FCC Actions to Make Spectrum Available for 5G

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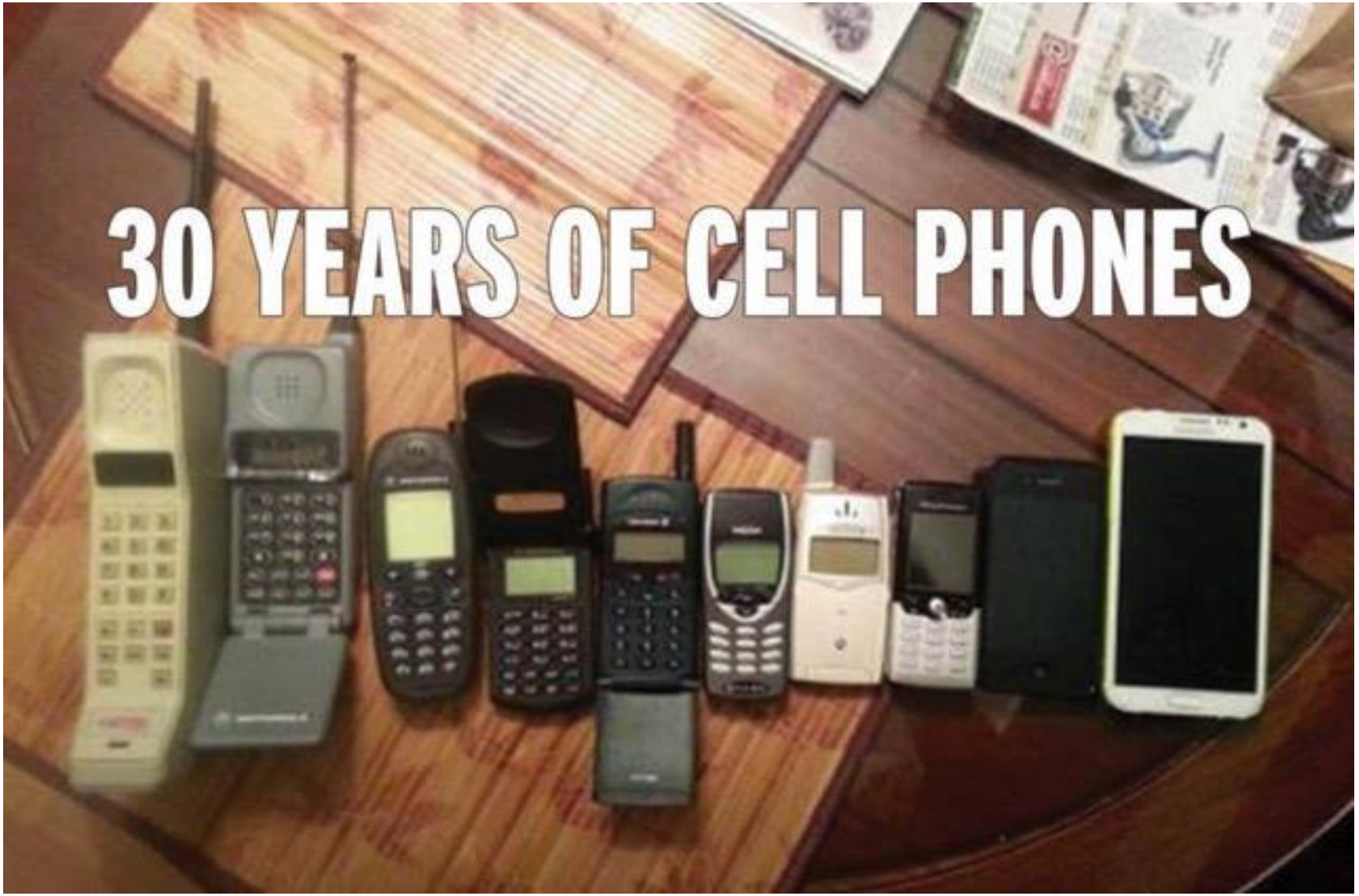
Second Global 5G Event
November 9, 2016

