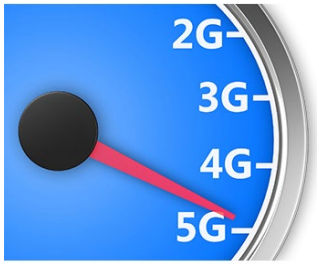
Spectrum Planning at the FCC and Emerging Technology Topics

Office of Engineering and Technology

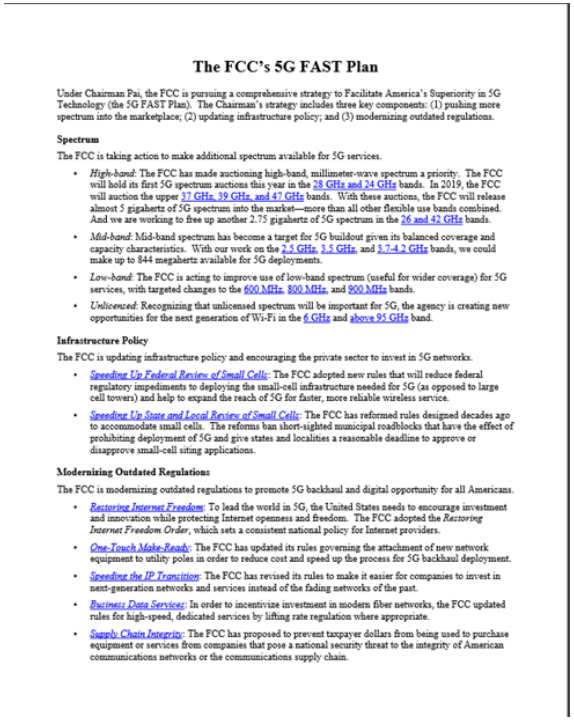
USTTI
August 27, 2020

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 FAST Plan



- FCC is pursuing a comprehensive strategy to Facilitate 5G Technology (the 5G FAST Plan)
- The Chairman's strategy includes three key components:
  - (1) pushing more spectrum into the marketplace
  - (2) updating infrastructure policy
  - (3) modernizing outdated regulations



The FCC's 5G FAST Plan

Under Chairman Pai, the FCC is pursuing a comprehensive strategy to Facilitate America's Superiority in 5G Technology (the 5G FAST Plan). The Chairman's strategy includes three key components: (1) pushing more spectrum into the marketplace; (2) updating infrastructure policy; and (3) modernizing outdated regulations.

Spectrum

The FCC is taking action to make additional spectrum available for 5G services.

- *High-band*: The FCC has made auctioning high-band, millimeter-wave spectrum a priority. The FCC will hold its first 5G spectrum auctions this year in the 28 GHz and 24 GHz bands. In 2019, the FCC will auction the upper 37 GHz, 39 GHz, and 47 GHz bands. With these auctions, the FCC will release almost 5 gigahertz of 5G spectrum into the market—more than all other flexible use bands combined. And we are working to free up another 2.75 gigahertz of 5G spectrum in the 26 and 42 GHz bands.
- *Mid-band*: Mid-band spectrum has become a target for 5G buildout given its balanced coverage and capacity characteristics. With our work on the 2.5 GHz, 3.5 GHz, and 3.7-4.2 GHz bands, we could make up to 844 megahertz available for 5G deployments.
- *Low-band*: The FCC is acting to improve use of low-band spectrum (useful for wider coverage) for 5G services, with targeted changes to the 600 MHz, 800 MHz, and 900 MHz bands.
- *Unlicensed*: Recognizing that unlicensed spectrum will be important for 5G, the agency is creating new opportunities for the next generation of Wi-Fi in the 6 GHz and above 95 GHz band.

Infrastructure Policy

The FCC is updating infrastructure policy and encouraging the private sector to invest in 5G networks.

- *Speeding Up Federal Review of Small Cells*: The FCC adopted new rules that will reduce federal regulatory impediments to deploying the small-cell infrastructure needed for 5G (as opposed to large cell towers) and help to expand the reach of 5G for faster, more reliable wireless service.
- *Speeding Up State and Local Review of Small Cells*: The FCC has reformed rules designed decades ago to accommodate small cells. The reforms ban short-sighted municipal roadblocks that have the effect of prohibiting deployment of 5G and give states and localities a reasonable deadline to approve or disapprove small-cell siting applications.

Modernizing Outdated Regulations

The FCC is modernizing outdated regulations to promote 5G backhaul and digital opportunity for all Americans.

- *Restoring Internet Freedom*: To lead the world in 5G, the United States needs to encourage investment and innovation while protecting Internet openness and freedom. The FCC adopted the *Restoring Internet Freedom Order*, which sets a consistent national policy for Internet providers.
- *One-Touch Make-Ready*: The FCC has updated its rules governing the attachment of new network equipment to utility poles in order to reduce cost and speed up the process for 5G backhaul deployment.
- *Speeding the IP Transition*: The FCC has revised its rules to make it easier for companies to invest in next-generation networks and services instead of the fading networks of the past.
- *Business Data Services*: In order to incentivize investment in modern fiber networks, the FCC updated rules for high-speed, dedicated services by lifting rate regulation where appropriate.
- *Supply Chain Integrity*: The FCC has proposed to prevent taxpayer dollars from being used to purchase equipment or services from companies that pose a national security threat to the integrity of American communications networks or the communications supply chain.

"Forward-thinking spectrum policy, modern infrastructure policy, and market-based network regulation form the heart of our strategy for realizing the promise of the 5G future." – FCC Chairman Pai

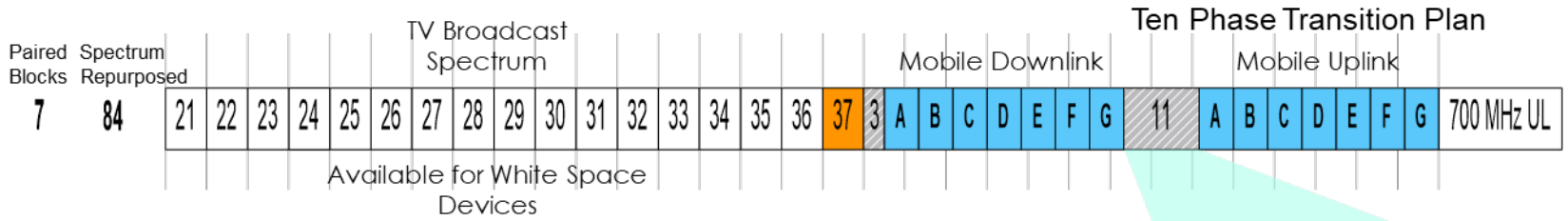
FCC Spectrum Actions for 5G Use

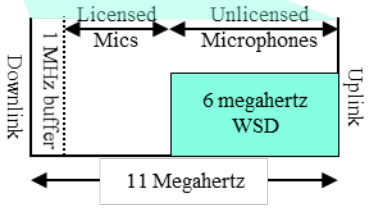
High-band:	28 GHz band auction (27.5 GHz – 28.35 GHz; 2 x 425) Completed January 2019 24 GHz band auction 103 (24.25 – 24.45; 25.25 -25.75 GHz; 7 x100) Completed May 2019 37 GHz, 39 GHz, and 47 GHz (concluded auction 103 March 2020, largest in American history, releasing 3,400 megahertz of spectrum into the commercial marketplace) Working to free up additional 2.75 gigahertz of 5G spectrum in the 26 and 42 GHz bands
Mid-band:	2.5 GHz, 3.5 GHz, and 3.7-4.2 GHz bands
Low-band:	Targeted changes to 600 MHz, 800 MHz, and 900 MHz bands to improve use of low band spectrum for 5G services
Unlicensed:	Creating opportunities for Wi-Fi in the 6 GHz, 61-71 GHz and above 95 GHz bands; also taking a fresh and comprehensive look at the 5.9 GHz (5.850-5.925 GHz) band that has been reserved for use by Dedicated Short-Range Communications (DSRC)

