CSMAC Subcommittee 2: 6G

March 10, 2023

Subcommittee Members

- Reza Arefi, Co-Chair
- Carolyn Kahn, Co-Chair
- Michael Calabrese
- Thomas S. Dombrowsky Jr.
- Mark Gibson
- Dale Hatfield
- Jennifer Manner
- Jennifer McCarthy
- Danielle Piñeres
- Glenn Reynolds
- Dennis Roberson
- Jesse Russell
- Steve Sharkey
- Mariam Sorond
- Rikin Thakker
- Jennifer Warren
- Kevin Holmes, FCC Observer
- Richard Orsulak, NTIA Liaison
- Jessica Quinley, FCC Liaison
- Antonio Richardson, Designated Federal Officer

Mandate

- NTIA seeks input on what sort of use cases 6G may entail
  - Importantly, NTIA would like the CSMAC to consider use cases beyond traditional wireless communications including safety, sensor, radar, space and other scientific applications and address 6G's potential impact on federal government users
- When considering spectrum bands that could be used to support 6G, NTIA observes that the THz bands have been identified for potential use
  - How would such use impact government users in that range and what recommendations could be made to help prepare for this
  - Are there other spectrum bands that may be appropriate for 6G and beyond use?

NTIA Clarification: The scope should concentrate on 6G services only. This effort should consider generally the benefits to federal government user, the positives for the federal government as a user or federal equities, and how federal agencies can benefit broadly from 6G.

Schedule

- Kicked off subcommittee: August 2022
- Holding regular subcommittee meetings
- Conducting interviews: December 2022 – June 2023
- Analyzing information and develop a draft report: September 2022 – August/September 2023
- Deliver draft paper and recommendations: August/September 2023
- Iterate interim findings and conduct follow-on work: August/September 2023 – December 2023
- Deliver final paper and recommendations: December 2023

Interview Status

- Conducting interviews
  - Federal agencies
  - Industry (service providers, cable companies, equipment manufacturers, chip manufacturers, hyperscalers, virtualization companies, HAPS manufacturers)
  - Academia and other non-profit organizations
- Requested written and/or verbal responses on 6G question topics

Surveys & Interviews*

- Federal agencies
  - AF, Army, **DHS S&T**, **DISA DSO**, DoD CIO, DoE, DoI, **DoJ**, **DoS**, **DoT**, FAA, FCC (TAC), FDA, NASA, Navy, NTIA ITS, NOAA, NSF, NIST, Treasury, OUSD R&E, **USAGM**, USDA, USCG, USPS, VA
- Industry
  - Service providers: AT&T, BlackSky, **Echostar**, HawkEye360, Intelsat, Kuiper, Maxar, Planet, OneWeb, SES, **SpaceX**, T-Mobile, Verizon, Viasat
  - Cable companies: Comcast, **CableLabs**, Charter
  - Equipment manufacturers: **Cisco**, **Ericsson**, **Nokia,** *Samsung*
  - Chip manufacturers: Broadcom, Intel, **Qualcomm**
  - Hyperscalers: AWS, **Google**, Meta, Microsoft, *Oracle*
  - Virtualization companies: *VMWare*
- Academia and other non-profit organizations
  - Standards organizations: *3GPP*
  - Non-profit organizations: IEEE (Future Networks Initiative), Next G Alliance, *O-RAN Alliance*
  - Academia: **SpectrumX**
  - International: 6G Flagship, **6GIA**, **B5GPG**, 5GForum, **Hexa-X**

* Surveys & interviews received/completed are denoted in bold font. Those the subcommittee is still planning to reach out to are shown in italics.

