



**MOBILE EXPERTS**

**Ruckus Wireless White Paper:  
CBRS Opens New Managed Services Opportunity**

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## CBRS Overview

To make more spectrum available for wireless broadband use, the US Government (FCC) adopted dynamic spectrum sharing of the 3550-3700 MHz (“3.5GHz”) band for commercial use. Formally known as *Citizen Broadband Radio Service* (CBRS), the 3.5GHz shared spectrum use is authorized into three tiers. The tier 1 “incumbents,” including ship-borne Navy radars, fixed satellite stations, and wireless ISPs, are protected from lower tier users at all times.<sup>1</sup> CBRS rules govern commercial tier 2 *Priority Access License* (PAL) and tier 3 *General Authorized Access* (GAA) users.

Under the plan, up to 150MHz of spectrum are made available for commercial use on a shared basis with incumbent users, primarily military radars and fixed satellite stations. Each PAL license covers a 10MHz channel per census tract for a three-year term, and up to seven PALs can be assigned in a census tract. GAA users are permitted to use any portion of the 3.5GHz band not assigned to higher tier users. Until a competitive PAL auction takes place, up to 150MHz of the band is open for GAA “unlicensed” use dependent on tier 1 incumbent use.

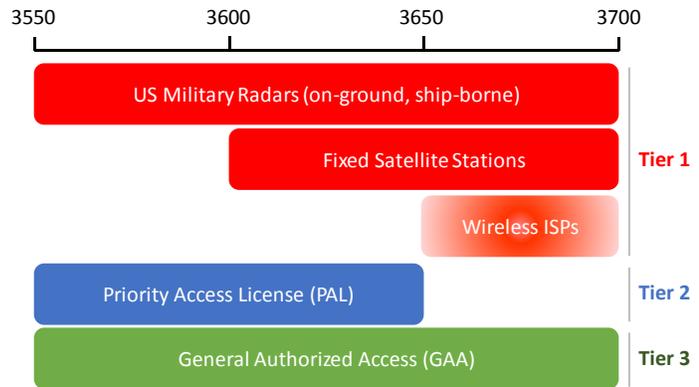


Figure 1. CBRS Three-Tier Shared Spectrum Licensing

The key dynamic spectrum channel assignment is handled by a *Spectrum Access System* (SAS) which maintains a database of all CBRS base stations, formally referred to as *Citizen Band Service Devices* (CBSDs). It works with environmental sensors known as *Environmental Sensing Capability* (ESC), mostly along coastal regions, to detect Navy radar activity. When radar use is detected, the ESC alerts the SAS, which then directs CBSDs to “move” over to other open channels. SAS enforces the three-tier licensing structure and dynamic channel assignments via centralized coordination.

## New Opportunities with CBRS

CBRS enables LTE-based solutions for both in-building wireless and outdoor coverage and capacity expansion. The 150MHz of CBRS shared spectrum, at low spectrum cost, opens a wide

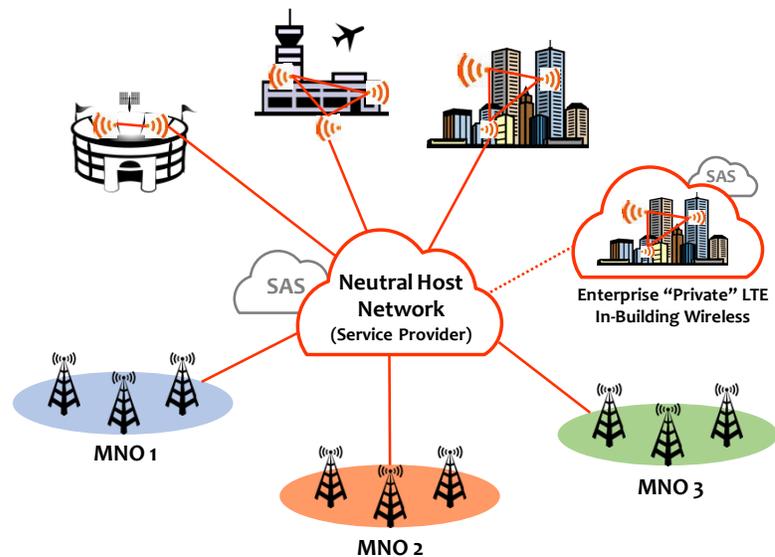
<sup>1</sup> Wireless ISPs currently operating in the 3650-3700 MHz spectrum band will be required to operate under the Tier 2 or 3 access after an initial five-year ‘grace’ period.