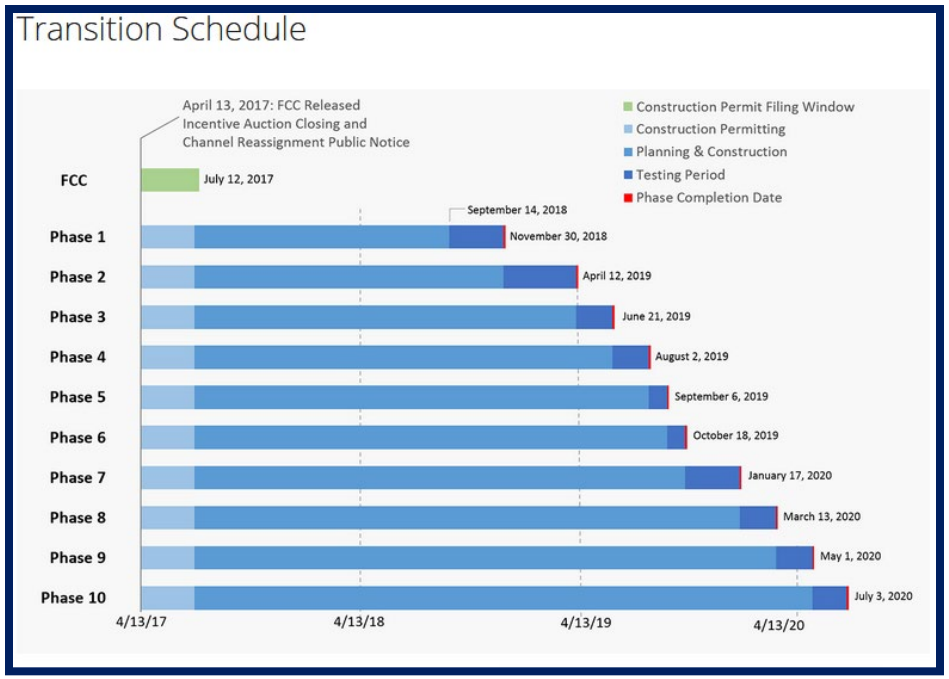
Spectrum Management

- Decisions should consider
  - Efficient spectrum use
  - Interference protection
  - New technology introduction
  - Harmonization
- And consider spectrum sharing
  - where risk of interference is minimal or uses are compatible and can be coordinated
    - Frequency separation - power and emission limits
    - Geographic separation – coordination zones
    - Power deltas – non-restricted bands
    - Time separation – manage authorized emitters

TV Incentive Auction (600 MHz)







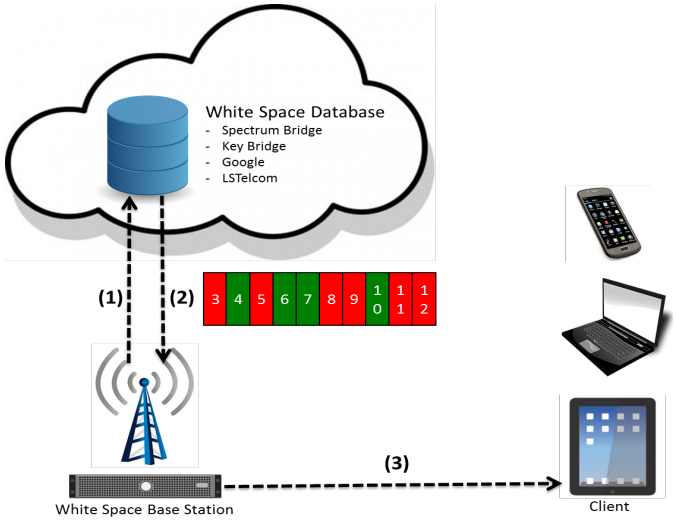
July 2020, FCC Announces Repack of TV stations from their pre-auction channels has been successfully completed, Spectrum Open for Wireless after 39 months

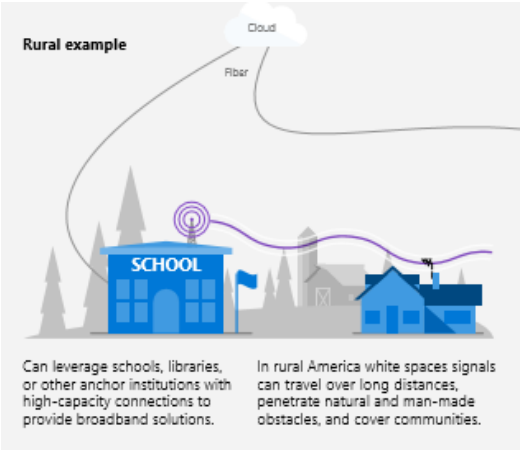
Orders & NPRMs

- Expanded Reimbursement for LPTV/Translator/FM Report and Order (March 15, 2019)
- Expanded Incentive-Auction Reimbursements NPRM and Order (Aug. 3, 2018)
- 2017 Channel Sharing Report and Order (Mar. 23, 2017)
- White Space Push Notification Waiver (Dec. 23, 2016)
- LPTV Report & Order and Further Notice of Proposed Rulemaking (Dec. 17, 2015)
- ISIX Third Report & Order (Oct. 26, 2015)
- Commencing Operations Report & Order (Oct. 22, 2015)
- Channel Sharing Second Order on Reconsideration (Oct. 21, 2015)
- Vacant Channel Notice of Proposed Rulemaking (June 16, 2015)
- Part 15 Report & Order (Aug. 11, 2015)
- Wireless Microphone Report and Order (Aug. 11, 2015)
- Mobile Spectrum Holdings Order on Reconsideration (Aug. 11, 2015)
- Updating Part 1 Competitive Bidding Rules Report & Order (July 21, 2015)
- Channel Sharing Reconsideration and Notice of Proposed Rulemaking (June 12, 2015)
- Incentive Auction Second Order on Reconsideration (June 19, 2015)
- ISIX Second Report & Order (Oct. 17, 2014)
- Updating Part 1 Competitive Bidding Rules Notice of Proposed Rulemaking (Oct. 10, 2014)
- Mobile Spectrum Holdings Order (June 2, 2014)
- Incentive Auction Report & Order (June 2, 2014)
- Incentive Auction Notice of Proposed Rulemaking (Oct. 2, 2012)

White Spaces

- Concept:
  - Data base of protected areas
  - Device contacts data base
  - Device operates on permitted frequencies
- Permitted in 600 MHz TV band
- Channel 37 acts as guard band between mobile systems and broadcast stations
  - No additional guard band for use by white space devices





See https://www.microsoft.com/en-us/airband/technology

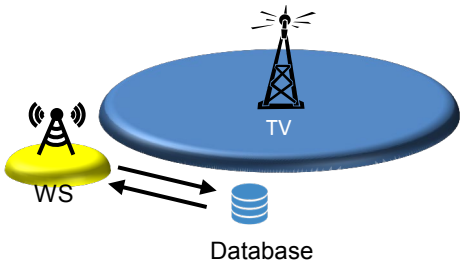
See https://www.fcc.gov/general/white-space

White Space

- Further Notice of Proposed Rulemaking (February 2020)

  Seeks comment on:

  - Higher radiated power in rural areas
  - Examining permitting higher-power WSD operations on 1st adjacent TV channel
  - Increasing HAAT limit for fixed WSD operation to 500 Meters in rural areas
  - Adjusting rules to support narrowband IoT
  - Permitting geofenced fixed WSD operations and fixed WSD operations on movable platforms within geofenced areas



- March 2019 – R&O & Order on Reconsideration:

