Federal Communications Commission
Technological Advisory Council Meeting

January 14, 2021

FCC Technological Advisory Council Agenda – January 14, 2020

10:00am – 10:10am	Introduction and Opening Remarks
10:10am – 10:20am	Announcements and Roll Call
10:20am – 10:55am	Artificial Intelligence WG
10:55am – 11:20am	Future of Unlicensed Operations WG
11:20am – 11:45am	5G RAN Technology WG
11:45pm – 12:10pm	5G IoT WG
12:10pm – 12:30pm	Closing Remarks
12:30pm	Adjourned

FCC TAC
Artificial Intelligence and Computing Working Group [AIWG] – Chairman's Briefing

Chairs: Lisa Guess, Cradlepoint
Adam Drobot, OpenTechWorks, Inc.

FCC Liaisons: Michael Ha, Mark Bykowsky, Monisha Ghosh, Martin Doczkat, Robert Pavlak, Chrysanthos Chrysanthou, Gulmira Mustapaeva

Date: January 14, 2021

2020 FCC TAC AIWG Team Members

- Shahid Ahmed, Independent
- Sujata Banerjee, VMware
- Nomi Bergman, Advance
- William Check, NCTA
- Brian Daly, ATT
- Adam Drobot, OpenTechWorks
- Jeffrey Foerster, Intel
- James Goel, Qualcomm
- Lisa Guess, Cradlepoint
- Russ Gyurek, Cisco
- Dale Hatfield, Univ of Colorado
- Stephen Hayes, Ericsson
- Mark Hess, Comcast
- Nageen Himayat, Intel
- Steve Lanning, Viasat
- Gabriel Lennon, Intern Univ of Colorado
- Kevin Leddy, Charter
- Anne Lee, Nokia
- Brian Markwalter, CTA
- Lynn Merrill, NTCA
- Jack Nasielski, Qualcomm
- Michael Nawrocki, ATIS
- Dennis Roberson, entigenlogic
- Marvin Sirbu, SGE
- David Tennenhouse, VMware

FCC TAC AIWG Activities in FY2020

Issues Addressed

1. Leveraging Federal Investments in AI
2. Understanding Data needs for AI
3. Extracting value from AI and Data to address issues of importance to the FCC
4. Safe use of AI

Strategic Priorities

1. Closing the Digital Divide
2. Promoting Innovation
3. Protecting Consumers and Public Safety
4. Reforming the FCC's Processes

Industry Trends

Considerations

1. The FCC's Strategic Priorities
2. Industry Trends
3. Technology Maturity
4. Timeliness
5. Impact

The FCC
Service Providers
Consumers
Industry
The Public Sector

Inputs

1. AIWG SME Discussions
2. External Presentations
3. Supporting Documents
4. FCC Liaisons

Nature of Recommendations

Lasting Impacts on the FCC

(Two) AI in FCC Strategy, and Data

Immediate Impacts on FCC, Service Providers, Consumers, Industry, and the Public Sector

(Three) Broadband Map, Safe Use of AI, and Pilot Projects

Recommendations

The FCC TAC AIWG has identified five recommendation areas:

1. **"Unlock transformational change" - The incorporation of considerations for Artificial Intelligence in the FCC Strategic Plan.**
2. **"To build knowledge, unleash the Data" - The creation of a Task Force to address how the FCC can best address important aspects of Data governance and curation for AI/ML applications to serve its internal needs, and those of industry and the public.**
3. **"Cast a wide net" - Develop a plan and strategy for designing, developing, deploying, operating, and maintaining a Broadband Map that takes advantage of the best technologies and capabilities available.**
4. **"Keep humans in control of the loop" - Policies and approaches to ensure the safe use of Artificial Intelligence as it impact the nation's networks, communication needs, and important applications.**
5. **"Get your feet wet" - Develop the FCC's capability for extracting value from Artificial Intelligence in solving issues and problems that come before the FCC by conducting pilot projects with near term return.**

Summary of White Paper

Follows the Flow of FCC TAC AIWG December 1st Briefing

White Paper Body	
Executive Summary	Overview and five high-level recommendations
Introduction and background	Context for WG and a few observations about AI, progress in AI, and shortfalls
AI/ML focus areas of relevance to the FCC	Considerations for impact and importance, identifying five areas that led to recommendations
Status of AI Technologies: What it takes to deliver on AI	A more detailed look at the issues and approaches to the areas of importance
Findings and Recommendations	Findings and recommendations for two strategic, and three near term priorities

Summary of White Paper - continued

Appendices	
Annotated Bibliography	Peer reviewed literature about AI in Telecommunications
Federally funded initiatives	A look at basic and applied research initiatives by the Federal Government applicable to Telecommunications
DARPA's Spectrum Collaboration Challenge	Lessons learnt from DARPA AI and Spectrum Sharing experiment
Data Management	A detailed look at one of the key issues for AI in the Telecommunications Ecosystem
Safe Uses of AI	AI in Telecommunications, harnessing the benefits and avoiding the downside.
Approaches to the National Broadband Map	Fulfilling the FCC mandate with a procurement process starting with an RFI
Pilot Projects	A description for five projects that could have short term yields for the FCC

Thank You!

