



Policy Innovation for the Millimeter Wave Ecosystem

Trends, Challenges, and Considerations

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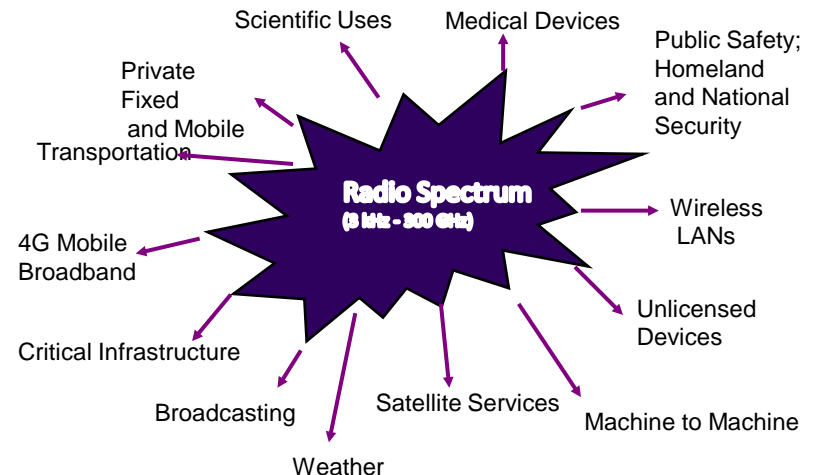
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Agenda

- Spectrum Management Trends and Millimeter Wave Policy Challenges
 - Sharing (Fed/Non-Fed, Fed/Fed)
 - Research, Development, Testing, and Evaluation
 - Enforcement

Policy Trends Over the Past Decade

- Presidential memorandum (2010) – 500 megahertz by 2020
- Middle Class Tax Relief and Jobs Creation Act (2012)
- President’s Council of Advisors on Science and Technology (PCAST) Report on Spectrum (2012)
- Presidential memorandum on sharing (2013)
- Spectrum Pipeline Act (2015) - Identify 130 megahertz by 2024
- Millimeter wave FCC proceedings:
 - Proposed 10.85 gigahertz for wireless broadband, with 3.85 gigahertz licensed and 7 gigahertz unlicensed
 - FNPRM for additional 17.7 gigahertz
 - NOI for frequencies between 3.7GHz to 24 GHz released
- Others..?



Spectrum Management Trends and Millimeter Wave Policy Challenges

- Trends:
 - Increasing federal and non-federal needs for spectrum
 - Shifting beach front
 - Technology innovation for paradigm shift in shared spectrum access and trust in sharing
- Policy Challenges
 - Realizing sharing (Fed/Non-Fed, Fed/Fed)
 - Supporting research, development, testing, and evaluation
 - Framework, process, tools, techniques, technology for enforcement

Millimeter Wave Bands in Consideration

Spectrum Frontiers: Total of 10.85 gigahertz

- Upper microwave flexible use service
 - 28 GHz (27.5-28.35 GHz); 850 megahertz
 - 37 GHz (37-38.6 GHz): 1600 megahertz
 - 39 GHz (38.6-40 GHz): 1400 megahertz
 - 425 megahertz blocks on a county basis in the 28 GHz band
 - 200 megahertz blocks across license areas in the 37 GHz and 39 GHz band
- Unlicensed band at 64-71 GHz
 - 7 gigahertz
 - Combined with existing 57-64GHz unlicensed forms 14 gigahertz of contiguous unlicensed spectrum.
- Federal and non-federal shared access in the 37-37.6 GHz spectrum

Additional 17.7 gigahertz of spectrum

24-25 GHz :

