CBRS: Making Spectrum Sharing a Reality in Mobile Networks

IEEE CVT Dallas

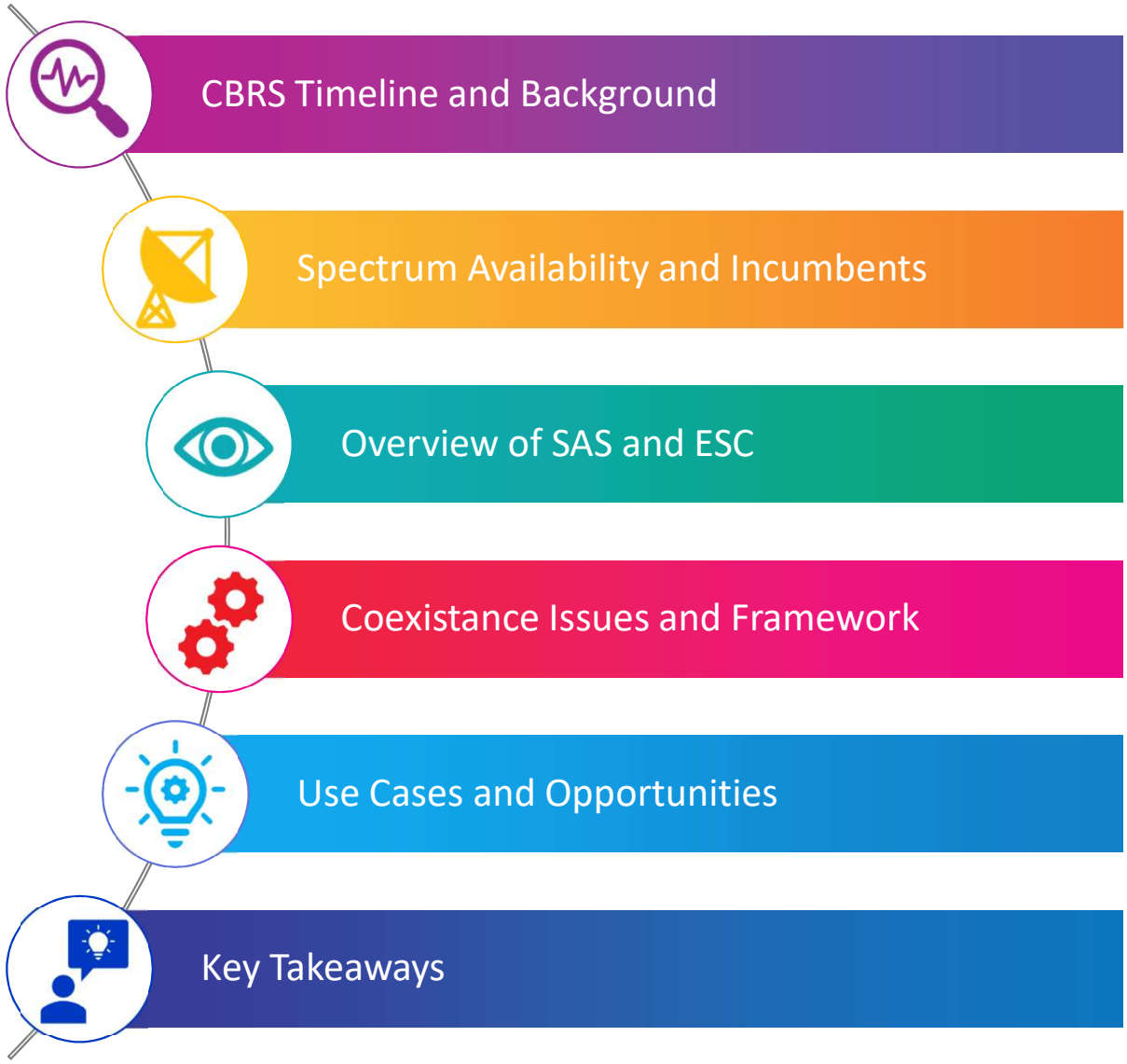
21 Jan 2020

Mike Wolfe

VP, Mobility Network Engineering

COMMSCOPE®

Agenda

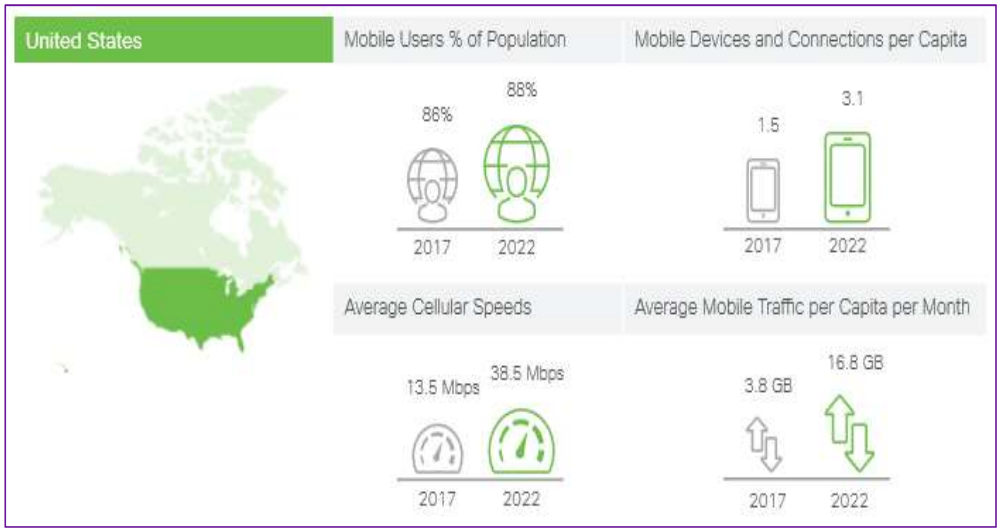


COMMSCOPE®

Trends

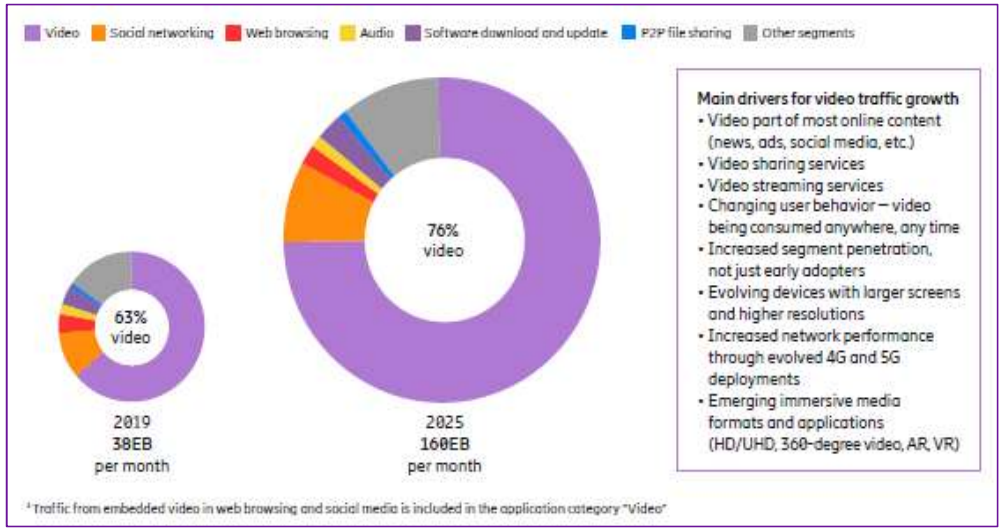
- Mobile Data Traffic Growth 5-fold 2017→2022 (36% CAGR)
- Mobile data accounts for 6% of all IP traffic by 2022

US Market



Source: Cisco VNI Feb 2019

Applications: Global



Source: Ericsson Mobility Report

The White House
Office of the Press Secretary

For Immediate Release June 28, 2010

Presidential Memorandum: Unleashing the Wireless Broadband Revolution

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES

SUBJECT:Unleashing the Wireless Broadband Revolution

America's future competitiveness and global technology leadership depend, in part, upon the availability of additional spectrum. The world is going wireless, and we must not fall behind. The resurgence of American productivity growth that started in the 1990s largely reflects investments by American companies, the public sector, and citizens in the new communications technologies that are what we know today as the Internet. The Internet, as vital infrastructure, has become central to the daily economic life of almost every American by creating unprecedented opportunities for small businesses and individual entrepreneurs. We are now beginning the next transformation in information technology: the wireless broadband revolution.

Directed NTIA to collaborate with the FCC to make available 500 megahertz of spectrum available for commercial wireless services while ensuring no loss of critical government capabilities.