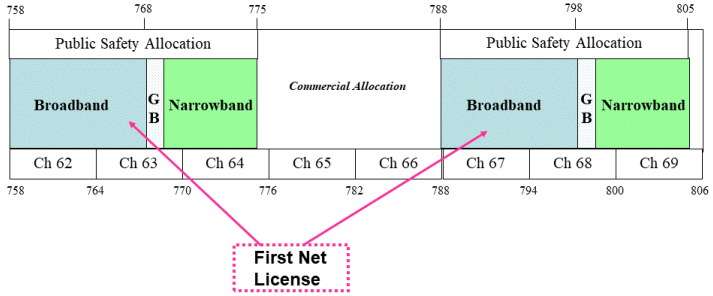
  - Requires all fixed white space devices to incorporate geolocation capability and automatically transmit to database
    - External source permitted
    - Antenna height still permitted to be entered manually
  - Clarifies that device operator is responsible party
    - Improve the accuracy and reliability of the white space databases
  - Increased antenna AGL from 30m to 100m in rural areas
  - Resolves certain outstanding white space reconsideration issues

700 MHz & 800 MHz

FirstNet

https://www.firstnet.gov

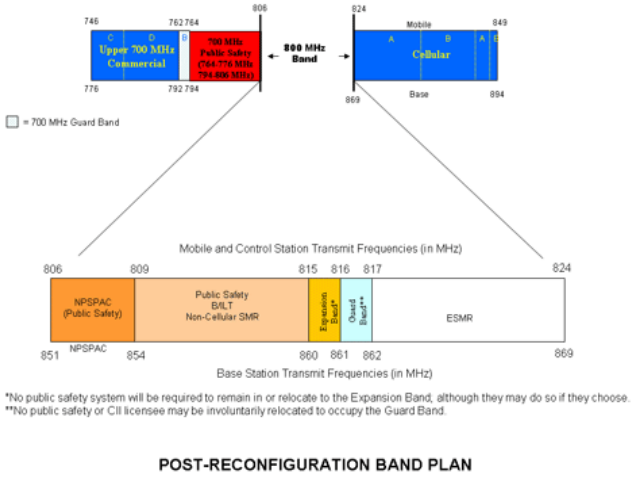
Nationwide broadband network for first responders



- Over 600,000 device connections being used by more than 7,250 public safety agencies
- All 50 states, five U.S. territories and Washington, D.C., have “opted in”

800 MHz Re-banding

See https://www.fcc.gov/general/800-mhz-spectrum

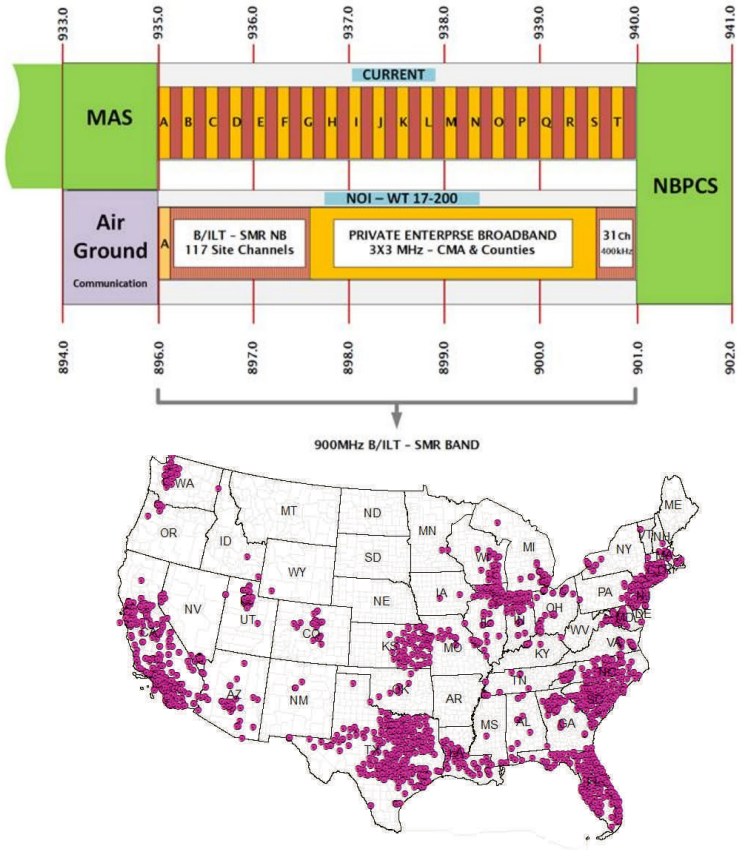


POST-RECONFIGURATION BAND PLAN

- 800 MHz re-banding near completion after many years
- Small number of systems need retuning near shared border with Mexico
  - 29 licenses in Texas,
  - 14 in California and
  - 2 in New Mexico

900 MHz Realignment

- Notice of Proposed Rulemaking adopted
  March 2019
- Proposes to realign the 896-901/935-940 MHz Band
  - 3x3 MHz Private Enterprise Broadband (PEBB)
  - Relocate site-licensed business/Industrial land transportation licensees to 1.5 megahertz and 0.5 megahertz segments
  - Voluntary license exchange process; alternatively an overlay or incentive auction
  - Under voluntary process, PEBB licenses would be limited to existing licensees holding all 20 geographically licensed SMR blocks
  - Technical rules include definition of unacceptable interference (modelled after 800 MHz rules)



~500 existing B/ILT licenses with ~ 2700 sites

1300 – 1350 MHz

- The band 1300-1350 MHz is used by Federal agencies for operating various types of long-range radar systems that perform missions critical to safe and reliable air traffic control (ATC) in the national airspace, border surveillance, early warning missile detection, and drug interdiction. FAA is studying under Spectrum Research Fund

Spectrum Efficient National Surveillance Radar (SENSR)

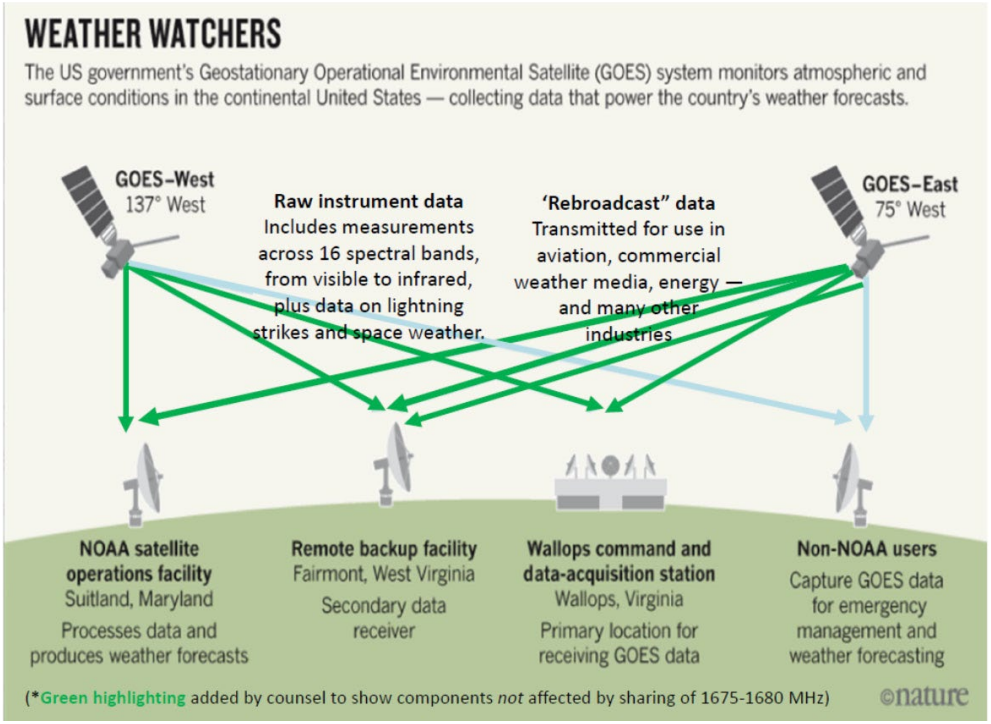
(click to enlarge)

The Spectrum Efficient National Surveillance Radar (SENSR) is a cross-agency program formed by FAA and three other partner agencies to assess the feasibility of vacating and auctioning a band of Government-owned radio frequency valued in the billions of dollars. Proceeds from the auction will be used to finance the deployment of a new system to meet the needs of all four agencies, providing surveillance for air traffic, weather, law enforcement, and national defense. The three partner agencies include Department of Defense (DoD), Department of Homeland Security (DHS), and the National Oceanic and Atmospheric Administration (NOAA). In August 2018, NOAA removed a key weather requirement and largely withdrew from the program, remaining in an advisory role.