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



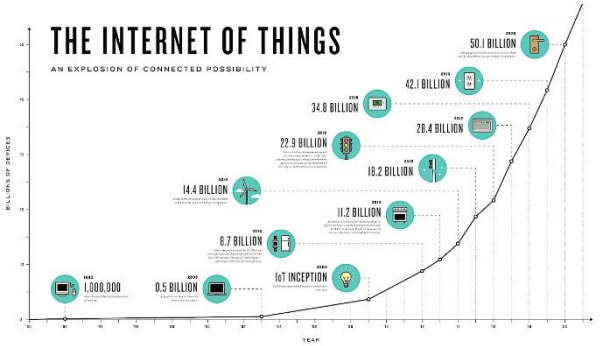
1G: Analog Cellular → 2G: Personal Communications Service → 3G: Advanced Wireless Service → 4G: 700 MHz

Drivers of Growth

Usage: 24/7

Apps Economy

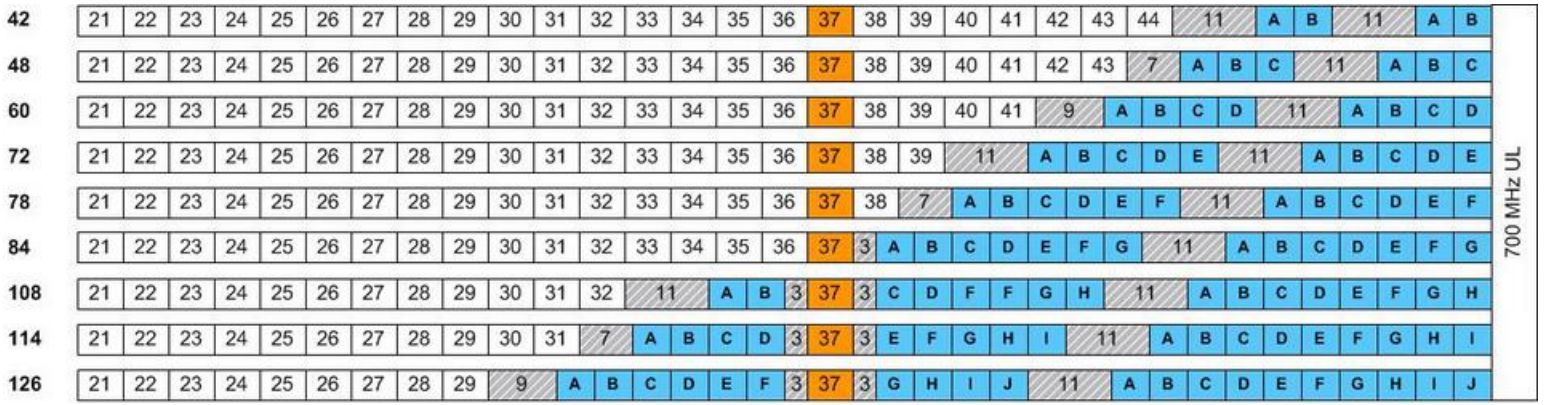
Social Media



Internet of Things

Spectrum Trifecta: Low Band

TV Incentive Auction



Repacked TV

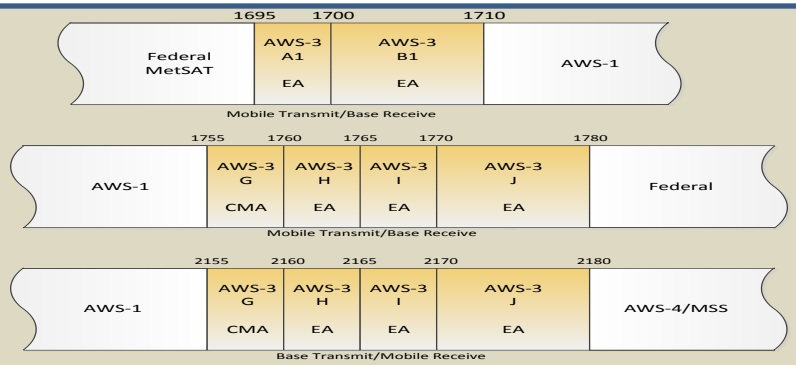
Guard Band

Medical Telemetry & Radio Astronomy

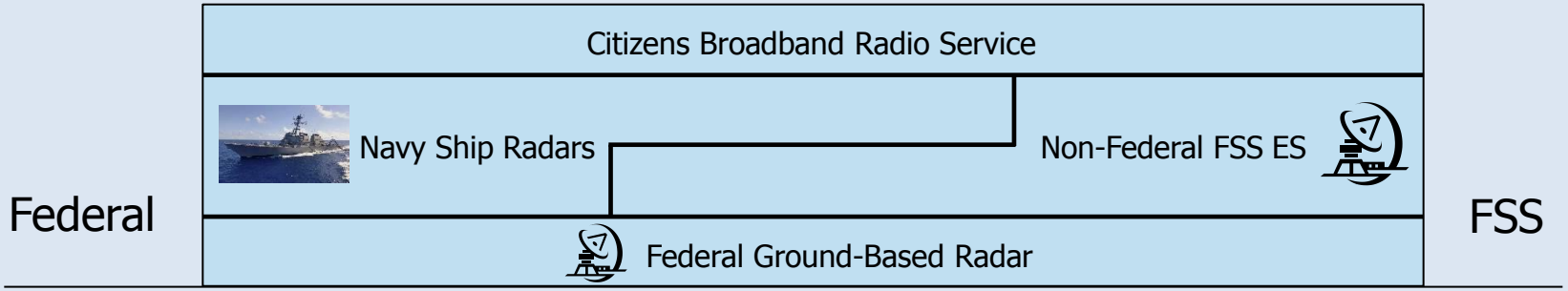
Duplex GAP

Repurposed For Wireless Auction

Spectrum Trifecta: Mid Band



AWS-3: Auctioned 1.7 GHz/2.1 GHz



Citizens Broadband Radio Service

Spectrum Trifecta: High Band

- U.S. has opened up high-band spectrum for 5G networks and applications

- Sticks to a proven formula:
  - Make spectrum available
  - Encourage and protect innovation-driving competition
  - Stay out of the way of technological development and details of implementation

Opening of High Band Spectrum

Spectrum Frontiers

Report and Order and Further Notice of Proposed Rule Making
Adopted by the Commission July 14, 2016

Spectrum Allocations

- 10.85GHz of Spectrum added for mobile
  - Licensed Bands (3.85GHz): 27.5-28.35 GHz; 37-38.6 GHz; 38.6-40 GHz;
  - Unlicensed Bands (7GHz): 64-71 GHz

Service Rules

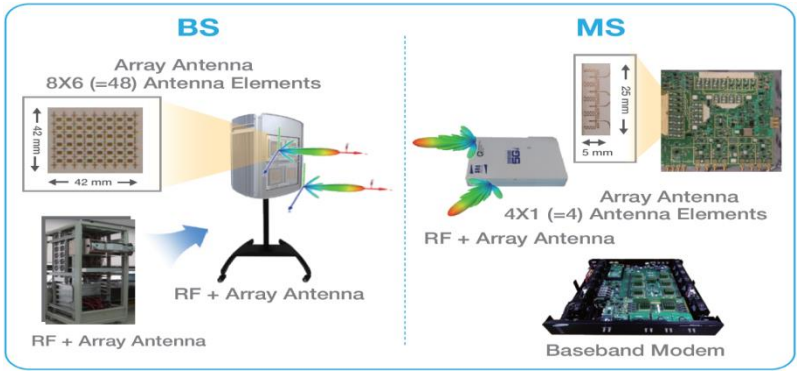
- Part 30: Upper Microwave Flexible Use Service (UMFUS)
- Geographic Area Licensing, Area Size, Band Plan, License Term, Overlay Auctions
- Technical rules
- Performance Requirements
- Ensure cyber protections considered from the start

