



Cambium Networks™

Dynamic Shared Access Spectrum

Matt Mangriotis, Senior Director of Product Management

- ITU has been working on identifying and assigning spectrum for “5G” use
- WRC-19 has designated more than 17 GHz of spectrum for this purpose
 - <https://news.itu.int/wrc-19-agrees-to-identify-new-frequency-bands-for-5g/>
- **However, implementing this globally is quite challenging**

- How can connecting more people be easier?
- Regulating telecommunications and spectrum use is difficult
- Internationally this is even more complex
 - Need local understanding of:
 - Policy
 - Local Market
 - Existing licenses and incumbent users
- **Spectrum Sharing can provide an avenue to avoid long, complex licensing schemes releasing more spectrum to more users, while protecting incumbents**

- **TVWS:** TV Whitespace – Shift to digital TV transmission freed up spectrum, but protection for existing users is required.
- **CBRS:** Success story in the US so far, attractive mid-band spectrum that is licensed but under-utilized in many geographies
- **WiFi 6e (6 GHz):** Additional (potentially unlicensed) spectrum that could be very quickly and widely adopted by many users, but again requires incumbent protection methods.
- **mmWave:** Short range but very high bandwidth means sharing could be easier to implement.

TVWS



Where are the Opportunities for TVWS

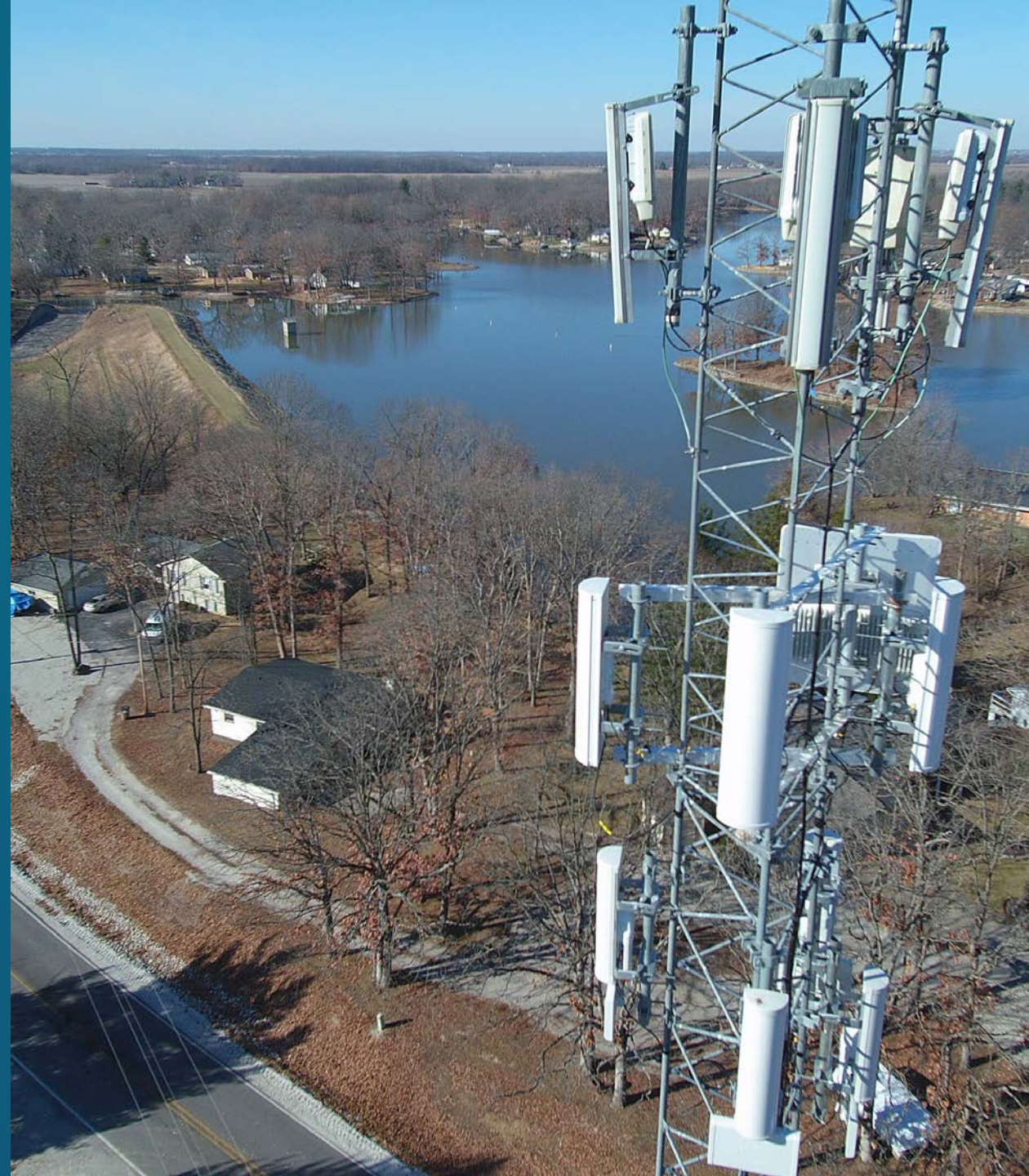


Source: Dynamic Spectrum Alliance

- Cambium had a product in 2009 that could operate in TVWS bands
- Regulations made deployment and operation very difficult
 - Extremely tight emissions mask
 - Deployment height restrictions
 - Channel size limitations
 - Lack of Database (for sharing administration)
- Discrete nature of products makes it expensive to produce
- Antennas are large, cumbersome and expensive

