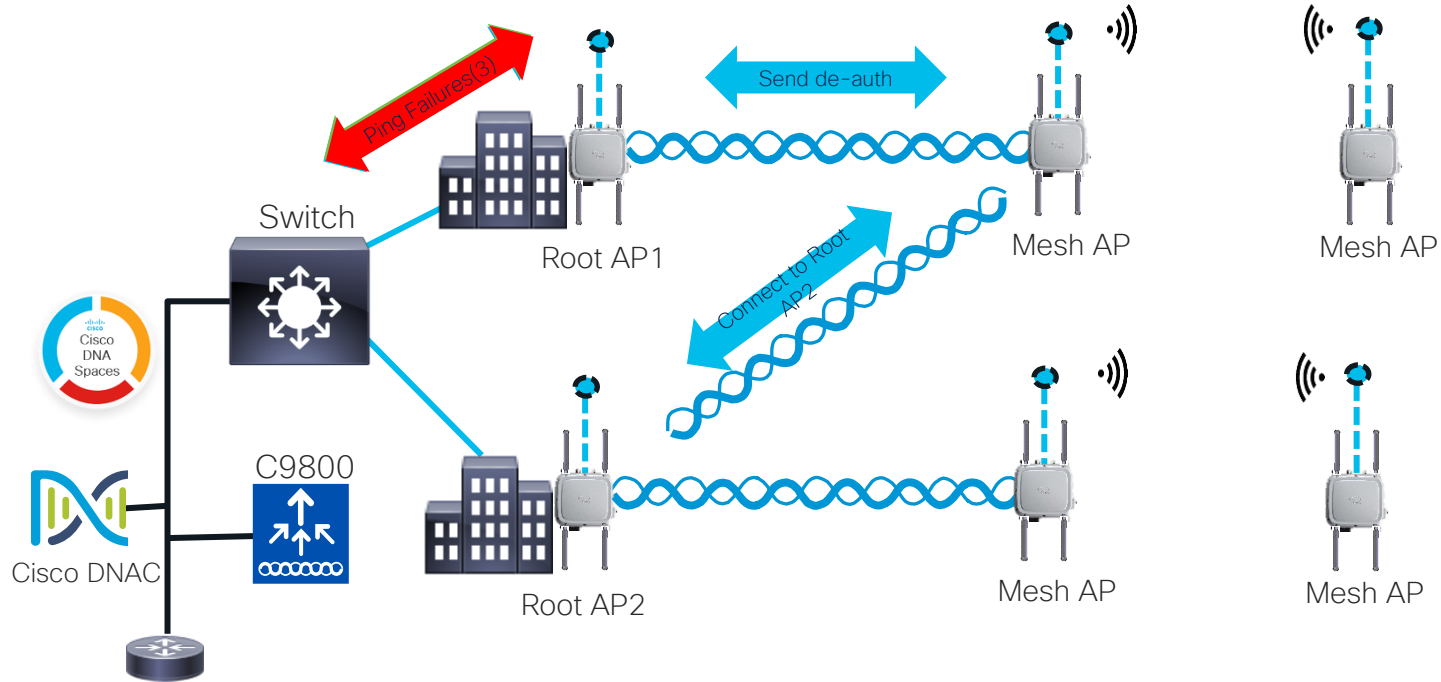
Problem: I need faster Uplink Loss Detection

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)

