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FINLAND

Aruba Wi-Fi 6E

Extending Wi-Fi into the 6 GHz frequency band

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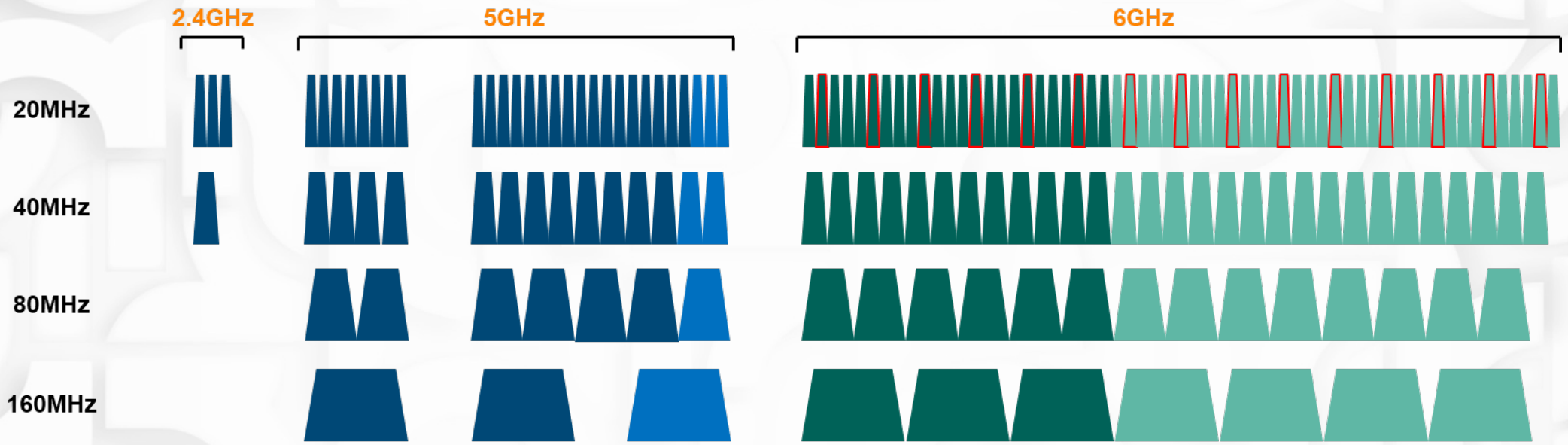
aruba
a Hewlett Packard Enterprise company

6GHz RF Opportunity

- **The 6GHz band spans 1.2GHz between 5,925MHz to 7,125MHz**
  - **Potential** for 59 20MHz channels, 29x 40MHz, **14x 80MHz or 7x 160MHz**
  - **In some regions/countries** limited to “just” the lower 500MHz (U-NII-5), for 24 20MHz channels (12 / 6 / 3)
  - Either way, adding the 6GHz band typically more than doubles the total spectrum capacity, and there’s no need for radar detection & avoidance (DFS)



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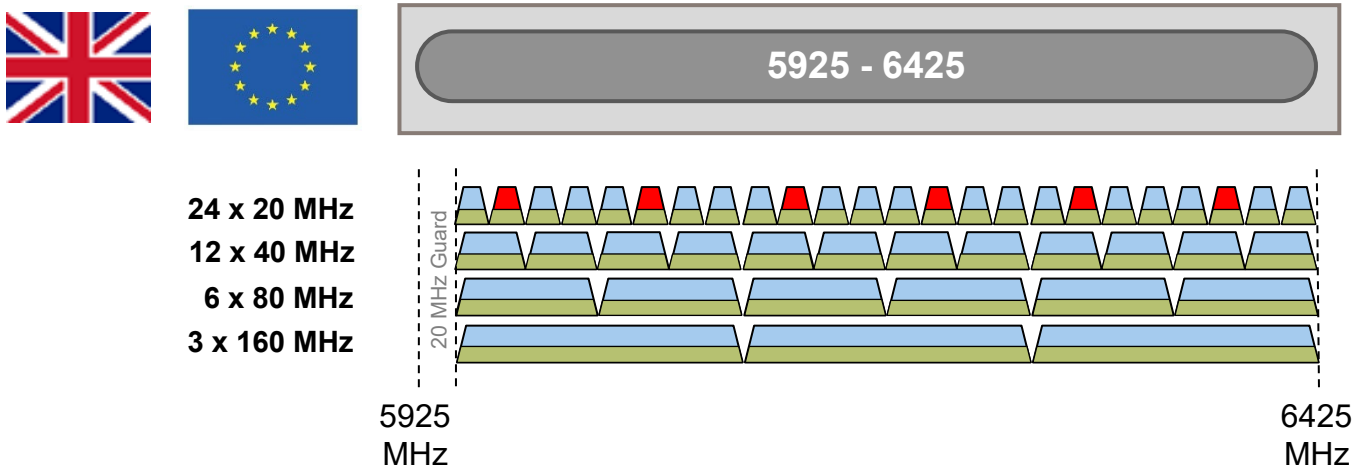
- **The 6GHz band is 802.11ax greenfield; there’s no need to support legacy devices/protocols (802.11a, 802.11n or 802.11ac)**
  - **No slow traffic in the fast lane!**

- **But: there will be some restrictions, and it will take some time**
  - Support for 6GHz and the timelines will vary by country. Roll out of products will take some time
  - Regulatory restrictions on what sub-bands and channels can be used, and under what conditions

6GHz RF Opportunity – EU Regulatory Restrictions

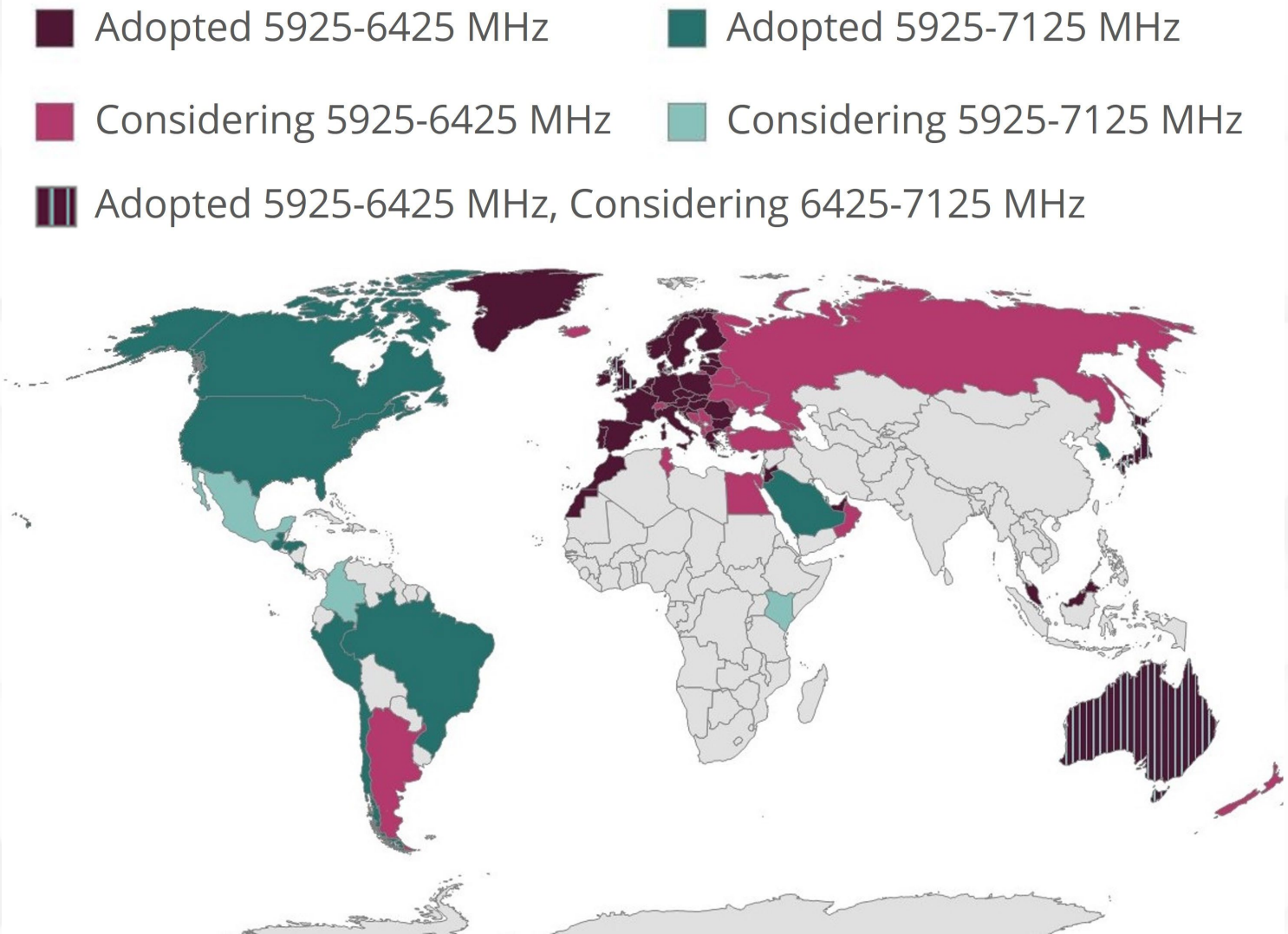
– **U-NII-5** sub-band only (500MHz), **Low Power Indoor** **(23dBm EIRP), no detachable antennas**.
  – That still provides 24 / 12 / 6 / 3 new channels. **No DFS, no AFC** requirements
  – Compare 5GHz: 24 /11 / 5 / 2 available channels (including DFS and U-NII-3), 4 / 2 / 1 / 0 (without)
  – 23dBm is plenty for indoor operation in an enterprise network
  – High-power/outdoor operation may be enabled later

– **Conclusion: Common LPI hardware for US and EU possible**



Support for Global Rollout

– Check https://www.wi-fi.org/countries-enabling-wi-fi-6e for the latest



Wi-Fi Alliance 6GHz Certification

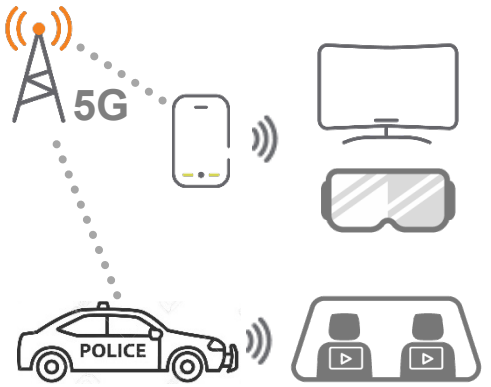
- Wi-Fi 6 certification program **release/wave R1.5** includes 6GHz operations **("Wi-Fi 6E")**
  - **Program was kicked off in January '21**
  - So far, a relatively small number of products has been certified (5/6/2022: 121), but it is growing
    - Including Intel AX210 and Samsung S21 Ultra client devices
    - Also included: the Aruba **AP-635 as the first enterprise AP to obtain 6E certification,** as well as the AP-655
- In addition to "just" 6GHz support, Wi-Fi 6E also requires:
  - WPA3-Personal support mandatory, WPA3-Enterprise is optional. No WPA or WPA2 allowed
  - OWE support required. No open, no WEP, no TKIP
- Note that 6E is not "**Wave 2 (R2) of Wi-Fi 6**", which was introduced independent from 6GHz
  - Offering the ability to (optionally) certify a number of features around performance, efficiency and power consumption
  - Aruba may re-certify some products, but we have no plan to introduce new products specifically for R2

Device Classes in 6 GHz

Low Power Indoor (LPI) AP
- Fixed indoor only
- Up to 63X lower energy
- No antenna connectors
- No weatherproofing
- Wired power

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

Very Low Power (VLP) AP
- Mobile indoor / outdoor
- 160X lower energy



~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
- 4X less power than connected AP

Fixed Outdoor Device
- Same rules as SP AP, ***plus***:
- Attached to structure

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
- 3 methods for In-Band AP Discovery
  - **Active scans on preferred scanning channels**
  - Fast Initial Link Setup (FILS) Discovery announcements*
  - Unsolicited Probe Responses*
- Security Enhancements
  - WPA3 Enterprise / Personal
  - Protected Management Frames (PMF)
  - Enhanced Open