variety of market opportunities for both traditional mobile operators and non-traditional players. Key initial use cases are expected to be:

1. Network operator capacity expansion and traffic offload
2. In-building mobile coverage and capacity expansion

Rising traffic demand and increasing competitive intensity (highlighted by heavy promotions of “unlimited” data plans) are forcing mobile operators to look for low-cost capacity solutions. Leveraging unlicensed and shared spectrum through carrier aggregation lowers their unit costs while increasing throughput gain. CBRS offers an economical path for the mobile operators to achieve this objective. Similarly, cable operators seeking to enter the wireless industry via an MVNO strategy can deploy LTE network on the CBRS band to improve the business case. Since the profitability of a MVNO business model is heavily dependent on network expenses associated with traffic going over to the host mobile operator network, traffic offloading to an MVNO-owned CBRS LTE network can significantly improve MVNO economics.

Beyond the immediate market opportunities for traditional network operators, the novel spectrum sharing approach of CBRS opens up new market opportunities for neutral host providers or large enterprises to address the pent-up demand for in-building wireless market especially in mid-sized enterprises and venues. There is a growing need for neutral host providers to bridge the gap between very large projects with direct mobile operator involvements and large numbers of smaller projects that are too small for mobile operators to consider, but too complex for enterprises to handle on their own. This problem is especially acute for CBRS that requires SAS coordination and managing core network integration with mobile operators for seamless LTE services in and out of buildings. Beyond the obvious large public venues such as stadiums and airports, high-rise office buildings, hospitality venues, hospitals, and university campuses are examples of vertical segments where a neutral host provider can effectively provide a mobile wireless “as-a-service” offering. It is also feasible for a large enterprise with IT/telecom resources to build out an LTE-based network in the CBRS band to provide “private” LTE services for enterprise applications.



**Figure 2. Neutral Host Network Provider / Large Enterprise LTE Network using CBRS**

### Advantages of CBRS for In-Building Wireless

LTE-based solutions in the CBRS band afford special advantages for in-building wireless market, including:

- Inexpensive “clean” spectrum in the favorable 3.5GHz mid-band;
- Robust ecosystem of handset and operator support; and
- Lower unit cost than other multi-operator mobile coverage solutions

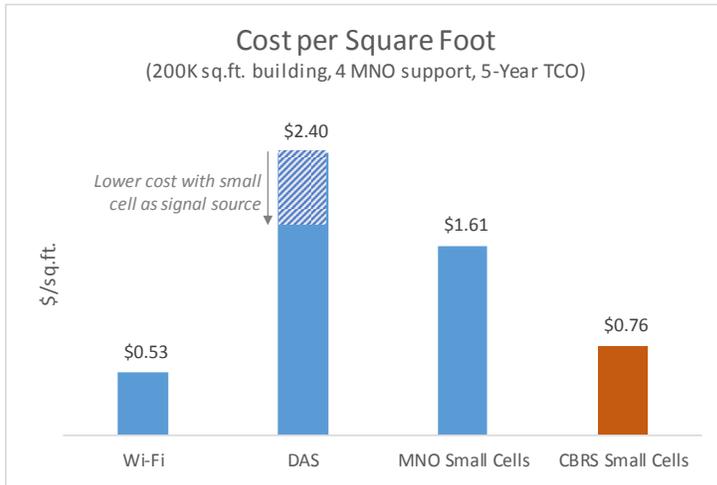
The 150MHz of nearly idle spectrum in the CBRS band offers a tremendous new spectrum resource that can be allocated for indoor mobile networks.<sup>2</sup> For mobile operators, dedicating the CBRS spectrum band for indoor networks frees up valuable licensed spectrum which would otherwise have to be allocated for the indoor use. More importantly, dedicating a separate “neutral” spectrum for indoor networks eliminates possible co-channel interferences between macro and indoor networks. This in turn simplifies RF engineering and enables third-party neutral host providers or large enterprises to build out indoor LTE networks without close coordination with mobile operators. The novel tiered approach of shared spectrum also encourages success-based investment by variety of stakeholders, not just the traditional mobile operators. With GAA open access, no spectrum ownership is required. This in turn enables enterprise-led indoor LTE network deployments without close coordination with mobile operators which has been a key impediment in wide spread adoption of DAS deployments especially in mid-sized enterprises and venues.