- This is all getting better though – Future is brighter

CBRS



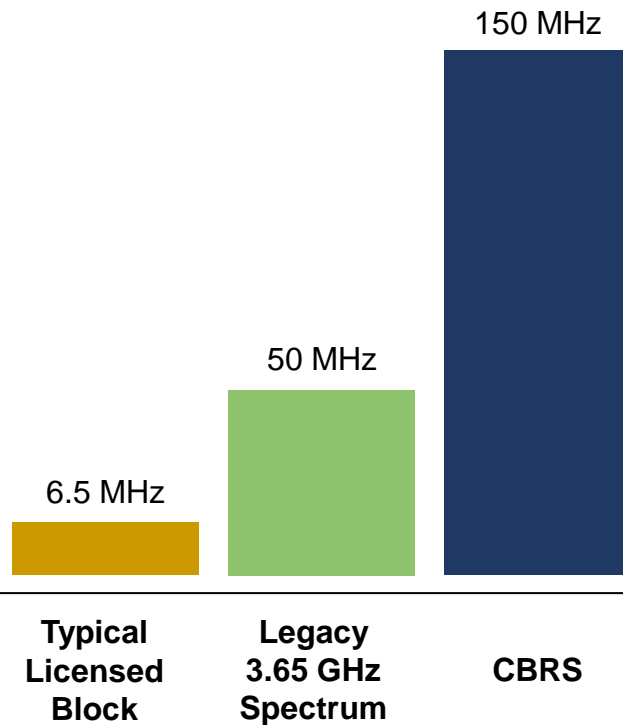
CBRS – Why does anyone care?

- Dynamic Spectrum Sharing model can be applied to any spectrum globally
 - Tiered approach to protect several classes of users of the spectrum
 - Allows sharing of unused portions of spectrum, while mitigating interference caused
- **CBRS** itself is quite complex

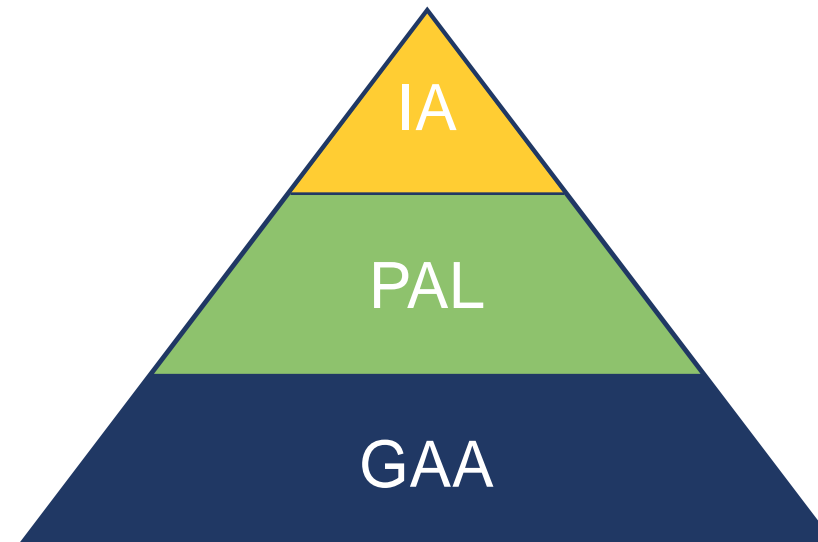
Pros	Cons
Lower Frequency than unlicensed 5 GHz (better penetration)	Spectrum sharing has a cost
Higher EIRP allowed	Hype around uses could cause congestion
Spectrum is actively managed	Equipment in this band slightly more expensive than traditional unlicensed
Incumbents protected	Standards-based (LTE) kit is predominant, and top of mind
Option to purchase license for priority use	Rules and requirements very complex

- Success being demonstrated now - many other regions and bands in process of adopting similar models

Opportunity



Tiered Flexible Use



Incumbents

- DoD Radars (coastal areas)
- Satellite Earth Stations

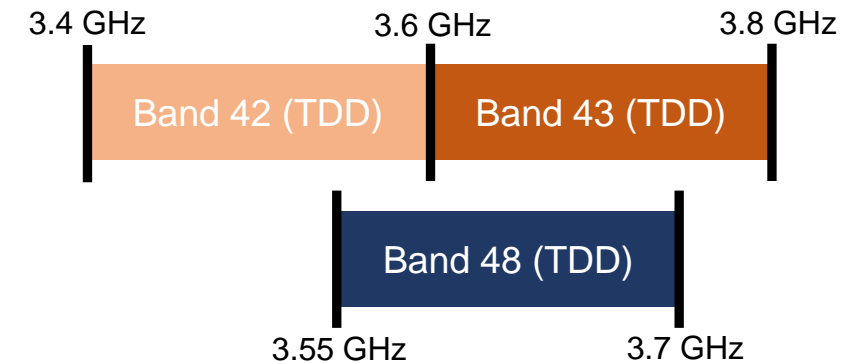
Priority Access Licenses (PAL)