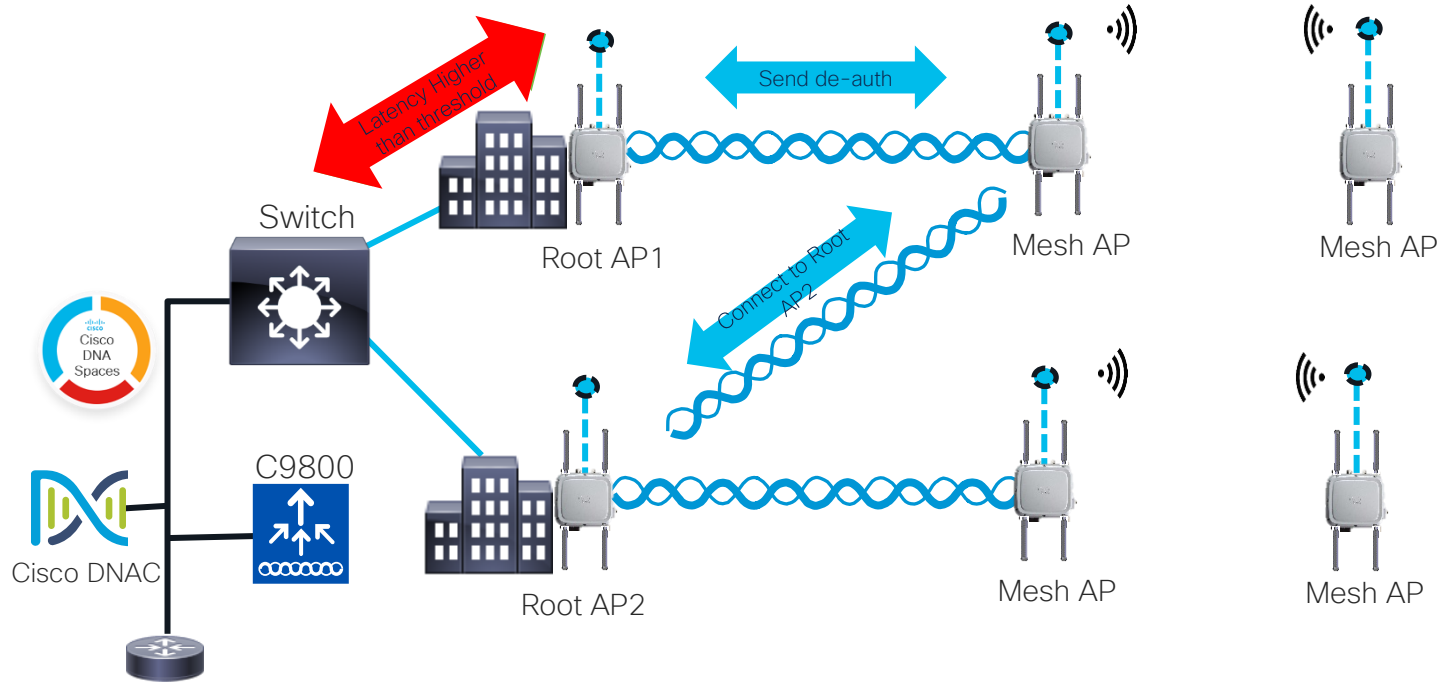
Solution: RAP uplink detection is made simple, and the teardown is automatically triggered from the RAP upon backhaul failure.

- 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)

