

Shared Spectrum Market Opportunity for Cable MSOs

Prepared by

*Mark Lowenstein
Managing Director, Mobile Ecosystem
September 2017*

mloenstein@m-ecosystem.com
www.m-ecosystem.com
[@marklowenstein](#)

Executive Summary

Cable MSOs have a new and unique opportunity to enhance their networks and generate new revenue streams. It's called spectrum sharing. In 2016, the FCC released its Second Report and Order to create the Citizens Broadband Radio Service (CBRS) in the 3550-3700 MHz band, making available 150 MHz of spectrum for mobile broadband and other commercial users. The 3.5 GHz band has historically been used by the Department of Defense and fixed satellite service providers. The 3.5 GHz band represents the first iteration of an ambitious spectrum sharing framework, which the FCC plans to extend to other bands over the next several years.

3.5 GHz-based services will be primarily unlicensed or 'lightly licensed' services, in that a Cable Multi-Service Operator (MSO) will not be required to buy and permanently own spectrum. Rather, the band will rely on a unique and innovative shared spectrum scheme. This allows MSOs to add LTE services without the costly burden of having to purchase spectrum in expensive FCC auctions. MSOs can enhance their indoor and outdoor Wi-Fi networks with LTE, providing improved service for businesses and consumers, plus the potential for new revenue opportunities. Spectrum sharing has the advantage of providing coverage and capacity augmentation using LTE, but employing a Wi-Fi like business framework and economic model.

Cable MSOs have invested heavily in recent years to extend their broadband networks, by deploying several hundred thousand access points (APs), under the Cable Wi-Fi brand, and equipping millions of household APs with dual SSIDs. The purpose is to offer their residential and business customers an extension of their broadband service beyond the home or office; provide an alternative to expensive cellular data plans; and lay the foundation to potentially offering a 'Wi-Fi-centric' cellular service. However, Wi-Fi has its limits. Deploying sufficient density of APs is expensive. And Wi-Fi, as an unlicensed service using limited channel bandwidth, suffers from limited capacity and quality of service challenges.

Some cable MSOs, such as Comcast, have also entered the wireless business through MVNO arrangements. In these situations, they are at the whim of host cellular provider contracts and wholesale pricing.

Spectrum sharing could be a viable new model for cable MSOs to complement their broadband and Wi-Fi business, and even MVNO arrangement with the wide-area, capacity-rich, and QOS benefits of LTE. It can be seen as "Wi-Fi with LTE". We believe spectrum sharing opportunities such as those enabled by the 3.5 GHz plan offers MSOs the following potential benefits:

- **Lower barrier to offering wireless services.** Historically, the only way an MSO could offer wireless services has been through expensive spectrum auctions or doing an

MVNO deal with a wireless operator. Spectrum sharing represents a faster, more flexible, and more economically viable alternative.

- **Complement to Broadband and Wi-Fi.** MSOs can cost effectively add LTE to their millions of installed APs, offering coverage extension and capacity augmentation. This can be translated into higher quality of service for existing customers, or potentially incremental B2C and B2B revenue opportunities through a premium service offering.
- **Cellular Offload Service.** Cable MSOs have relied on expensive “carrier Wi-Fi” deployments to offer a cellular offload service. Shared spectrum presents a cost-effective, higher capacity alternative.
- **Premium Enterprise Services.** Offering broadband/Wi-Fi services to enterprises has been a fast-growing business for MSOs. The capacity and coverage augmentation capabilities offered by shared spectrum can be used by MSOs to offer a premium in-building service to customers.
- **Wireless MVNO.** Shared spectrum makes the wireless MVNO business case eminently more viable, reducing cost and dependency on the host MVNO. A hybrid mobile network combining Wi-Fi, shared spectrum, an MVNO relationship, and owned spectrum assets could be a compelling opportunity for an MSO.

