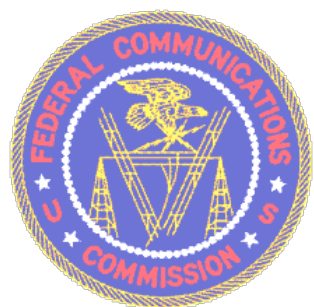


FCC Actions to Introduce 5G in the United States



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5G HUDDLE 2016
April 26 - 27, 2016

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

FCC Approach to 5G



Remarks of FCC Chairman Tom Wheeler at March 8, 2016 Satellite Leadership Dinner:

“The United States approaches the kind of opportunity 5G presents somewhat differently from other countries. We do it by indicating which spectrum will be made available and then relying on a private sector-led process for producing technical standards best suited for those frequencies. We won’t wait for the standards to be first developed in the sometimes arduous standards-setting process or in a government-led activity.”

“Last summer, the Commission launched what we call our Spectrum Frontiers rulemaking to explore the use of millimeter wave spectrum – the airwaves at 24 GHz and above – for 5G. Our Spectrum Frontiers rulemaking reflects the need to be innovative and flexible in how we utilize spectrum. We cannot limit ourselves to old models or worst-case analyses.”

5G – Policy Perspective



- ❑ 5G is a national priority for US
 - ❑ We indicate which spectrum will be made available
 - ❑ Rely on a private sector-lead process for producing technical standards best suited for those frequencies
- ❑ Flexible licensing rules to support various service models
 - ❑ Carrier-driven vs. new entrant vs. end-user driven network
- ❑ Technical rules to take advantage of propagation characteristics of mmW bands
 - ❑ Enable sharing opportunities
 - ❑ Enhance spectrum reuse
- ❑ Create opportunities for innovators to build and deliver new services and applications to consumers

Key Events



- ❑ FCC Spectrum Frontiers Notice of Proposed Rulemaking (NPRM)
 - ❑ Released on October 23, 2015
 - ❑ Comments and Reply Comment were due on Jan 26th and Feb 23rd, 2016

- ❑ WRC15
 - ❑ Identified 11 bands to study for 5G in WRC19
 - ❑ Not all of Spectrum Frontiers NPRM bands are aligned with WRC15 study bands

- ❑ 2016 MWC in Barcelona
 - ❑ 5G took a center stage

- ❑ FCC 5G Workshop
 - ❑ One-day workshop on April 10th, 2016
 - ❑ Panel discussions on key topics with industry leaders
 - ❑ Latest 5G equipment were demonstrated

Spectrum Frontiers NPRM



☐ Core Principles

- ☐ 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

☐ Frequency Bands

- ☐ Proposed 27.5-28.35 GHz; 38.6-40 GHz; 37-38.6 GHz; 64-71 GHz
- ☐ Invited comment on 24.25-24.45 GHz; 25.05-25.25 GHz; 29.1-29.25 GHz; 31-31.3 GHz; 31.8-33 GHz; 42-42.5 GHz; 71-76 GHz; 81-86+ GHz

☐ Licensing, Operating and Regulatory Rules/Issues

- ☐ Part 30: Upper Microwave Flexible Use Service (UMFUS)
- ☐ Geographic Area Licensing, Area Size, Band Plan, License Term
- ☐ Technical rules
- ☐ Performance Requirements

