FCC Spectrum Planning Challenges

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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

Wireless Growth

(Cisco Visual Networking Index)

- In the United States, mobile data traffic will grow 4-fold from 2016 to 2021, a compound annual growth rate of 34%.
- U.S. mobile data traffic will grow 2 times faster than U.S. fixed IP traffic from 2016 to 2021.
- The United States's mobile data traffic grew 41% in 2016.
- In the United States, mobile data traffic in 2021 will be equivalent to 12x the volume of the entire U.S. Internet in 2005.
- In the United States, mobile video traffic will grow 5-fold from 2016 to 2021, a compound annual growth rate of 40%.
- Video will be 80% of The United States' mobile data traffic in 2021, compared to 64% at the end of 2016.

Change Factors

- ‘Traditional’ clearing reallocation methods increasingly ineffective
  - Time/Cost/Practicality
- Mobile is dominant interest in spectrum planning
- Rebalancing satellite interests
  - GEO/MEO/LEO/Terrestrial and HAPs
- Satellite growth due to commercialization
  - 10x Launches, 8x potential satellites per launch
- UAS spectrum needs
- Blurring between Licensed/Unlicensed allocations
- Emergence of 5G
- Re- evaluation of interference concepts
  - From ‘no harmful interference’ to ‘risk based assessment’

FCC Spectrum Planning Efforts

- FCC in midst of largely unprecedented planning effort focused on low, mid and upper spectrum bands
  - Attempting to reallocate maximal amount of spectrum to expected mobile applications
  - Going from just in time approach to maximal allocation
  - Will set environment to come for decades

Why This Approach

- "It's difficult to make predictions – especially about the future"
  - Yogi Berra (NY Yankees), Niels Bohr (Brooklyn Dodgers), Winston Churchill (played in minor leagues)
- Mobile broadband growth still at early stage
  - Video growth continuing
  - IOT seen as new emerging application
  - 5G supporting IOT and requiring mm wave spectrum allocations
- Downside risk of underestimating spectrum needs driving spectrum strategy
  - We know more spectrum is needed if not the exact amount
  - Actual needs driven by convolution of demand, spectrally efficient technologies, and information processing
  - How much we provide can drive how much will be needed
- Future technological evolution will be driven by what results from these planning efforts

Challenges

- Traditional clearing methods failing
  - 10+ years + tens of billions of dollars
  - Need place to move legacy operators
- Mobile as dominant interest
  - Presents most difficult challenge in protecting existing legacy applications
  - Factors: Antenna height, indoor/outdoor operation, power, location restrictions, spectrum management systems, spectrum characteristics

Challenges (cont.)

- Rebalancing Satellite Interests
  - GEO/MEO/LEO/Terrestrial/HAPS must share same spectrum allocations/bands
  - Upper band spectrum 28GHZ to 100 GHz lightly utilized until recently and largely allocated to expected satellite systems
    - Ka Band (28 GHz) satellites launched 2011
    - Upper band also proposed for terrestrial use
      - Satellite signals suffer up to 180 dB attenuation, complicating spectrum sharing
- Satellite growth
  - 1200 satellites at present, over 13,000 planned
    - Not counting cubesats, femtosats, thumbsats
- UAS/HAP
  - No allocations, no service rules at present
- Sharing between satellite/terrestrial applications
  - Mixing Weak & Strong

Challenges (cont.)

- Blurring between licensed/unlicensed allocations
  - Licensed/unlicensed allocations used to imply different services and technologies
    - Licensed operators used to see unlicensed as competitive threat
      - One cellular operator disabled WiFi capabilities on phone
  - But as markets evolve:
    - Licensed operators using unlicensed bands to augment their capacity
    - Fixed line operators using unlicensed bands to extend their services
  - In an error of multiband radios, spectrum is spectrum
- Industry tussles
  - WiFi forum advocates for protection of unlicensed for WiFi
  - 3GPP develops various unlicensed standards
- FCC attempting to balance allocations between licensed/unlicensed
  - Differences should exist only in QOS expectations and ownership models
  - FCC supports technology neutrality generally in both models
  - We have relied upon standards groups to rationalize conflicts with prodding from Commission

Challenges (cont.)