In addition to being an important element of an MSO’s network capacity augmentation and densification strategy, we believe spectrum sharing offers the potential for an entirely new network framework, based on the idea of ‘network as a service’. Network capacity or coverage is acquired on an as-needed basis, similar to cloud-based services we are seeing across the business landscape. This is consistent with the evolution toward virtualized, software-defined network services. We believe this could result in potentially dramatic savings in CapEx.

Spectrum sharing has broad regulatory and industry support. It’s a lynchpin of the FCC’s effort to release substantially more spectrum for mobile broadband, while also encouraging a shared spectrum approach. All of the major radio equipment vendors have committed to making equipment available for 3.5 GHz, and we are encouraged by what we’ve seen from the broader ecosystem, such as device OEMs. In August 2016, six wireless technology leaders — Access Technologies (Alphabet), Federated Wireless, Intel, Nokia, Qualcomm and Ruckus Wireless (now part of Arris) — announced the launch of the CBRS Alliance, to promote LTE-based solutions utilizing the shared spectrum of the U.S. 3.5 GHz band. The Alliance now boasts some 70 members.

We believe spectrum sharing is a game-changing approach to solving network coverage and capacity challenges, providing MSOs with revenue enhancement, cost savings, and competitive advantage opportunities in the coming years.

This White Paper will discuss opportunities in spectrum sharing, with a focus on 3.5 GHz-related opportunities for cable MSOs. We begin with an overview of how the 3.5 GHz spectrum sharing structure will work, and the timeline for market readiness. The bulk of

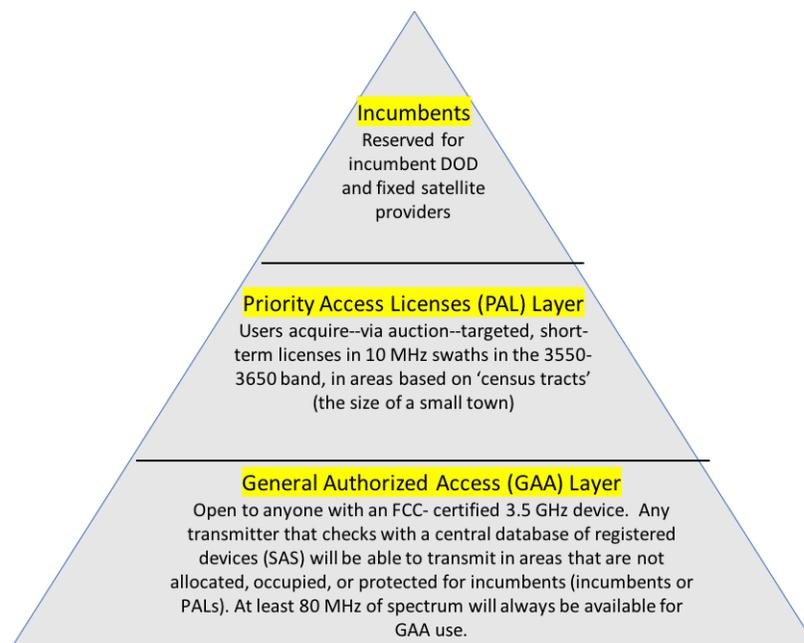
this report is focused on the advantages of spectrum sharing, use cases, the business/economic framework, and our recommendations for a successful go-to-market.

1. **Brief Overview of the 3.5 GHz Band**

The 3.5 GHz band has historically been used by the Department of Defense and fixed satellite service providers. There has been a movement over the past several years to open up the band and make it available for shared use between government and commercial interests, provided the incumbents are given the proper protection. On April 28, 2016, the FCC released its Second Report and Order to create the Citizens Broadband Radio Service (CBRS) in the 3550-3700 MHz band, making available 150 MHz of spectrum for mobile broadband and other commercial users.