- 24.25-24.45

- 25.05-25.25 GHz

32 GHz: 31.8-33.4 GHz

42 GHz: 42-42.5 GHz

48 GHz: 47.2-50.2 GHz

51 GHz: 50.4-52.6 GHz

70 GHz: 71-76 GHz

80 GHz: 81-86 GHz

Millimeter Wave Policy Challenges

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Spectrum Sharing Policy

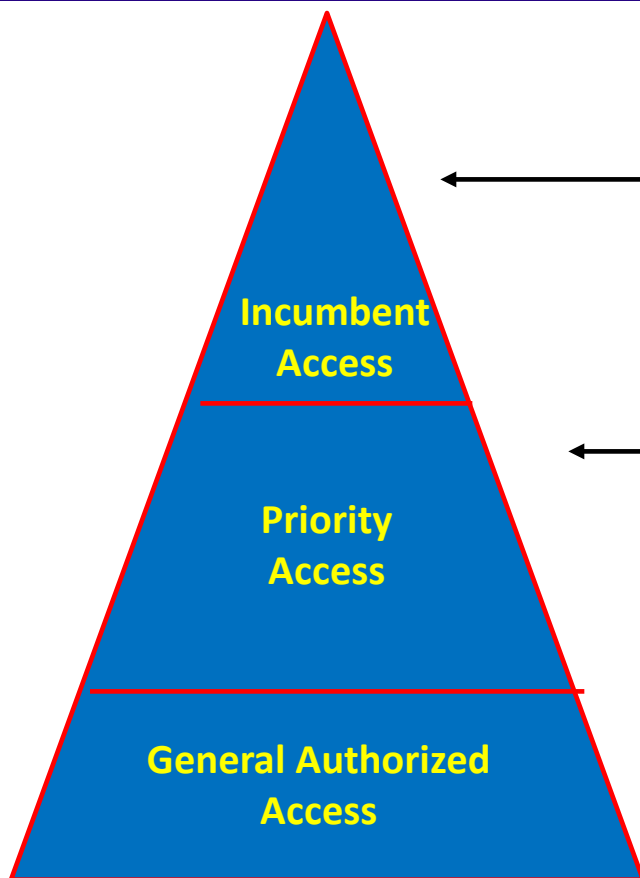
Considerations for Millimeter Wave

- Do we adopt new regulatory frameworks enabled by technology and databases (like 3.5 GHz)
- Adopt simple site/ geography based sharing vs.:
 - “Heavy Duty” engineering
 - Consider relocation vs. sharing with numerous continued federal operations
 - Co-equals in sharing partially/across the band?
- Do we implement sharing based on: realistic vs. worst case – What are the implementation issues?
- Beach front shift: Is more focus needed for millimeter wave and associated bi-directional sharing R&D, in addition to looking for additional sharing opportunities in the lower and mid bands?

37 GHz

- Limited federal operations
- Federal space research service
- Non federal fixed satellite service

Adopt 3-Tier 3.5 GHz Sharing Framework for Sharing in Millimeter Wave Bands?



Incumbent Access: Federal and non-federal Fixed Satellite Service (FSS) users currently operating in the 37 GHz Band

Priority Access: Users authorized to operate with some interference protection in the 37 GHz Band at specific locations

General Authorized Access: Users authorized to use the 37 GHz Band opportunistically within designated geographic areas (required to accept interference from Incumbent and Priority Access tier users)

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RDT&E: Fundamental Wave Characteristics

- Atmospheric losses due to water, oxygen absorption can exceed free space losses.
- Propagation/ technologies limited to a few miles , but do not penetrate solid materials.
- Densely packed communications links.
- Possibly better privacy and security due to localized links.
 - Depends on orchestration of security issues.

RDT&E Challenges

- Characterization of millimeter wave doesn't exist. Need new propagation models.
- Coverage, directionality, and reliability of mmWave communications will require new innovations in signal processing, system architectures, and communication technologies that are far from trivial.
- Antenna technology, scheduling algorithms needs fine tuning to allow large number of spectrum agile devices and back end network processing.
- New architectures and devices combining and both lower bands and millimeter wave bands to be evaluated.

Considerations for RDT&E Innovation

- Advancing Innovation
 - Policies needed for increasing technology resources, capabilities
- Developing dual use technologies
 - Standardization
 - Maximize reuse of hardware, software
 - Enable sharing
- Testbeds
 - Need for Millimeter “Smart City” and other Test Beds
- Funding mechanisms
 - Increased industry collaboration and Public Private partnerships (PPP)
- Some federal RDT&E related Initiatives in Progress
 - R&D innovation at NIST and ITS supporting millimeter wave bands
 - WSRD Coordination of research efforts

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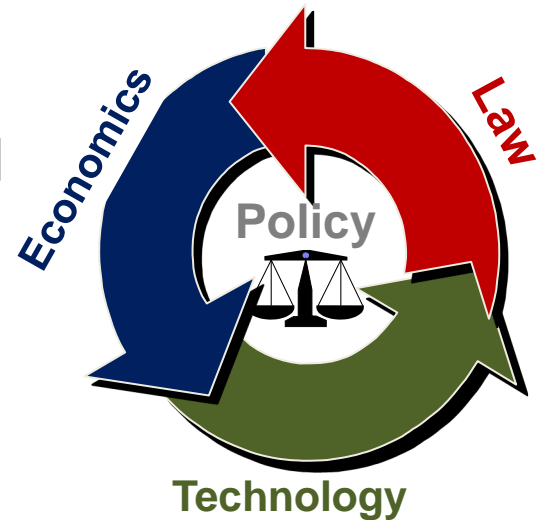
Enforcement, Dispute Resolution Policy Challenges

- Harmful interference claim threshold
- Risk-informed interference assessments
- Fair and effective procedures for enforcement
- Device/ Equipment identification
- Device/ Equipment support for interference avoidance, reporting and (triangulation) identification
- Back-end big-data processing issues

Summary

Policy Innovation for the Millimeter Wave Ecosystem

- Enduring process to identify a sustainable pipeline of spectrum to satisfy growing federal and non-federal requirements
- Innovative spectrum sharing technologies
- Advanced analytical methods and tools
- Improved spectrum automation
- Enforcement



Millimeter Wave adoption is an essential element to achieving broadband spectrum access for growing public and private sector requirements