*if implemented, and not default behavior

Enhancements In 5 GHz & 2.4 GHz

- 2 methods for Out-of-Band AP Discovery
  - Reduced Neighbor Reports (RNR)
  - Access Network Query Protocol (ANQP)*
- Possible Future Beacon Enhancements To 2G/5G
  - Multiple-BSSID Beacons*
- Security Enhancements
  - Expanded requirements for recent WFA standards

Wi-Fi 6E General Requirements

Required support:

- Security
  - WPA3-(Enterprise, Personal) and Protected Management Frames (PMF)
    - WPA3-Enterprise with 192-bit cryptographic strength is optional
  - Enhanced Open
- Discovery
  - Out-of-band signaling and discovery
  - In-band signaling, discovery, and association
  - PSC and Non-PSC scanning rules
- Regulatory
  - Updated regulatory rules for 6 GHz
  - Updated 6 GHz channelization (1 – 233)
- Management Frame Information Elements
  - 6 GHz band and 6 GHz operations

Not allowed and not supported:

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

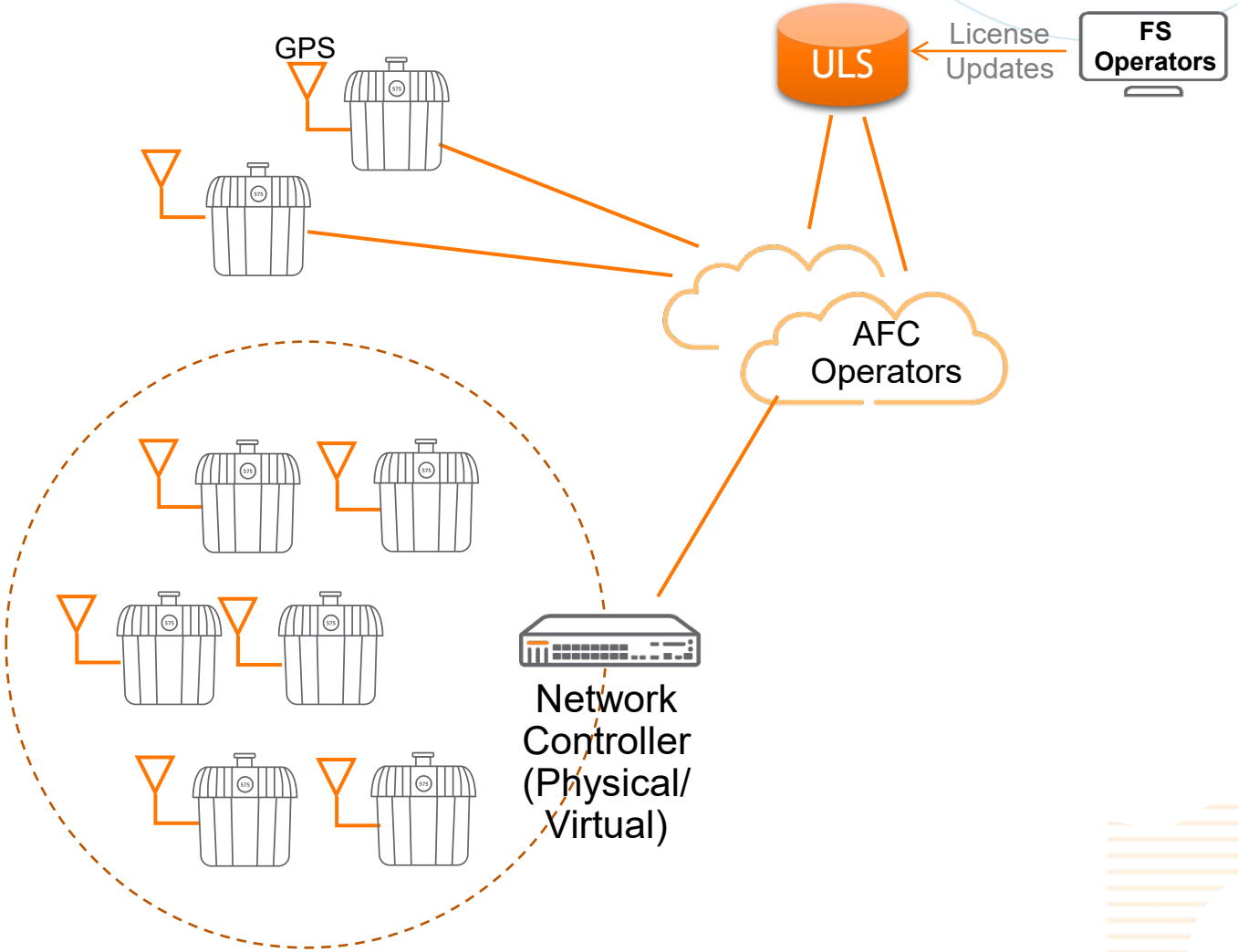
Automated Frequency Coordination

Aruba Partners with Federated Wireless for AFC

- Aruba is partnering with Federated Wireless to provide the AFC service which is required to sell Standard Power devices outdoors and indoors.
- Partnership began in 2018 with early prototypes and proof of concept which will be covered in the following slides.

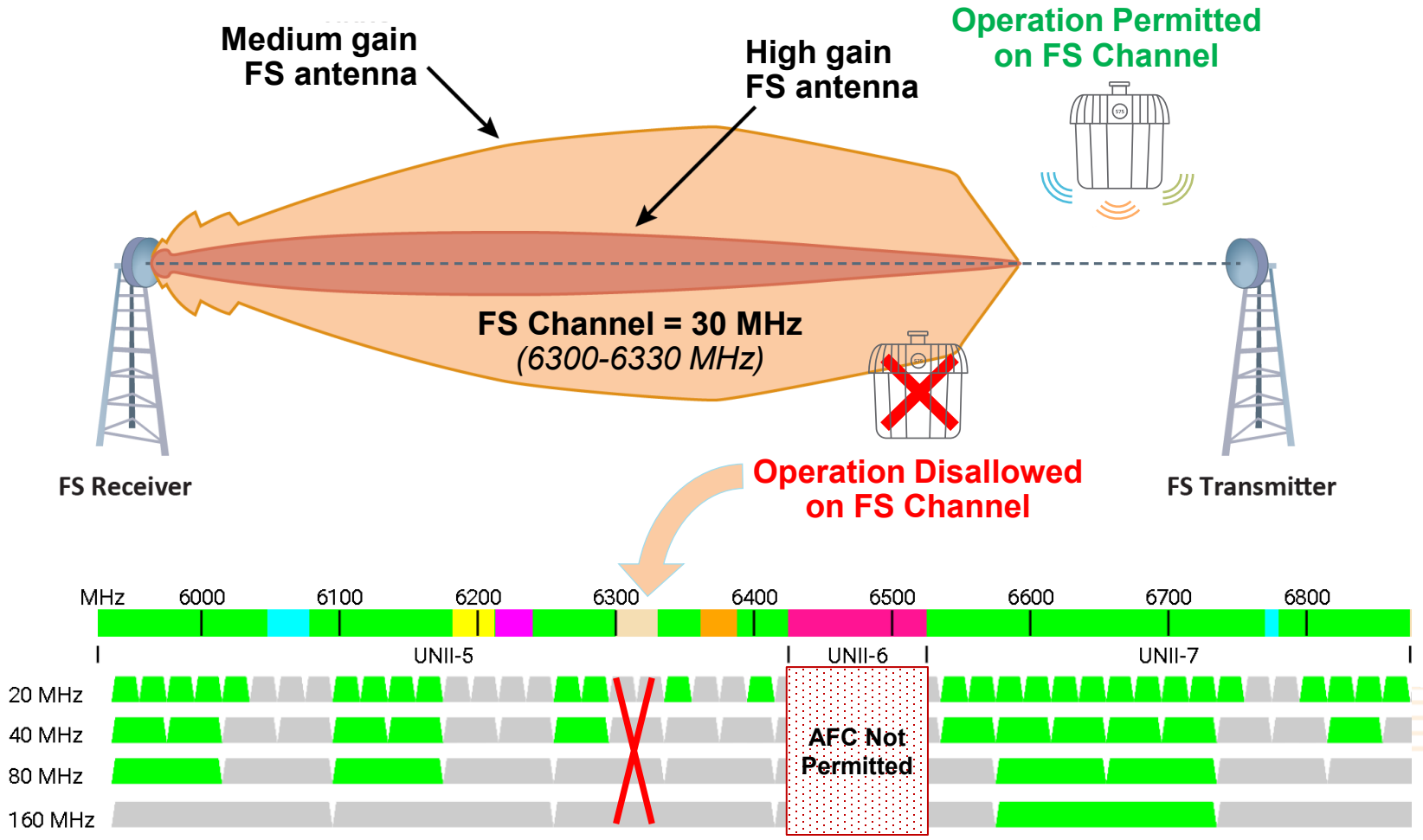
How a Notional AFC Deployment Works

- Collection of APs under local or remote management and control
- SP access points must be capable of determining their location
- SP access points must request a list of available channels from an AFC Operator every 24 hours
- Channel availability requests include AP geolocation (with uncertainty estimate), FCCID, and AP serial number
- AP or network controller chooses operating channel(s)

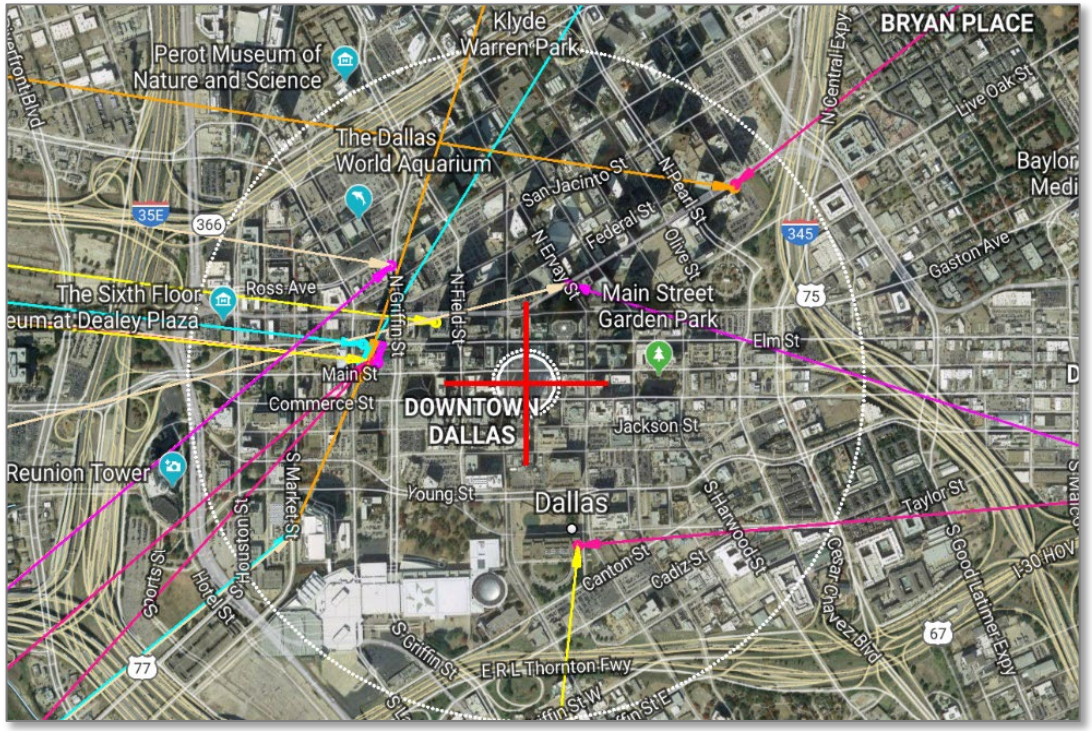


How Does the AFC Protect Incumbent Microwave Links?

