



C-Band & 3.1-3.55 GHz

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Overview

- The U.S. mid-band spectrum landscape is undergoing dramatic change as the FCC and NTIA make significant moves to free up spectrum for commercial use
- The 3700-4200 MHz band (“C-band”) and the 3450-3550 MHz band are two key components
- Because U.S. midband spectrum has significant encumbrances not encountered in many other regions of the world, deployment of commercial mid-band in the U.S. necessarily involves aspects of shared spectrum, and/or greater consideration of co-existence and compatibility among disparate users

U.S. Midband Spectrum: Predominant Current Use

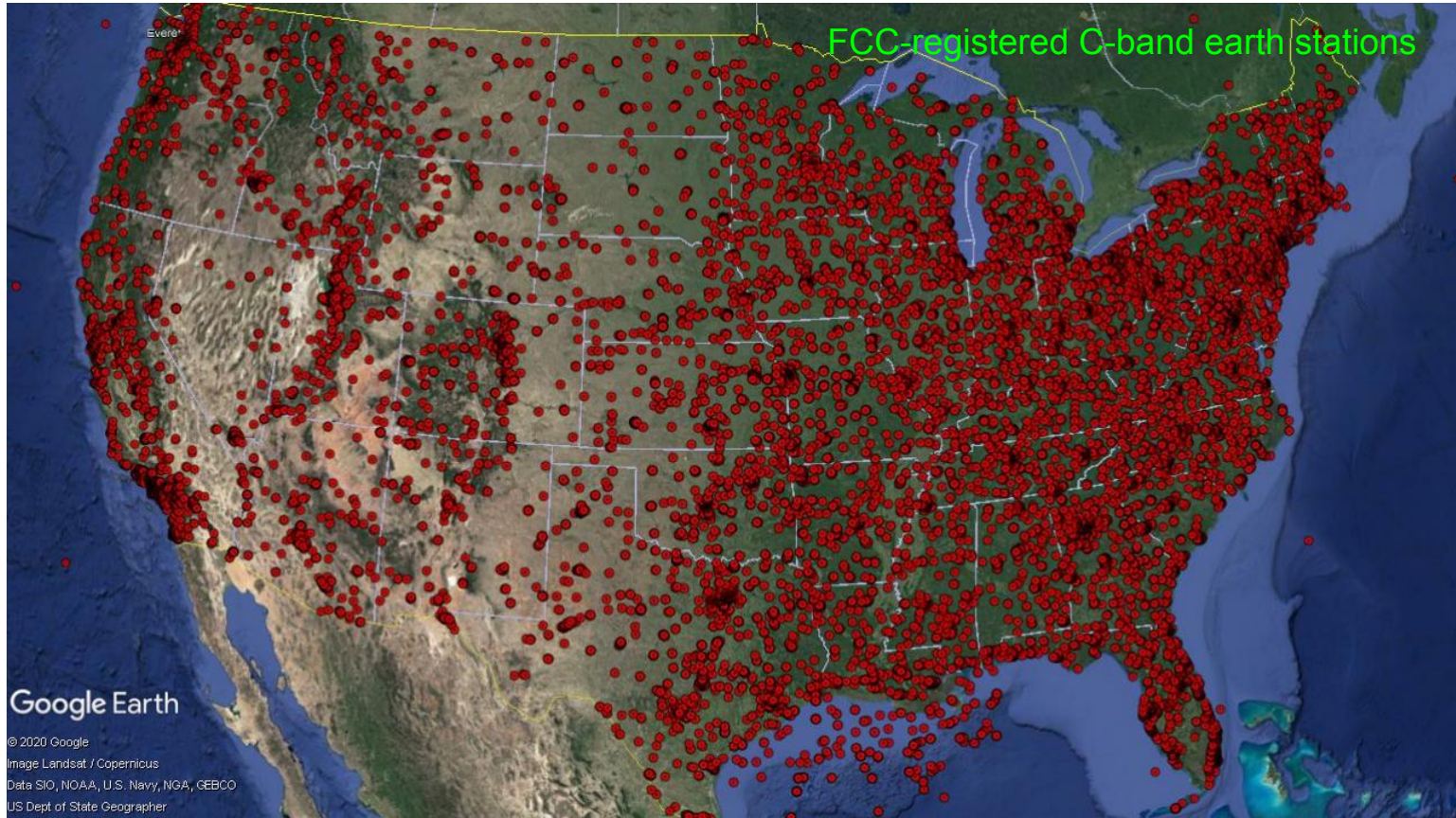
3100 - 3300	3300 - 3500	3500 - 3550	3550 - 3700	3700-3980
DoD Airborne, Shipborne, and Ground-based Radars		DoD Shipborne Radars		
	Amateur Radio	Wx Radar	CBRS	Fixed-Satellite Service
Radiolocation				
EESS (active) & Space Research (active)				