Overview of R&O Bands

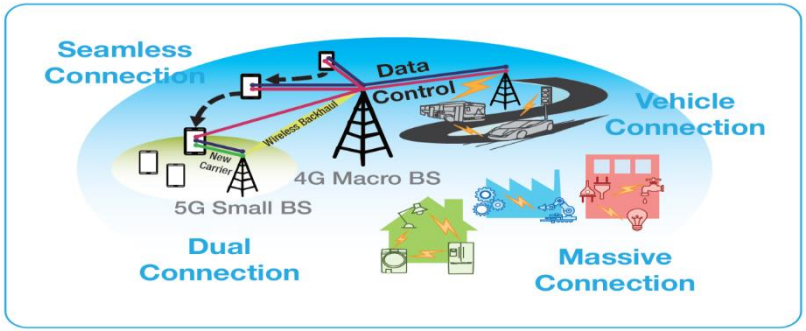
	28 GHz	*37 GHz*	*39 GHz*	*64-71 GHz*
Frequency	27.5-28.35 GHz	37-38.6 GHz	38.6-40 GHz	64-71 GHz
Bandwidth	850 MHz	1600 MHz	1400 MHz	7000 MHz
Terrestrial Allocation	Licensed for fixed operations, with about 75% of the population covered by existing licenses; remaining licenses in inventory	Yes (no current 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)
Federal Allocation	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
Satellite Allocation	Yes	Yes (no current use)	Yes (no current use)	Yes (no current use)
Licensing Scheme	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

