CBRS: AN UNPROVEN SPECTRUM SHARING FRAMEWORK

Executive Summary

In 2012 the President's Council of Advisors on Science and Technology (PCAST) was asked to write a report on how it envisioned the allocation of wireless spectrum in the future.

Taking the position that clearing spectrum for unencumbered use was too difficult in some cases, the report called for sharing spectrum between incumbent federal, state and local users and commercial users. Licenses should be small, reused, and relicensed and would thereby increase the capacity by a factor of 1,000. The FCC formalized this approach with the creation of CBRS out of 150 megahertz (MHz) of spectrum in the 3.5 gigahertz (GHz) band.

Today, a decade after this approach was proposed, a review of the current CBRS marketplace reveals a gap between the promise of this type of sharing and its reality. Key points include:

- Real-world studies indicate low utilization of CBRS spectrum, while there is no way to measure whether CBRS spectrum is being used at greater levels of efficiency
- The most prevalent use cases are traditional wireless deployments
- The supply of sharing services is declining, particularly those supplied by non-traditional providers, driven by low demand for these services

This situation can be explained by the following factors:

- Federal preemption of commercial spectrum rights are a barrier to applications that require guaranteed levels of service
- Low power levels and small license sizes limit the ability to provide coverage and increase cost
- This sharing has proven to be more complex than anticipated

These factors combine to discourage CBRS adoption and limit use cases. They also carry a significant and underappreciated opportunity cost. Across every dimension and every metric – efficiency, utilization, demand – full power, exclusive use, licensed commercial spectrum has succeeded where CBRS has struggled to date.

The inescapable conclusion is that CBRS spectrum would be more widely utilized, at greater levels of efficiency, and deliver more value to federal incumbents, commercial users and the American consumer had it been made available for excusive, licensed use.

Given the highly effective, proven track record of exclusive-use licensed spectrum, need for more data on CBRS' performance, and the fact that all available data points to CBRS

underperforming expectations, policymakers should refrain from using CBRS sharing as a model for bands in the future.

CBRS BACKGROUND

In 2010, recognizing the importance of creating a sufficient spectrum pipeline, President Obama asked the President's Council of Advisors on Science and Technology (PCAST) to develop a report with recommendations on how to make optimal use of federal spectrum.

The report, named "Realizing the Full Potential of Government-held Spectrum to Spur Economic Growth" was submitted in 2012[1]. The report argued that it would be too expensive and time consuming to continue to clear spectrum for unencumbered, exclusive licensed commercial use, and that spectrum resources were not being used efficiently. The report recommended that spectrum should be shared between federal and commercial users and parceled into small licenses, with shorter durations, for maximum reuse.

In an effort to implement some of the PCAST recommendations and realize the purported benefits, in 2012 the FCC created the Citizen's Broadband Radio Service (CBRS) out of spectrum previously reserved for federal government use. CBRS is 150MHZ of spectrum in the 3.5 GHz band (3550 MHZ to 3700MHZ).

Under the FCC's rules, the federal government would share CBRS spectrum with commercial users in a three-tiered structure. Access to spectrum would be managed by a dynamic spectrum access system (SAS). The tiers were structured as follows:

- *Incumbent Access*: Federal and satellite users already operating in the band. These users would continue to operate and be protected from harmful interference from Priority Access and General Authorized Access users.
- *Priority Access:* Users who would gain Priority Access Licenses (PALs) following a competitive auction of 70 MHZ of the available spectrum. These users would have access to their spectrum whenever it was not in use by federal government users and would be protected from interference from General Authorized Access (GAA) users.
- *General Authorized Access*: A tier of spectrum that is available to a broad pool of potential users when not in use by the incumbent or the PAL, and at no cost. GAA users would not be entitled to interference protection.

The FCC began the process of making CBRS available for use with a Notice of Proposed Rule Making (NPRM) in December 2012. After several years of planning and preparation, the FCC auctioned PALs in 2020, raising $4.6B.

[1] https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf

CBRS TODAY: REVIEWING CURRENT MARKET REALITIES

Ten years after the FCC created CBRS there is little evidence that this experiment in spectrum sharing is meeting the goals originally set in the PCAST report. On the contrary, the indicators that are available suggest the promised benefits have not been achieved despite significant efforts by policyholders and industry.