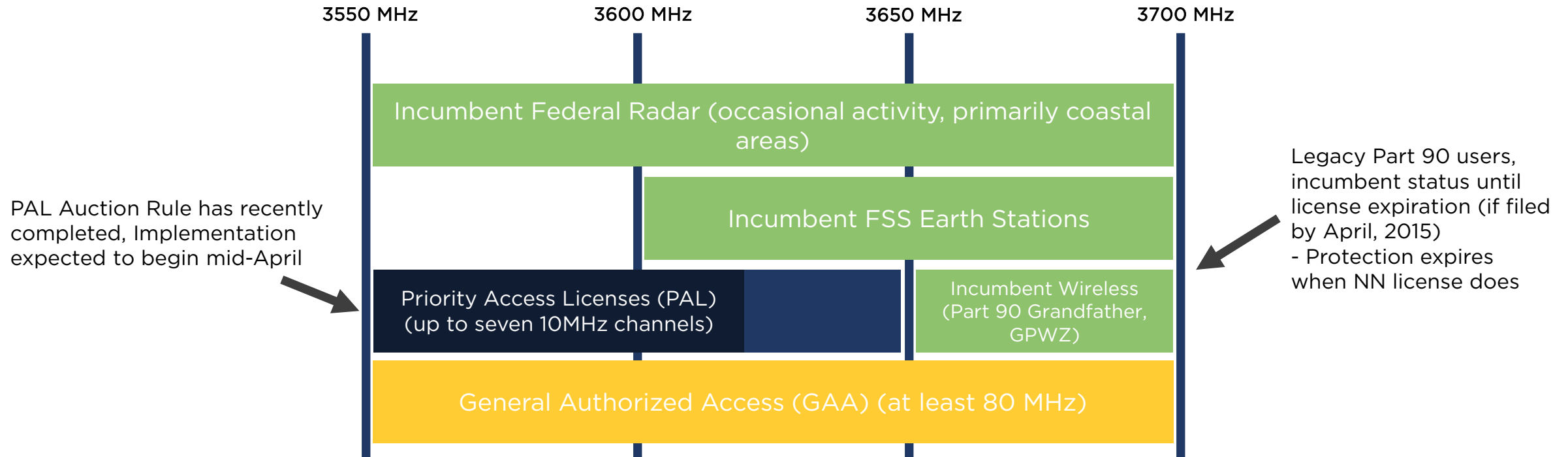
- Up to 70 MHz of spectrum licensed by auction

General Authorized Access (GAA)

- At least 80 MHz nationwide

Establishing a New Common Band





Cambium expects that many of its customers have won PAL licenses in counties in which they are operating, affording them some protection in using CBRS, and assuring the continued use and expansion of their networks.

- **450 platform works with all major SAS providers**

federated wireless

Google

COMMSCOPE®

- Market-leading adoption:
 - Nearly 100,000 Cambium devices operating in CBRS today
- Large Ecosystem of capable products:
 - LTE-based equipment available also
- Successful auction for PALs (\$4.58 Billion)



All 3 GHz 450
platform equipment
approved for Part 96!
(as of July 10, 2019)

