Hewlett Packard Enterprise

HPE aruba networking

A New Era for 'Unlicensed Wi-Fi'
What we've learned for optimal deployments

Dobias van Ingen
EMEA CTO & Sr. SE Director

March 2023

#WiFiDesignDay
by Ekahau and Open Reality

Topics to discuss

WIFI 6E STATE OF THE NATION

DEVICES

DESIGN FUN

How Europeans connect to Internet

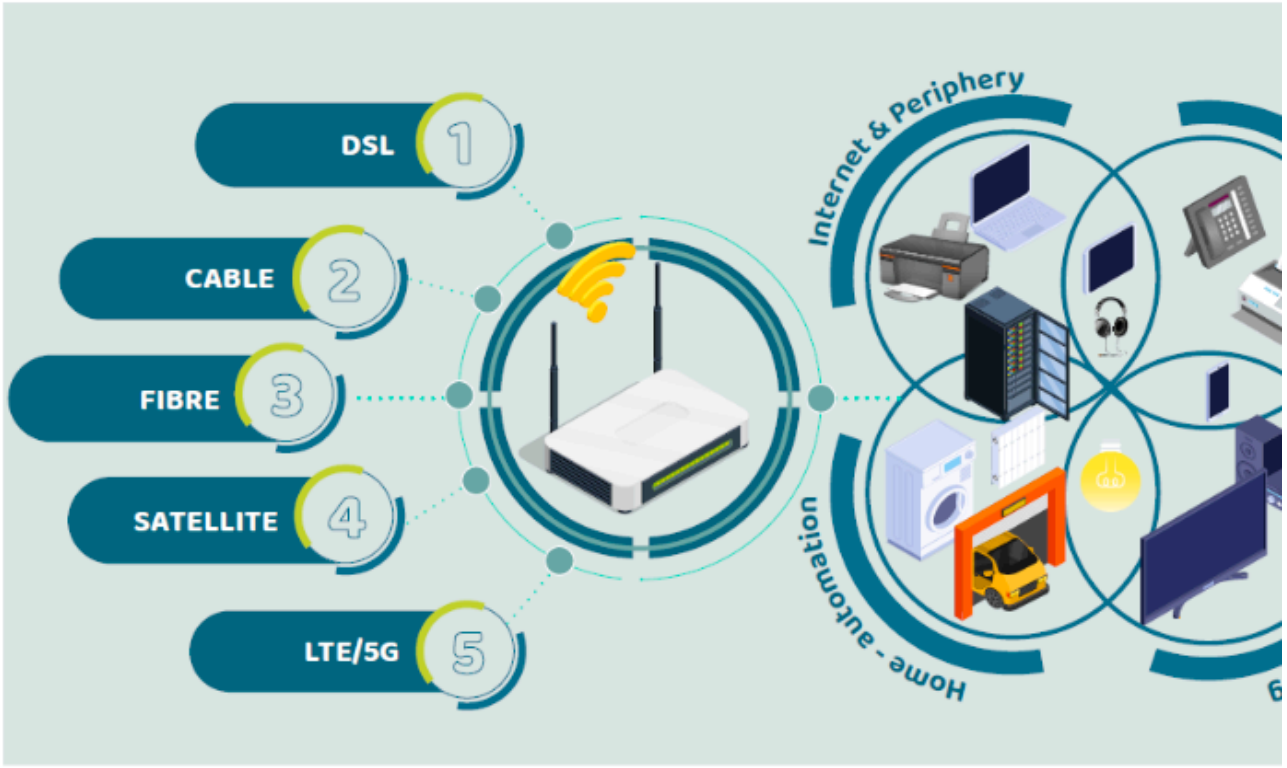
Broadband is brought to people's and companies' doorsteps through a variety of access technologies: DSL, cable, fiber, satellite, FWA (LTE/5G)

For bridging the last meters, however, the broadband connectivity technology of choice is Wi-Fi.

People spend ~90% of their time indoors, and 90% of work is done indoors.

More than 90% of data traffic originates or terminates indoors.

More than 90% of data traffic is transferred over Wi-Fi, and Wi-Fi traffic doubles every three years (ASSIA).



How most people connect to the internet (Source: DSA)

Outdoor broadband usage is typically for short periods and low bit rates (not considering FWA).

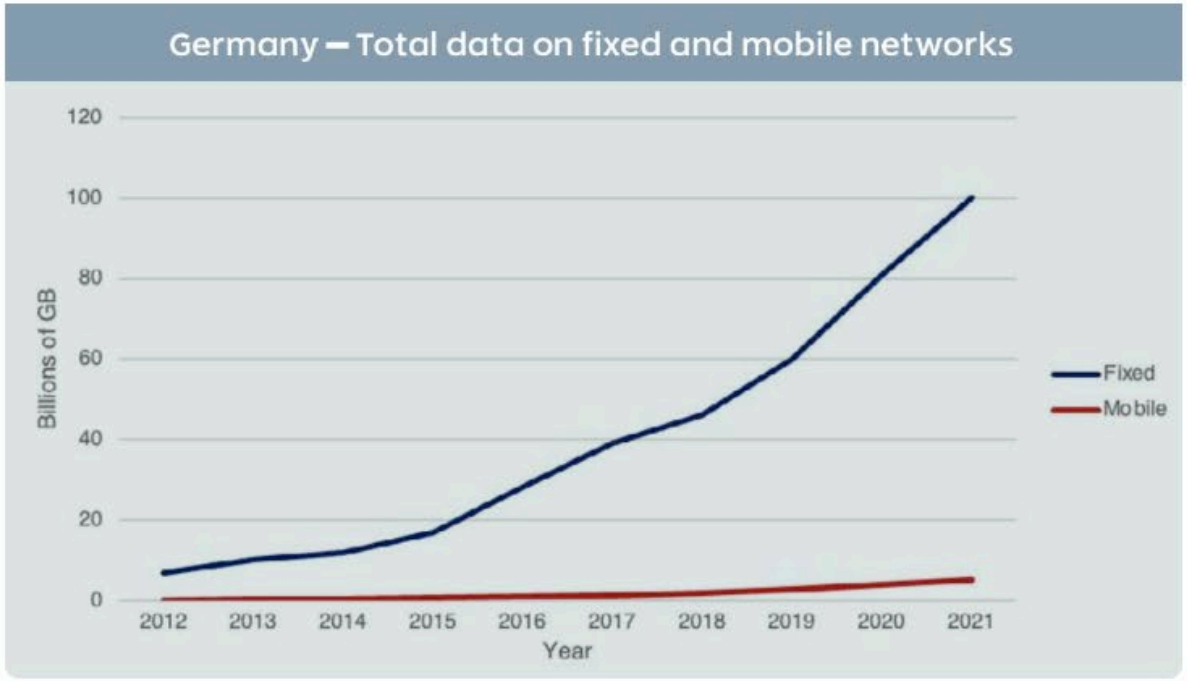
Fixed and Mobile traffic evolution

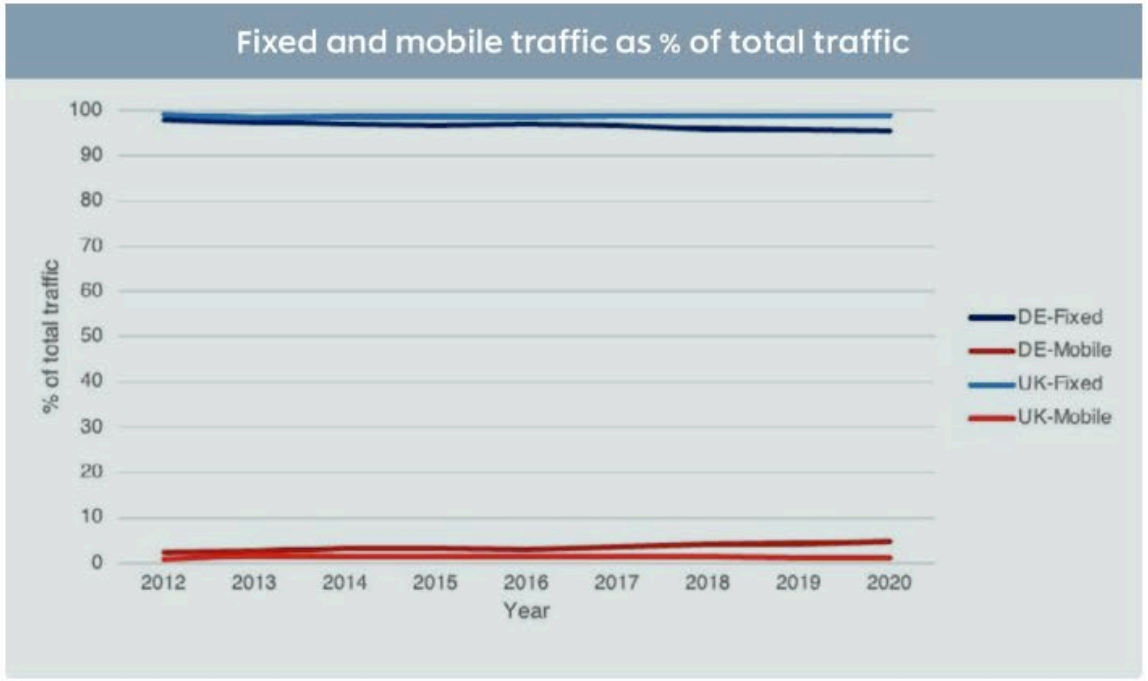
The vast majority of data traffic (>90%) in Europe is delivered over fixed networks.

Annual figures from German regulator BNetzA show a rapid increase in fixed data traffic.

Mobile traffic is growing too, but it remains a small fraction of fixed traffic.

Germany is not an isolated example. Data from other regulators, such as OFCOM UK, confirms the same trend.



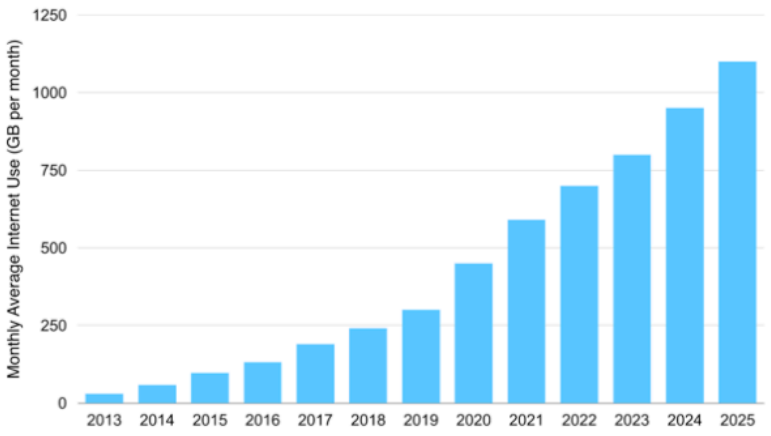


Source: DSA paper: How do Europeans connect to the Internet?

In developed markets, fixed lines carry 95% of the traffic

Fixed network traffic projections

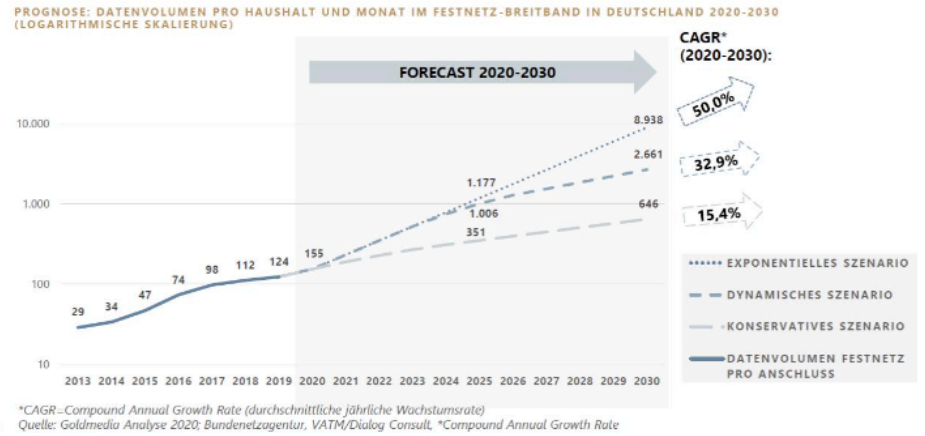
UK



Source: https://www.increasebroadbandspeed.co.uk/average-home-monthly-internet-usage-forecast

- Assumes 2020-2025 CAGR of 19.7%
- Resulting 2030 demand: 2704 GB/HH/month
- Actual CAGR (2011-2021): 38.9% (Ofcom)

Germany

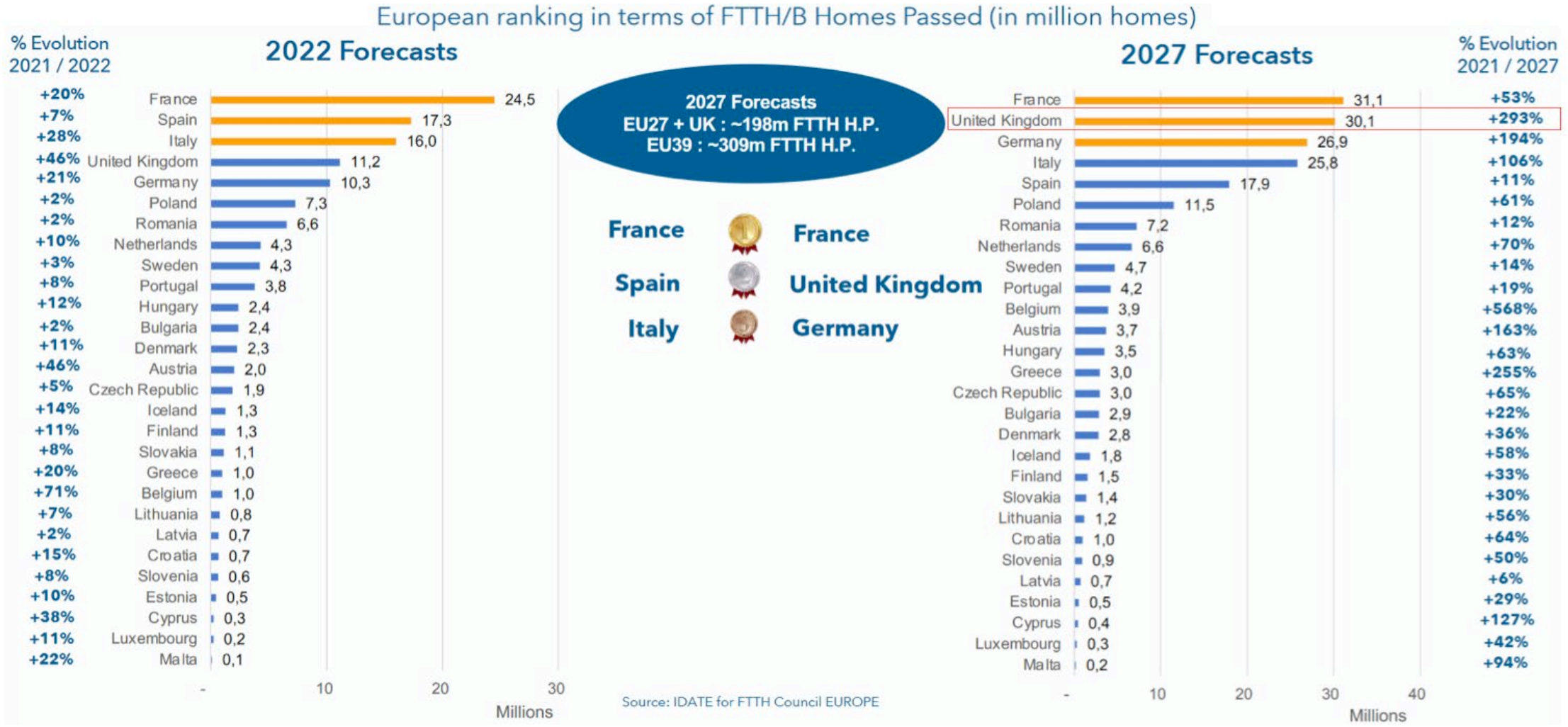


Source: Evolution-von-HFC-Netzen-Kurzstudie-Goldmedia-Vodafone-Institut.pdf

- Mid-scenario 2020-2025 CAGR: 32.9%
- Resulting 2030 demand: 2661 GB/HH/month
- Actual CAGR (2011-2021): 29.5% (BNetzA)