SENSR is currently assessing the technical solutions, which will culminate in an investment decision in 2021 in support of the 2024 auction.

See: https://www.faa.gov/air_traffic/technology/sensr/

1675 – 1680 MHz

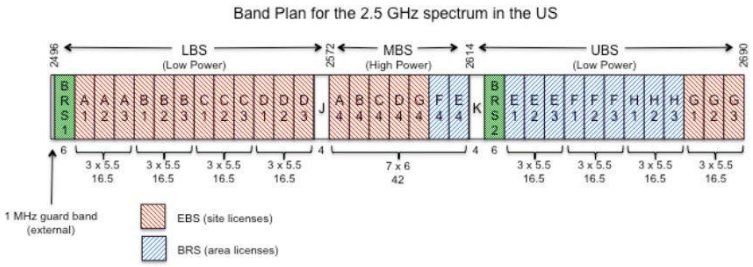


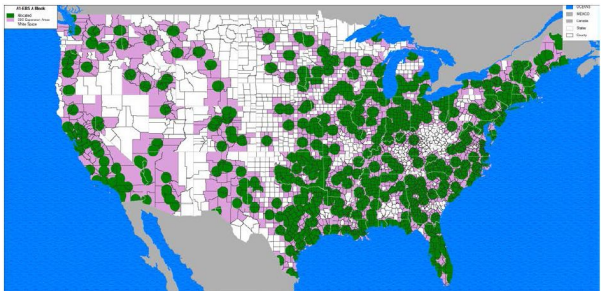
- President's FY2020 budget proposed that the Commission "either auction or use fee authority to assign spectrum frequencies between 1675-1680 megahertz for flexible use by 2020, subject to sharing arrangements with Federal weather satellites."
- The 1675-1680 MHz band is currently used for weather forecasting services.

- NPRM adopted May 2019
- Proposes to reallocate the 1675-1680 MHz band on a co-primary basis for terrestrial fixed and mobile (except aeronautical mobile) use on a shared basis with existing federal users.
- Seeks comment on how to implement a sharing framework that would create opportunities for commercial operations in this band while also protecting incumbent federal users

2.5 GHz (2496-2690 MHz)

- Constitutes largest band of contiguous spectrum below 3 GHz
  - Prime spectrum for advanced mobile, including 5G
  - Home to Broadband Radio Service (BRS) and Educational Broadband Service (EBS)



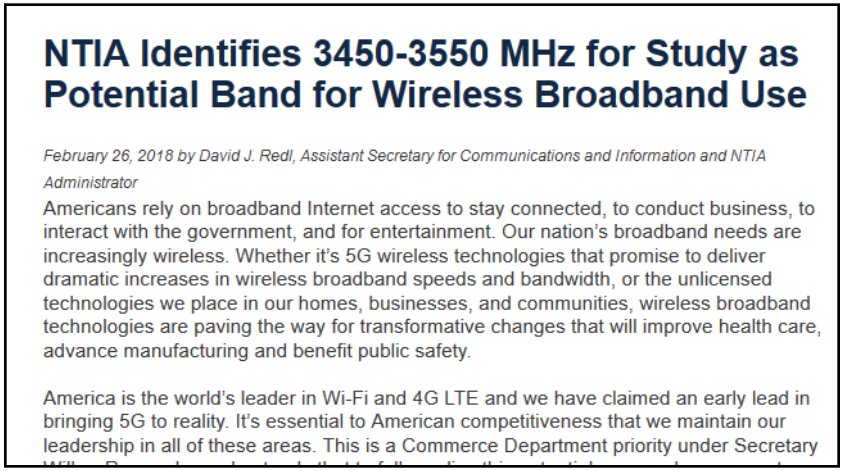


EBS Licensed Areas

- Report and Order adopted July 2019:
  - Priority filing window for rural Tribal Nations to address community needs
  - Remaining unassigned spectrum to be made available via auction
  - Auction a 100-megahertz and 16.5-megahertz block on countywide basis
  - Construction deadlines – 4 year interim; 8 year final
  - Eliminate eligibility and usage restrictions; as well as leading restrictions
  - All in-force private agreements remain unaffected

3100 – 3550 MHz Band

- Mobile Now Act
  - By March 23, 2020 requires a report evaluating the feasibility of allowing commercial wireless services, licensed or unlicensed, to share use of the frequencies between 3100 megahertz and 3550 megahertz.
- NTIA Action
  - Identified 3450-3550 MHz band for study as having greatest potential for repurposing
- FCC Action
  - December 2019, NPRM proposes to remove the existing non-federal secondary radiolocation and amateur allocations in the 3.3-3.55 GHz band and to relocate incumbent non-federal operations out of the band
  - February 2019, Public Notice issued a temporary freeze on applications for new or expanded Radiolocation Service operations in the 3100-3550 MHz frequency band.

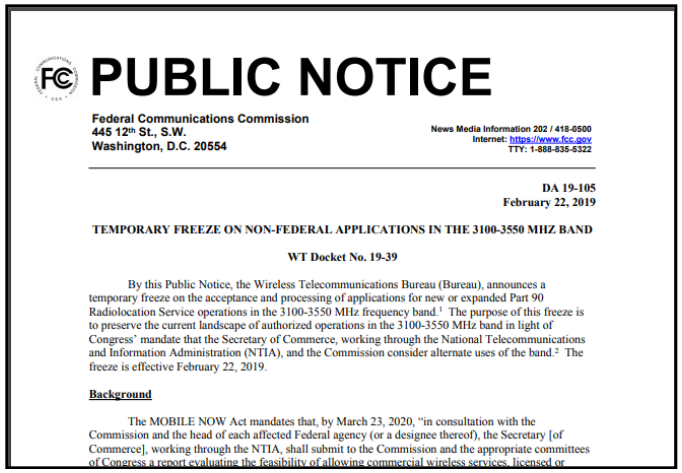


NTIA Identifies 3450-3550 MHz for Study as Potential Band for Wireless Broadband Use

February 26, 2018 by David J. Redl, Assistant Secretary for Communications and Information and NTIA Administrator

Americans rely on broadband Internet access to stay connected, to conduct business, to interact with the government, and for entertainment. Our nation's broadband needs are increasingly wireless. Whether it's 5G wireless technologies that promise to deliver dramatic increases in wireless broadband speeds and bandwidth, or the unlicensed technologies we place in our homes, businesses, and communities, wireless broadband technologies are paving the way for transformative changes that will improve health care, advance manufacturing and benefit public safety.

