

# FCC Initiatives to Support R&D for 5G

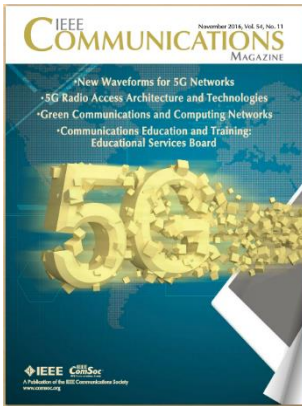


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Note: The views expressed in this presentation are those of the author and may not necessarily represent the views of the Federal Communications Commission

# Spectrum for 5G



## □ Core Principles of FCC Approach

- Identify substantial spectrum in MMW bands for new services
- Protect incumbent services against interference
- Flexible use: Enable market to determine highest valued use
- Overlay auctions where no existing assignments
- Provide spectrum for both licensed and unlicensed use
- Ensure cyber security protections are considered from the start

## □ Added 10.85 GHz of for mobile service

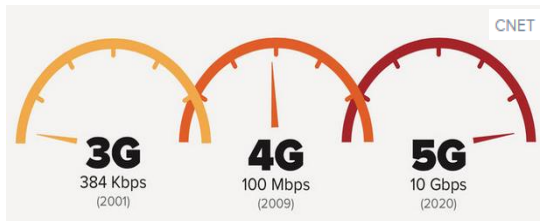
- Licensed: (3.85GHz): 27.5-28.35 GHz; 38.6-40 GHz; 37-38.6 GHz
- Unlicensed: (7GHz): 64-71 GHz

## □ Adopted licensing, operating & technical rules

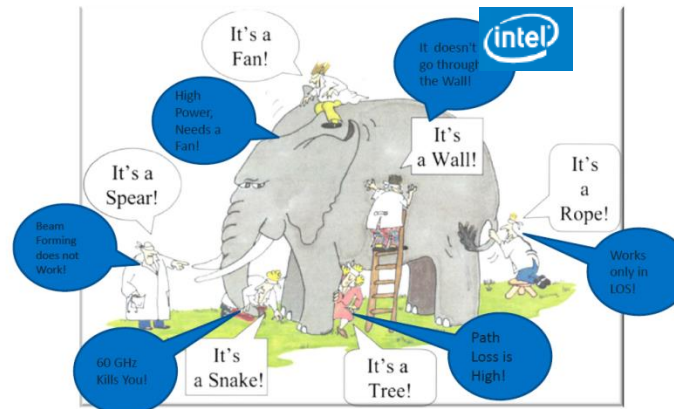
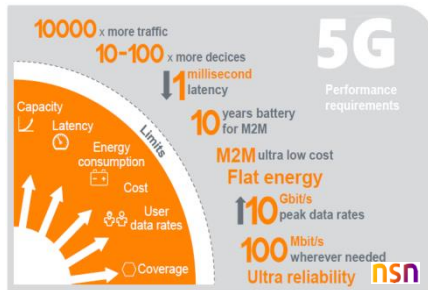
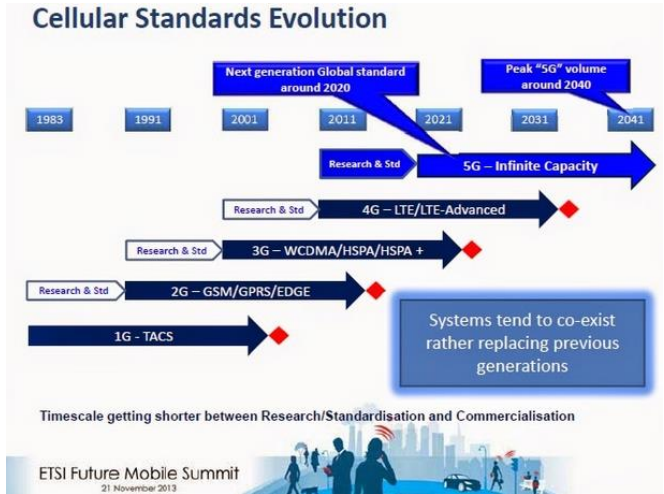
## □ Considering add'l 15.8 GHz + above 95 GHz

