

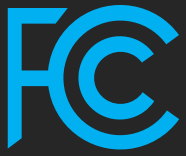
# 5G Standards

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Robert Nelson  
Chief Engineer, IB, FCC

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# What is 5G ?



- Multiple performance metrics
  - Not just peak rates
  - Low latency and high latency applications
  - Low throughput and high throughput applications
- Multiple levels of integration
  - Multiple bands – carrier aggregation plus
  - Multiple topologies – heterogeneous networks plus
- Many ideas, much marketing
- Many possible paths
  - Evolution of LTE?
  - Evolution of Wi-Fi?
  - Something else?
- Still early days of defining 5G

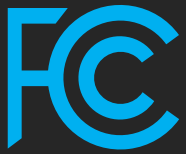
# Key Technology Principles



- **Technology neutrality**
  - The FCC's goal is to develop flexible rules that will accommodate a wide variety of current and future technologies.
    - Do not specify technologies for bands
    - Let industry and the market find the best use of the spectrum
  - Flexible rules allow for a rapid pace of technological development, and timely deployment based on changing market conditions
  - Flexible regulatory framework also provides manufacturers and providers certainty toward design and offerings
  - We do not intend to define what qualifies as "5G".
    - Standard bodies like 3GPP and the International Telecommunications Union (ITU) plan to develop the requirements by early 2017
    - We intend to take an active role on 5G internationally, monitor standardization processes, and encourage global harmonization to the extent possible

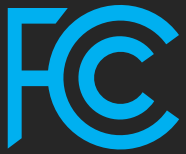
- Bands above 24 GHz
  - Technological Advisory Council (TAC) recommendation to study millimeter wave spectrum
  - Notice of Inquiry (NOI) in October 2014
  - Received comments from multiple industries and academia, 66 comments and reply comments
  - Notice of Proposed Rulemaking October 2015.

# Spectrum Frontiers NOI



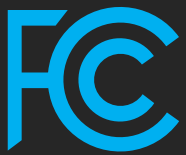
- Explored a number of bands above 24 GHz, asking questions in three areas
- What bands?
  - Physical properties
  - Existing uses
- What licensing models?
  - Licensed
  - Unlicensed
  - Innovative hybrids
- What technical rules?
  - Maintain flexibility for antenna arrays, massive MIMO, etc.

# NOI Technologies



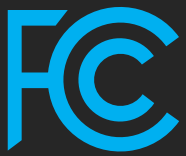
Technology	Representative Comments
Smart Antennas	<ul style="list-style-type: none"><li>• Multi-element base station antennas (32, 64 elements, patch antennas)</li><li>• Multi-element device antennas (modular arrays of 4 elements or more)</li><li>• Digital, analog, and hybrid beam forming and MIMO processing of array(s)</li><li>• Modules including an RFIC chip and beam forming unit</li></ul>
Bandwidth	<ul style="list-style-type: none"><li>• Throughput is a function of available bandwidth</li><li>• Large contiguous blocks of spectrum present certain advantages over multiband spectrum aggregation, particularly with respect to devices</li><li>• Interest in contiguous blocks of 500 MHz- 2 GHz</li></ul>
Key Performance Indicators	<ul style="list-style-type: none"><li>• Throughput up to 10 Gbps and at least 100 Mbps at cell edge</li><li>• End-to-end latency of &lt; 5 milliseconds and air latency of &lt; 1 millisecond</li><li>• Channel bandwidths in excess of 1-2 GHz</li></ul>
Backhaul	<ul style="list-style-type: none"><li>• Integrated backhaul and access (multi-hop communication)</li><li>• In-band and out-of-band options in the mmW bands</li><li>• Fiber and other options</li></ul>
Deployment Scenarios	<ul style="list-style-type: none"><li>• Complementary / limited area deployment?</li><li>• Ubiquitous coverage?</li></ul>

# Key Regulatory Principles



- Regulatory flexibility
  - Flexible use
    - Rules that will enable flexibility in the uses and technologies that might be deployed in these bands in a way that also promotes coexistence between these different uses and technologies
    - Do not exclude particular technologies
    - The Commission historically has sought to promote the development of interoperable equipment, allowing smaller providers to benefit from the scale generated by equipment capable of operating across an entire band or adjacent bands
- Regulatory framework
  - Requirements focus on in-band and out-of-band power levels
    - Focused on compatibility with existing incumbents

# Upcoming NPRM



- NPRM
  - The NPRM is an opportunity to take another step toward creating a regulatory environment in which 5G technologies can flourish
    - further support flexible use spectrum policies and innovative licensing schemes.
  - The NPRM proposes a mix of licensed and unlicensed, and creates opportunities for sharing among different kinds of users and use cases: fixed/mobile/FSS/government; terrestrial/satellite; indoor/outdoor; carrier network/private network.



Thank You