The CBRS timeline: the path to commercial deployments, PALs and 5G

2012	▪ The US President's Council of Advisors on Science and Technology releases a report on spectrum sharing, entitled "Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth."
2013	▪ President Barack Obama issues a presidential memorandum giving the FCC a mandate to pursue spectrum-sharing opportunities for the 3.5 GHz band.
2014	▪ The FCC finalizes a proposal for the creation of CBRS. WInnForum forms a Spectrum Sharing Committee to develop baseline standards.
2016	▪ The FCC adopts rules for shared commercial use of the 3550–3700 MHz band, with a three-tiered access and authorization framework. ▪ Alphabet/Google, Federated Wireless, Intel, Nokia, Qualcomm and Ruckus Wireless (now CommScope) form the CBRS Alliance.
2017	▪ The FCC finalizes rules for spectrum sharing in the CBRS band.
2018	▪ The CBRS Alliance publishes Release 1 of the Network and Coexistence Baseline Specifications, and launches the OnGo brand and certification program. ▪ WInnForum releases final test code for CBSD protocol testing and approves the first six test labs for CBRS standards compliance. ▪ The FCC and NTIA begin the SAS and ESC certification process, and SAS testing for Amdocs, CommScope, Google, Federated Wireless and Sony. ▪ The FCC announces the establishment of the ICD process and ESC registration process, and SAS administrators submit ICD proposals to the FCC. ▪ The FCC issues the first CBSD certifications to Ericsson, Nokia, Sercomm, and Ruckus Networks, and the first EUD certification to Sierra Wireless. ▪ The CBRS Alliance announces the first OnGo certifications. ▪ The FCC increases PAL license areas to county size and lengthens PAL license terms to 10 years in the 3rd Report & Order.
2019	▪ WInnForum approves Nokia, CommScope, Federated Wireless, and Google as CPI Training Program Administrators. ▪ NTIA announces completion of lab testing of ESC equipment for select providers. ▪ ESC deployment plans approved by the FCC for CommScope, Federated Wireless, and Google. ▪ The FCC approves of five SAS administrators: Amdocs, CommScope, Google, Sony and Federated Wireless. ▪ CBRS officially launches, with FCC approval of ICDs on September 16, 2020, with initial commercial GAA service available. ▪ Upon completion of ICDs, final SAS certification and full commercial service will start by the end of 2019. ▪ The CBRS Alliance expects to finish Release 3 with 5G support at the end of 2019.
2020	▪ The FCC will hold PAL auctions in June 2020. ▪ OnGo 5G service is expected to become available.

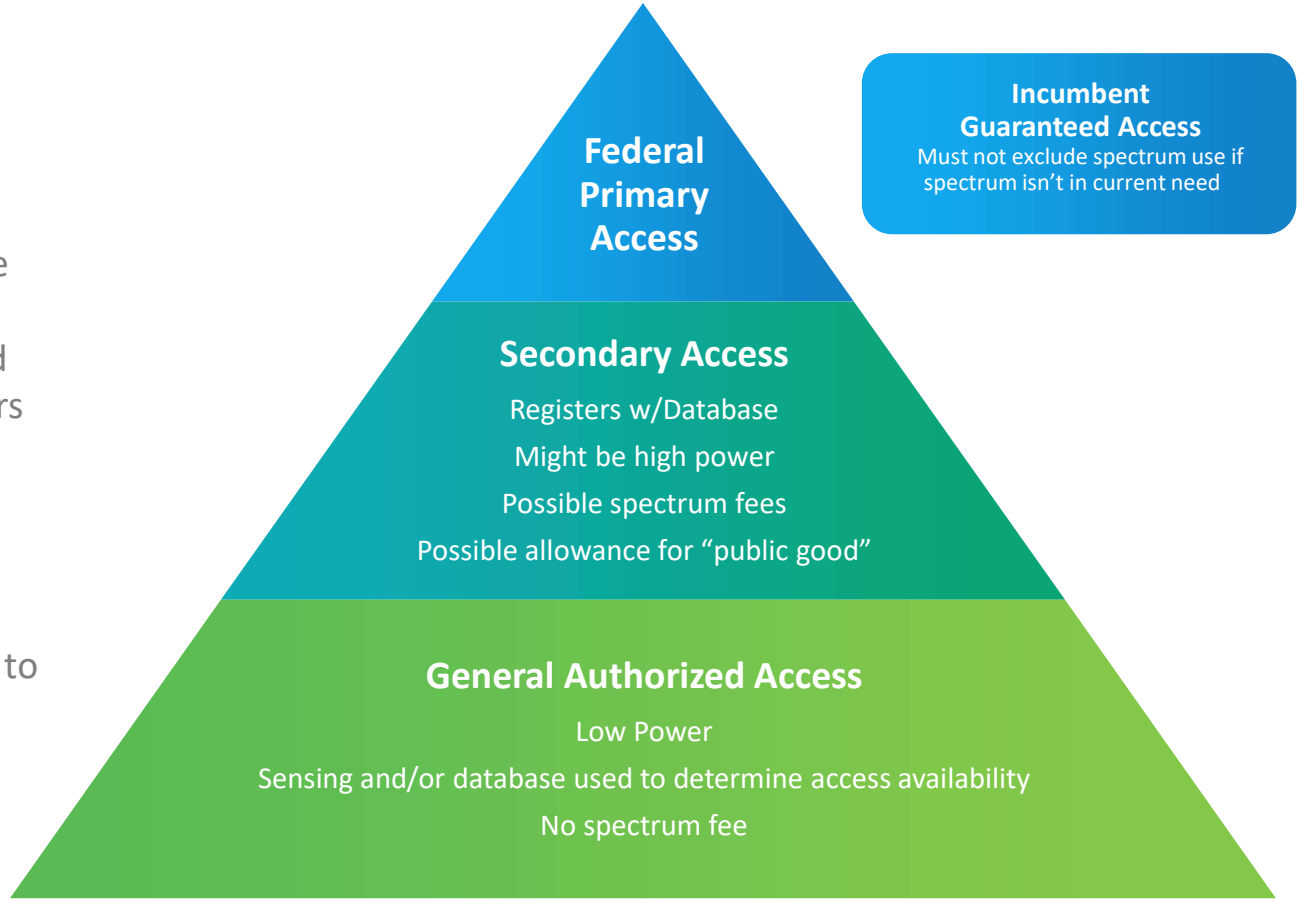
Source: Senza Fili CBRS Deep Dive Report

CBRS Timeline

PCAST* Concept
July, 2012

"The Federal Government, using industry partners, [should] establish a new Federal Spectrum Access System (SAS) that will serve as an information and control clearinghouse for band-by-band spectrum registrations and conditions of use and allow non-Federal users to access underutilized spectrum in Federal bands."

"The SAS will put into practice the fundamental principle that underutilized spectrum capacity should be used or shared to the greatest possible extent."



*President's Council of Advisors on Science and Technology

3.5 GHz CBRS Band
3550-3700 MHz

2900 MHz	3000 MHz	3100 MHz	3200 MHz	3300 MHz	3400 MHz	3500 MHz	3600 MHz	3700 MHz
					Band 22	Band 22		
					Band 42		Band 43	
						Band 48		
		AN/SPY-1 Radar (Aegis) 3100-3500 MHz				SPN-43 Radar 3500-3700 MHz		
RADIOLOCATION					FIXED FIXED SATELLITE			
MARITIME RADIONAVIGATION		Earth exploration-satellite Space research		Mobile Amateur		MOBILE		
				Fixed	Radiolocation			

CBRS Allocation

Tiered Sharing

Authorized Federal and Grandfathered FSS

Grandfathered Wireless Broadband

"Use It Or Share It"

Incumbent Primary Access

Priority Access License (PAL)

Licenses awarded by auction

Licensed by County

Ix-protected from GAA users, but must protect incumbents

Registers with and controlled by SAS

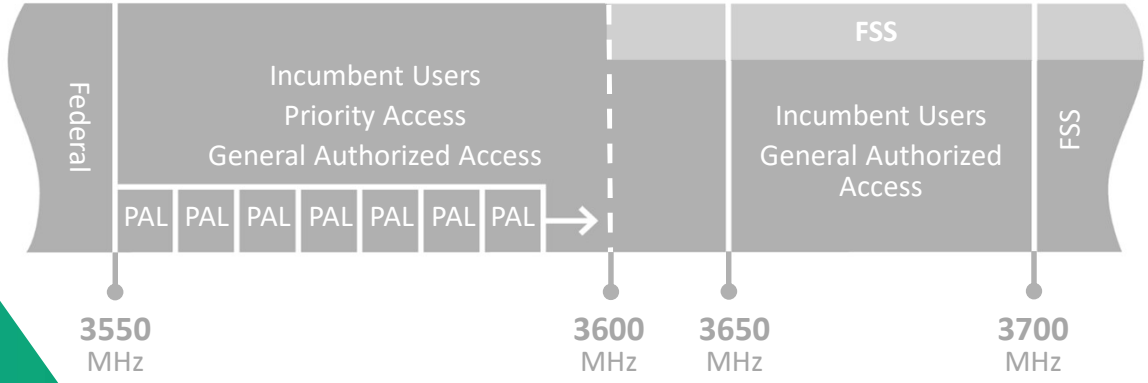
General Authorized Access (GAA)

Open eligibility

No interference protection

Registers and is controlled by SAS

Reverts to GAA in 2020



U.S. Counties

COMMSCOPE

Device Type		Maximum EIRP (dBm/10 MHz)	Limitations
Category A CBSD		30 (1W)	• Outdoor antenna height limited to 6m HAAT • If operation exceeds antenna height or max Cat A powers, it's subject to Cat B limitations
Category B CBSD		47 (50W)	• Can only be authorized for use after an ESC is approved and commercially deployed • Limited to outdoor operation • Must be professionally installed
End User Device (EUD)		23 (200mW)	• Can operate only if they can positively receive and decode an authorization signal transmitted by a CBSD • Subject to Cat A/B classification if it operates at power higher than specified for EUD

Citizens Broadband Radio Service Devices (CBSDs)

COMMSCOPE®

Incumbents

Navy Shipborne Radar (SPN-43)

- 3550-3650 in coastal areas
- On only 19 ships
- To be replaced in 2025(?) with SPN-50