Fast Teardown - Gateway Down



Fast Teardown- Latency High



Fast Teardown – 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

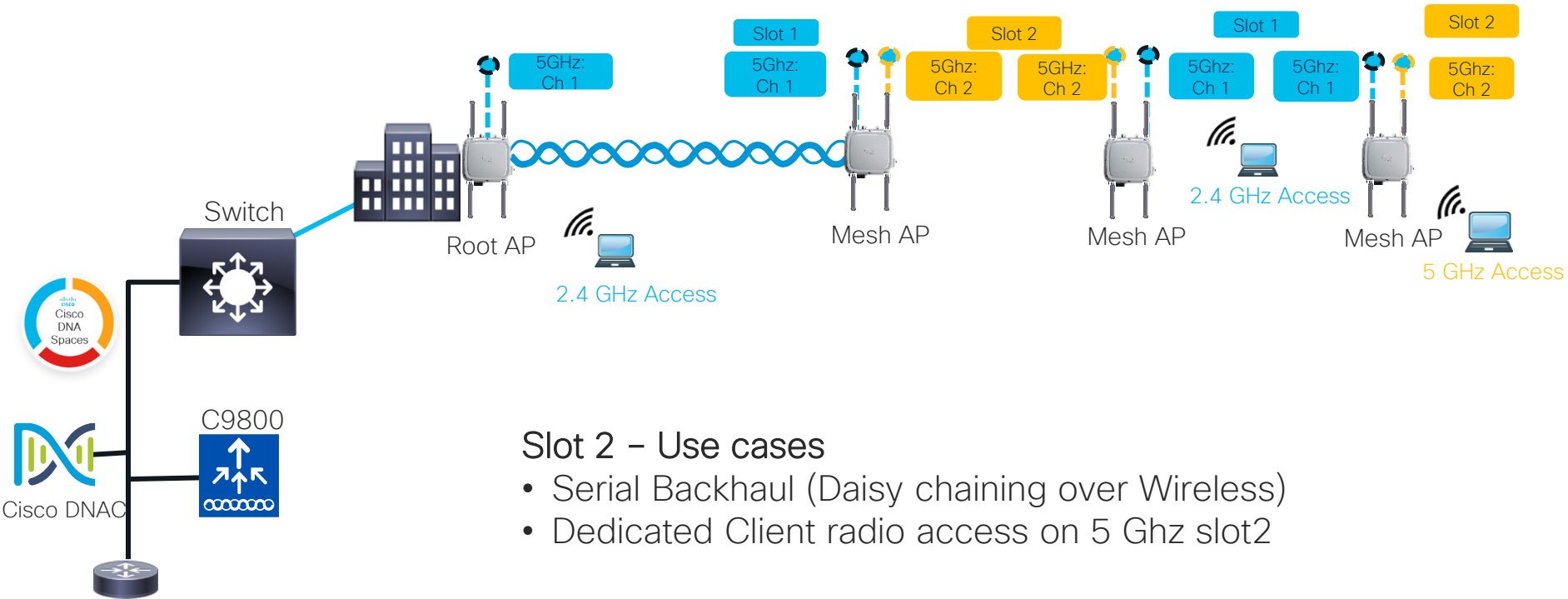
```
C9800#show wireless profile mesh detailed default-mesh-profile
Mesh Profile Name      : default-mesh-profile
-----
Description            : Default multi bssid profile
Bridge Group Name      : unconfigured
.....
Fast Teardown          : ENABLED
Number of Retries      : 4
Interval in sec        : 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

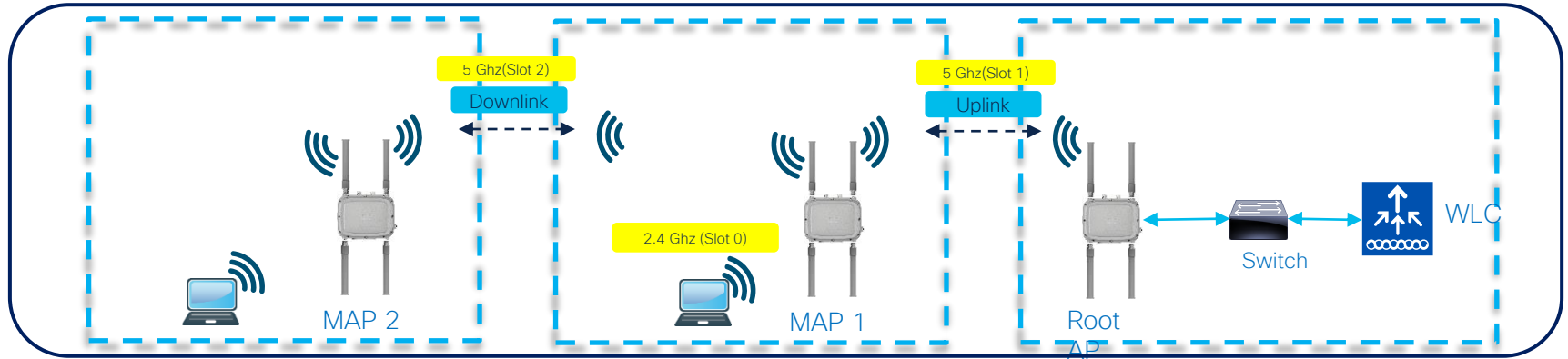
Solution Overview – Mesh Serial Backhaul



Slot 2 – Use cases

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

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

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

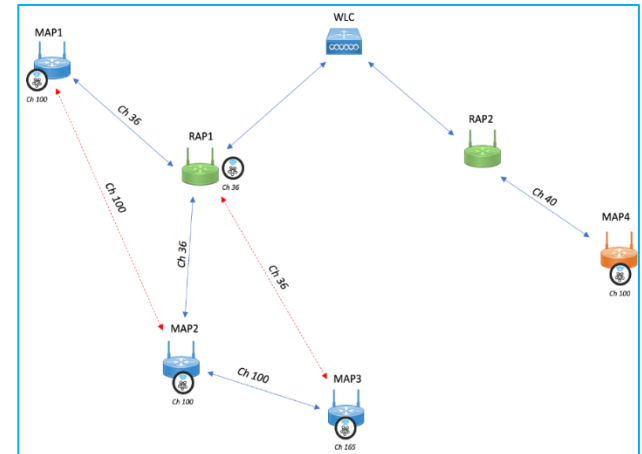
Verify

