

Automatic Frequency Coordination vs Radio Resource Management

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Adding the 6GHz band to the Wi-Fi was great jump that promised with more reliable connection than before, however; the celebration wasn't perfect as the bad news stepped to the door and said:

“WAIT, LOWER DOWN THE DJ VOLUME; YOU ARE ANNOYING THE NEIGHBORS”.

Yes, this is exactly what happened with 6GHz welcome party, it was banned to carry the enjoyment to the outdoors to avoid annoying their neighbors which are other systems operating on the same band.

But it's not the end of story; as usual hero came out of the crowds carrying the solution, we may guess it's called the AFC.

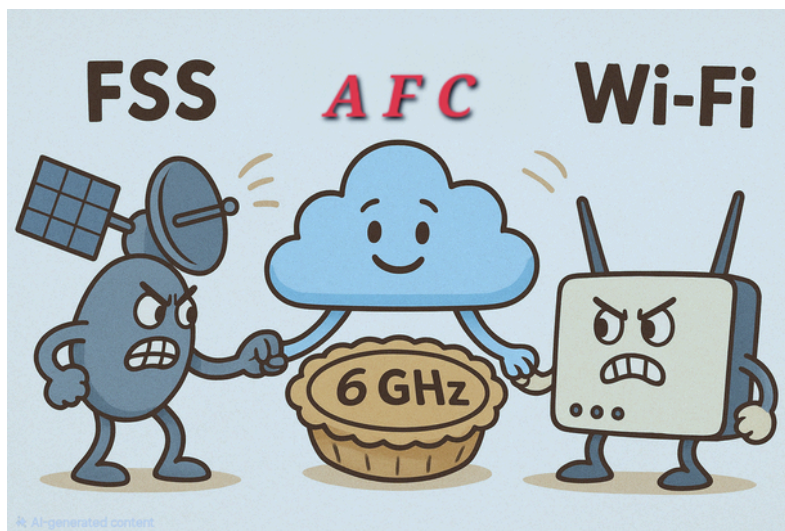


Figure 1: AFC coordinates 6GHz pie sharing between FSS and Wi-Fi

Let's break down the story above using the language we speak in CWNP world; the technical one.

Following the end of our last scene, “AFC” we will move on. AFC stands for “Automatic Frequency Coordination”, a solution for major issue in Wi-Fi 6E/7 standards, which was the interference created in the outdoor environment with incumbent systems under the 6GHz licensed band part.

Power Class	LPI	SP	VLP
EIRP Max (dBm)	24	36	14
Use Environment	Fixed Indoor	Fixed Indoor/Outdoor	Mobile Indoor/Outdoor
Use Cases	1. Enterprise network 2. Home wireless (mesh deployment) 3. Industrial IOT	1. Outdoor Coverage. 2. Pt-to-Pt links. 3. Large Indoor areas (warehouses)	1. VR/AR usage. 2. High resolution video streaming (4K/8K)
Power Class	LPI	SP	VLP

While the first one already clarifies its meaning, it has low power that can be useful within indoor environments but within the outdoor side, MIMO best friend (Multipath) won't be there to help, so we have to speak loud to get heard, and this requires more TX power that may result with interference on other systems that already using 6GHz band (UNII5-UNII7) where SP step in to solve this problem. So, what are these systems we care about?

1. Microwave Links

“There are nearly 50,000 registered 6 GHz microwave links in the US. Most links are in the UNII-5 band, followed by UNII-7.” [Ref.4]

However, *if you don't see it, you won't believe it*, that's why I have listed couple of vendors utilizing these bands on their Microwave products.

- a. Aviat WTM4500.
- b. CableFree FOR3.

2. Fixed Satellite systems

Within this system, 6GHz can be deployed for multi-use cases such as:

- a. Satellite Passive sensors that observe global soil moisture, Sea surface temperature and Wind, these data can be used in climate monitoring.
- b. Inmarsat Network is another example as well, that provides critical communication to European citizens, business and government users, this includes provision of satellite communications for the Global Maritime Distress and Safety System (GMDSS), which could be unable to operate if interference was to occur to the C-band satellite uplinks, causing lives risk. [Source: Ref.10]



Figure SEQ Figure * ARABIC 2 CableFree FOR3
[Source: CableFree-REF19]

Bands where AFC is required

The band portions where AFC is required are mainly two bands:

1. UNII-5 (5925-6425) MHz
2. UNII-7 (6525-6875) MHz

The above-mentioned bands interfere with C-Band in satellite systems, most specifically the Uplink part: Earth-to-Space deployment.