Military Ground-Based Radars

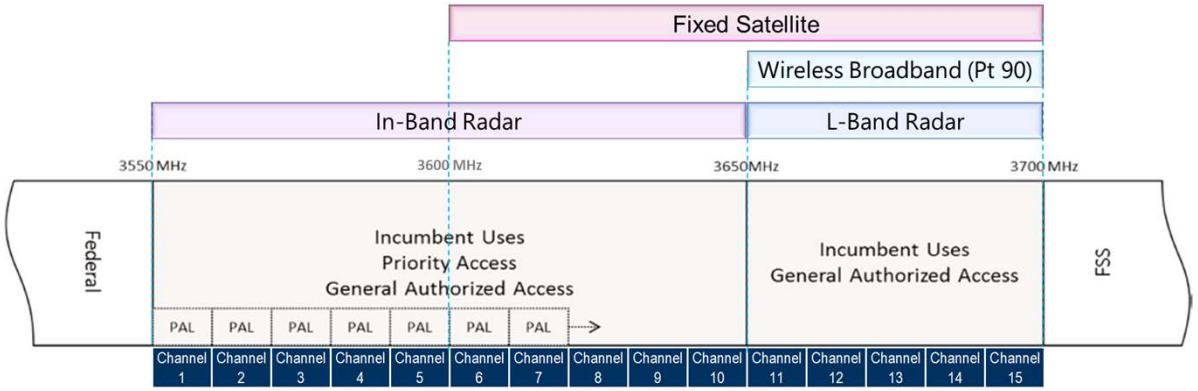
- Protected at three sites:
  Pensacola, FL; Pascagoula, MS; St Inigoes, MD
- Operations can extend below 3550 MHz at several sites
- Over 50 total GB radars

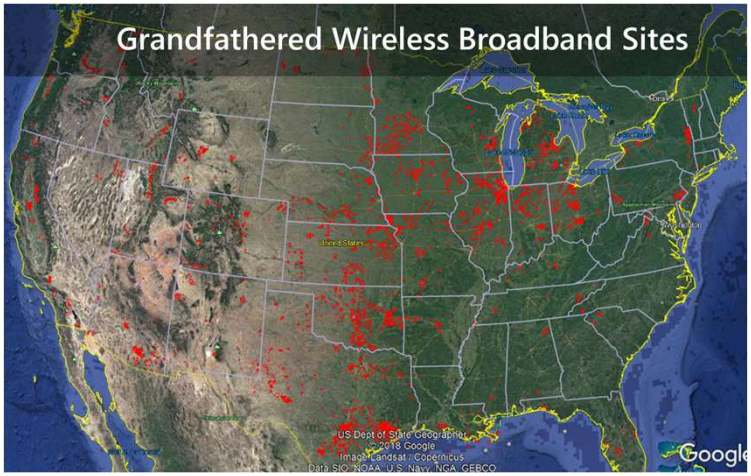
Fixed Satellite Systems (FSS)

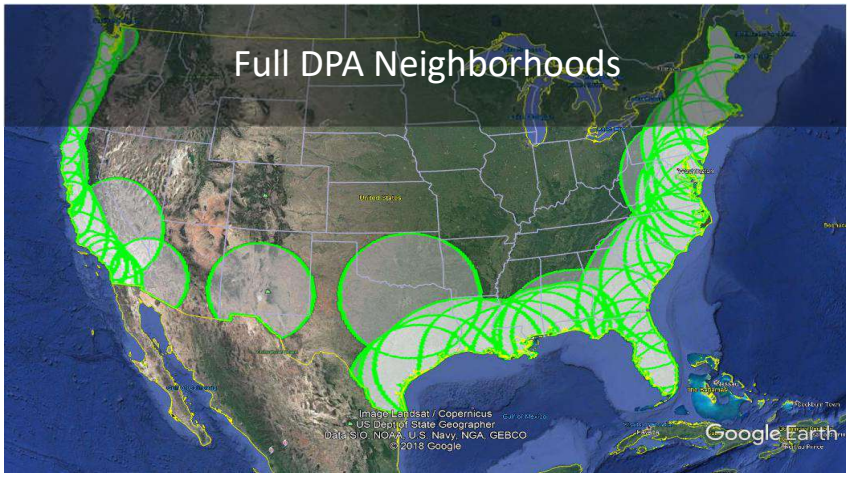
- In band (3600-3700 MHz) at 35 sites
- Adjacent-band operation (3700-4200 MHz) at thousands of sites, but only TT&C sites protected

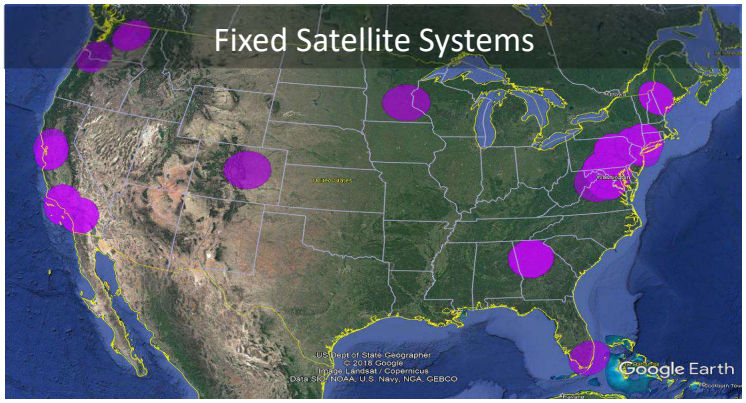
Wireless Broadband and Utility Services (Part 90, subpart Z) (3650-3700 MHz)

- Many thousands around the country (~4700)
- Will be transitioned to PAL or GAA operation in 2020 (most) through 2023 (few)