- 24.25-24.45 GHz; 24.75-25.25 GHz; 31.8-33.4 GHz; 42-42.5 GHz; 47.2-50.2 GHz; 71-76 GHz; 81-86 GHz; bands above 95 GHz

# What is 5G?



5G = evolution of existing standards + complementary new technologies

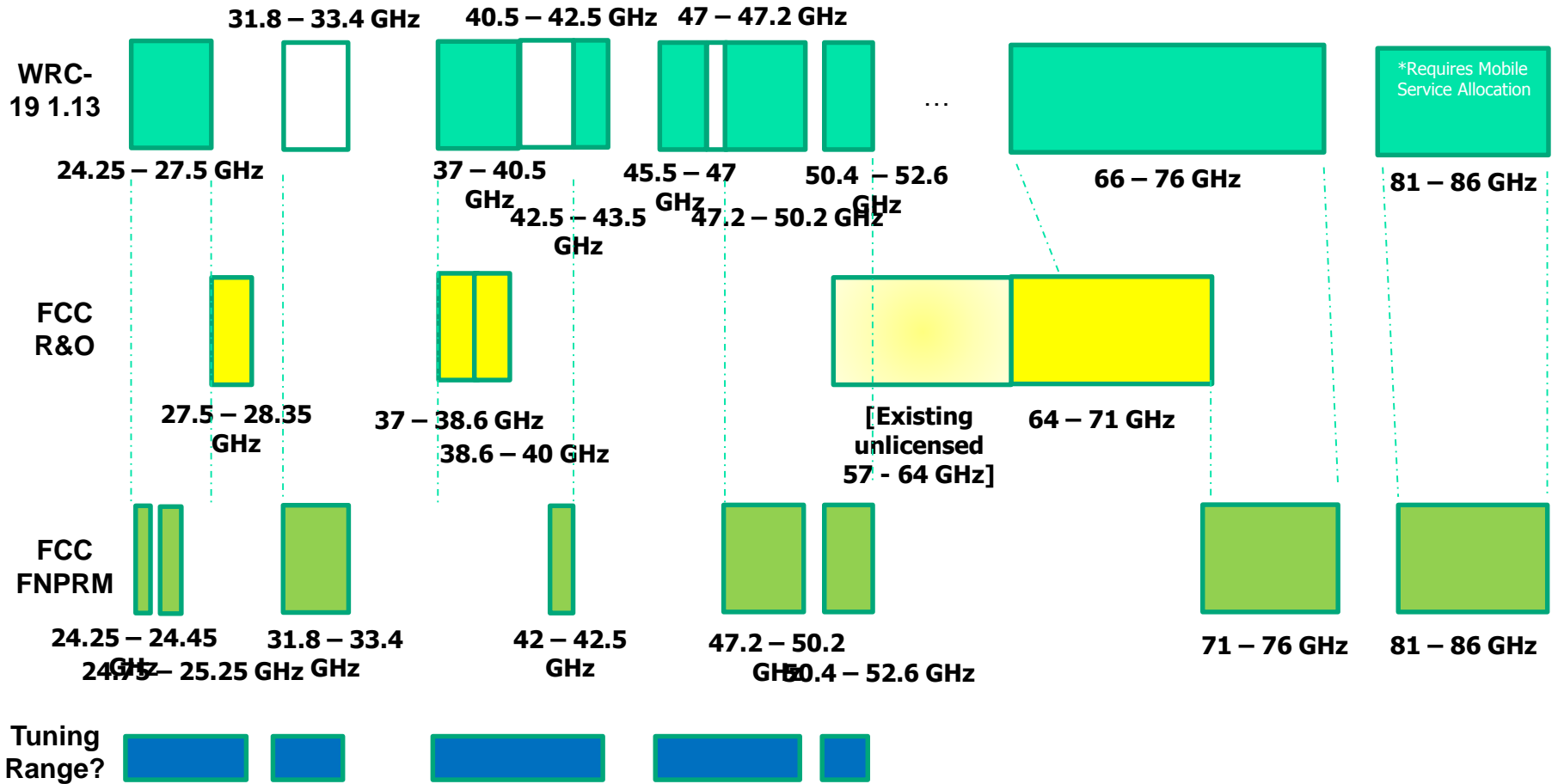


- Components of 5G are being identified and under discussion/development
  - Throughput (>50x of 4G, or 5-10Gbps) and latency (<1msec air latency) are often discussed
- The overall network architecture and end-user experience are being developed

# Overview of New Bands

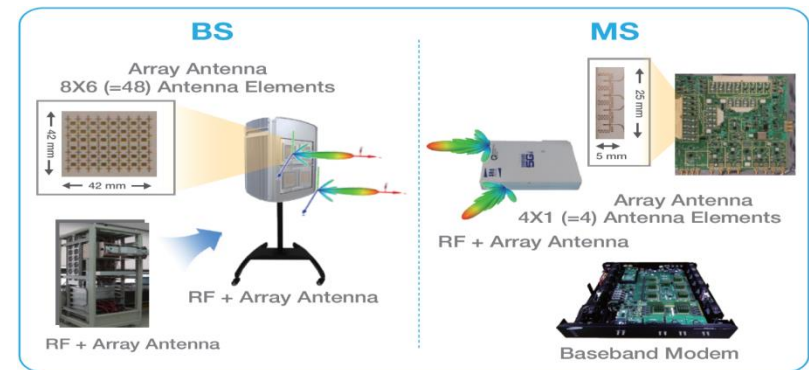
	<i>28 GHz</i>	<i>37 GHz</i>	<i>39 GHz</i>	<i>64-71 GHz</i>
<i>Frequency</i>	27.5-28.35 GHz	37-38.6 GHz	38.6-40 GHz	64-71 GHz
<i>Bandwidth</i>	850 MHz	1600 MHz	1400 MHz	7000 MHz
<i>Terrestrial Allocation</i>	Licensed for fixed operations, with about 75% of the population covered by existing licenses; remaining licenses in inventory	