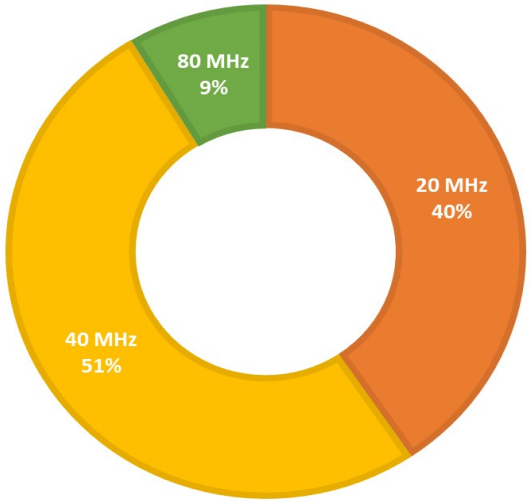
Project Gigabit in the UK

How will gigabit speeds be brought to UK consumers and businesses?



Why 6 GHz?
Explosion of Devices Limited to Sub-Gigabit Channels

CAPACITY LIMITS AND NARROW CHANNELS CONSTRAIN APPS



91%
NARROW CHANNELS
20 MHZ OR 40 MHZ

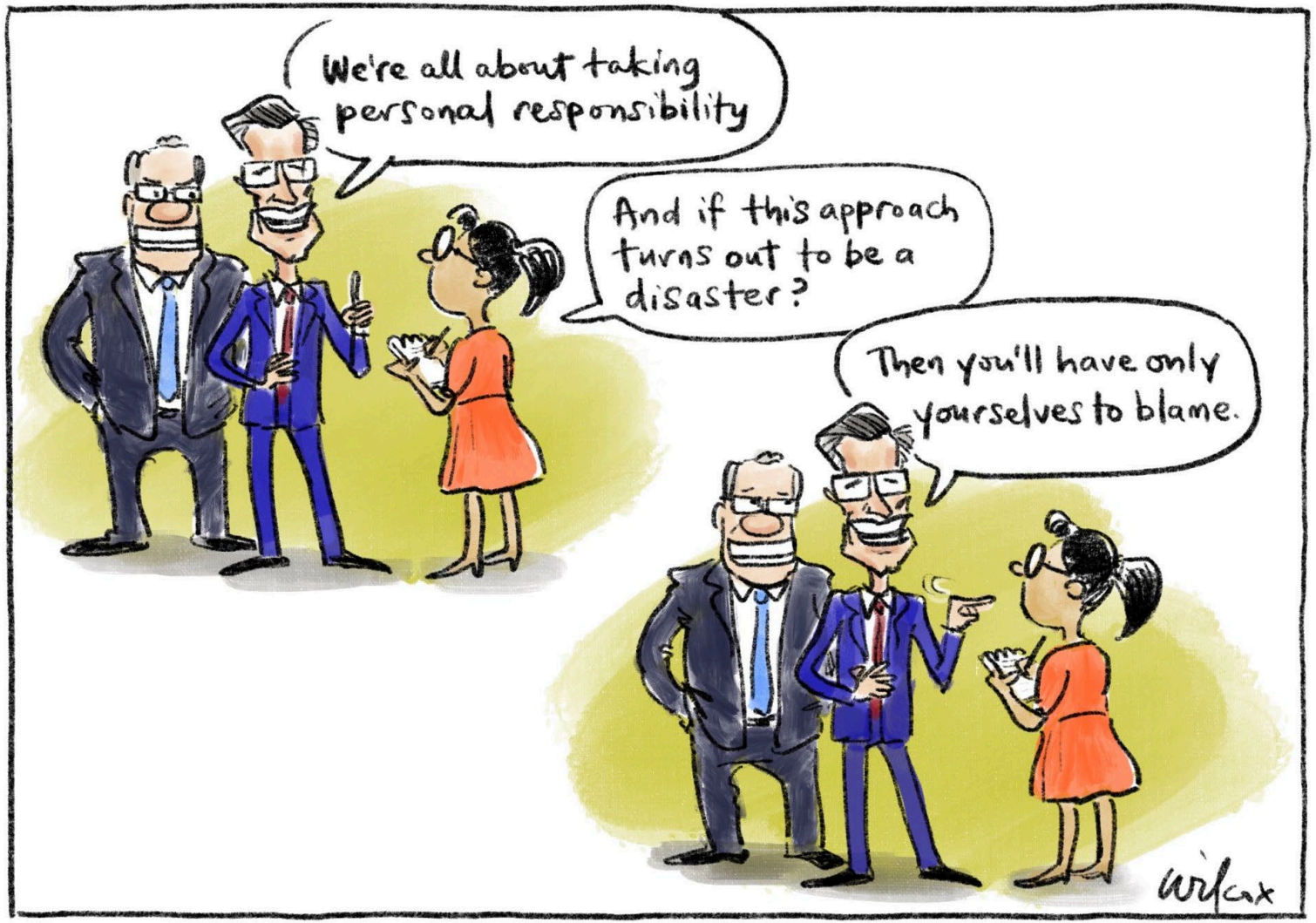
Source: HPE, customer study

DEVICE GROWTH AND LEGACY DEVICES SLOW DOWN NETWORKS

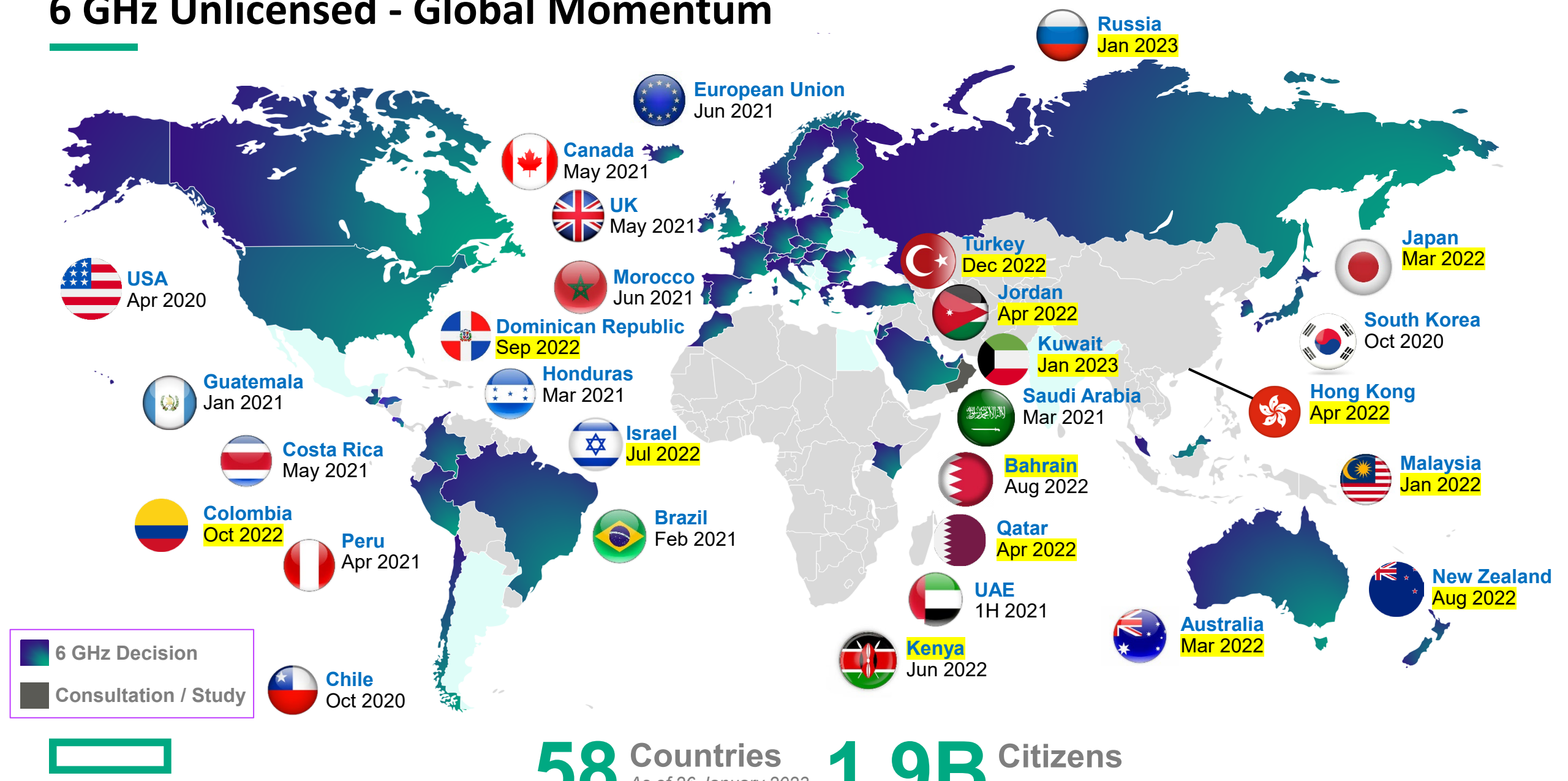
6.2B
CLIENT DEVICES
ALREADY IN USED IN 2021

Source: Gartner

….but

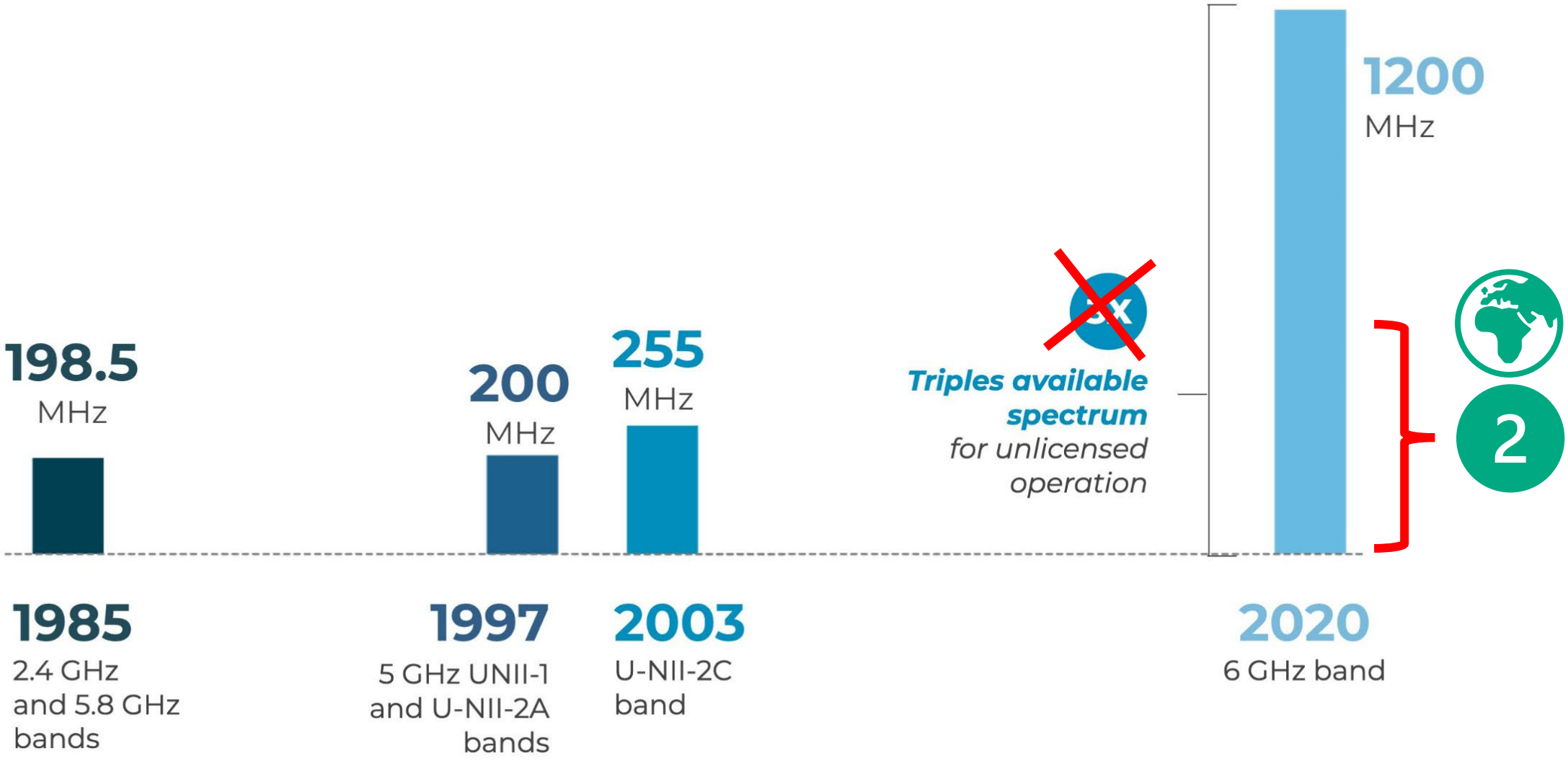

We're all about taking personal responsibility
And if this approach turns out to be a disaster?
Then you'll have only yourselves to blame.
wilcox