- Emergence of 5G
  - 4.8B use mobile devices today
  - In 2018, IOT devices expected to surpass mobile phones
    - 29B connected devices by 2022 of which 18B will be IOT devices
    - 70% of IOT devices to use cellular technology in 2022
    - >> 95% of applications non-consumer
- 5G/IOT expected to provide foundation for innovation
  - Provided there is sufficient spectrum
  - U.S. first country to authorize mm wave spectrum for mobile applications

Challenges (cont.)

- Re- evaluation of interference concepts; a work in progress
- Past policy is to protect incumbents from harmful interference
  - Like beauty, harm is in the eye of the beholder
  - No definitive definition of harm
- Satellite industry has argued that standard is 1 dB degradation in C/I is policy
  - This argument not supported by record; 1dB criteria applied in specific instances to reach resolution
  - C/I poorly correlated with performance
  - 1 dB C/I can be calculated but not measured in real world environment

- From ‘no harmful interference’ to ‘risk based assessment’
- Inline with some industry sectors beginning to advocate for statistically informed risk thresholds
  - From worst case to statistical standard
- Will try to apply to some future service proceedings
- Represents a major shift in policy with incumbents being asked to accept some level of risk

Current Efforts

- Incentive Auction (Low band)
- 3.5 GHz and 5-7 GHz (Mid band)
- Spectrum frontiers (High band)

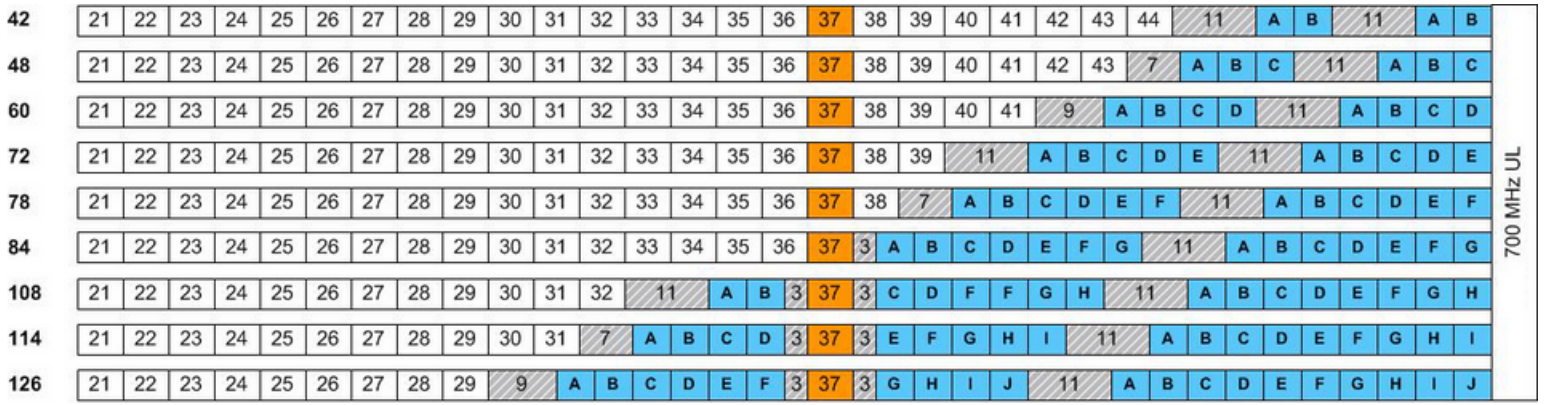
1G: Analog Cellular → 2G: Personal Communications Service → 3G: Advanced Wireless Service → 4G: 700 MHz