STUDIES INDICATE LOW UTILIZATION AND THERE IS NO WAY TO DETERMINE IF CBRS SPECTRUM IS BEING USED EFFICIENTLY WHERE IT IS BEING UTILIZED

The original vision for sharing, articulated by the PCAST and echoed by the FCC when it made CBRS available under a shared model, was to multiply the capacity of federal spectrum by a factor of 1,000 through dynamic spectrum sharing.[2]

Proponents point to specific deployments like the New York City Library System and the Fort Worth School District to suggest CBRS success. Given the stated promise of CBRS, those laudable but isolated use cases alone are inadequate to assess the experiment's success. Indeed, the PCAST envisioned measuring spectrum effectiveness through a more sophisticated metric that accounted for factors such as the quantity of data delivered, the number of users, and the interference range, among others.[3]

Ten years later, however, it is impossible to demonstrate that CBRS is being used effectively based on the metric and the terms originally envisioned by PCAST or through any similar metric. There is no mechanism for collecting nationwide CBRS data – such as the amount of data transmitted, or the number of users – that would make such calculations possible. Nor are there any apparent plans to collect such data and compare CBRS effectiveness today with the increasing effectiveness of full power, large license size, and exclusive-use commercial spectrum over the same period.

In the absence of data to demonstrate the effectiveness of the PCAST approach using the terms envisioned by its proponents, fortunately we can turn to publicly available information on actual CBRS use from a study[4] commissioned by CTIA, the wireless industry trade group. This study examined CBRS spectrum utilization in the fall of 2021 in Atlanta, Kansas City and Phoenix. These measurements showed that CBRS being significantly underutilized.

In Atlanta, only one entity was using the CBRS band, and less than half of the city showed installed transmitters. Just nine of the fifteen CBRS channels were used in Atlanta. In Kansas City, three entities were using CBRS spectrum. Twelve of the fifteen channels were in use, but only within a limited area; much of Kansas City had no CBRS transmissions. Phoenix had only four network operators transmitting. Different channels were assigned across the city such that all fifteen channels were used, but in approximately half of Phoenix, no CBRS channels were detected. Across the three markets, no CBRS transmissions were detected in parts of each city, and just a portion of the band was in use at any given location. There was ample supply of spectrum, particularly GAA access, which was unused in each of the three cities.

These measurements confirm limited CBRS transmissions, but do not demonstrate the CBRS approach is successful in increasing capacity or improving spectrum efficiency.

[2] https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf
[3] https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/pcast_spectrum_report_final_july_20_2012.pdf Appendix B
[4] https://www.ctia.org/news/cbrs-spectrum-occupancy-measurements

In short, the metrics by which CBRS performance was intended to be determined were never measured but the metrics we have indicate CBRS is greatly underutilized. Licensed spectrum, by contrast, has been shown to be increasingly well utilized, as is shown below in the section titled, "Understanding the Opportunity Cost."

THE PROFILE OF USERS AND USE CASES FALLS SHORT OF EXPECTATIONS

Spectrum sharing was devised, in part, to broaden the base of spectrum users and support the development of innovative use cases. To facilitate this, the FCC created two tiers of non-government usage tiers: PAL and GAA. Ten years after the CBRS NPRM, however, it is clear that the profile of actual CBRS users and use cases does not match expectations.

PAL USERS AND USE CASES

The FCC auctioned PAL licenses at the county size in 2020 with the expectation that enterprise companies, large and small, would acquire these licenses and use them in novel ways. A list of the top 20 PAL auction winners shows that reality failed to live up to the promise:

EXHIBIT: CBRS PAL Auction Winners

Company	Number of Licenses	Net Payment	Likely Use Case
Verizon	**557**	**$1.8 billion**	**MNO**
Dish Network	**5,492**	**$912 million**	**MNO**
Charter	**210**	**$464 million**	**MNO/FWA**
Comcast	**830**	**$458 million**	**MNO/FWA**
Cox	**470**	**$212 million**	**FWA**
Southern California Edison	20	$118 million	Industrial
Windstream	**1,014**	**$38 million**	**FWA**
Mediacom	**576**	**$29 million**	**FWA**
Nextlink Internet	**1,072**	**$28 million**	**FWA**
JBG Smith	7	$26 million	FWA
San Diego Gas and Electric	3	$21 million	Industrial
ATN International	**1,569**	**$20 million**	**MNO**
Puerto Rico Telelphone	**231**	**$19 million**	**MNO/FWA**
Alabama Power Company	271	$19 million	Industrial
Shentel	**262**	**$16 million**	**FWA**
VTX Communications	**112**	**$15 million**	**FWA**
NE Colorado Cellular	**558**	**$15 million**	**MNO/FWA**
US Cellular	**243**	**$14 million**	**MNO**
WATCH TV Company	**517**	**$11 million**	**FWA**
Cable One	**547**	**$11 million**	**FWA**