The 3.5 GHz band will be primarily unlicensed or 'lightly licensed', in that an organization will not be required to buy and permanently own spectrum. Rather, they will rely on a unique and innovative shared spectrum scheme (more details below). Spectrum sharing allows MSOs to add LTE to their networks, either themselves or through another entity such as a mobile network operator (MNO), enterprise, or systems integrator (or some combination thereof), using a neutral host model. This would provide the advantage of coverage and capacity augmentation using LTE, but employing a Wi-Fi like business framework and economic model.

The FCC's proposal is for a three-tiered access system, shown in the diagram below. Users in each tier will be protected by a new and innovative spectrum sharing structure called the Spectrum Access System (SAS).



Spectrum Access System (SAS) and Environmental Sensing Capability (ESC)

The most unique and innovative element of the spectrum sharing concept is the development of the Spectrum Access System (SAS). The SAS administrators will serve as advanced, highly automated frequency coordinators across the band, protecting higher tier users (i.e. incumbent and PAL layer) from interference from lower tier users (GAA layer). They will check availability of spectrum resources, assign channel(s), provide a certificate, and coordinate and ensure interference-free operation.

Note that the FCC is currently reviewing petitions to both increase the geographic areas covered by a PAL license beyond census tracts (i.e. make the areas larger) and to make the PAL license terms longer. Decisions on these requested changes are expected by the end of 2017.



There will also be Environmental Sensing Capability (ESC) operators. The ESCs will consist of networks of sensors that detect the presence of signals from federal systems in the band and communicate that information to one or more SASs to facilitate protection of federal operations in the band. The ESCs will also protect incumbent users within a certain radius, particularly around 'exclusion zones', which are principally within 200 km of the coast.

In December 2016, the FCC conditionally approved seven entities that have met the rules to be SAS administrators: Google, Federated Wireless, Amdocs, Comsearch, CTIA, Keybridge, and Sony. In May 2017, additional applications were submitted by Rivada Networks, Nokia, Fairspectrum and RED Technologies. We believe Google and Federated Wireless are the two most serious candidates at this time. It is generally believed there will be between two and four (2-4) SASs. Over the next few months, the FCC will certify the approved applicants through testing, with full certification expected in early 2018. A few of the organizations who submitted applications to be a SAS administrator have also applied to be ESC administrators, including Google and Federated Wireless.

How Spectrum Sharing Might Be Used

These services will primarily employ small cells, or leverage Wi-Fi APs, for outdoor and indoor network densification. The major difference is that these cells could support multiple operators, in a way that neutral host distributed antenna systems (DAS) do today. The cells need only one antenna, and do not need to coordinate with the outdoor/macro

network in the same way as a traditional small cell deployment. This overcomes what has been one of the major inhibitors of the indoor small cell market to date. The FCC constructed the 3.5 GHz band rules such that whoever controls the venue can control the spectrum in that building for that band.

The equipment being developed uses the same form factor as today's indoor and outdoor small cells but at a new frequency and with new software. The indoor versions will look like Wi-Fi access points but with LTE capabilities, and some vendors are simply adding 3.5 GHz radios to W-Fi APs. We expect that much of the network administration, control, authentication, and so on, will be managed in the cloud.

Note that the FCC has also modified its original proposal to create a new category of CBRS devices that allow for increased output power of 3.5 GHz cells, extending their radius to potentially as much as one mile. **This means that there are also outdoor applications being planned for 3.5 GHz services.** Compelling opportunities here could include university campuses, business campuses, and venues such as stadiums.

With this new framework, it is likelier that an enterprise, a building owner, or a systems integrator might deploy equipment, using a neutral host model. They will do deals with any one of a number of service providers, either at the PAL or GAA tier. Private enterprises, venues, and fixed network operators, for example, could autonomously deploy high-quality in-building LTE networks into which all mobile network subscribers can roam. This benefits all network operators. An MNO is able to offer a more consistent overall network experience, while improving coverage and capacity for less cost. An MSO is able to complement their fixed network assets with a mobile option, or could even wholesale their services to an MNO or other entity.