FCC TAC
Future of Unlicensed Operations
Q4 2020 Report

Chairs: Kevin Leddy, Charter & Brian Markwalter, CTA

FCC Liaisons: Monisha Ghosh, Michael Ha, Nick Oros, Bahman Badipour, Mark Bykowski, Chrys Chrysanthou, Martin Doczkat

Date: January 14, 2021

Regulatory Background and Google Request

- 60 GHz band (57-71 GHz) regulated as unlicensed intentional radiator through 47 CFR 15.255
  - For personal radar, *FCC 15.255(c)(3)*: "short-range devices for interactive motion sensing, the peak transmitter ***conducted output power shall not exceed –10 dBm and the peak EIRP level shall not exceed 10 dBm***."
  - A number of waiver requests have been submitted to the FCC to permit operation at higher power levels and aboard aircraft
    - Google Project Soli field disturbance sensor, is instructive because the FCC has acted on it in DA-18-1308A1
    - But also Vayyar Imaging Ltd, Leica Geosystems AG's and recently Tesla Motors
- DA-18-1308A1 Grant of Google Waiver Request
  - The waiver for Google included the following requirements for Soli:
    - "…allow the device to operate in the 57-64 GHz band at a maximum ***+13 dBm EIRP, +10 dBm*** transmitter conducted output power, and +13 dBm/MHz power spectral density"
    - "operate with a maximum transmit duty cycle of 10 percent in any 33 milliseconds (ms) interval"
    - Waiver "not to be considered to apply generally to other field disturbance sensors"

Industry Consensus to Improve Regulations for 60 GHz Band

- Our working group had briefings from Google, Facebook, Intel and Qualcomm
- Industry has formed a 60 GHz Coexistence Study Group for Communications and Radar (above companies plus Infineon, Samsung and Socionext America) on record with the FCC in Leica and Vayyar waivers (filing of February 3, 2020)
- All indicate that it is time to start a rulemaking proceeding to permit higher power levels for radars and preserve coexistence between radars and communication systems

60 GHz Radar Recommendation

- The FCC should start a rulemaking proceeding to examine 60 GHz rules in 47 C.F.R. 15.255 to address issues raised by waiver requests for field disturbance systems
  - Power levels for radar applications, including potential for equivalent power levels to communication systems for LBT radar
  - Coexistence mechanisms, including duty cycle requirements and contention-based protocols

- Potential areas of consideration:
  1. Should FCC rules allow greater radiated power for radar applications than currently permitted?
  2. Should the parameters for Google Soli, for which other entities have filed “me too” requests, be included in the rules?
  3. What changes to the recent waiver parameters are needed to improve sharing with communications applications?
  4. Should the FCC require communications applications (and radar applications) to use a contention based protocol?
  5. Should radar applications that perform LBT be allowed to use the same power levels as communications applications in this band?

Chairman's Summary

- Recommendations – Our report includes three recommendations:

1. The FCC should continue its light touch approach to unlicensed spectrum and allow industry to collaborate to determine the best methods for sharing the airwaves. The FCC should avoid further codifying standards in regulation, and **allow industry to define technical specifications.**

2. However, when requirements and conditions evolve, so should the regulations. In particular, **we recommend a rulemaking on personal radars be opened on 60 GHz spectrum** where the FCC has received several waiver requests to use the spectrum for personal radar. The FCC needs to move from waivers to rules.

3. Finally, sharing technologies have the potential to unlock large swaths of spectrum for public use. What is clear is that there are many "tools in the tool belt" for sharing spectrum and that there must be careful alignment between technologies, incumbents, and use cases. With several sharing technologies and commercial deployments under development in 2020/2021, further study is needed and **the FCC should dedicate a TAC working group** to focus on spectrum sharing in 2021.

FCC TAC
5G RAN Technology Working Group
Final 2020 Chairman's Brief

WG Chairs: Tom Sawanobori, CTIA & Kevin Sparks, Nokia

FCC Liaisons: Bahman Badipour, Reza Biazaran, Bob Pavlak, Ken Baker, Kamran Etemad, Sean Yun, Charles Mathias, Monisha Ghosh, Michael Ha