Yes (no current use)	Licensed for fixed operations, with about 50% of the population covered by existing licenses; the remaining licenses are in inventory.	Yes (no current use)
<i>Federal Allocation</i>	No	Radio Astronomy / Space Research in 37-38 GHz @ 3 sites;  Federal Fixed/Mobile in 37-38.6 GHz @ 14 locations	Fixed Satellite Service / Mobile Satellite Service in 39.5-40 (military use only)	Earth Exploration Satellite  Fixed/Mobile/Satellite
<i>Satellite Allocation</i>	Yes	Yes (no current use)	Yes (no current use)	Yes (no current use)
<i>Licensing Scheme</i>	Licensed	Licensed	Licensed	Unlicensed

# Possible International Harmonization

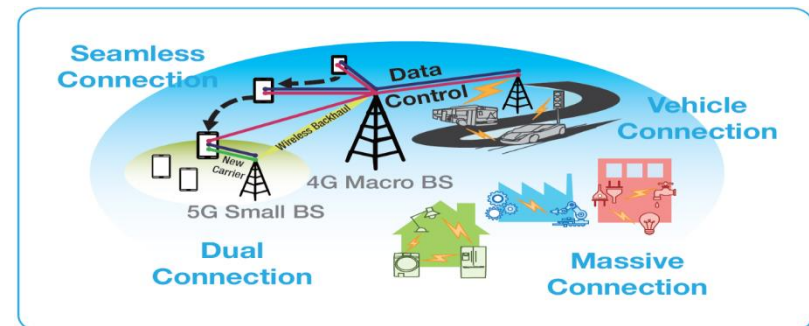


# Some Factors Enabling Sharing

- High amount of spectrum provides flexibility to avoid interference
- Relatively high path loss
- Adaptive antenna technology (steered beams)
- Heterogeneous networks