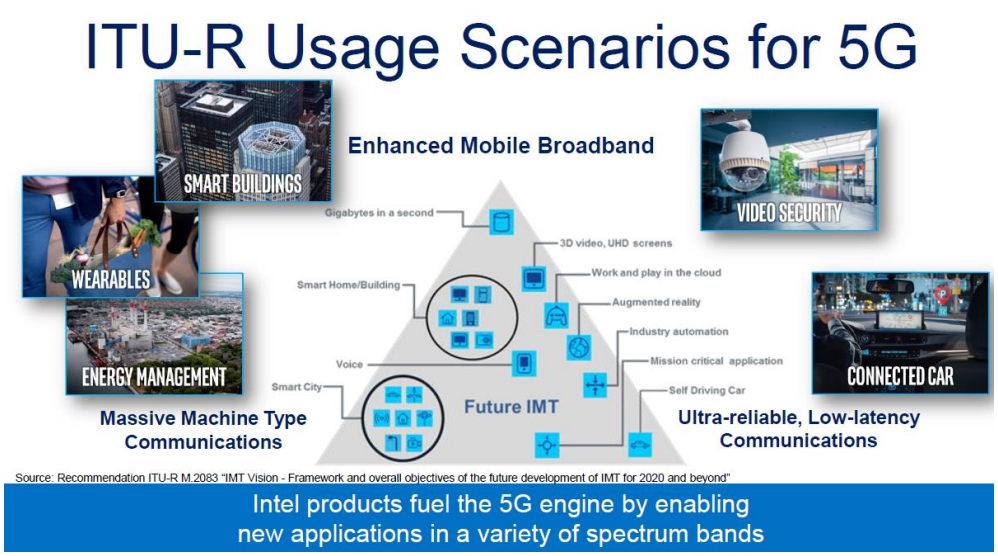


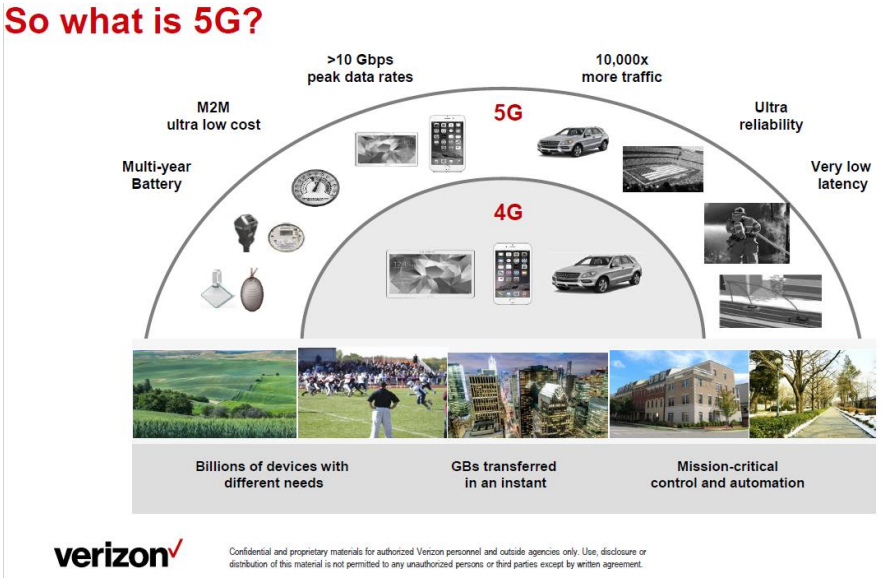
Full Dimensional MIMO

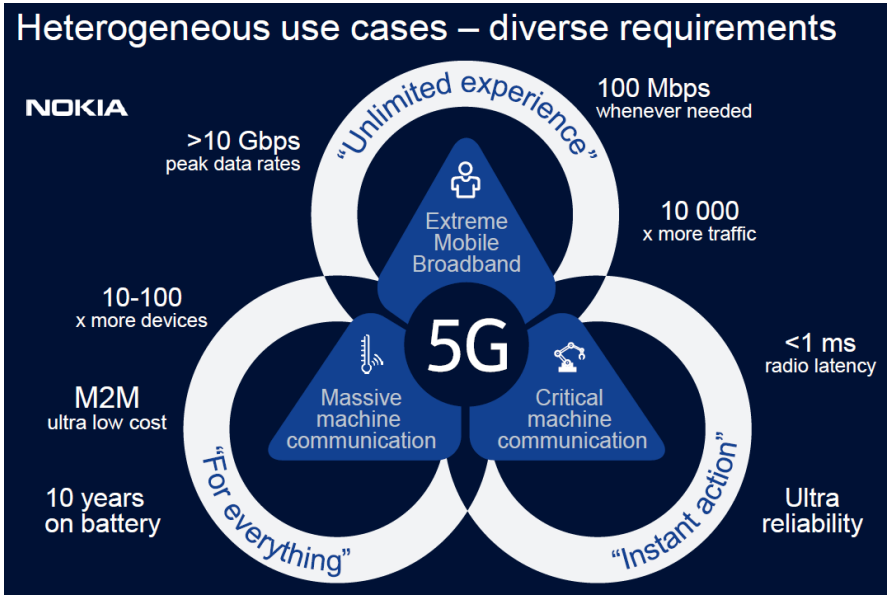


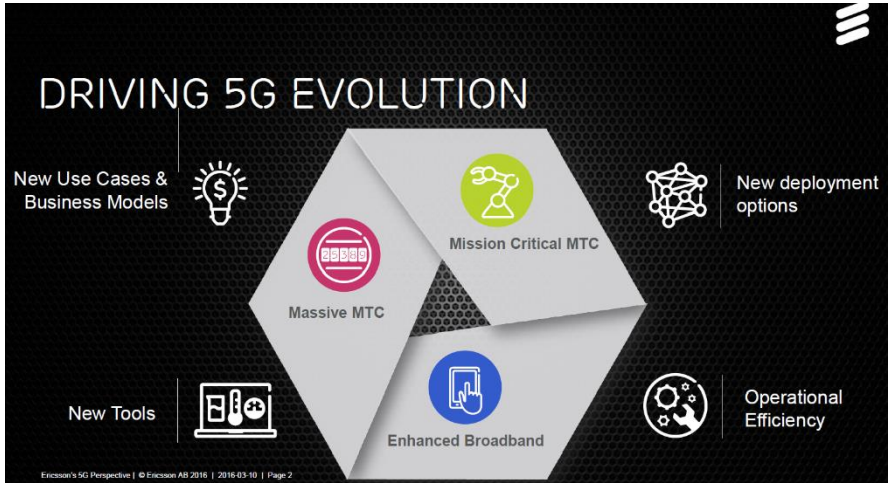
5G Deployment Scenario

What is 5G?