6G Use Cases*

- Traditional wireless communications
  - Unlicensed/shared spectrum (slide 10)
  - Exclusively licensed (cellular, satellite, HAPS)
- Non-traditional
  - Network fabric
  - Immersive technologies, including AR and VR
  - Artificial intelligence and machine learning
  - Holograms
  - Digital twinning
  - Ultra-realistic interactive sport – drone racing
  - Immersive gaming/entertainment
  - Mixed reality co-design
  - Mixed reality telepresence
  - Immersive education with 6G
  - High-speed wireless connection in aerial vehicle for entertainment service
  - Personalized user experiences
  - Personalized shopping experience

* Not an exhaustive list. Some use cases overlap.
Source: "6G Applications and Use Cases," Next G Alliance, 2022.
https://www.dhs.gov/sites/default/files/2022-06/22_0630_st_5G_6G_Horizon_Scanning_Use_Case_Addendum_Infographic.pdf
https://www.ngmn.org/wp-content/uploads/220222-NGMN-6G-Use-Cases-and-Analysis-1.pdf

6G Use Cases*

- Safety
  - National security and public safety applications
  - Smart cities/roads
  - Field robots for hazardous environments
- Sensor
  - Synchronous data channels
  - Pervasive sensing and tracking
  - Connected intelligent machines, including robots, cobots, and IoT
  - Autonomous systems
  - Online cooperative operation among a group of service robots
- Radar
  - Integrated communications and sensing
  - Automotive radar
- Space
  - Space-air-ground integrated network
  - Communication in space
  - Commercial space flights and space tourism
  - Space research
- Other scientific applications
  - Sustainability
  - Smart industry and autonomous supply chain
  - Hyper-accurate positioning, localization, and tracking
  - Security
  - Untethered wearables and implants
  - Health care – in-body networks
  - Teleoperation
  - Intelligent transportation systems
  - smart agriculture
  - Deep sea communications
  - Mining

* Not an exhaustive list. Some use cases overlap.

Source: "6G Applications and Use Cases," Next G Alliance, 2022.
https://www.dhs.gov/sites/default/files/2022-06/22_0630_st_5G_6G_Horizon_Scanning_Use_Case_Addendum_Infographic.pdf
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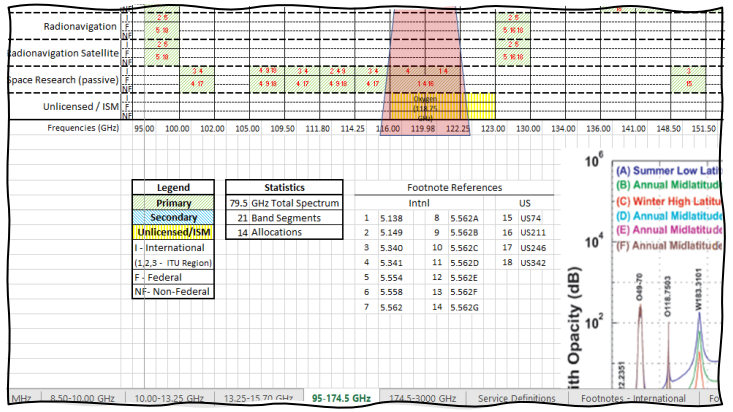
6G Unlicensed and Shared Spectrum Use Cases

- Like 5G, next-generation wireless networks will be heterogenous and rely on access to a variety of spectrum bands regulated in different ways and accessed using a variety of technologies
- Proposed unlicensed and shared spectrum use cases include*:
  - Device-to-device (D2D) communications for home networking, peer-to-peer communications, AR/VR, whole-home video distribution, gaming, telemedicine, enterprise connectivity, training, education, and large venue networking
  - Environment sensing, condition monitoring and motion control
  - Internet of Things (IoT), Ultra-Reliable Low-Latency Communication transmissions, and private wireless networks to support industrial/smart factory operations
  - XR applications requiring very high data rates, low-latency, and synchronized transmissions across multiple devices
  - Wireless local and personal area networks and “information showers” relying on mmW unlicensed bands
  - Small cell backhaul infrastructure and mmW distribution networks for indoor and outdoor P2P and P2MP connectivity
  - “In-X” subnetworks that can operate autonomously when out of coverage of an overlay wide area network, but can benefit from wide area network connectivity where available; these highly specialized radio cells can be installed within the entity where an application runs, in robots, production modules, vehicles, even the human body