☐ Further NPRM planned post-WRC

Overview of Proposed Bands

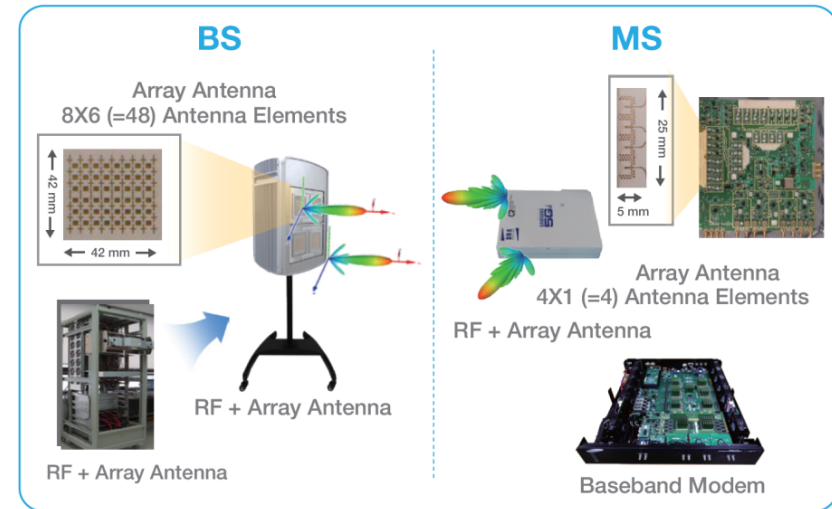


	28 GHz	37 GHz	39 GHz	64-71 GHz
<i>Frequency</i>	27.5-28.35 GHz	37-38.6 GHz	38.6-40 GHz	64-71 GHz
<i>Bandwidth</i>	850 MHz	1600 MHz	1400 MHz	7000 MHz
<i>Terrestrial Allocation</i>	Licensed for fixed operations, with about 75% of the population covered by existing licenses; remaining licenses in inventory	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 Secondary E-S	Yes (no current use)	Yes (no current use)	Yes (no current use)
<i>Proposed Licensing</i>	Licensed	Licensed	Licensed	Unlicensed

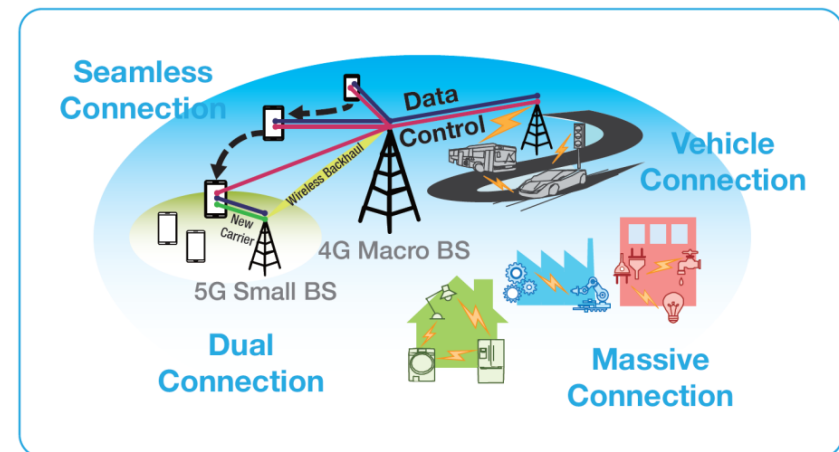
Some Factors Enabling Sharing



- 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

Proposed Technical Rules

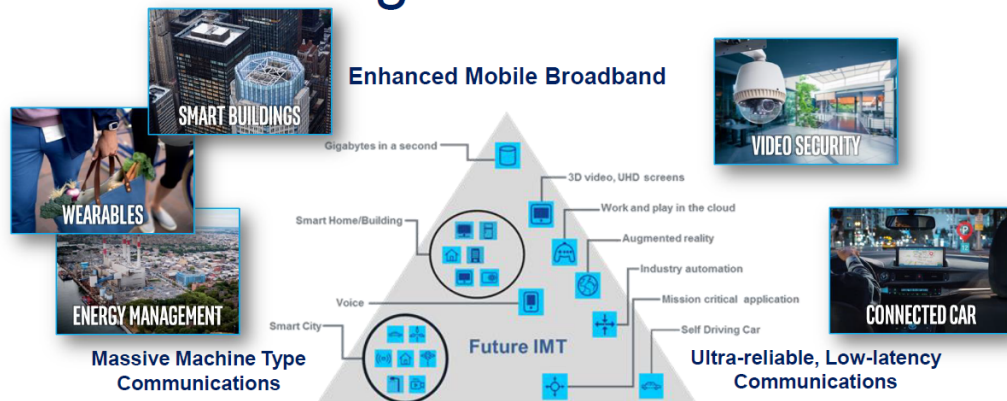


- ☐ Flexible Duplexing
 - ☐ TDD and/or FDD
- ☐ TX Power
 - ☐ Max EIRP of 62dBm/100MHz is proposed for BS
 - ☐ Max EIRP of 43dBm is proposed for MS
 - ☐ Sought comments on the bandwidth factor for mmW band technologies
- ☐ Out of Band Emissions (OOBE)
 - ☐ Radiated measurement is assumed due to lack of RF port
 - ☐ $43+10\log P$ is proposed and sought comments on the measurement bandwidth, offset and other parameters as applicable from existing FCC rules
- ☐ Field Strength at Market Borders
 - ☐ Sought comments on the applicability of 47dBuV/m per Part 27 rules
- ☐ Measurement Techniques
 - ☐ Sought comments on measurement challenges of mmW bands, particularly on the radiated measurement techniques