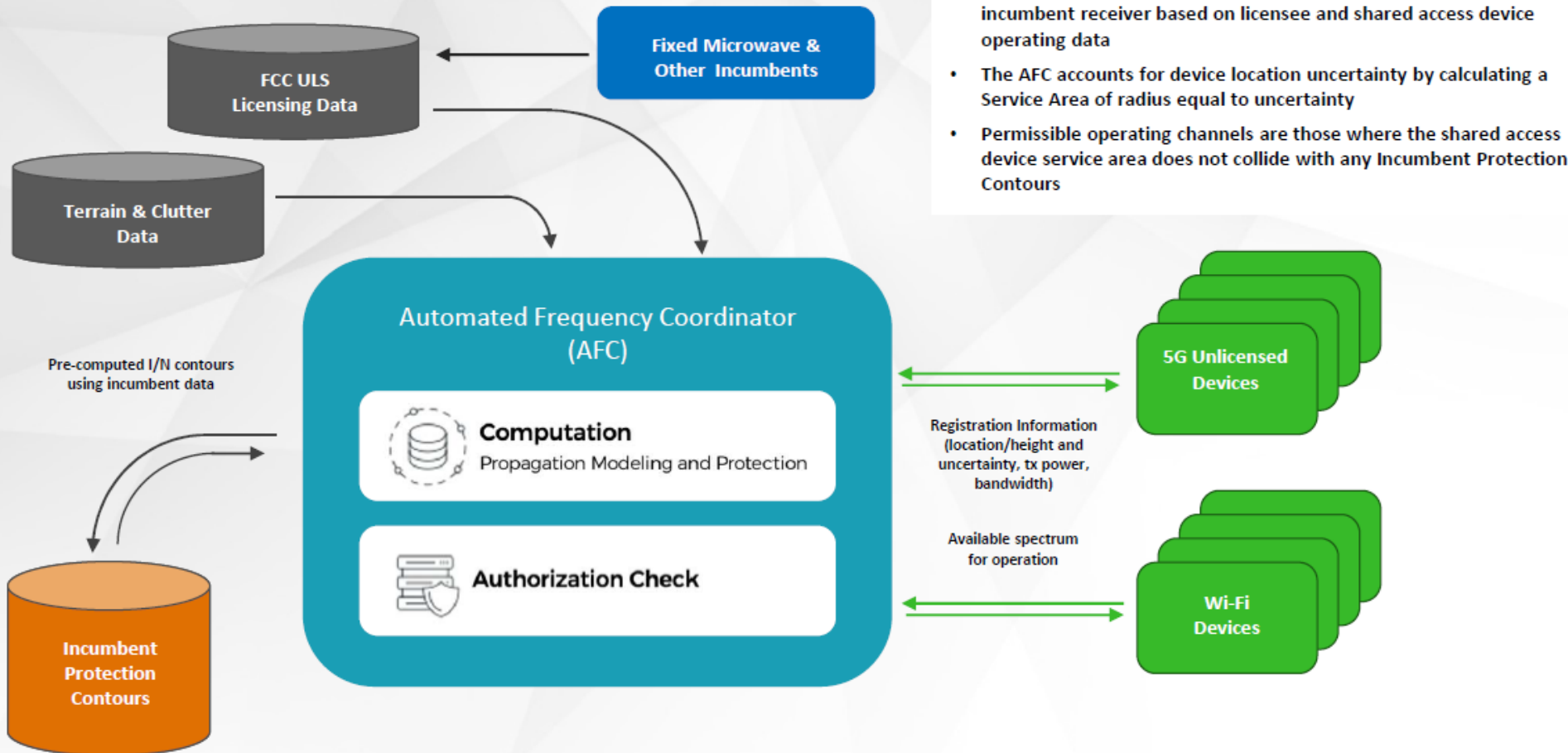
6 GHz



- Typically Wi-Fi is used in unlicensed bands
- This requires self-coordination to effectively use spectrum
 - Cambium does this using GPS Synchronization
 - Further complicated in many regions because of license holders that demand protection
- **Wi-Fi 6 and 6e provide a standard for efficiency and performance gains and will likely be the predominant technology used in the band**
 - Alternative technologies, such as the SDR protocols utilized by the 450 platform will also work quite well in this band
- **Incumbent License holders need to be protected, hence AFC**

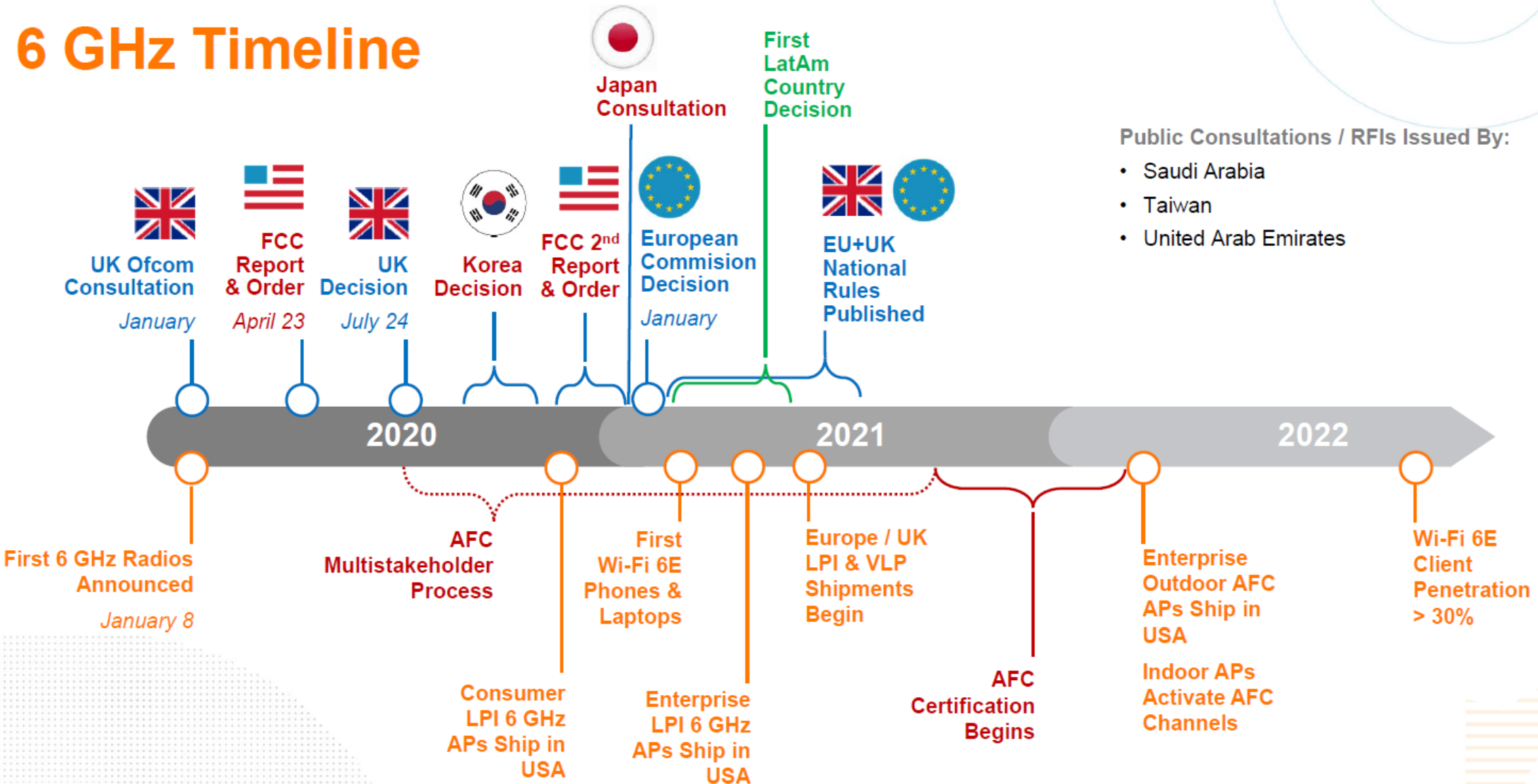
Automated Frequency Coordinator (AFC)