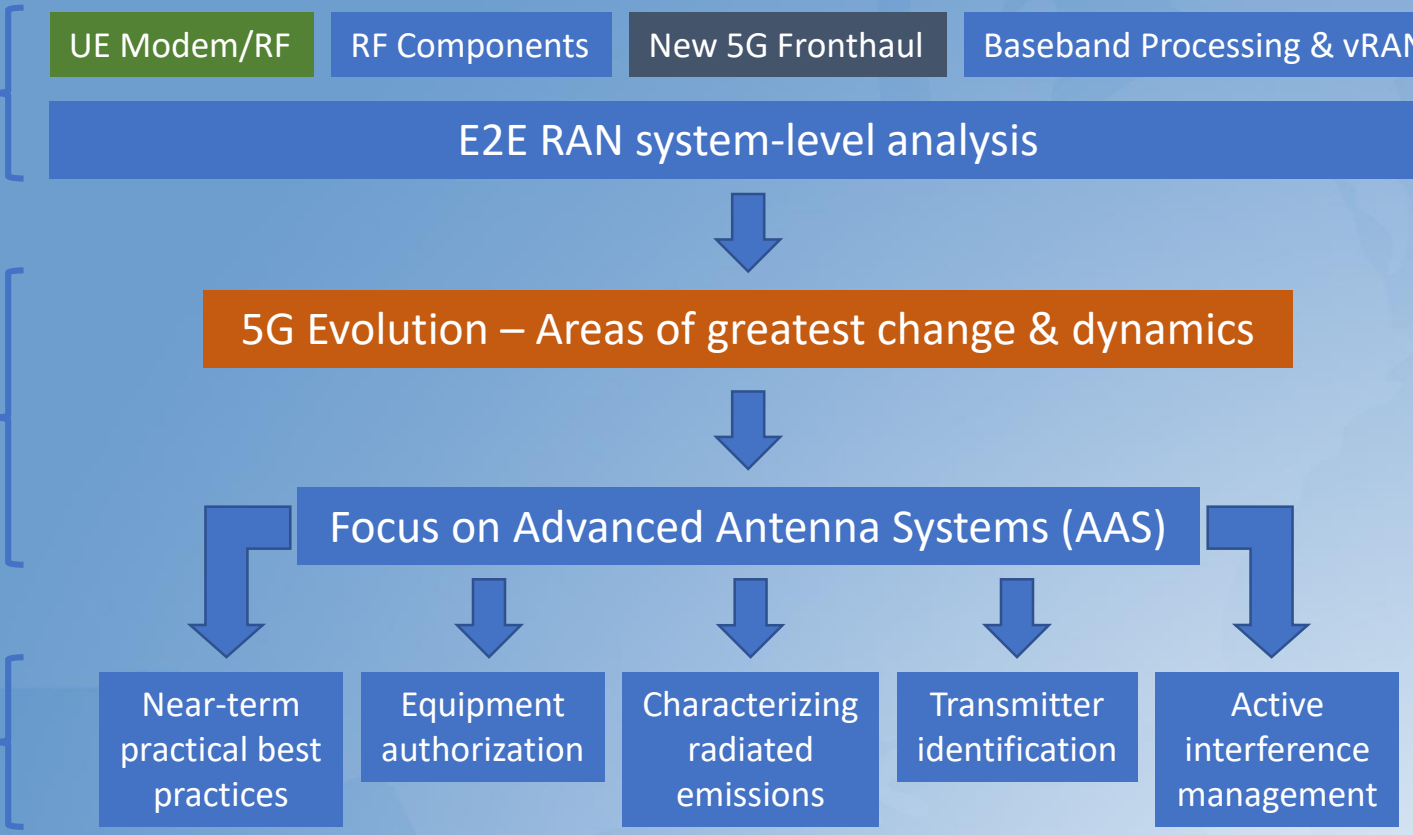
Date: January 14, 2021

Accomplishments

Performed component & system analysis of 5G evolution

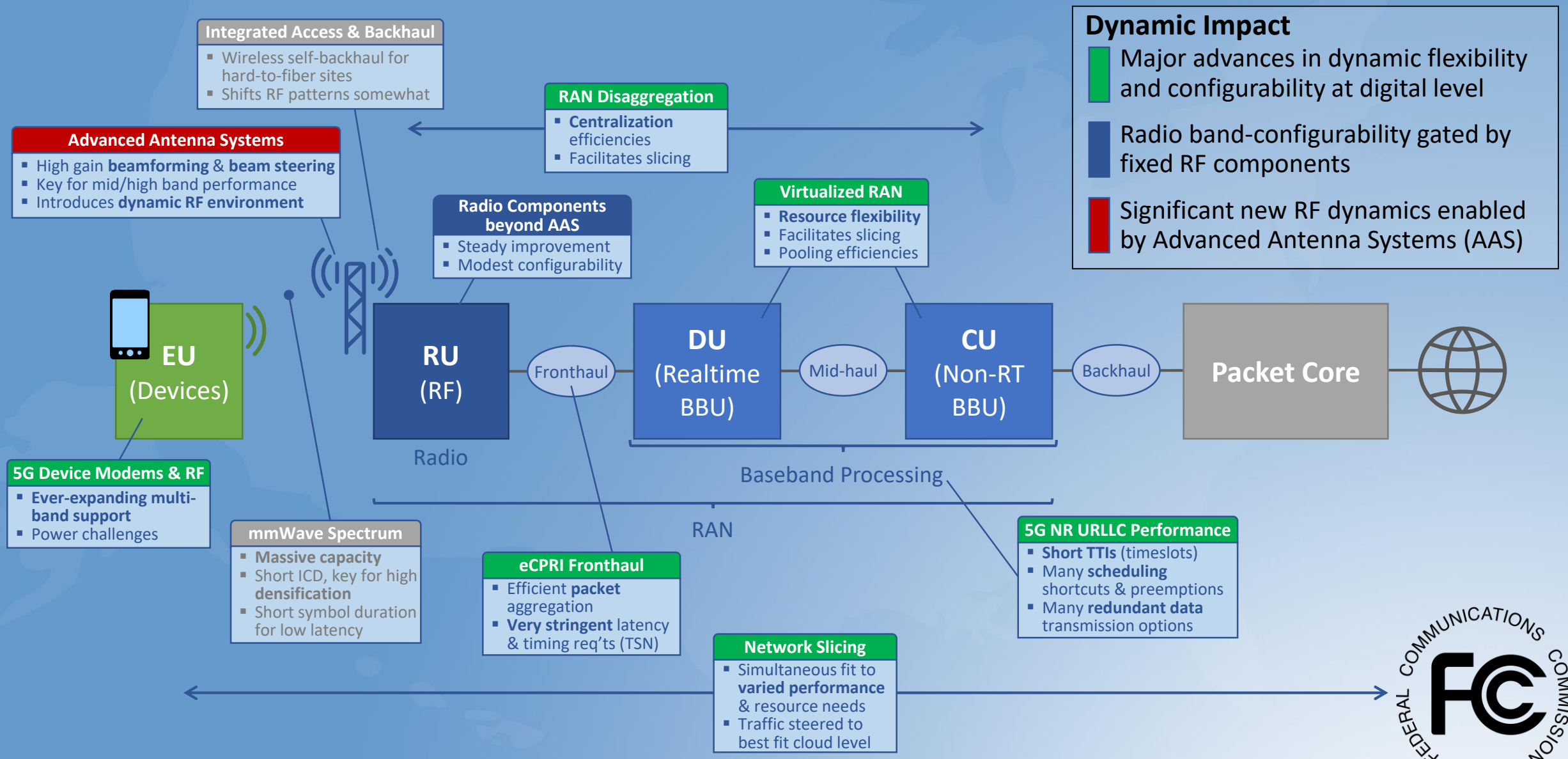
Narrowed focus to areas of greatest impact on spectrum management