FCC 5G Workshop - Service Vision



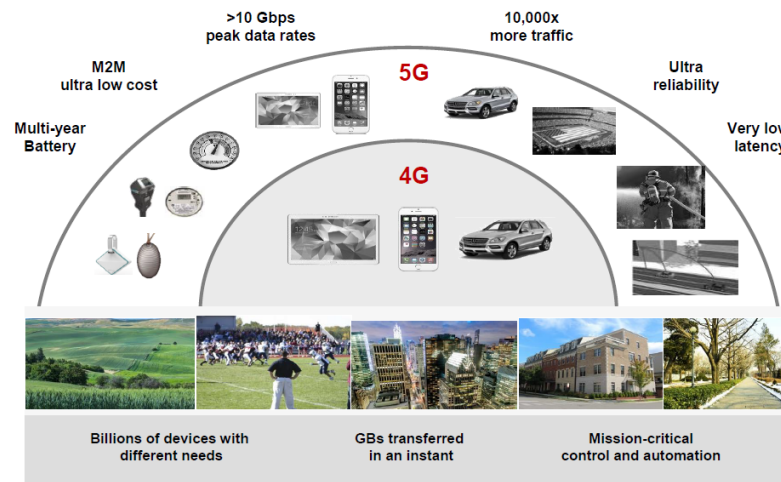
ITU-R Usage Scenarios for 5G



Source: Recommendation ITU-R M.2083 "IMT Vision - Framework and overall objectives of the future development of IMT for 2020 and beyond"

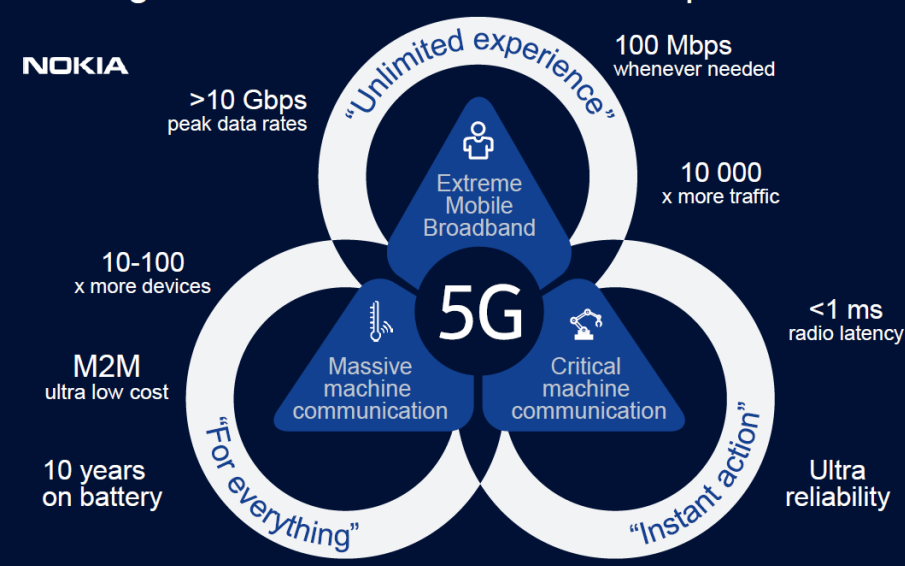
Intel products fuel the 5G engine by enabling new applications in a variety of spectrum bands

So what is 5G?

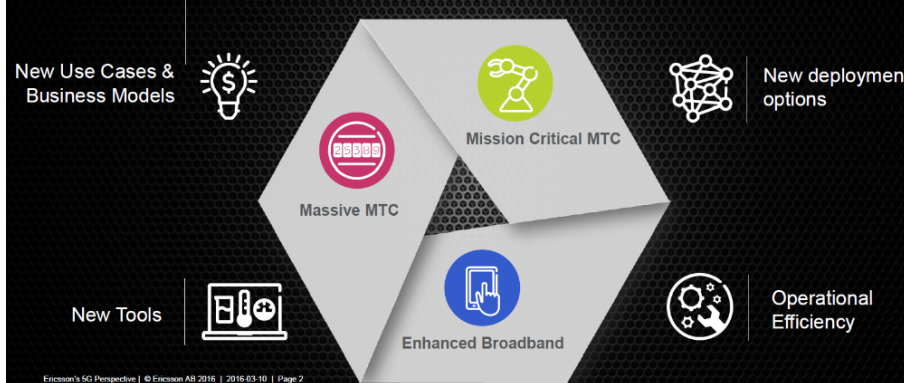


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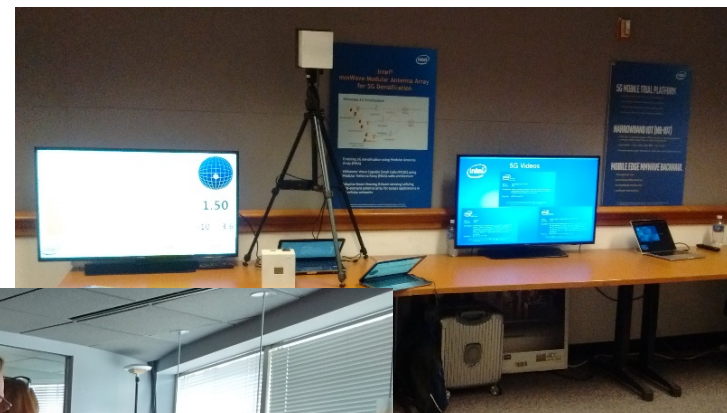
Heterogeneous use cases – diverse requirements