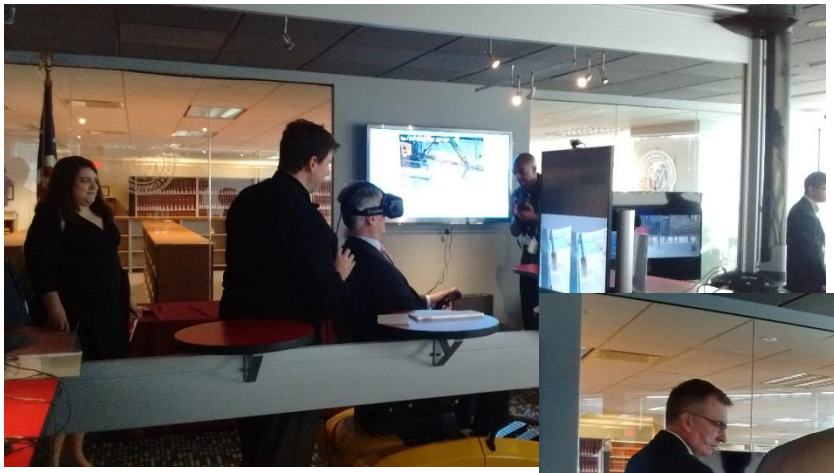

ITU-R Usage Scenarios for 5G
SMART BUILDINGS
Enhanced Mobile Broadband
VIDEO SECURITY
WEARABLES
ENERGY MANAGEMENT
Gigabytes in a second
3D video, UHD screens
Work and play in the cloud
Smart Home/Building
Augmented reality
Industry automation
Voice
Mission critical application
Smart City
Self Driving Car
Future IMT
CONNECTED CAR
Massive Machine Type Communications
Ultra-reliable, Low-latency Communications
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

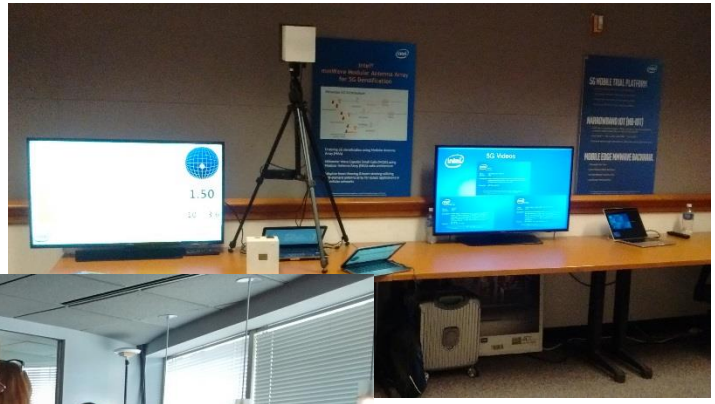

So what is 5G?
>10 Gbps peak data rates
10,000x more traffic
M2M ultra low cost
5G
Ultra reliability
Multi-year Battery
Very low latency
4G
Billions of devices with different needs
GBs transferred in an instant
Mission-critical control and automation
verizon
Confidential and proprietary materials for authorized Verizon personnel and outside agencies only. Use, disclosure or distribution of this material is not permitted to any unauthorized persons or third parties except by written agreement.