America is the world's leader in Wi-Fi and 4G LTE and we have claimed an early lead in bringing 5G to reality. It's essential to American competitiveness that we maintain our leadership in all of these areas. This is a Commerce Department priority under Secretary



PUBLIC NOTICE

Federal Communications Commission
445 12th St., S.W.
Washington, D.C. 20554

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DA 19-105
February 22, 2019

TEMPORARY FREEZE ON NON-FEDERAL APPLICATIONS IN THE 3100-3550 MHZ BAND

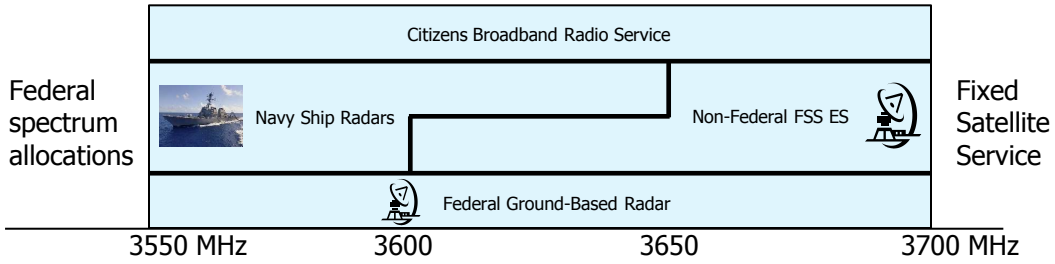
WT Docket No. 19-39

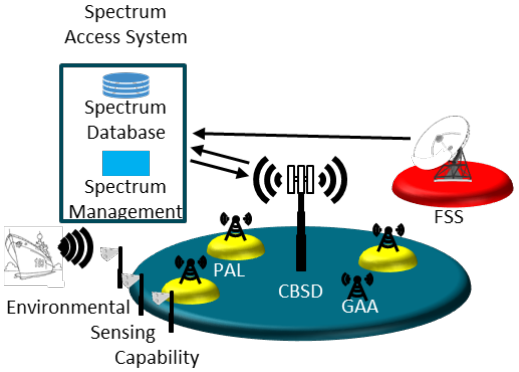
By this Public Notice, the Wireless Telecommunications Bureau (Bureau), announces a temporary freeze on the acceptance and processing of applications for new or expanded Part 90 Radiolocation Service operations in the 3100-3550 MHz frequency band.[1] The purpose of this freeze is to preserve the current landscape of authorized operations in the 3100-3550 MHz band in light of Congress' mandate that the Secretary of Commerce, working through the National Telecommunications and Information Administration (NTIA), and the Commission consider alternate uses of the band.[2] The freeze is effective February 22, 2019.

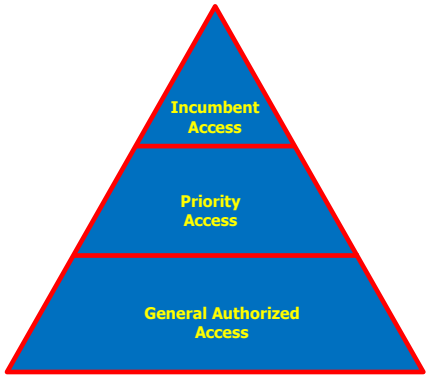
Background

The MOBILE NOW Act mandates that, by March 23, 2020, "in consultation with the Commission and the head of each affected Federal agency (or a designee thereof), the Secretary [of Commerce], working through the NTIA, shall submit to the Commission and the appropriate committees of Congress a report evaluating the feasibility of allowing commercial wireless services, licensed or

Citizen's Broadband Radio Service (3.5 GHz)







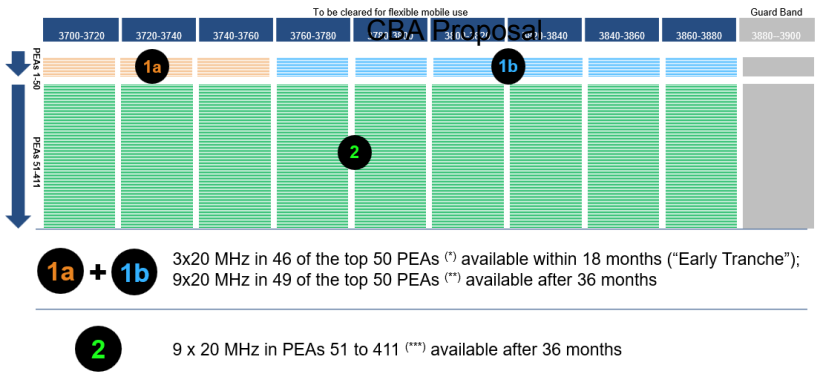
Spectrum sharing across three tiers

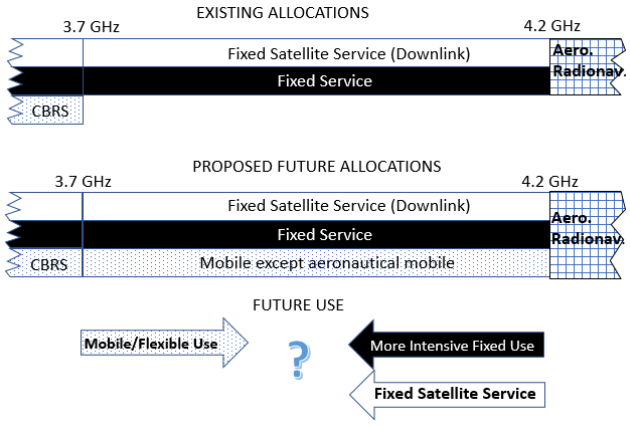
Where We Are In The Process

- Rules revised in Oct. 2018- - Licensing areas, license terms, emissions mask, etc.
- 5 approved wave 1 Spectrum Access System (SAS) Administrators, 1 more pending.
- Completed Initial Commercial Deployments (ICDs) for all 5 approved wave 1 SASs, one more pending
- Three tested and approved Environmental Sensor Capabilities (ESC) system and deployments
- Certified many (100+) base stations and end user devices
- Thousands of base stations deployed all as GAA
- PAL auction ongoing since July, 2020

3700 – 4200 GHz (C-Band)

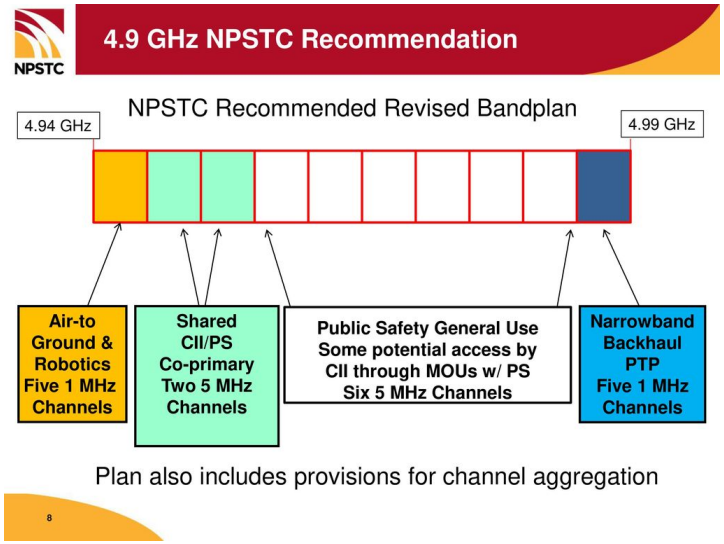
- FCC adopted Report and Order in March 2020
  - makes 280 Megahertz available for 5G
  - allocates 3.7-4.0 GHz band for mobile use
    - 280 megahertz (3.7-3.98 GHz band) will be for wireless services with 20 megahertz guardband
    - satellite operations will be repacked into the upper 200 megahertz of the band
  - spectrum will be transitioned to flexible use no later than December 5, 2025.
    - Public auction scheduled for December 2020
    - incumbent fixed microwave services licensees to relocate their point-to-point links to other bands by December 5, 2023
  - technical considerations (ES protection, OOBE, power, etc.)