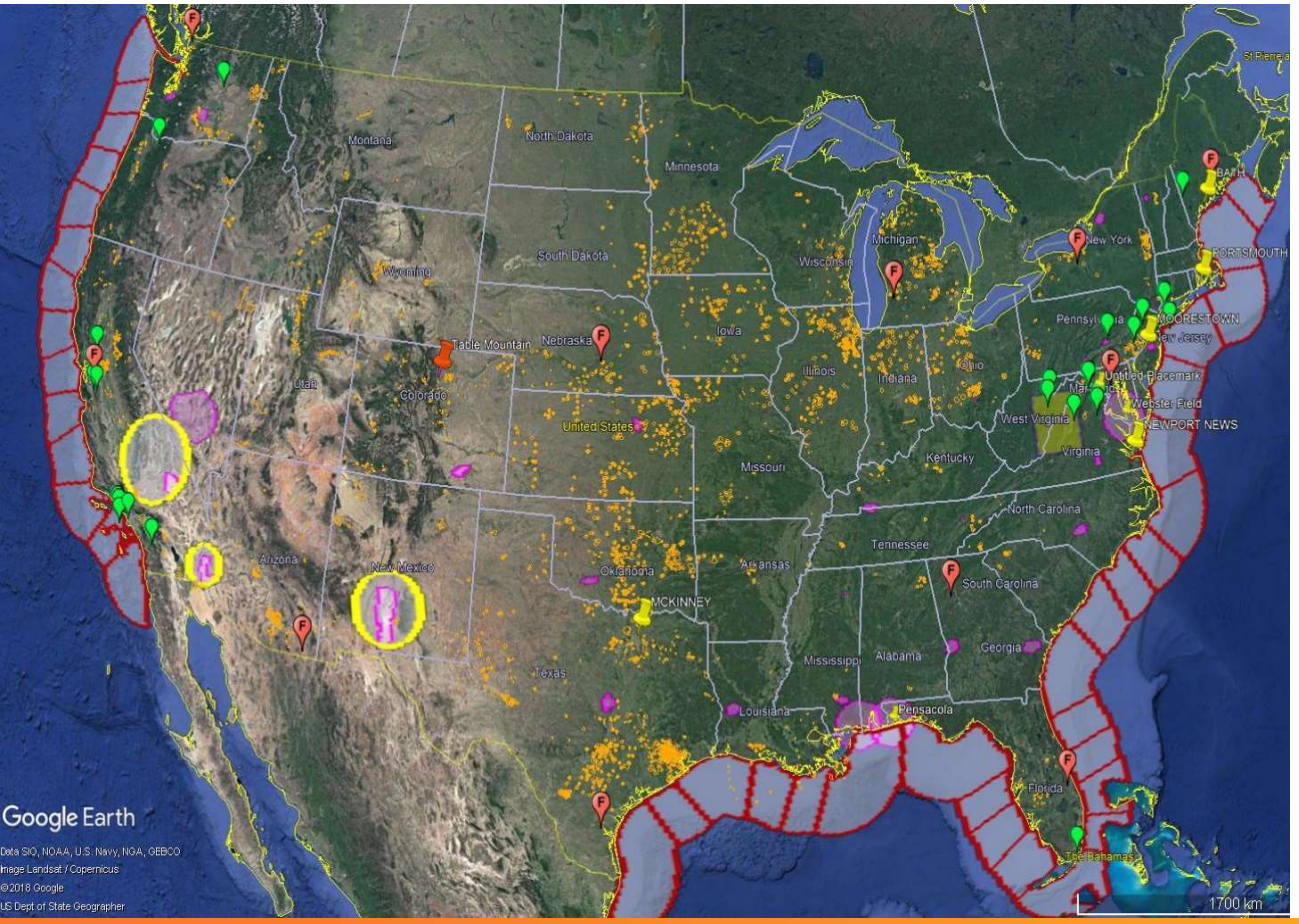






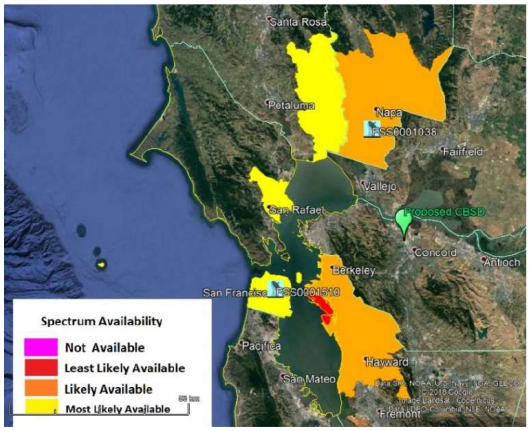


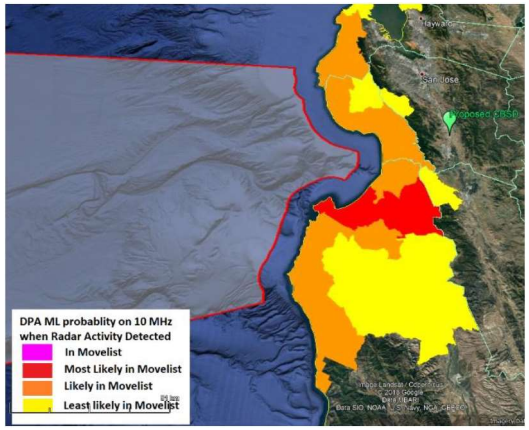
Spectrum Availability



- US Military Ship-borne Radar
- US Military Ground-borne Radar
- Fixed Satellite Sites
- Grandfathered Wireless Broadband
- Federal Quiet Zones
  - FCC Field Offices
  - Table Mountain, CO
  - NRAO/NRRO, WV
- Part 90 Exclusion Zones

Incumbent Primary Access





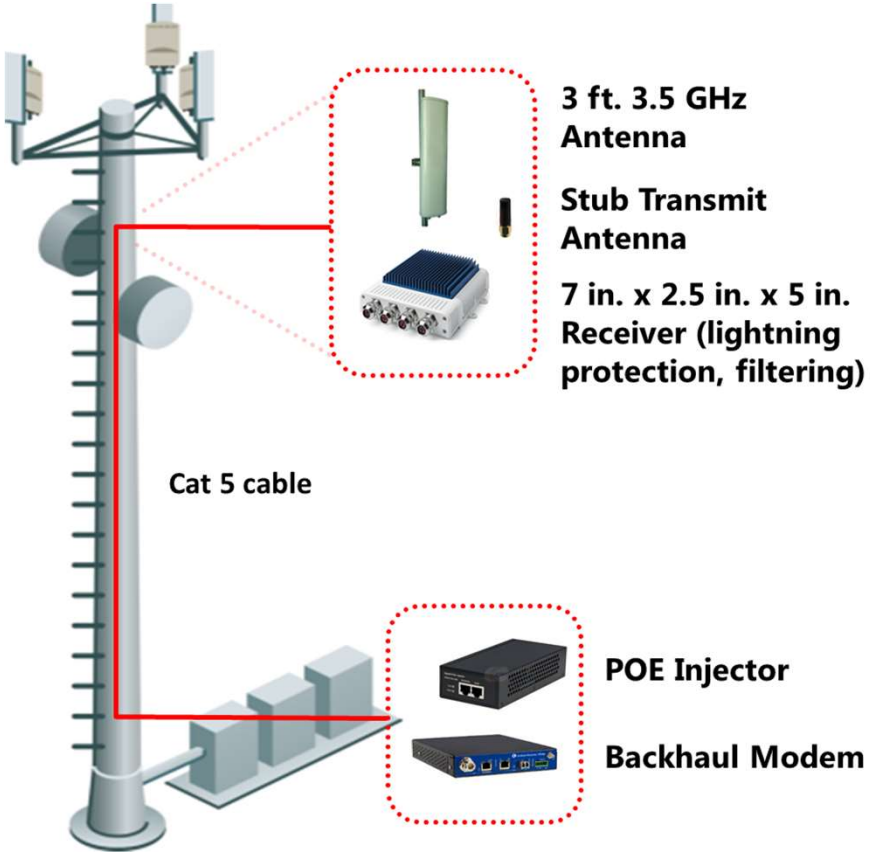
Provides key information about areas affected by the presence of incumbents and potential future CBSDs.

Results provide:

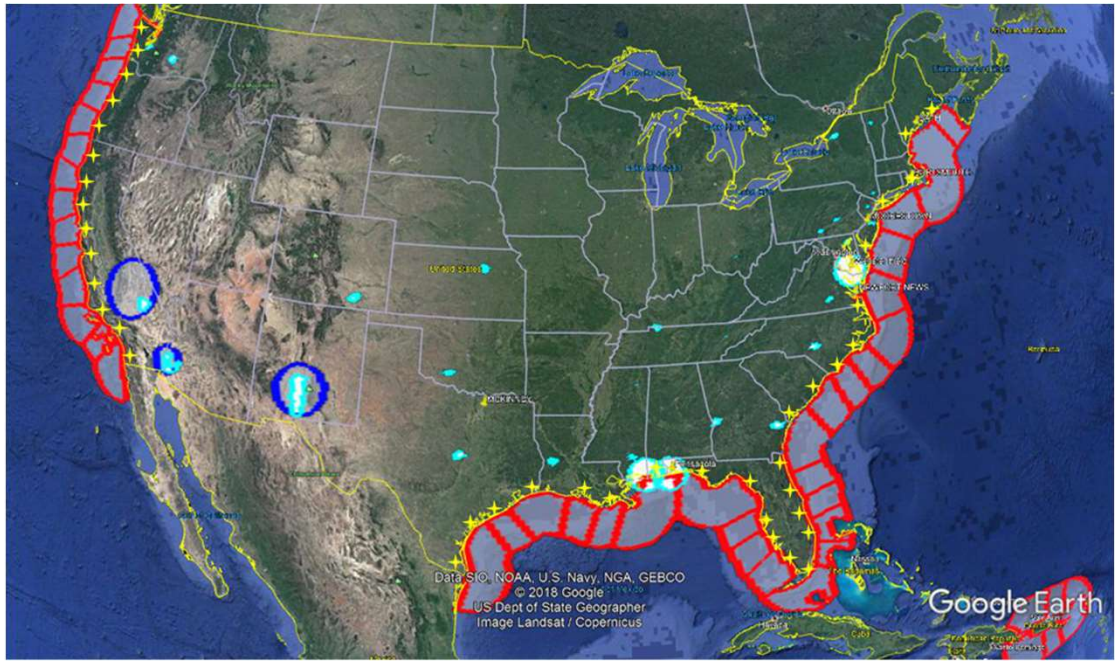
- Analysis of spectrum availability at a granular level to understand operational frequency and power ranges
- Statistical information on spectrum availability for both current and future market conditions as CBSD penetration increases
- Prediction of actual areas affected by dynamic incumbent activity and provides backup channel planning
- PAL auction planning support (similar to “Auction Planner™”)
- Guidance to optimize installations based on spectrum availability

Spectrum Availability Analysis

SENSOR



DEPLOYMENT



Environmental Sensing Capability (ESC)

COMMSCOPE®

ESC Requirements

- Timely detection of radar pulses at a threshold of -89 dBm/MHz
- 99% probability of detection within 60 seconds at the threshold
- Event detection and declaration in the presence of Gaussian noise (-109 dBm/MHz)
- Detection/declaration across 3550-3650 MHz
- Proper operation in the presence of high power in-band and adjacent OOB radar signals

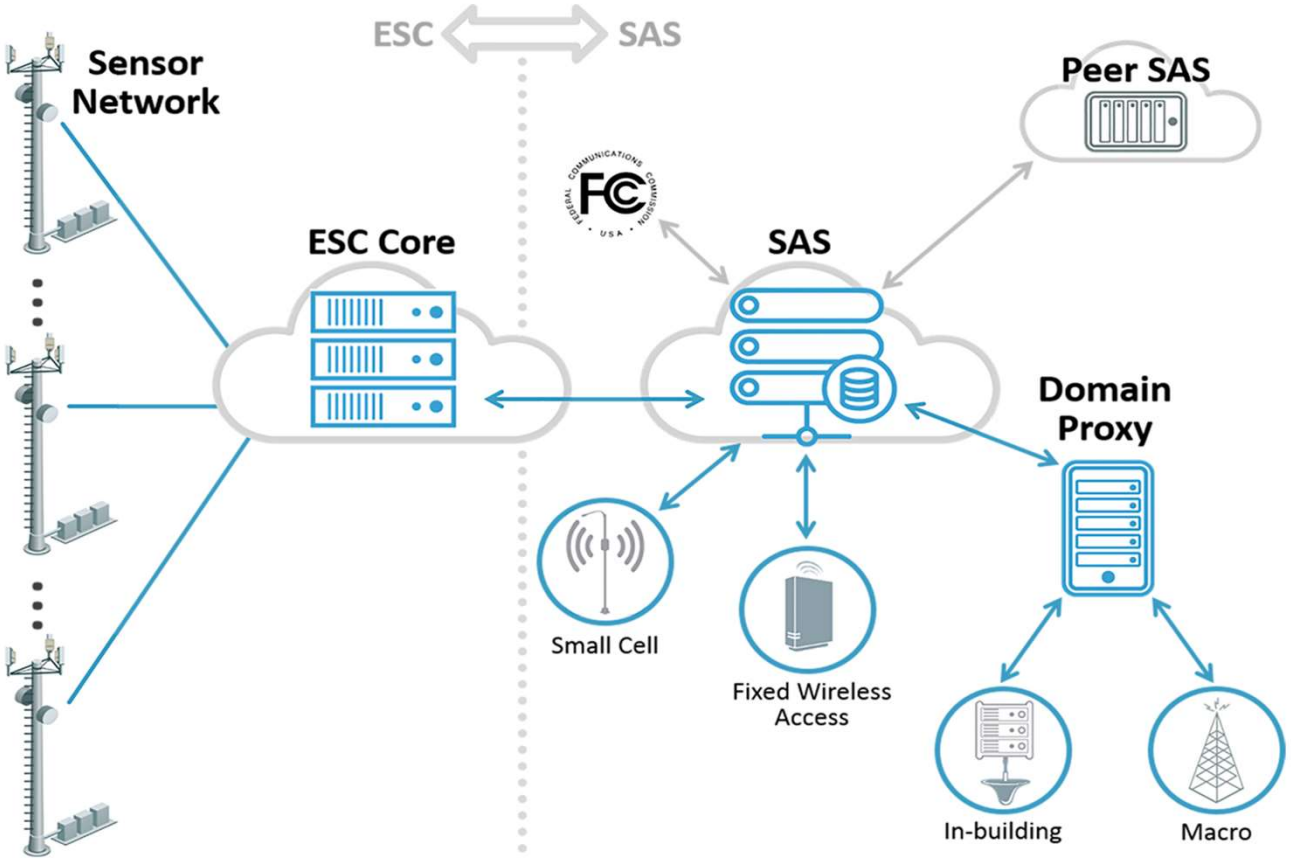
Radar Waveform Types for ESC Verification