6 GHz Unlicensed - Global Momentum



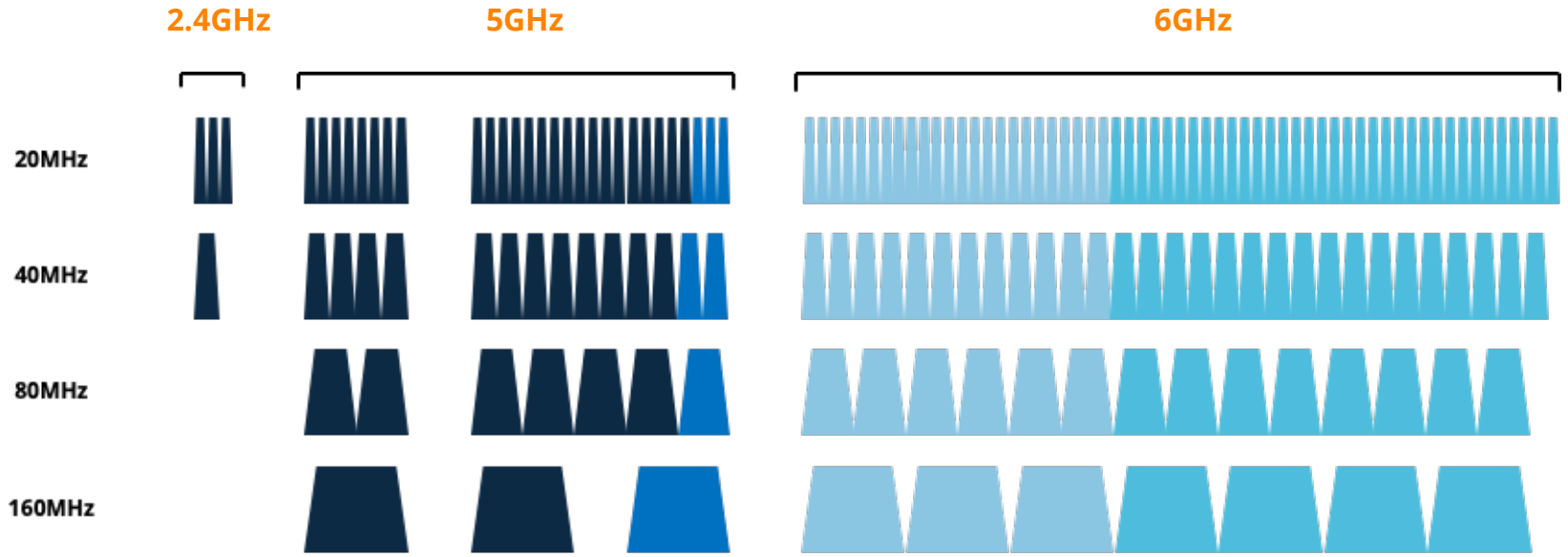
58 Countries *As of 26 January 2023* **1.9B** Citizens

The Largest Unlicensed Allocation in History Started With the FCC



Visualizing the Massive Capacity Increase

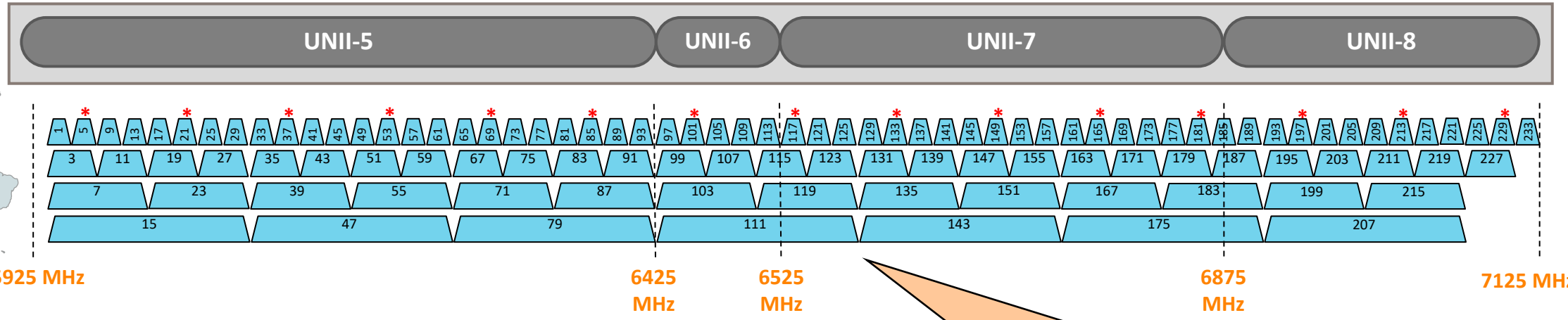
- More than 3x the existing amount of unlicensed spectrum depending on country
- Up to seven 160 MHz wide channels for higher performance and reduced airtime
- 6 GHz is a greenfield band for the Wi-Fi specification (no need for backwards compatibility with older versions)



What are the channels in Americas & Europe / CEPT

Countries adopting 500 MHz are limited to Sub-Gigabit Speeds

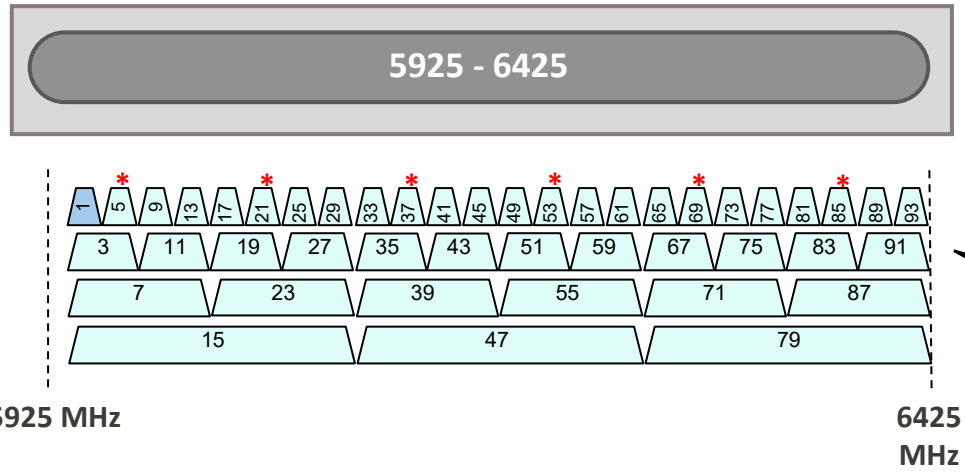
Americas Model



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

2x2 Client 160 MHz MCS 11 (1K QAM) = **2.4 Gbps**

European Model



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

2x2 Client 40 MHz MCS 11 (1K 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)*

A closer look to Europe / CEPT

But we should be happy!!!

5GHz +/- 500MHz spectrum but only 9 x 20MHz non-DFS channels

ETSI - EU

5925 - 6425 - Proposed 500 Megahertz

5935 — 6415

UNII-5

Qty	Radio Band / Center Freq	5.945	5.965	5.985	6.005	6.025	6.045	6.065	6.085	6.105	6.125	6.145	6.165	6.185	6.205	6.225	6.245	6.265	6.285	6.305	6.325	6.345	6.365	6.385	6.405	Qty
24	20 MHz	1	5	9	13	17	21	25	29	33	37	41	45	49	53	57	61	65	69	73	77	81	85	89	93	**24**
12	40 MHz	3		11		19		27		35		43		51		59		67		75		83		91		**12**
6	80 MHz	7				23				39				55				71				87				**6**
3	160 MHz	15								47								79								**3**

https://wlanprofessionals.com/updated-unlicensed-spectrum-charts/

Wi-Fi 6E = Wi-Fi 6 in the 6 GHz Band

New Features in 6 GHz

- Native Wi-Fi 6 Transmissions
  - High-Efficiency (HE) PHY/MAC structure
  - Native HE beacons
- Methods for In-Band AP Discovery
  - Multiple-BSSID Beacons
  - Active scans on preferred scanning channels
  - Fast Initial Link Setup (FILS) Discovery announcements [1]
  - Unsolicited Probe Responses [1]
- Security Enhancements
  - WPA3 Enterprise / Personal
  - Protected Management Frames (PMF)
  - Enhanced Open

Enhancements in 2.4 and 5 GHz

- Method for Out-of-Band AP Discovery
  - Reduced Neighbor Reports (RNR) on co-located 2.4 / 5 GHz radios advertise 6 GHz channel in beacon and probe response
- Potential Future Beacon Enhancements to 2.4 / 5 GHz
  - Multiple-BSSID Beacons [2]
- Security Enhancements
  - Expanded requirements for recent WFA standards

[1] In-band methods meant for discovery of APs operating in single radio scenarios
[2] May be implemented in the future

Maximum Power is regulated by EIRP and PSD

- Equivalent Isotropic Radiated Power (EIRP)
  - The maximum amount of power that is allowed to be radiated from an antenna (N EIRP)

- Power Spectral Density (PSD)
  - A measure of the amount of power within a given bandwidth (N dBm/MHz)
  - 10 dBm/MHz means 10 dBm per 1 MHz

HPE aruba networking

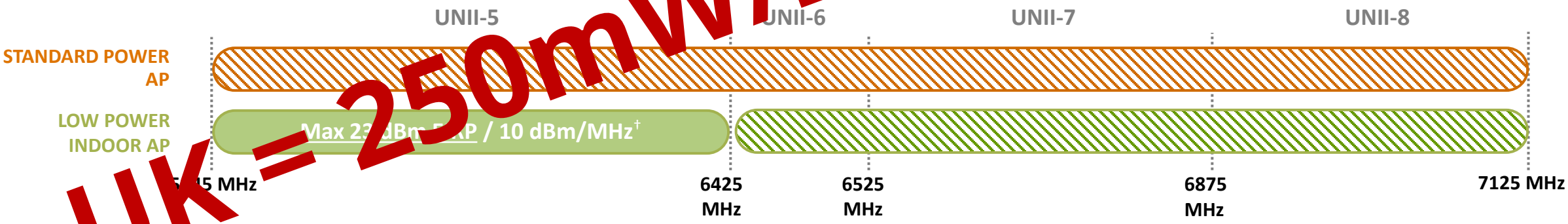
EIRP = Per-Chain Conducted Power + MIMO GAIN + Antenna Gain

The more restrictive limit applies first

6 GHz Rules in Europe/CEPT

- Low power indoor across the first 500 MHz (UNII-5)
  - 10 dBm/MHz PSD
  - **Max EIRP of 23 dBm for AP or client (200mW)**
- No Standard Power AP currently approved or planned
- No Low Power Indoor AP currently approved or planned for UNII-6/7/8

UK = 250mW/24dBm EIRP

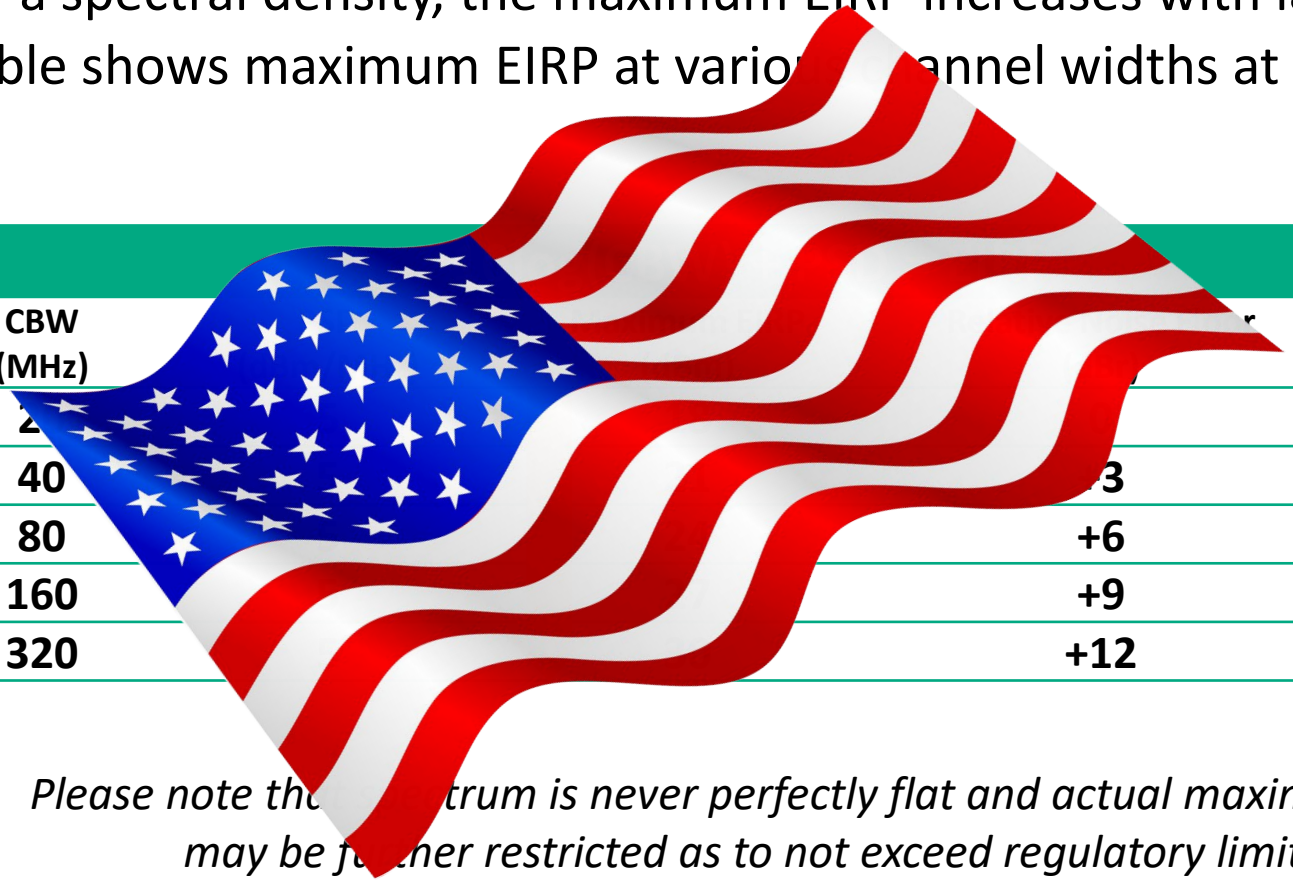


†PSD or EIRP limits in 6 GHz vary per regulatory domain – the most restrictive limit applies first

BUT WAIT…

Power Spectral Density

- When limited by a spectral density, the maximum EIRP increases with larger channel width
- The following table shows maximum EIRP at vario[illegible]annel widths at 5 dBm/MHz spectral density



CBW (MHz)	[illegible]	[illegible]	EIRP - NF (dBm)
2[illegible]			18
40		[illegible]3	18
80		+6	18
160		+9	18
320		+12	18

Please note th[illegible]trum is never perfectly flat and actual maximum EIRP may be f[illegible]ther restricted as to not exceed regulatory limits

Channel width is also not exactly 20 / 40 / 80 / 160 MHz

Power Spectral Density

- When limited by a spectral density, the maximum EIRP increases with larger channel width
- The following table shows maximum EIRP at various channel widths at 10 dBm/MHz spectral density