DRIVING 5G EVOLUTION



FCC 5G Workshop - Equipment Demos

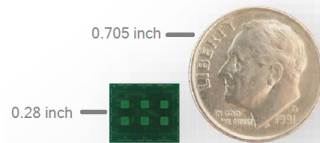


5G Technology Status



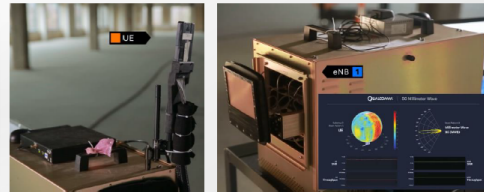
Making mmWave a reality for mobile Qualcomm is driving 5G mmWave

60 GHz chipset commercial today for mobile devices



Qualcomm® VIVE™ 802.11ad technology with a 32-antenna array element

Developing robust 5G mmWave for extreme mobile broadband

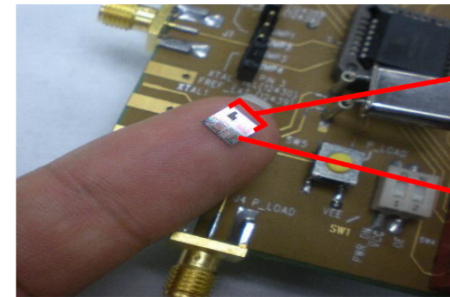


Qualcomm Research 28 GHz end-to-end prototype system demonstrates beam forming and scanning to address NLOS scenarios, improve indoor/outdoor range, and provide robust mobility

Qualcomm VIVE is a product of Qualcomm Atheros, Inc.; Qualcomm Research is a division of Qualcomm Technologies, Inc.

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mmWave Wavelength Visualization – 60 GHz



5 millimeters
16 antennas

Integrated Circuit

Source: F. Gutierrez, S. Agarwal, K. Parrish, and T.S. Rappaport, "On-Chip Integrated Antenna Structures in CMOS for 60 GHz WPAN Systems," IEEE Journal on Selected Areas in Communications, vol. 27, no. 8, October 2009, pp. 1367 – 1377.



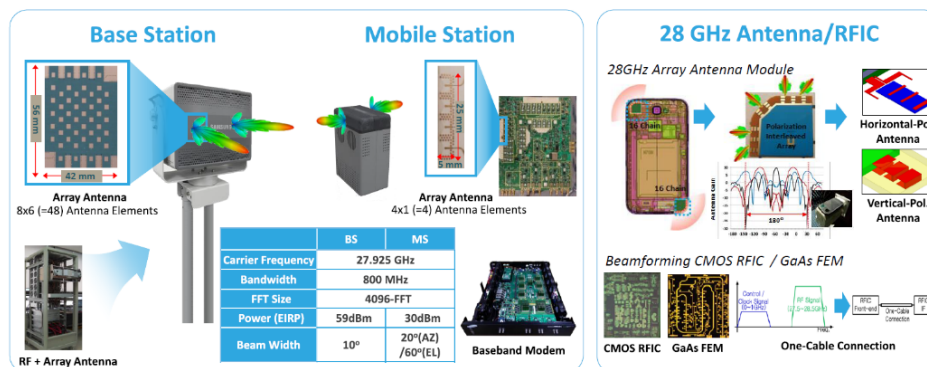
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mmWave Testbed / Chipset Development

SAMSUNG

World's 1st mmWave Testbed and Antenna/RFIC for Devices



Verizon 5G Technology Forum Partners



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Source: <https://www.fcc.gov/news-events/events/2016/03/spectrum-frontiers-workshop>

Next Steps



- ❑ NPRM enjoys strong support
 - ❑ Suppliers have developed equipment
 - ❑ Carriers are conducting tests & planning trials
- ❑ Work is proceeding to fine tune proposals
 - ❑ Satellite and Wireless industries collaborating to develop sharing framework
 - ❑ Developing incumbent protections
- ❑ FCC plans to act this summer
 - ❑ Will identify spectrum & adopt rules for 5G
 - ❑ Will propose or consider additional spectrum (including WRC bands)
 - ❑ FCC action is not at odds with international harmonization
- ❑ Research by government and industry is ongoing

Thank You