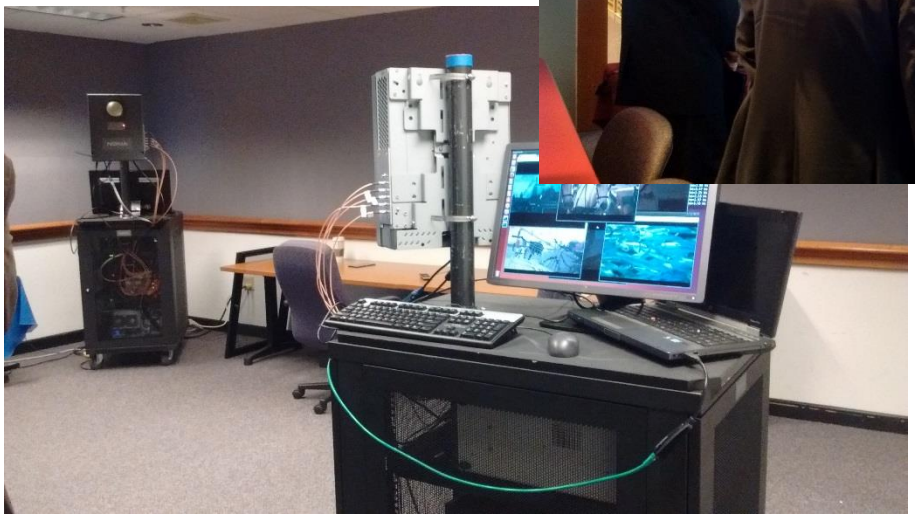

Heterogeneous use cases – diverse requirements
NOKIA
"Unlimited experience"
100 Mbps whenever needed
>10 Gbps peak data rates
Extreme Mobile Broadband
10 000 x more traffic
10-100 x more devices
5G
<1 ms radio latency
M2M ultra low cost
Massive machine communication
Critical machine communication
"For everything"
"Instant action"
10 years on battery
Ultra reliability


DRIVING 5G EVOLUTION
New Use Cases & Business Models
New deployment options
Mission Critical MTC
Massive MTC
New Tools
Enhanced Broadband
Operational Efficiency
Ericsson's 5G Perspective | © Ericsson AB 2016 | 2016-03-10 | Page 2