Incentive Auction

- Transition to DTV created an excess of spectrum which broadcasters returned
  - 108 MHz recovered (20 MHz allocated to public safety) by statute
- FCC proposed incentive auction to further recover spectrum
  - Simultaneous auction of buyers (mobile svc companies) and sellers (broadcasters)
  - Sellers either abandon business or repack with remaining stations
  - $20B bid with $10B going to broadcasters
- 84 MHz spectrum recovered in 600 MHz band
  - However spectrum available for White Spaces services severely reduced in metropolitan areas as a result of repacking

Spectrum Trifecta: Low Band

TV Incentive Auction



Repacked TV

Guard Band

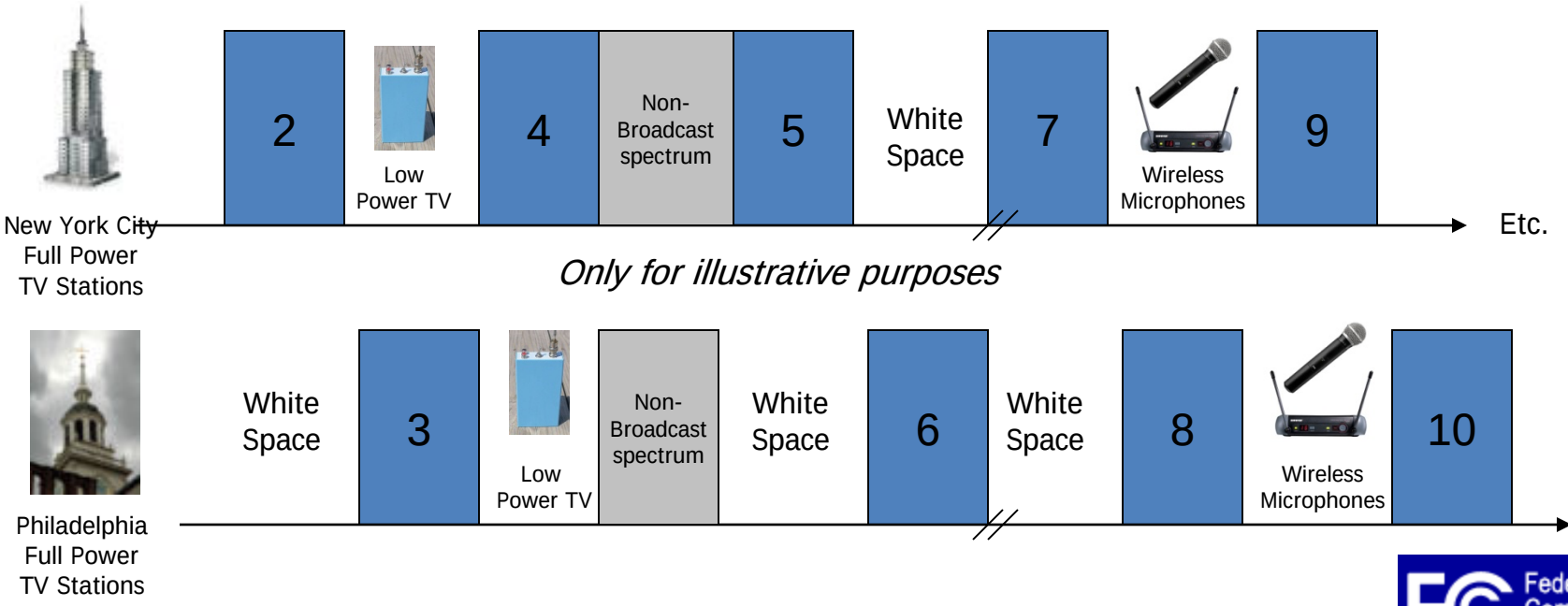
Medical Telemetry & Radio Astronomy

Duplex GAP

Repurposed For Wireless Auction

IA Impact on White Space Service

