Aruba Baltic Day 2022

Wi-Fi-6E

Extending Wi-Fi into the 6GHz band

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Agenda

- Fundamentals
- Design Considerations
- ArubaOS Support
- AP Discovery

Fundamentals

Wi-Fi 6E Overview

– Wi-Fi 6E is Wi-Fi 6 (802.11ax) extended into the 6 GHz band (5.925 – 7.125) to increase total capacity and performance

Key Features of Wi-Fi 6E:

- 6 GHz allows for Wi-Fi 6 and OFDMA only which means APs / clients are not permitted to use *slower* legacy PHYs (such as 802.11a/b/g/n/ac)
- Cleaner RF due to lower noise floor (compared to 2.4 and 5 GHz bands)
- More bandwidth with use of the largest allocation of unlicensed spectrum in history
- Scheduling is based on the High Efficiency (802.11ax) IEEE standard
- PHY latency improvements through exclusive use of HE PPDU formats for preamble and channel access, restrictions on probe request transmissions, and signaling and discovery enhancements

Wi-Fi 6E General Requirements

Required support:

- Security
  - Protected Management Frames (PMF)
  - WPA3-{Personal, Enterprise}
    - WPA3-Enterprise with 192-bit cryptographic strength is optional (CNSA SuiteB)
  - Enhanced Open (OWE)
- Discovery
  - Out-of-band (2.4/5) signaling and discovery
  - In-band (6) signaling, discovery, and association
  - Primary Scanning Channel (PSC) and Non-PSC scanning rules
- Regulatory
  - Updated regulatory rules for 6 GHz (Power Spectral Density (PSD) and EIRP)
  - Updated 6 GHz channelization (1 – 233)
- Management Frame Information Elements
  - 6 GHz band and 6 GHz operations

Not allowed and not supported in 6 GHz:

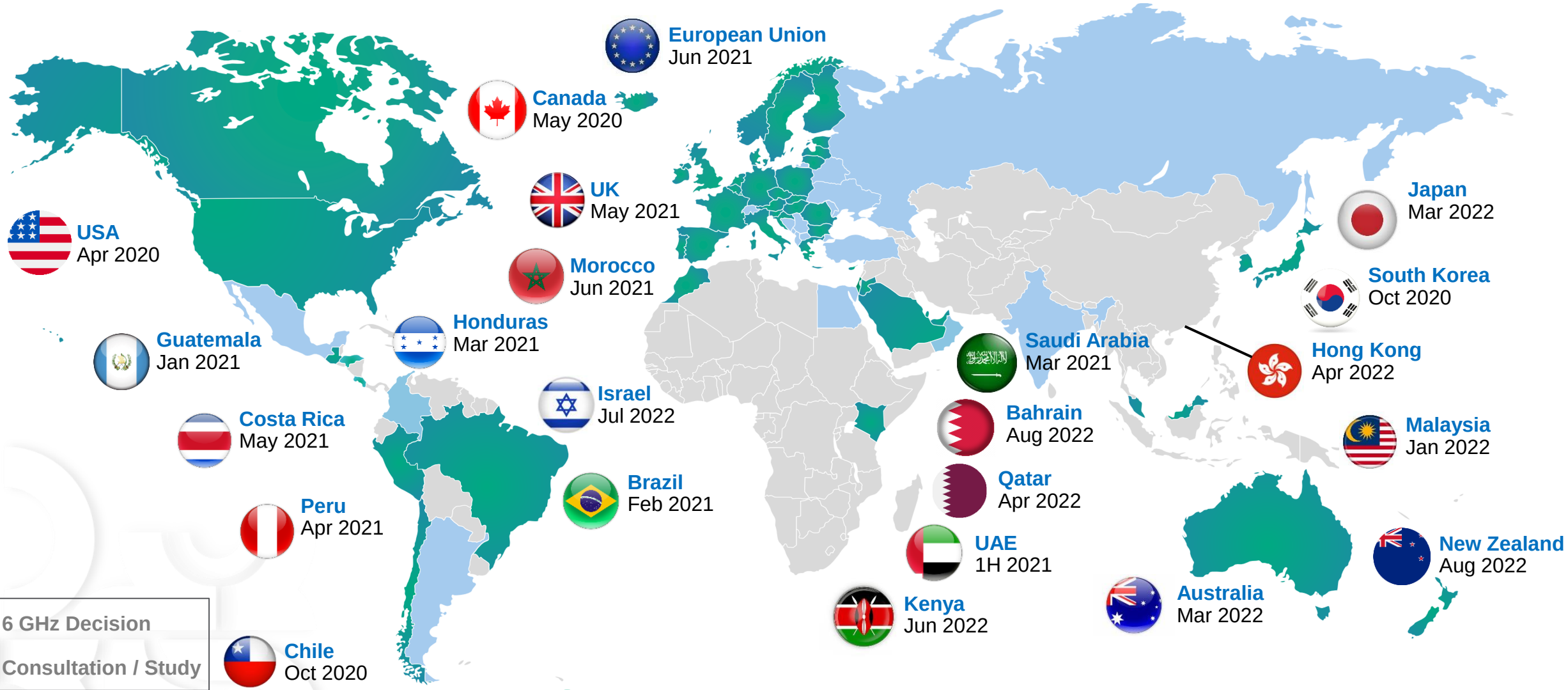
- Open Networks
- WEP and TKIP
- Legacy WPA2/WPA
- Transition Mode for WPA3 or Enhanced Open (OWE)

Take away? 6 GHz requires new SSID planning

Key Acronyms

- EIRP – Effective Isotropic Radiated Power
- LPI – Lower Power Indoor
- PMF – Protected Management Frames
- PSC – Preferred Scanning Channel
- PSD – Power Spectral Density
- UTB – Ultra Tri Band

6 GHz Unlicensed: Global Momentum

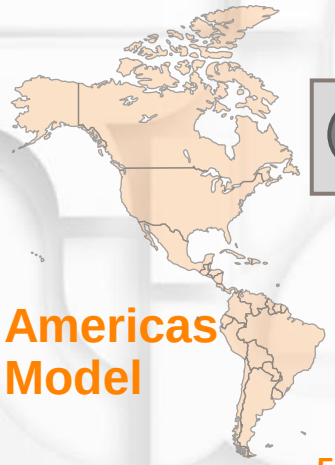


53 Countries *As of 1 August 2022*

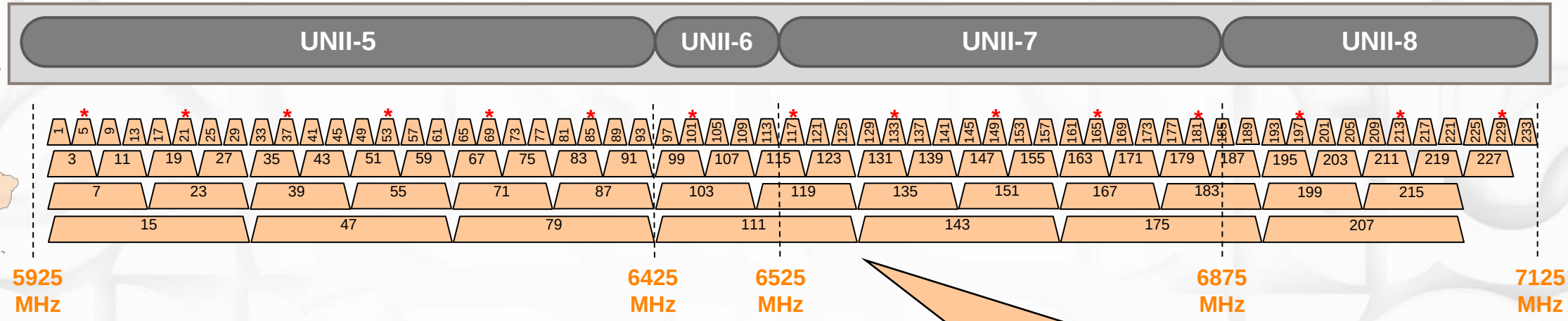
1.7B Citizens

6 GHz Channels in Americas & Europe/CEPT

Countries Adopting 500 MHz are Limited to Sub-Gigabit Speeds



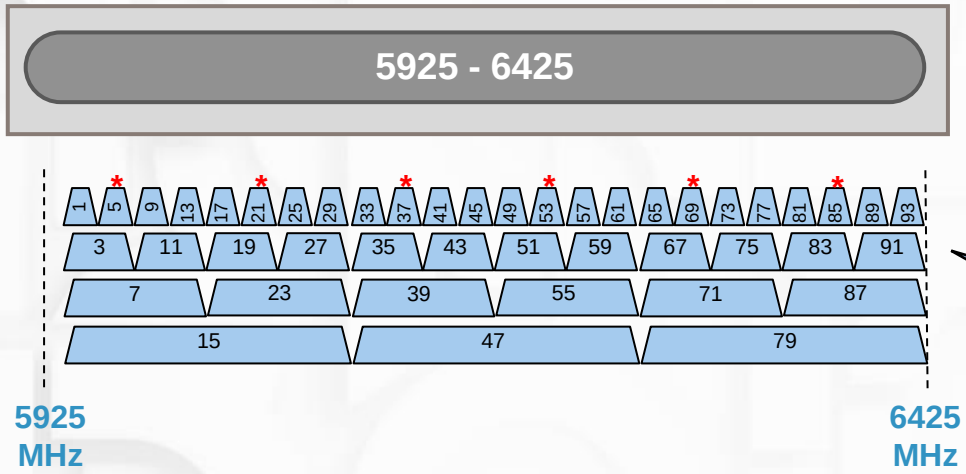
Americas Model



80 and 160 MHz channels will be the default for 1200 MHz countries

2x2 Client 160 MHz 1024 QAM = **2.4 Gbps**

European Model



20 and 40 MHz channels will continue to be default for 500 MHz countries

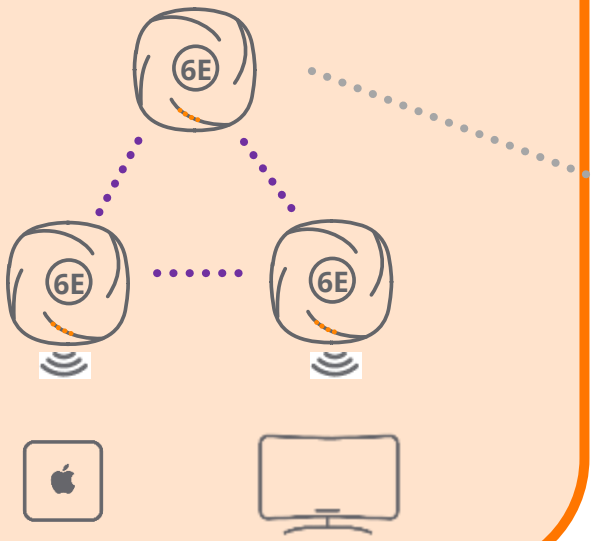
2x2 Client 40 MHz 1024 QAM = **574 Mbps**