Federal Primary	Non-Federal Primary	Non-Federal Secondary
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3700 - 4200 MHz (C-band)

C-band (3700-4200 MHz)

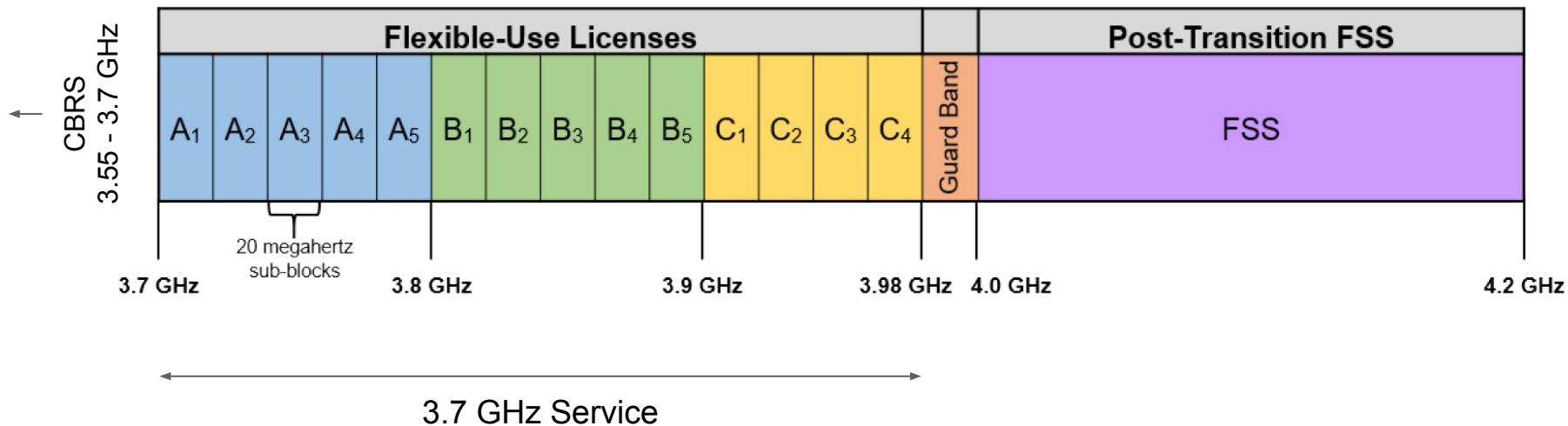
- Currently used for fixed-satellite service (FSS) space-to-earth downlinks from geostationary satellites
- Uses range from major ground station/head-end facilities (receiving and distributing large numbers of programming streams) to small “backyard” dishes (receiving a single video or even audio stream)
- Approximately 18,000 earth station facilities across the U.S. are registered in the FCC’s database