Status and Timing

Spectrum sharing has been gathering momentum. Major infrastructure OEMs and chipset manufacturers have indicated support for spectrum sharing and the 3.5 GHz band, including committing to timelines for equipment support. A year ago, six wireless technology leaders — Access Technologies (Alphabet), Federated Wireless, Intel, Nokia, Qualcomm and Ruckus Wireless (now part of Arris) — announced the launch of the CBRS Alliance, to promote LTE-based solutions utilizing the shared spectrum of the U.S. 3.5 GHz band. The CBRS Alliance has since ballooned to 70 members.

Exhibit 1 Update on Network and Device Readiness for 3.5 GHz

Category	
<p>Equipment OEMs & Operators</p>	<ul style="list-style-type: none"> • Verizon leading first end-to-end carrier grade CBRS trial, partnering with Ericsson, Qualcomm, & Federated Wireless. Verizon has said that all new Verizon small cells will be equipped w/CBRS capability. • Numerous demonstrations and trials: Ericsson demonstrated 3.5 GHz small cells at MWC 2017; Alphabet, Nokia and Qualcomm completed a live test of 3.5 GHz technology over a private 4G network at a Las Vegas race track in Feb. 2017. • Federated Wireless and Alphabet demonstrated SAS-SAS interoperability in Dec. 2016. • Federated Wireless has announced interoperability with all key 3.5 GHz radio vendors, including Ericsson, Nokia, Ruckus, Samsung, and SpiderCloud Wireless.
<p>Chipset OEMs</p>	<ul style="list-style-type: none"> • Qualcomm announced support for 3.5 GHz in their Snapdragon™ X20 LTE chipset/modem in Feb. 2017 • Intel announced support for 3.5 GHz in their XMM™ 7560 modem in Feb. 2017
<p>Industry Organizations</p>	<ul style="list-style-type: none"> • CBRS Alliance. Formed August 2016 by Access Technologies (Alphabet), Federated Wireless, Intel, Nokia, Qualcomm and Ruckus Wireless (now part of Arris), now has over 70 members, including Charter, Comcast, and all 4 U.S. Mobile Operators. Involved in commercializing 3.5 GHz through certification programs. Has conducted live trials at CBRS events. • Wireless Innovation Forum (WinnForum). Involved in setting standards for 3.5 GHz based on the rules set by the FCC. Has published Release 1 specs.

There has also been a significant amount of trial activity. This fall, Verizon will be leading the first end-to-end carrier grade CBRS trial, partnering with Ericsson, Qualcomm, & Federated Wireless. Verizon has said that all new Verizon small cells will be equipped with CBRS capability. Charter and American Tower are also engaged in CBRS field trials.

We believe the first commercial spectrum sharing services of the 3.5 GHz band could be launched by 2018, initially at the GAA layer. It is likely that the MNOs will lead commercial availability of the market. The principal milestones that need to be reached are:

- **Finalizing rules for the SAS and selecting the vendors.** The FCC is setting the rules of how the SASs will operate. The FCC has conditionally certified seven vendors, with final certification expected in early 2018.
- **Determining the auction process and scheduling the auction.** There will be an auction process for temporary spectrum at the PAL layer. The FCC has issued a framework for this but still has to finalize rules and announce a schedule. We expect a PAL auction during the second half of 2018.

- **Equipment Availability.** As shown in Exhibit 1, equipment and chipset support has fallen into place. There should be device support by the end of 2017 and into early 2018.

2016	2017	2018
<ul style="list-style-type: none"> • FCC NPRM • Google K.C. trial • Trials in coastal cities • Finalize rules for SAS 	<ul style="list-style-type: none"> • FCC conditional certification of first SAS vendors • Some network equipment avail. • Chipset availability • Device OEM announcements • Several field trials underway • Schedule PAL auction 	<ul style="list-style-type: none"> • Final certification of SAS vendors • GA of consumer devices • Select GAA market launches 1H, broader launch 2H • PAL auctions, likely 2H

Mobile Ecosystem believes MSOs are likely to deploy spectrum sharing services once a 3.5 GHz ecosystem is in place. It is likely that mobile network operators will lead the early deployments, starting in 2018. MNOs will also play an important role in pushing the device ecosystem. MSOs should be thinking about a 2018 timeframe for their initial shared spectrum services.