Pulse Modulation	Pulse Width (μs)	Chirp Width (MHz)	PRR (pulses per second)	Pulses per Burst (Min to Max)	Comments
P0N #1	0.5 to 2.5 Δ = 0.1	N/A	900-1100 Δ = 10.0	15 to 40 Min Δ = 5	Similar to currently deployed Radar 1
P0N #2	13-52 Δ = 13	N/A	300-3000 Δ = 10.0	5 to 20 Δ = 5	Simulates possible phase-coded waveforms that could be used in future radar modulations
Q3N #1	3-5 Δ = 1.0	50-100 Δ = 10	300-3000 Δ = 30	8 to 24 Δ = 2	Simulates possible future multi-function Q3N-type radar • Short τ • Wide Bc
Q3N #2	10-30 Δ = 1.0	1-10 Δ = 1	300-3000 Δ = 50	2 to 8 Δ = 2	Simulates possible future multi-function Q3N-type radar • Intermediate τ • Intermediate Bc
Q3N #3	50-100 Δ = 5.0	50-100 Δ = 10	300-3000 Δ = 100	8 to 24 Δ = 2	Simulates possible future multi-function Q3N-type radar • Wide τ • Wide Bc

COMMSCOPE®

SAS Architecture & Functions

- Register and authenticate the identification information and location of CBSDs;
- Determine the available frequencies and max powers at a given geographic location and assign them to CBSDs;
- Enforce Exclusion Zones to ensure compatibility between CBRS users and incumbent operations;
- Process information from ESCs through ESC Core to detect and protect federal radar operations;
- Protect Priority Access Licensees from harmful interference from General Authorized Access Users;
- Ensure secure transmission of information between the SAS and CBSDs.

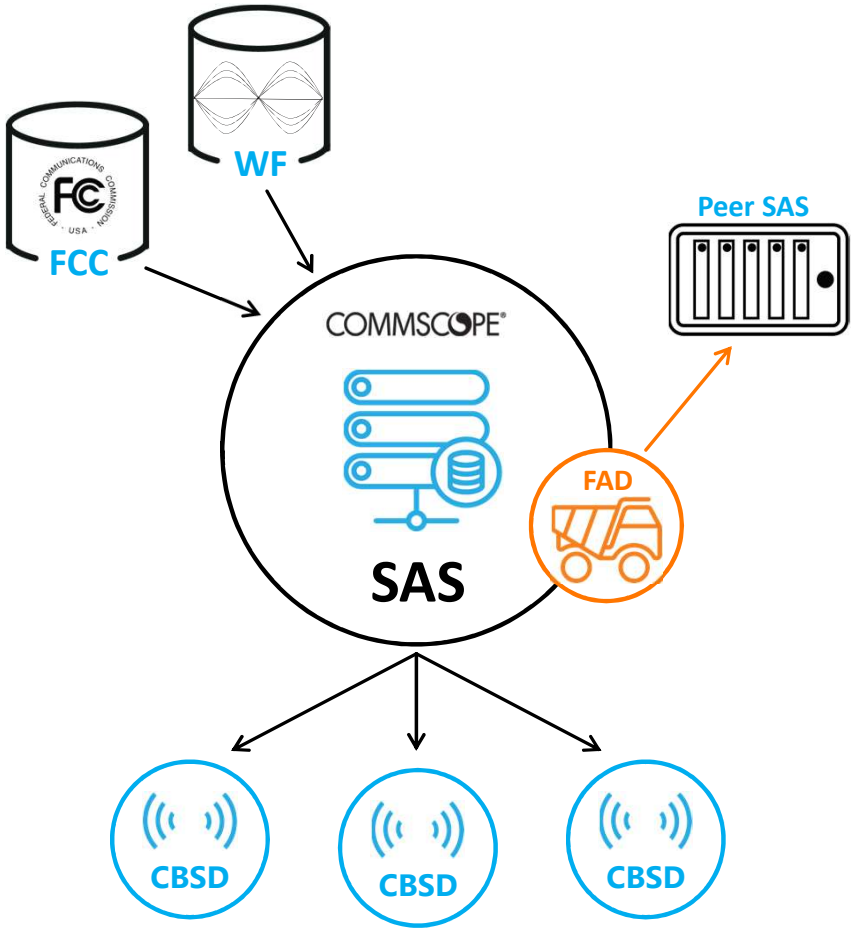


SAS Coordinated Activities | CPAS*

SAS Nightly Processing

- Create a Full Activity Dump (FAD) of local SAS data
- Exchange FAD with Peer SASs
- Update FCC/NITA and WInnForum provided data
- Evaluate any exclusion zone changes
- Re-compute CBSD allocated transmit power
  - IAP—Interference Allocation Partition
- Re-compute DPA move lists
  - DPA – Dynamic Protection Area
- Communicate any changes to CBSD(s)

* CPAS = Coordinated Periodic Activity among SASs



COMMSCOPE®

Coexistence Issues

- Debate on SAS control of GAA coordination

  FCC Rule §96.35: “General Authorized Access Users operating Category B CBSDs must **make every effort to cooperate** in the selection and use of available frequencies provided by an SAS to minimize the potential for interference and **make the most effective use of the authorized facilities**. Such users shall coordinate with an SAS before seeking station authorization, and make every effort to ensure that their CBSDs operate at a location, and with technical parameters, that will minimize the potential to cause and receive interference among CBSDs. Operators of CBSDs suffering from or causing harmful interference are **expected to cooperate and resolve interference problems** through technological solutions or by other mutually satisfactory arrangements.”
- Non-LTE and LTE Community
  - Part 96 is RAT neutral
- Fair BW partition
- Minimum BW allocation in congested situation

COMMSCOPE®

Coexistence Framework

Focus is on Frequency Allocation

- Managing CBSD transmit power for GAA coexistence is not desired . CBSD transmit power shall be controlled only in the context of protecting interference in the tiered model.
- “Slow Reaction” – updates on a daily basis

Industry Contention over Fairness

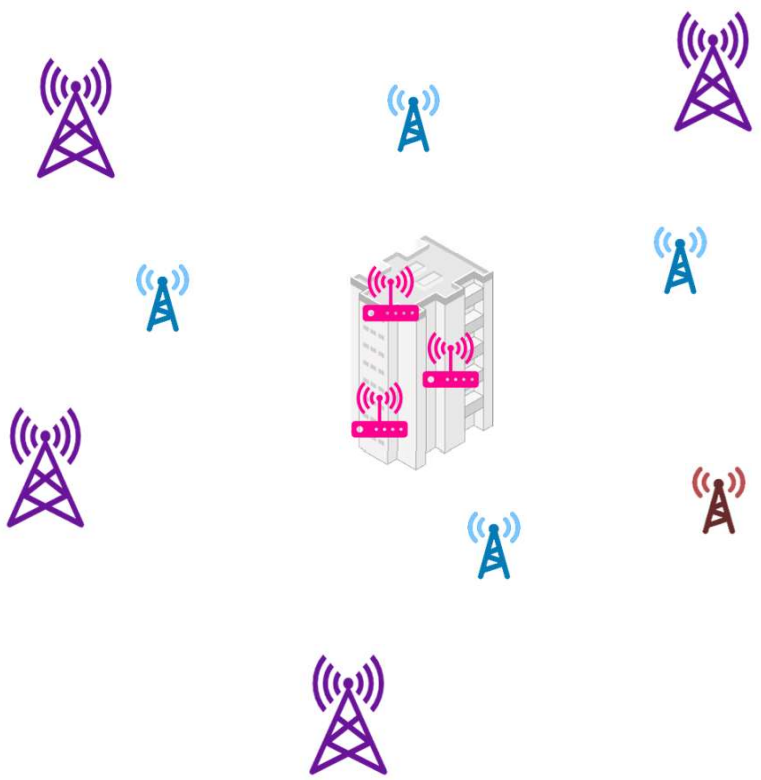
How is the spectrum divided?