FCC C-Band Proceeding

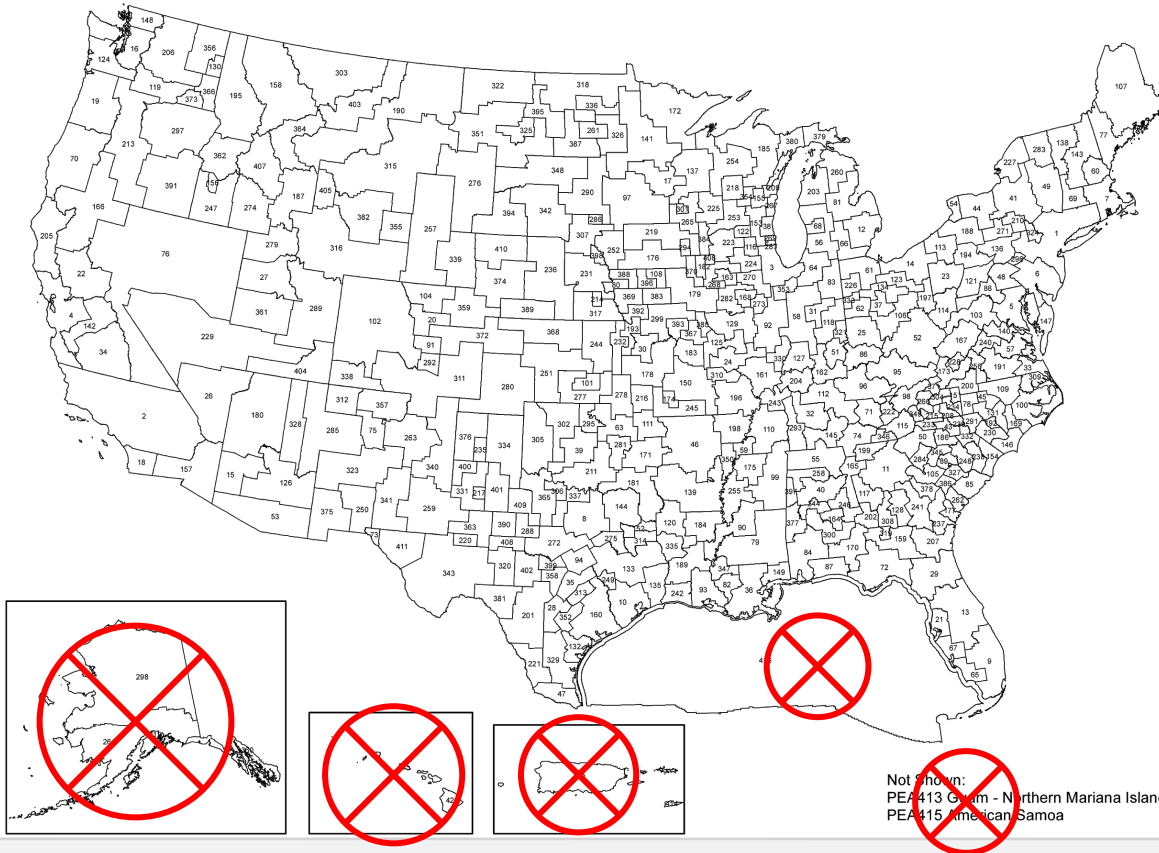
- Beginning in 2017, the FCC conducted a proceeding ([Notice of Inquiry](#), [Notice of Proposed Rulemaking](#)) to look at transitioning some or all of C-band from FSS to flexible (fixed/mobile) use, especially to support midband 5G
- In 2020, FCC adopted an [Order](#) that implements the following:
 - Repacks FSS into 4000-4200 MHz
 - Adopts rules that support flexible use (base/mobile) broadband operations in 3700-3980 MHz (280 MHz of bandwidth)
 - Establishes a 20 MHz guard band between the two segments
- “3.7 GHz Service” geographic licenses in the contiguous U.S. will be auctioned beginning in December 2020

3.7 GHz Service Band Plan



Source: [FCC 20-23](https://www.fcc.gov/record/2023-01-12/fcc-20-23)

FCC Partial Economic Area (PEA) Boundaries

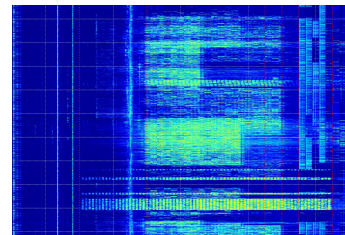


C-Band Timeline

- December 8, 2020: 3.7 GHz Service auction ([Auction 107](#)) begins
- 1Q 2021: Auction ends
- December 5, 2021: Phase I voluntary accelerated clearing deadline
 - Lower 120 MHz
 - Satellite operators [have agreed](#) to meet the accelerated deadline
- December 5, 2023: Phase II voluntary accelerated clearing deadline
 - Upper 180 MHz
- [December 5, 2025: Original (non-accelerated) FSS clearing deadline]

3100 - 3550 MHz

3100-3550 MHz



- The band is heavily used by the federal government/ DoD for various ship-, air-, and ground-based systems
 - Limited non-federal use, on a secondary basis
- MOBILE NOW Act (2018) required NTIA review of 3100-3550 MHz for shared use or reallocation
- Earlier this year, NTIA released a detailed study of [3450-3550 MHz](#) and a pamphlet on [3100-3450 MHz](#)
- Main conclusion:
 - “The 3450-3550 MHz portion of this band is a good candidate for potential spectrum sharing, including at the commercial system power levels sought by the wireless industry.”