Sixteen out of the top 20 are traditional telecommunications providers and nine out of ten plan to use their spectrum for traditional mobile wireless or fixed wireless purposes. Verizon appears

to be using CBRS to augment capacity in large parts of their network. Charter announced that it will use the CBRS spectrum to expand its operations adjacent to where it operates its cable network and that it would use the CBRS spectrum for mobile off-load as well. Comcast and Cox are probably going to use it for similar purposes. Windstream, Mediacom, and Nextlink will use it for fixed wireless access. Based on our research, wireless internet service providers (WISP) seem to be the most significant pool of operators. JBG Smith is a real estate company that will use its PALs to work with mobile operators to provide better connectivity to its tenants.

Two power companies, Southern California Edison and San Diego Gas and Electric, will also use CBRS to provide regular connectivity services in addition to installing transmitters on every electricity tower to detect when a branch or tree hits a transmission line, or if a tower is falling to the ground. Looking further down the list of auction winners reveals four universities and a small number of corporations, such as John Deere and Chevron.

In short, far from diversifying the base of spectrum users or use cases, CBRS PAL auction winners reflect the types of users and use cases that would be expected under a traditional licensing framework – but with rules that restrict their ability to optimize the use of this spectrum, as detailed in the following section.

GAA USERS AND USE CASES

The GAA tier is effectively the unlicensed access of the CBRS regime. Despite users such as the New York City Library system and the Fort Worth School District – the profile of use cases is disappointing to date. In fact, the overwhelming majority of use cases are, for all practical purposes, indistinguishable from WiFi deployments with the sole difference being the slightly lower number of access points needed per deployment than a traditional WiFi deployment.

CBRS is certainly capable of serving as a WiFi replacement system, but it is difficult to argue that this is the most productive use of this spectrum, particularly when there is already eight times more spectrum available for unlicensed use in the 6 GHz band alone than for CBRS, available at lower price points and with far greater device choices.

In other words, the profile of GAA users and use cases can best be summarized as non-traditional users applying CBRS for traditional use cases at greater costs than other, readily available solutions.

SUPPLY IS DWINDLING IN THE FACE OF LOW DEMAND

As noted previously, under the CBRS rules, access to spectrum would be managed by a dynamic spectrum access system (SAS). When CBRS licenses were auctioned, there were three primary SAS vendors from which companies that were interested in using GAA spectrum could choose from: Google, Federated Wireless, and Commscope. Subsequently, Amdocs and Sony were also certified.

In early 2022 Commscope left the market, announcing that it would no longer be a SAS provider for CBRS[5]. While Commscope remained silent about its reasons one can reasonably surmise it was due to a lack of expected demand. Companies do not often abandon profitable lines of business.

While the SAS supply is dwindling, market demand is also falling. In March and April 2022, Technalysis Research[6] interviewed 400 US-based businesses using or interested in deploying private networks – the kind of entities that CBRS spectrum was intended for. Only 2% of companies were planning to use CBRS spectrum. The vast majority, 81%, were interested in sub-6 GHz spectrum –WiFi. Even more interestingly, Technalysis Research found that none of the medium size businesses it interviewed were interested in CBRS.

Other market data tells a similar story. Dell'Oro Group determined that only 2% of the North American RAN market consisted of CBRS. Meanwhile, of the two remaining SAS providers, Federated Wireless states that it has more than 375 customers serving 110,000 access points. Google has not disclosed how many companies it provides SAS and related CBRS services for.

Overall, we estimate that there are approximately 240,000 access points with less than 1,000 businesses operating them. Considering that there are 20,139 large businesses and 31.7 million small businesses[7], CBRS adoption among American business is tepid at this time. This number also pales in comparison to Wi-Fi which boasts more than 50 million free or paid access points in addition to tens of millions of private Wi-Fi access points in people's homes and businesses.

ANALYSIS: WHY IS CBRS STRUGGLING?

Why is CBRS struggling to meet the lofty goals set out for it ten years ago? The answer lies in a series of overlapping factors.

PREEMPTIBLE SHARING IS UNATTRACTIVE

One fundamental problem with CBRS is that the sharing is unequal; federal governmental users can use the licenses whenever they want or need them. PAL licensees and GAA users do not possess reliable, predictable access to use CBRS spectrum.