EIRP = PSD + 10log(CBW)					
CBW	PSD	Maximum EIRP	Relative Noise Floor	EIRP - NF	
160	10	23	+9	14	3
320	10	23	+12	11	1

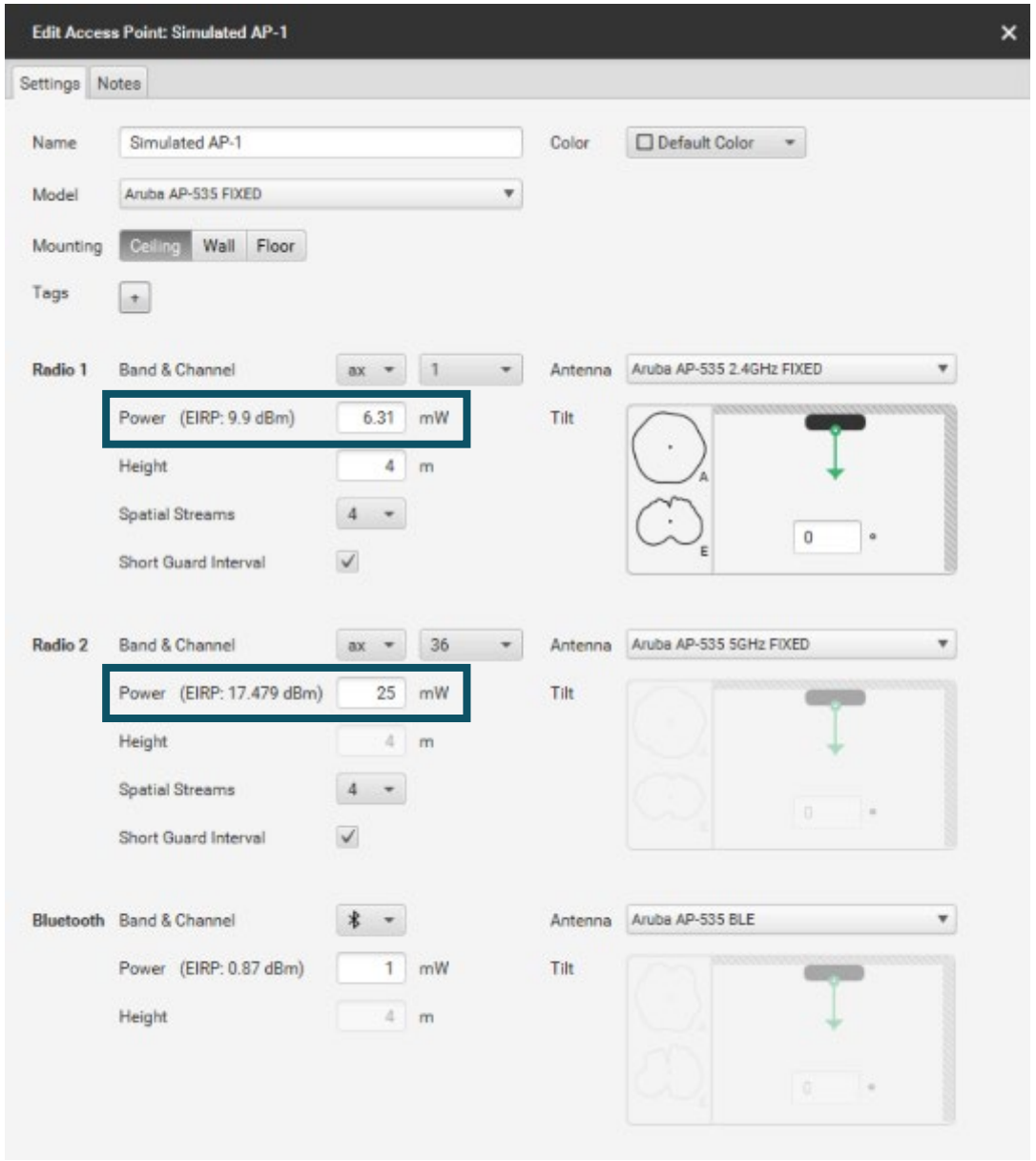
…Most WiFi designs are based on 18dBm

Please note that spectrum is never perfectly flat and actual maximum EIRP may be further restricted as to not exceed regulatory limits

Channel width is also not exactly 20 / 40 / 80 / 160 MHz

A note about Ekahau and other planning tools

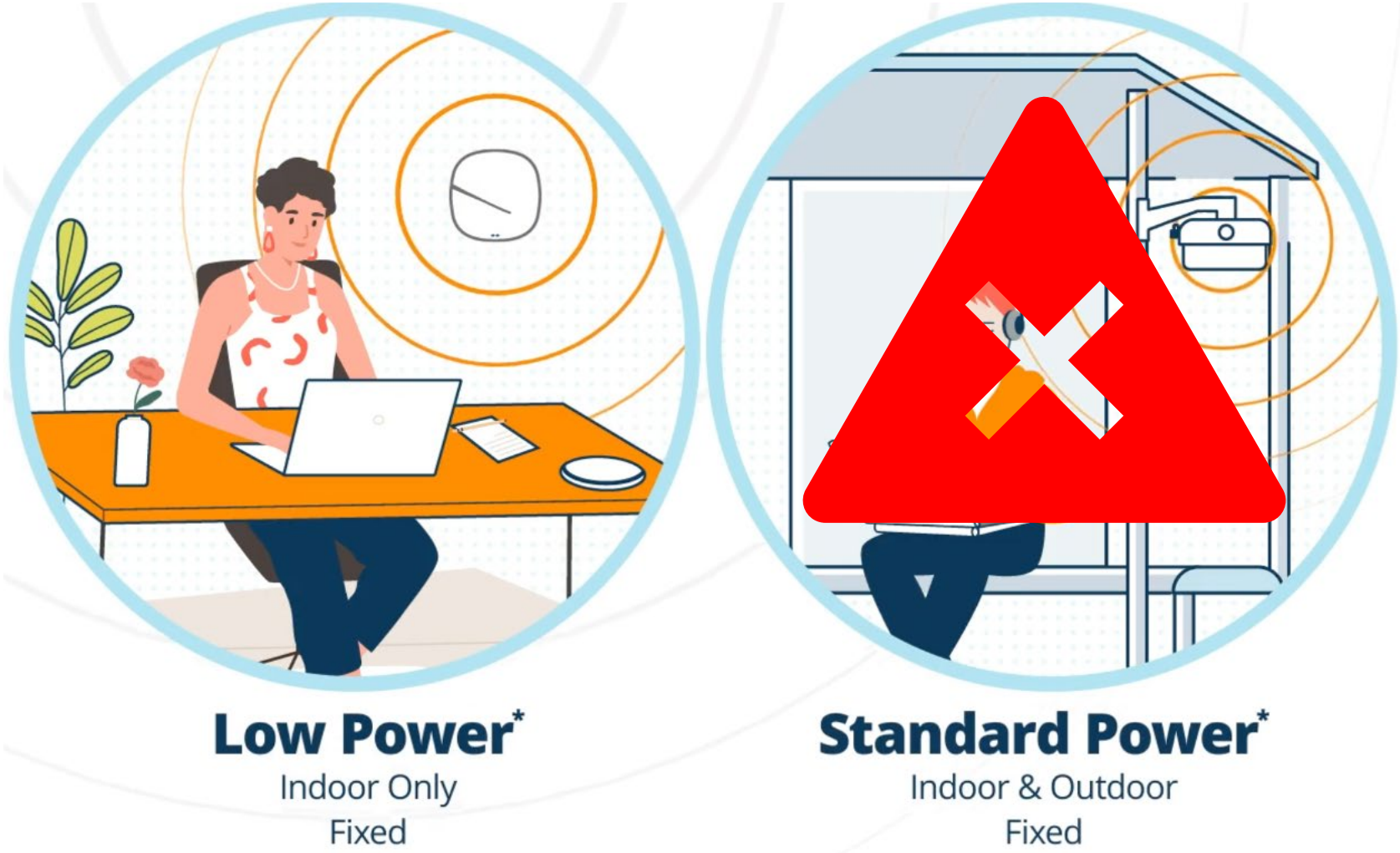
- Note if using Ekahau, Ekahau does NOT calculate AP EIRP like Aruba
  - Ekahau only takes conducted power + antenna gain for EIRP
- By default, Ekahau (on an example AP-535) will use 6.3mW conducted on 2.4Ghz and 25mW conducted on 5Ghz, regardless of AP model or MIMO streams supported
- In essence, Ekahau's EIRP value is off in dBm in the amount of the MIMO gain provided by the outdoor AP, and is (to some degree) 'under-representing' the coverage the AP will provide on it's configured settings
- Indoor AP antenna gain, expecting full reflections, includes the MIMO gain in the antenna pattern values
- To accommodate for this discrepancy, in translating the plan to deployment, you can either
  - Include the MIMO differences as part of the client offset for outdoor APs
  - Define the 'Aruba EIRP' levels ahead of time and then configure the planned APs in Ekahau with the correct conducted power to properly reflect the actual Aruba EIRP



Wi-Fi 6E

Device Classes and Rules of Operation

Device Classes for Operation in 6 GHz

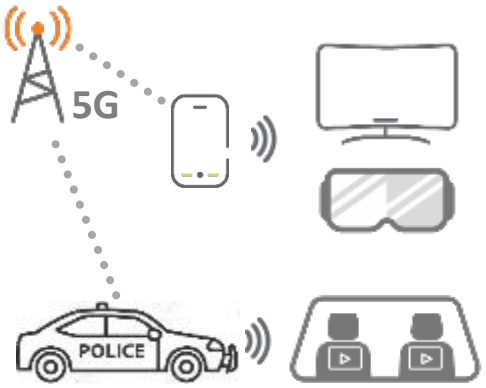


Device Classes in 6 GHz

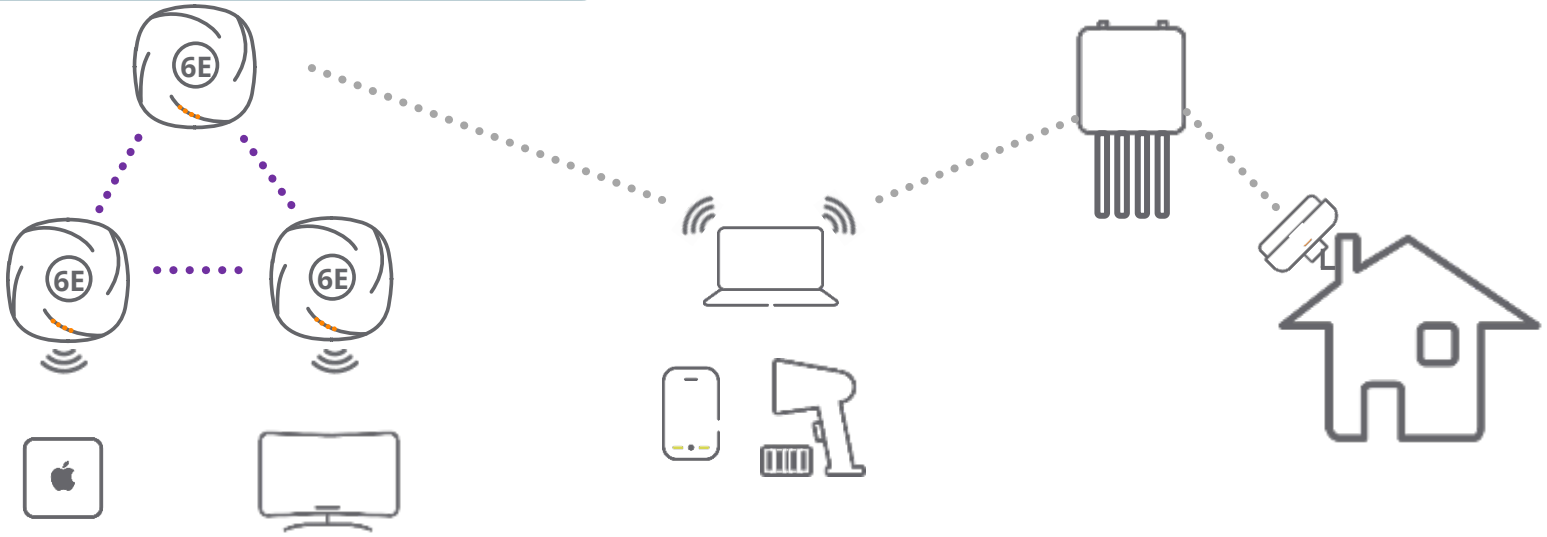
Low Power Indoor (LPI) AP
- Fixed indoor only
- No antenna connectors
- No weatherproofing
- Not battery powered
- Labeled for Indoor Use Only

Standard Pow P) AP
- Fixed ind tdoor
- Control by AF database
- Autor geo ion
- Poin ion

Very Low Power (VLP) AP
- Mobile indoor / outdoor
- 14 dBm EIRP



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



Subordinate Indoor Device
- Same rules as LPI AP, ***plus***:
- Under AP control
- No direct Internet connection

Mobile Client
- Indoor / outdoor
- 23dBm max EIRP

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

6 GHz Device Classes Work Together

	Standard Power	Low Power Indoor	Very Low Power
	> LPI power or antennas indoors; > VLP power outdoors	(EIRP between VLP & AFC; no antennas)	(EIRP <= 14 dBm, integrated antennas, indoor/outdoor)
Residential & Consumer	n/a	– Work from home – Internet streaming & gaming – Wi-Fi calling (WFC) – Indoor mesh	– A/R & V/R streaming & gaming – Home audio & IoT
Medium & Large Business	– Outdoor security cameras – Roaming between buildings	– All wireless office – Unified communications – Indoor mesh	– Conference room display – 5G mobile hotspot Wi-Fi
Universities & Schools	– Temporary classroom backhaul – Roaming between buildings – Emergency call boxes	– Teaching & examinations – Study & homework – Residential dormitories	– Student peer-to-peer apps – Lecture hall screen displays
Retail & Logistics	– Warehouses & loading docks – Railyards & port terminals	– Mobile registers & inventory – Product demos – Guest Wi-Fi for shopping & WFC	– Electronic shelf labels – Wayfinding
Stadiums & Arenas	– Seating coverage – Ticketing, plazas & garages	– Concourses & skyboxes – Team training – Press & video replay/streaming	– 5G driven A/R

Client Devices

Wi-Fi 6E Security Requirements

New security requirements

- WPA3-Personal or WPA3-Enterprise
  - WPA3-Enterprise with 192-bit cryptographic strength is optional
- Protected Management Frames (PMF)
- Enhanced Open (OWE)

Not allowed and not supported in 6 GHz

- WEP, TKIP, or WPA
- Open Authentication
- WPA2-Personal or WPA2-Enterprise
- Transition Mode for WPA3-Personal or WPA3-Enterprise
- Transition Mode for Enhanced Open