FCC Action on 3100-3550 MHz

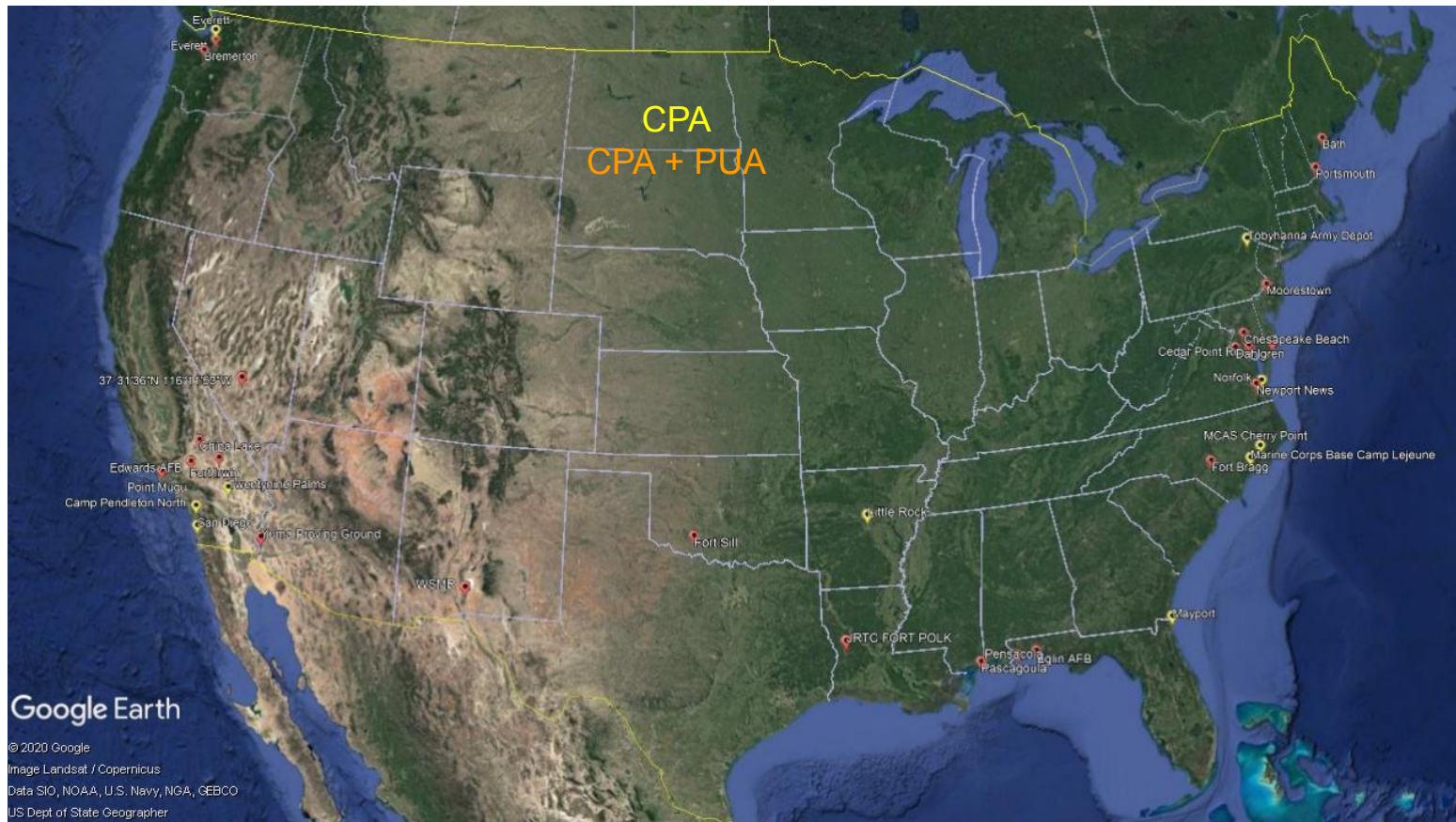
- Feb 22, 2019: [Temporary freeze](#) on applications for non-federal systems in the band
- Dec 16, 2019: [Proposes](#) removing non-federal secondary allocations for radiolocation and amateur radio in the 3300-3550 MHz band
- Sep 9, 2020: Releases *draft* [Report and Order and Further Notice of Proposed Rulemaking](#)
 - Affirms removal of non-federal secondary radiolocation and amateur radio allocations within the 3300-3550 MHz band
 - Proposes commercial flexible use service in 3450-3550 MHz
 - License auction to begin in December 2021.
 - Partial Economic Areas/15 year terms
 - Document will be voted on at FCC meeting on Sep 30
 - Comments/replies due ~Thanksgiving/Christmas 😞

White House/DoD/NTIA Action on 3100-3550 MHz

- DoD and White House [announced](#) on Aug 10 that 3450-3550 can be mostly cleared and available for 5G “by the end of the summer”
 - Some geographic areas would need to be shared
 - Technical work was conducted by America’s Mid-Band Initiative Team (AMBIT), a White House/DoD/NTIA-created team focused on identifying opportunities for 5G in government-held midband spectrum
- Concurrent with FCC release of draft Order and FNPRM this month, NTIA submitted a [letter](#) to FCC encouraging an FNPRM for 3450-3550 MHz and providing additional information related to ongoing government operations in the band