- To protect incumbents, a spectrum database called AFC will govern all standard power APs (indoors and outdoors)
- Each AP using standard power is required to send its 3D geolocation to an AFC prior to transmission
- The AFC calculates a protection area for the incumbent
- The AFC sends each AP a list of permissible operating frequencies at the AP's location

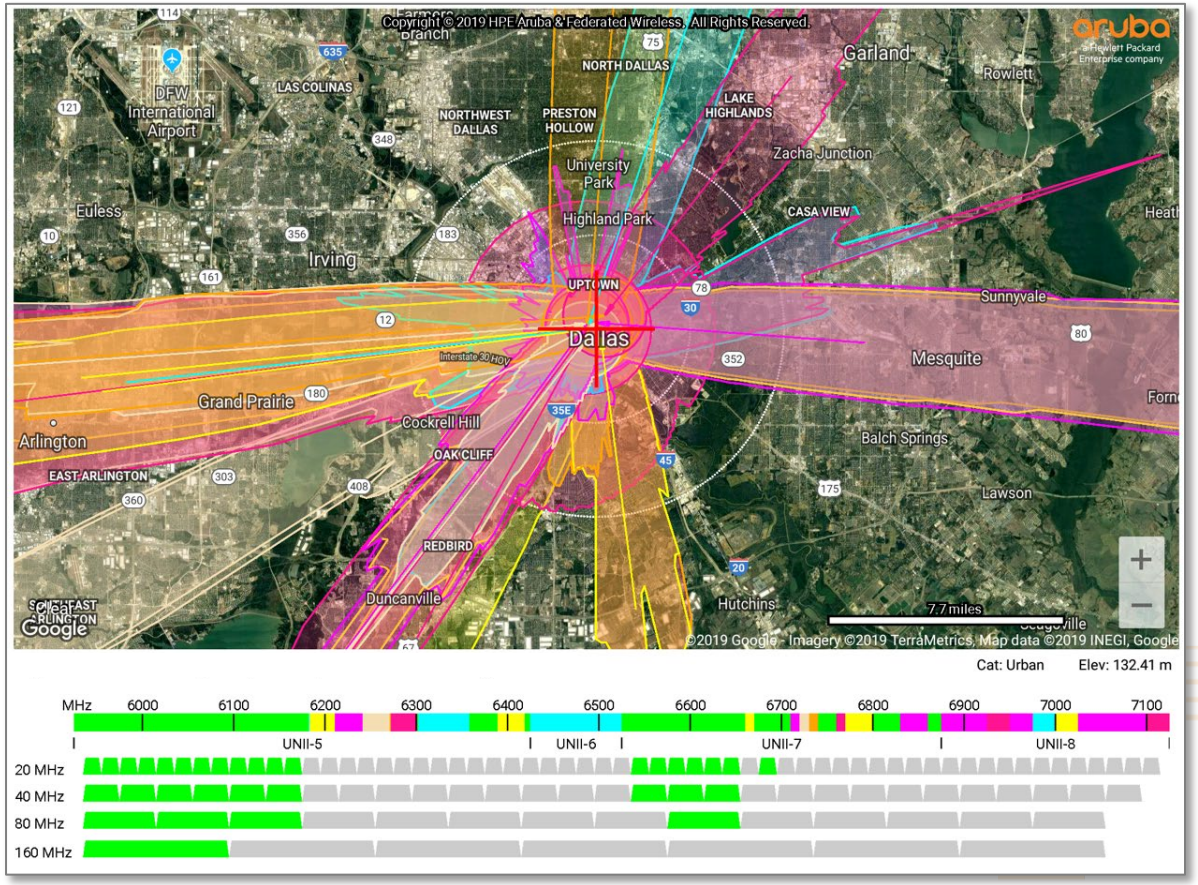


Real World Example – Dallas



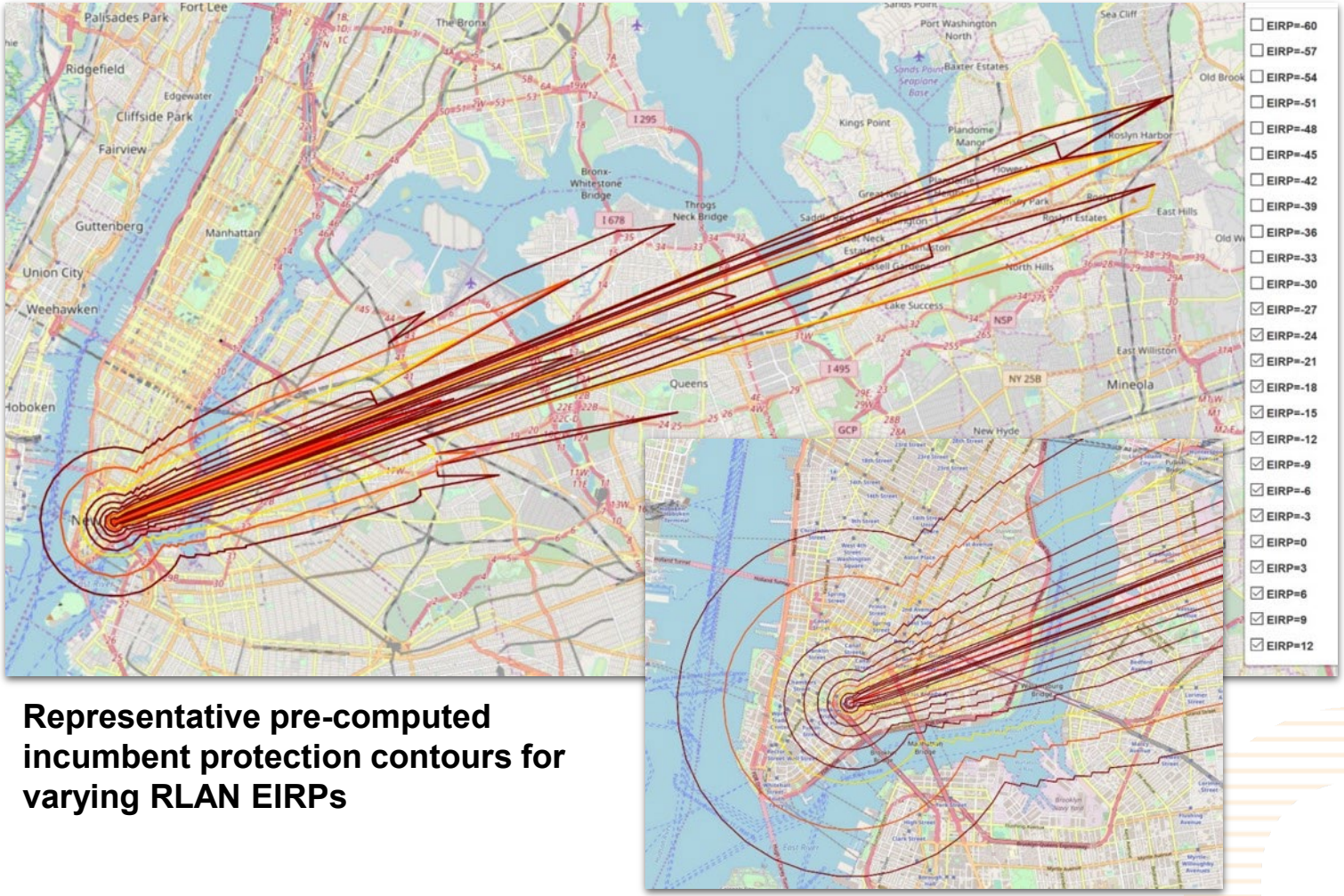
Dallas has numerous long-haul FS paths terminating on high-rise buildings downtown.

The Dallas Metroplex is relatively flat, resulting in reduced spectrum availability outdoors.



AFC Protection Contours Vary With EIRP & Terrain

- Hills, mountains and other terrain blockages can reduce protection contours in certain directions.
- Protection contour size grows with the EIRP of the Wi-Fi device.
- This is intuitive, since the AFC is solving for a fixed interference target of -6 dB I/N, any increase in Wi-Fi power must necessarily grow the protection contour to compensate.
- Conversely, reducing Wi-Fi EIRP shrinks the protection contour for a given incumbent.
- This creates an incentive for Wi-Fi operators to use as little power as necessary to complete their mission.



Representative pre-computed incumbent protection contours for varying RLAN EIRPs

Access Point Discovery

In-Band Discovery Techniques

Technique	Airtime Efficiency	Faster AP Discovery	Notes
Preferred Scanning Channels (PSCs)		Yes	One in four 20 MHz channels designated for beacons and 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)

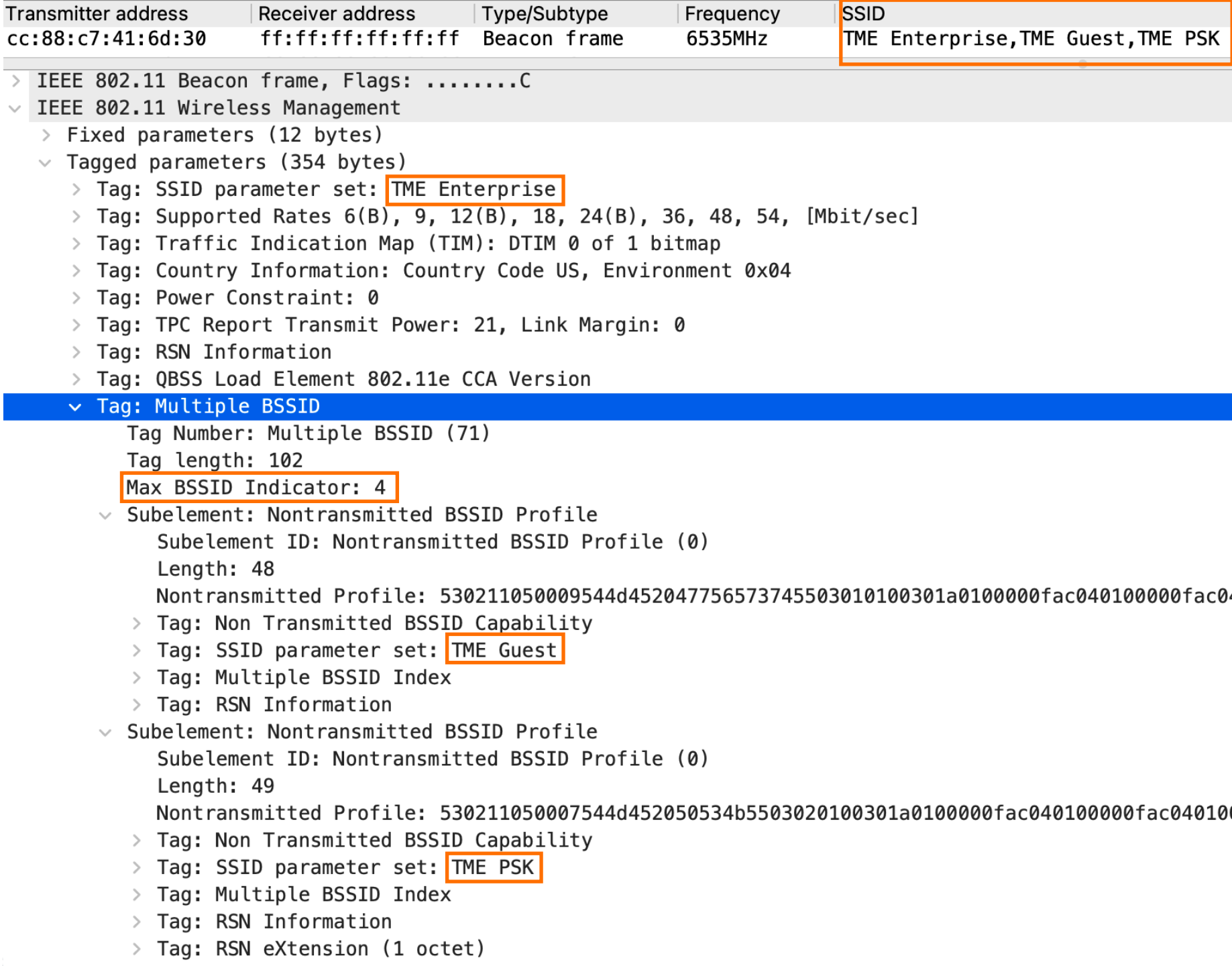
Preferred Scanning Channels (PSCs)

- One in every four 20 MHz channels is designated for beacons and discovery.
- For in-band network discovery, clients only need to 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).

PREFERRED SCANNING CHANNEL	CHANNEL CENTER FREQUENCY
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

In-Band Discovery Multiple BSSID Beacon Frame

- Frame type 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.
  - Compared to 2G/5G where each VAP has a separate beacon.
- AOS has a 4 BSSID limit. In the future, may still need to support multiple beacons when 5 or more SSIDs are used.