	European Model	Americas Model
20 MHz	24	59
40 MHz	12	29
80 MHz	6	14
160 MHz	3	7

* *Denotes Primary Scanning Channel (PSC)*

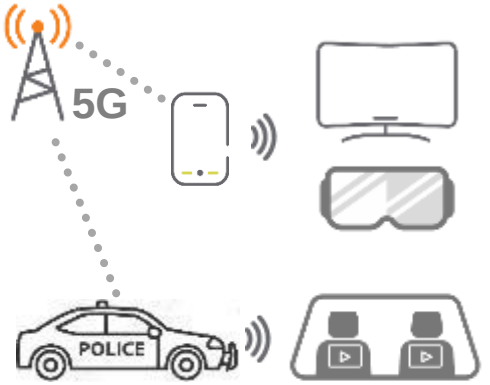
Device Classes in 6 GHz

Low Power Indoor (LPI) AP
- Fixed indoor only
- No antenna connectors
- No weatherproofing
- Not battery powered
- Labeled for Indoor Use Only



Standard Power (SP) AP
- Fixed indoor / outdoor
- Controlled by AFC database
- Automated geolocation
- Pointing angle restriction

Very Low Power (VLP) AP
- Mobile indoor / outdoor
- 22 dB lower energy



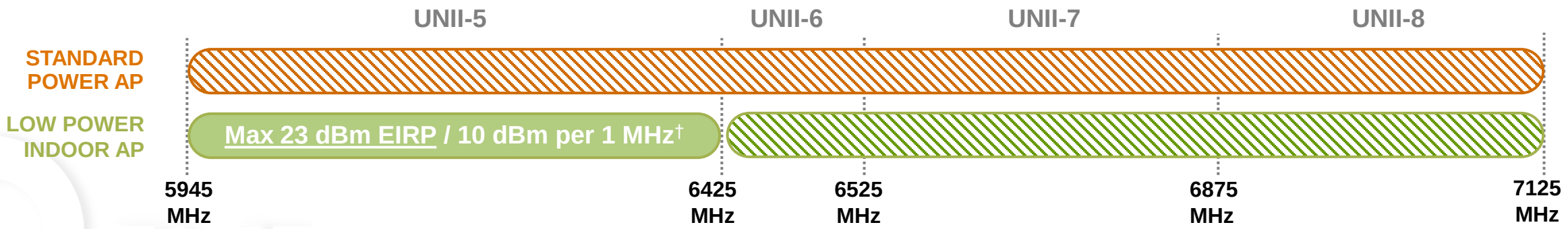
~2 Gbps throughput with sub-ms latency at 3m

Mobile Client
- Indoor / outdoor
- 6 dB less power than connected AP

Fixed CPE
- To run at full power, must behave like an AFC-controlled device

6 GHz Rules in Europe/CEPT

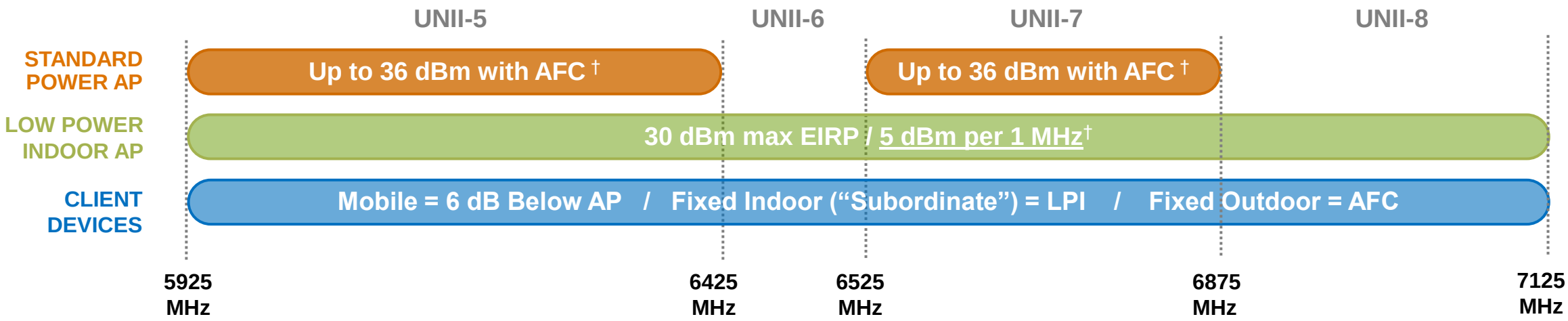
– Low power indoor across the first 500 MHz (UNII-5)
  – Up to 10 dBm per 1 MHz (PSD)
  – **Max EIRP of 23 dBm for AP or client**
– No Standard Power AP currently approved or planned
– No Low Power Indoor AP currently approved or planned for UNII-6/7/8



†PSD or EIRP limits in 6 GHz vary per regulatory domain – the most restrictive limit applies first

6 GHz Rules in United States

– Low power indoor across the entire band (UNII-5 through UNII-8) without AFC requirement
  – **5 dB per 1 MHz (PSD)**
  – Up to 30 dBm for AP or 24 dBm for client
– Automated Frequency Coordination (AFC) required in UNII-5/7 for “full” power indoor and all outdoor APs



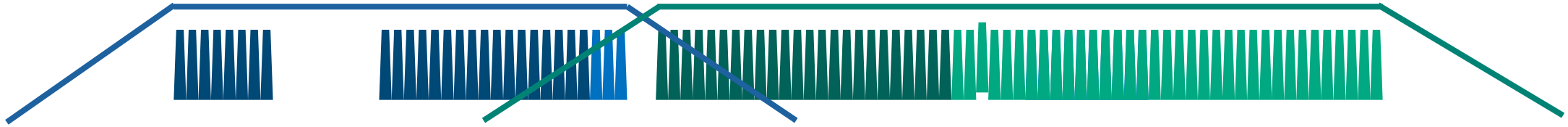
†PSD or EIRP limits in 6 GHz vary per regulatory domain – the most restrictive limit applies first

Challenge: Small Gap Between 5 GHz and 6 GHz

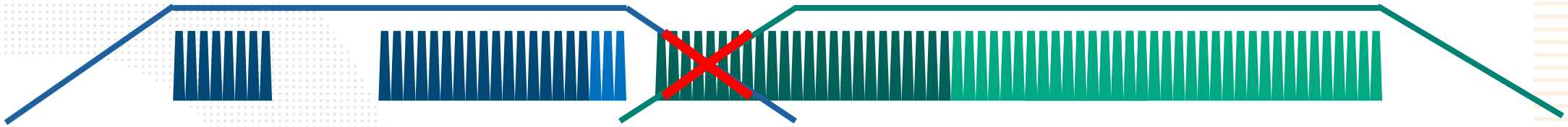
– Traditional filter solutions sacrifice some channels

  – The 5 GHz and 6 GHz bands are separated by a gap of just 50 MHz

  – Traditional filter solutions to protect the 5 GHz and 6 GHz bands can not effectively block energy from channels in the other band close to the gap (need at least 200MHz separation)



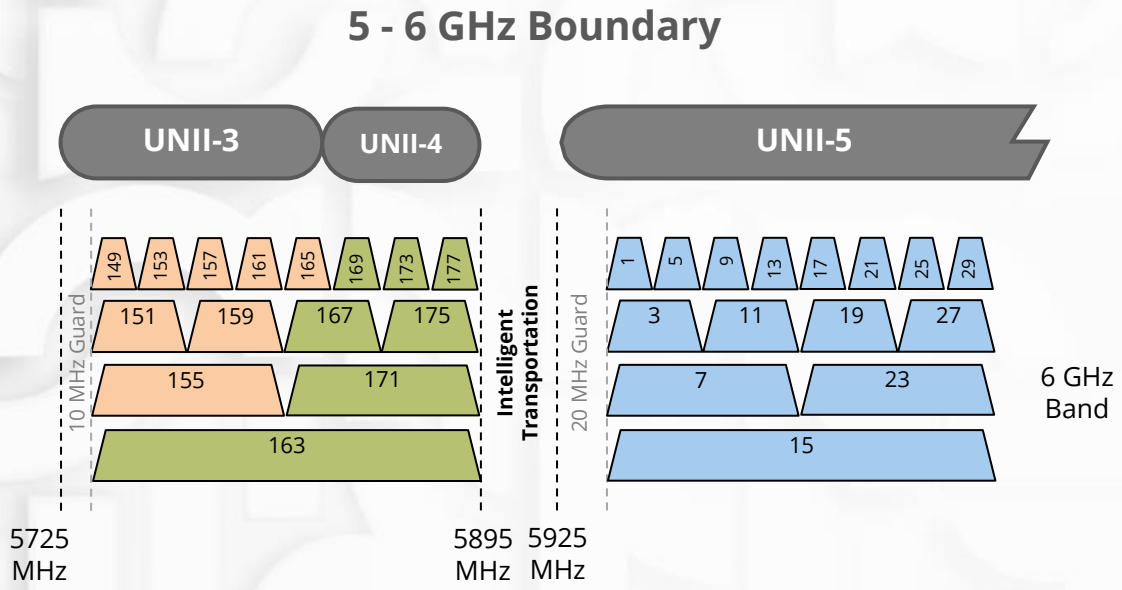
  – The typical way to deal with that is by sacrificing some channels. Typically, that would be the lower eight 6 GHz channels



Ultra-Tri Band filtering for max channel reuse

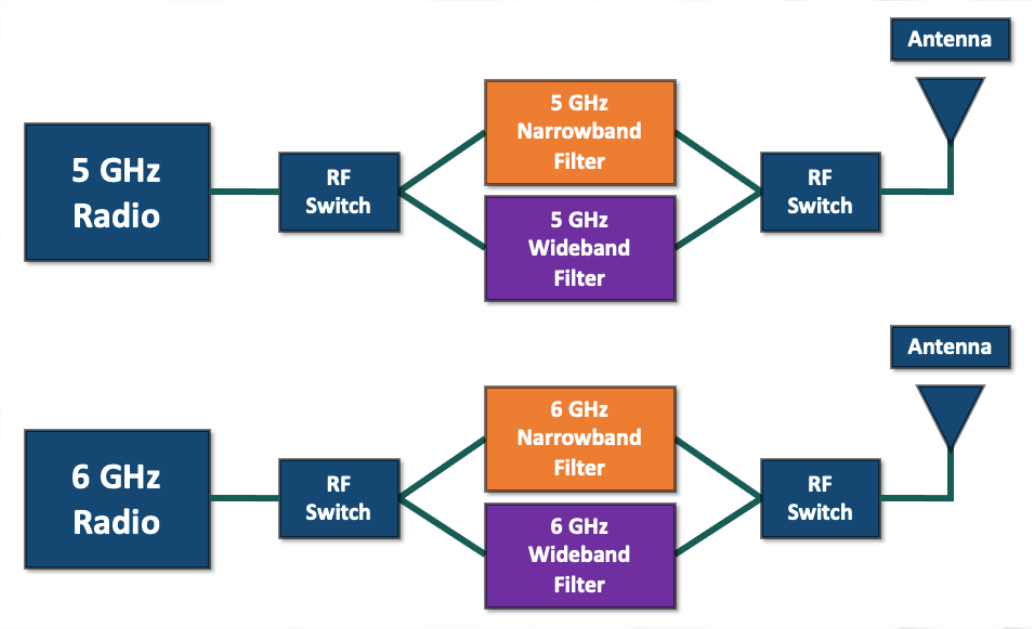
CHALLENGE:

The 5 and 6 GHz are separated by just 50 MHz, which may cause interference between radios using traditional filtering



SOLUTION:

Aruba's ultra tri-band technology delivers dynamic filtering

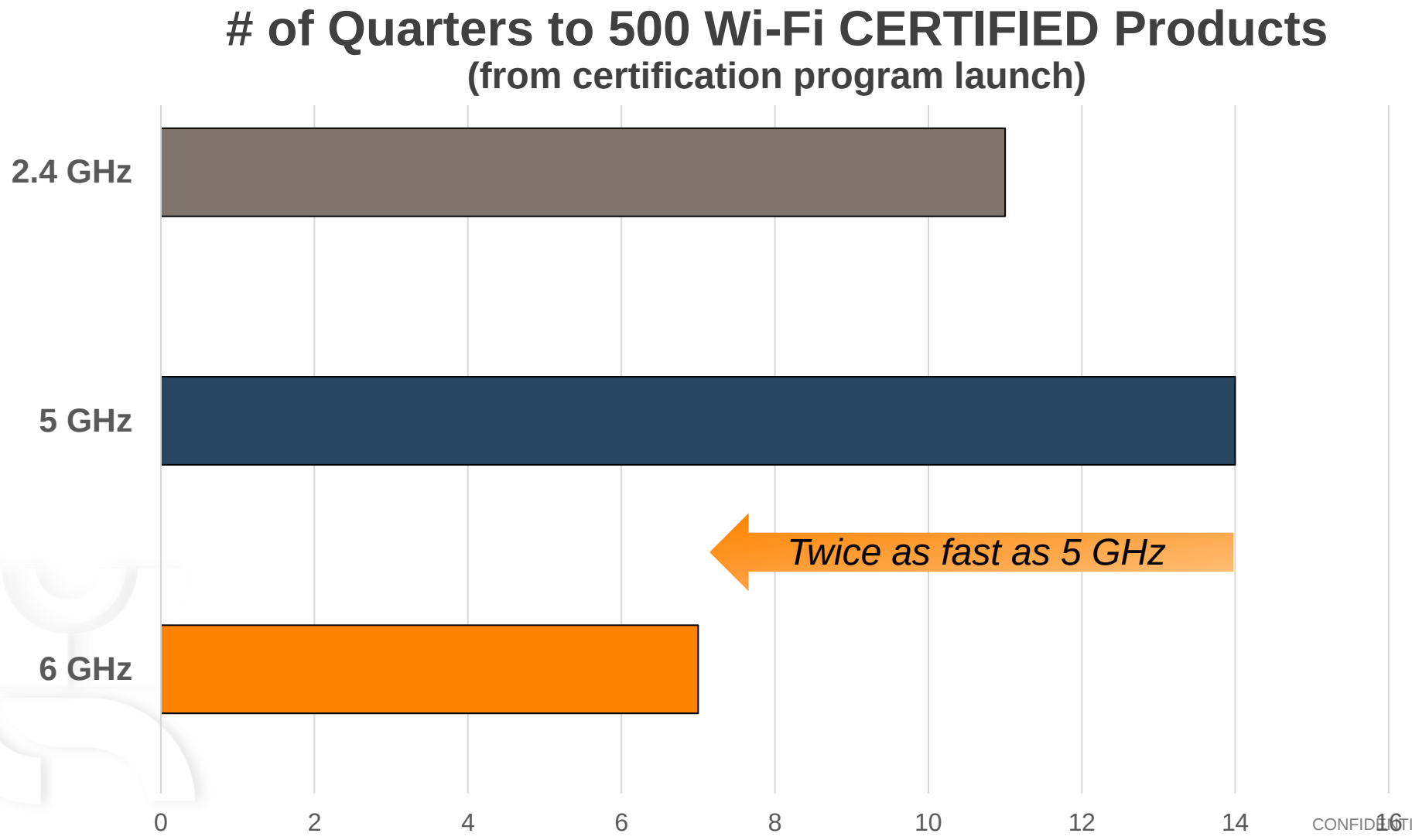


RESULT:

Less interference and unrestricted channel selection between radios for better spectrum utilization

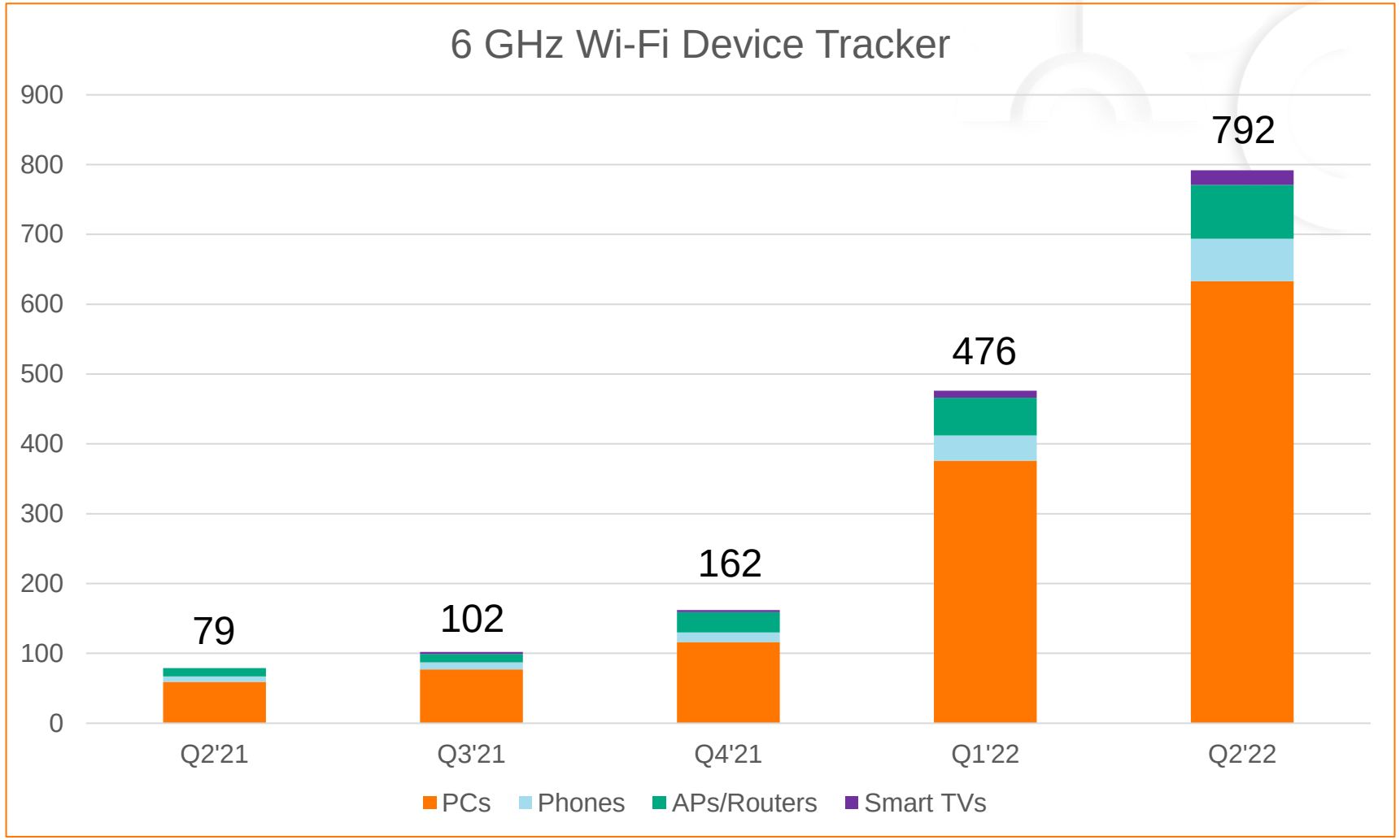
Wi-Fi 6E

Unprecedented Ecosystem Development



Source: Wi-Fi Alliance®

The Wi-Fi 6E Ecosystem
Diverse and Growing Rapidly

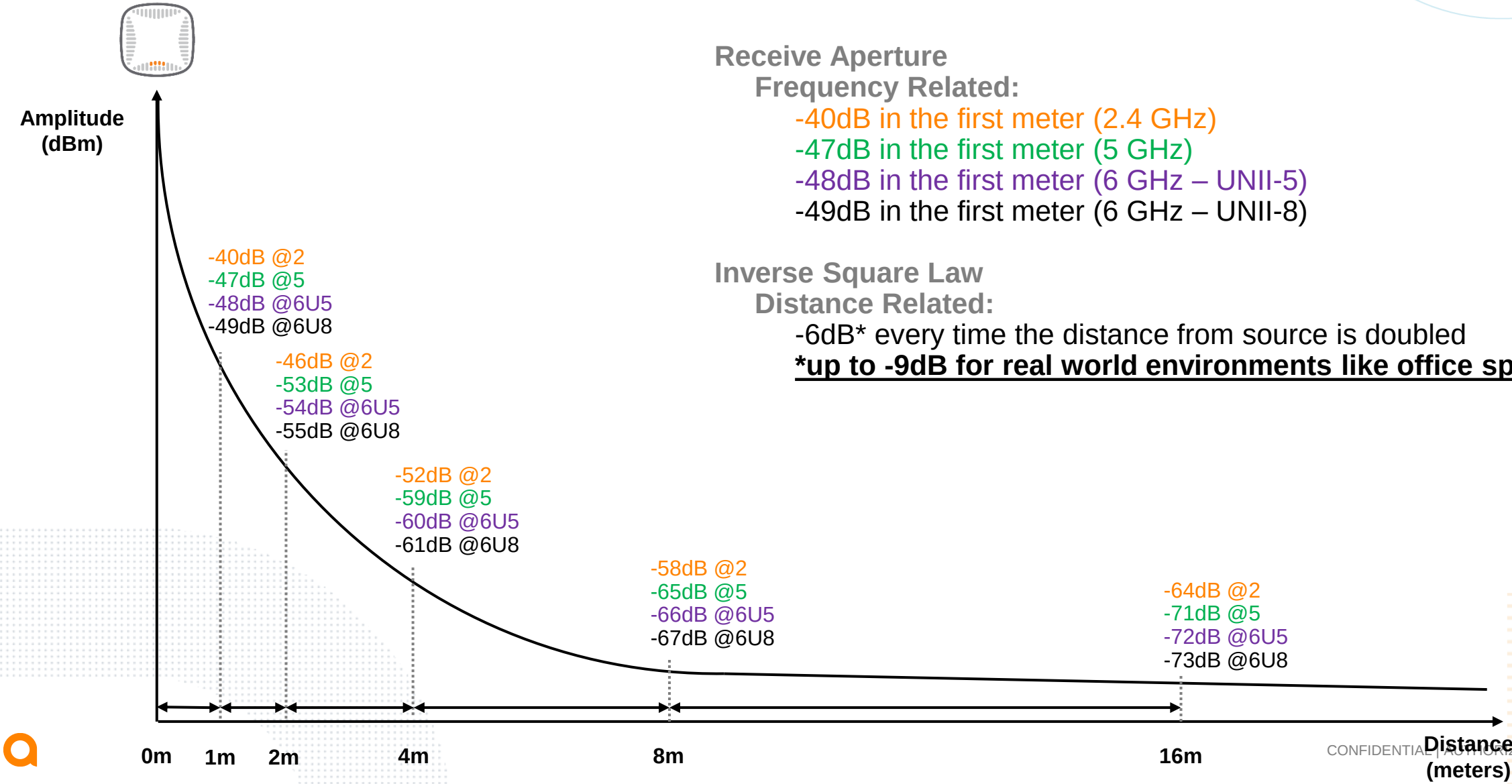


Source: Intel

Wi-Fi 6E device tracking summary is public information compiled by Intel from vendor websites, press releases, and third-party device reviews. Intel provides this assessment for informational purposes only, does not guarantee its accuracy, and it is subject to change without notice.