Continued Government Operations in 3450-3550 MHz

- Cooperative Planning Areas (CPAs)
 - Geographic locations where federal use shall retain priority indefinitely over non-federal operations in the band
 - CPAs will include technical constraints on commercial use to avoid interference to federal operations, and commercial systems may not claim interference protection from federal systems
- Periodic Use Areas (PUAs)
 - Geographic locations where federal use shall retain priority over non-federal operations for episodic periods
 - Each PUA is co-located with a CPA, but requires a greater level of protection when active
 - Not every CPA has an associated PUA



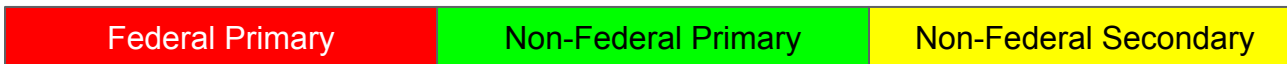
U.S. Midband Spectrum: Current Use

3100 - 3300	3300 - 3500	3500 - 3550	3550 - 3700	3700-3980
DoD Airborne, Shipborne, and Ground-based Radars		DoD Shipborne Radars		
	Amateur Radio	Wx Radar	CBRS	Fixed-Satellite Service
Radiolocation				
EESS (active) & Space Research (active)				

Federal Primary	Non-Federal Primary	Non-Federal Secondary
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U.S. Midband Spectrum: Future Use (2021/22 and beyond)

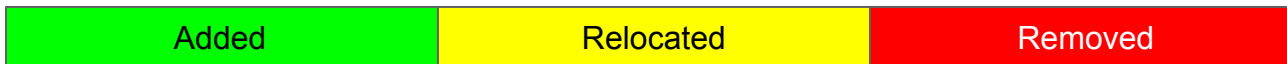
3100 - 3300	3300 - 3450	3450-3550	3550 - 3700	3700-3980
DoD Airborne, Shipborne, and Ground-based Radars		Less DoD Use*	DoD Shipborne Radar	
		5G* (3.45 GHz Service)	CBRS	5G (3.7 GHz Service)
Non-Fed Radiolocation*				
EESS (active)* & Space Research (active)*				



* Draft proposal

U.S. Midband Spectrum: Changes between Now and Future

3100 - 3300	3300 - 3450	3450-3550	3550 - 3700	3700-3980
		5G* (3.45 GHz Service)		5G (3.7 GHz Service)
		DoD*^		Fixed-Satellite Service
	Non-Fed Radiolocation*	Wx Radar*		
	EESS (active)* & Space Research (active)*			
	Amateur Radio*			



* To be confirmed at Sep 30 FCC meeting ^ Some operations remain in certain geographic areas

Spectrum Sharing and Co-existence in Midband Spectrum

Spectrum Sharing/Co-existence Implications in U.S. 3 GHz Band

- Shared federal/commercial use of 3450-3550 MHz
- Co-existence between 3.45 and 3.7 GHz services and CBRS
- Not addressed in this presentation:
 - Co-existence between 3.7 GHz service and repacked FSS
 - Co-existence between 3.7 GHz service and aeronautical radio altimeters in 4.2-4.4 GHz
 - Both topics are being addressed in NCTA Technical Working Groups

Shared Federal/Commercial Use of 3450-3550 MHz

- While DoD will substantially reduce use of 3450-3550 MHz, some operations will remain at numerous sites
- NTIA/DoD envision an “AWS-3” model for shared use
 - Protection of DoD remains in certain geographic areas
 - Industry and government will collaborate to establish protection framework
- Draft FNPRM seems to envision exclusive-use type licensing for 3450-3550 MHz, as opposed to CBRS-like multi-tier “use-it-or-share-it” framework

3450-3550 MHz Sharing Framework

- Federal incumbents:
 - Modification of concept of operations
 - Compressing operations outside of 3450-3550 MHz
 - Some systems to be fully/partially relocated to other bands
 - Equipment Modification
 - Includes restrictions on tuning range
 - Creating separation in space and/or time (CPAs/PUAs)
- Commercial Users:
 - Prescribed protections for federal incumbents where/when needed (CPAs/PUAs)

3450-3550 MHz Sharing Framework

- To the extent possible, federal use in CPAs will be chosen to minimize operational impact on non-federal users
- DoD intends to collaborate with wireless industry before the spectrum is auctioned regarding commercial network planning and deployments to minimize respective impacts while enabling operations
- Possible workshops similar to AWS-3
- Once licenses are issued, DoD would reach mutual agreements with individual licensees for commercial network planning
- DoD will establish coordination offices for the DoD and industry coordination, which will be published through NTIA