Full Dimensional MIMO



5G Deployment Scenario

# Advanced Wireless Research Initiative



- ❑ Executive Branch this past July launched a \$400 million Advanced Wireless Research Initiative led by the National Science Foundation (NSF)
- ❑ For details see <https://nsf.gov/cise/advancedwireless/>
- ❑ New program will enable the deployment and use of four city-scale testing platforms for advanced wireless research over the next decade and builds upon the Federal Communications Commission's (FCC) action on *Spectrum Frontiers*



# Some Thoughts on R&D

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## 5G Is Breaking New Ground In Many Areas

- Channel Modelling
- Propagation
- Transmission format
- Adaptive antennas
- Massive MIMO
- Services/applications
- Heterogeneous networks
- Network traffic management
- Spectrum sharing
- Etc.





# Funding Opportunities for 5G Research (From NSF Web Site)

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## Testbed/Research Platforms Infrastructure Programs:

- [Platforms for Advanced Wireless Research \(PAWR\)](#)
- [CISE Research Infrastructure \(CRI\)](#)
- [Major Research Instrumentation \(MRI\)](#)
- [Campus Cyberinfrastructure - Data, Networking, and Innovation Program \(CC\\*DNI\)](#)
- [CISE Research Infrastructure: Mid-Scale Infrastructure - NSFCloud \(CRI: NSFCloud\)](#)
- [Global Environment for Networking Innovations \(GENI\)](#)

## Research Programs:

- [NSF/Intel Partnership on Information-Centric Networking in Wireless Edge Networks \(ICN-WEN\)](#)
- [Networking Technologies and Systems \(NeTS\)](#)
- [Communication and Information Foundations \(CIF\)](#)
- [Communications, Circuits, and Sensing-Systems \(CCSS\)](#)
- [Enhancing Access to the Radio Spectrum \(EARS\)](#)
- [Future Internet Architectures -- Next Phase \(FIA-NP\)](#)
- [Industry/University Cooperative Research Centers Program \(I/UCRC\)](#)
- [Wireless Innovation between Finland and US \(WiFiUS\)](#)
- [NSF SBIR/STTR Program](#)

## Testbeds:

- [ORBIT GEN 3 - Enhancing the ORBIT Testbed with LTE and Cloud Radio Processing](#)
- [PhantomNet: An End-to-End Mobile Network Testbed](#)
- [WiMi: A Reconfigurable Platform for Millimeter-Wave Wireless Networking and Sensing](#)
- [A Reconfigurable Multi-Cell Research Platform for Massive Multiple Input Multiple Output \(MIMO\) Networks](#)
- [WiSER Dynamic Spectrum Access Platform and Infrastructure](#)
- [An Open Observatory for the Internet's Last Mile](#)
- [PhoneLab: A Programmable Participatory Smartphone Testbed](#)
- [ROAR - A Research Infrastructure for Real-time Opportunistic Spectrum Access in Cloud based Cognitive Radio Networks](#)
- [GENI; CloudLab; Chameleon Cloud](#)



# Experimental Licenses

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- Experimental License

- License to use radio frequencies otherwise not granted to or held by applicant
- Can permit RF operation in manner not permitted by current regulations
  - Power, bandwidth, application, location .....