Wi-Fi 6E Probe Request and Response

- Client may discover in-band by probing PSCs (with probing restrictions; no blind probes, must first listen for beacon up to ~20ms; restrictions on how often)
- Probe response from AP to unicast probe request must be broadcast.

Probe Request

Transmitter address	Receiver address	Type/Subtype	Frequency	SSID
d8:f8:83:36:48:6d	ff:ff:ff:ff:ff:ff	Probe Request	6535MHz	
cc:88:c7:41:6d:30	ff:ff:ff:ff:ff:ff	Probe Response	6535MHz	forest

```
> Frame 28: 162 bytes on wire (1296 bits), 162 bytes captured (1296 bits)
> 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 (78 bytes)
    > Tag: SSID parameter set:
    > Tag: Supported Rates 6, 9, 12, 18, 24, 36, 48, 54, [Mbit/sec]
    > Tag: Extended Capabilities (10 octets)
    > Ext Tag: HE Capabilities
    > Ext Tag: HE 6 GHz Band Capabilities
    > Tag: Vendor Specific: Wi-Fi Alliance: Multi Band Operation - Optim
    > Ext Tag: Short SSID
```

Probe Response

Transmitter address	Receiver address	Type/Subtype	Frequency	SSID
d8:f8:83:36:48:6d	ff:ff:ff:ff:ff:ff	Probe Request	6535MHz	
cc:88:c7:41:6d:30	ff:ff:ff:ff:ff:ff	Probe Response	6535MHz	forest

```
> Frame 29: 321 bytes on wire (2568 bits), 321 bytes captured (2568 bits)
> Radiotap Header v0, Length 56
> 802.11 radio information
> IEEE 802.11 Probe Response, Flags: ........C
v IEEE 802.11 Wireless Management
  > Fixed parameters (12 bytes)
  v Tagged parameters (225 bytes)
    > Tag: SSID parameter set: forest
    > Tag: Supported Rates 6(B), 9, 12(B), 18, 24(B), 36, 48, 54, [Mbit/s
    > 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: 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: RSN eXtension (1 octet)
    > Tag: Vendor Specific: Microsoft Corp.: WMM/WME: Parameter Element
    > Tag: Vendor Specific: Qualcomm Inc.
    > Tag: Vendor Specific: Qualcomm Inc.
```

Probe Request Rules

— To enforce more efficient probing behavior, several rules are in place to reduce excessive probing and encourage device designers 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.

Sample Devices Already Supporting Wi-Fi 6E

Samsung Galaxy Book Pro 360

Samsung Neo QLED 8K TV

Windows 11

Laptops include Dell, HP, Lenovo, MSI, ++

Upcoming Devices?:

- ~~*iPhone 13*~~
- ~~*Surface Duo 2*~~
- *iPhone 14*
- *MacBook Refresh (2022)*
- *Surface Refresh (2022)*

Galaxy S21 Ultra and Galaxy Z Fold 3

Xiaomi Mi 11 Ultra

Motorola Edge

Google Pixel 6 Pixel 6 Pro

Various Chipsets Announced:

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

Wi-Fi 6E Overview Takeaways

– 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.

Required ArubaOS Software for Wi-Fi 6 and Wi-Fi 6E

- WFA Mandatory Wi-Fi 6 feature functionality on capable hardware has been supported since ArubaOS 8.6.0.2
- Wi-Fi 6E FCS Support in ArubaOS 8.9.0.0 (controller-less and controller-based)
  - WFA 6E certification will follow.
- *Central 2.5.4 introduced support for AOS 8.9.0.0, but Central UI is not ready for 6E.**
- *Central 2.5.5 has target 6E support**
- *AOS 10 target support for AP-635 is AOS 10.3.1**

ArubaOS 8.9.0.0 Release

- System-Wide Changes
- Support for 3rd band (3-radio was already supported)
  - Config, MRT, AirMatch, ClientMatch, WIDS, Central, Airwave
- Channel Representation
  - 6 GHz channels: 1 – 233
  - Overlap with 2.4 GHz and 5 GHz
- MBSSID Support
- Limited to 6 GHz radio
- # of VAPs support is 4
- Future release will increase # of VAPs to 16
- Upgrading to 8.9
- Users have to re-think their deployment
- Existing VAPs will not automatically apply to the 6 GHz radio
- Configure WPA3 opmodes to enable roaming between bands

Known Limitations: Client Behavior

If only 6 GHz radio is enabled (with 2.4 / 5 disabled), some clients may not discover/connect to 6 GHz SSID.

- Why? No RNR to assist AP discovery

With same SSID on all three radios (2.4 / 5 / 6), some 6 GHz clients may not connect to, or prefer, the 6 GHz radio.

- Pro tip: Intel driver settings on Windows allows setting of preferred band to 6 GHz (non-default value)

Recommended way to force 6 GHz connectivity is to configure unique SSID on 6 GHz and different SSID on other bands.

- How? RNR will provide 6 GHz connection information; even if ESSID is not the same

Known Limitations: Configuration

- ArubaOS 8.9.0.0 FCS supports only 4 SSIDs in the 6 GHz MBSSID
  - Max beacon size from chipset vendors limits the number of VAPs for a single MBSSID beacon.
  - Support for > 4 SSIDs is planned for future release.
- Default Behavior
  - On SSID config creation, 6 GHz is disabled by default; administrator must explicitly enable it per SSID.
- Non-UTB hardware
  - The utb-filter-block default is 6 GHz. To enable the lower 6 GHz channels, must set block to 5 GHz.
  - On APs with UTB support, can go crazy on channel selection.
- Open and WPA2 opmodes not allowed (Wi-Fi Alliance)
  - SSID configuration must use WPA3 or Enhanced Open (OWE)
  - Addt., WPA3 and OWE transition modes not allowed.
- Central UI and configuration limitations in 2.5.4

Design Considerations

POTENTIAL ENTERPRISE SSID ASSIGNMENT WITH WI-FI 6E

Consider how traditional dual-band SSID layouts may evolve in a tri-band 6E deployment

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)

Dual-band

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

Tri-band

Enterprise 6E LPI RF Design Considerations

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

Q: What does your RF design look like today?

A: Coverage only?
- New design and RF plan which factors density and capacity is required.

A: Capacity Based? Primary and secondary?
- Existing density numbers should work. Review antenna pattern changes.
- 6 GHz signal loss compared to 5 GHz is minimal (assume 2 dB for RF plans). The “cell” size will be similar.

Q: What power levels are you currently using?
- The LPI class supports RF power for the typical indoor enterprise deployment.
- 5 dBm per 1 MHz* PSD (18 dBm @ 20 MHz, 21 dBm @ 40 MHz, 24 dBm @ 80 MHz).

*depending on the regulatory domain

Enterprise 6E LPI Access Layer Considerations

Network access layer?

—Multi-gigabit switches which support 1/2.5/5 GbE and Class 6 PoE.

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.

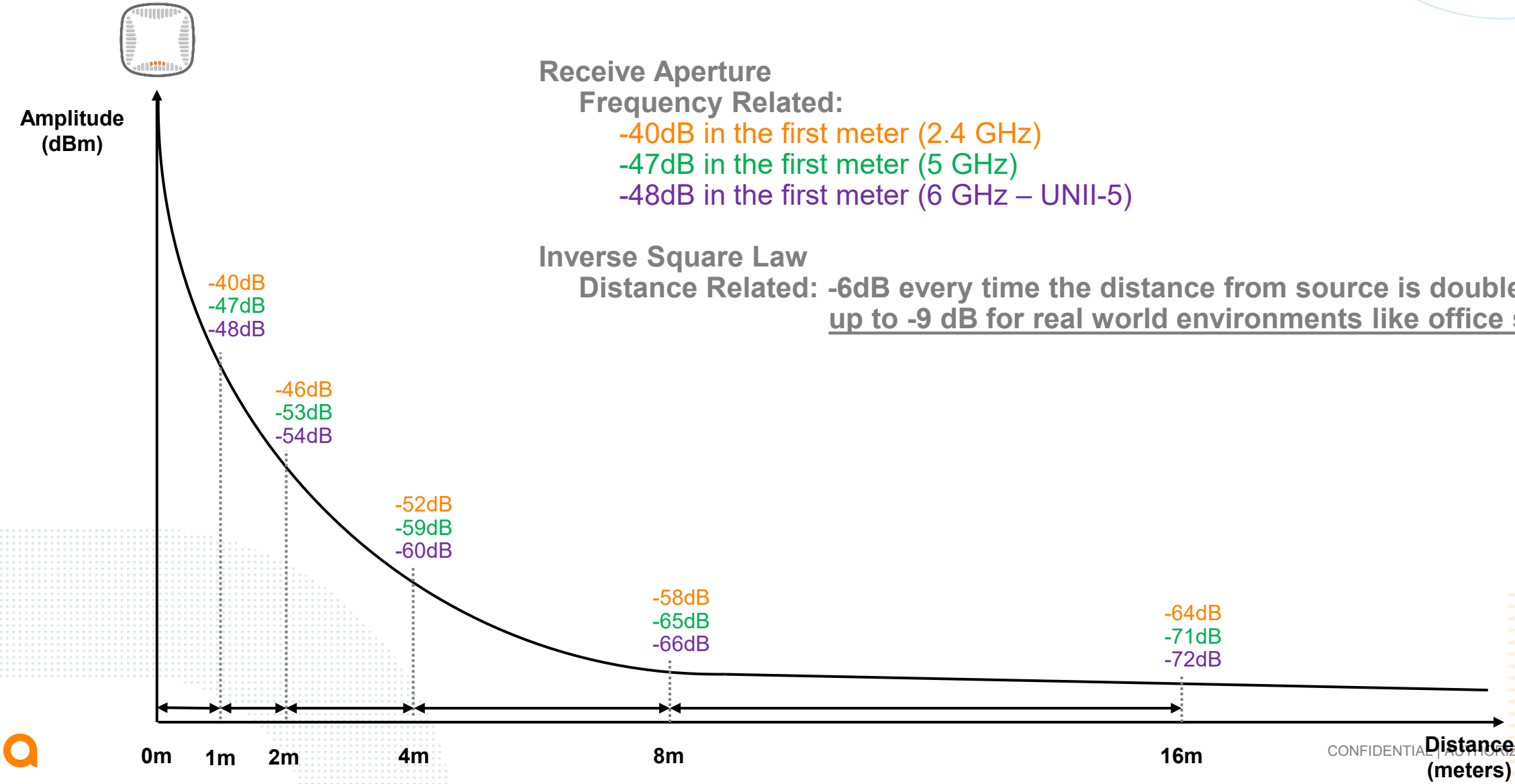
Cabling plant?

—Plan for a cable technology which minimally supports 2.5 Gbps and 60W over copper.

AP-635 RF Modeling

- Until planning software is updated, use 5 GHz (AP-505 could be used) and assume 2 dB less RF power.
- Consider regulatory EIRP/PSD limits in your model.
- Ekahau does not yet include support for the AP-635, however the antenna and RF information has been provided.

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)

Inverse Square Law

Distance Related: -6dB every time the distance from source is doubled.

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

Low Power Indoor (LPI) Design Considerations

- Following capacity-based best practices in current design?
  - In typical indoor deployment, the 6 GHz capable access points will work with similar density.
  - The path loss between 6 GHz and 5 GHz is minimal (thus “cell” size will be similar).
- Following a coverage-based design?
  - Evaluate and compare your existing EIRP needs and plan accordingly to meet density requirements.
- Single RF layer?
  - Plan for 80 MHz channels as baseline and consider 160 MHz in regdomains with full 1200 MHz available.
- Access layer?
  - Recommended to deploy switches with 2.5 Gbps and/or 5.0 Gbps Smart Rate (802.3bz) ports.
- Power over Ethernet?
  - 2x2 tri-band will fit in Class 4 PoE budget with IPM enabled (PD will request Class 5).
  - 4x4 tri-band will likely need Class 6 budget or operate with reduced functions with IPM enabled.
- Cabling Plant?
  - Plan for a cable technology that supports 2.5 Gbps and 60W over copper.