For example, within 288 miles of the coast, when an aircraft or amphibious assault carrier approaches and needs to turn on their aircraft radar for flight operations, CBRS commercial licensors need to turn off their system.

In effect, this situation is akin to that of being a permanent subtenant. But commercial users, by necessity, expect that their network of choice be available at the performance characteristics they expect on a consistent basis. As a permanent subtenant, with their spectrum right pre-emptible at a moment's notice, there is no guarantee that the license holder receives what they expect and paid for.

[5] https://www.lightreading.com/5g/commscope-ditches-sas-business-in-35ghz-cbrs-band/d/d-id/776471
[6] https://www.technalysisresearch.com/downloads/TECHnalysisResearch%20Private%205G%20Networks%20Study%20Highlights.pdf
[7] https://cdn.advocacy.sba.gov/wp-content/uploads/2020/11/05122043/Small-Business-FAQ-2020.pdf

It is no wonder, therefore, why commercial users who have a responsibility to use their financial resources wisely, are choosing not to invest in CBRS.

CBRS LICENSE AREAS AND POWER LEVELS INCREASE DEPLOYMENT COST

In designing CBRS for sharing the FCC limited the geographic size of licenses to counties and restricted power levels. Compared to C-band spectrum, for instance, CBRS power limits are 327 times lower in non-rural, and 654 times lower in rural areas.

Considering the significantly lower power emission levels of CBRS compared to other licensed bands, deploying CBRS is very challenging. CBRS cannot easily be used to create contiguous coverage areas. CBRS coverage either has significant coverage gaps, or the provider must deploy significantly more cell sites. A study by Rysavy Research calculated that to compensate for the coverage gaps, providers would need to deploy five times the number of cells sites typically deployed in suburban areas and seven times as many in rural areas.[8]

Requiring more cell sites inevitably increases infrastructure deployment costs and slows deployment cycles to cover the same area. Driving up cost suppresses geographically significant deployments and limits them to focused solutions which, in turn, limits the effectiveness and utilization of CBRS spectrum. Compared to other approaches, in most cases CBRS is just too expensive.

It is also worth noting that this approach makes CBRS energy inefficient. It takes more energy to run multiple low power CBRS sites, for instance, than one full power C-band site – thereby undermining government efforts to improve energy efficiency.

CBRS SHARING IS TOO COMPLICATED

CBRS sharing is also proving to be far too complicated and cumbersome.

One example is the struggle with environmental sensing capabilities (ESC). The PCAST report promoted ESC as a strategy to automate the process of effectively sharing spectrum with incumbents. When the ESC system senses that an incumbent is using shared frequencies, the other licensees with lesser rights would be blocked from using them until the incumbent was finished.

In practice, ESC has had the reverse effect. Google, one of two ESC operators, told the FCC that a “deficiency” in its ESC network causes “spectrum waste” and represents “major shortcomings” in the “flawed” CBRS ESC framework with “millions of potential users [being] blocked from using CBRS spectrum” as a result. Sensing networks result in large ‘quiet zones’ which block users from being able to use the spectrum.

The NTIA in its 2020 Feasibility of Commercial Wireless Services Sharing with Federal Operations in the 3100-3550 MHz Band[9] recommends using an incumbent-informing capabilities (IIC)

[8] https://rysavyresearch.files.wordpress.com/2021/02/2021-02-5g-mid-band-spectrum-deployment.pdf
[9] https://www.ntia.doc.gov/files/ntia/publications/ntia_3100-3550_mhz_mobile_now_report_to_congress.pdf

system instead. NTIA points to security concerns if there were too many environmental sensors located too closely around military and other federal emitters.

The fear is that transmissions in the 3.45 GHz to 3.55 GHz Band could trigger ESC sensors and shut down CBRS systems in the vicinity of the 3.45 GHz emitter. As a result, the system would reconfigure all CBRS systems as far as 288 miles from the coast, a 150,000 square mile area covering more than 130 million people or about 40% of the U.S. population.

Another example is GAA coexistence. Ten years after CBRS was born, there is no regulatory framework to mitigate interference issues between multiple organizations using GAA in the same area at the same time. This leads to the risk of degradation in performance, which makes CBRS all but unusable in mission critical applications such as manufacturing. The bottom line is that the failure to address this problem actively encourages users to abandon GAA CBRS for more reliable solutions.

Another technical area is the requirement for SAS operators to perform cumulative interference calculations, which are computationally intensive. Furthermore, the SAS makes decisions only once every 24 hours. With such limitations, spectrum users may be put off by the variable nature of spectrum availability and how it may impact their use cases.