- Purpose

- Promote innovation & research
- Support product/service development process
- Allow RF operations necessary for certain business processes (e.g. EMI testing)



# Experimental License Process

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- Applicant files for experimental license
  - Purpose and operational characteristics described
  - Application is coordinated with FCC Bureaus/Offices responsible for existing commercial license stakeholders and/or with NTIA for federal frequencies
  - Examination of application to determine potential for harmful interference to existing stakeholders or if other impediments exist
- License granted
  - Periods of 6 months, 2 years, 5 years (uncommon)
  - Conditions can be attached to ensure minimal impact
  - Licensee may cause no harmful interference to commercial/federal licensed users and must accept all interference from other parties
  - Licenses take, on average, 4 to 6 weeks to grant

# Process Issues for R&D Institutions



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- Each experiment requires separate license:
  - Many experiments = Many Licenses
- Some institutions (e.g. universities) may not be familiar with application process and may lack 'tribal knowledge' due to fluidity of staff
- 'Seek consent of license holder' condition can prove onerous:
  - Requires applicant to obtain consent of license holder before operation
  - Ensures protection of license holder and is commonly applied
  - Consent may not be withheld without cause
    - FCC retains authority to over-ride this condition if consent held without cause
  - It can be a significant burden to identify, communicate, and negotiate with parties to obtain consent
  - Where consent is unreasonably withheld, mediation by FCC can take months



# Program License

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- **New license to support R&D organizations:**
  - Recognizes that many R&D institutions control the space within which experiments occur - - Campuses, test ranges, etc.
  - Risk of interference is minimized within such controlled spaces
- **Program License:**
  - Grants general authority to conduct experiments in defined geographic area
  - Must describe experiment & post on FCC program license website
  - Website permits inspection by public and automatic notification by triggers on experiment characteristics to interested parties
  - If no objections received within 10 day period (15 federal frequencies), applicant is authorized to proceed
  - Report on experiment including any interference incidents must be posted on website within 30 days of experiment termination



# Program License Benefits

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- Lower overhead per experiment for application
- 4 to 6 week interval reduced to 10/15 days
- Potentially affected parties must:
  - Self-identify
  - File objection for cause
- Paradigm shift:
  - Presumptive right to proceed subject to valid objections for cause
  - Prior: experimenter had to seek stakeholders and negotiate for permission
    - Stakeholders could range from one party to many
    - Actual stakeholders may be obscured thru lease or other business arrangements
- What remains:
  - Obligation to avoid creation of harmful interference
  - Obligation to accept any interference from authorized operations



# Eligibility

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- College or university with a graduate research program in engineering that is accredited by the Accreditation Board for Engineering and Technology (ABET)
- Research laboratory
- Hospital or health care institution
- Manufacturer of radio frequency equipment; or a manufacturer that integrates radio frequency equipment into its end product.



# Obligations of Licensee

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- The radiofrequency experimentation will be conducted in a defined geographic area under the applicant's control
- The applicant has institutional processes to monitor and effectively manage a wide variety of research projects
- The applicant has demonstrated expertise in radio spectrum management or partners with an entity with such expertise
- Applications must specify a geographic area that is inclusive of an institution's real-property facilities where the experimentation will be conducted and that is under the applicant's control





# Program License Not Permitted When:

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- An environmental assessment must be filed
- An orbital debris mitigation plan must be filed
- Applicant requires non-disclosure of proprietary information as part of its justification for its license application; or
- A product development or a market trial is to be conducted.



# Medical Testing Experimental License

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- Similar to program license with some adjustments to account for unique needs of medical device testing:
  - General license covering geographic area
  - Notification requirements (10/15) remain same
- Differences:
  - Market trials permitted
  - Yearly reporting requirement rather than by experiment



# Innovation Zone

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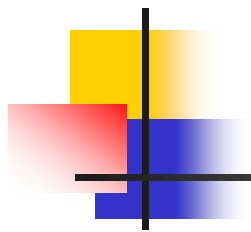
- A specified geographic location
- Pre-authorized boundary conditions (such as frequency band, maximum power, etc.)
- Created by the Commission on its own motion or in response to a request from the public
- Innovation zones will be announced via public notice and posted on the Commission's program experimental registration Web site



# Innovation Zone Participants

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- Must have program license
  - All conditions of program license apply
  - Innovation Zone is the defined geographic area for the program licensee Innovation Zone participants
- Experiments must be consistent with boundary conditions defined for Innovation Zone



# Questions