Developed recommendations on top spectrum/interference management topics



15 SME talks under-pinning WG effort end-end

5G RAN Evolution – Main New Areas of RAN Dynamics



Recommendations

Near-term practical best practices	▪ Partial **TDD synchronization guidelines** (for future bands beyond C Band) that consider all the tradeoffs and global comparisons, applicable to 4G LTE and 5G technologies, offer an opportunity for coordination
Equipment authorization	▪ FCC Regulations should be examined in regard to adding **field strength limits** for certification of Advanced Antenna Systems, as conventional conducted power measurements not possible with AAS ▪ Areas for future study: (1) practicality of **3D probabilistic power flux** characterization to improve sharing, and (2) evaluation of the **impact of power control on out-of-band emissions**
Characterizing radiated emissions	▪ Initiate multi-stakeholder studies on application of **properly averaged radiated power** measurements for coverage/compatibility analysis purposes, considering the dynamics of AAS RF transmissions
Transmitter identification	▪ Promote a feasibility study - working with industry, SDOs, academia and federal agencies as needed - on **effective methods of identifying transmitters** (including RF fingerprinting and explicit Tx identifiers) for interference mitigation purposes
Active interference management	▪ Form multi-stakeholder expert technical group to study in detail the potential for generalization of intra-system mechanisms to **inter-system active interference management** ▪ Encourage and build, via FCC fora or similar, broad industry interest and engagement in research programs pursuing more accurate **data-driven localized propagation modeling**

Adjacent Band Coexistence Recommendations

- Maximize use of spectrum across adjacent bands
  - Most countries are planning spectrum allocations without guard bands
  - Without synchronization, modifying antenna orientations or planning for separation distance may be needed
- Tradeoffs

TDD synchronization	Benefits	Cons	Comments
Full synchronization	Maximizes spectral efficiency. Allows close base station placements.	Minimizes flexibility for different/evolving use cases.	Works best if adjacent operators have similar use cases (e.g. enhanced MBB)
Semi-synchronization	Partial synchronization provides some interference mitigation	Requires some geographical separation to maintain good performance.	Adjacent operators need to coordinate to mitigate interference.
Unsynchronized	Flexibility in use cases	Requires large geographical separation or outdoor/indoor separation (e.g. indoor factory).	Unlikely, but possible if one operator has unique use case (e.g. video uploads).

- Findings and draft recommendations
  - Partial TDD synchronization guidelines (for future bands beyond C Band) that consider all the tradeoffs and global comparisons, along with 4G LTE and 5G technologies, offer an opportunity for coordination. To assess its effectiveness a public comment process may be useful.

AAS Equipment Authorization Recommendations

1) FCC Regulations should be examined in regard to adding field strength limits for certification of Advanced Antenna Systems. Systems could be tested with either field strength or EIRP, however there should be equivalency for mobile and other services.
2) No changes are needed to existing FCC testing protocols. After reviewing current FCC testing documents (KDB 842590), 3GPP Testing Specifications (38.141-1,-2), ANSI Testing Standard (C63.26), and the CTIA Test Plan for Wireless Device Over-the-Air Performance, we have concluded that, based on existing FCC regulations, current FCC antenna testing protocols correctly specify testing requirements for Advanced Antenna Systems and do not require more testing than is necessary, given the FCC's light touch regulatory approach.

AAS Testing Recommendations For Future Study

1) **Measurement of power flux densities over a probabilistic 3D pattern, across multiple frequencies, could allow for additional opportunities to improve spectrum efficiency.** This would entail more involved antenna testing procedures, which would have to be developed. The costs and benefits of this approach must be weighed. Availability of these data in a frequency sharing database could allow for more dense spacing of transmitters and feed into efforts to address active interference management (see recommendations in that later section).
2) **For user equipment, explore and evaluate the impact of power control on out-of-band emissions.** It has been shown that under the highest power settings many handsets exhibit excessive out-of-band emissions due to nonlinearities in the amplifiers. At lower power settings the out-of-band emissions are decreased much more than would be attributable to the decrease in power level. However, current evaluations are made at the worst case, highest power levels, which may overstate the out-of-band behavior of the device.