```
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)

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

YouTube: Unplugged Connectivity

The image shows a YouTube video player interface. At the top left, there is a menu icon and a 'Premium' badge. A search bar is located at the top center. The main video area displays a large crowd at a conference with the text 'Episode 25 : Cisco Live Amsterdam' overlaid in white. In the bottom left of the video, a 'Live in 7 hours' notification indicates the start time as 'February 7 at 5:25PM'. The Cisco logo is visible in the bottom right corner of the video frame. Below the video, the title 'Episode 25: Cisco Live Amsterdam' is shown, followed by the channel name 'Unplugged Connectivity' with 662 subscribers and a 'Subscribed' button. At the bottom right, there are icons for 'Like' (1), 'Comment', 'Share', 'Save', and a menu icon.



<http://cs.co/unplugged>



youtube.com/@getunplugged



The bridge to possible

Thank you

CISCO *Live!*

The Cisco Live! logo features the word "CISCO" in a bold, black, sans-serif font, followed by "Live!" in a black, cursive script font. The background of the entire image is a vibrant, multi-colored abstract pattern of overlapping, wavy bands in shades of red, orange, yellow, green, and blue, creating a sense of motion and energy.

CISCO *Live!*

Let's go

BACKUP / Reference Content



Old Family Photos...



1572IC



AP-IOS

1572EAC



AP-IOS



1562E



1540

AP-COS for All three



1562I

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

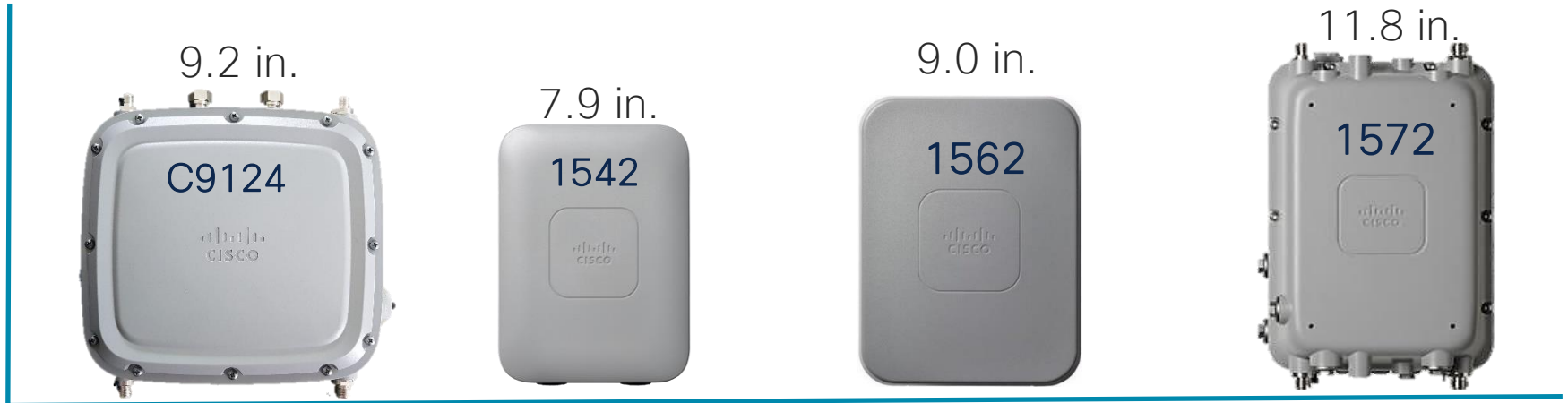


Powered by
Cisco RF ASIC

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)

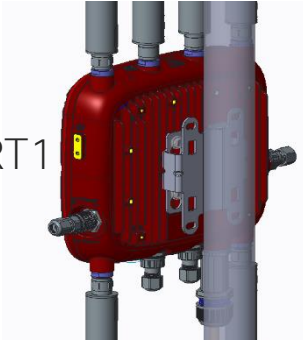
1562E: 9.0 x 6.8 x 3.9 in.
(22.9 x 17.1 x 9.8 cm)