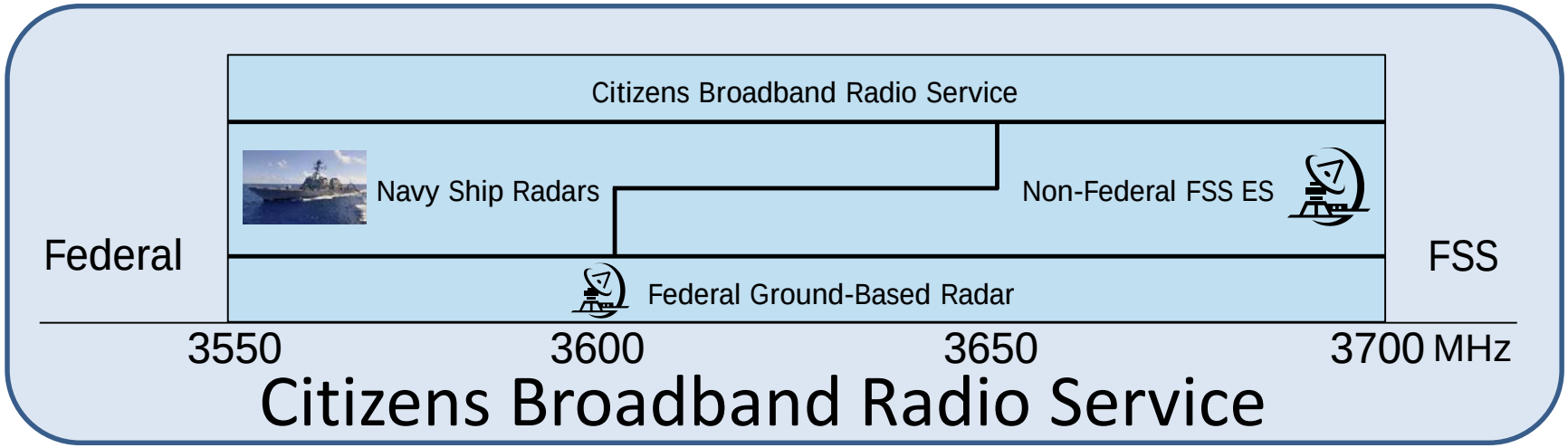
- Commission allocated unused TV spectrum to unlicensed "white space service"
  - Required spectrum management system to identify unused spectrum
- Incentive Auction and DTV allowed repacking and elimination of many white space channels
- Remaining channels contended for by Low Power TV, unlicensed microphones and White Space Devices
- Limited unused channels available where most people are
- Large amounts of unused channels available where most people aren't



Federal Communications Commission

Spectrum Trifecta: Mid Band

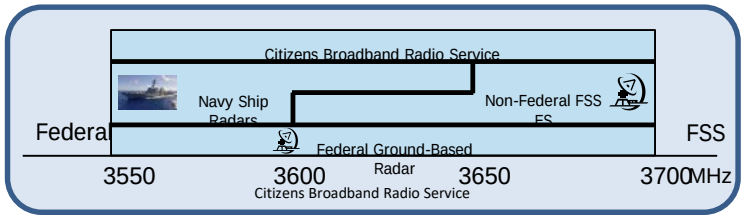
- Presidents Council of Advisors on Science & Technology recommended the FCC investigate sharing strategies for spectrum usage
- Technological Advisory Council recommended FCC focus on small cell deployment strategies