Summary Recommendations on Evaluating the Radiated Emissions

- **For Active Antenna Systems** (AAS)
  - **Integrated amplifiers** make conducted power measurements difficult
  - **Total radiated power** (TRP) is accepted as an alternative to EIRP for equipment certification
    - Suitable for AAS antennas in mid- and high-bands
    - Conducted emissions still applicable for traditional sectorized/fixed antenna systems
  - Dynamic beamforming make use EIRP based measures less applicable
  - Studies are needed on optional use for AAS of **an averaged radiated measurements for interference susceptibility**
    - Coverage and compatibility analysis for in-band coverage planning and spectrum sharing, and out-of-band protection

- **TAC recommends multi-stakeholder studies** on application of properly averaged radiated power measurements for coverage/compatibility analysis
  - Does TRP offer adequate representation of average radiated power in-band and out-of-band?
  - TRP represents a spatial average of radiated power while instantaneous power can reach the level of EIRP
    - Victim bandwidth dependencies need consideration
    - Are spatially averaged assumptions representative of the interference impact on compatibility analysis?
      - Other licensees in adjacent channels or across service boundaries
      - Other services sharing spectrum in-band or out-of-band
    - What are the effects of power amplifier non-linearities and digital-pre-distortion on average radiated out-of-channel emissions?

* Effective Isotropic Radiated Power

Transmission Identification – Summary & Recommendation

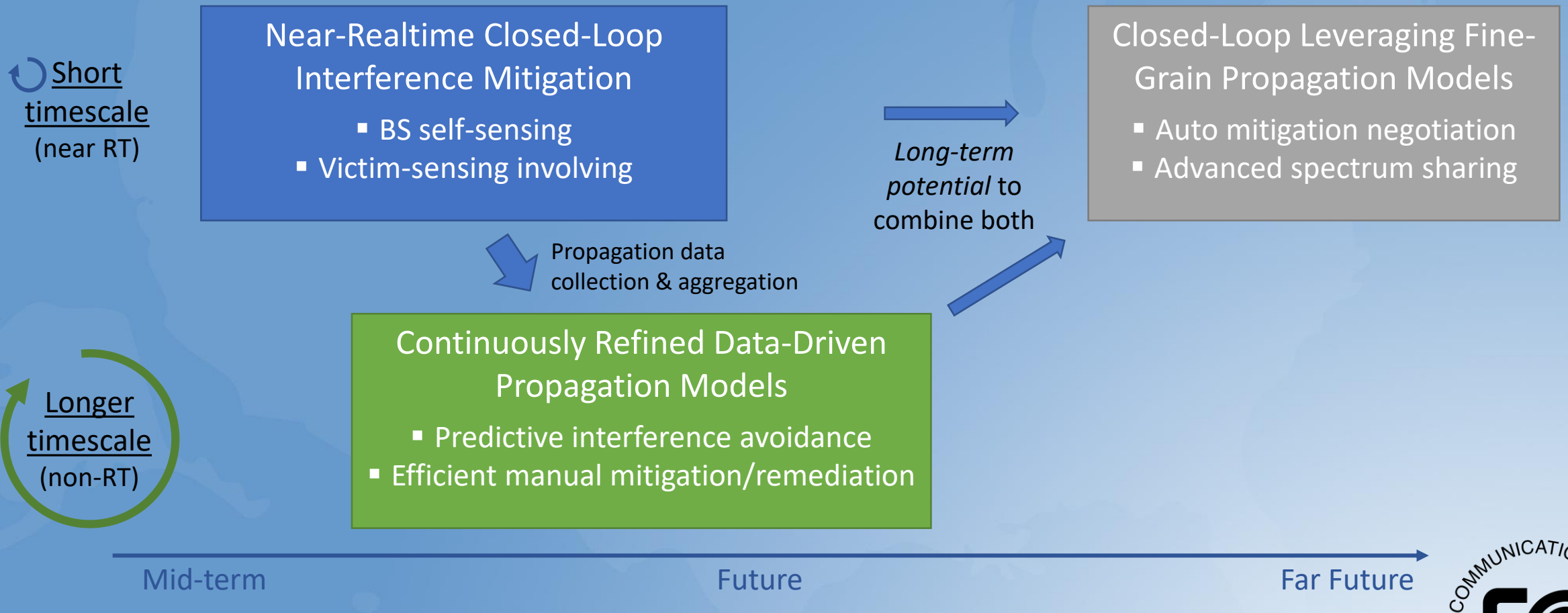
- In many sharing and coexistence scenarios identifying the type and location of interference sources can be an essential part of effective mitigation
- Two approaches to transmitter identification were considered: (1) RF fingerprinting and (2) Tx Identifiers

1) RF fingerprinting involves victim system RF monitoring/reporting with centralized AI/ML RF signature analytics to identify interfering Tx
   - Benefits include applicability to existing Tx systems, and potentially less impact to Rx systems for monitoring
   - Challenge is deterministic identification may not be reliable in some use cases.
2) A generic broadcast transmitter identifier may further facilitate the identification of type and location of interference sources
   - If used for inter-system interference, the Tx ID would need to be simply readable without full decoding of the TX signal
   - Benefits include simplicity and reliability, and challenge may be industry adoption and standardization.