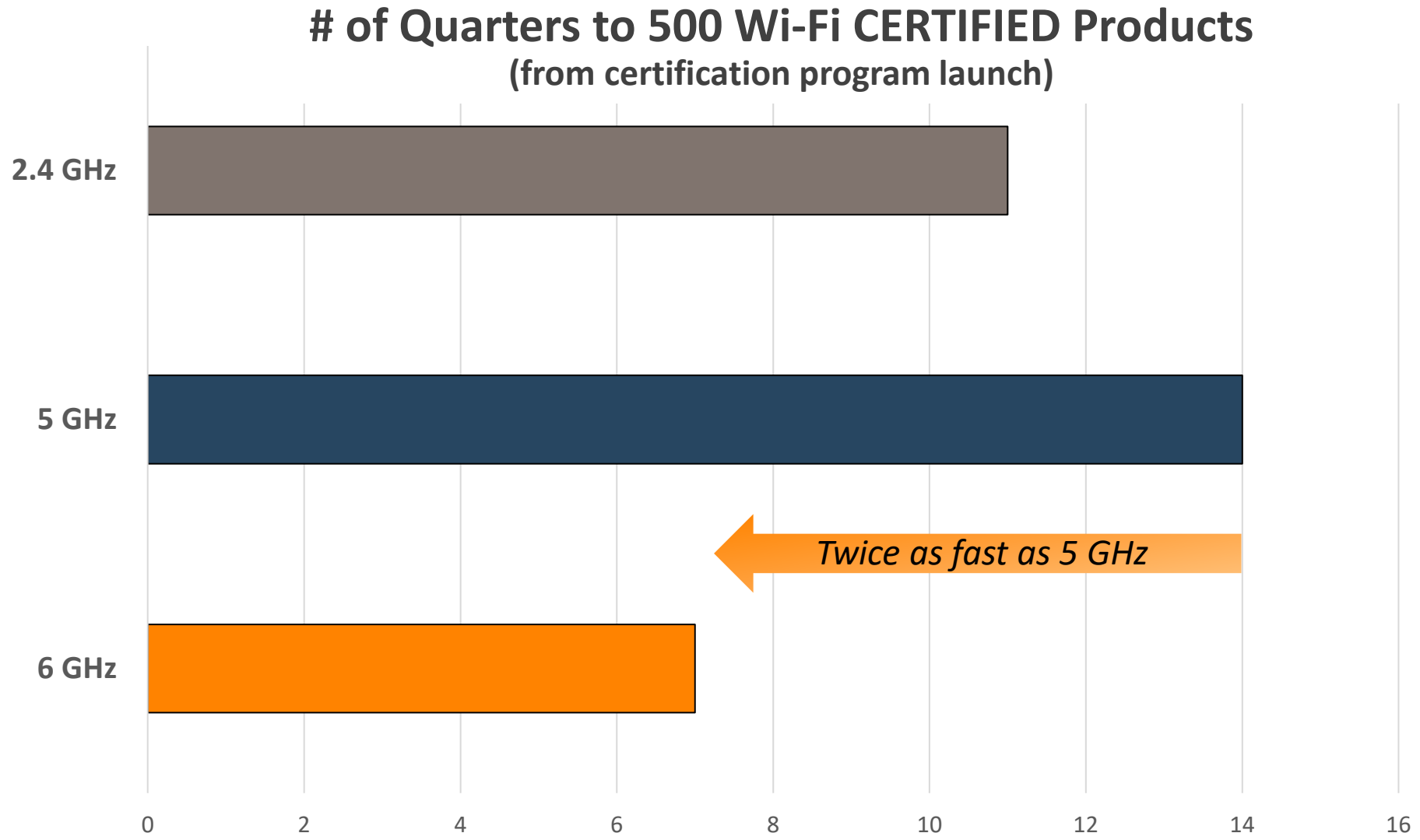
Why is this interesting?

New security requirements force administrators to think about SSID planning when adding 6 GHz to existing VAPs

Wi-Fi 6E

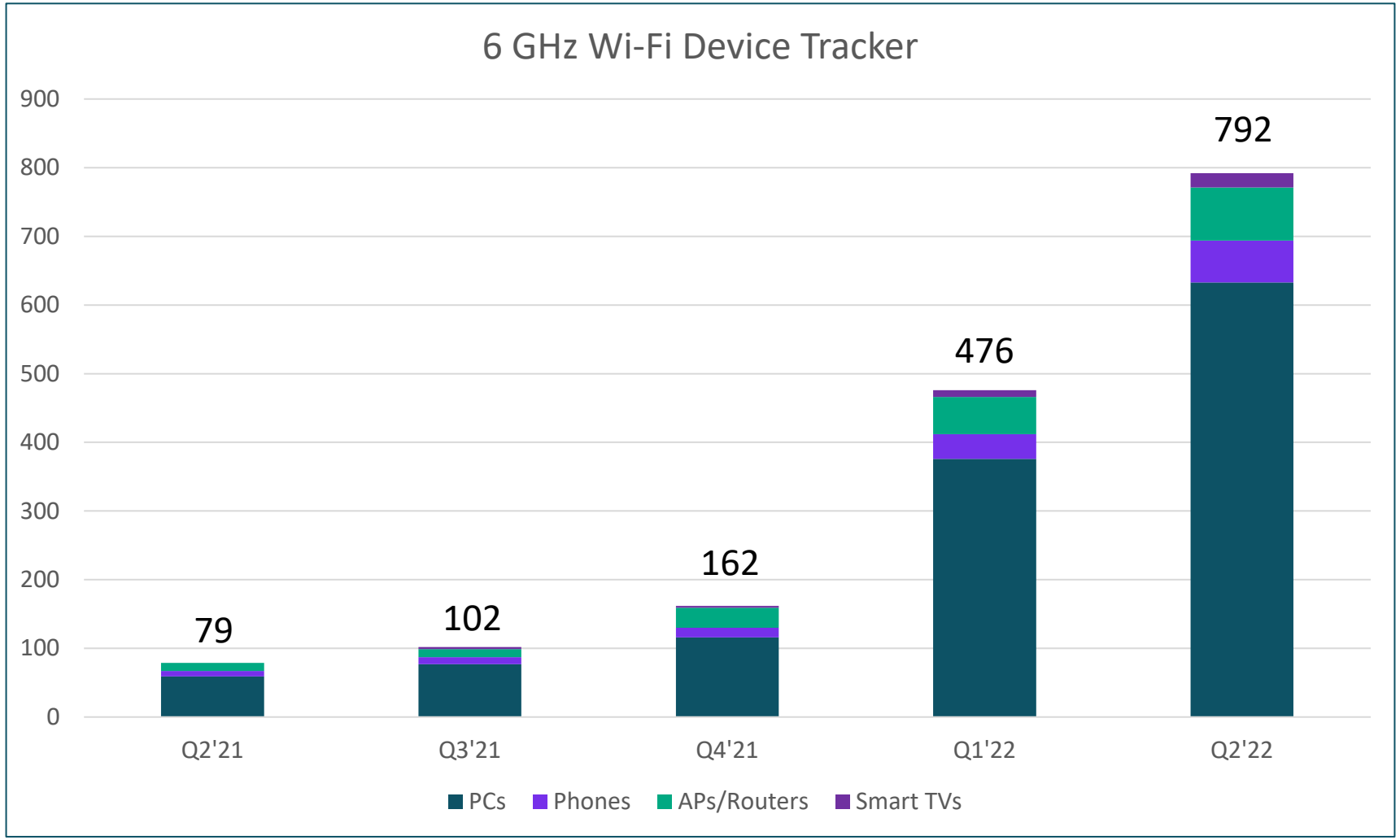
Clients

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.

Sample Devices Supporting Wi-Fi 6E

Various Chipsets:

- Broadcom
- Intel
- LG
- MediaTek
- ON Semi
- Qualcomm
- Rekong

Samsung Galaxy Book Pro 360

Windows 11

Laptops include Dell; HP; Lenovo; MSI; Razer ++

Zebra TC58

Amazon Fire TV Cube (3rd Generation)

Galaxy S21 Ultra; S22; Z Fold 3; Flip/Fold 4; Tab (S8, S8+, S8 Ultra)

Xiaomi Mi 11 Ultra; 12; 12 Pro

Motorola Edge (2021, 2022)

Google Pixel 6; 6a; 6 Pro; 7; 7 Pro

USB Dongles

….. and finaly

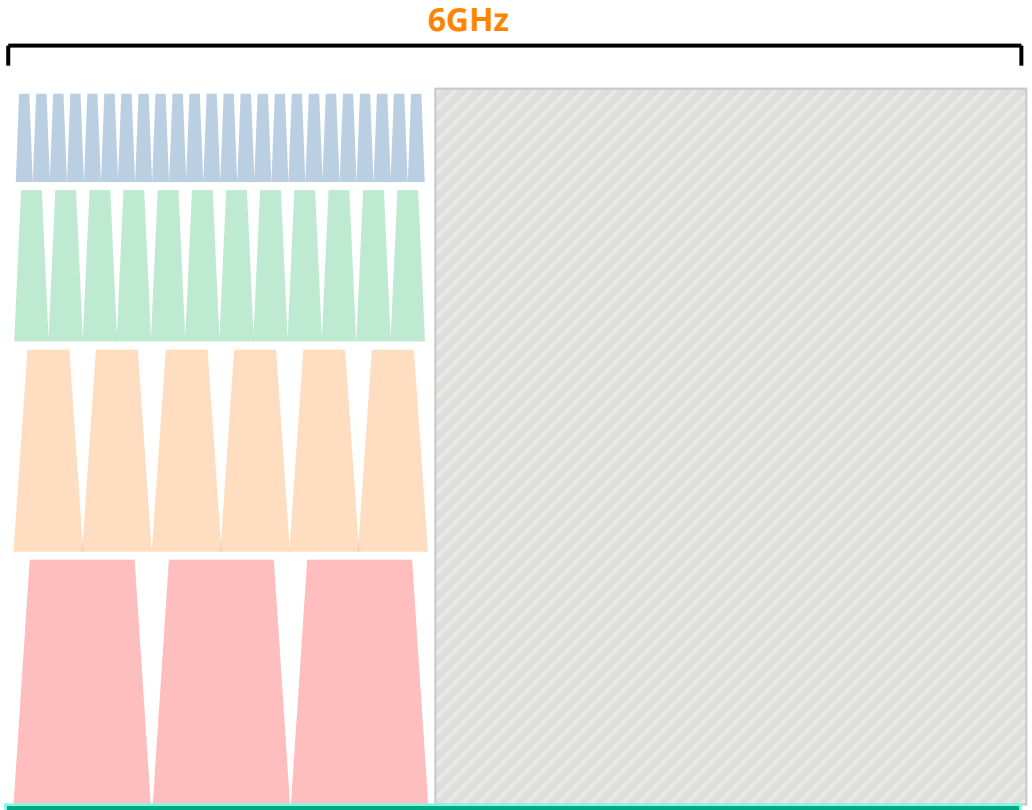
- MacBook Pro (14-inch, 2023) or MacBook Pro (16-inch, 2023)
- Mac mini (2023)
- iPad Pro 11-inch (4th generation) or iPad Pro 12.9 inch (6th generation)

https://support.apple.com/en-us/HT213433

WiFi 6E
Design FUN

What Does All This New Spectrum "MEAN" for LPI? (Focus: EU)

- **20Mhz – 24 Channels @ 286Mbps = 6.86Gbps**
  - PSD forces lower EIRP with less noise
  - Lots of channels to work with
  - Lots of opportunity for re-use
- **40Mhz – 12 Channels @ 573Mbps = 6.87Gbps**
  - Wider channel offers +3dBm EIRP
  - Fewer channels, but similar in ratio to 20Mhz in 5Ghz
- **80Mhz – 6 Channels @ 1.2Gbps = 7.2Gbps**
  - Wider channels offer more throughput
  - Faster consumption of airtime requires lower re-use
  - Use smaller RF domains if desired
- **160Mhz – 3 Channels @ 2.4Gbps = 7.2Gbps**
  - Ultra-wide, ultra-fast, re-use at severe risk
  - Not advised unless RF domains are small and separation distances are minimal



EIRP = PSD + 10log(CBW)

CBW (MHz)	PSD (dBm/MHz)	Maximum EIRP (dBm)	Relative Noise Floor (dBr)	EIRP - NF (dBm)	#Channels
20	10	23	0	23	24
40	10	23	+3	20	12
80	10	23	+6	17	6
160	10	23	+9	14	3
320	10	23	+12	11	1

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 the data sheets
- Enabling Aruba Intelligent Power Management (IPM) allows customization of power usage when access switch does not provide full power to the AP

Throughput

- Aggregate data throughput on a tri-band tri-radio AP can exceed 1 Gbps and reach up to 2-4 Gbps depending on the configuration and model
- Access switch port rate should be considered to maintain high speeds through the WLAN

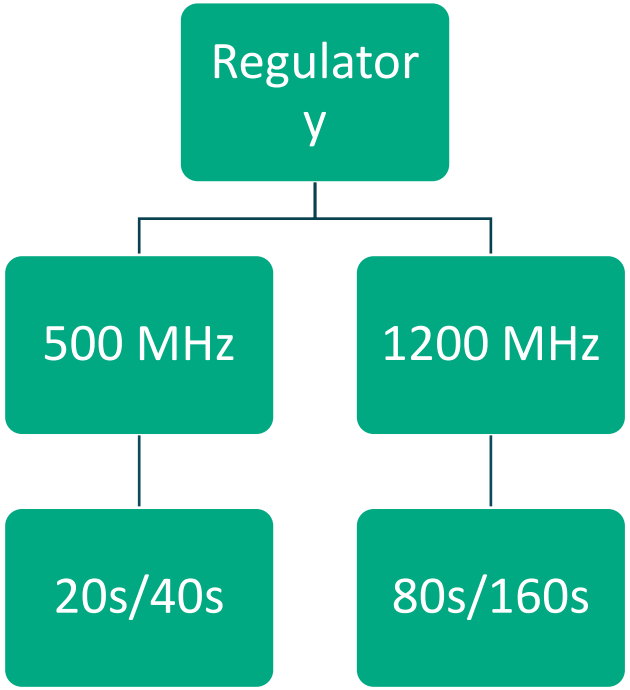
Redundancy

- Wireless as the primary connection medium is becoming the norm, not the exception, in the industry
- Consider options which factor resiliency considering both wireless layout and wired connections

Indoor Enterprise (LPI) 6 GHz RF Planning
Channel Width

- Available additional spectrum for Wi-Fi in 6 GHz varies by country and regulator
- Consider channel widths based on available spectrum
- Wider channels offer many benefits
  - More RUs = Greater simultaneous clients with OFDMA
  - Higher aggregate throughput
  - Higher effective EIRP in 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**