- Weighted by CBSD count
- Weighted by geographic coverage – small cell vs. macro cell
- **Interference Conflict graph**
  - **CBSD Grouping**

COMMSCOPE®

CBRS-Alliance Coexistence Approach

- CBRS alliance addresses Intra-CxG coordination
  - Assumes CxM will have a pool of spectrum to handle assignment within CBRS alliance CxG
- CxM functionality defined in CBRS-A
  - LTE-TDD connected graph for selection of TDD configuration
  - Protocol extensions of CBRS Alliance Coexistence Object
  - CbrsAllianceInfo object from CBSD/DP to CxM
    - Provides Cell Information(EARFCN and PCI) and measurements(RSSI and RSRP)
  - CbrsAllianceConfig object from CxM to CBSD/DP
    - Provides frequency guidance and list signals CxM is interested



Operator 1

Outdoor – high power

Operator 2

Outdoor – low power

Operator 3

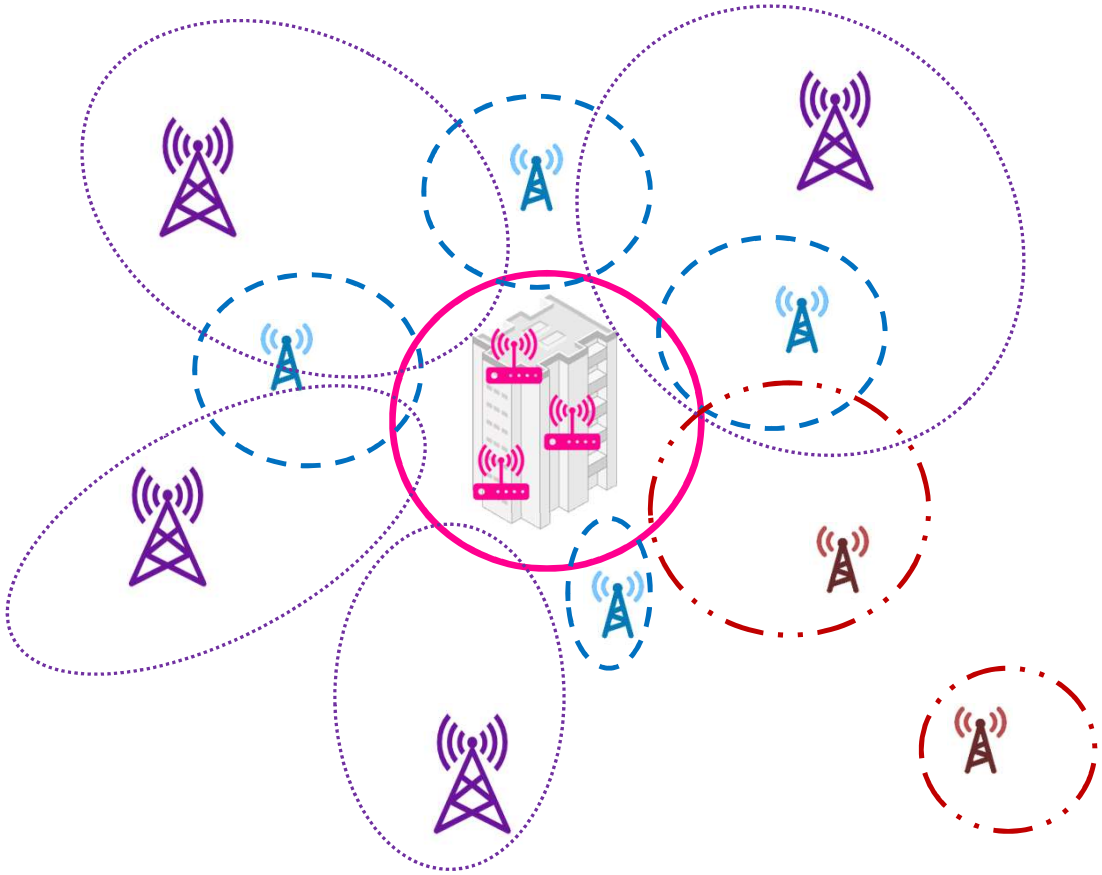
Outdoor – low power

Operator 4

Indoor – low power

Deployment Scenario

Multiple Operators Wish To Coexist in GAA Spectrum



Operator 1

Outdoor – high power

Operator 2

Outdoor – low power

Operator 3

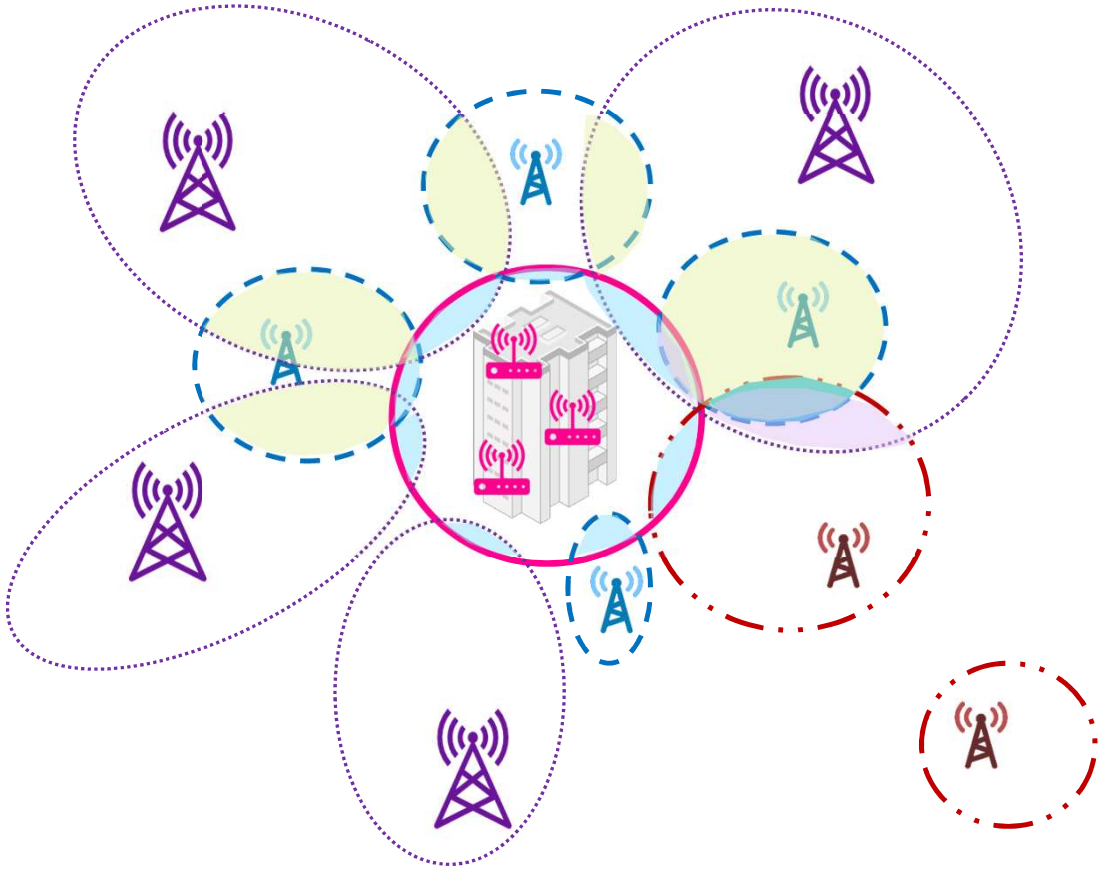
Outdoor – low power

Operator 4

Indoor – low power

Deployment Scenario

Geographic Coverage Is Predictively Modeled



Operator 1

Outdoor – high power

Operator 2

Outdoor – low power

Operator 3

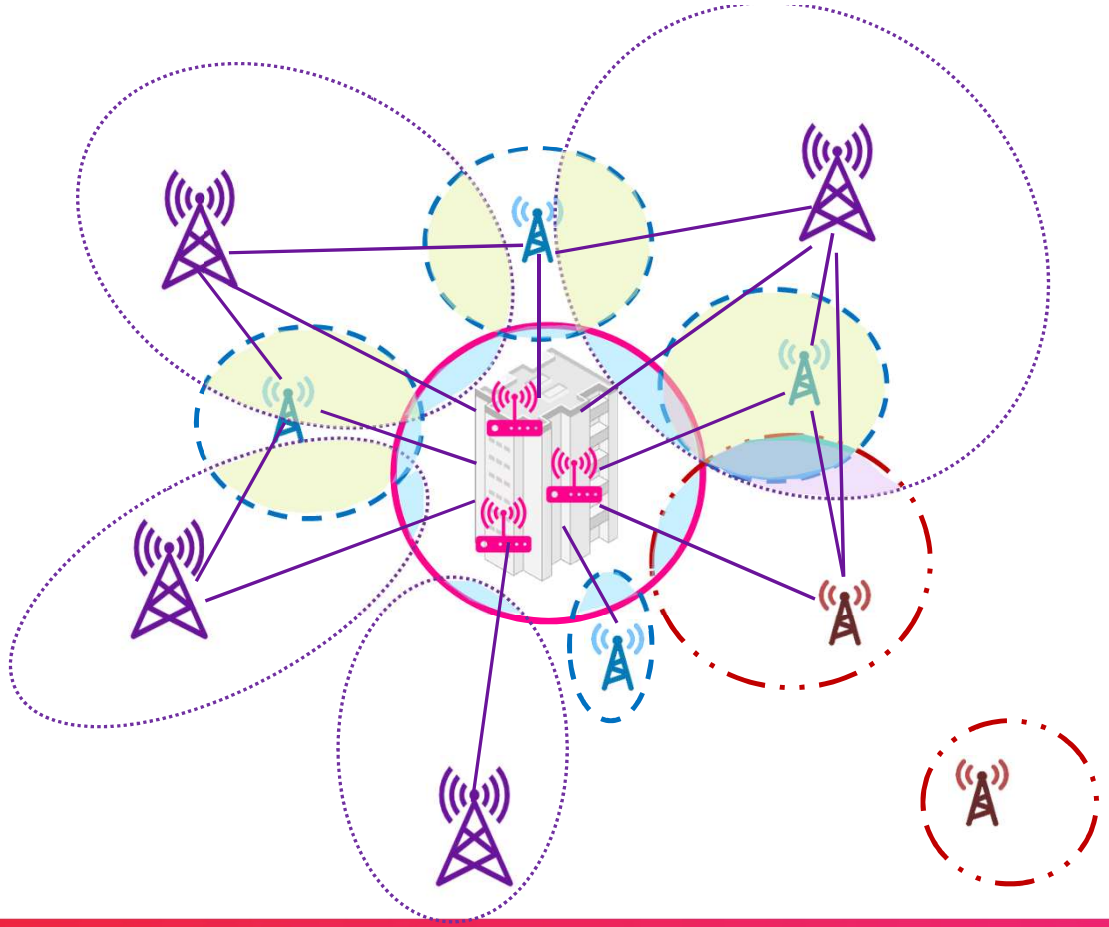
Outdoor – low power