4.9 GHz (4940 – 4990 MHz)

- Sixth NPRM adopted March 2018
- Proposals to encourage greater use and investment in band
  - goal to promoting increased public safety use of the band, protecting users from harmful interference and opening the spectrum to additional uses
- Provide for limited aeronautical and robotic use
- Seek comment on encouraging adoption of voluntary technical standards
- Permit increasing channel aggregation up to 40 megahertz
- Elevate point-to-point and point-to-multipoint use on some channels to primary status
- Expand eligibility to critical infrastructure users

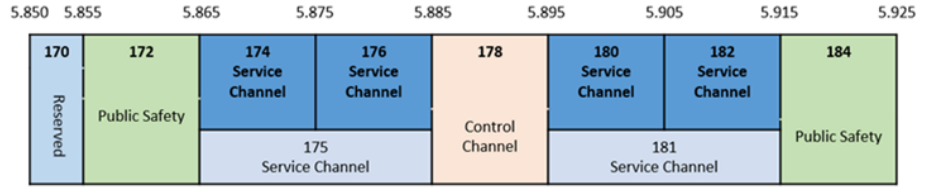


5030-5091 MHz Band

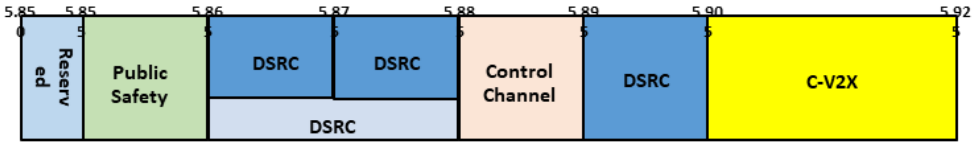
- Aerospace Industries Association Petition for Rulemaking; February 2018
- Recommends licensing procedures and service rules for UAS Control and Non-Payload Communications (CNPC) links
  - Individual licensing for UAS operators
  - Restrict UAS operation to safety-of-life (non-payload) communications
  - Establish frequency assignment mechanism to dynamically assign frequencies to licensed pilots-in-command (PICs)
  - Flexible rules to encourage future UAS development
  - Modify Frequency Allocation Table to provide for CNPC links and establish protection zones around microwave landing system stations
  - License under aviation rules
- Aerospace industry in-favor of proposals
- Cellular industry recommends flexibility so that other operators outside of traditional aviation licensees could provide service to UAS

5.9 GHz Band

- December 2019, Commission proposes fresh look at the 5.9 GHz (5.850-5.925 GHz) band
  - For past two decades, entire 75 megahertz has been reserved for Dedicated Short-Range Communications (DSRC) use
- NPRM proposes to designate lower 45 megahertz for unlicensed use
  - 45 megahertz can be combined with existing unlicensed operations to provide high-throughput broadband applications on channels up to 160 megahertz wide
- Proposes to dedicate remaining 30 megahertz for transportation and vehicle safety-related communication
  - proposes to provide Cellular Vehicle to Everything (C-V2X), access to the upper 20 megahertz of the band
  - seeks comment on whether to retain the remaining 10 megahertz for use by DSRC systems or to dedicate it for C-V2X



Dedicated Short Range Communications (DSRC) Channel Plan



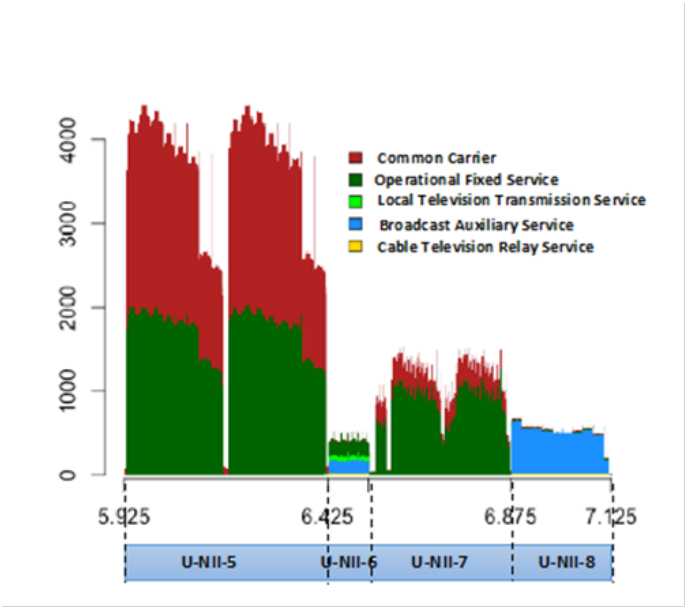
C-V2X Waiver Petition to use 20 megahertz channel at top of band (ET 18-357)

6 GHz Band

- April 2020 - Commission adopted rules to make 1,200 megahertz in 5.925–7.125 GHz available for unlicensed use
  - Promotes next generation of Wi-Fi, and growth of the Internet of Things
  - Increases amount of spectrum available for Wi-Fi by nearly a factor of five
- Authorizes indoor low-power operations over full 1,200 megahertz and standard-power devices in 850 megahertz using an automated frequency coordination system
  - AFC to prevent standard power access points from operating where they could cause interference to incumbent services
- Further Notice of Proposed Rulemaking
  - seeks comment to permit very low-power devices to operate across the 6 GHz band
    - to support high data rate applications including high-performance, wearable, augmented-reality and virtual-reality devices
  - seeks comment on increasing the power at which low-power indoor access points may operate.

Band (GHz)	Primary Allocations	Reference used in this NPRM[63]	Devices
5.925-6.425	Fixed Service FSS	U-NII-5	Standard-Power Access Point
6.425-6.525	Mobile Service FSS	U-NII-6	Low-Power Access Point
6.525-6.875	Fixed Service FSS	U-NII-7	Standard-Power Access Point
6.875-7.125	Fixed Service Mobile Service FSS	U-NII-8	Low-Power Access Point

U-NII-5 / U-NII-7 would rely on Automated Frequency Coordination (AFC)



mmWave Bands Overview

Spectrum Allocations

12.55 gigahertz for mobile

- **Licensed Bands (Total 3.85 GHz):**
  - 24.25-24.45 GHz
  - 24.75-25.25 GHz
  - 27.5-28.35 GHz
  - 37-38.6 GHz
  - 38.6-40 GHz
  - 47.2-48.2 GHz
- **Unlicensed Use:**
  - 64-71 GHz (added to 57 – 64 GHz) and Above 95 MHz (21.2 gigahertz in four bands

Service Rules

Upper Microwave Flexible Use Service (UMFUS)

- Geographic Area Licensing
- Various Area Sizes
- Band Plan
- License Term
- Technical rules
- Performance Requirements
- Overlay Auctions

Often Associated with “5G”

First Report and Order Bands - 2016

	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 (Uplink)	Yes (no current use)	Yes (no current use)	Yes (no current use)
Licensing Scheme	Licensed	Licensed	Licensed	Unlicensed
Auction	Concluded January, 2019 $700M Gross Bids for 2,965 Licenses	Incentive auction Ended March 2020	Incentive auction Ended March 2020	

Granted incumbent fixed licensees authority to offer mobile service; led to market transactions

Lower 600 MHz identified for sharing between Federal Government and Private Sector - - invited comment on sharing method