Cloud Automation for 6 GHz Sharing



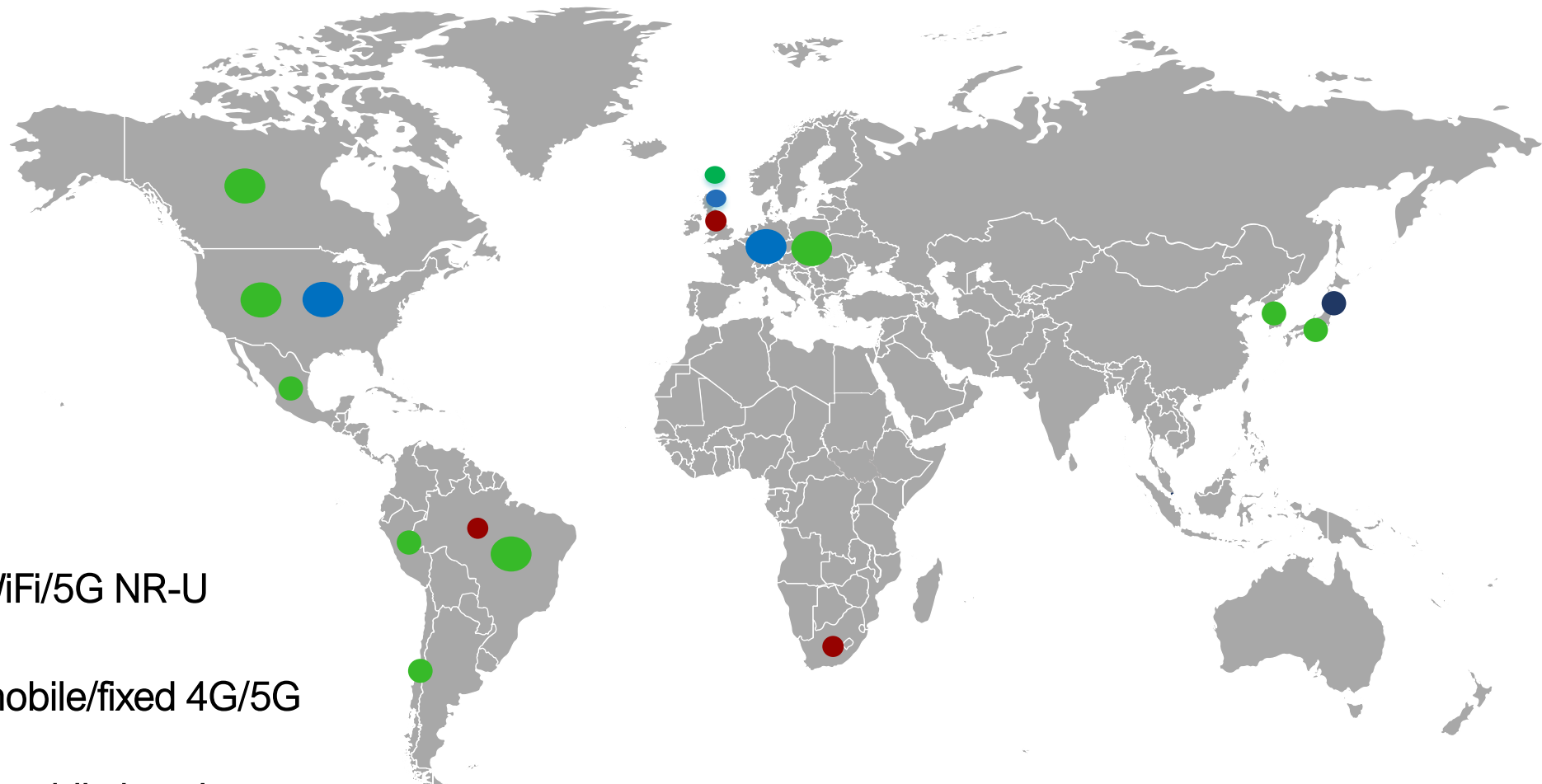
Source: Federated Wireless

6 GHz Timeline



Source: Aruba

Many Countries Have Begun Evaluation



 6 GHz WiFi/5G NR-U

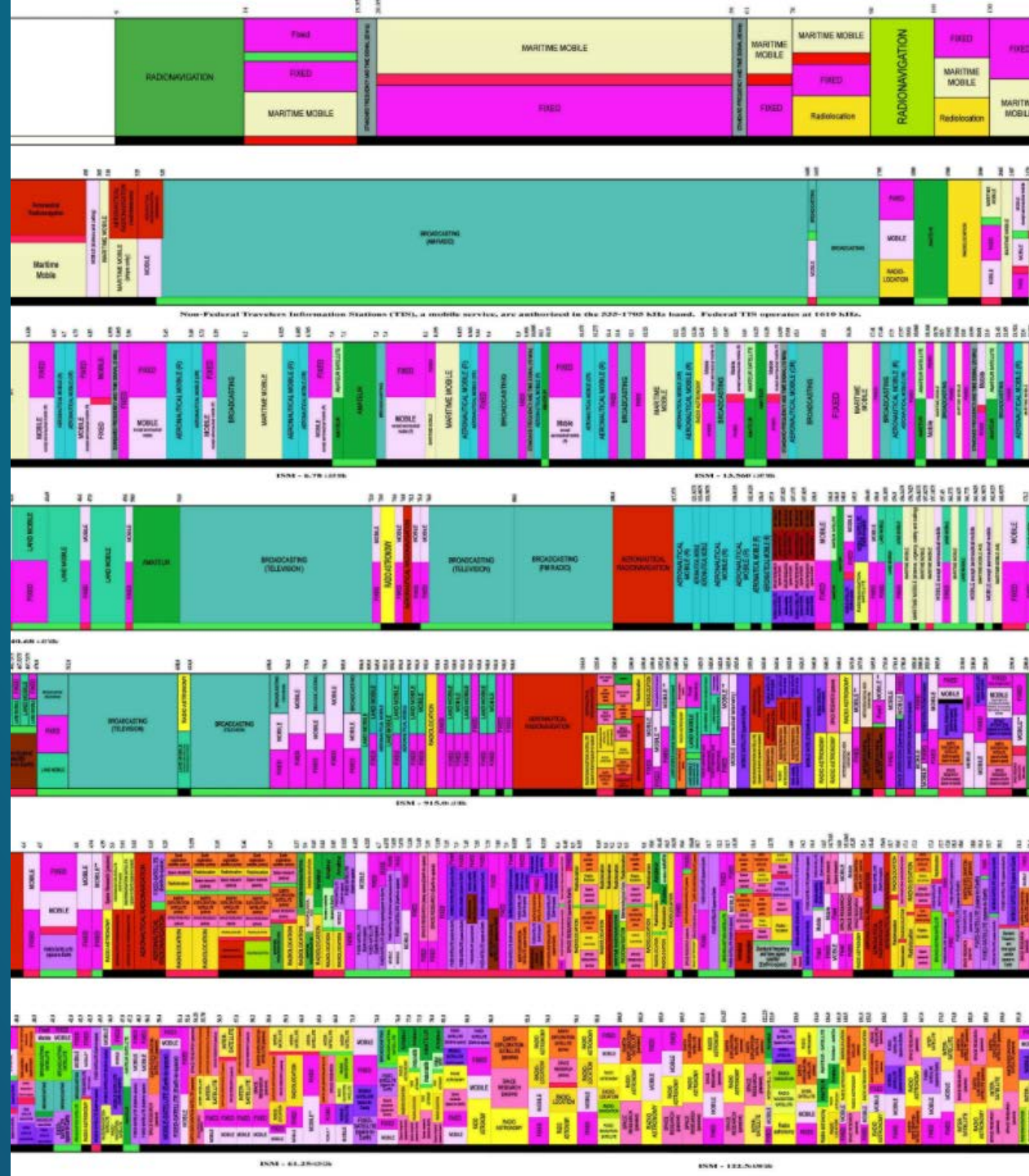
 3 GHz mobile/fixed 4G/5G

 Existing mobile bands

Source: Federated Wireless

* Sharing rules adopted, consultations launched and/or trials planned

Spotlight on Regulatory Efforts



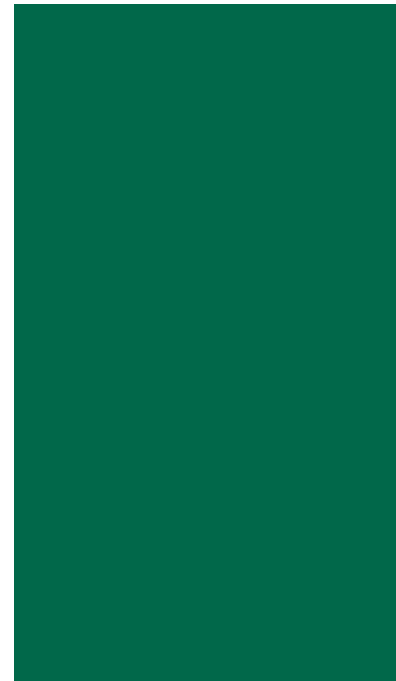