- Additional study is needed to assess the feasibility and effectiveness of both and hybrid approaches

➢ **Recommendation:** Promote a feasibility study - working with industry, SDOs, academia and federal agencies as needed - on effective methods of identifying transmitters for interference mitigation purposes

Potential Evolution Path of Active Interference Management



Summary Recommendations on Active Interference Management

- Many current methods of *intra-system* active interference management may be **extensible to *inter-system***
  - Measurement parameters will need to be generalized/genericized to work across different radio systems
  - Intermediate coordination functions may be needed for interference-related data exchange between un-like systems
  - Such a system could also serve as a platform for collecting and aggregating measured propagation data over time

➢ Recommendation: Form a multi-stakeholder expert technical group to study **inter-system active interference management** potential in detail

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- A longer-term ambition would be to develop **field data-driven localized propagation models**
  - Combining crowdsourced propagation data with AI/ML analytics to better predict and avoid interference
  - Accurate location-specific models could also improve spectrum utilization by avoiding overly conservative constraints
  - Building such models would take considerable resources and organization over an extended period of time
  - If successful for predictive purposes, such models might ultimately be utilized in closed loop mitigation

➢ Recommendation: Encourage and build, via FCC fora or similar, broad industry interest and engagement in **research programs pursuing data-driven propagation modeling**
  - Including NSF (funding, leadership), NIST, NTIA/ITS, academia and industrial research

Thank You

FCC TAC 5G/IoT/O-RAN Working Group

Chairs: Russ Gyurek- Cisco, Brian Daly- AT&T

FCC Liaisons: Michael Ha, Padma Krishnaswamy, Charles Mathias, Ken Baker, Nicholas Oros, Monisha Ghosh

WG Team Members:

- Ahmad Armand, T-Mobile
- Mark Bayliss, Visualink
- Marty Cooper, Dyna
- Bill Check, NCTA
- Adam Drobot, OpenTechWorks
- Jeffrey Foerster, Intel
- Dale Hatfield, Univ of Colorado
- Haseeb Akhtar, Ericsson
- Steve Lanning, Viasat
- Greg Lapin, ARRL
- Lynn Merrill, NTCA
- Robert Miller, inc Networks
- Jack Nasielski, Qualcomm
- Milo Medin, Google
- Mike Nawrocki, ATIS
- Charlie Zhang, Samsung
- Dennis Roberson, entigenlogic
- Scott Robohn, Juniper
- Jesse Russell, incNetworks
- Travis Russell, Oracle
- Kevin Sparks, Nokia Bell Labs
- Marvin Sirbu, Spec. Gov. Emp.
- Tom Sawanobori, CTIA
- Paul Steinberg, Motorola
- David Young, Verizon
- David Tennenhouse, VMware

5G/IoT/Open RAN Charter 2020

Open RAN

- Industry developments and overview
- Challenges and roadblocks
- Adoption and scalability
- Multi-vendor support in disaggregation
- Testing
- Evolution

6G

- Technology trends, planning & obstacles
- FCC engagement opportunity

IoT

- Is dedicated or shared spectrum needed to support industrial IoT applications
- IoT verticals and service requirements

Other

- Spectrum sharing- future needs, opportunities and frameworks
- 5G security, reliability and resiliency

5G Deployment Update – Nov 2020

AT&T:

- Covers >205M people in >395 markets using mmWave and sub-6 GHz.

T-Mobile:

- Covers >7,500 towns & cities and >270M people across 1.4M sq. mi primarily using sub-6 GHz.

Verizon:

- Covers >200M people in >1,800 towns & cities, 19 stadiums and six airports using sub-6 GHz and mmWave.

U.S. Cellular:

- Offers 5G in IA, ME, NC, and WI, will activate 5G in 11 more states by YE2020.

5G Smartphones

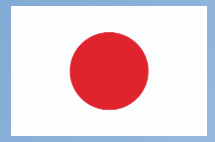
- **Samsung, Motorola, LG, Apple**
- 17 – 23 5G handset models offered per operator.

South Korea:

- SK Telecom, KT and LG Uplus launched April 2019. Regulators say >115,000 5G base stations deployed. 8.7M 5G subs as of August, ~15% of country's handset base.

China:

- China Mobile, China Telecom, China Unicom & CBN have all turned on 5G services. 300 prefecture-level cities expected to be covered by YE2020



Japan:

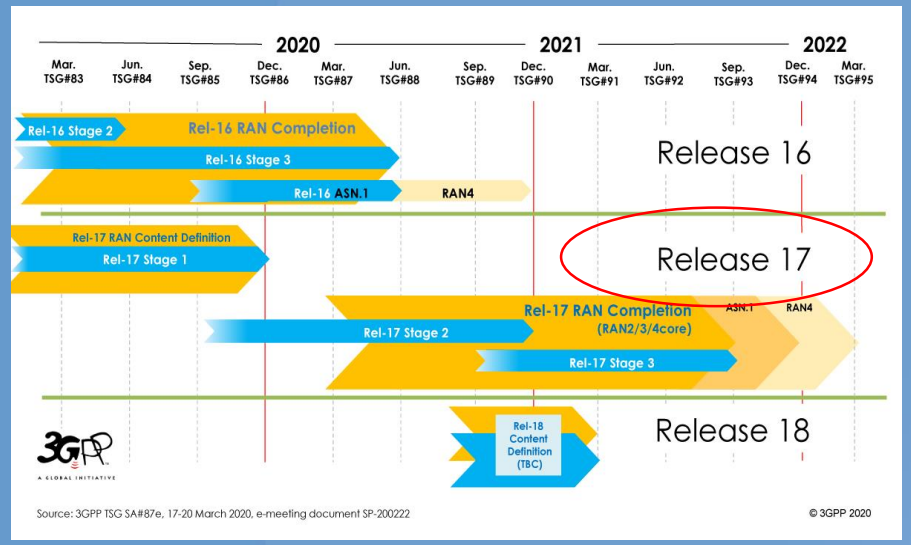
- NTT DOCOMO, KDDI & Softbank launched 5G service in select cities in March; Rakuten in six cities in Sept. 2020. ~330,000 5G users as of June

U.K.:

- UK MNO's EE, Three, O2 and Vodafone all offer 5G service. MVNOs BT Mobile, Tesco Mobile, Sky Mobile & VOXI have also launched 5G services.