Satellite/terrestrial sharing accomplished by well defined protections & rights

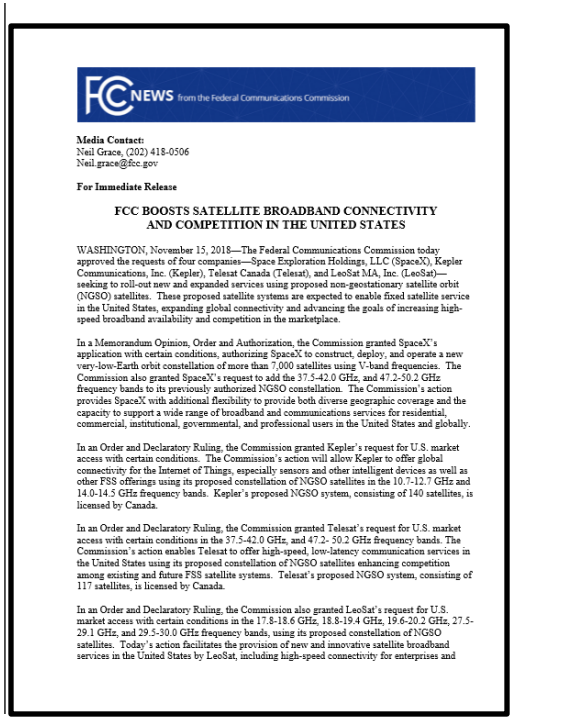
Second Report and Order Bands -2017

	24 GHz	*47 GHz*
Frequency	24.25-24.45 GHz and 24.75-25.25 GHz	47.2-48.2 GHz
Bandwidth	700 MHz	1000 MHz
Terrestrial Allocation	Lower segment is licensed for two types of fixed operations: 24 GHz service and Digital Electronic Messaging Service (DEMS). 5 active 24 GHz licenses, and 38 active DEMS licenses; remaining licenses in inventory	Yes (no current use)
Federal Allocation	No	No
Satellite Allocation	Yes, 24.75-25.25 GHz band segment is non-Federal allocated for FSS (Earth-to-space)	Yes (no current use and the Commission designated this band for terrestrial use)
Licensing Scheme	Licensed	Licensed
Auction	Concluded 28 May 2019 Over $2B Gross Bids for 2,904 Licenses	Auction ended March 2020

Commission invited comment on 25.25-27.5 GHz (26 GHz) and 42.0 – 42.5 GHz

Satellite Services

- Satellite services will have a complementary role in the 5G ecosystem
  - Proposed constellations of satellites in NGSO orbits offer Internet and other advanced services
  - Ensured core MMW spectrum for satellite systems (48.2-50.2 GHz and 40-42 GHz bands).
  - Allowed flexibility in FCC's earth station siting rules in the 28 GHz and 39 GHz bands.
  - Adopted FSS earth station siting criteria in the 24GHz band and permitted individually licensed FSS earth stations in the 50.4-51.4 GHz band.
- Space Month – November 2018:
  - Approved four separate petitions from companies seeking to initiate
    or expand services for low-earth-orbit satellite constellations
  - Authorized Galileo Global Navigation System service in U.S.
  - Proposed to update rules for orbital debris
  - Proposed additional rules to facilitate E-SIMs
  - Proposed further streamlining of satellite licensing rules



FCC NEWS from the Federal Communications Commission

Media Contact:
Neil Grace, (202) 418-0506
Neil.grace@fcc.gov

For Immediate Release

FCC BOOSTS SATELLITE BROADBAND CONNECTIVITY AND COMPETITION IN THE UNITED STATES

WASHINGTON, November 15, 2018—The Federal Communications Commission today approved the requests of four companies—Space Exploration Holdings, LLC (SpaceX), Kepler Communications, Inc. (Kepler), Telesat Canada (Telesat), and LeoSat MA, Inc. (LeoSat)—seeking to roll-out new and expanded services using proposed non-geostationary satellite orbit (NGSO) satellites. These proposed satellite systems are expected to enable fixed satellite service in the United States, expanding global connectivity and advancing the goals of increasing high-speed broadband availability and competition in the marketplace.

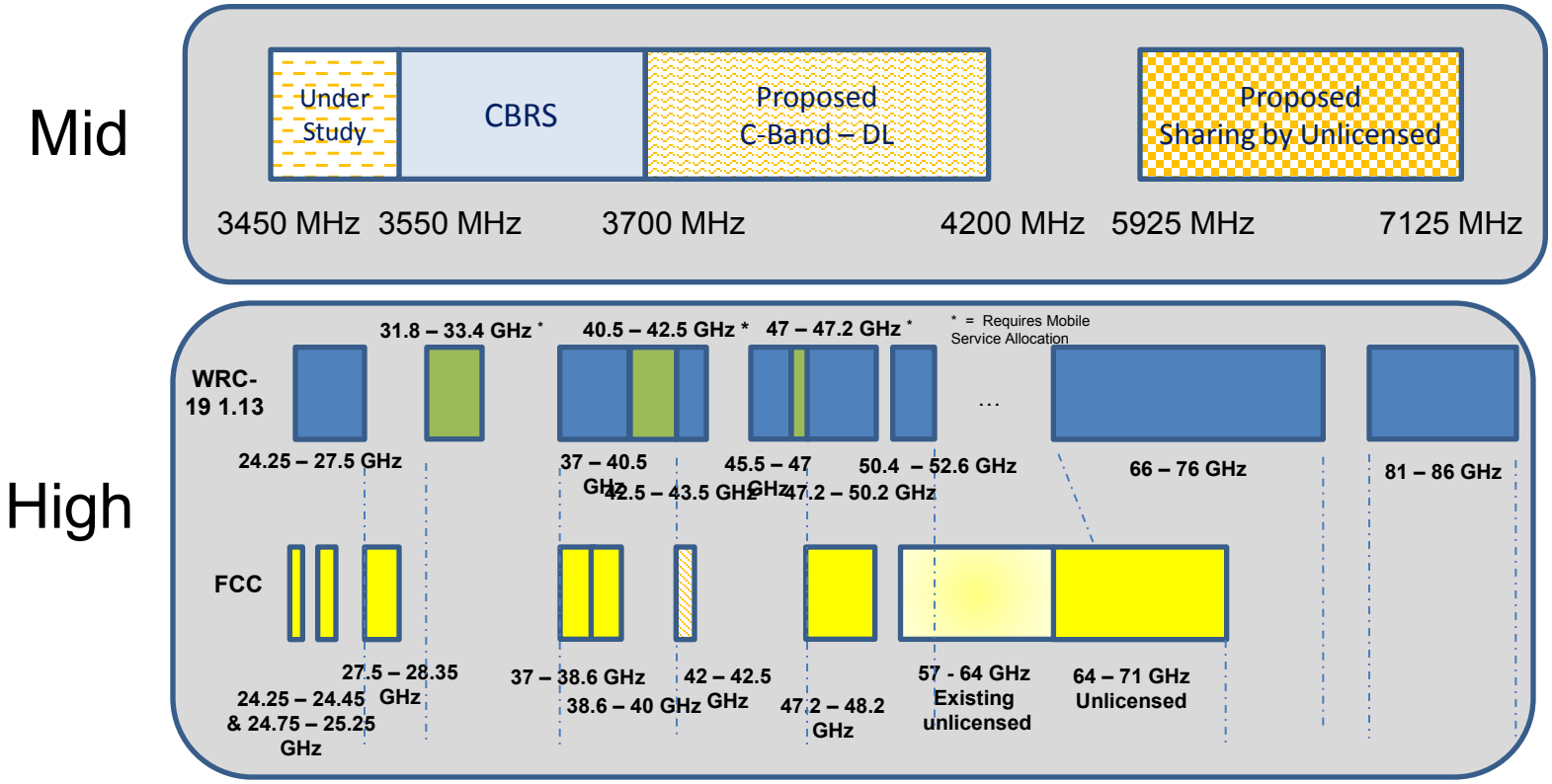
In a Memorandum Opinion, Order and Authorization, the Commission granted SpaceX's application with certain conditions, authorizing SpaceX to construct, deploy, and operate a new very-low-Earth orbit constellation of more than 7,000 satellites using V-band frequencies. The Commission also granted SpaceX's request to add the 37.5-42.0 GHz, and 47.2-50.2 GHz frequency bands to its previously authorized NGSO constellation. The Commission's action provides SpaceX with additional flexibility to provide both diverse geographic coverage and the capacity to support a wide range of broadband and communications services for residential, commercial, institutional, governmental, and professional users in the United States and globally.

In an Order and Declaratory Ruling, the Commission granted Kepler's request for U.S. market access with certain conditions. The Commission's action will allow Kepler to offer global connectivity for the Internet of Things, especially sensors and other intelligent devices as well as other FSS offerings using its proposed constellation of NGSO satellites in the 10.7-12.7 GHz and 14.0-14.5 GHz frequency bands. Kepler's proposed NGSO system, consisting of 140 satellites, is licensed by Canada.