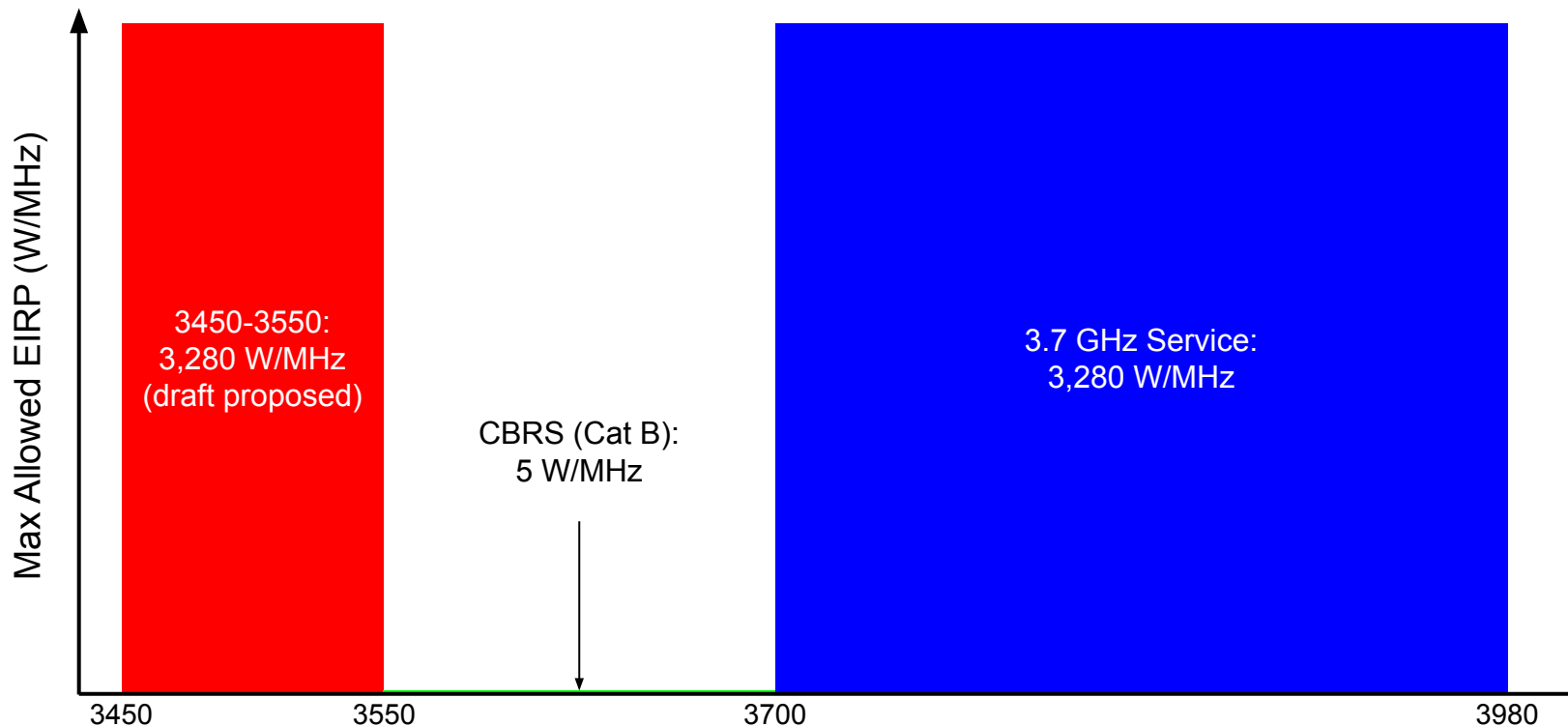
3450-3550 MHz Sharing Framework

- DoD may preempt commercial operations during National Emergencies (to be define)
- DoD may establish an “informing incumbent” framework that notifies commercial users of federal activity without the need of a sensing network
 - Could such an informing incumbent framework be extended to CBRS and eliminate the need for ESCs?