With all four tier 1 operators voicing support of CBRS, CBRS LTE small cells have become a realistic multi-operator mobile coverage solution. This is a major step because this kind of product fills the void in the marketplace between Wi-Fi and DAS. While Wi-Fi is considered inexpensive, it lacks in seamless mobile voice services. On the other hand, the multi-operator DAS solution is considered too expensive for many enterprises, not to mention the difficulty of securing a signal source from the operators. CBRS small cells with inherent multi-operator support and simplicity of Wi-Fi like installation can provide a cost-effective mobile coverage solution for third-party neutral host providers and large enterprises. Mobile operators’ self-interest to leverage the CBRS band for their own capacity expansion is likely to hasten the enterprise adoption of CBRS as enterprises see broad availability of CBRS-capable handsets coming to the marketplace.

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<sup>2</sup> A major US mobile operator, on average, holds about 130MHz of licensed spectrum.

CBRS small cells offer a lower-cost alternative for indoor mobile coverage. Our analysis shows that a CBRS small cell can offer lower “cost per square foot” unit economics against other



**Figure 3. Comparative In-building Wireless Economics**

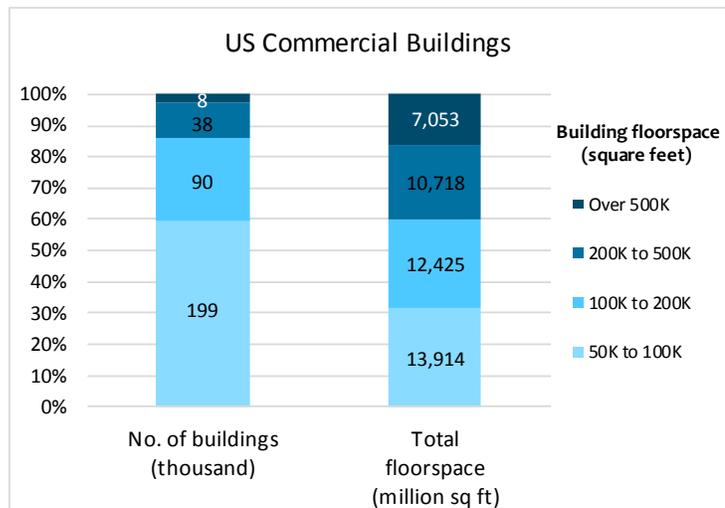
alternatives, including DAS and traditional small cell deployments. A key factor driving this lower unit cost is the fact that a single CBRS small cell can support all four major operators in the “neutral” 3.5GHz band. In comparison, multiple operator-specific small cells are required in a traditional small cell deployment. Although DAS cost can be brought down with less expensive small cell as a signal source for smaller venues, CBRS still offers a lower-cost alternative for mobile LTE coverage. It should be noted that

while Wi-Fi offers a lower cost solution for in-building wireless coverage, it has been a poor substitute for seamless mobile voice services indoors. In contrast, CBRS promises seamless voice services over higher-performance LTE links.

**In-Building Wireless Market Opportunity**

The scale of in-building enterprise market is immense. There are over 5.5 million commercial buildings in the U.S. of varying sizes, representing over 88 billion square feet of floor space. At the high end (i.e., buildings with over 500K square feet of floor space), there are about 8,000 buildings representing over 7 billion square feet of total floor space.

Meanwhile, over 5.2 million of these commercial buildings are less than 50K square feet in size. Assuming smaller venues less than 50K square feet can be addressed through low-cost options like repeaters or Wi-Fi access points, the market opportunity for more robust in-building mobile coverage and capacity solutions is over 44 billion square feet of floor space.



Source: US Energy Info Admin

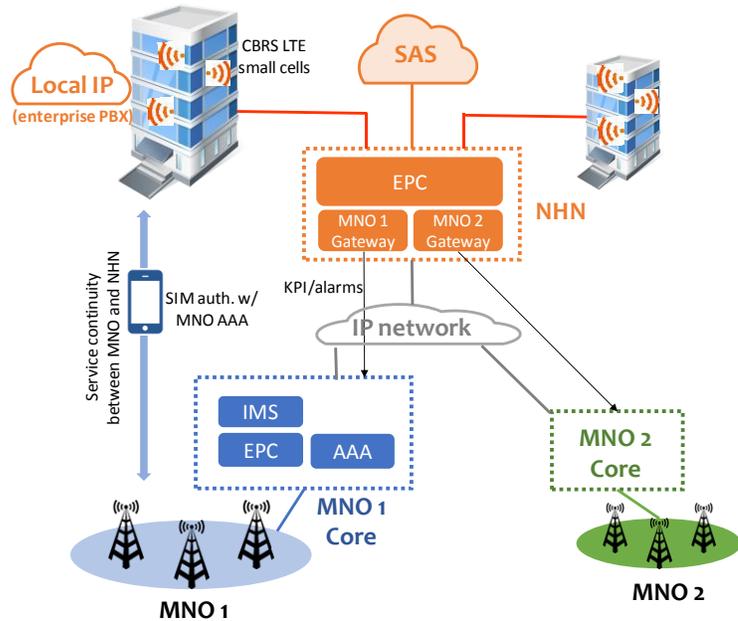
**Figure 4. US Commercial In-Building Wireless Opportunity**