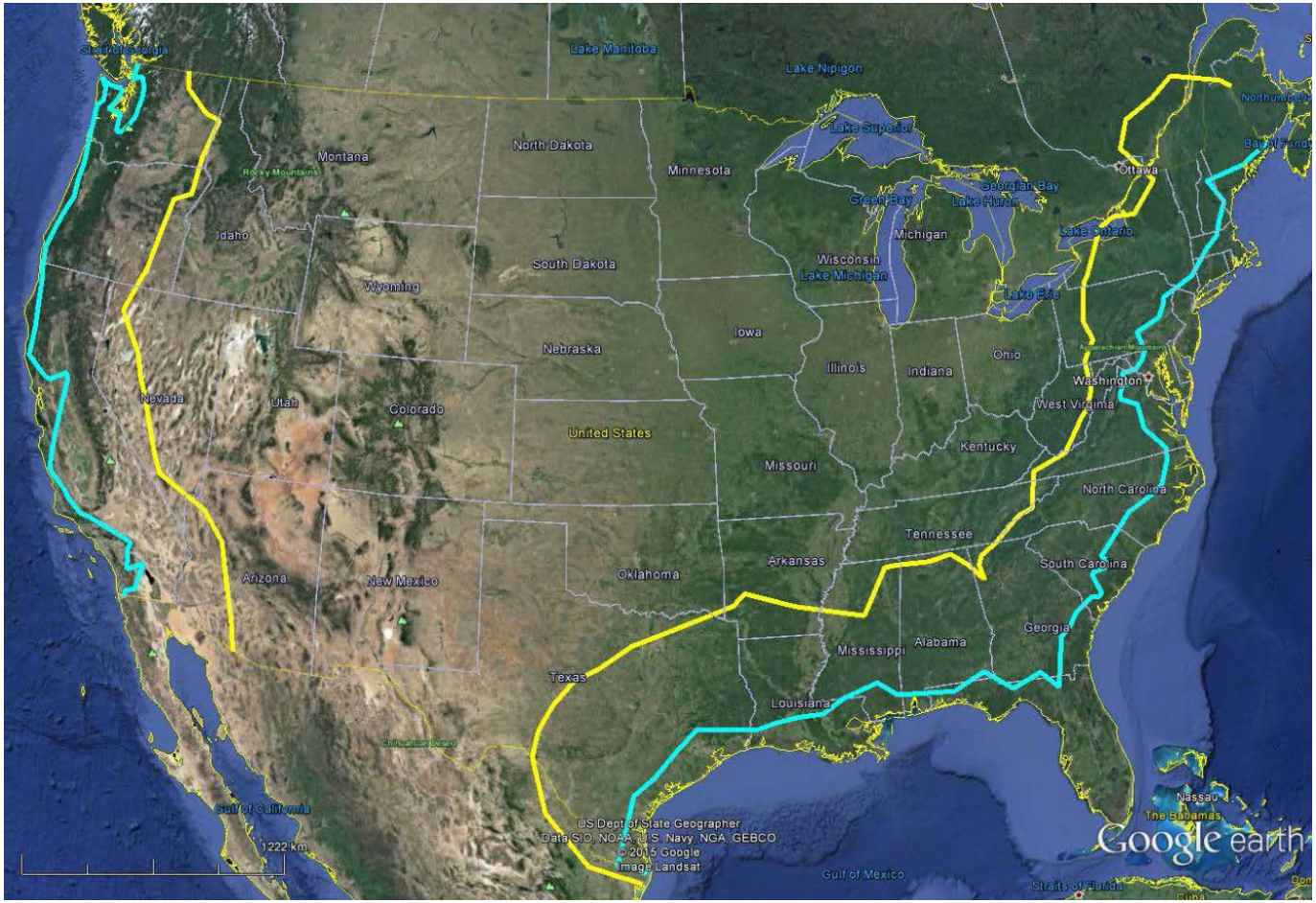
Spectrum: Midband

- FCC Notice of Inquiry (NOI) asked how dynamic access can provide more intensive and efficient use of spectrum

- President's Council Of Advisors on Science and Technology (PCAST) Issued Report in August 2012: *Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth*
  - Recommended building upon the white space model for access to federal spectrum, particularly in the band 2700 – 3700 MHz
  - Can apply model for both licensed services and unlicensed devices
- Technological Advisory Council recommended small cell deployment
- Actions:
  - NTIA/FCC identified 3550 – 3650 MHz for wireless broadband services
  - Specified exclusion zones along coasts based on potential interference with Navy radars
  - NPRM adopted Dec. 12, 2012 builds on PCAST report and advanced sharing techniques