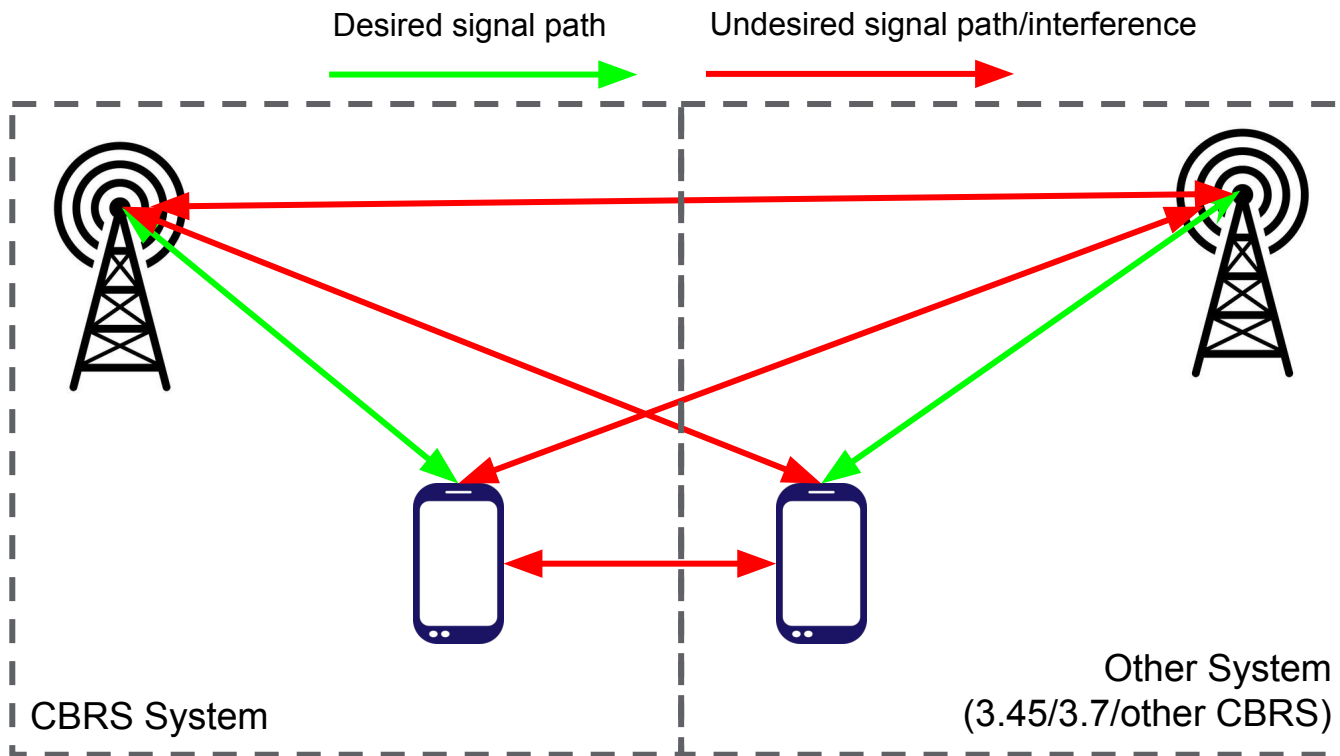
Co-existence of 3.45/3.7 GHz Services with CBRS

- CBRS is sandwiched between 3.45 GHz Service and 3.7 GHz Service bands
- There are no guard bands between CBRS and 3.45/3.7 GHz services
- Technical rules, especially maximum allowed radiated power, are different for CBRS than for the other services
- Concerns have been raised regarding co-existence between uncoordinated operations of CBRS and the other services at the frequency boundaries