2. Spectrum Sharing Benefits to Cable MSOs

Spectrum sharing services allow an MSO to add LTE to its network, but with economics more akin to Wi-Fi. It is lower cost, and easier to install and maintain than traditional indoor cellular solutions, and can provide a capacity and coverage augmentation to Wi-Fi. The MSO gains the option of mobile/wireless on top of fixed network assets, and can control how traffic moves between fixed and mobile networks.

Exhibit 2 Summary of Key Benefits of 3.5 GHz to MSOs

Benefit	Notes
Capacity and Coverage Augmentation	<ul style="list-style-type: none"> • LTE makes more sense in certain situations than adding more APs • Wi-Fi suffers from interference challenges and limited capacity • Keeps subscribers on MSO network
Lower Costs	<ul style="list-style-type: none"> • Might be less expensive than adding more Wi-Fi capacity • If MSO is offering wireless service through an MVNO, this is a way of keeping traffic off the more expensive cellular network • Only have to use spectrum where and when needed • Might also make sense where have not deployed fixed assets
Revenue Enhancement	<ul style="list-style-type: none"> • Potential premium service for consumers or enterprises • Charge for coverage/capacity boost • Keep traffic “on-net” • Customer acquisition potential (3.5 GHz a differentiator)
Subscriber Experience	<ul style="list-style-type: none"> • More seamless experience for customers

A. *More Cost-Effective Way to Add LTE*

Historically, there have been two vehicles for cable MSOs to add a mobile option to their networks: either spend billions in expensive FCC spectrum auctions and then spend billions more to build out a network, or put themselves at the mercy of an MVNO agreement with a mobile network operator.

Shared spectrum provides an additional option. MSOs can add LTE to their networks through any combination of the following:

- Add LTE to fixed network assets, such as indoor and outdoor APs that they already own and manage. This is a GAA layer option.
- Acquire spectrum through the PAL auction, at locations or venues that make sense for the business. This added coverage/capacity could be a value-added service for existing customers or a wholesale network revenue opportunity.
- Buy network coverage or capacity on a wholesale basis from another entity, such as a systems integrator, tower company, MNO, etc.

These options represent an add-on to Wi-Fi network assets, or are an alternative when deploying more APs is too expensive or does not solve coverage or capacity requirements.

The structure proposed for the 3.5 GHz band presents an added, and important tool for MSOs to improve coverage and capacity, at far lower cost than traditional spectrum auctions, or expensive alternatives such as DAS and carrier Wi-Fi. The FCC's rules allowing for increased power output for 3.5 GHz devices is important for MSOs as well, as they can now consider adding shared spectrum to their outdoor APs.

B. *Improved In-Building Coverage and Capacity*

Improving coverage and capacity for indoor wireless is one of the key strategic priorities of MSO network executives. Providing good in-building wireless coverage and adequate capacity continue to be a challenge in many situations. Despite the need to improve in-building coverage, there have been few solutions that have found significant scale. They're either too expensive, complex to deploy, or the business model is not workable in large numbers. There are limits to simply adding more Wi-Fi APs. Adding indoor small cells don't make sense for an MSO without a macro network. DAS solutions also don't make sense for an MSO lacking a macro network, and can be an overkill solution in certain contexts, both in terms of cost and time to deploy, sat an enterprise level.

Shared spectrum is an opportunity to add coverage or capacity where doing so with Wi-Fi is too expensive or logistically challenging. It can also be an augmentation to Wi-Fi, given

the known issues with Wi-Fi coverage and capacity. Consider, for example, a hospital or hotel, which have a high amount of ‘guest’ traffic.