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

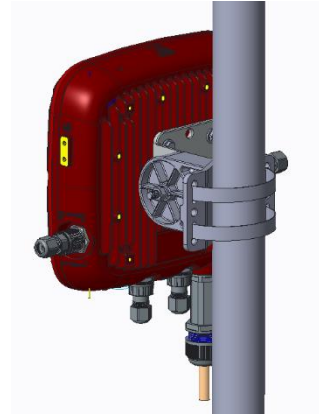
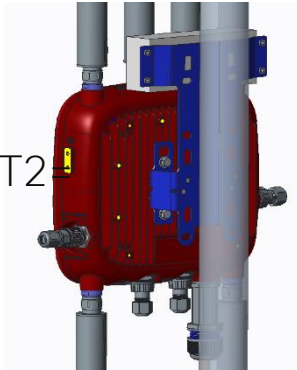
1572IC: 11.8 x 7.9 x 7.9 in.
(30.0 x 20.1 x 20.1 cm)

Catalyst 9124AX Series: Mounting Brackets

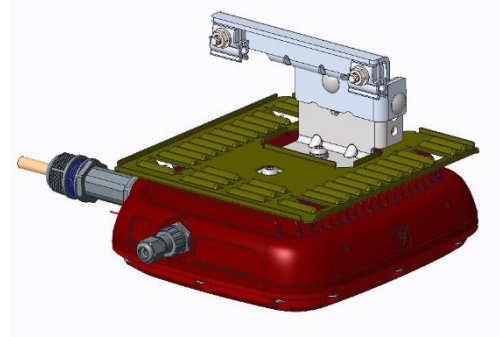
AIR-MNT-VERT1



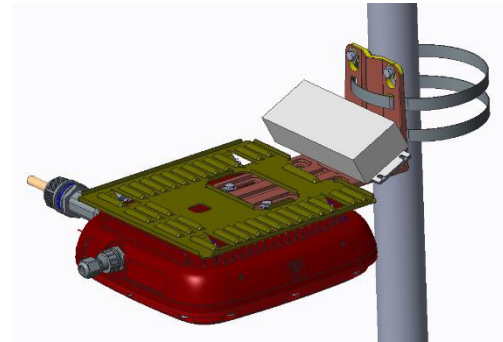
AIR-MNT-VERT2



AIR-MNT-ART1=

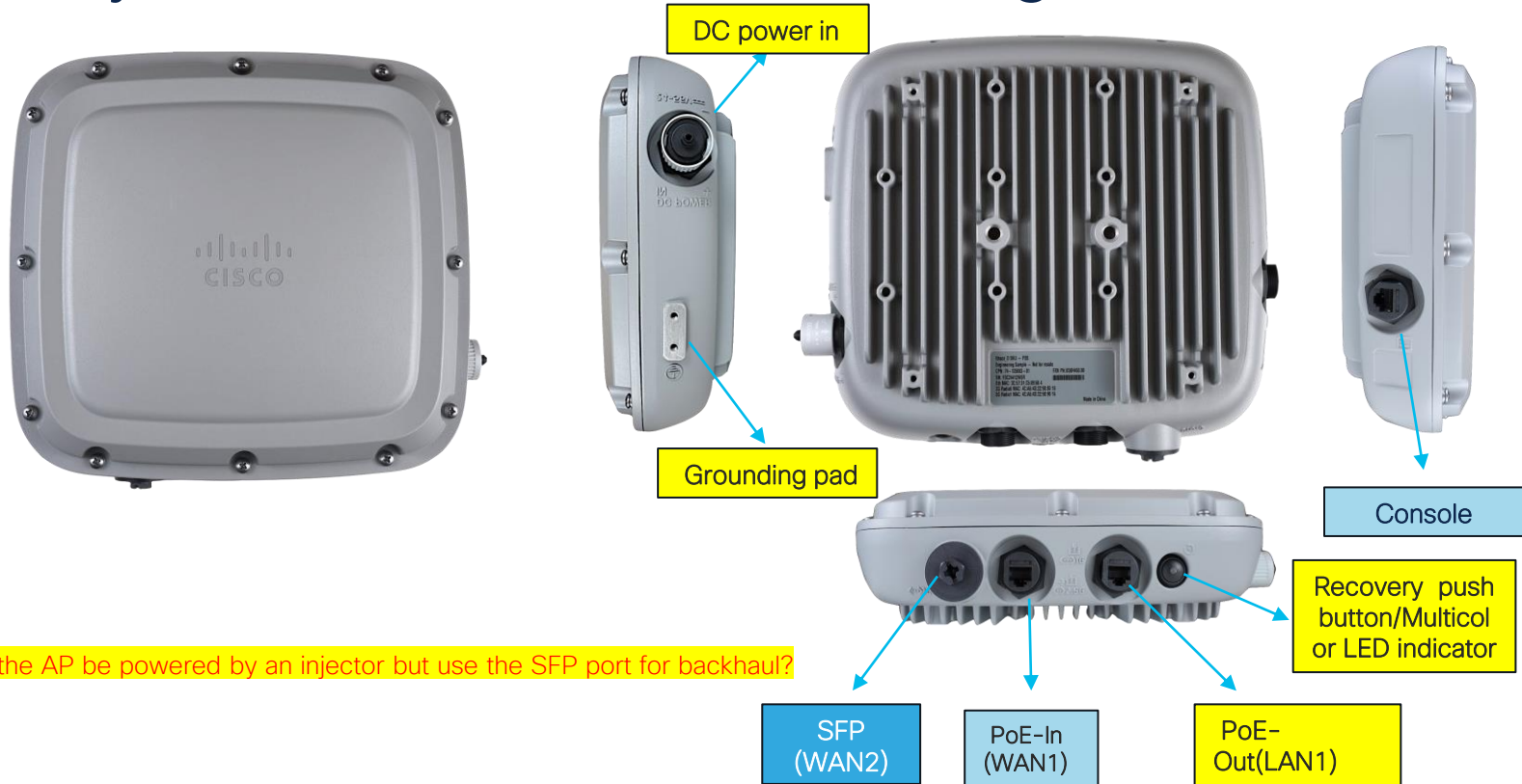


AIR-MNT-STRAND1=



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

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



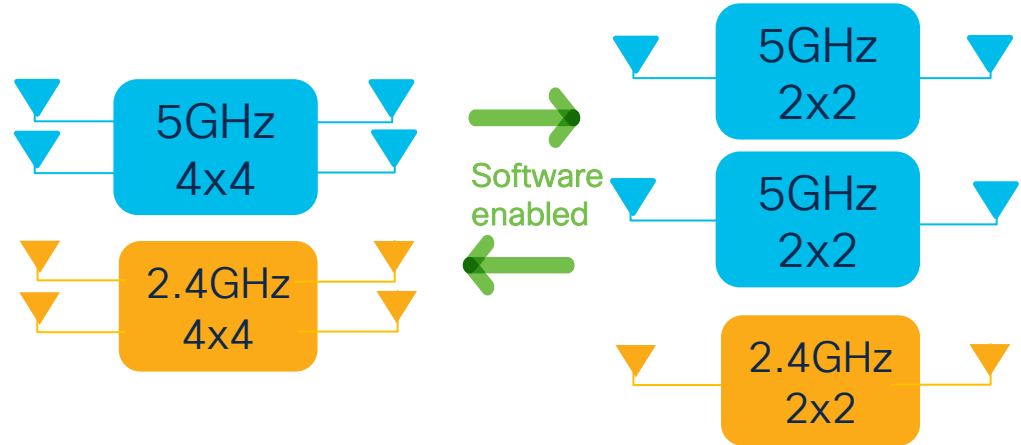
FAQ:

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

A1: YES.

C9124AXE – Radio Mode 17.7+

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 (off)	1,2,3,4	1,2,3,4	OFF

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

The first screenshot shows the '5 GHz Network Status' section with the following settings:

- 5 GHz Network Status:
- Beacon Interval*: 100
- Fragmentation Threshold (bytes)*: 2346
- DTPC Support:
- Tri-Radio Mode:

The second screenshot shows the '5 GHz Radios' table with the following data:

AP Name	Slot No	Base Radio MAC	Admin Status
C9124-3	1	4ca6.4d22.f6c0	Enabled
C9124-3	2	4ca6.4d22.f6c0	Disabled