Assuming 70% of these venues have poor “outside-in” coverage,<sup>3</sup> that yields about 30 billion square feet of floor space across over 300,000 buildings. Estimating the market demand at \$1 per square foot for equipment and installation, the market opportunity for in-building mobile coverage in the U.S. stands at around \$30 billion.

**Managed Services - Technical and Commercial Aspects**

Managed services through a neutral host network (NHN) provider requires integration of core networks between the NHN and multiple mobile network operators (MNOs) as shown in Figure 5. The interworking between NHN and multiple MNOs leverages the WLAN internetworking architecture as defined in 3GPP. A mobile device can use ePDG to gain access to mobile operator IP services, including voice services over IMS. The service continuity is maintained between NHN and MNO network, and local IP services (e.g., enterprise PBX) can be provided through local breakout at the neutral host network.

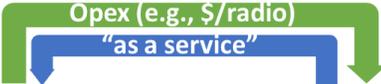
Another key aspect of the NHN core network is to provide KPI or charging metrics to MNO core network through so-called MNO gateway. Since the NHN in this case needs to meet the CBRS governing rules, the NHN core also needs to interface with SAS for dynamic channel assignments as necessary.



**Figure 5. Neutral Host Network (NHN) Architecture**

A managed service offering from a NHN provider is a great match for CBRS radios. Because the CBRS radios operate in the neutral 3.5GHz spectrum, there is no need for close coordination with mobile operators in RF design. The CBRS radio deployment can be led by NHN providers or enterprises themselves. CBRS essentially allows NHN providers to independently deploy indoor LTE networks and support neutral hosting of multi-operator services. Effectively this is similar to NHN or enterprises deploying Wi-Fi networks to support multi-operator device usage (since Wi-Fi is ubiquitously supported on most user devices today).

<sup>3</sup> Ericsson Consumer Lab Survey finds that only three in 10 smartphone users find indoor coverage to be good.



	Enterprise / Venue	Neutral Host Network (NHN) Service Provider	Mobile Network Operator (MNO)
<b>Operations</b>		<ul style="list-style-type: none"> <li>• Network management</li> <li>• RAN optimization</li> <li>• Network maintenance</li> <li>• Seamless MNO interoperability</li> <li>• Charging</li> </ul>	<ul style="list-style-type: none"> <li>• KPI monitoring</li> <li>• Seamless NHN interoperability</li> </ul>
<b>Core Network for local networks</b>		<ul style="list-style-type: none"> <li>• Core networking</li> <li>• SAS coordination</li> <li>• Spectrum licensing</li> <li>• MNO network integration</li> <li>• LBO/enterprise application integration</li> </ul>	
<b>Radio Access Network (RAN) at local venues</b>		<ul style="list-style-type: none"> <li>• RF design and commissioning</li> <li>• Radio purchase and installation</li> </ul>	

**Figure 6. Commercial Model for CBRS Neutral Host Networks**

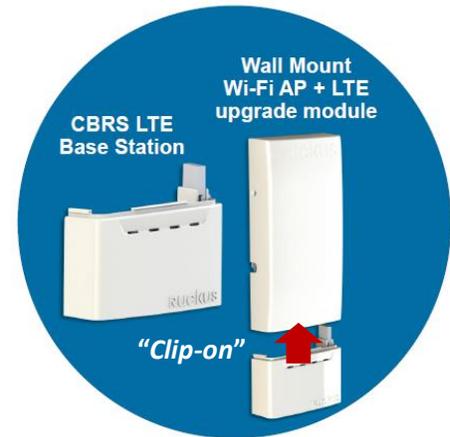
As listed above, an NHN provider takes ownership of various tasks required to operate a mobile wireless network and offer managed services to enterprises as an OPEX item (e.g., “\$ per radio” or “\$ per GB”). While a neutral host provider can take on full ownership of capital investments in core networking and RAN, in addition to on-going network management and operations, it is possible for enterprises to take on the radio network investment and/or installation, since CBRS LTE small cell deployment is expected to be similar to Wi-Fi.