UNDERSTANDING THE OPPORTUNITY COST

What would the story be like had the same 150 MHz of spectrum been cleared and auctioned for full power, exclusive, licensed commercial use? Fortunately, there is a wealth of data over the past ten years that demonstrates the benefits to all stakeholders.

GREATER UTILIZATION AND HIGH SPECTRUM EFFICIENCY

As has been shown, it is impossible to measure CBRS efficiency, and the data that are available show low utilization. Wireless providers using full power, exclusive-use, licensed commercial spectrum have, by contrast, demonstrated significant efficiency improvements and high utilization.

Since the 2012 CBRS NPRM, commercial wireless providers have increased their spectrum efficiency by a factor of 42 – reporting a 3543% increase in mobile data traffic against a 117% increase in the amount of low- and mid-band spectrum available to meet that demand[10]. It is reasonable to assume that CBRS, under the same regulatory rules, would be more highly utilized and with demonstrably high spectrum efficiency.

USERS GET INCREASING LEVELS OF PERFORMANCE AT LOWER COST

It is impossible to truly gauge CBRS performance due the lack of any real data. However, over the past ten years wireless customers have benefited from unprecedented performance improvements thanks to full power, exclusive use, and licensed commercial spectrum. Over the past decade, for instance, the amount of mobile data traffic has grown 108X with speeds 85X

[10] https://www.ctia.org/news/2022-annual-survey-highlights

faster while the price of unlimited plans have dropped 43% and the price per MB has dropped 98%.[11]

CLEARING IS FAST AND AUCTION PROCEEDS HELP MODERNIZE FEDERAL MISSIONS

The 2012 PCAST report concluded that "reallocation of Federal spectrum is not a sustainable basis for spectrum policy due to the high cost, lengthy time to implement and disruption to the Federal mission." This claim has been repeatedly disproven.

For instance, within two years of identification, the government was able to clear 100 MHz in the 3.45 to 3.55 GHz band from government use, and auction it in 2022 for more than $22 billion. In fact, since the initial CBRS NPRM, the FCC has held 10 spectrum auctions, consisting of a total of 5,662.5 MHz, at an average time to implementation of less than 5 years (compared to 8 years from the CBRS NPRM to its auction in 2020).

These auctions have generated $177.5 billion to help advance federal missions. Auction proceeds flow into the Spectrum Relocation Fund which agencies use to cover their relocation costs and underwrite other programs. For instance, the AWS-3 auction provided the Department of Defense with $3.5 billion, which allowed it to deploy new equipment and supported research into new spectrum technology and equipment. As Maj. General Robert E. Wheeler (USAF Ret.) has said, "the military's capabilities and systems are greatly improved as a direct result of proceeds of the last two auctions of spectrum reallocated for commercial use."

In hindsight, CBRS should therefore be viewed as a missed opportunity to support federal missions. In fact, were CBRS spectrum auctioned with the same licensing rules as the neighboring 3.45 GHz spectrum it could have raised $15.5 billion instead of $4.6 billion.

CONCLUSION

A review of present-day market realities shows that CBRS is an experiment which, so far, has struggled to prove its hypothesis. Studies indicate low utilization. There are no, apparent, innovative use cases unique to CBRS. The supply of sharing services is narrowing, and enterprise demand is low.

There is no evidence at this time that CBRS sharing is a model to emulate. Despite the expectations laid out in the PCAST report a plethora of new market entrants have not materialized. Despite wide-spread adoption of CBRS in mobile handsets, only one wireless provider has deployed a significant number of sites. Meanwhile cable companies are not using CBRS to expand their networks, but to offload traffic stemming from their MVNO agreements with mobile providers which rely on licensed exclusive-use spectrum as the guaranteed foundation.

Yet the demand for more wireless connectivity, and therefore more spectrum continues to increase. What is to be done?

[11] https://www.ctia.org/news/2022-annual-survey-highlights

When comparing CBRS with the performance of full power, exclusive use, licensed commercial spectrum over the past ten years there is simply no debate. Wireless providers demonstrate every day that full power, exclusive use, licensed commercial spectrum is highly efficient, highly utilized, in great demand, and providing new levels of value to American consumers and federal incumbents.

Unencumbered, exclusive use spectrum at full power has proven to be far more useful over the past ten years than CBRS. As policymakers look to address the next ten years of wireless demand, they must refrain from using CBRS as a model and commit to freeing up a robust pipeline of full power, exclusive use, and licensed commercial spectrum.