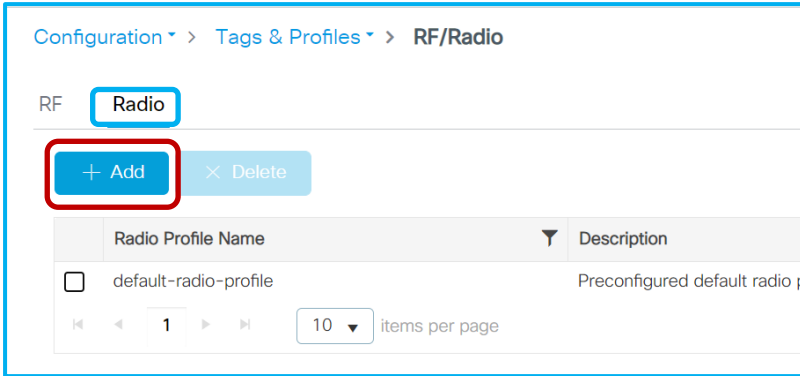
The third screenshot shows the 'Edit Radios 5 GHz Band' configuration page with the following settings:

- AP Name: C9124-3
- Admin Status: ENABLED
- CleanAir Admin Status: ENABLED
- Global Tri-Radio Mode: Disabled ⓘ
- Dual Radio Mode: Enabled, Disabled
- Antenna Type: External

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

Configuration > Tags & Profiles > Edit RF Tag

Policy Site **RF** AP

+ Add × Delete

RF Tag Name

RF Tag Name
<input type="checkbox"/> default-rf-tag

1 10 items

Name* default-rf-tag

Description

5 GHz Band RF Profile

2.4 GHz Band RF Profile

Show slot configuration

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

Step 3: Map the Radio profile for each slots

Edit RF Tag

Changes may result in loss of connectivity for clients that are associated to APs with this RF Tag.

Name* default-rf-tag

Description default RF tag

5 GHz Band RF Profile Global Config

2.4 GHz Band RF Profile Global Config

5 GHz Slot 1 Radio Profile Radio_Profile

5 GHz Slot 2 Radio Profile Radio_Profile

2.4 GHz Slot 0 Radio Profile Radio_Profile

Catalyst 9124AX – Radio Profile

Configuration > Wireless > Access Points

▼ All Access Points

Total APs : 2

Misconfigured APs

Tag :	Country Code :	LSC Fallback :
0	0	0

AP Name	AP Model	Slots	Admin Status	IP Address	Base Radio MAC
C9124-2	C9124AXI-B	2	✓	192.168.1.203	4ca6.4d22.7020
C9124-1	C9124AXI-B	2	✓	192.168.1.202	4ca6.4d22.8140

1 10 items per page 1 - 2 of

Edit Radios 5 GHz Band

Configure Detail

General

AP Name C9124-1

Admin Status **ENABLED**

CleanAir Admin Status **ENABLED**

Antenna Parameters

Antenna Type Internal

Antenna Mode Omni

Radio Profile Radio_Profile [↗](#)

Number of antennae selected 2

4

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

Catalyst 9124AXE – Radio Profile

Edit Radios 5 GHz Band

Antenna Parameters

Antenna Type	External
Antenna Mode	Omni
Self-Identifying Antenna (SIA)	Not Present
Radio Profile	Radio_Profile
Number of antennae selected	2
Supported Antenna Modes	1x1, 2x2, 4x4
Antenna Port Mapping	3, 4
Antenna Gain (in .5 dBi units)	8

Slot 1

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

Edit Radios 5 GHz Band

Antenna Type	External
Antenna Mode	Omni
Self-Identifying Antenna (SIA)	Not Present
Radio Profile	Radio_Profile
Number of antennae selected	2
Supported Antenna	1x1, 2x2
Antenna Port Mapping	5, 6
Antenna Gain (in .5 dBi units)	8

Download [Core Dump](#) to bootflash

Slot 2

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.

Mode	5Ghz Radio				2.4Ghz Radio				IoT	CW	
	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:

Mode	5Ghz Radio 1 (Primary)				5Ghz Radio 2 (Secondary)		2.4Ghz Radio				IoT
	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

Mode	5Ghz Radio 1 (Primary)				5Ghz Radio 2 (Secondary)		2.4Ghz Radio				IoT
	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: 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=

The Cisco Live! logo features the word "CISCO" in a bold, black, sans-serif font, followed by "Live!" in a black, cursive script font. The background of the entire image is a vibrant, multi-colored abstract pattern of overlapping, wavy bands in shades of red, orange, yellow, green, and blue, creating a sense of motion and energy.

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