- OFCOM working to enable several bands for sharing
 - 1800 MHz
 - 2.3 GHz
 - 3.8-4.2 GHz
 - 24.25 – 26.5 GHz
- Objective: to increase quality wireless broadband coverage where people live, work and travel across the UK and to encourage the development of new uses which will benefit both businesses and consumers.



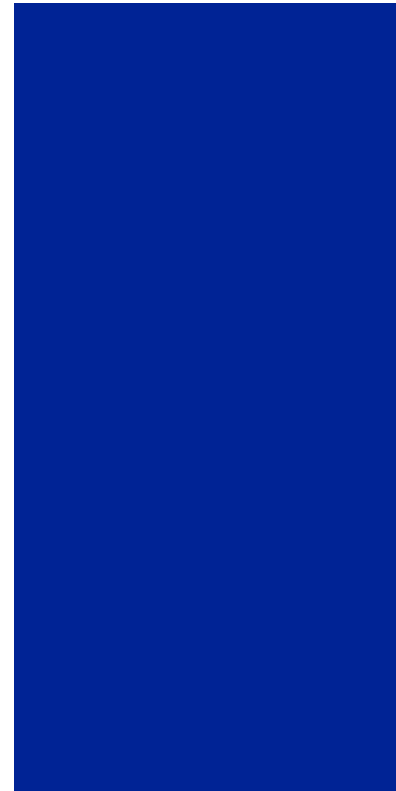
- ICASA working toward support of spectrum sharing technology
- Goal to provide affordable broadband to areas previously unserved or underserved