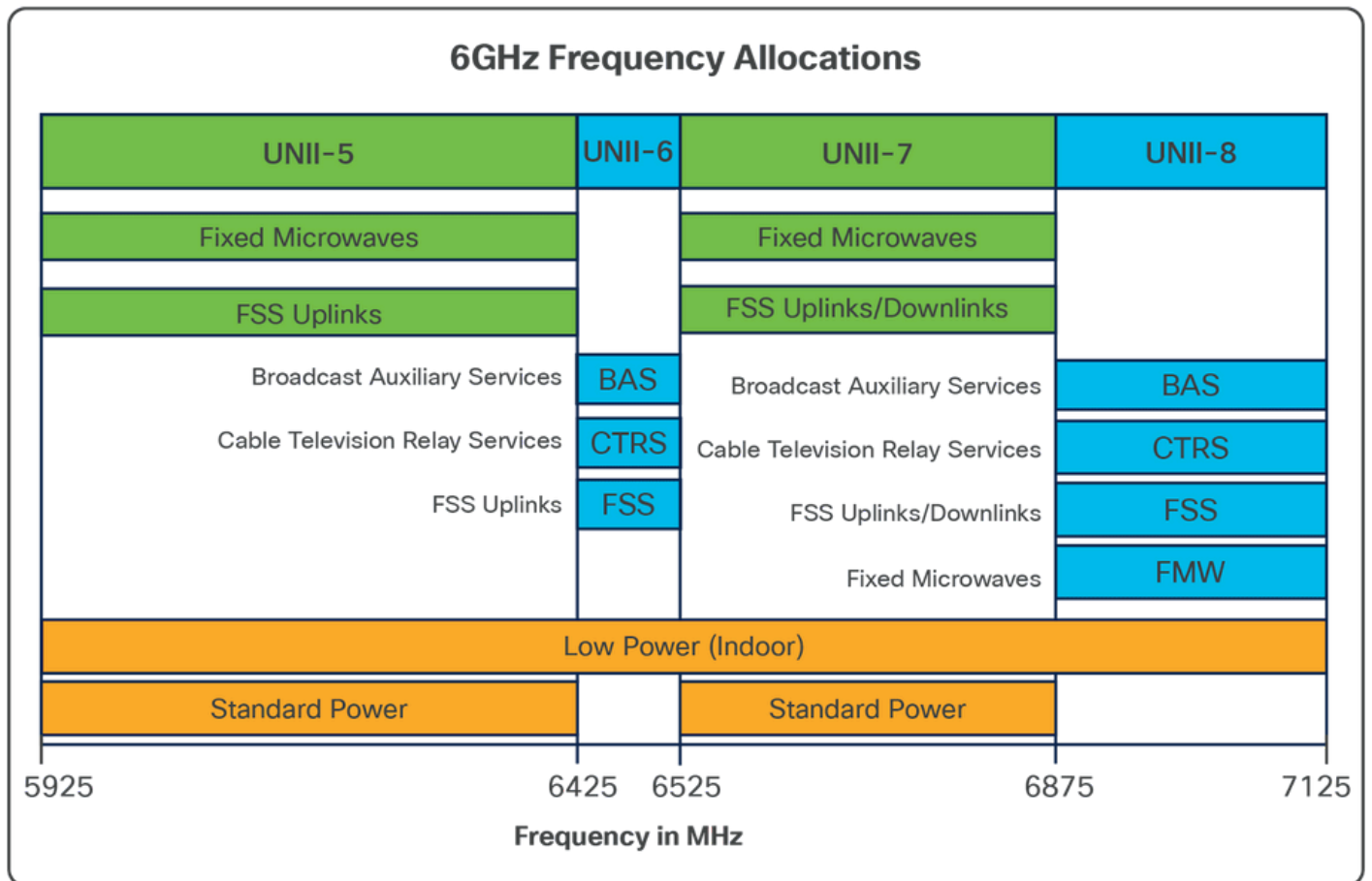


Figure 4 6GHZ SPECTRUM [SOURCE: CISCO-REF1]