Impact of Small Cell Approach



Citizens Band Radio Service

- Shared application with radar systems and fixed satellite services
  - Incumbents protected
- Initial exclusion zones protect naval radar operation
- FCC/Industry partnership on dynamic spectrum access system (SAS)
  - WinForum developing requirements
  - No fixed allocations; dynamic allocations for fixed time interval
  - Spectrum allocated under licensed and unlicensed models
- Environment Sensing Capability (ESC) detects when radar systems in use
  - ESC in combination with SAS will allow operation within exclusion zones

Future Midband Work

- Studying upper 5GHz to 7GHz spectrum
  - Fixed point to point allocations
  - Estimating amount of holes in Swiss cheese
    - Amount of spectrum in gaps remaining from fixed p/p allocations in urban areas.
- If promising would likely develop rules incorporating some form of SAS system

Spectrum Trifecta: 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

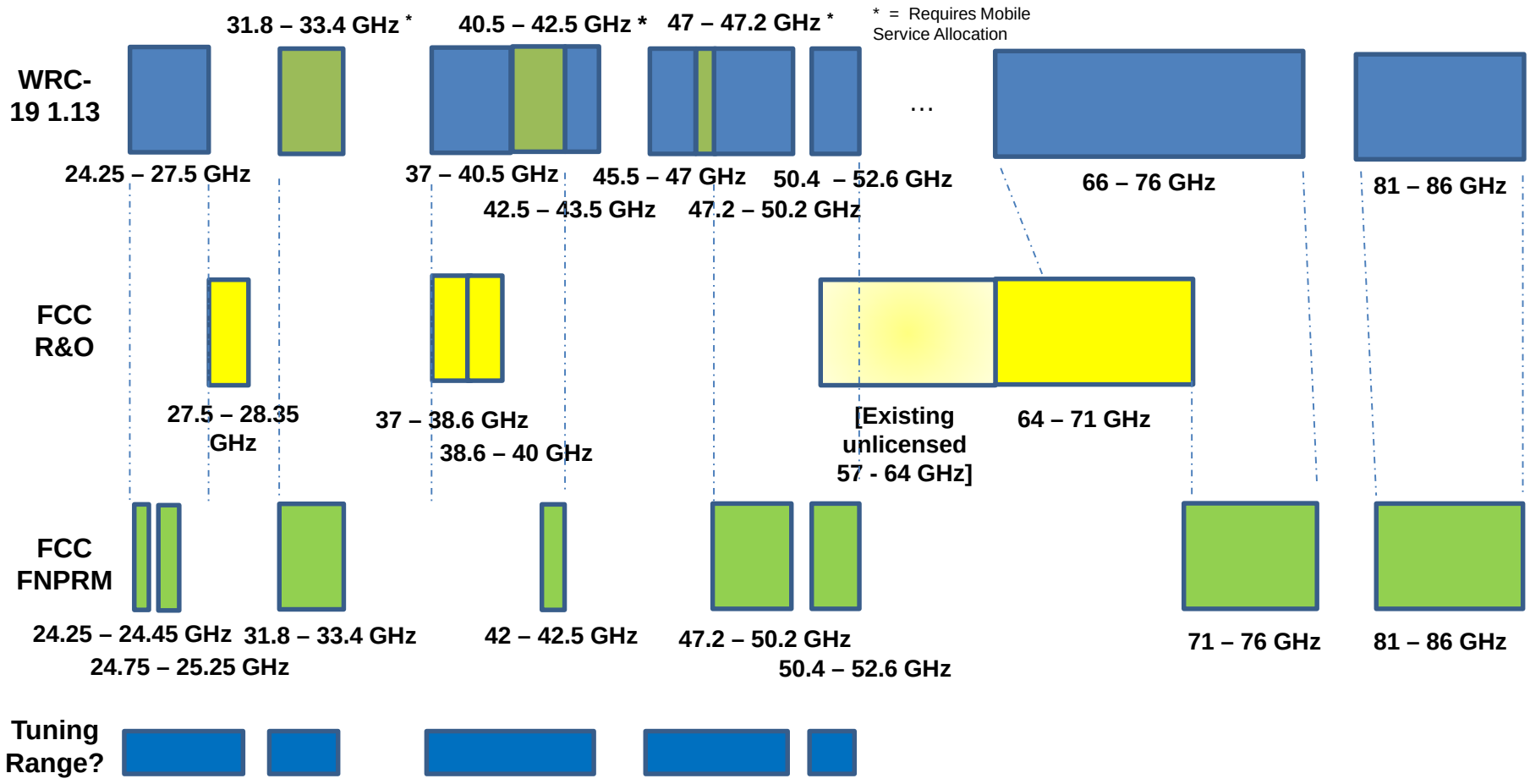
Service Rules

- 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

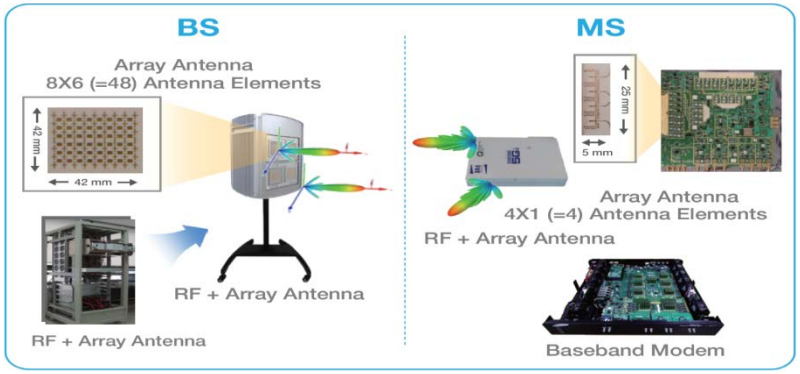
	28 GHz	*37 GHz*	*39 GHz*	*64-71 GHz*
Frequency	27.5-28.35 GHz	37-38.6 GHz	38.6-40 GHz	64-71 GHz
Bandwidth	850 MHz	1600 MHz	1400 MHz	7000 MHz