Design Considerations

Free Space Path Loss



Receive Aperture

Frequency Related:

-40dB in the first meter (2.4 GHz)

-47dB in the first meter (5 GHz)

-48dB in the first meter (6 GHz – UNII-5)

-49dB in the first meter (6 GHz – UNII-8)

Inverse Square Law

Distance Related:

-6dB* every time the distance from source is doubled

***up to -9dB for real world environments like office spaces**

5 GHz EIRP versus 6 GHz PSD

Low Power Indoor APs† in 6 GHz are limited to 5 dBm per 1 MHz Power Spectral Density (PSD). PSD compensates for noise floor rise, thus incentivizing use of wide channels.

		20 MHz	40 MHz	80 MHz	160 MHz	320 MHz
Channel Width						
Noise Floor Rise vs. 20MHz			+3 dB	+6 dB	+9 dB	+12 dB
5 GHz UNII-2b	**EIRP**	**30 dBm**	**30 dBm**	**30 dBm**	**30 dBm**	**30 dBm**
	PSD (dBm/MHz)	17	14	11	8	5
	EIRP - Noise	30 dBm	27 dBm	24 dBm	21 dBm	18 dBm
6 GHz LPI	**EIRP**	18 dBm	21 dBm	24 dBm	27 dBm	30 dBm
	PSD (dBm/MHz)	**5**	**5**	**5**	**5**	**5**
	EIRP - Noise	18 dBm	18 dBm	18 dBm	18 dBm	18 dBm

"Effective EIRP" drops in wide channels due to noise floor rise

With constant PSD, the AP increases power to compensate added noise in wider channels

† *Note: AFC APs in 6 GHz are limited by EIRP*

New ways to think about network design with Wi-Fi 6E

- RF Design
  - Advice on adding 6 GHz APs to your current WLAN deployment
  - Present some ideas that *may* be useful for high density and shared real estate use cases, for example
  - *Resource: https://www.arubanetworks.com/assets/wp/WP_Wi-Fi-6E.pdf*
- Power
  - Power consumption varies by model and features, check your data sheet
  - Aruba Intelligent Power Management (IPM) allows customization of power usage when access switch does not provide full power to the AP
- Throughput
  - Aggregate throughput on a tri-band tri-radio AP can reach up to 2-4 Gbps depending on the configuration and model
  - Access switch port rate needs to be considered to maintain the speed through the WLAN
- Redundancy
  - Wireless as the primary connection medium is becoming the norm, not the exception, in the industry
  - We will present design options to improve resiliency, considering wireless layout and wired connections

6E LPI RF Design: Evaluate Current Design

First! Wi-Fi 6E does not fix bad/no design

Q: What does the existing RF design look like today?

A: Current design *coverage* only? Using high power? No overlapping cells?

– Consider efforts to create a new design and RF plan

– Factor in considerations for density and capacity with both 5 and 6 GHz

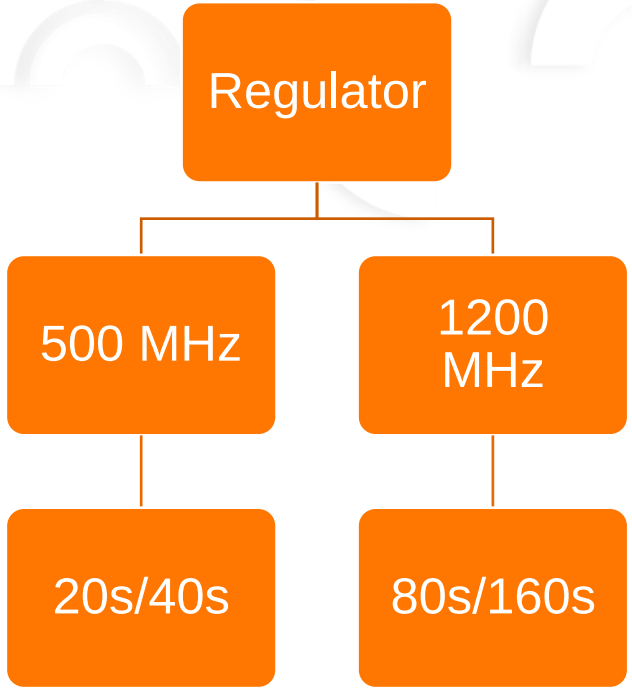
A: Current design *capacity* based? With overlapping primary and secondary cells?

- At the same EIRP, the “cell” size in 6 GHz will be similar to 5 GHz because the signal loss is minimal
  - Americas model assume -2 dB
  - European model assume -1 dB
- For attenuation, watch out for heavy and highly absorbent materials in walls like lead or concrete for both 5 and 6 GHz RF planning
- Design might be a candidate for 1:1

LPI 6 GHz RF Design: Channelization

- Available spectrum varies for each country (regulator)
- Consider different channel widths based on available spectrum
- Wider channels offer many benefits
  - More RUs = Greater simultaneous clients with OFDMA
  - Higher aggregate throughput
  - Higher effective EIRP for 6 GHz when limited by PSD

	European Model	Americas Model
20 MHz	**24**	**59**
40 MHz	**12**	**29**
80 MHz	**6**	**14**
160 MHz	**3**	**7**



LPI 6 GHz RF Design: AP Density

– The different EIRP and PSD power capping mechanisms found in 5 GHz and 6 GHz force evaluation of current deployments in brownfield upgrade efforts.

– The LPI device class supports the required RF power for a typical indoor enterprise deployment

– When the *current* 5 GHz EIRP is **above 20 dBm**, the designer must consider increasing AP density to meet their 6 GHz capacity requirements.

– When the *current* 5 GHz EIRP is **below 20 dBm**, the nuance between bands is minimal for typical indoor enterprise deployments.

Recommendations:

–Deployments with EIRP > 20 dBm

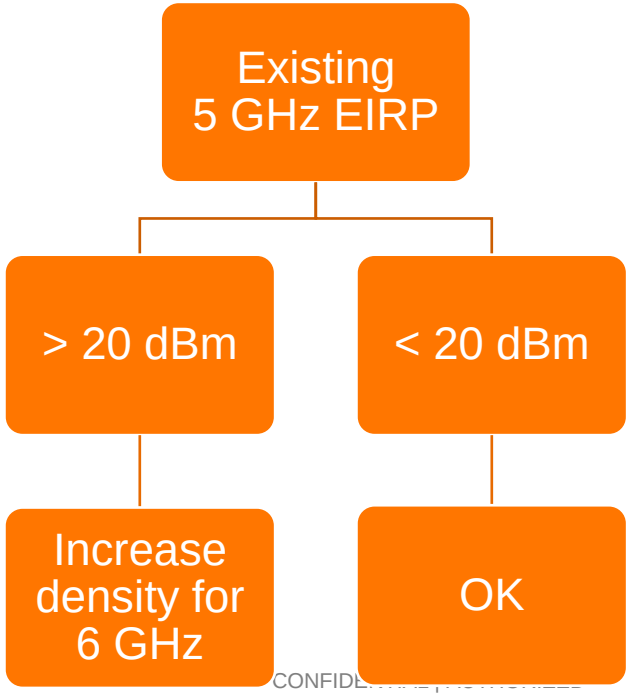
–Example: 5 GHz coverage only based deployment

–*Likely requires increased AP density to support 6 GHz*

–Deployments with EIRP < 20 dBm

–Example: Existing 5 GHz capacity-based deployment with overlapping cells

–OK for 6 GHz



Wi-Fi 6E SSID Planning

Possible security modes in 6 GHz:

- **Enhanced Open (OWE)**
  - Leverages Opportunistic Wireless Encryption to replace Open System Authentication
  - Diffie-Hellman exchange encrypts all wireless traffic
  - Offers encryption without user authentication
- **WPA3-Personal (SAE)**
  - Simultaneous Authentication of Equals replaces the one-way key generation found in WPA2-PSK with Diffie-Hellman key exchange
- **WPA3-Enterprise**
  - Offers widest compatibility for legacy and new .1X clients sharing the same ESSID
  - Operation in 2.4 and 5 GHz shares the same key management and ciphers as WPA2-Enterprise; Difference: PMF capable (optional)
- **WPA3-Enterprise (operation in 6 GHz)**
  - New key management (SHA-256); CCMP-128 ciphers; PMF required
- **WPA3-Enterprise with 256 bits**
  - New key management (SHA-256); GCMP-256 ciphers; PMF required
- **WPA3-Enterprise with CNSA suite**
  - New key management (SHA-384); GCMP-256 ciphers; PMF required; strong EAP-TLS methods only (no mix and match)

2.4 GHz Radio	5 GHz Radio
Corp_SSID (802.1X)	Corp_SSID (802.1X)
Guest_SSID (Open)	Guest_SSID (Open)
IOT_SSID (PSK)	IOT_SSID (PSK)

Conventional Dual-Band SSIDs

2.4 GHz Radio	5 GHz Radio	6 GHz Radio
	Corp_SSID (802.1X)	Corp_SSID (802.1X)
IOT_SSID (PSK)	Guest_SSID (OWE)	Corp_6Only_SSID (802.1X)

Potential Tri-Band 6E SSID Strategy

ArubaOS Support

Release history and required ArubaOS versions for Wi-Fi 6E

On-Premises Managed Deployments-

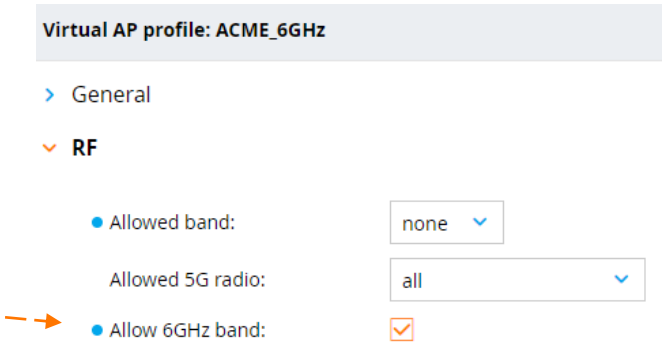
- Mandatory Wi-Fi 6 feature functionality per Wi-Fi Alliance certification has been available on capable hardware and supported since ArubaOS 8.6.0.2
- Wi-Fi 6E FCS support in ArubaOS 8.9.0.0 for InstantOS (controller-less) and ArubaOS (controller-based)
- AP-655 FCS with ArubaOS 8.10.0.1 (LSR)
- Mobility Conductors / Controllers managed by Central On-Premises (COP) 2.5.4+