C-band variations around the world

Band	Transmit frequency (GHz)	Receive frequency (GHz)
Standard C band	5.850–6.425	3.625–4.200
Super extended C band	6.425–6.725	3.400–3.625
INSAT / ITU Appendix 30B	6.725–7.025	4.500–4.800
Russian C band	5.975–6.475	3.650–4.150
LMI C band	5.7250–6.025	3.700–4.000

Figure 5 C-BAND VARIATIONS [SOURCE: WIKIPEDIA-REF14]

What are the AFC requirements

1. Global Positioning System (GPS)

It is required to determine the location that needs to be checked on incumbent system existence before assigning the 6GHz channel and transmit power for requesting AP, and this process varies based on deployment environment as below:

- a. Outdoor: this requires having Global Positioning Antenna (GPS) installed to the AP, below is a sample GPS antenna from Cisco.



Figure 6 Cisco GPS antenna [Source: Meraki-REF-20]

- b. Indoor installations determine the position for inside the building Access Points by adopting anchor AP method, this makes some Aps with clear GPS signal to share the location with others inside the perimeter of the building through wired link, for indoor environment accuracy varies based on AP to window distance and GPS signal clearance. For Aps that have weak built in GPS, or no GPS, it can have modular one installed (using USB) or another type of connector to enhance signal strength and grant more accurate position.

The best practice for this method is to have GPS connected AP on each switch, so that all Aps on that switch will be in 200m maximum distance from GPS-AP location. [Source: Cisco]

2. AFC client

Usually, this software is pre-loaded by vendors and linked to their cloud management (by burned in domain name) that will be reachable through internet. This agent that performs responsible for:

- a. Query the AFC operator's database via either HTTPS or even API integration.
- b. Share device related parameters like location, antenna gain, height
- c. Receives authorized frequency and power levels and apply it in real time.

3. Regulatory Certificates & Vendor Approval

- a. The AP should be AFC approved and integrated with an approved AFC system to perform the AFC check.
- b. Having certified firmware listed in AFC certification.

4. Internet connectivity

Allowing HTTPS port 443 on Firewall as well as DNS to locate and reach the AFC server.

All 6ghz capable hardware support AFC?

Short answer: NO if the hardware can't fulfill above requirement.

How does it work?

The AFC system will have a database for all surrounding incumbent systems with below Parameters so it can build coverage prediction model that shows area of possible interference based on it will decide the allowed TX channel and power for the Wi-Fi AP.

These parameters are:

- 1.Distance between license-exempt device and incumbent system
- 2.Terrains
- 3.Incumbent antenna direction/model.
- 4.Climate data.

On the other hand, it will receive request from AP desire to use SP, that request includes information as below:

- 1.Geographic location (Longitude, Latitude).
- 2.Antenna gain and pattern.
- 3.Antenna height above ground.
- 4.Channel Bandwidth.
- 5.Device ID, Serial Number or FCC ID.

Once it has all above inputs, the AFC will assign proper channel and TX power for the requesting AP. This process should be repeated every 24 hours to grant interference in a clear environment and avoid disturbance on the incumbent systems.