Indoor Enterprise (LPI) 6 GHz RF Planning

To begin Wi-Fi 6E does not fix poor planning or lack of a design

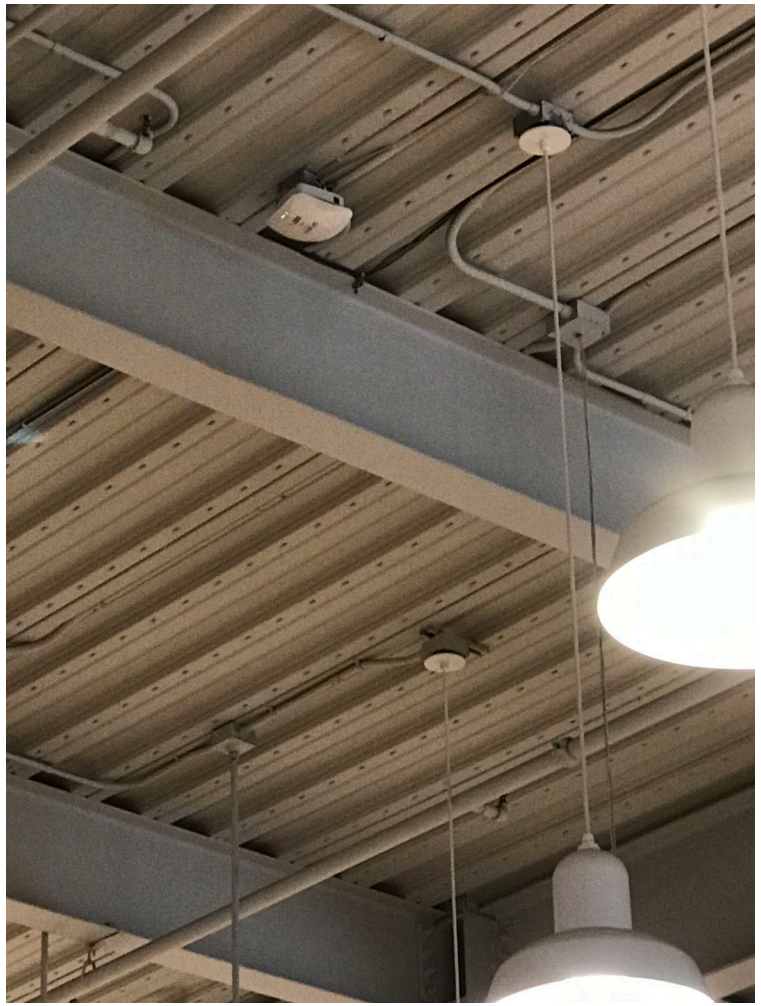
For brownfield upgrades, evaluate the existing RF design and EIRP levels before 1:1 swap.

Q: Current design *coverage* based? Using high power? Lack of 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

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

- With same EIRP, the 6 GHz “cell” size should be similar to 5 GHz due for typical indoor environments
  - Americas model (full 1200 MHz) assume -2 to -3 dB
  - **European model (lower 500 MHz) assume -1 to -2 dB**
- Existing AP placements *may* be a candidate for 1:1



Indoor Enterprise (LPI) 6 GHz RF Planning
AP Density

- The LPI device class supports the required power levels to add 6 GHz to the typical high-capacity indoor enterprise deployment
  - Typical: 5 GHz radio with a configured max EIRP between 15 and 20 dBm
- Brownfield
  - 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 ban… …ments

Initial Recommendations

–Deployments with EIRP > 20 dBm

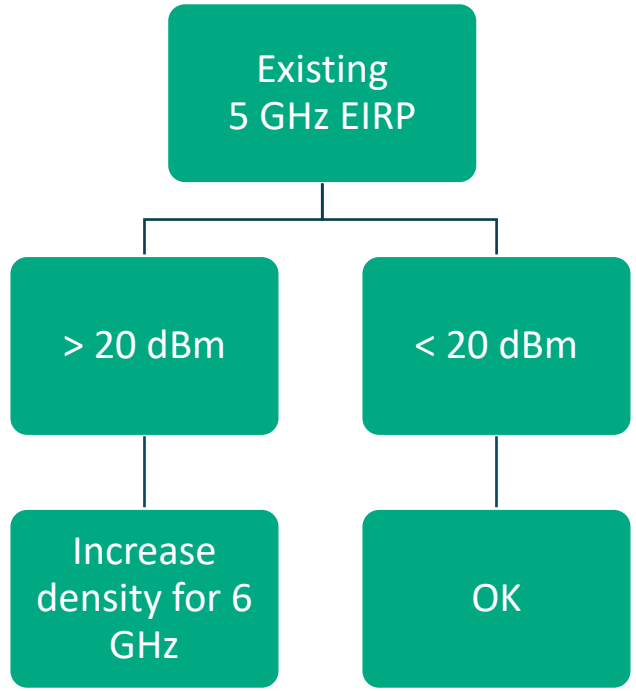
–Example: 5 GHz coverage only based deployment

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

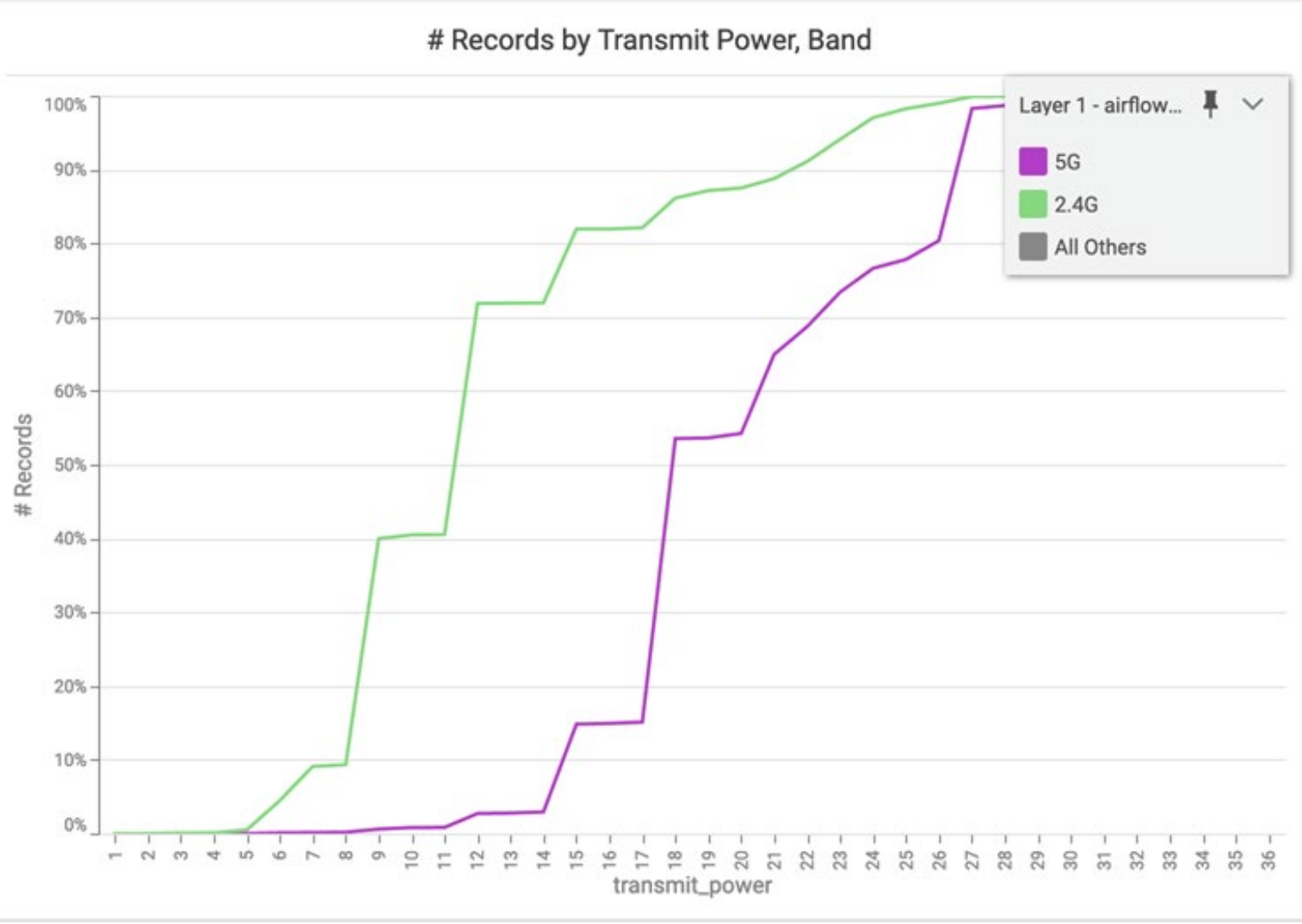
–Deployments with EIRP < 20 dBm

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

–OK for 6 GHz

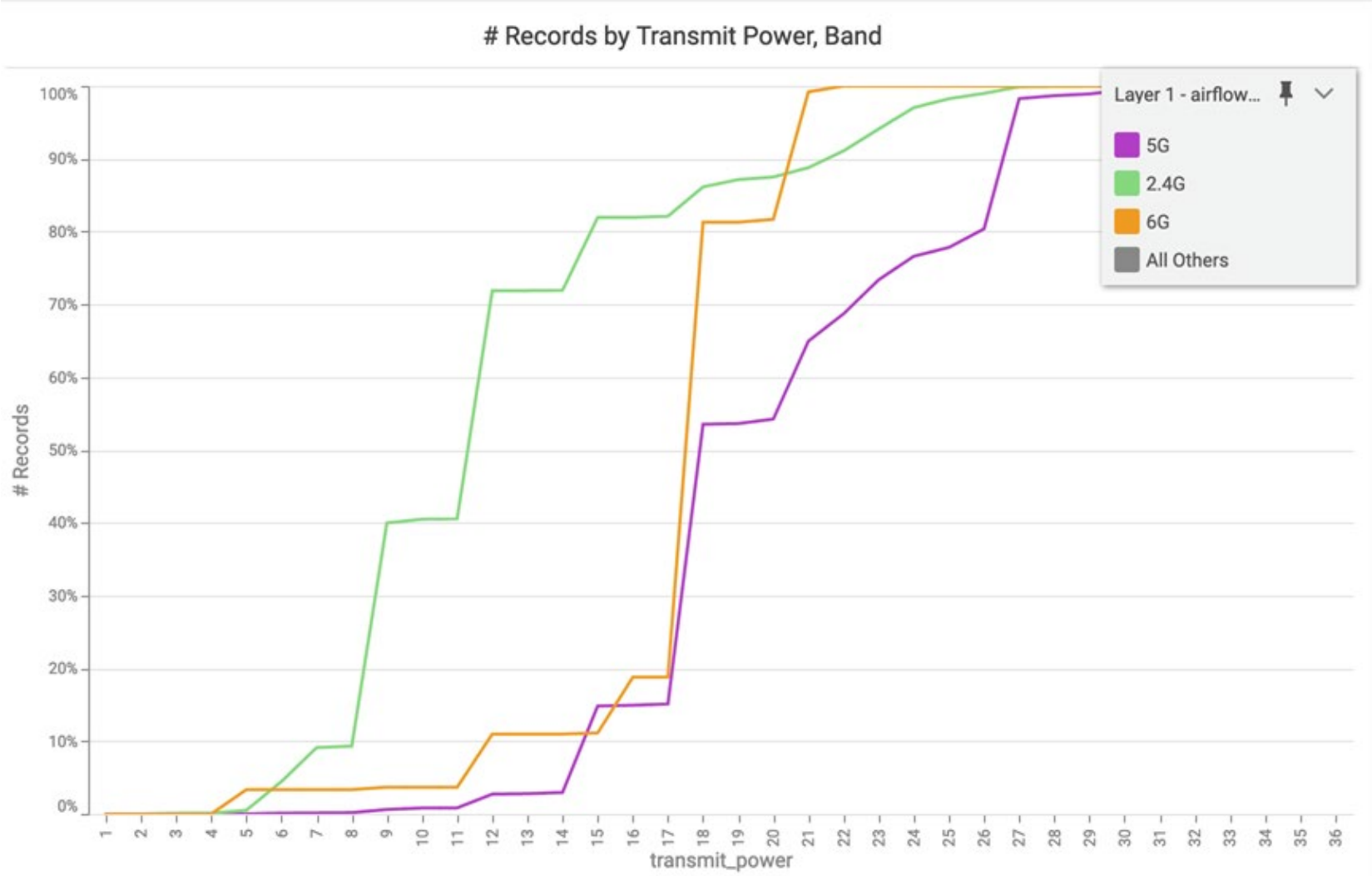


EIRP within Aruba Central



- Histogram showing EIRP across Aruba central devices
- 2.4 / 5 GHz data is based on a ~2M sized dataset

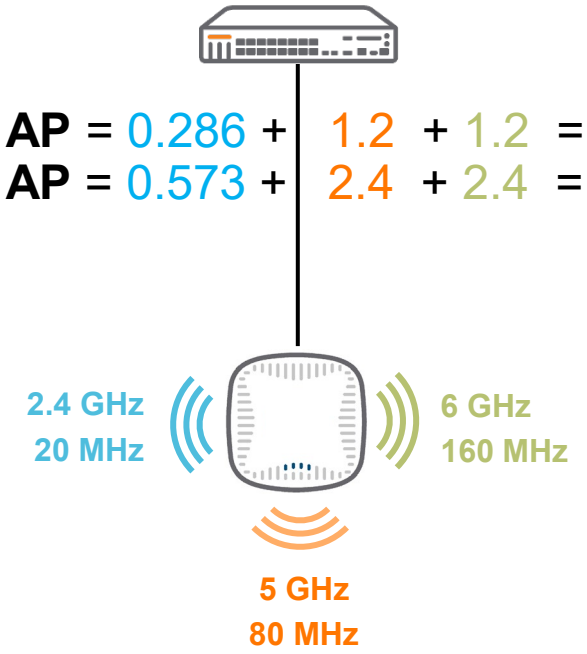
EIRP within Aruba Central



- Histogram showing EIRP across central devices
- 2.4 / 5 GHz data is based on a ~2M sized dataset
- 6 GHz portion is obviously much smaller in terms of dataset

Dimensioning the Edge for Wi-Fi 6E

Speeds and feeds



		80 MHz		160 MHz
2x2 AP = 0.286 +	1.2	+ 1.2	= **2.6 Gbps**	= **3.9 Gbps**
4x4 AP = 0.573 +	2.4	+ 2.4	= **5.3 Gbps**	= **7.8 Gbps**

Spatial Streams	20 MHz
1SS	143 Mbps
2SS	**286 Mbps**
3SS	430 Mbps
4SS	**573 Mbps**

Spatial Streams	40 MHz	80 MHz
1SS	286 Mbps	600 Mbps
2SS	**573 Mbps**	**1.2 Gbps**
3SS	860 Mbps	1.8 Gbps
4SS	**1.14 Gbps**	**2.4 Gbps**

Spatial Streams	80 MHz	160 MHz
1SS	600 Mbps	1.2 Gbps
2SS	**1.2 Gbps**	**2.4 Gbps**
3SS	1.8 Gbps	3.6 Gbps
4SS	**2.4 Gbps**	**4.8 Gbps**

Enterprise Access Layer Considerations for 6E

Network access layer

- Multi-gigabit switches which support Smart Rate 1/2.5/5 GbE and Class 6 PoE for connected APs

Power over Ethernet

- 2x2 tri-band/tri-radio will fit in a Class 4 PoE budget (with IPM enabled)
- 4x4 tri-band/tri-radio will request Class 6 budget or operate with reduced functions with IPM enabled

Cabling plant

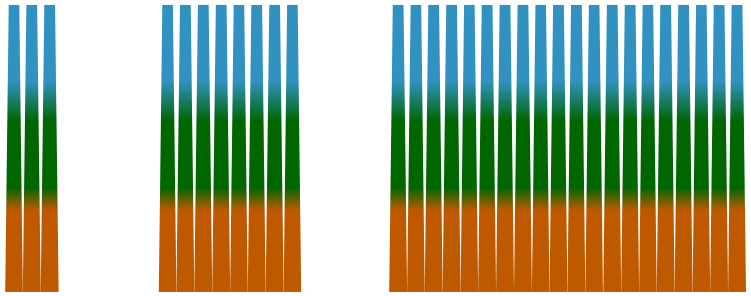
- Plan for a cable technology which minimally supports 2.5 Gbps and 60W over copper
- Cat 6 or better recommended.