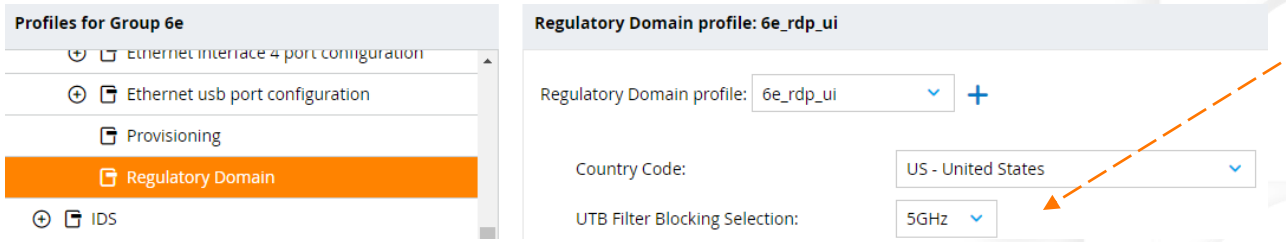
Cloud Managed Deployments-

- Central 2.5.5 introduced UI support for 6E which can manage AP-635 or AP-655 running InstantOS 8.10 code
- No current AOS 10 support for 6E as of presentation
  - *Target AOS 10 support for AP-635 or AP-655 is Central 2.5.6 and AOS 10.4*

Known Limitations: Configuration

- ArubaOS 8.9.0.0 FCS supports only up to 4 SSIDs in 6 GHz MBSSID beacon
  - This is a max beacon size limitation from chipset vendors
  - Support for more than 4 SSIDs is planned for future release
- Existing VAPs will not automatically apply to the 6 GHz radio
  - On SSID config creation, 6 GHz is disabled by default
  - Administrator must explicitly enable it per VAP
- Open and WPA2 security opmodes are not allowed in 6 GHz (Wi-Fi Alliance)
  - SSID configuration must use one of the WPA3 modes or Enhanced Open (OWE)
- Non-UTB hardware
  - To enable lower 6 GHz channels on non-UTB capable AP (AP635v1), user must explicitly set filter block to 5 GHz
  - The utb-filter-block default setting is 6 GHz and is user configurable in the *Regulatory Domain Profile*
  - On APs with UTB support (e.g., AP-635v2 and any AP-655), there is no restriction on channel selection and the utb-filter-block setting is automatically ignored





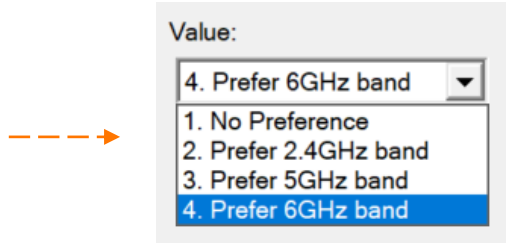
Known Limitations: Client Behavior

If multi-radio AP is in single radio mode with only 6 GHz enabled and 2.4 / 5 GHz is disabled, some clients may not discover/connect to 6 GHz SSID-

- Why? No Reduced Neighbor Report (RNR) IE in 2.4 / 5 GHz management frames to help with out-of-band discovery

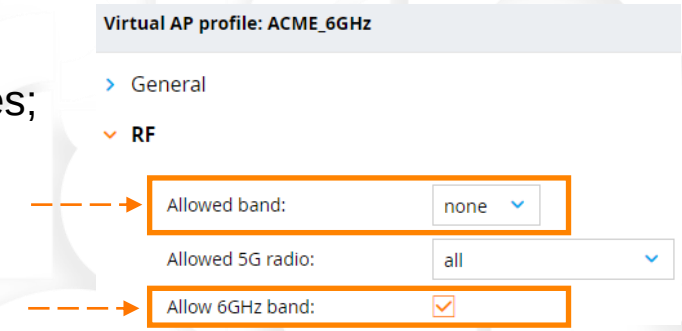
With same SSID operating on two radios (5 / 6) or three radios (2.4 / 5 / 6), some capable 6 GHz clients may not connect or prefer the 6 GHz radio-

- Clients are *primarily* responsible for discovery and association decisions
- Intel and Windows troubleshooting tip:
  - The Advanced Intel driver settings allows configuration of Preferred Band
  - Preferred Band will affect which band is typically used



Need to force 6 GHz connectivity? Recommended method to force 6 GHz connectivity is to configure a unique SSID and allow operation on 6 GHz only-

- How does discovery work when the SSID isn't the same in 6 GHz as 2.4 / 5 GHz?
- The RNR IE is automatically appended to the Beacon frames across VAPs in 2.4 / 5 GHz and provides 6 GHz connection information for capable devices; even if SSID is not the same!



Enterprise AP Platforms

Campus AP Wi-Fi 6 & 6E Platforms

802.11ax Wi-Fi 6

550 Series (AP-555)
802.11ax (Wi-Fi 6) 8x8:8SS / 4x4:4SS, tri-radio mode, 5.4Gbps
2x 5GE, USB, BLE, 15.4, 37RU, MU-MIMO
Wi-Fi 6 flagship, 802.3bt, IPM, Smart POE

530 Series (AP-53x)
802.11ax (Wi-Fi 6) dual 4x4:4SS, 3.0Gbps
2x 5GE, USB, BLE / 15.4, 37RU, MU-MIMO
Wi-Fi 6 high-performance, 802.3at, IPM, Smart POE

510 Series (AP-51x)
802.11ax (Wi-Fi 6) 4x4:4SS / 2x2:2SS, 2.7Gbps
1x 2.5GE + 1x 1GE, USB, BLE / Zigbee, 16RU, MU-MIMO
Wi-Fi 6 mid-range, 802.3at, IPM

500 Series (AP-50x)
802.11ax (Wi-Fi 6) dual 2x2:2SS, 1.5Gbps
1x 1GE, USB, BLE / 15.4, 8RU
Wi-Fi 6 entry-level, 802.3af, IPM

802.11ax Wi-Fi 6E

650 Series (AP-655)
802.11ax (Wi-Fi 6E) triple 4x4:4SS, 7.8Gbps
2x 5GE, USB, BLE / 15.4, 37RU, MU-MIMO
Wi-Fi 6E flagship, 802.3af/at/bt, IPM, Smart POE

630 Series (AP-635)
802.11ax (Wi-Fi 6E) triple 2x2:2SS, 3.9Gbps
2x 2.5GE, USB, BLE / 15.4, 8/37RU
Wi-Fi 6E mid-range, 802.3at/bt, IPM, failover

Entry-level: 610 Series (AP-615)
802.11ax (Wi-Fi 6E) dual / tri-band 2x2:2SS, 3.6Gbps
1x 2.5GE, USB, BLE / 15.4, 8RU
Wi-Fi 6E entry-level, 802.3af/at, IPM

AP-6xx Campus Access Points – Size and Weight

AP-555
260 x 260
1570g

AP-655
260 x 260
1800g

AP-635
220 x 220
1300g

AP-615
160 x 160
520g

AP-505
160 x 160
500g

Access Point Discovery

In-Band Discovery Techniques Overview

Technique	Airtime Efficiency	Faster AP Discovery	Notes
Preferred Scanning Channels (PSCs)		Yes	One in four 20 MHz channels designated for beacons and in-band discovery
Beacon Changes	Yes		Remove information elements for older generations. Add parameters to Wi-Fi 6 information elements.
Multi-BSSID Beacon	Yes		For multiple virtual APs on a single radio, transmit one beacon with elements for VAP deltas, rather than multiple beacons.
Rules for Probing	Yes		No probing on non-PSC channels unless beacon is received. Restricted Probing on PSC channels.
Unsolicited Broadcast Probe Responses (UPR)		Yes	Short AP announcement every 20 msec (vs 102 msec for a beacon)
Fast Initial Link Setup (FILS) Announcements		Yes	Short AP announcement every 20 msec (vs 102 msec for a beacon)

In-Band Discovery Options

Multi-Band APs

Option 1: In-Band Active

Active Probing on PSC
- Preferred Scanning Channels

Single-Band APs

Option 2: In-Band Passive

FILS Discovery*
- Concise beacon (action frame every 20 TU)

Unsolicited Probe Response*
- Pre-empt active probing in time to speed roaming

*if implemented

Preferred Scanning Channels (PSCs)

- One in every four 20 MHz channels is designated for beacons and discovery^
- For in-band network discovery, clients only scan up to 15 channels
- The 20 MHz PSC is also the primary channel in bonded channels
- Current European model uses 5 – 85 (first 500 MHz)

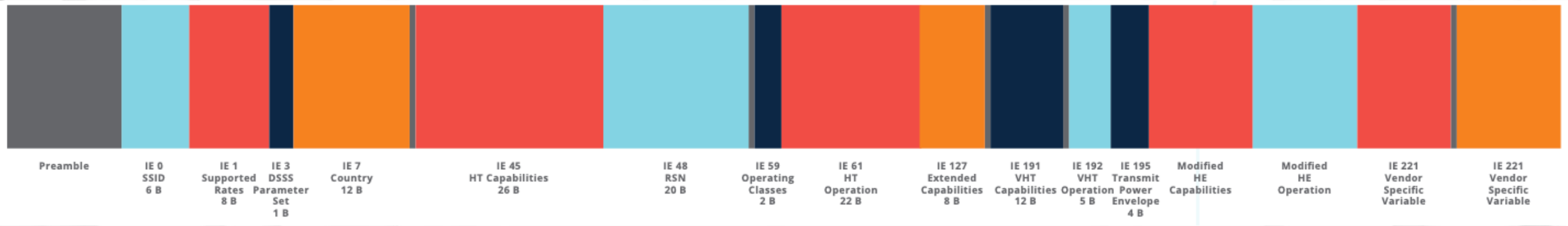
European Model	Americas Model

PREFERRED SCANNING CHANNEL	CHANNEL CENTER FREQUENCY (GHz)
5	5.975
21	6.055
37	6.135
53	6.215
69	6.295
85	6.375
101	6.455
117	6.535
133	6.615
149	6.695
165	6.775
181	6.855
197	6.935
213	7.015
229	7.095