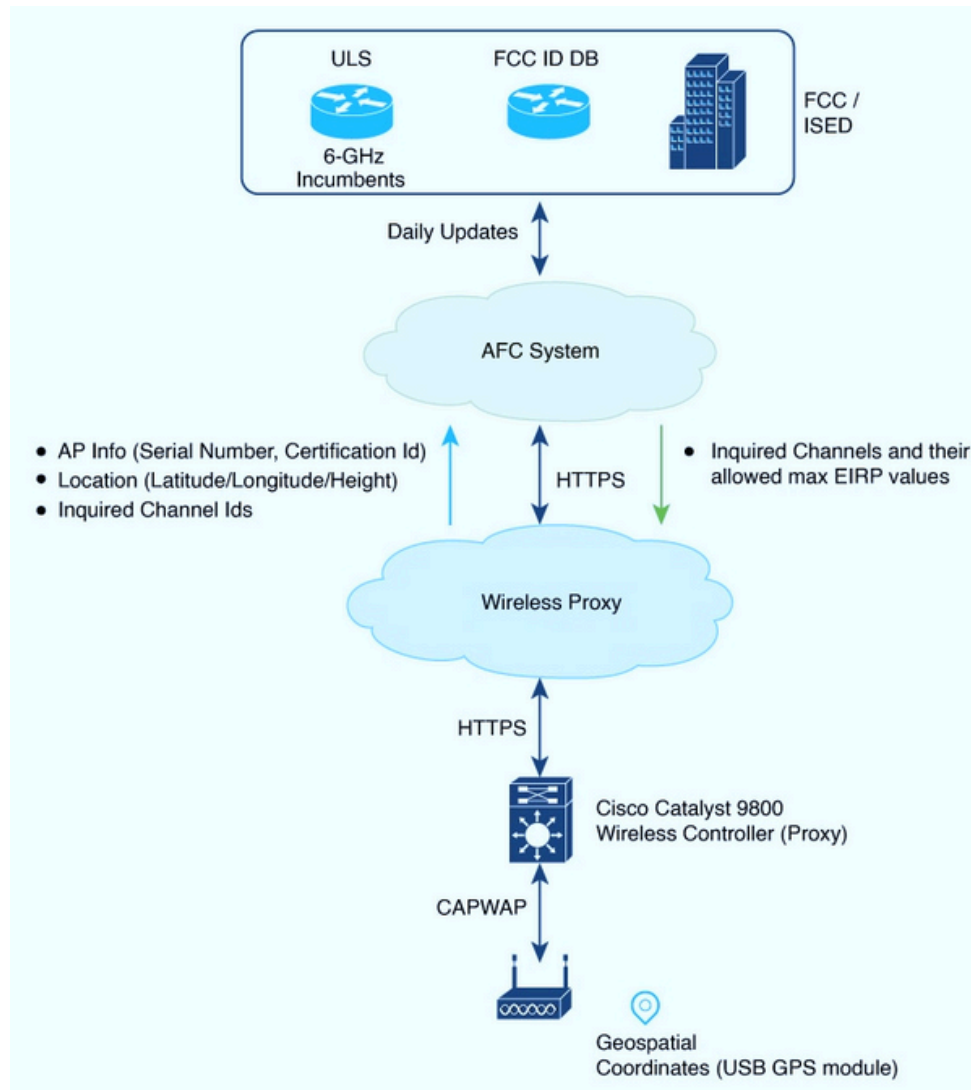


Figure 7 AFC request-Response flow [SOURCE: CISCO-REF17]

But who will be responsible for handling the above-mentioned process?

AFC system can be either one of the choices below:

1. Private entity hosted server.
2. Government entity could be within national datacenter connected to country RF database.
3. Broadband service providers.
4. Wi-Fi network Vendors might act as proxy for contacting AFC database.

AP to AFC reachability Failure

In such scenario, we have two cases as below for losing connectivity to the AFC system:

- 1.First Case -AP just booted UP: it will not transmit on SP until it receives AFC response.
- 2.Second Case -AP already using SP: The AP will remain using SP till the next check time (i.e. after 23hrs:59m), then AP should either disable 6GHz radio if it is outdoor AP or Reflects to ILP in case it is an Indoor AP model. [Source: Cisco-Ref.17]

AFC is only contacted for outdoor or only it is required for indoor

As described above, AFC was created to allow adoption of SP, while below are another examples of environment that requires SP, then AFC will be in presence as well.

- 1.Large warehouse
- 2.Indoor Stadiums.
- 3.Large houses.

AFC is enough to operate in SP

Unfortunately, AFC won't be the guard that SP only needs to operate, in addition to it , there are several requirements that apply to standard power deployment:

- Maximum allowed EIRP is 21 dBm for transmissions with 30 degrees angle above horizon.
- Probing is not allowed (this is an effort to reduce neighbor messages).
- Hot spots are not allowed.
- Vehicular deployments (even battery-powered devices) are not allowed (except for commercial planes above 10,000 feet).
- All devices (or proxy) must report their serial number (SN) and FCC ID. [Ref.1]

Real AFC Configuration steps for some vendors:

- 1.Aruba ([here](#)). [Ref.16]
- 2.Cisco ([here](#)). [Ref.17]

Conclusion

Referring to document main title ,it's worth mentioning that AFC doesn't replace the original Radio Resource Management(RRM) process which is done by wireless controllers nor compares with it , AFC only assigns pool of allowed channels to be used and maximum TX power after verifying certain regulatory database of incumbent systems deployed in specific regions, but it will not assign specific values for those parameters.