Operator 4

Indoor – low power

Deployment Scenario

Regions Of Coverage Overlap Are Identified To Represent Potential Interference



Operator 1

Outdoor – high power

Operator 2

Outdoor – low power

Operator 3

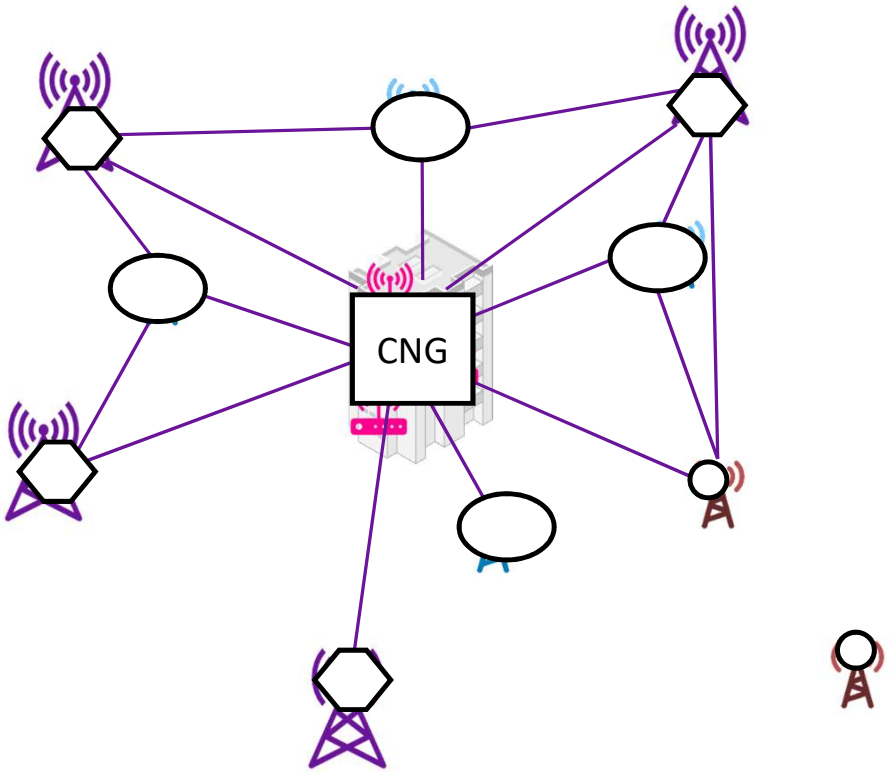
Outdoor – low power

Operator 4

Indoor – low power

Deployment Scenario

Edges Are Defined Between CBSDs Which Overlap In Coverage



Operator 1

Outdoor – high power

Operator 2

Outdoor – low power

Operator 3

Outdoor – low power

Operator 4

Indoor – low power

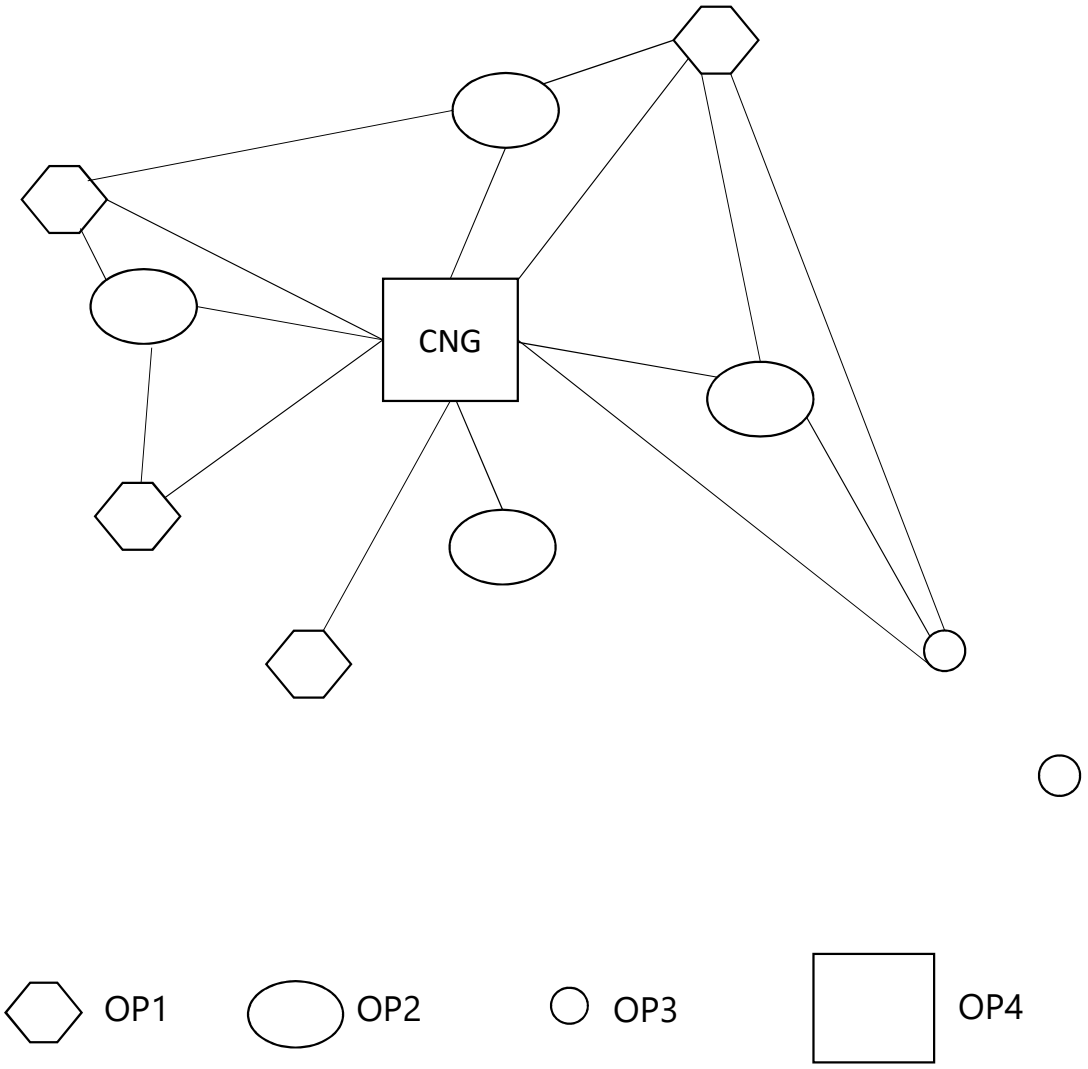
Deployment Scenario

CBSDs Are Grouped (If Applicable) And Replaced With Vertices

COMMSCOPE®

Network Graph Representation

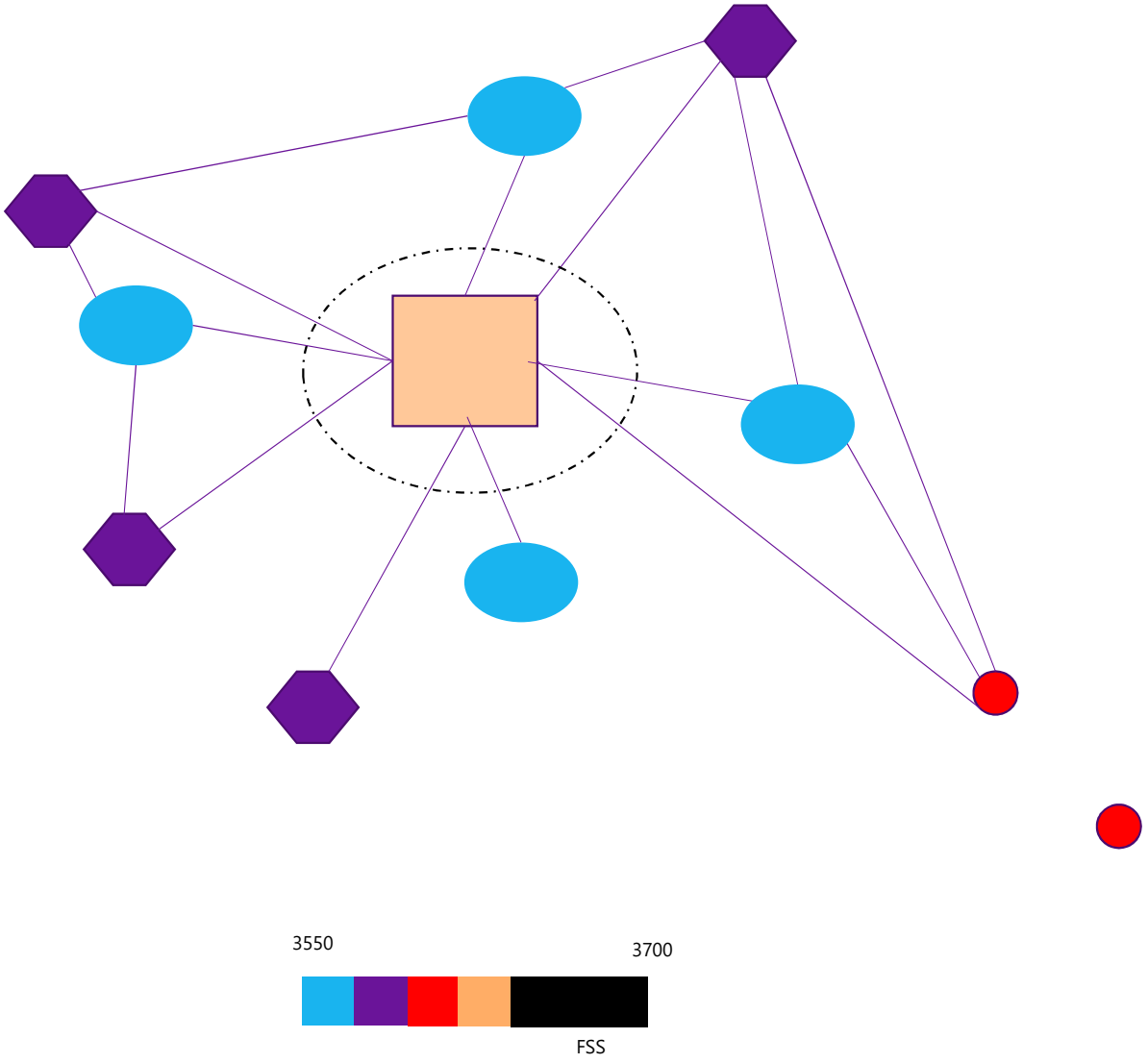
- Each CBSD or CBSD Group is represented as a vertex
- Unless directed by an operator, no edge is established between CBSD devices of the same operator
- Find minimum color required so that no two vertices connected by an edge get the same color. Minimum color required for the interference graph is calculated
  - This is known as chromatic number of the graph



COMMSCOPE®

Allocation Using Operator Level Graph Coloring

- Each operator gets ¼ of available spectrum
- FSS/ESC can power limit and make some spectrum unavailable
  - 75 MHz could be power limited
- The objective function will be used to find channel allocation



CBRS CxM policy