- **Exploring a tiered system similar to that of CBRS**
- Evaluation still ongoing but the push is strong



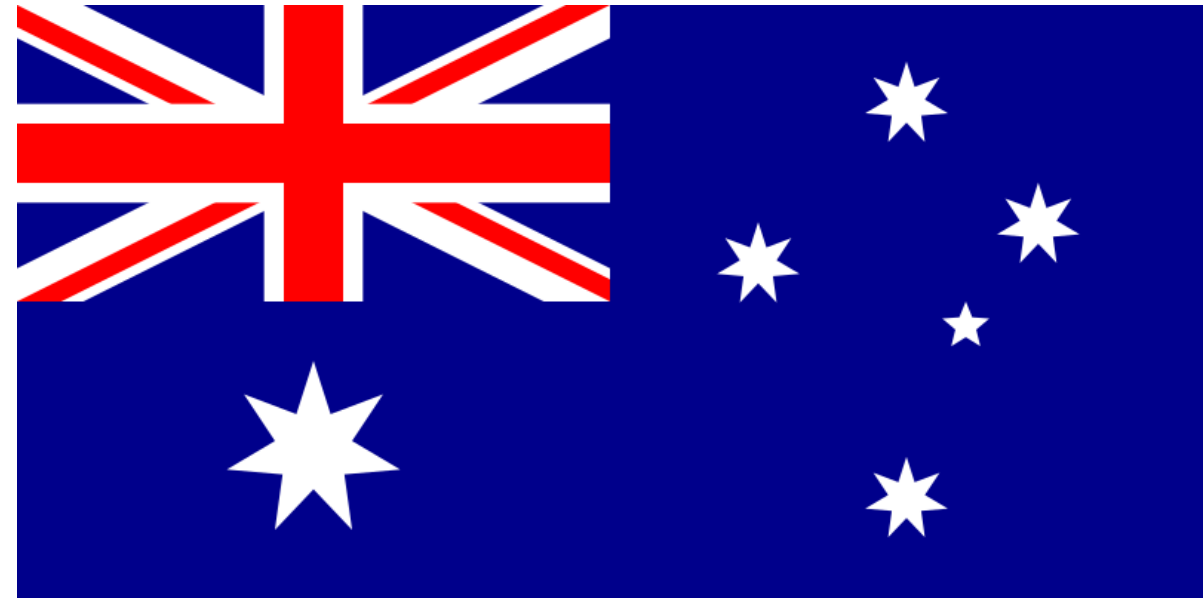
- IFETEL establishing many areas of potential sharing
- 900 MHz – some availability now, sharing between narrowband mobile users and fixed
- 2.3 GHz – “refarming” of fixed services, may be used for varying use cases
- 3.4-3.6 GHz – Protection of fixed satellite stations is key
- 6 GHz – Public consultation ongoing
- Exploring “secondary use” for TVWS