6 GHz Offers Wireless Architects Unprecedented Options

Example – Redeployment of SSIDs between bands to optimize experience

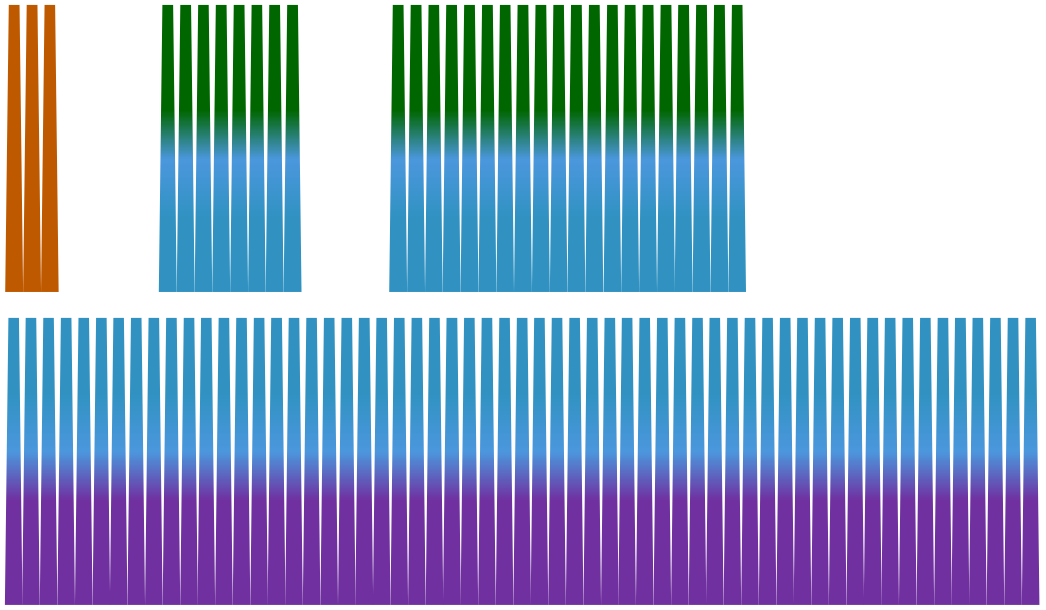
Conventional Dual-band SSID

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



Tri-Band 6E SSID Strategy

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



- Dual-Band ends up with 2-3 SSIDs across all bands
- ***Tri-Radio allows the network to design for 6Ghz as the next high-performance zone, with 5Ghz as the general access, and leverage 2.4Ghz for IoT/IIoT***

Wi-Fi 6E SSID Planning
Security Modes Available in 6 GHz

WPA3, transition mode is there but it's inefficient

- **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 paired with MFP
- **WPA3-Enterprise (operation in 6 GHz)**
  - New key management (SHA-256); CCMP-128 ciphers; MFP required
- **WPA3-Enterprise with 256 bits**
  - New key management (SHA-256); GCMP-256 ciphers; MFP required
- **WPA3-Enterprise with CNSA SuiteB**
  - New key management (SHA-384); GCMP-256 ciphers; MFP required; strong EAP-TLS methods only (no mix and match)

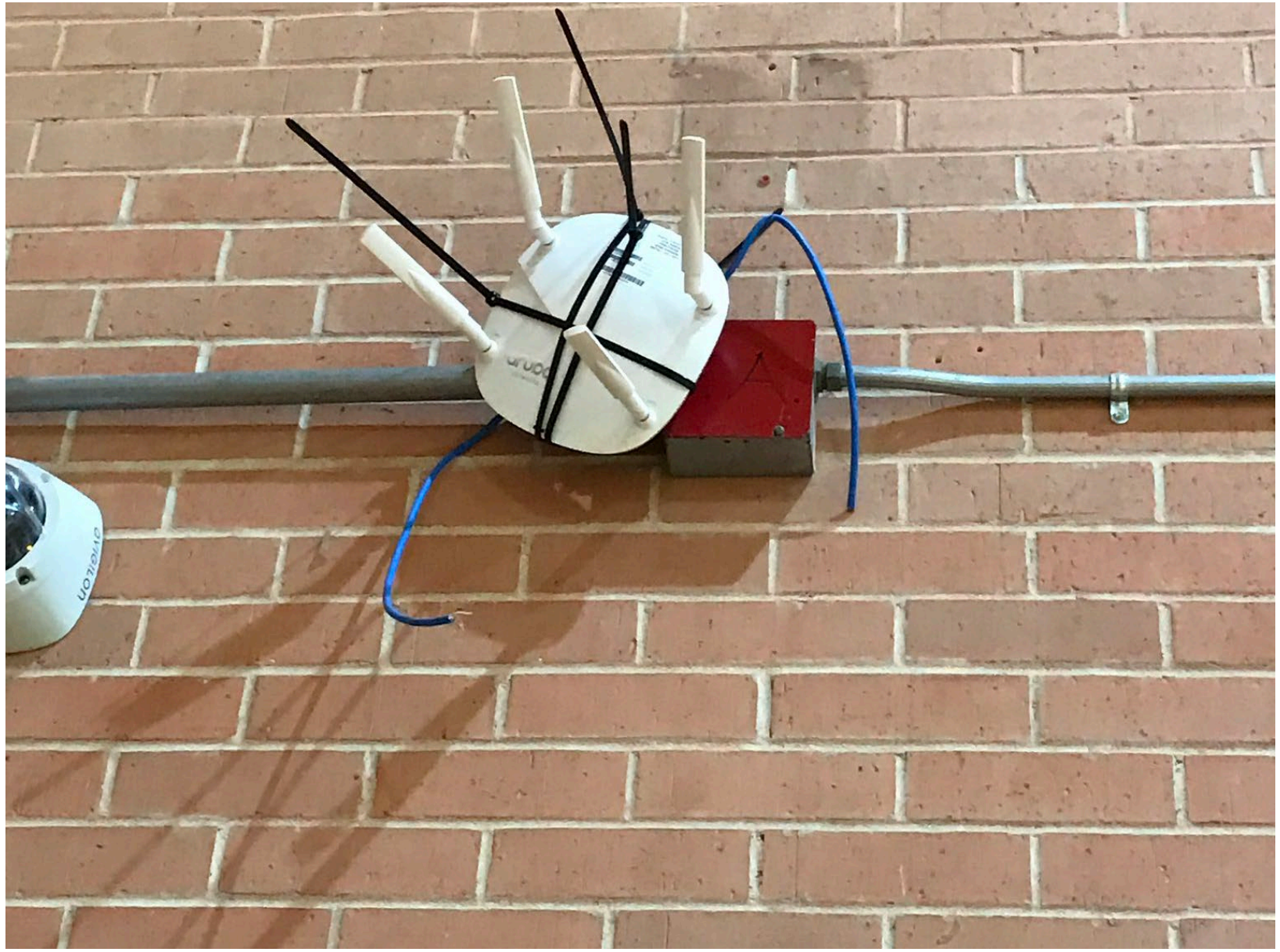
2.4 GHz Radio	5 GHz Radio
Corp_SSID (802.1X)	Corp_SSID (802.1X)
Guest_SSID (Open)	Guest_SSID (Open)
IOT_SSID (PSK)	IOT_SSID (PSK)

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

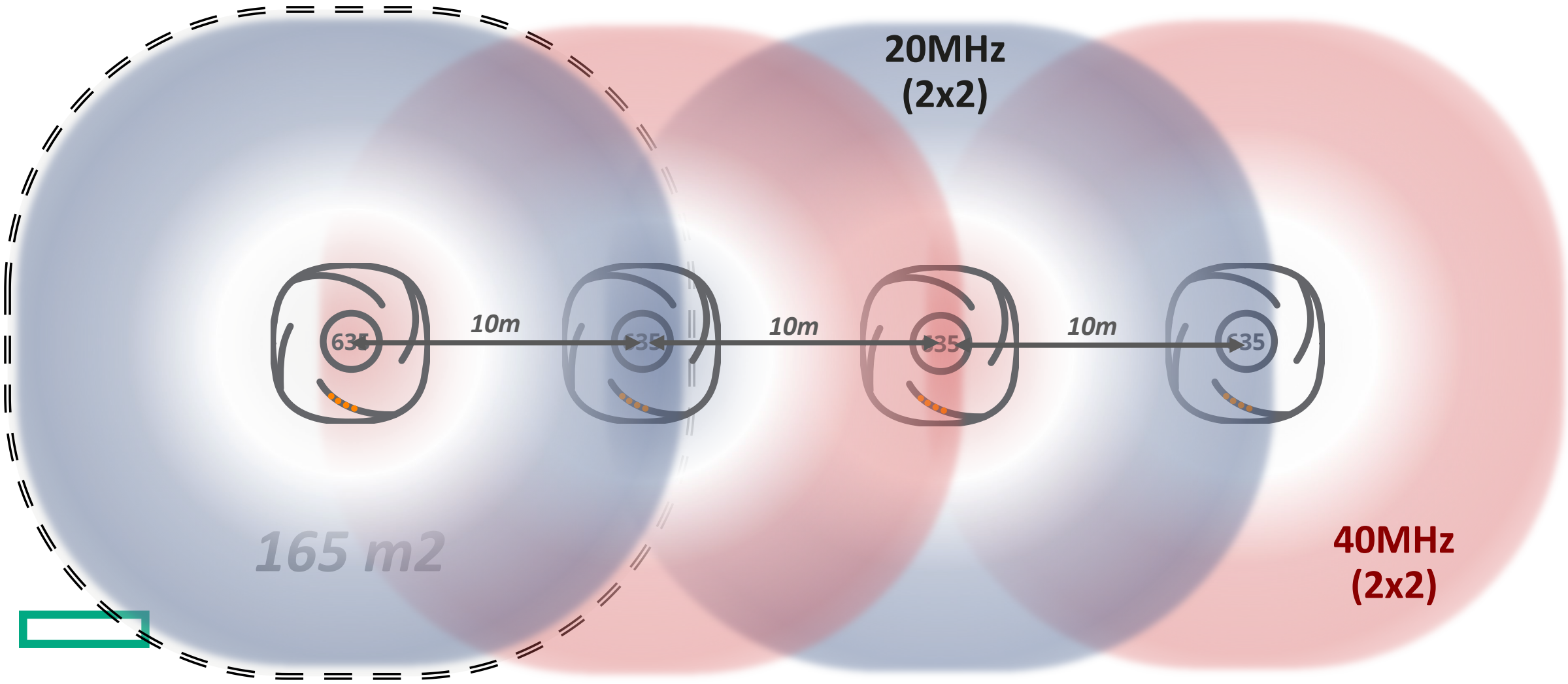
Band Partitioning
A Thought Exercise




No thanks!
We are too busy

How To Measure Coverage? Assumptions on 100% Re-use

General Rules and Assumptions = 165 m^2 per AP cell, red is 40Mhz, and blue is 20MHz, PSD should govern roughly similar SNRs @ 2x2 at max power



Standard square meters for office building (NL)

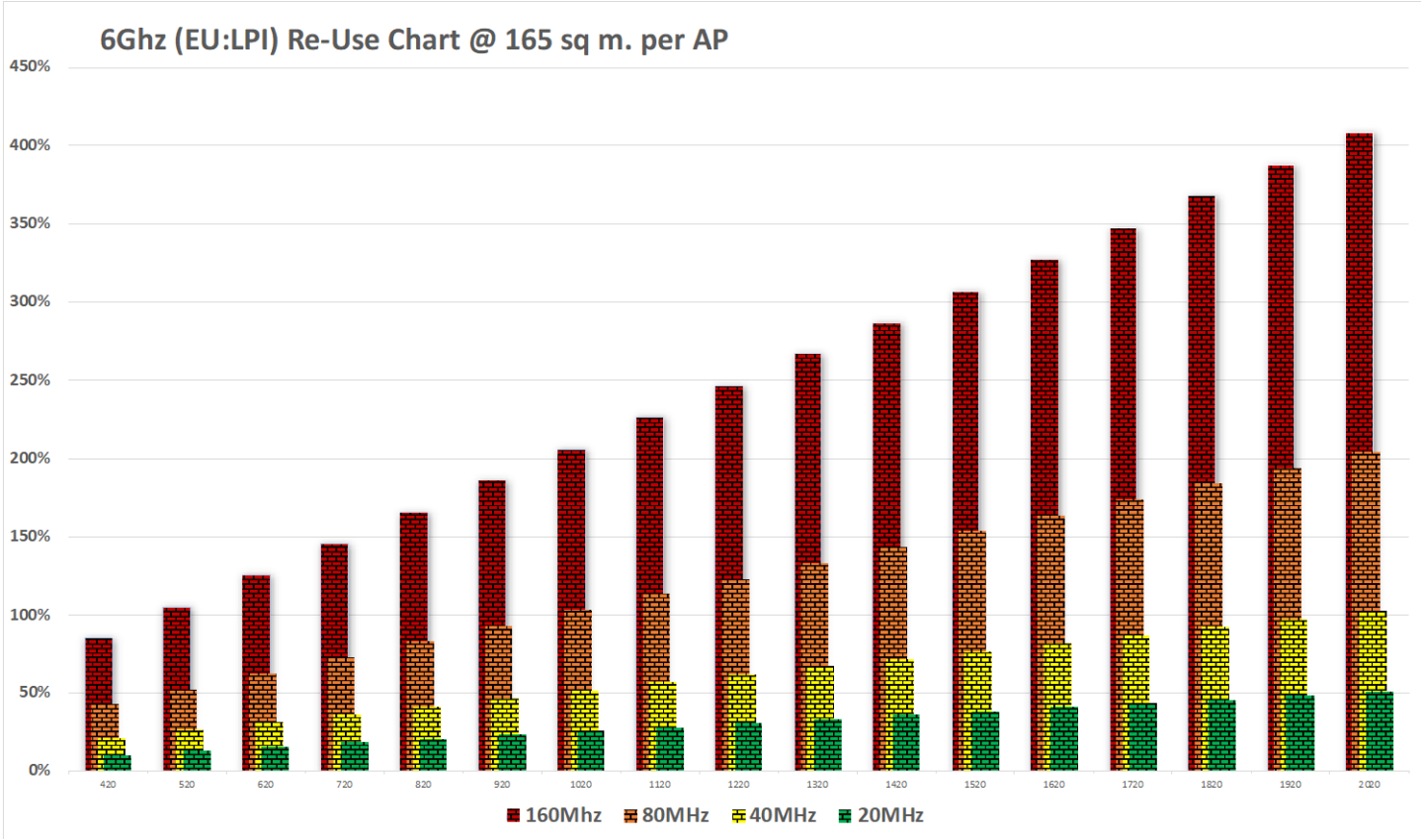
#People	#Square meter
1	7
2	17
3	21
4	28
5	35
10	70
20	140
40	280
60	420
80	560
100	700

https://skepp.nl/nl/blog/kantoorruimtetips/zoveel-vierkante-meter-kantoorruimte-heb-je-nodig-per-persoon

6Ghz LPI: To be fast, or to be numerous @ 700m²

- Ex AP @165m² per AP, that gives us a per-AP spacing of approx. 20m, with an AP radius of 10m.
- As the coverage areas get larger, it requires more APs to cover, requiring more channel re-use
- ***Going the other way***, with the numerous 6Ghz channels, can we build multiple Wi-Fi layers in the same space without more than 1x re-use?