Midband Max Allowed Radiated Power by Service, to Scale



Midband Interference Scenarios



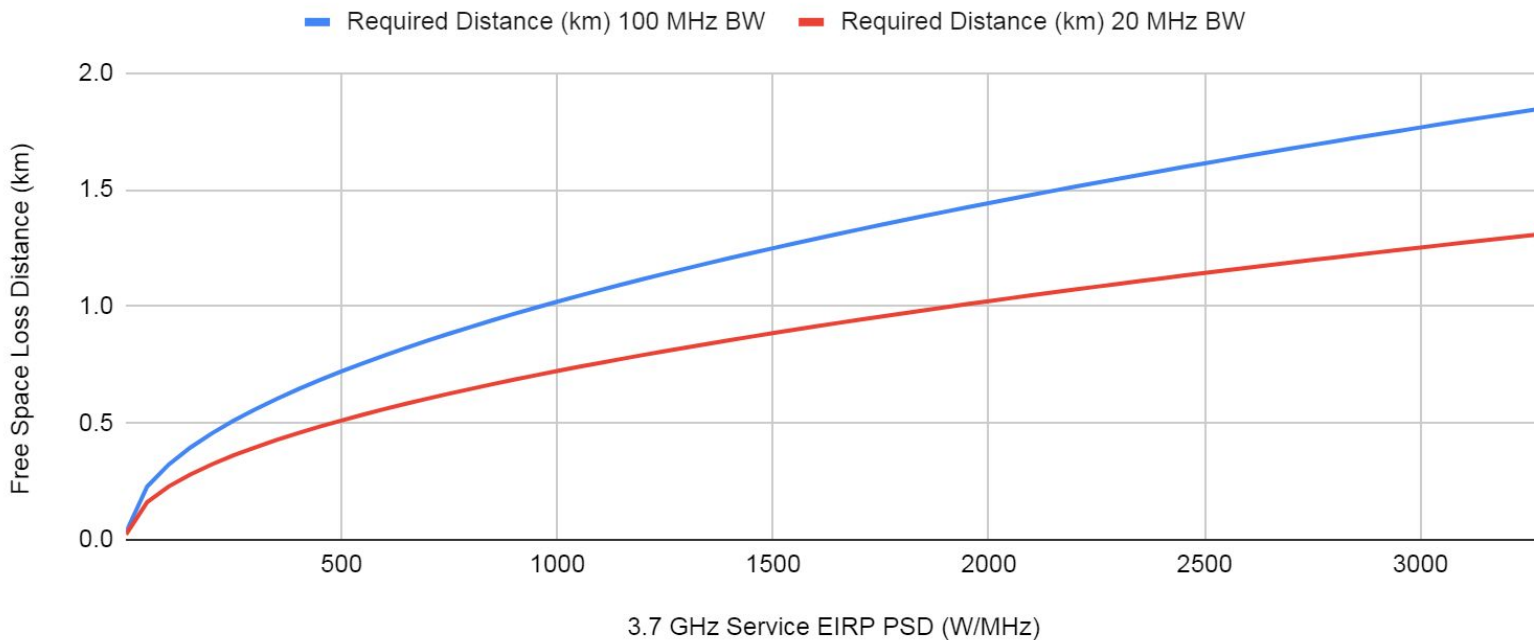
Co-existence Challenges Related to Uncoordinated Operations

- Fundamental (in-band) and out-of-band emissions from one system can interfere with systems in the adjoining band
- Initial analysis shows that desensitization is the main concern
 - With no guard band, it may not be possible for one system to effectively filter or mitigate strong signals transmitted in the immediately adjacent band
 - This results in desensitization of the victim system, negatively impacting reception of desired signals
 - Desensitization is of particular concern given the power disparity between CBRS and the two adjoining midband services
 - However, the same interference mechanism can also occur between CBRS systems, from CBRS into adjoining systems, and between adjoining systems

Addressing the Co-existence Challenges

- A technical working group has been established within the National Cable Television Association to examine the issue. WinnForum has also taken a look
- The degree and extent of interference is highly situation-dependent and depends on a very large number of factors
 - Actual transmit power
 - Propagation/clutter
 - Distance between systems
 - Antenna pointing direction and beam
 - Equipment characteristics & performance
- Coordination between systems (i.e., TDD synchronization) can help, but is not a cure-all
- Some initial analyses shows that interference could occur over distances ranging from a few tens of meters to well over 10 km, depending on deployment details

Distance to Achieve Cat B Blocking Requirement



20 MHz sim assumes CBRS Rx filtering = 20 dB
 100 MHz sim assumes CBRS Rx filtering = 24 dB

Takeaways on Midband Co-existence

- There is no magic technical solution to adjacent band co-existence
- There will be circumstances that lead to interference
- Cooperation among all involved parties will be required to mitigate interference when it occurs

Defense Spectrum Sharing RFI

- DoD released a spectrum sharing [Request for Information](#) (RFI) last Friday
- DoD seeks information on innovative solutions and alternative approaches to enable Dynamic Spectrum Sharing (DSS) within the Department's currently allocated spectrum with the goal of accelerating spectrum sharing decisions and 5G deployment
- Response deadline: October 15th, 2020

3100-3550 MHz Related Questions in RFI

- While the Department has made available the 3450-3550 MHz spectrum band for 5G, are there new technologies or innovative methods as to how additional mid-band spectrum currently allocated to DoD can be made available for 5G faster?
- What are other innovative ideas as to how 5G can share spectrum with high-powered airborne, ground-based and ship-based radar operations in the 3100-3550 MHz spectrum band?

DoD RFI

- Many other questions asked, related to:
 - Possible DoD ownership/operation of 5G networks
 - Federal spectrum leasing
 - Other bands that could be shared quickly
 - Spectrum sharing technology and barriers to use
 - Standards
 - Modernization of spectrum data

Conclusions

- C-band and 3100-3550 MHz are valuable new opportunities to expand broadband systems and services in U.S. midband spectrum
- Optimal use of U.S. midband spectrum will involve the continued development of new and innovative spectrum sharing and co-existence technologies