AP-635 Tri-Radio Campus Access Points

Product Introduction – 630 Series Campus Access Points

Mid-range Wi-Fi 6E 802.11ax tri-radio

AP-635

Product Introduction – 630 Series Campus Access Points

High-level Summary

– First Enterprise Wi-Fi 6E Access Point, announced May 25, 2021
  – Adding 6GHz support in a tri-radio AP to more than double the AP performance and total wireless network capacity
  – Bringing Wi-Fi 6 to the 6GHz band, and taking advantage of a much-needed boost in spectrum and capacity
  – AP-635 will be Wi-Fi 6 certified to ensure full backwards compatibility, full interoperability with legacy and Wi-Fi 6/6E client devices, and meeting (and exceeding) the industry baseline for 6/6E features and performance
  – AP-635 incorporates many existing and new Aruba AP innovations

– Over time, we'll add more platforms to the Wi-Fi 6E AP portfolio
  – Initially focusing on indoor (LPI class) products, which implies:
    – **Indoor deployments only**
    – **No connectorized antennas**
    – **Moderate RF transmit power levels (good enough for typical indoor enterprise)**

Product Introduction – 630 Series Campus Access Points

Some key specifications

- Wi-Fi Radio Specifications
  - 6GHz radio: 2x2 MIMO, 20/40/80/160MHz, 802.11ax. Peak datarate: 2.4Gbps (2.9Gbps with 4096-QAM)
  - 5GHz radio: 2x2 MIMO, 20/40/80MHz, 802.11a/n/ac/ax. Peak datarate: 1.2Gbps
  - 2.4GHz radio: 2x2 MIMO, 20/40MHz, 802.b/g/n/ax. Peak datarate: 287Mbps (574Mbps @ 40MHz)
  - Aggregate peak datarate: 3.9Gbps
  - Up to 512 associated clients per radio (hard limit; 100 limit for active clients recommended)
  - Max number of 802.11ax OFDMA Resource Units: 8
  - Up to 16 BSSIDs per radio (4 only for 6GHz initially)
  - Transmit power up to 18dBm, receive sensitivity down to -92dBm (conducted per chain)
  - All mandatory features for WFA certification (as well as some optional ones) are supported
  - No MU-MIMO (limited/no added value on 2x2 radios)

- Ethernet: two 2.5Gbps Smart Rate ports (E0, E1)
  - Both support POE

Product Introduction – 630 Series Campus Access Points

Some key specifications

- Power options: DC power 12Vdc or POE power (802.3at / 802.3bt)
  - Maximum power consumption (excluding USB): 20.7W (DC) or 23.8W (POE)
    - Maximum consumption when idle: 8.7W (DC) or 11.7W (POE)
  - No power-combining (Smart POE) support on AP-635 (single POE source only, active/standby)
    - No need since the AP-635 can operate without restrictions from a single class 4 POE source in almost all situations (see next slide)
  - Intelligent Power Monitoring (IPM) feature to optimize functionality and performance when on a limited power budget
  - Deep-sleep mode support for Green AP system feature (Central, roadmap feature)
    - Max power consumption in deep-sleep: 1.1W (DC) or 1.9W (POE)

- Physical specifications
  - Environmental: 0C to +50C (+32F to +122F)
    5% to 95% relative humidity
    Plenum rated (UL2043)
  - Physical: 220mm x 220mm x 50mm (8.7” x 8.7” x 2.0”)
    1300g (2.87lbs)

Product Introduction – 630 Series Campus Access Points

Relative size and weight

AP-535
240 x 240
1270g

AP-635
220 x 220
1300g

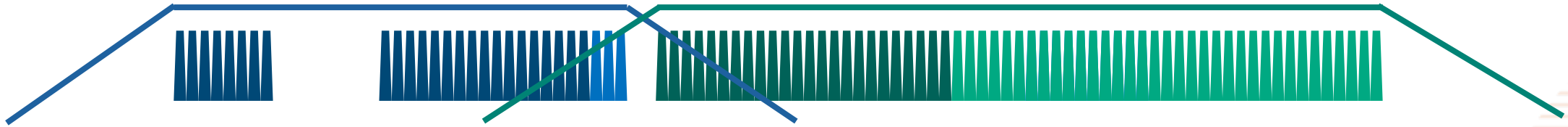
AP-515
200 x 200
810g

Challenge: Small Gap Between 5GHz and 6GHz

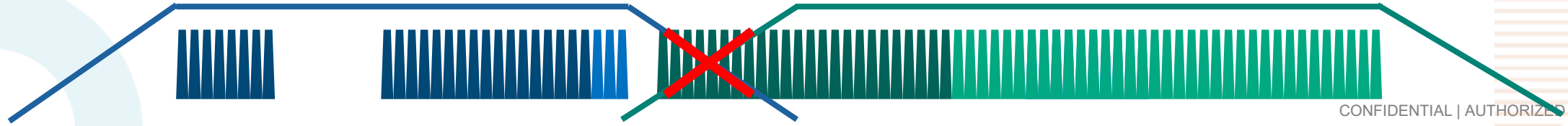
Traditional filter solutions sacrifice some channels

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

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

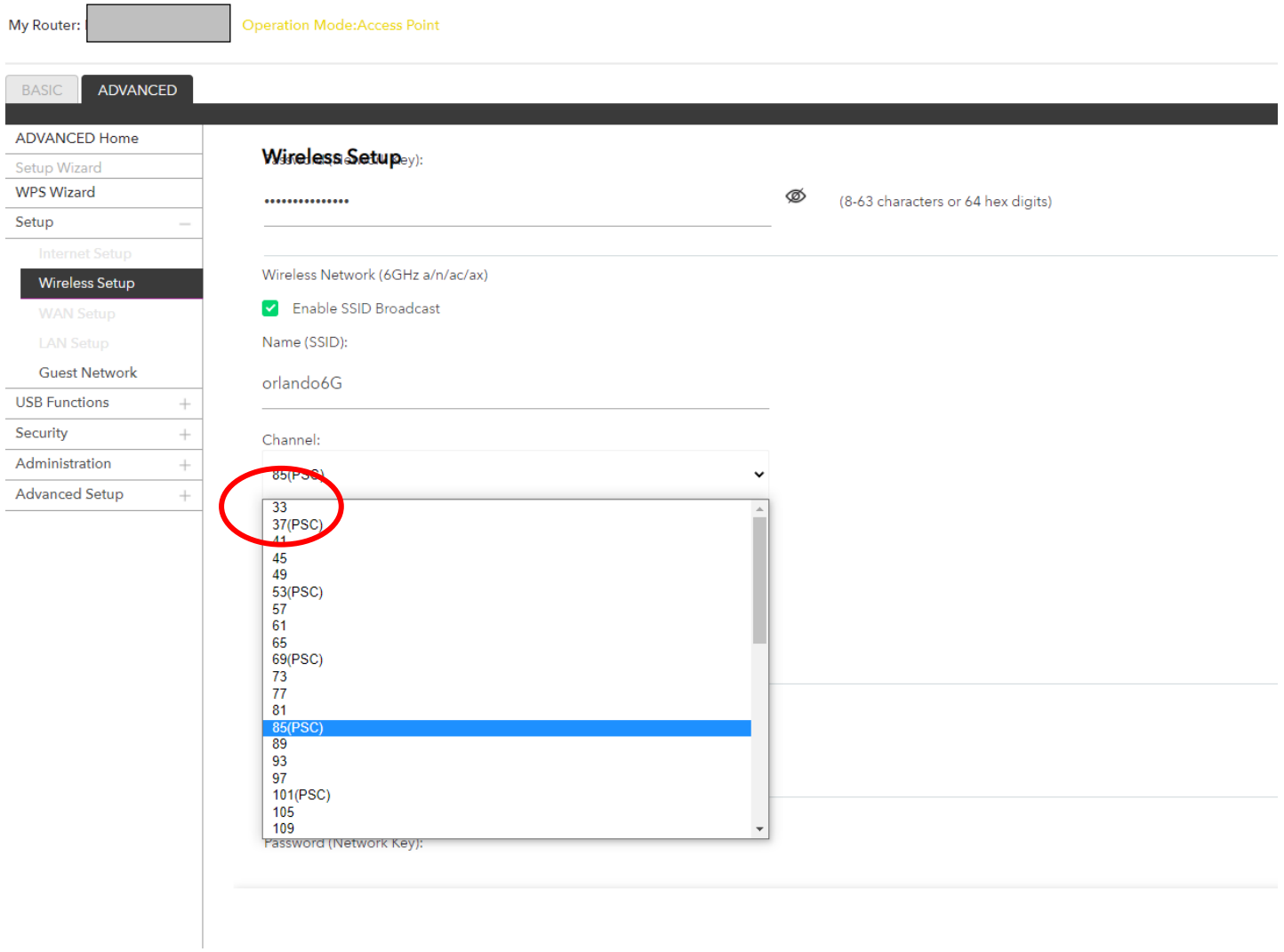


– The typical way to deal with that is by sacrificing some channels. Typically that would be the lower eight 6GHz channels



One Approach to Wi-Fi 6E Filtering

High-end consumer-grade 6E gaming router



New Approach: Ultra Tri-band Filtering (UTB)

Patent-pending technology allows for use of all 5GHz and 6GHz channels

- Losing 8 out of 58 (HE20) channels may not seem a big deal, but it does limit the potential of 6GHz
  - Note that it also means losing 1 out of the 7 HE160 channels
  - It's a bigger deal in Europe and several other countries where we "only" get 500MHz in 6GHz (24 HE20 channels)
  - In that case, 8 channels represent a third of the band

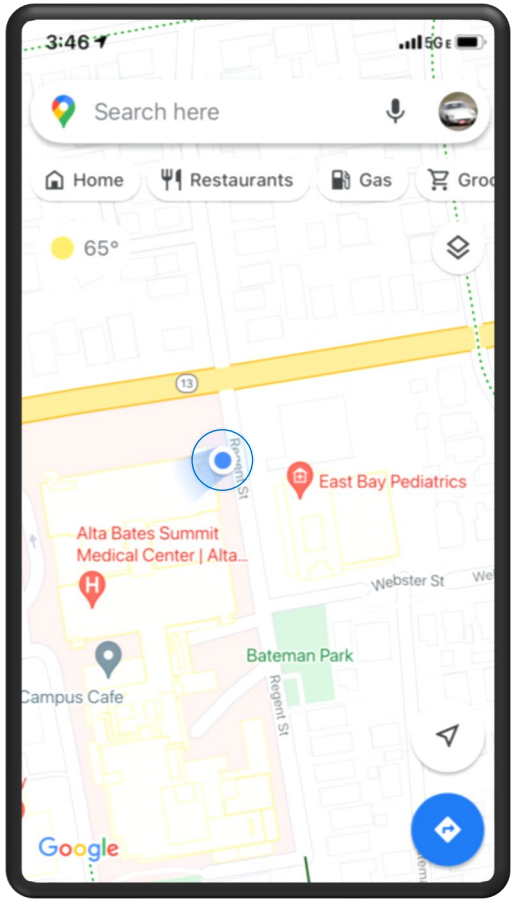
- Aruba is introducing “Ultra Tri-Band” or UTB, a patent-pending feature to avoid this issue
  - Dynamic filtering, depending on what channels are actively used
  - Allows the use of all 5GHz and 6GHz channels and any combination, **without any performance degradation**

- Developed for our planned flagship 6E AP model, but will introduce it in the midrange AP-635 as well
  - To be **phased into the AP-635 hardware** later this year