*Some of these use cases could also be covered under a licensed regime

Potential Spectrum Bands

- Catalogued 5-3000 GHz (will add 3.1-5 GHz)
- Information collected include:
  - International (Regions 1,2,3) primary and secondary allocations and footnotes
  - Domestic federal and non-federal primary and secondary allocations and footnotes
  - Unlicensed/ISM bands
  - Bandwidth
  - Atmospheric absorption peaks
- Possible additions:
  - Usage data, if available, e.g., major fixed links bands, 3GPP bands, federal bands, etc.
  - Bands currently proposed for consideration
  - External sources, if any, for how much spectrum needed



Uncertainties

- Providing a realistic approach that considers uncertainty, opportunities, and challenges
- Speculation typical in earliest phases of technology development
- 6G remains undefined
- The evolution of the connectivity ecosystem (e.g., satellites, Wi-Fi, cellular)
- Timeline: what is ready by required timeline?
  - What features will be established in a release in an expected timeline?
- Demand for applications and services that are truly 6G
- Regulatory framework and spectrum allocations
- Ability of systems to meet performance requirements in accordance with the expected timeline
- Development of specifications to support use cases, depending on demand/profitability/business model

Challenges

- Research support and strategy
- Security and privacy issues
- Sustainability, including power consumption
- RF exposure
- Dependency of 6G on the pace of development of certain technologies that may be slower/faster (e.g., AI/ML)
- Risk of global standard fragmentation
- Spectrum availability and flexibility
- Capital intensive industry
- System-level challenges in achieving very high reliability/availability (e.g., 99.999%, 99.9999%)

Observations

- Federal agency engagement early-on will help shape use cases
  - Need to identify R&D gaps for federal agencies use cases
  - Build into a national R&D spectrum strategy and roadmap
  - Influence standards and technology development
- More advanced spectrum sharing techniques (e.g., schedulers)
  - Customizing sharing techniques to frequency bands (e.g., mid-band vs sub-THz) and range of incumbent systems
  - Digitized (automated analytics-based) spectrum sharing for some bands and/or use cases

Back-Up

Interview Questions

Introduction

1. What is your organization's involvement in 6G development?

6G Use Cases

2. What traditional wireless 6G use cases do you expect?
    a. Do you expect federal government users to benefit from these?
    b. If so, how?
    c. If not, why?
3. What 6G use cases do you expect beyond traditional wireless communications including safety, sensor, radar, space and other scientific applications, and any emerging/new use cases?
    a. Do you expect federal government users to benefit from these?
    b. If so, how?
    c. If not, why?
4. What unlicensed 6G use cases do you expect?
    a. Do you expect federal government users to benefit from these?
    b. If so, how?
    c. If not, why?
5. Are there any differences across domestic and international use cases and, if so, what?
6. Do you have any other thoughts or suggestions on how federal government users can benefit from 6G?

Interview Questions

Spectrum Considerations

7. How would use of mid-band spectrum for 6G impact government users in that range?
    a. If additional spectrum sharing is required for 6G services, would this be feasible, and why or why not?
    b. If so, in broad terms, what are your thoughts on how this spectrum could be shared?
    c. If not, what are the pertinent obstacles?
    d. What could help prepare for use of mid-band spectrum for 6G?
8. How would use of THz bands (with specific interest above [95 GHz]) impact government users in that range?
    a. If additional spectrum sharing is required for 6G services, would this be feasible, and why or why not?
    b. If so, in broad terms, what are your thoughts on how this spectrum could be shared?
    c. If not, what are the pertinent obstacles?
    d. What could help prepare for use of THz bands for 6G?
9. Do you expect open networks and virtual networks to impact government users and, if so, how?
10. Do you have any other thoughts or suggestions on how to help prepare for impacts to government users?
11. What international spectrum considerations are important?

Other

12. What other national or international considerations are important?
13. What are the most important steps or research needed to make sure your organization's requirements are met?
14. Are there any other thoughts you would like to provide?