One could view spectrum sharing as opening up a new market opportunity for the traditional DAS/neutral host model. It is more cost effective, and can be deployed more quickly than traditional DAS. Additionally, the on-demand nature of shared spectrum means that MSOs can acquire whatever network capacity they need.

C. Keeping Subscriber/Quality of Experience

Wi-Fi makes sense for in-home broadband users and office workers sitting at their desks. But Wi-Fi also suffers from some challenges:

- **Limited capacity.** 2.4 and 5 GHz Wi-Fi channels have become congested in many in-building environments. Mobile Ecosystem research indicates that in public or quasi-public venues such as hotels, convention centers, stadiums, and restaurants/cafes, the average LTE speeds experienced by the user exceed that of Wi-Fi 50% of the time. This is a huge change from several years ago where Wi-Fi was the default for in-building.
- **Wi-Fi Coverage Issues.** Even where enterprise Wi-Fi is deployed, we find that there are often situations where Wi-Fi coverage in the building is inadequate. The very limited range of Wi-Fi makes it logistically and economically challenging to provide ubiquitous in-building coverage.
- **Quality of experience.** For the user, Wi-Fi certainly comes with a ‘hassle factor’. Every time one wants to use a Wi-Fi network at a new location it requires an elaborate sign-on procedure, with multiple network names to choose from and passwords. Many venues offering free Wi-Fi now require users to view an advertisement before they can get join the network. Where the MSO doesn’t control the Wi-Fi assets, there can be coverage, capacity, and QOS challenges.

Offering LTE allows MSOs to offer enhanced coverage and capacity to their fixed network assets where it makes sense situationally, or as an add-on where they might not have facilities. Having an LTE option gives the MSO the opportunity to offer a much more seamless and consistent quality of experience, saving customers from some of the hassles and inconsistencies associated with Wi-Fi.

- **As an alternative to deploying more Wi-Fi APs.** Deploying additional APs to improve coverage and capacity is a cumbersome and expensive approach, notwithstanding congestion issues. We are seeing enterprises and venue owners in particular verticals (such as hospitals and hospitality) pushing back on these deployments or passing the cost on to users.

D. *Competitive Asset*

MSOs might need to consider a shared spectrum model for competitive reasons. Mobile network operators wanting to improve coverage and capacity have an increasing array of alternatives to just adding more macros. They are deploying outdoor small cells in large numbers as part of a comprehensive network densification strategy. They are improving in-building coverage by acquiring more mid- and lower- band spectrum and deploying indoor LTE small cells, which are becoming cheaper and more capable. MNOs are also deploying LTE-U and soon LAA services in order to improve coverage and capacity. And they are starting to invest in 5G . . . starting with trials for fixed wireless services.

The upshot is that if MNOs are able to improve network coverage and capacity, at a favorable economic cost, they will keep more traffic on their LTE networks. They will be less interested in carrier Wi-Fi or offload solutions. They might become less hospitable to hosting cable MVNOs. There is also the specter of Internet companies such as Google and Facebook providing some form of connectivity solution to compete with the MSOs.

The longer term implication is that if cellular networks continue to improve and prices for data services continue to come down, budget-conscious users might not be prepared to spend some \$300-500 per month for *both* fixed and mobile services. Mobile broadband could start to cannibalize fixed broadband, as has happened in some countries in Europe. Cable MSOs, whose business is becoming increasingly dependent on broadband, will need mobile assets in some shape or form.

E. *Complement to Other Unlicensed Services Such as LWA/MulteFire*

There are numerous options emerging in unlicensed services as a complement to traditional licensed spectrum. MNOs are looking at LAA as a way of expanding capacity, using channel aggregation with their licensed spectrum. There are also options emerging for Wi-Fi centric companies that do not require a licensed anchor, such as LWA and MulteFire. The industry is moving forward on ways to better leverage WLAN infrastructure. Shared spectrum could be a suitable complement to other MSO LWA/MulteFire initiatives.

3. Business Use Cases

Mobile Ecosystem believes there are several primary use cases for shared spectrum for MSOs, as outlined below.