Neutral host managed services provide benefits to all key stakeholders involved.

- Enterprises can offload the complexity of building and managing LTE-based mobile network services, including complex internetworking with MNO core networks for seamless services in and out of buildings. In addition, the OPEX model associated with managed services provides a known expense outlook, without the uncertainty of building and operating a network.
- For mobile operators, dealing with a fewer number of NHN providers and their networks is more efficient than working with lots of smaller enterprises, many of whom do not have telecom experience. Enabling LTE network coverage indoors can benefit mobile operators’ subscriber experience.
- Finally, for the neutral host providers, indoor network deployments can be independently led by themselves or enterprises, and removes the huge barrier of working closely with mobile operators in traditional small cell or DAS projects. This

freedom to deploy without coordination with mobile operators provide business agility to quickly deploy and activate LTE services. CBRS small cells, operating in the neutral spectrum, are naturally well-suited for neutral host indoor mobile solution.

For the in-building enterprise market, the “clip-on” CBRS LTE radio modules (as shown in Figure 7), for example, can provide added benefits of leveraging existing Wi-Fi infrastructure. The “clip-on” modules can be selectively plugged into installed base of Wi-Fi access points to take advantage of existing cabling, power and backhaul connectivity. Since CBRS LTE radios operating in the 3.5GHz band can propagate farther than typical 802.11ac access points operating in the 5GHz band, the CBRS LTE modules do not need to be plugged into every Wi-Fi access points in a venue to create a similar indoor coverage. Innovations such as “clip-on” modules can further lower the total investment required to enable cost-effective LTE mobile coverage indoors.



Source: Ruckus Wireless

Figure 7. CBRS LTE 'clip-on' to Wi-Fi AP

### Opportunity for Neutral Host Providers and Large Enterprises

Demand for in-building mobile coverage, and increasingly capacity, is rising every day as mobile device usage for voice communication and enterprise applications grows at work places and public venues. Beyond giant venues like stadiums, the mainstream in-building enterprise market is largely underserved. Higher installation costs and mobile operator cooperation in securing a signal source for DAS have been key impediments in addressing the wider enterprise market in commercial buildings. Although lower-cost Wi-Fi has been widely deployed to address this need, it does not provide consistent quality that's associated and expected with cellular voice services.

The pent-up demand in the enterprise market is growing for a better solution.

CBRS offers a tremendous opportunity to address this market need for a cost-effective in-building mobile solution. Because they operate in neutral spectrum, CBRS LTE networks inherently support multiple operators. In comparison, traditional small cell solutions require separate deployments for each mobile operator – making such solution cost prohibitive. Unlike DAS solutions that require a dedicated signal source from each operator, CBRS small cells implicitly includes a low-cost signal source. Hence, **CBRS small cell deployment is much simpler; it can be simple as deploying Wi-Fi access points.**

While CBRS LTE radios can be easily deployed by enterprises without close coordination with mobile operators, core network integration is necessary for seamless service continuity in and

out of buildings. Here, neutral host providers can play a crucial role in “bridging” mobile operator macro networks and enterprise indoor networks. The neutral host providers are natural stakeholders to handle complex core network integration with mobile operators, along with CBRS SAS management to enable seamless mobile services in and out of buildings. Many mid-sized enterprises do not have dedicated telecom resources to build or manage complex LTE networks. Neutral host providers, who can take on that challenge, are well positioned to address the pent-up demand for in-building mobile services.

CBRS momentum is growing, and there is a growing optimism around new business opportunities that can be enabled by LTE solutions in the CBRS band. With the FCC approval of several key SAS providers recently, the road is clear for CBRS radio deployment indoors. Moreover, the expanding CBRS ecosystem that now includes all major mobile operators bodes well for the key device support that is necessary to “seed” the market for enterprise adoption. Meanwhile, the chipset, handset and infrastructure developments are progressing well towards product introduction in the second half of 2017. We expect strong growth and forecast about 500,000 CBRS radios to be shipped in 2020.

Enterprises have been seeking cost-effective in-building cellular solution for years, and CBRS promises cost-effective LTE services with the simplicity of Wi-Fi. The key foundations of multi-operator and handset support are now visible on the horizon. Neutral host providers who can leverage the growing and maturing CBRS ecosystem, are well positioned to reap the rewards of addressing the pent-up demand for in-building enterprise market.