Uplink-Downlink Config	UL:DL ratio	Subframe Number									
		0	1	2	3	4	5	6	7	8	9
1	4:4	D	S	U	U	D	D	S	U	U	D
2	2:6	D	S	U	D	D	D	S	U	D	D

- Cell phase synchronization and well-defined partitioning of downlink and uplink resources required for co-existence
  - No guard band necessary
- CxM shall facilitate cooperation between CBSDs belonging to the same connected set to reach agreement on a common TDD configuration
  - If no agreement reached, CBRS Alliance CxM shall designate the use of one mandatory TDD configuration from those listed
- CBRS Alliance CxM shall designate the use of one mandatory TDD configuration on a connected set
- All CBSDs that are part of the CBRS-A Coexistence group shall support the mandatory TDD shown here

CBRS - Opportunities

Shared spectrum opens the door for a range of possibilities

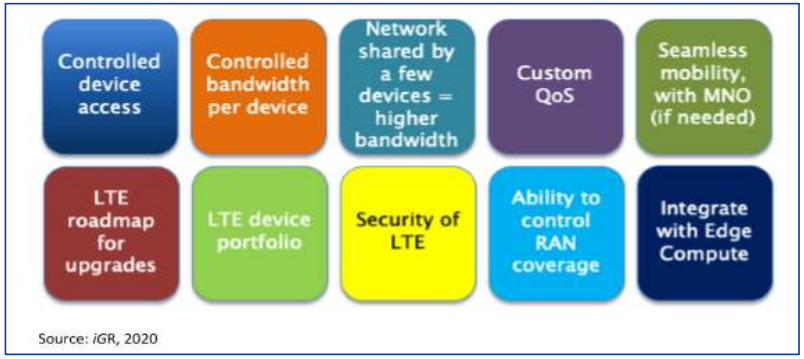
Mobile Network Capacity Layer

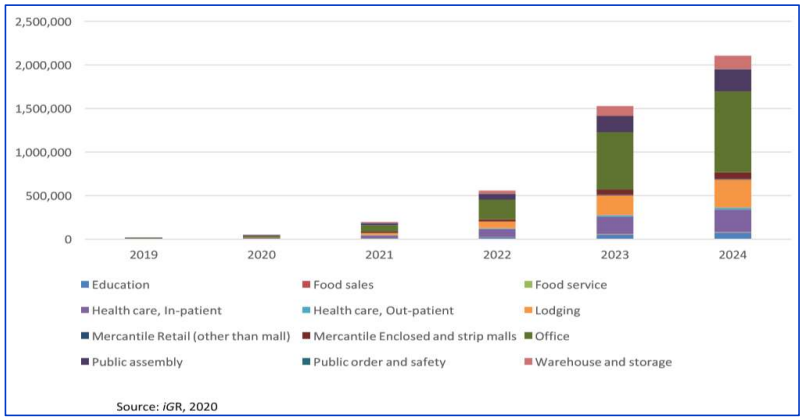
Fixed Wireless Access

Private Networks

© 2020 CommScope, Inc.

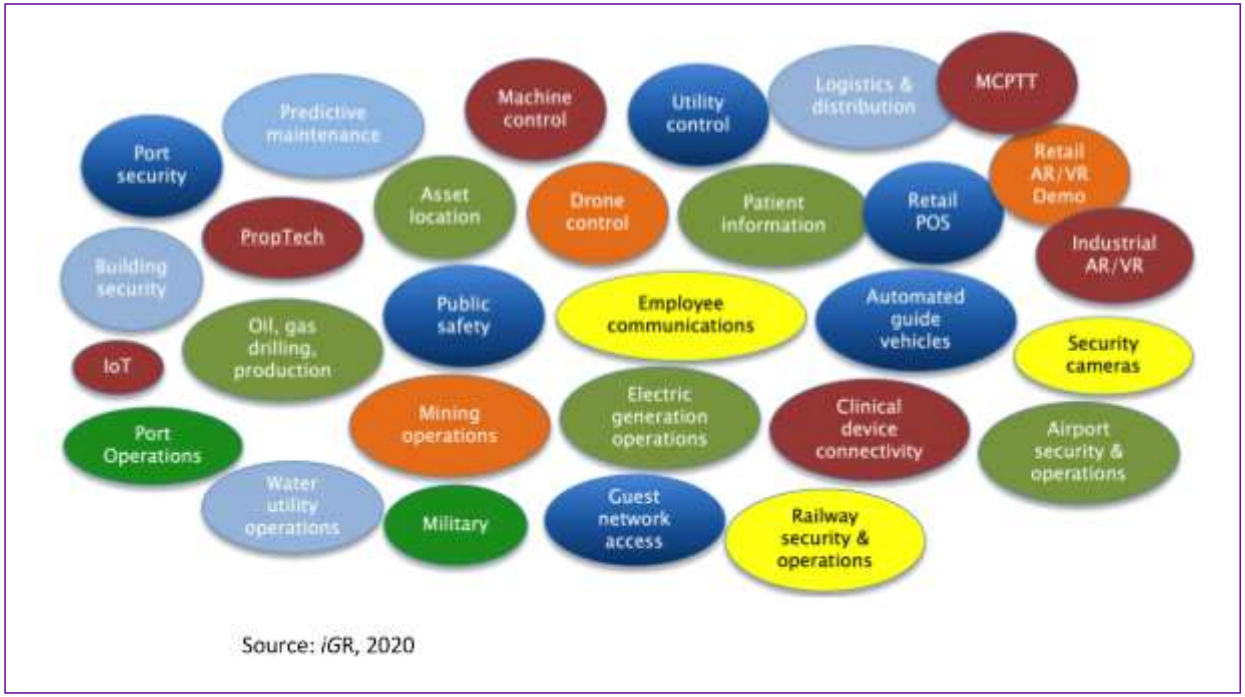
Why?





PLTE CAGR >170%

Opportunities



CBRS Private Networks

COMMSCOPE®

Key Takeaways

- Open Access to 150 MHz of midband spectrum for a variety of use cases
- Spectrum sharing increases utilization and access
- Supports licensed and unlicensed uses (PAL and GAA)
- Public and Private Use Cases
- Improved QoS and security over WiFi