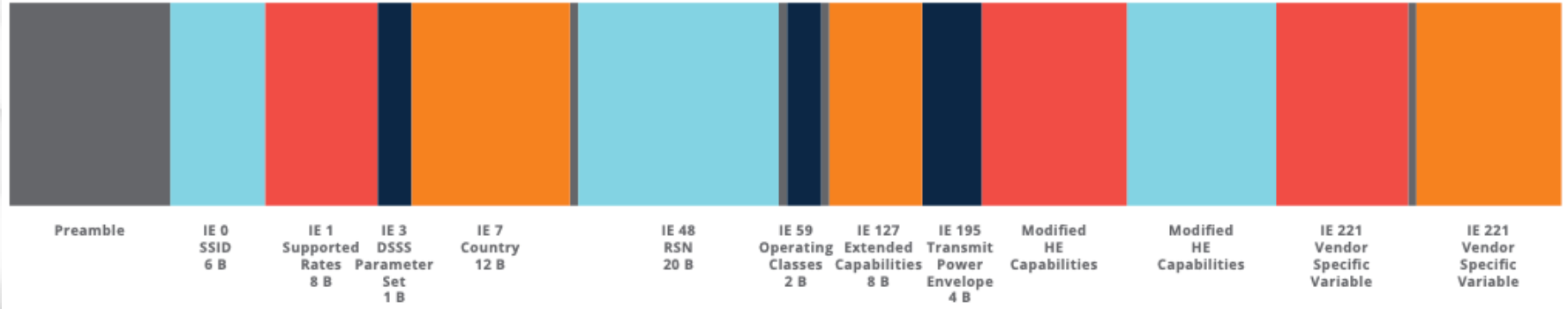
^ beginning with channel 5

In-Band Beacon Optimization

- Wi-Fi 6 (802.11ax HE) beacon example in 5 GHz

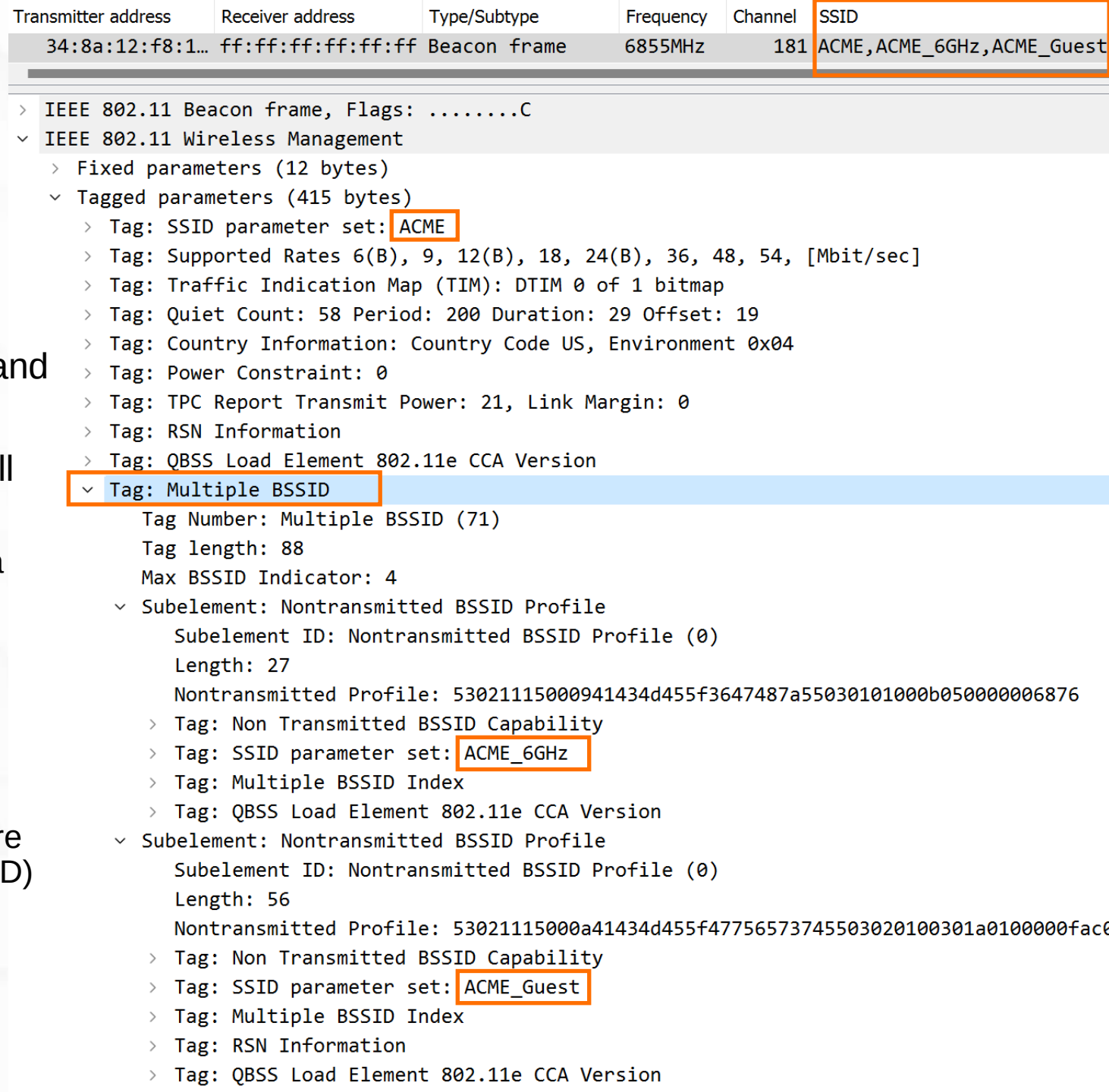


- Wi-Fi 6 (802.11ax HE) beacon example in 6 GHz



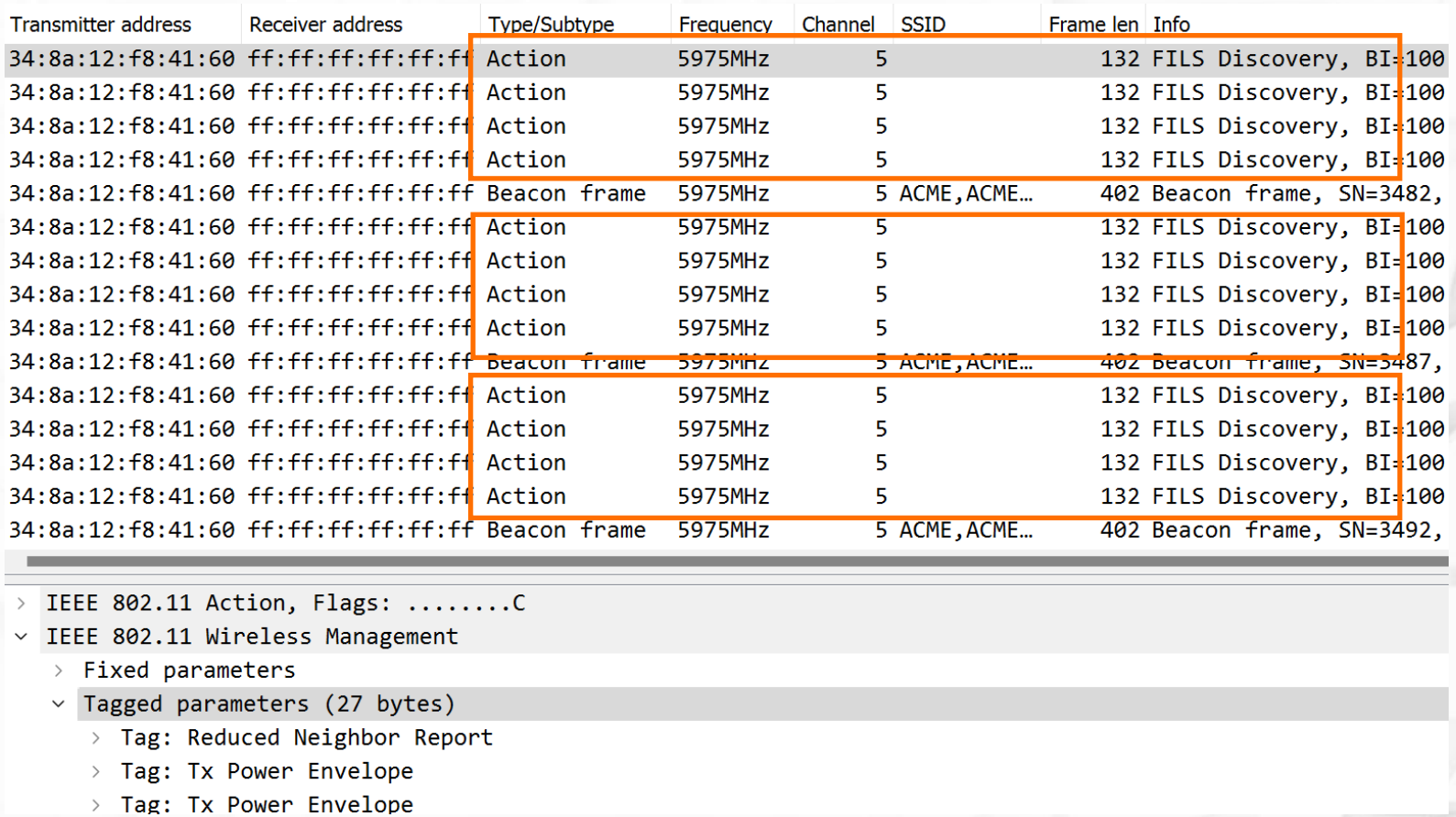
In-Band Discovery
Multiple BSSID (MBSSID) Beacon Frame

- MBSSID introduced with 802.11v but was optional and not implemented
- In 6 GHz, MBSSID is mandatory for clients and APs to support
- What is it? A single beacon with details for all VAPs
  - Compare to 2.4 / 5 GHz where each VAP has a separate beacon
  - Optimizes airtime by consolidating beacons
- ArubaOS currently has a 4 BSSID limit in 6 GHz
  - Future versions will likely address this limit by using multiple MBSSID beacons when 5 or more VAPs are enabled in 6 GHz (exact behavior TBD)



In-Band Discovery
Fast Initial Link Setup (FILS) Discovery Frames

- FILS Discovery support is planned in future release.
- Automatically enabled when AP-6xx is operating with a single active radio in 6 GHz.
- What is FILS Discovery?
  - A broadcast action frame from the AP
- FILS Discovery is a smaller frame sent at 4x rate of the MBSSID beacon



In-Band Client Probe Request Rules

- Client may discover in-band by probing which is restricted to Primary Scanning Channels (PSCs) and how often
- To enforce more efficient probing behavior, several rules are in place for 6 GHz to reduce excessive probing and encourage device makers to optimize their probing algorithms.

Type of Probe Request			Condition to Send Probe Request	Purpose
Destination Address	**BSSID**	**SSID**		
Broadcast	Wildcard	Wildcard	Not Allowed	Ban indiscriminate probe reponses from all BSSs from all ESSs.
Broadcast	Wildcard	SSID	Not more than 1 per 20 ms.	Probe ESS but with reduced frequency.
Broadcast	BSSID/Non-transmitted BSSID		Not more than 3 per 20 ms.	Probe specific BSS with reduced frequency.

In-Band Probe Request and Response Frame Examples

- This is a **slower** discovery method and does not work for all scenarios in 6 GHz on its own
- Note that in 6 GHz, *if there is a probe request*, the response to probe request (from AP to client) must be broadcast (`ff:ff:ff:ff:ff:ff`) rather than unicast – like in 2.4 / 5 GHz
- MBSSID Information Element also found in Probe Response

– Probe Request

Transmitter address	Receiver address	Type/Subtype	Frequency	Channel	SSID
64:79:f0:55:ae:79	ff:ff:ff:ff:ff:ff	Probe Request	6855MHz	181	◆
7e:30:da:d2:65:fc	ff:ff:ff:ff:ff:ff	Probe Request	6855MHz	181	ACME

```
> Frame 5007: 197 bytes on wire (1576 bits), 197 bytes captured (1576 bits) on
> Radiotap Header v0, Length 56
> 802.11 radio information
> IEEE 802.11 Probe Request, Flags: ........C
v IEEE 802.11 Wireless Management
  v Tagged parameters (113 bytes)
    > Tag: SSID parameter set: ACME
    > Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]
    > Tag: Extended Capabilities (10 octets)
    > Ext Tag: FILS Request Parameters: Undecoded
    > Ext Tag: HE Capabilities
    > Ext Tag: HE 6 GHz Band Capabilities
    > Ext Tag: Short SSID
    > Tag: Vendor Specific: Microsoft Corp.: Unknown 8
    > Tag: Vendor Specific: Broadcom
    > Tag: Vendor Specific: Wi-Fi Alliance: Multi Band Operation - Optimized
```