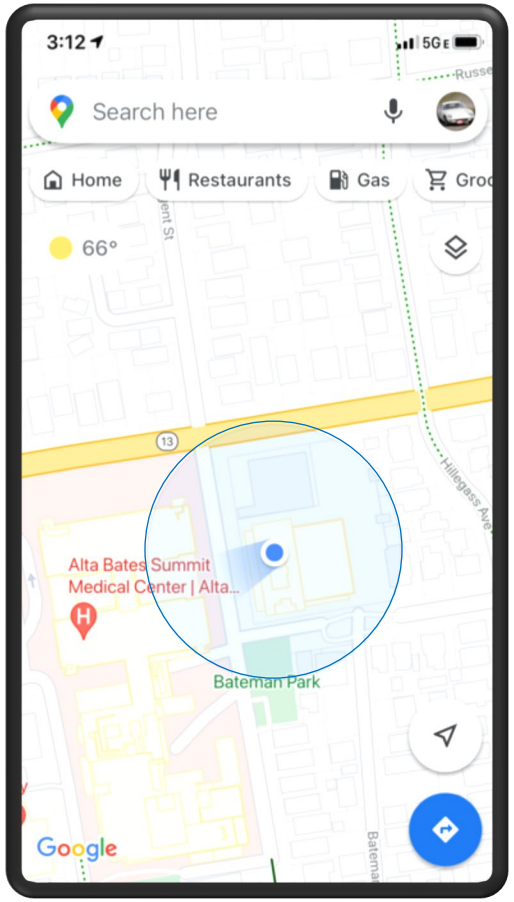
The Power of GPS…. Indoors

DESPITE DECADES OF EFFORT
INDOOR LOCATION STILL FAILS

Outdoor Location ☺



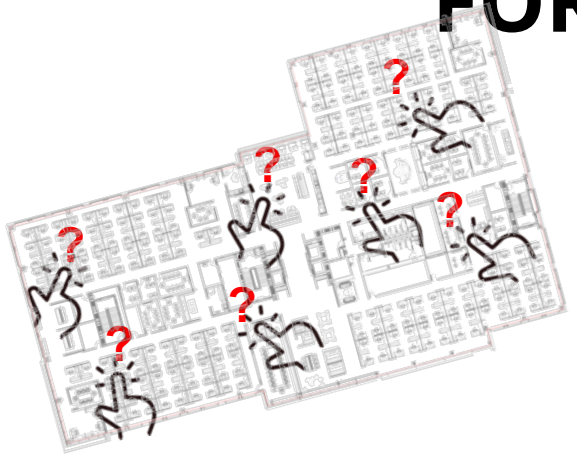
Indoor Location ☹

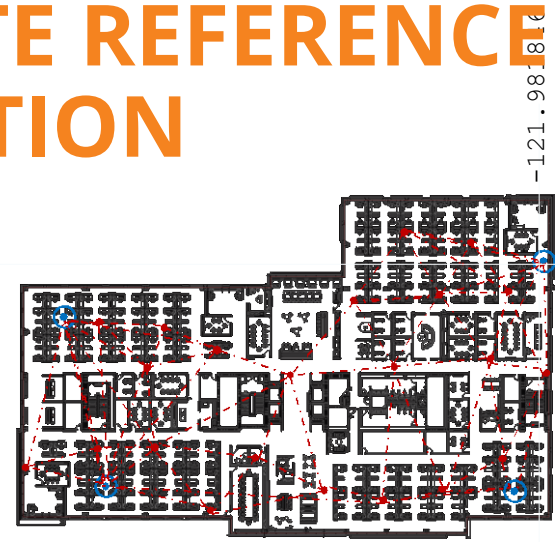


How We Lost Our Way

- Despite substantial advances in Wi-Fi ranging technology, indoor reference points remain the weakest link
- Most APs are unaware of their own location
- Processes to determine AP locations are costly, non-scalable and fraught with errors
- Where available, AP location is locked to local reference frames
- Crowd-sourced approaches have yielded poor results
- Most APs do not support the latest ranging technologies

MAKING WI-FI THE ABSOLUTE REFERENCE FOR INDOOR LOCATION





Out with Error-Prone Manual AP Placement

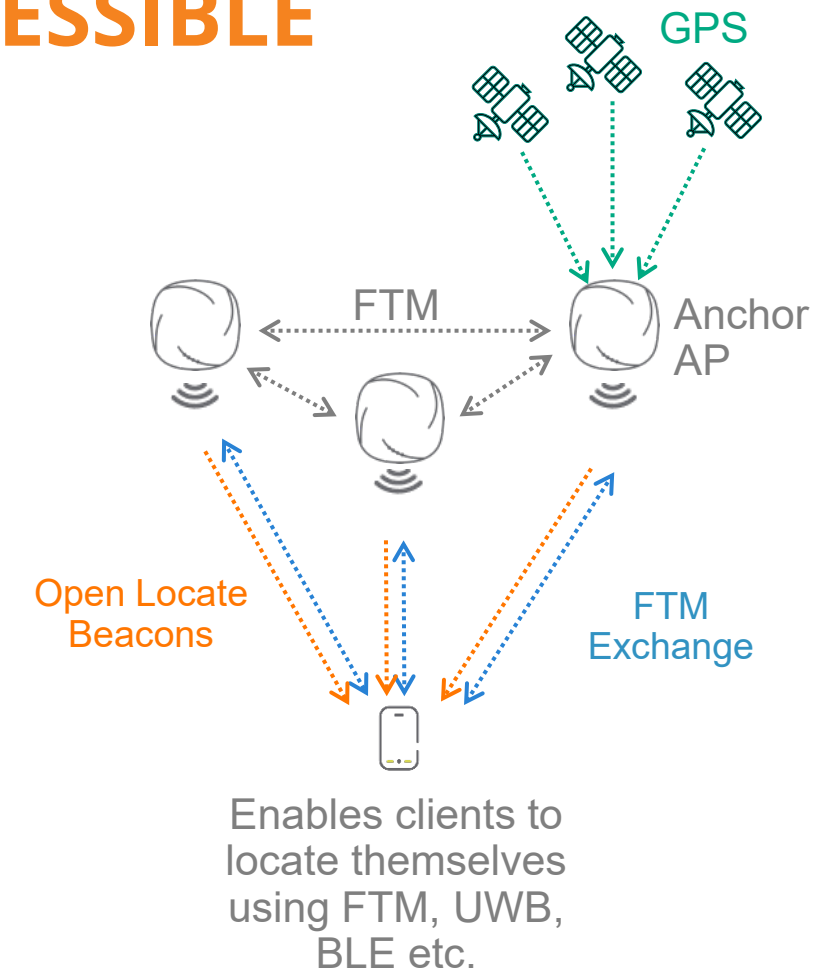
- Manually placed on crude image files, often inconsistently scaled and cropped
- Stored in local coordinate system without reference to any common geospatial reference frame
- Best effort placement with no indication of location uncertainty or confidence levels
- Inconsistent map resolution and placement methods magnify errors
- No knowledge of floor elevations
- Only recorded on largest networks
- Unreliable reference for BLE, UWB, FTM, etc.

In with Accurate, Automated Provisioning

- Zero-touch determination of all AP locations
- Recorded in universal geospatial reference frame (WGS84), allowing use without knowledge of local floorplans
- Continuously validated and self-healing with well-characterized uncertainty and confidence
- Easily transposed onto any floor map or application environment
- Roadmap to automated determination of elevation
- Automatically determined for every Aruba deployment
- Reliable reference for any location technology

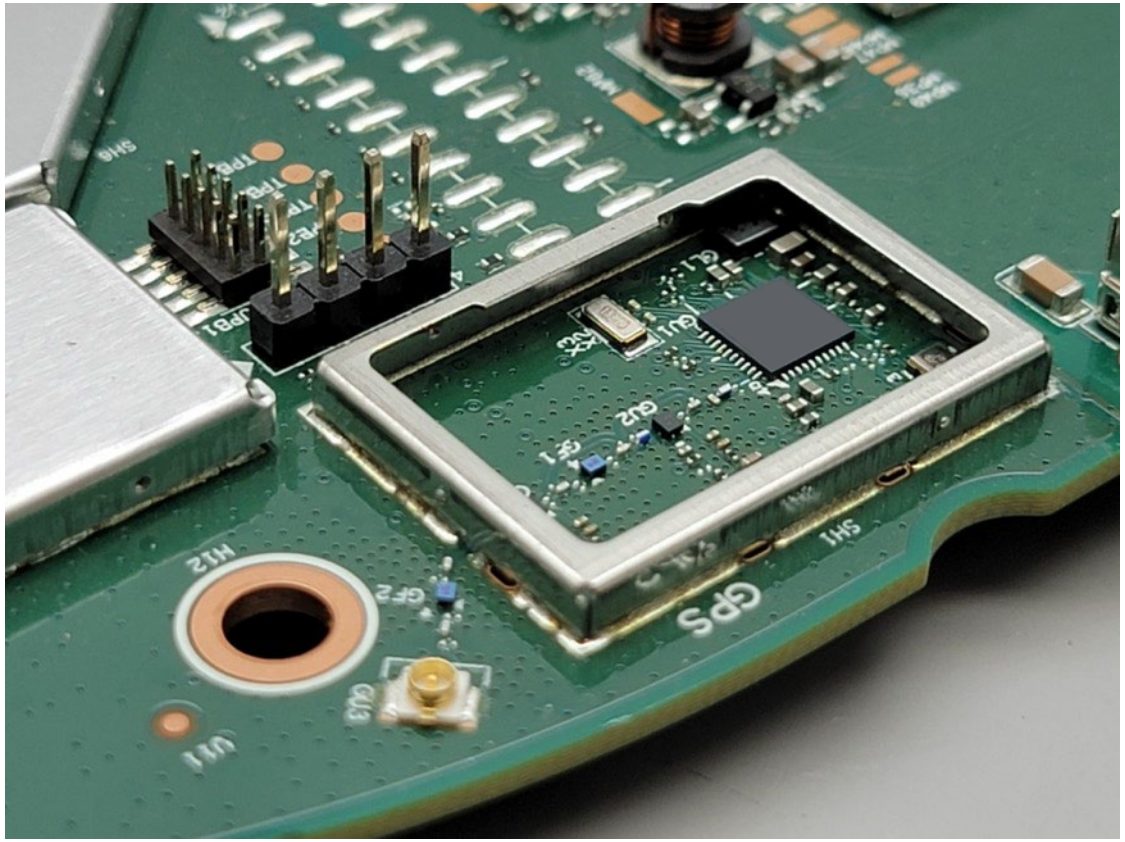
OPEN LOCATE: NETWORK LOCATION – UNIVERSALLY ACCESSIBLE

- High-sensitivity GPS receivers in every Aruba Wi-Fi 6E Access Point anchor network location in a universal reference frame
- High-resolution, time-based ranging among all Wi-Fi 6 and Wi-Fi 6E Aruba APs establish relative positions among all network nodes
- Measurements orchestrated and processed by Aruba Central to establish a reservoir of absolute and continuously validated locations and telemetry measurements from all Aruba APs
- WFA Wi-Fi CERTIFIED Location across the entire AP-500 and AP-600 portfolios enabling Fine Time Measurements initiated from any mobile OS with full network node location information (LCI)
- Network location advertised over the air to allow clients using various technologies to orient themselves with respect to AP locations
- APIs of the Central Location Engine allow location to be woven through the workflow of every Aruba service



HIGH-SENSITIVITY GPS RECEIVER
IN EVERY WI-FI 6E ACCESS POINT

- Optimized for indoor, stationary operation
- Roots AP locations in absolute universal reference frame of WGS84 coordinates compatible with any geo-referenced map
- Establishes world's largest GPS reference network, capable of generating high quality assistance to improve AP and client location
- Prepares every currently-available Wi-Fi 6E LPI AP to operate at Standard Power pending forthcoming regulatory approval



HOW CAN GPS WORK INDOORS?