Finally, photo below shows the regions allowed SP with AFC or still progressing the regulatory framework.

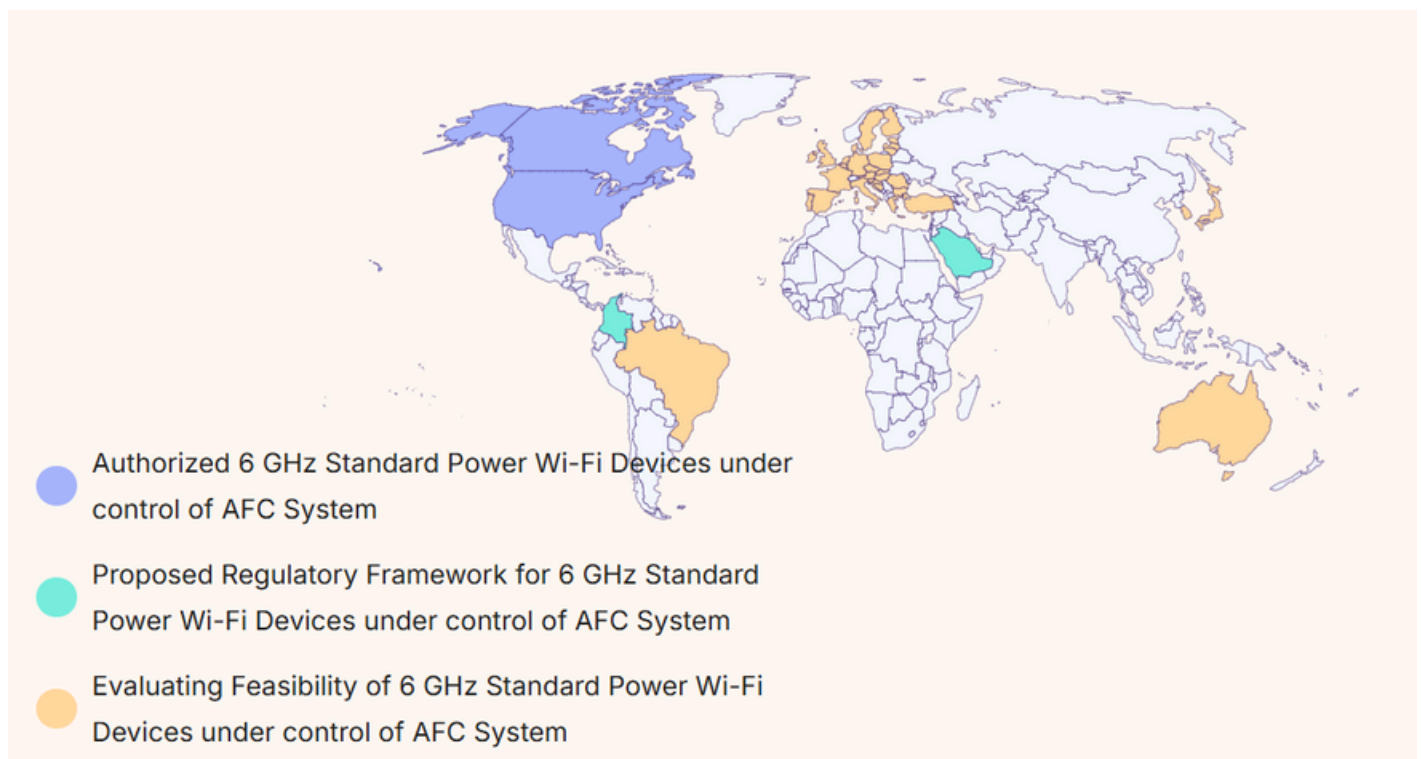


Figure 8 Countries allowing SP with AFC [Source: Wi-Fi.org-REF21]

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