FCC 5G Workshop – Equipment Demos







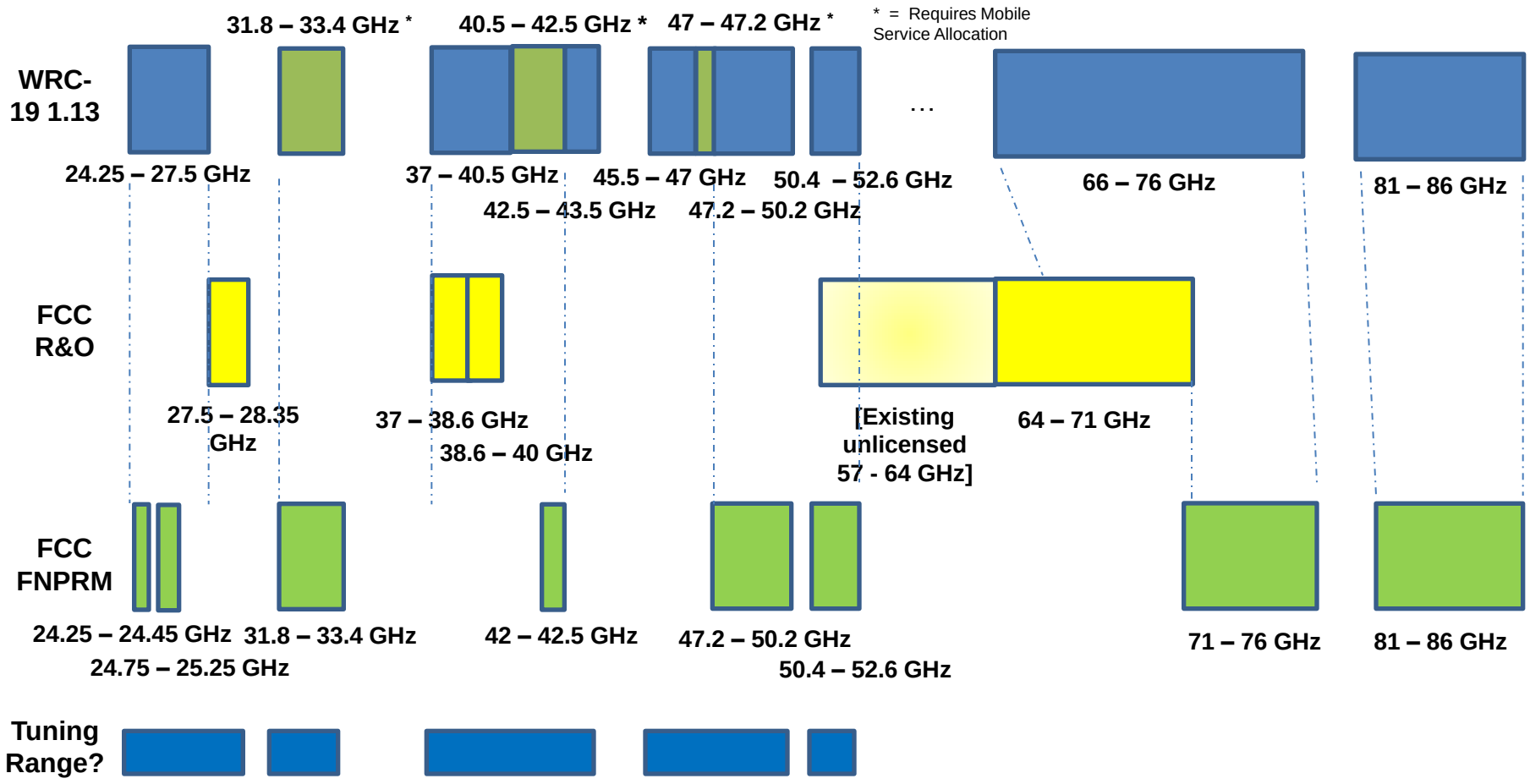
Next Steps

- Mobile service in mmW band has strong support
  - Suppliers have developed equipment
  - Carriers are conducting tests & planning trials
- Further Notice of Proposed Rule Making
  - Seeks comment on 15.8 GHz + above 95 GHz band
  - 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; and, bands above 95 GHz
  - Invites comment on various details including sharing spectrum with federal users
- Comments September 30, 2016; Replies October 31, 2016
- Notice of Inquiry on to ensure attention to cybersecurity

Expansion of Experimental Licensing Program (ET Docket No. 10-236)

- ***Greater flexibility to conduct research and development*** by permitting flexibility to adapt experiments within a broad range of parameters
- ***Program experimental license***: Allows colleges, research laboratories, health care institutions, and manufacturers that have demonstrated experience in RF technology to conduct ongoing series of research experiments and tests
- ***Clarifies, simplifies, and expands rules for market trials*** - allows greater number of devices to enter U.S. for testing and evaluation purposes

Opportunities for International Harmonization



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*

Advanced Wireless Initiative Description of Potential Benefits of 5G

- **Mobile phones and tablets that can download full length HD movies in less than 5 seconds, 100 times faster than 4G** (6 minutes) and 25,000 times faster than 3G (26 hours).
- **First responders and emergency room doctors who get live, real-time video and sensor data** from police vehicles, ambulances, and drones, along with patient vitals and medical records—all before the patient arrives at the hospital door.
- **Semi- or fully-autonomous vehicles** that can communicate with the outside world and with each other to improve travel efficiency and safety.
- **Factories equipped with always-connected smart manufacturing equipment** that self-diagnose and repair themselves before they break.
- **Gigabit-speed wireless broadband** available in businesses, public transportation stations, stadiums, campuses, schools, malls, parks, and other public spaces.
- **Virtual reality training environments and simulators** that allow entry-level workers to develop and demonstrate skills in high-demand fields like solar energy installation—anytime, from anywhere.

FCC Chairman Tom Wheeler: 5G is not a technology. It is a revolution.

- Chairman Wheeler: *Let's talk about the benefits of smart-city energy grids, safer transportation networks, and new opportunities to improve health care. Let's paint the picture of how 5G will unleash immersive education and entertainment industries, and how 5G will unlock new ways for local employers to grow, whether it's a small specialty shop or a large factory, creating new jobs and improving services for the community.*

Other Keys to Unlocking the 5G Opportunity

- Foster competitive provision of infrastructure
  - 5G will require a lot more cells
  - We'll need a lot more backhaul
  - Commission will take up a reform proposal that will encourage innovation and investment in what we now call Business Data Services
- Remove unnecessary hurdles to siting
  - Estimates of 10x or more growth in cell sites
  - Need to tell story of 5G in terms of deliverables
  - Committed to working to lessen siting burdens and costs to ensure that 5G is available nationwide, while respecting the vital role that the communities themselves play in the siting process

Questions?