Our investigations* have shown that:

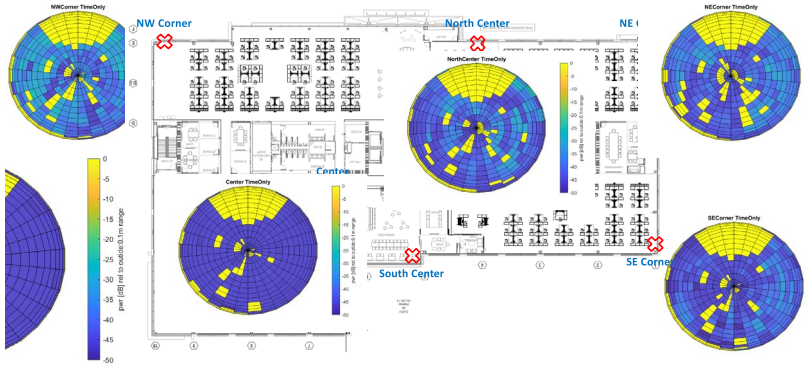
Individual GPS satellite signals are visible over a wide range of in-building environments

Signal availability varies widely with interior depth, floor level, and over time

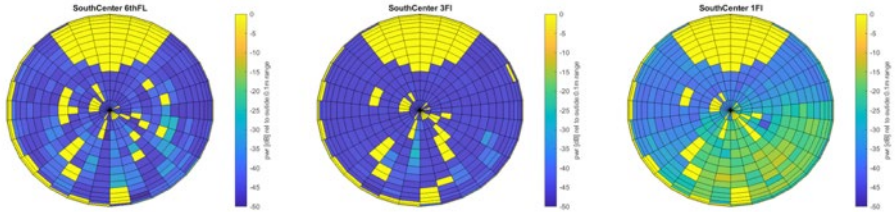
Challenges of deep indoor environments can be offset by

- Combining measurements taken at different times or by receivers with different views of the sky
- Optimizing search and acquisition algorithms for specific characteristics of a stable constellation of collaborative receivers
- Sharing precise, local assistance information among proximate receivers

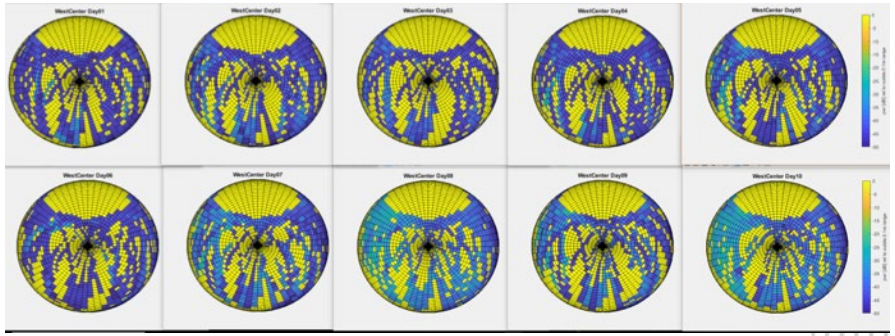
Residual uncertainty in GPS measurements can be minimized through the use of ranging measurements among collaborative receivers



Spatial Variation in Signal Visibility



Floor-Level Variation in Signal Visibility

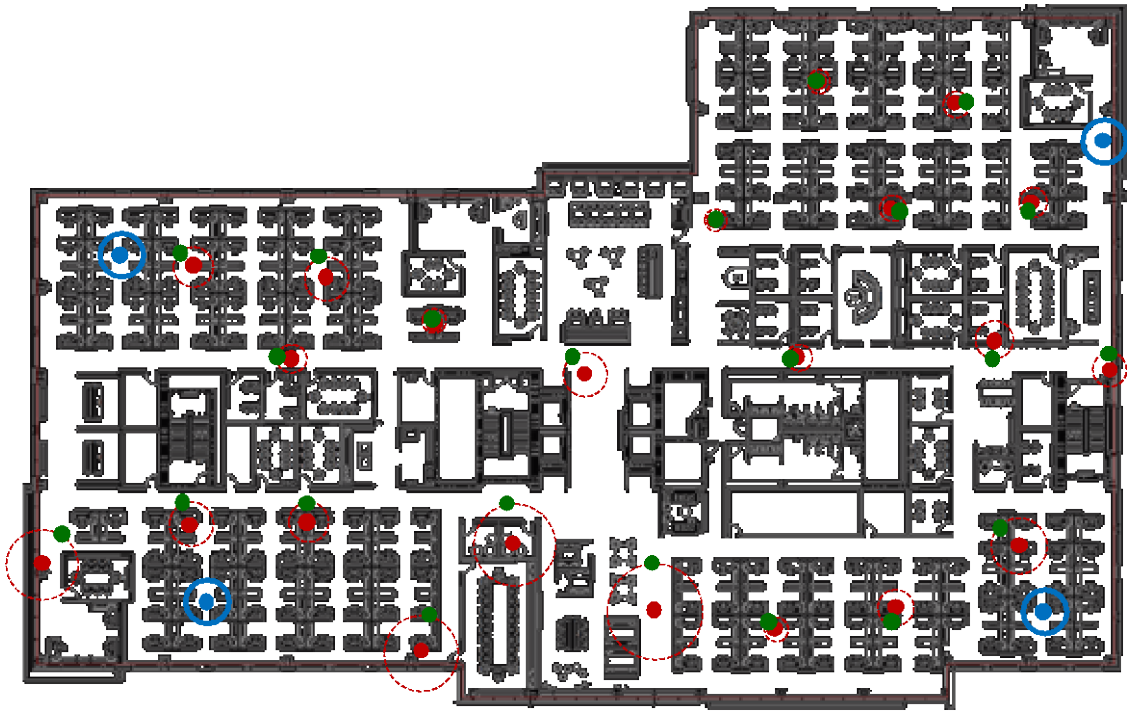


Temporal Variation in Signal Visibility

*Studies conducted in collaboration with iPosi

THE ENGINEERING BEHIND ARUBA'S SELF-LOCATING NETWORKS

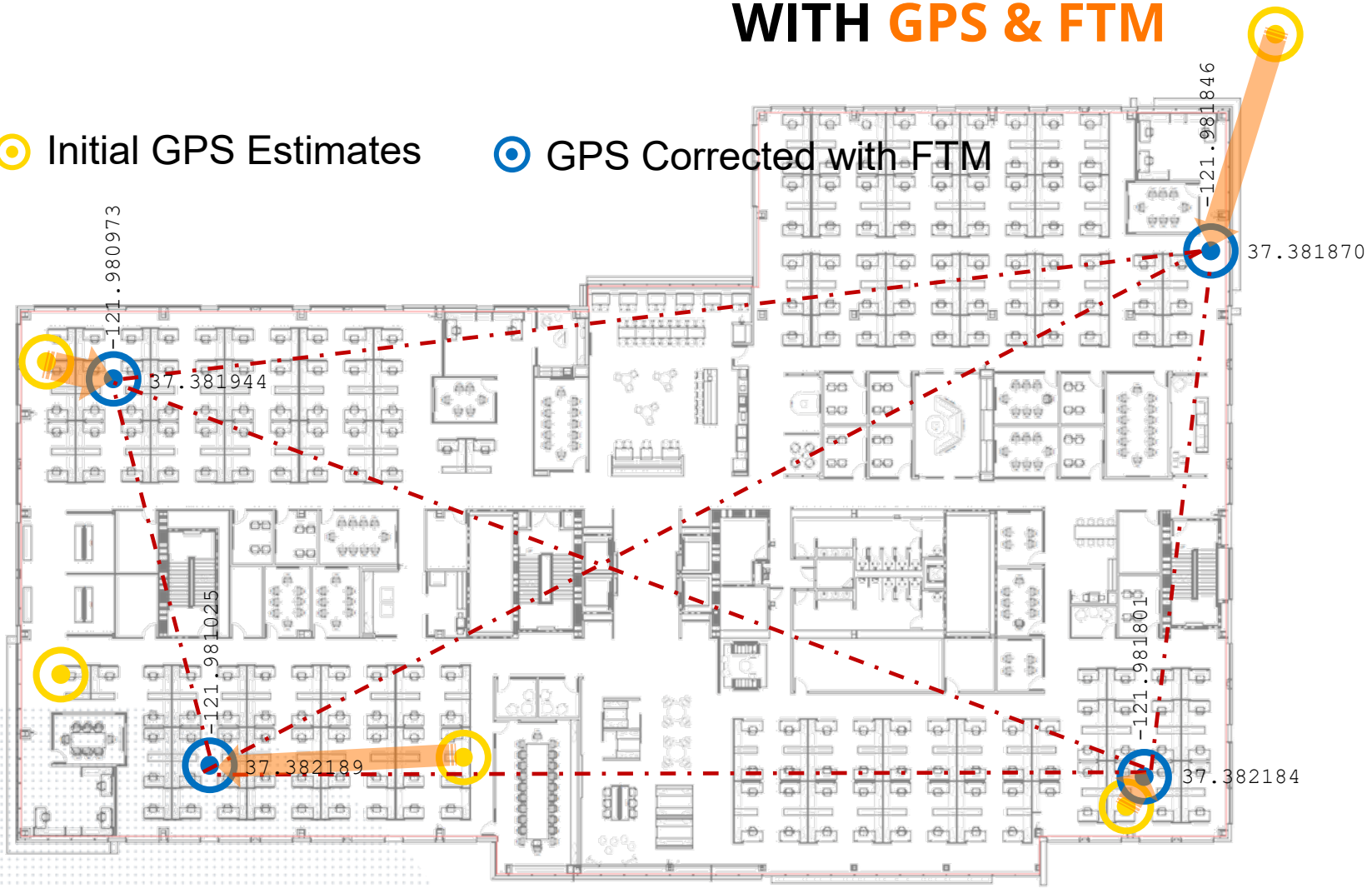
- GPS receivers generate candidate anchor points rooted in universal coordinate system
- Coordinated FTM establishes initial estimates of relative AP locations and constrain GPS uncertainty
- Iterative application of multi-dimensional scaling algorithms refine position estimates, including those of candidate anchor APs
- Measurements orchestrated opportunistically and continuously re-evaluated to ensure integrity and improve accuracy
- Client devices and network-based services receive AP locations over the air and via Central APIs using Open Locate interfaces
- Using FTM and/or other methods, clients locate themselves in any geo-referenced map or application

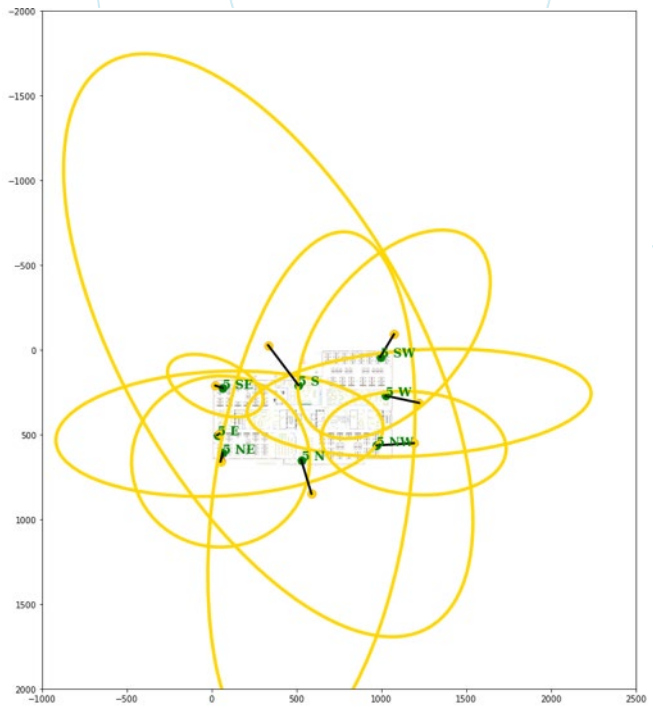


ESTABLISHING ANCHOR LOCATIONS WITH GPS & FTM

Initial GPS Estimates

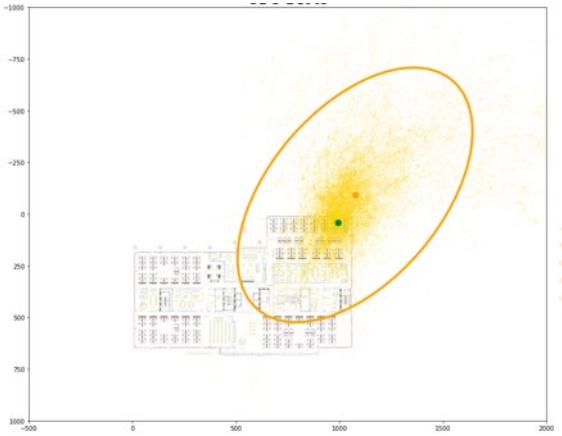
GPS Corrected with FTM





True AP Location

GPS Uncertainty Ellipse (95%ile)



Typical 24hr GPS Distribution

OPEN LOCATE: NETWORK LOCATION FOR ALL

Industry initiative to make network location information freely accessible in standardized formats

Collaboration spanning network equipment vendors, client operating systems and devices, chipset manufacturers, service providers, and applications developers

To be aligned with Wi-Fi Alliance certification programs

Over the Air

- Advertise location capabilities, resolution, confidence, and integrity
- Broadcast reference location in 802.11 and BLE beacons
- Respond to location queries in ANQP exchanges
- Populate location information in LCI fields of FTM exchanges
- Provide additional assistance data to support client location and sensor calibration

Through Cloud APIs

Respond to queries from network administrators and authorized service providers for:

- Network node location
- Client device location
- Venue-based location analytics

COLLABORATING WITH MOBILE OS VENDORS TO ENSURE INDOOR LOCATION AVAILABILITY

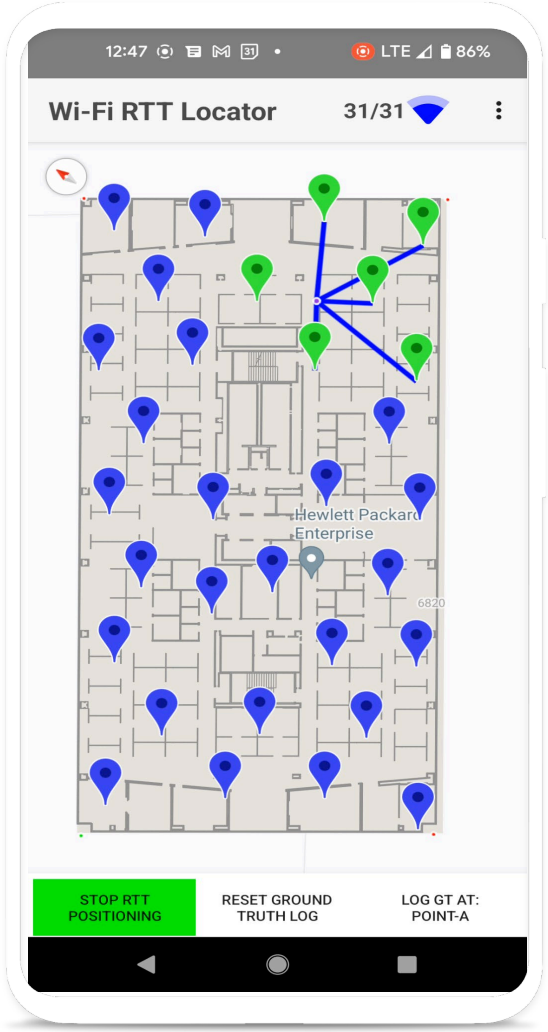
Open Locate within the Google Ecosystem

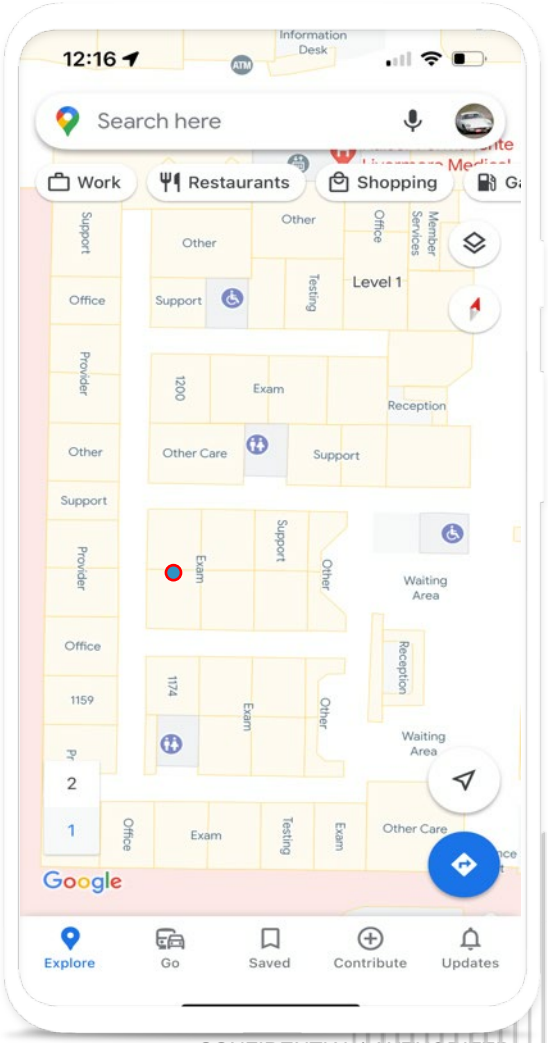
Android Wi-Fi RTT API

- Returns FTM ranges and AP location, where available
- Developers must integrate measurements with their own location engine
- Currently delivers best results with accuracy of 1-2m

Fused Location Provider

- Location API within Google Play Services
- Standard method for accessing location information
- Integration of FTM underway
- AP locations currently estimated from crowd-sourced sightings
- Existing FTM standards allow incorporation of Aruba self-locating AP data as these become available
- Seamless support in existing applications





ARUBA'S VISION FOR THE FUTURE OF INDOOR LOCATION

Our Aims

- Locate every AP in the enterprise Wi-Fi footprint
  - Automatically, without any manual survey or customer intervention
  - Accurately – on par with the highest quality client ranging methods
  - In a universal reference frame (lat/long), with no dependencies on local customer maps or floorplans
  - Scalable across our entire global installed base of Wi-Fi
- Make this information freely and readily available in all network tools and applications and throughout the ecosystem over standardized interfaces
- Prepare all Wi-Fi 6E APs, indoors or out, to operate at Standard Power
- Enable existing location-aware applications to work indoors without modification

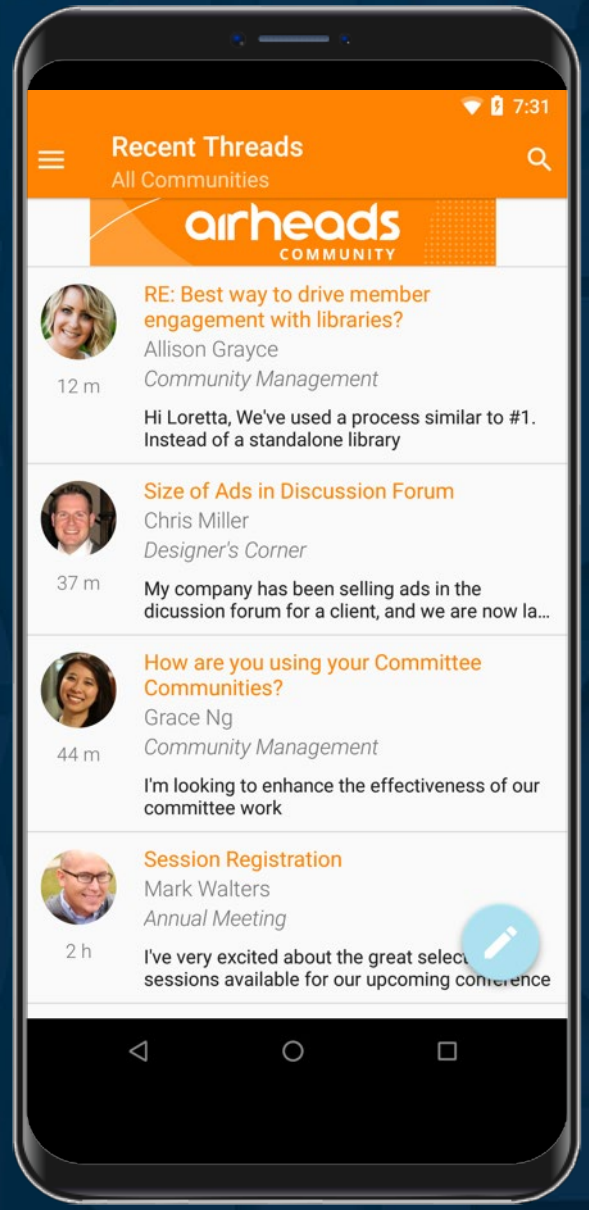
First Steps

- Embedded GPS receiver in every Aruba Wi-Fi 6E AP
- WFA Wi-Fi Location (FTM) support across the Aruba Wi-Fi 6/6E portfolio
- Open Locate initiative to make this information universally available and freely accessible throughout the networking ecosystem

airheads COMMUNITY

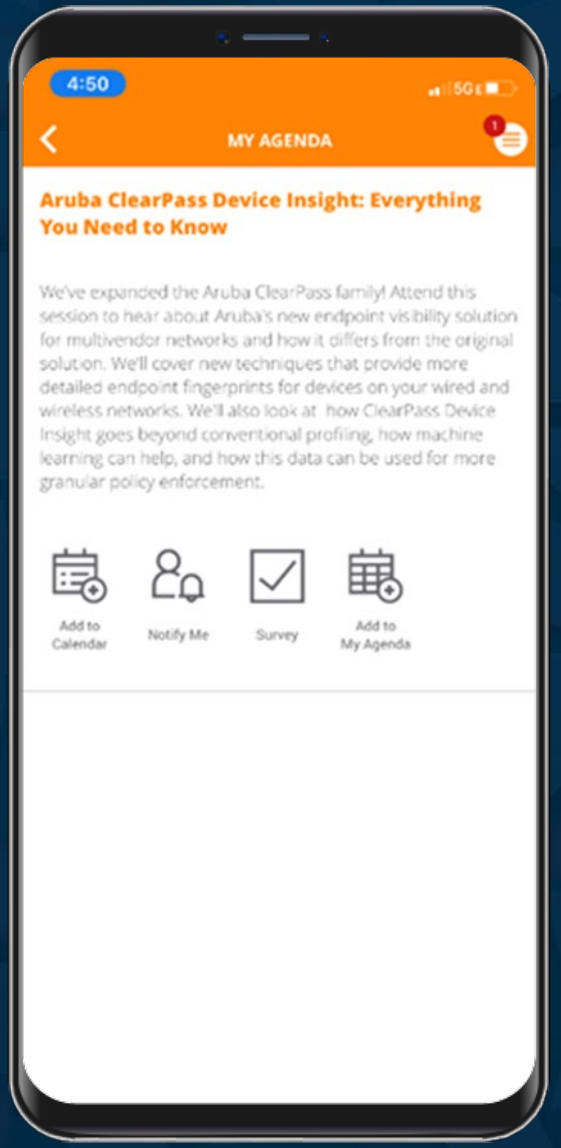
Still not part of the Airheads Community?

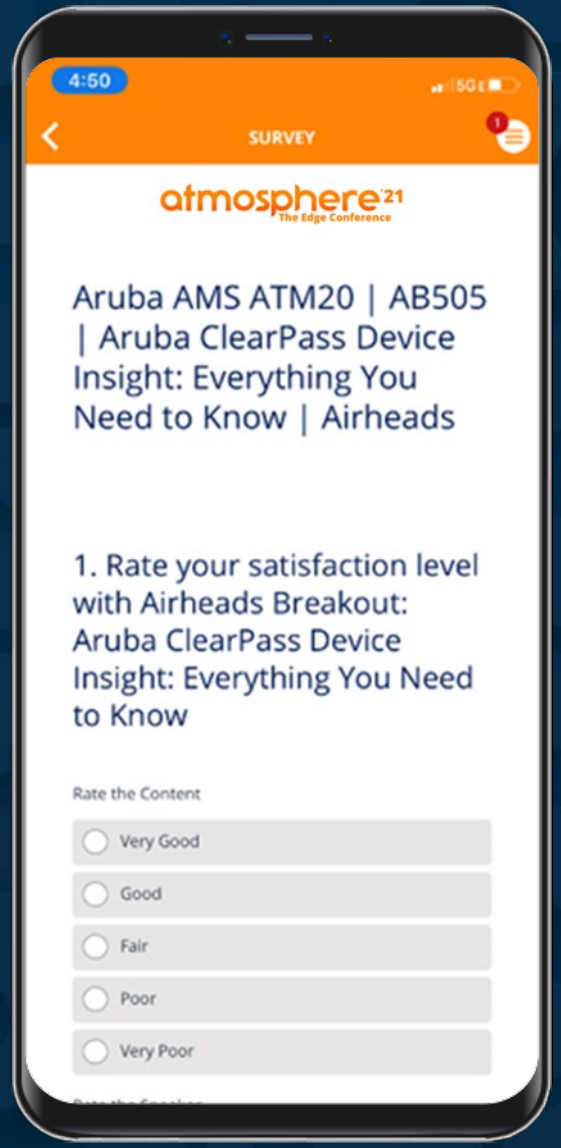
Sign up today:
www.community.arubanetworks.com



Please give us your feedback:

- ✓ Click on "Agenda" icon
- ✓ Click on the session
- ✓ Tap the "Survey" icon





atmosphere'22

FINLAND

Thank you

John Schaap
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June 2, 2022

aruba
a Hewlett Packard Enterprise company

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