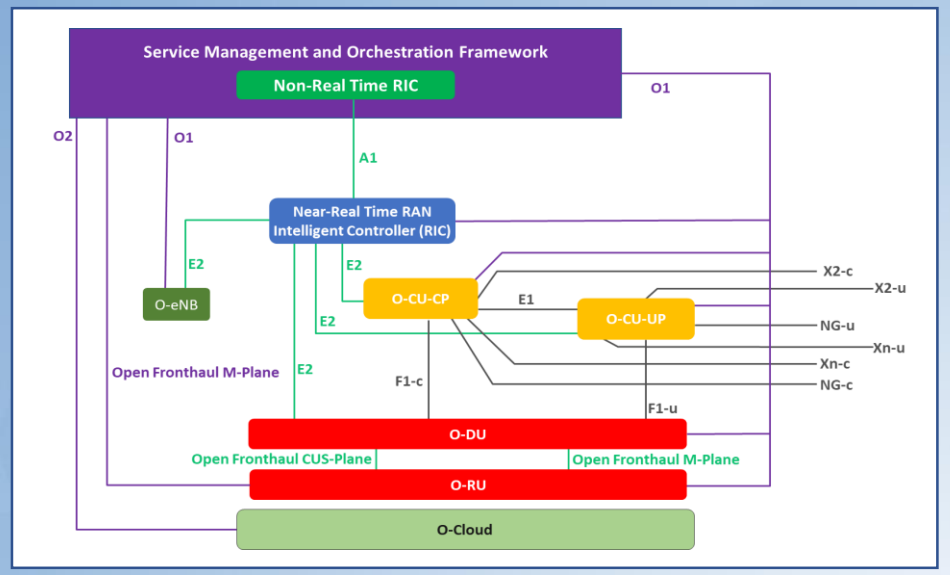
Source: CTIA

5G Standards and Technical Specifications Update



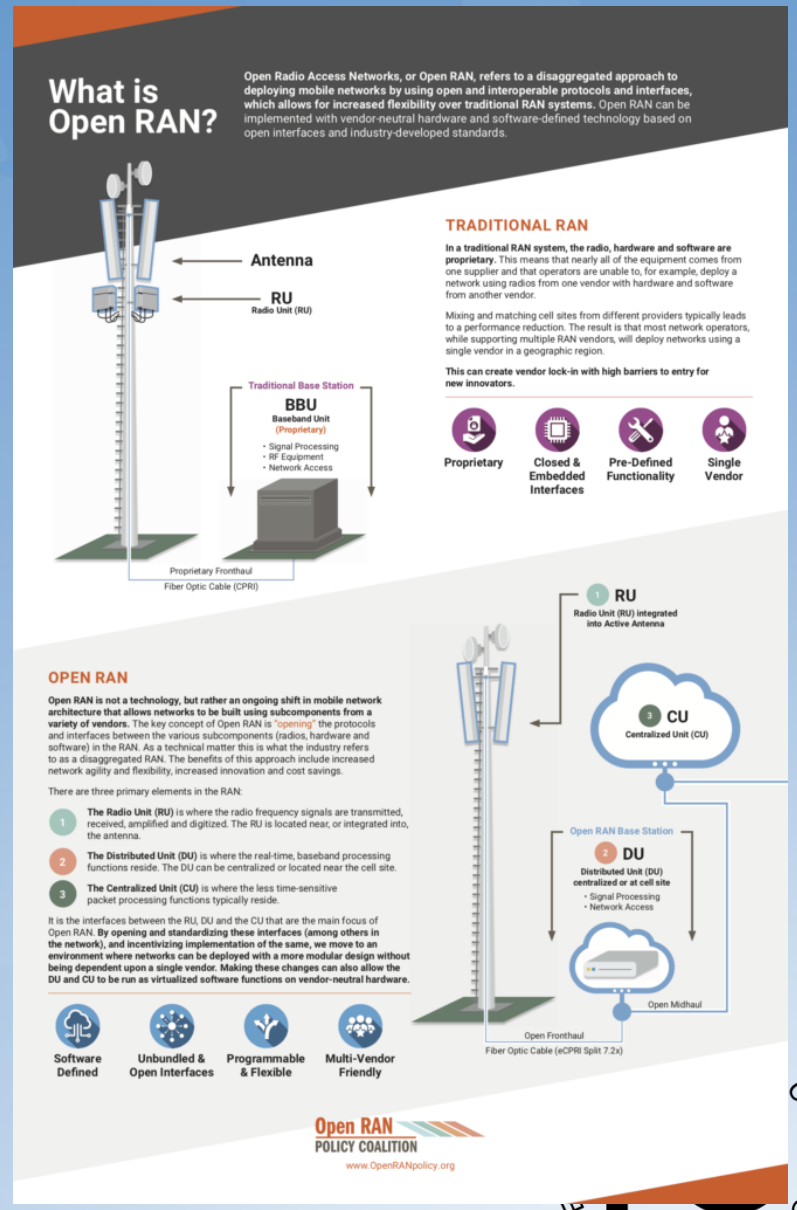
- 20 new O-RAN specifications since June 2020, including:
  - O2 interface – General Aspects and Principles
  - HW reference designs for indoor picocells (7-2 and 8.0 split options)
  - End-to-end system testing framework
  - Criteria and guidelines for the Open Testing and Integration Centers (OTIC)
- O-RAN ALLIANCE Security Task Group tackles security challenges on all O-RAN interfaces and components