- ANFR has many programs in process for spectrum sharing
- Working with CEPT on 3 GHz band
- 26 GHz for 5G – Protection required for space and scientific services (Earth stations)
- 6 GHz being explored, agree that geolocation is key tool to success



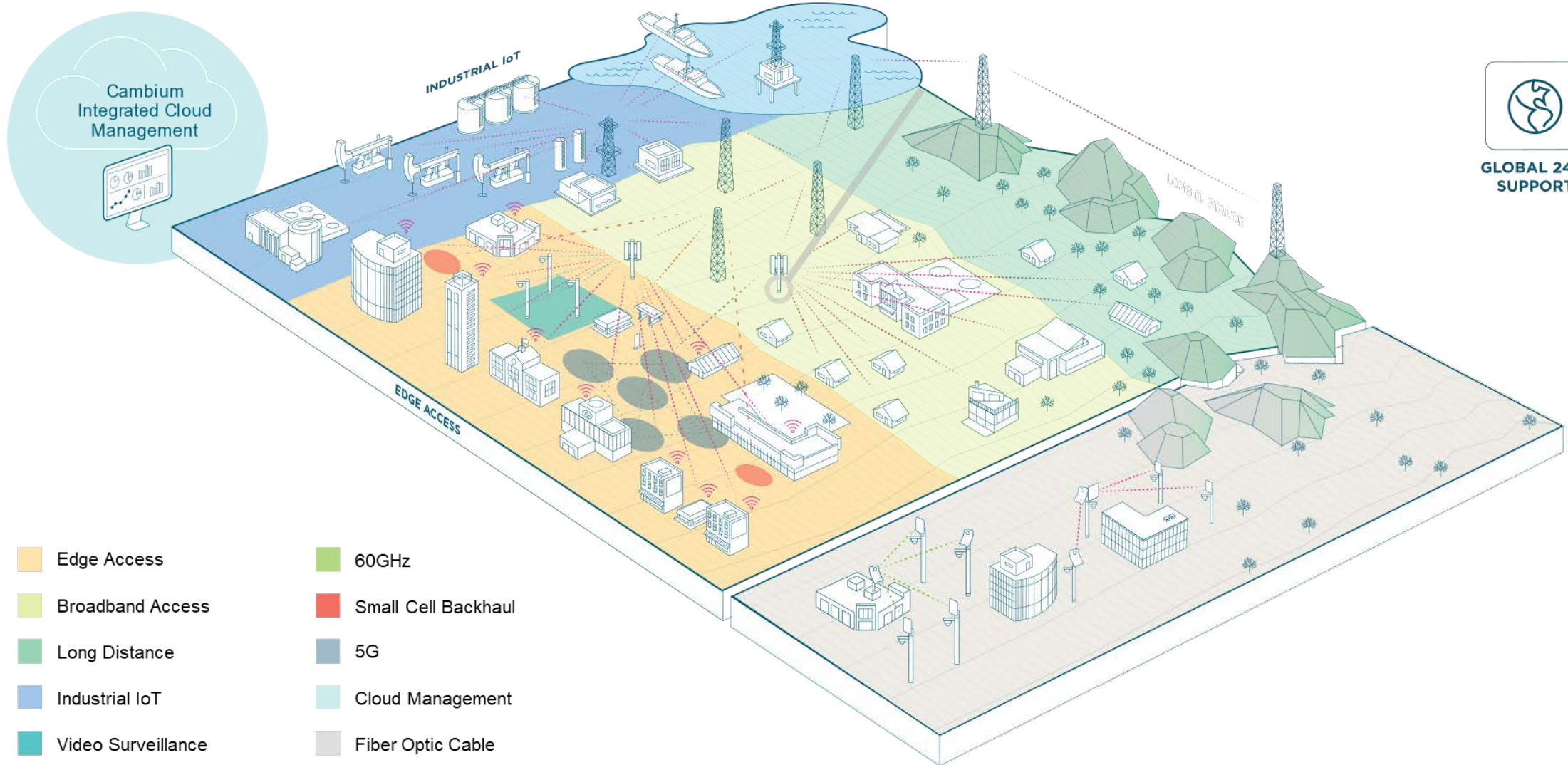
- ACMA following closely “non-traditional” sharing approaches in other countries
- To date, nothing implemented
- 6 GHz being explored, likely to adopt AFC similar to US



Summary



Cambium Networks' Gb Wireless Fabric



- **Spectrum Sharing will undoubtedly be a useful tool to drive economic growth and access to broadband**
- **Many technologies will help enable this growth and can be applied to Dynamic Sharing Model**
 - 3GPP 5G
 - Wi-Fi 6
 - Software-Defined Radio Systems
- **Cambium Networks is adding threads to our Wireless Fabric**
 - Adopting Standards
 - Addressing 28 GHz
 - Addressing 60 GHz
- **Leveraging Decades as a Fixed Wireless Broadband Leader**



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Questions?



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