– Probe Response

Transmitter address	Receiver address	Type/Subtype	Frequency	Channel	SSID
34:8a:12:f8:11:f0	ff:ff:ff:ff:ff:ff	Probe Response	6855MHz	181	ACME,ACME_6GHz,ACME_Guest
34:8a:12:f8:11:f0	ff:ff:ff:ff:ff:ff	Probe Response	6855MHz	181	ACME,ACME_6GHz,ACME_Guest
34:8a:12:f8:11:f0	ff:ff:ff:ff:ff:ff	Probe Response	6855MHz	181	ACME,ACME_6GHz,ACME_Guest
34:8a:12:f8:11:f0	ff:ff:ff:ff:ff:ff	Probe Response	6855MHz	181	ACME,ACME_6GHz,ACME_Guest
34:8a:12:f8:11:f0	ff:ff:ff:ff:ff:ff	Probe Response	6855MHz	181	ACME,ACME_6GHz,ACME_Guest

```
> IEEE 802.11 Probe Response, Flags: ........C
v IEEE 802.11 Wireless Management
  > Fixed parameters (12 bytes)
  v Tagged parameters (383 bytes)
    > Tag: SSID parameter set: ACME
    > Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/sec]
    > Tag: Country Information: Country Code US, Environment 0x04
    > Tag: Power Constraint: 0
    > Tag: TPC Report Transmit Power: 21, Link Margin: 0
    > Tag: RSN Information
    > Tag: QBSS Load Element 802.11e CCA Version
    > Tag: Multiple BSSID
    > Tag: RM Enabled Capabilities (5 octets)
    > Tag: AP Channel Report: Operating Class 131, Channel List : 1, 5, 9, 13, 17, 21, 25, 29,
    > Tag: BSS Available Admission Capacity
    > Tag: Extended Capabilities (11 octets)
    > Tag: Tx Power Envelope
    > Tag: Tx Power Envelope
    > Ext Tag: HE Capabilities
    > Ext Tag: HE Operation
    > Ext Tag: MU EDCA Parameter Set
    > Ext Tag: HE 6 GHz Band Capabilities
    > Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Parameter Element
    > Tag: Vendor Specific: Qualcomm Inc.
    > Tag: Vendor Specific: Qualcomm Inc.
    > Tag: Vendor Specific: Aruba, a Hewlett Packard Enterprise Company: AP Name (ap655_811e)
```

Wi-Fi 6E Features: Out-of-Band Discovery
Reduced Neighbor Report (RNR)

- WFA Optimized Connectivity (OCE) feature
- Lists adjacent radios in same housing
- Broadcast both bands in Beacon frame, or supplied to client in Probe Response frame
- TBTT provides client accurate time to go off-channel from current AP and passively scan for the beacon of the 6 GHz BSSID
- RNR supports ClientMatch from day one
- Supports Airtime Efficiency and Faster AP Discovery
- **Applied automatically to 2.4 / 5 GHz and SSID does not need to match.**

Signal Propagation Testing

Testing Setup

Test Client

5 GHz
6 GHz

Test AP
(AP-635 & AP-655)

Eth1

TB 3
1/2.5/5/10 GbE
Smart Rate compatible dongle

M1 MBA
iPerf3 server

Eth0 SR CL6 PSE

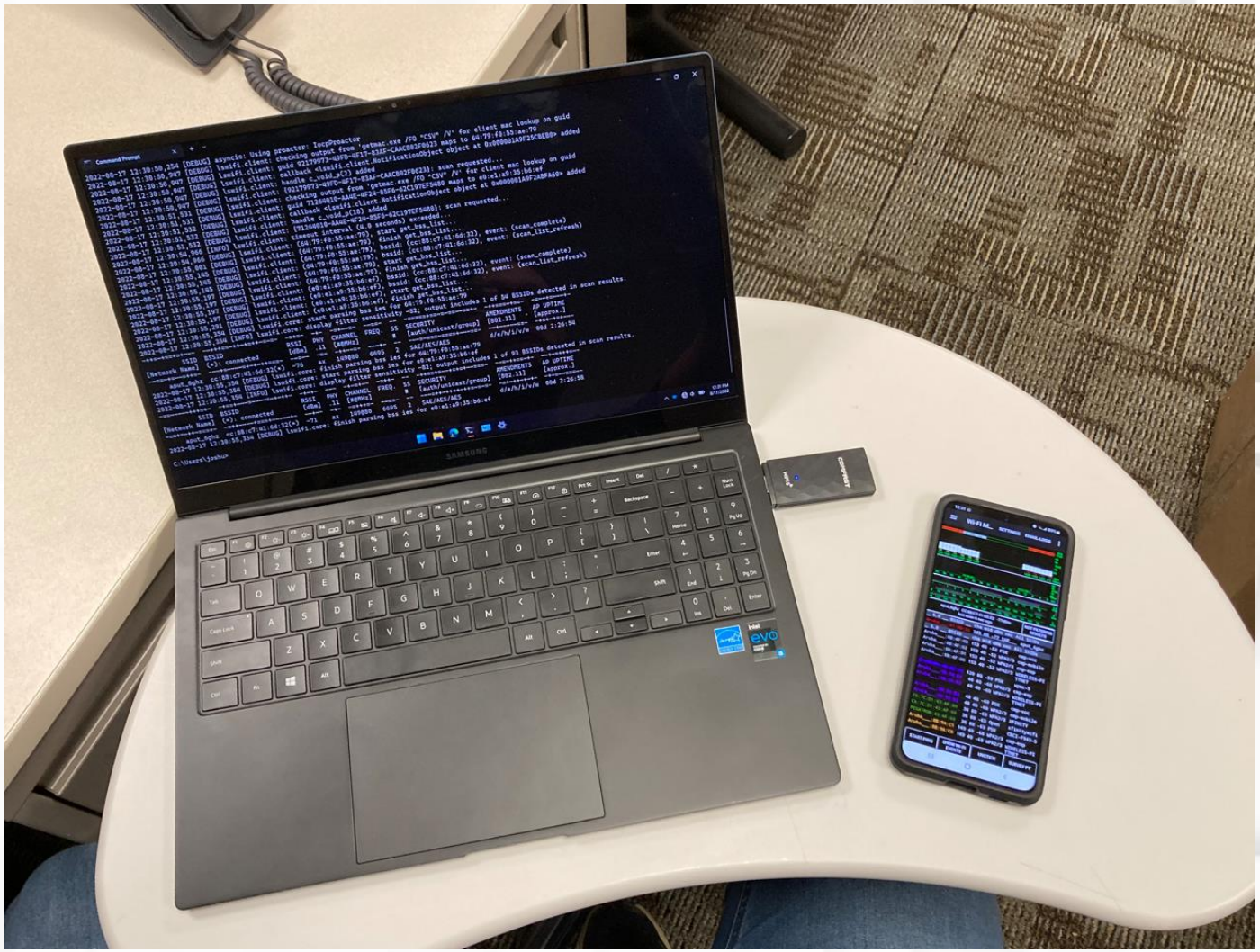
Test devices

– Samsung Galaxy Book with AX210

– Comfast CF951AX USB dongle

  – MT7921U (supports HE80 & 6 GHz)