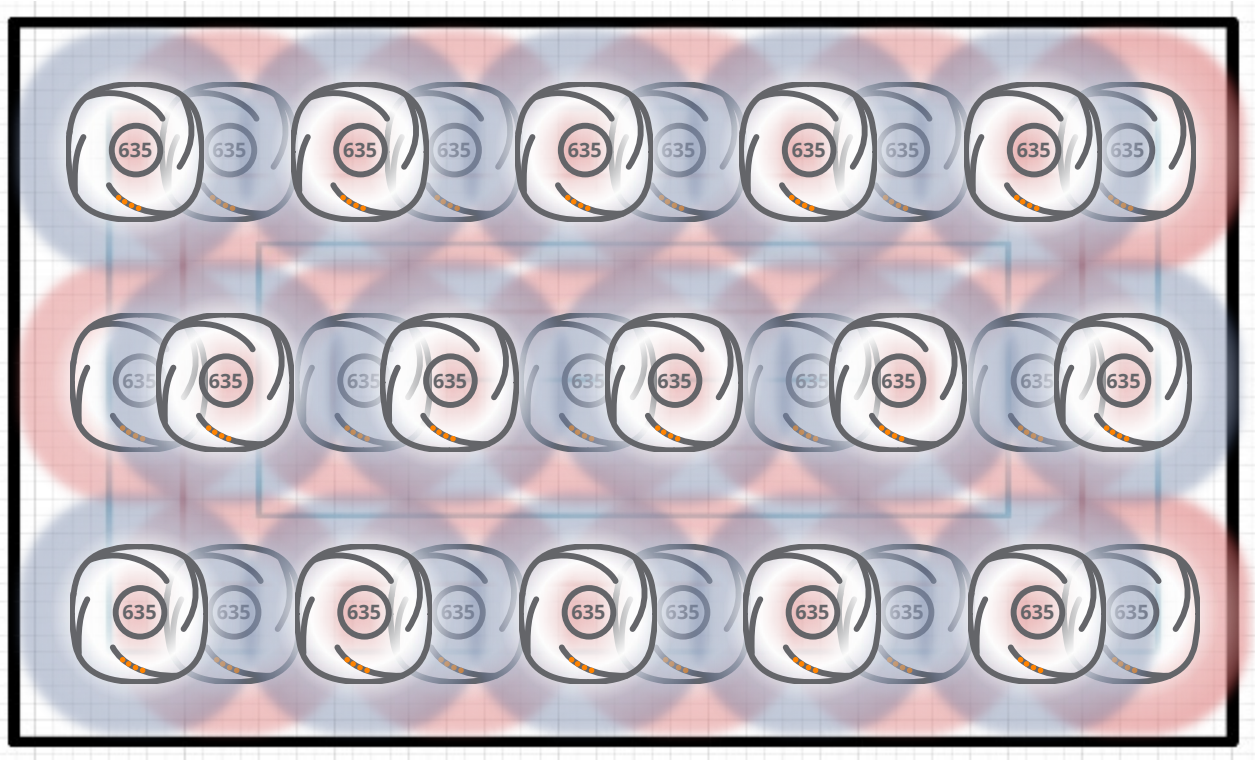
BLDG	700m² (10m x 70m)
Square meters per AP	165m²
# of APs Total	5
Max Re-use(BW20)	18%
Max Re-use(BW40)	36%
Max Re-use(BW80)	73%
Max Re-use(BW160)	145%



Use-Case: Dual-6GHz Wi-Fi Layers – Physical RF Segmentation

- Situation: Shared retail/office space has internally managed via leasing agreements internal spectrum management
- Design: Actual demand/load on the network has not changed, new spectrum allows for multiple layers of Wi-Fi to co-exist in the same physical space, either to be managed by the same admins but with different policies (physical guest v corp). Benefit over multi-zone is this kind of spectrum 'sharing' is certainly possible in large area use cases

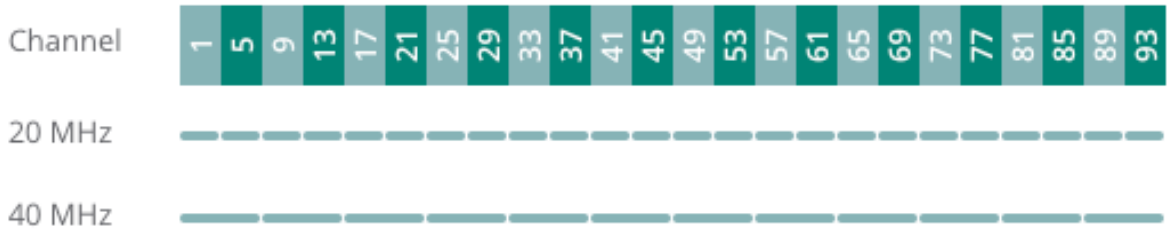
BLDG	980m² (20m x 49m)	
Sq.Ft. per AP	165m²	
# of APs Total	6	
Channel Width	**Primary 40MHz**	**Secondary 20Mhz**
MaxRe-use(BW20) *24*	25%	25%
MaxRe-use(BW40) *12*	49%	49%
MaxRe-use(BW80) *6*	99%	99%
MaxRe-use(BW160) *3*	198%	198%



Network Layering – Traditional Single-Layer Approach

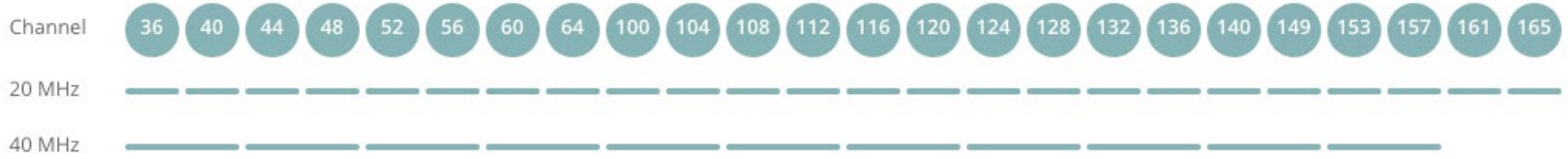
SSID1, SSID2, SSID3, SSID4

6 GHz Radio



12 x 40 MHz
6.87 Gbps

5 GHz Radio



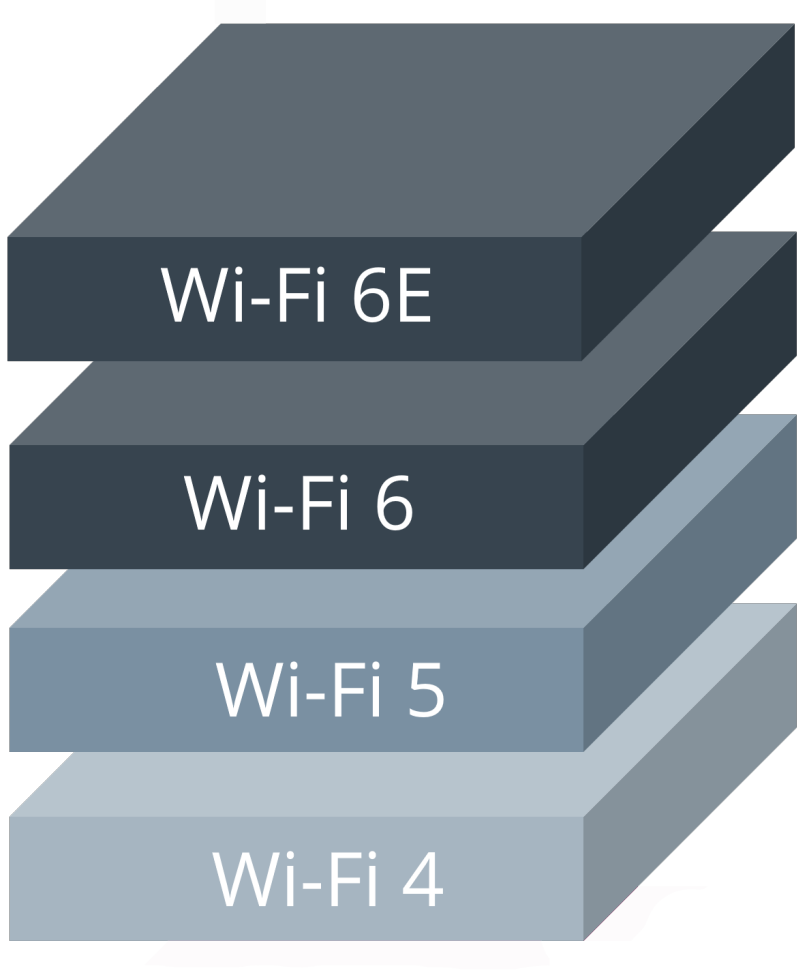
11 x 40 MHz
6.3 Gbps

2.4 GHz Radio

3 x 20 MHz
858 Mbps

Enterprise 6E LPI RF Layering Considerations

- With new channels and spectrum abundance, is it best to continue deploying all channels in a single layer of coverage?
- For some customers, is it time to start adding another layer of APs and segregating the new channels into sub-bands to serve different device types?
- If so, what are the optimal channel widths for each layer?
- What would the role of 5 GHz and 2.4 GHz be going forward in managed networks?

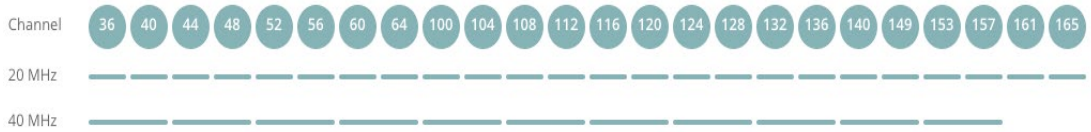


Network Layering – Two Layer Approach (1)

SSID1, SSID2

6 GHz Radio

5 GHz Radio

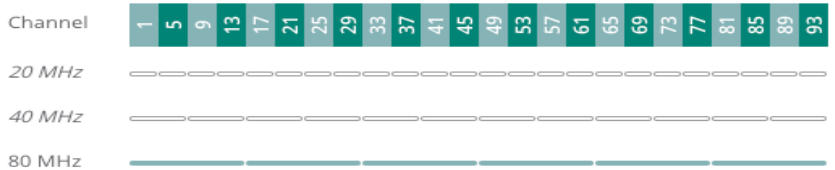


11 x 40 MHz = 6.3 Gbps

2.4 GHz Radio

2 x 20 MHz = 8.58 Gbps

SSID3, SSID4



6 x 80 MHz = 7.2 Gbps

Network Layering – Two Layer Approach (2)

SSID1, SSID2

6 GHz Radio

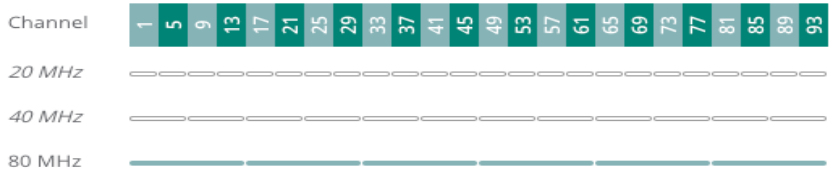
5 GHz Radio

9 x 20 MHz = 2.58 Gbps

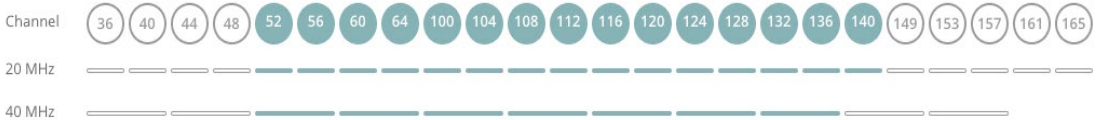
2.4 GHz Radio

3 x 20 MHz = 858 Mbps

SSID3, SSID4



6 x 80 MHz = 7.2 Gbps



7 x 40 MHz = 4.0 Gbps

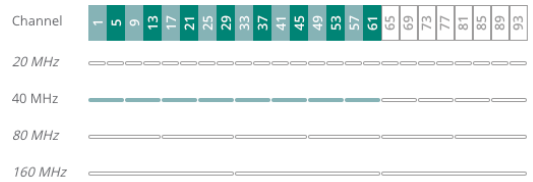
Network Layering – Triple Layer Approach

SSID1, SSID2

SSID3, SSID4

SSID5

6 GHz Radio



8 x 40 MHz = 4.58 Gbps

8 x 20 MHz = 2.3 Gbps

5 GHz Radio

9 x 20 MHz = 2.58 Gbps

NO DFS

7 x 40 MHz = 4.0 Gbps

2.4 GHz Radio

3 x 20 MHz = 858 Mbps

Thank you

dobias.vaningen@hpe.com

@networkingdvi

Dobias van Ingen

+31 651785440