- Firm decision on Release 17 delay in December plenary meeting
- First half of 2021 meetings will be e-Meetings
  - Hoping that the next three months will bring clarity as to whether 3GPP can start to plan for getting back to face-to-face meetings
- If e-meetings go beyond June, the delay to Release 17 could be greater than the six months currently being projected



Open RAN Recommendation- FCC role

- Encourage development of Open RAN eco system by supporting the following:
  - Open RAN innovation
  - Open RAN standardization
  - Open RAN testing
  - Open RAN security and reliability
- Support “open” R&D opportunities
  - Support research on open 5G/6G technologies
  - Support interoperability through public-private events such as “plug-fests” and testing in existing 5G testbeds
- Awareness of differences between Open RAN new entrant, greenfield, and brownfield deployment timelines



Source: Open RAN Policy Coalition

Advisement and Recommendation: Reliability

- Power reliability, back-up for 5G architecture and service
  - Reliability of power grid is essential for communications infrastructure
    - Critical services require very high-reliability: zero down time
    - Massive deployment challenge: availability/capability vs economics
  - Leverage efforts with the FCC including:
    - BDAC work and related reports on disaster recovery: https://www.fcc.gov/broadband-deployment-advisory-committee
    - Operators are focused on meeting critical needs in deployments
    - Wireless Resiliency Cooperative Framework (voluntary commitment to FCC):
    - Collaboration with FERC, EPRI, 911 operations
  - Industry collaboration efforts: ATIS working group on reliability

  - Recommendation: carry reliability (safety focus) work into 2021 5G/IoT/RAN working group

6G Planning & Research is in Progress

- FCC to promote creation of a US national roadmap- US leadership
- Key 6G areas that need attention
  - Spectrum: planning to support 6G network requirements
  - Architecture: further densification may cause site location challenges
  - Fiber x-haul: will be a challenge for US overall without investment and focus
- FCC research support:
  - Hi-frequency mmWave and THz use
  - Spectrum efficiency technologies

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SPECTRUM SHARING 2021- a Proposed WG and Framework

Goals:

1. Long term goal for devices to be able to operate in most any spectrum based on need, availability and purpose

2. Move from a licensed approach to a usage approach- very dynamic and flexible

3. A “Spectrum aware” approach. Q: What is the top of Spectrum’s “Maslow Hierarchy to get to self-actualization”

Specifics to solve:

- Interference:
  - Quantify: measurement
  - RAN, UE, Geo, other services
  - Other
- Radio and receiver capabilities and sensitivity
- Noise- how to manage and mitigate
- Rules, regs and enforcement
  - Bands
  - Devices
  - Radios
- Security related topics
- Content centric view?

Recommendations/Advisements

- **O-RAN**
  - FCC to support MV interoperability, plugfests
  - Encourage acceleration of ORAN adoption
- **Security**
  - Spoofing, interference are real concerns
  - System supply chain, MV systems
  - Network reliability, resilience- area to monitor
- **6G**
  - Challenges: lack of fiber for x-haul, power reliability
  - Architecture changes: Mesh, evolved IAB*
  - Create US roadmap- partner with industry
  - Readiness of THz is uncertain- support research
- **Spectrum Sharing**
  - Hi-level framework: guidelines, rules, and goals,
  - Sharing is dependent on the spectrum band; incumbents, etc
  - Interference; need to quantify, measure & enforce
  - 2021: Formal FCC TAC WG for spectrum sharing
- **IIoT**
  - IoT and enterprise use cases are quickly emerging
  - Demands vary widely on QoS/determinism
  - Locally licensed spectrum desired to provide necessary determinism, control, and compete with worldwide options (e.g. BNetzA)
  - Both mid-band and mmWave are suitable
    - Facilitates spectrum re-use

*IAB- Integrated Access and Backhaul

5G/IoT/RAN WG- 2021 *proposal*

2021 5G/IoT/RAN Working Group (proposed) Focus Areas

- Transition from NSA to SA
- Open-RAN & vRAN
- 6G Evolution and planning
  - X-haul needs and potential models to stimulate investment
  - 6G/edge/storage/cloud interoperability
  - Multiple Radio Access Technology (RAT) interoperability
- IoT requirements, local license details
- Impacts of “Private” networks
- Technology roadmaps (new)
- Spectrum advances in mmWave and Thz
- Small cell deployment and reliability
- Network reliability & resiliency
- Standards coordination and post Covid progress
- Security: jamming, spoofing, supply-chain

Thank You

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