Terrestrial Allocation	Licensed for fixed operations, with about 75% of the population covered by existing licenses; remaining licenses in inventory	Yes (no current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

Opportunities for International Harmonization

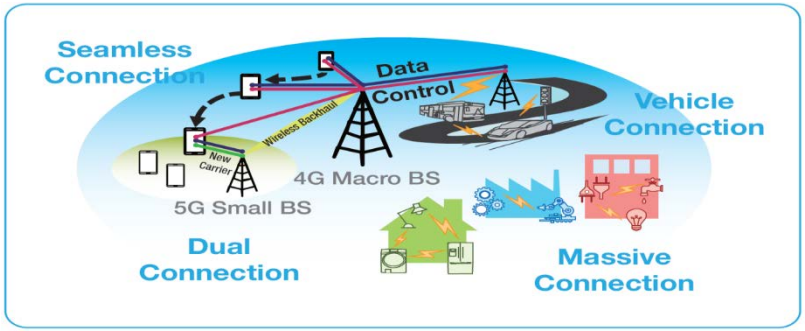


Some Factors Enabling Sharing

- 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

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

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.

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

Final Frontier
Above 95 GHz

- Commission looking to allocate bands in range of 95 GHz to 300 GHz
- Some interest expressed
  - Mainly near 100 GHz for point to point
  - Scanning devices with high resolution
- Little in record to suggest best use
  - Limited number of experimental applicatin
- Technical challenges for use
- Extend RF safety regime to cover
- Need to assess best use
  - Perspective may develop over time

Summary

- Testing new paradigms for sharing and interference assessment
- All spectrum regions being put into play
  - Lower bands nearly played out
  - Looking for sharing paradigms in mid bands
  - Upper bands being allocated
- Mixing satellite (GEO, MEO, LEO), HAP, and terrestrial
- Successful efforts will guide allocations for decades to come