– Samsung Galaxy S21 Ultra 5G

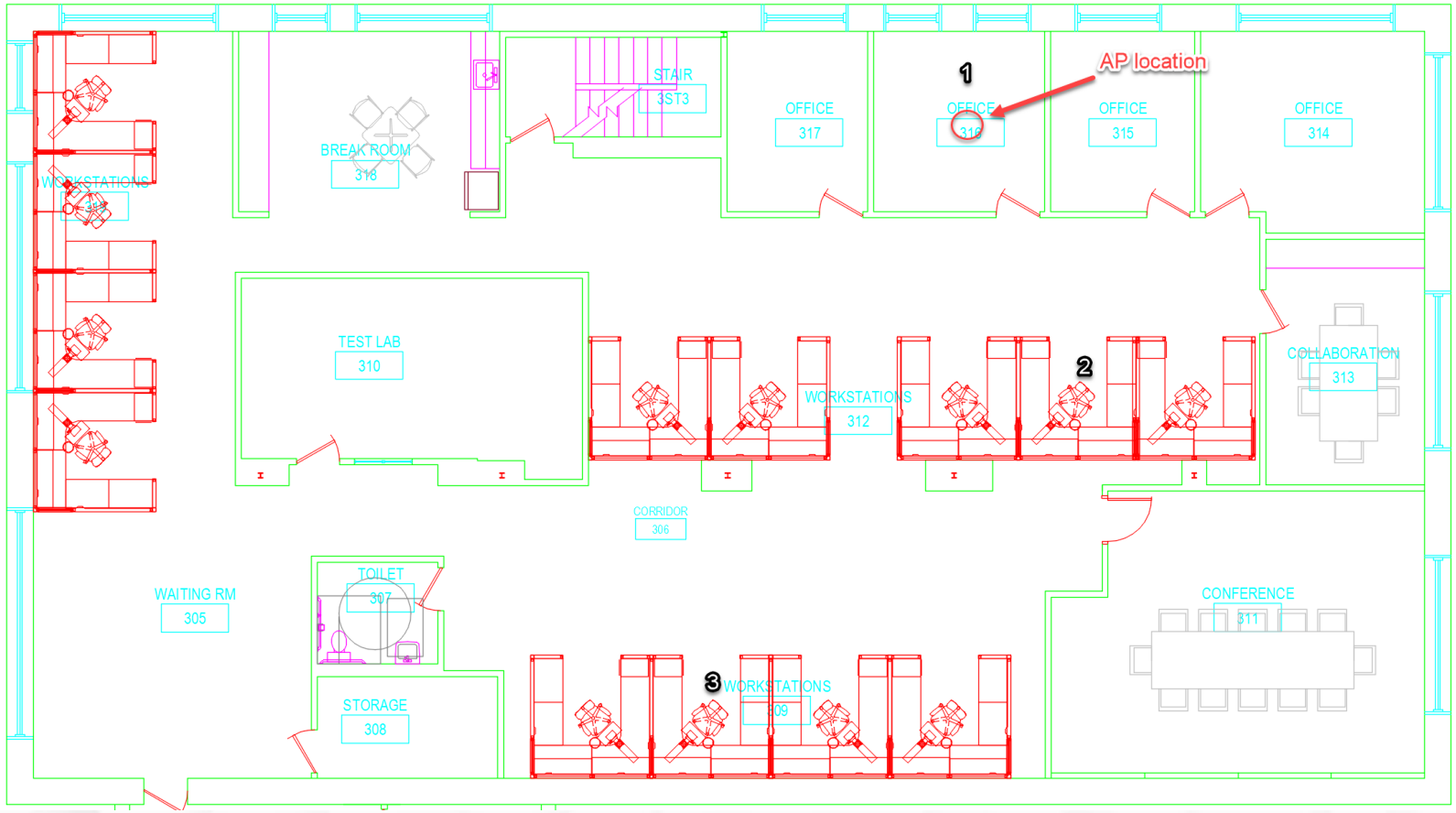


Test Locations

– 3rd floor with cubicles and metal cabinets

– Spread for 3 testing locations is roughly 1m/3ft – 5m/16ft – 12m/40ft

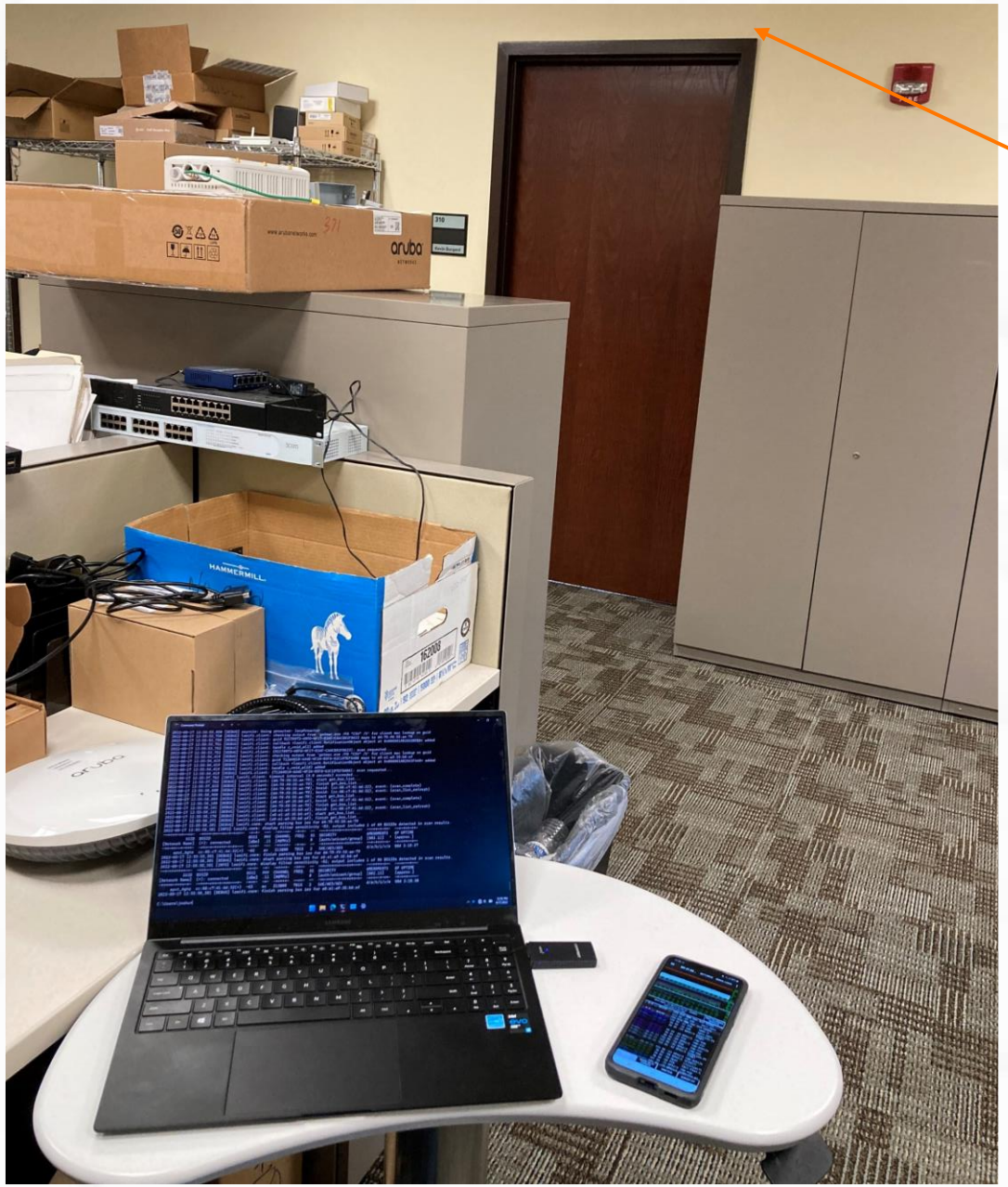
– Door closed when testing at spots 5m / 12m locations



AP location: Center Office

Test location # 1 – 1m/3ft

Test location # 2 – 5m/16ft



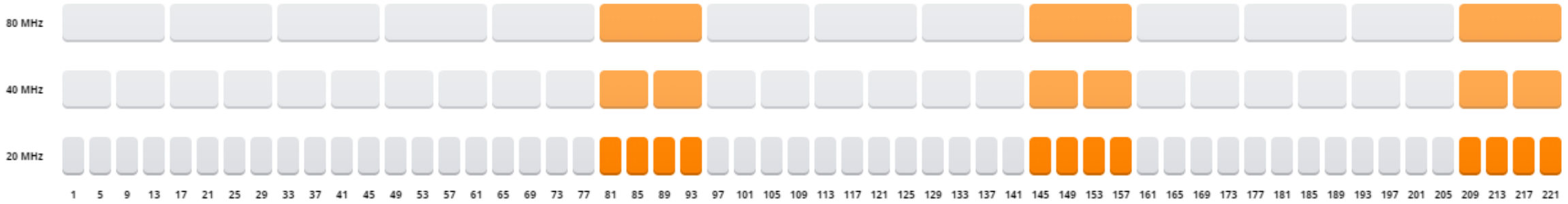
AP is in this office

Test location # 3 – 12m/40ft

AP is in this office

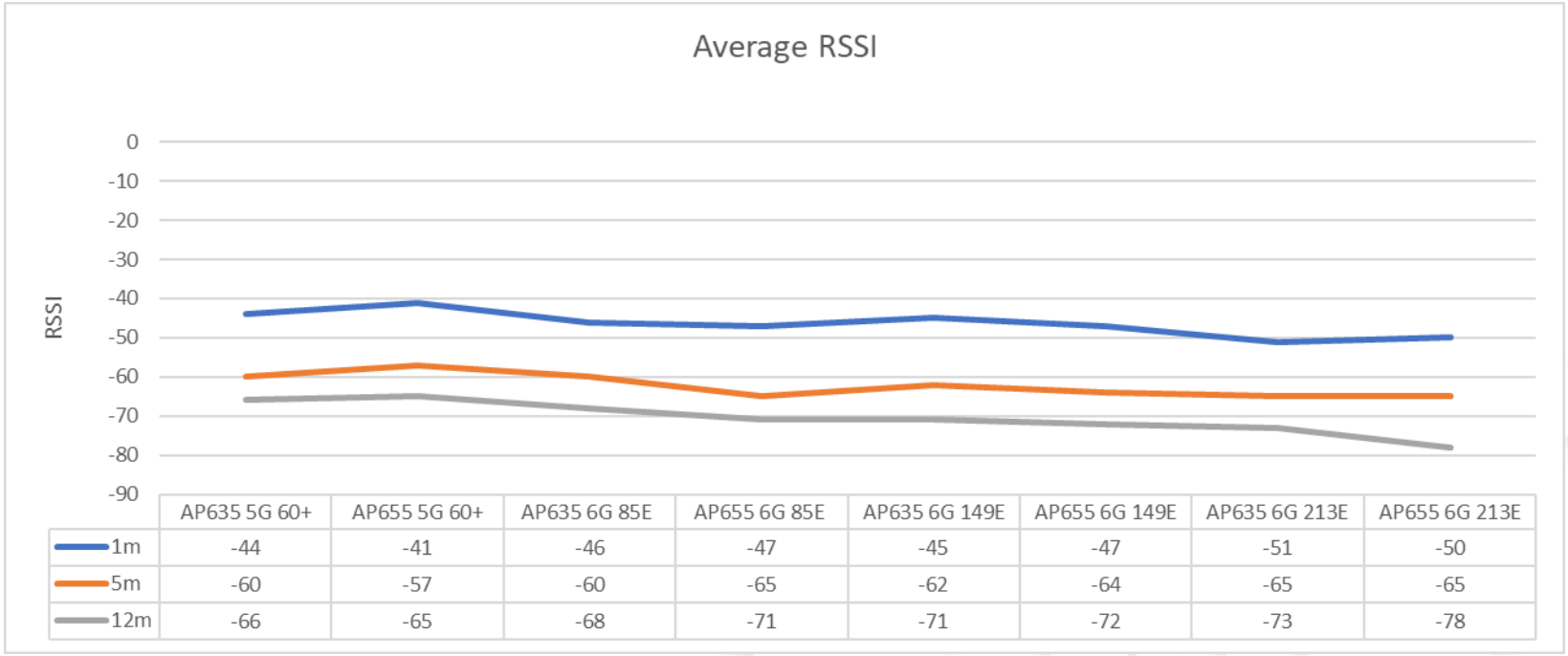
Overall Results

*Values are an average of all clients



Test Parameters

- 5 GHz
  - 60+ @ 18 dB
- 6 GHz
  - 85E @ 21 dB
  - 149E @ 21 dB
  - 213E @ 21 dB
- APs
  - AP-635
  - AP-655



	AP635 5G 60+	AP655 5G 60+	AP635 6G 85E	AP655 6G 85E	AP635 6G 149E	AP655 6G 149E	AP635 6G 213E	AP655 6G 213E
1m	-44	-41	-46	-47	-45	-47	-51	-50
5m	-60	-57	-60	-65	-62	-64	-65	-65
12m	-66	-65	-68	-71	-71	-72	-73	-78

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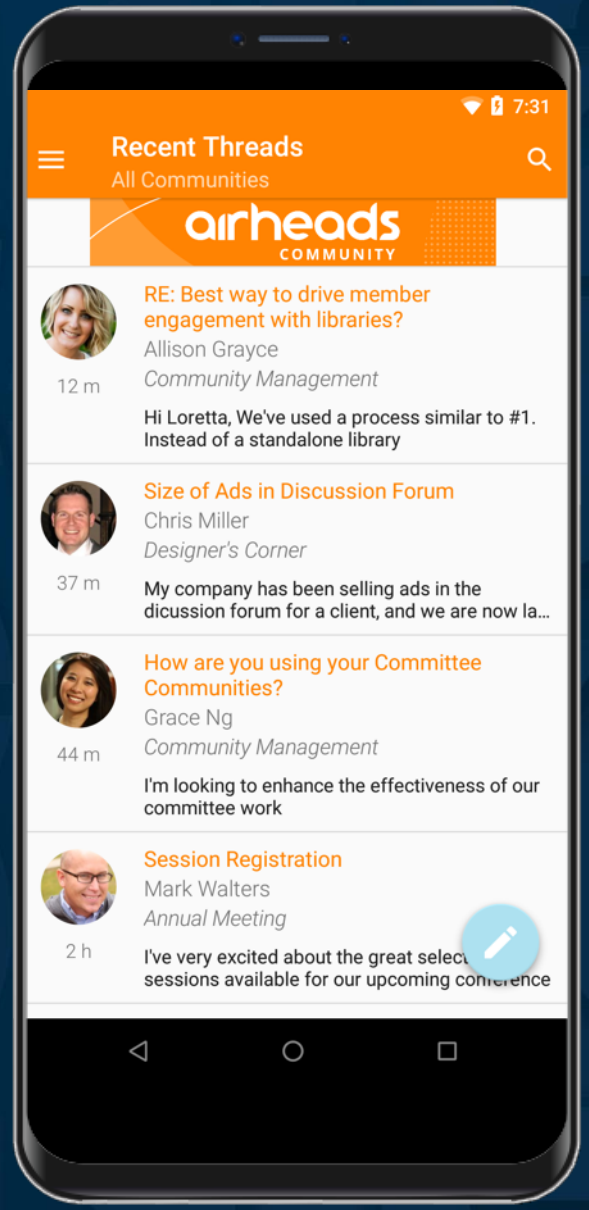

Thank you

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