In an Order and Declaratory Ruling, the Commission granted Telesat's request for U.S. market access with certain conditions in the 37.5-42.0 GHz, and 47.2- 50.2 GHz frequency bands. The Commission's action enables Telesat to offer high-speed, low-latency communication services in the United States using its proposed constellation of NGSO satellites enhancing competition among existing and future FSS satellite systems. Telesat's proposed NGSO system, consisting of 117 satellites, is licensed by Canada.

In an Order and Declaratory Ruling, the Commission also granted LeoSat's request for U.S. market access with certain conditions in the 17.8-18.6 GHz, 18.8-19.4 GHz, 19.6-20.2 GHz, 27.5-29.1 GHz, and 29.5-30.0 GHz frequency bands, using its proposed constellation of NGSO satellites. Today's action facilitates the provision of new and innovative satellite broadband services in the United States by LeoSat, including high-speed connectivity for enterprises and

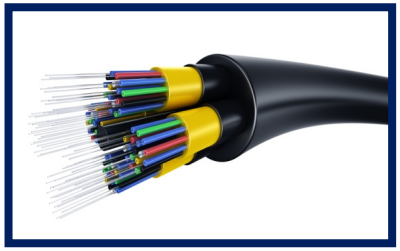
Spectrum Harmonization



Spectrum Horizons: Above 95 GHz

- Rules to expand access above 95 GHz adopted 15 March 2019
- Total of 21.2 GHz for unlicensed use
  - 116-123 GHz
  - 174.8-182 GHz
  - 185-190 GHz
  - 244-246 GHz
- Similar to 60 GHz band rules, High absorption bands enable sharing with passive services
  - Earth Exploration Satellite Service
  - Space Research Service
  - Radio Astronomy Service
- New type of experimental licenses > 95 GHz
  - Longer license terms (10 years)
  - Ability to sell devices

Much of the spectrum above 95 GHz is allocated for passive services

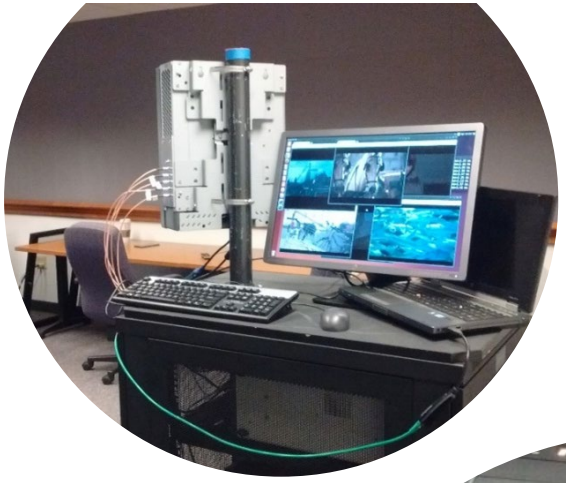


Achieve Fiber Capacity

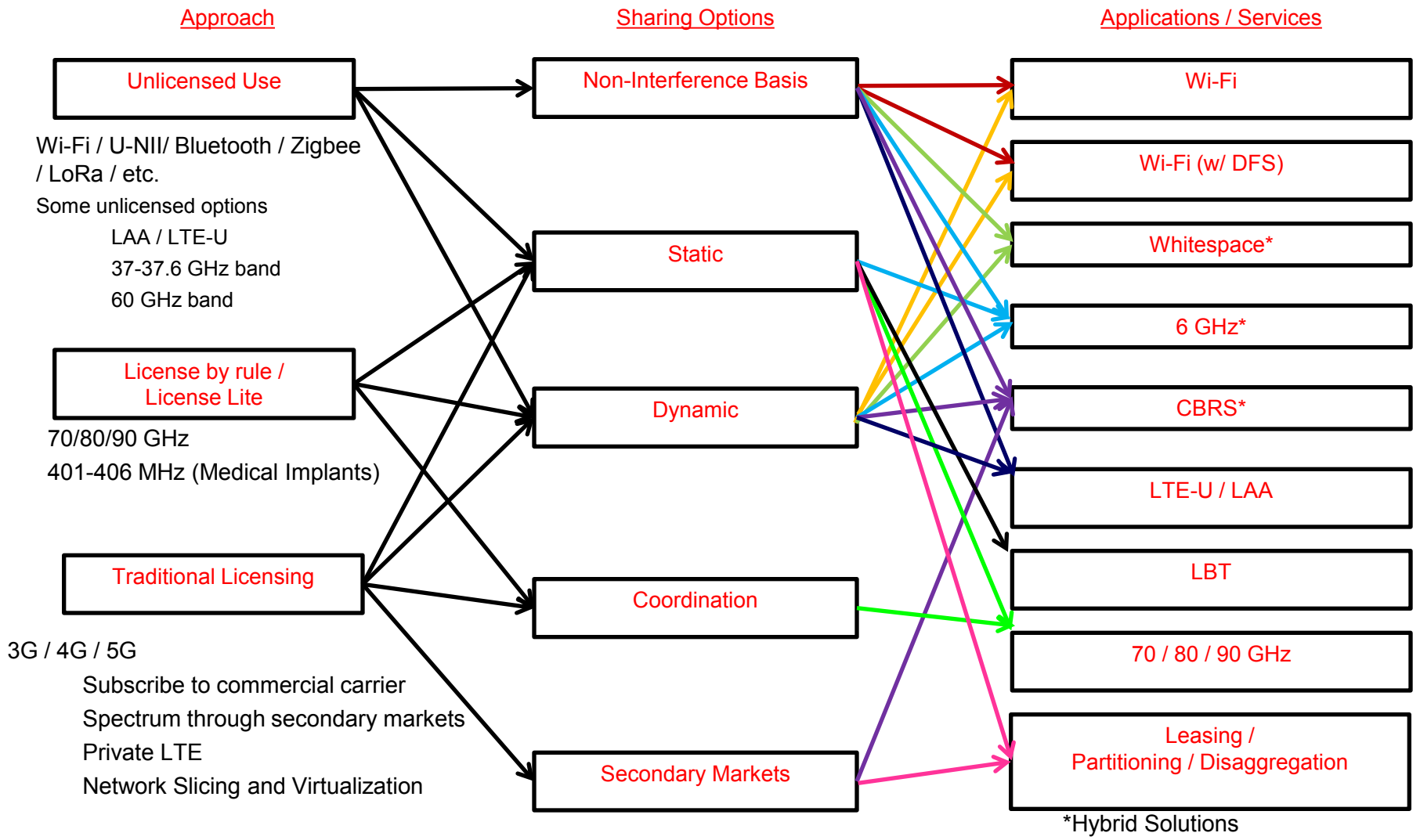
Innovations

Experimental Licensing

- Experimental licensing plays a key role in facilitating innovative new products and services while protecting incumbent services against harmful interference.
- Experimental licenses enable trials of new technologies like 5G. The FCC typically grants more than 2,000 experimental licenses a year.
- The FCC has a streamlined experimental licensing process for universities, research labs, health care facilities, and equipment manufacturers that frequently conduct trials at a specific location.



Approaches to Spectrum Sharing



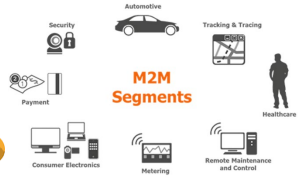
Vertical Markets

Companies that identify themselves in a narrow industry or group of companies

- Produce similar products or provide similar services
- Often compete with each other
- Buy and use similar goods and services
- Have similar spectrum requirements

Examples

- Convention centers
- Public Safety
- Entertainment/Sports
- Healthcare
- Defense
- Transportation
- Manufacturing
- Education
- Finance
- …
- Limitless ways to define



Spectrum needs generally are outside scope of commercial carriers regarding coverage and reliability

Thank You!