A. *Premium Services*

We believe cable MSOs can use shared spectrum to offer premium services on top of their broadband and Wi-Fi capabilities. Forms this can take include:

- **Coverage boost.** In areas hard to reach with Wi-Fi.
- **Capacity augmentation.** In situations where Wi-Fi hotspots are congested, have limited capacity, or suffer from interference.
- **Value-added services.** With LTE, cable MSOs can offer some premium voice services, often referred to as ‘Rich Communications Services’ (RCS). Examples include VoLTE, HD Voice, and premium messaging and video services.

B. Enterprise Market

Cable MSOs have been expanding their presence in the business segment in recent years. Most installations in the enterprise involve a broadband connection and then some sort Wi-Fi configuration.

We believe there is a significant opportunity for MSOs to use shared spectrum services to expand connectivity options in the enterprise. Shared spectrum can be used to help deliver an optimized 3.5 GHz/Wi-Fi integrated network. There are a few different scenarios possible here:

- **As a complement to Wi-Fi.** Every Wi-Fi set up is different. But there are often situations where there are parts of a building or campus that are difficult to reach with Wi-Fi, so cable LTE could be an option there. In other cases, Wi-Fi networks can be easily overburdened, so LTE could be used for additional capacity.
- **For capacity boosts.** Think of hotels at night, or when there are conferences. It might be easier to temporarily boost capacity than deploy expensive Wi-Fi infrastructure.
- **As an alternative to Wi-Fi.** There are certain types of businesses or venues where it might make sense to keep certain traffic on cellular. Consider hospitals, bars, and other types of enterprises that cater to large numbers of guests. Given the capacity potential of 3.5 GHz, it might make business sense and also be a better user experience to offer guests an extension of their cellular service, rather than having them muck around with Wi-Fi passwords and the like.
- **As an alternative to cellular.** Cable MSOs might use shared spectrum services to offer customers an alternative to cellular, so customers don’t have to use data off their cellular plan. The situation here is similar to how Cable Wi-Fi has been marketed, except that LTE coverage and performance might be better than Wi-Fi in certain contexts. This could be an important offering to enterprise customers and small businesses concerned about their cellular service spend.

- **Backhaul solution.** There are sufficient channels being made available at 3.5 GHz that LTE shared spectrum could be used for backhaul in certain locations—especially as a supplement to Ethernet/fiber, as a temporary solution, or for redundancy.

There are myriad business model options here, as well. There could be cost sharing between the MSO and the enterprise in terms of paying for the infrastructure or the service. In certain contexts, the enterprise or venue might charge end-users for the service. In certain locations and contexts, it might be easier for the MSO to guarantee QOS over LTE than over Wi-Fi.

Building and venue owners would view providing superior wireless coverage and significant network capacity over a building envelope as one of the features/benefits of that venue in order to attract tenants—much like utilities, LEED/green initiatives, and so on. This could also take the load off enterprises having to deploy Wi-Fi as extensively.

C. Particular Verticals

Mobile Ecosystem believes that there are certain types of buildings or venues for which shared spectrum is particularly suited. Some examples are in the table below.

Exhibit 2 Target Venues/Locations for Shared Spectrum

Vertical	Benefits of Shared Spectrum
Hospitals	<ul style="list-style-type: none"> • Complement Wi-Fi network • Secure, dedicated network to manage competing interfering devices • Large number of outside users/visitors
University Campuses	<ul style="list-style-type: none"> • Large number of users moving in and out of buildings • Wi-Fi coverage can be a challenge for every building • Extra capacity needed for multimedia • Diversity of MNO relationships speaks to need for hosted solution
Hospitality/Hotel	<ul style="list-style-type: none"> • Improve indoor wireless coverage and capacity • Balance traffic between Wi-Fi and cellular, and possibly charge for premium service • Keeping customers on LTE might be preferable to some building/venue owners
Sporting Venues	<ul style="list-style-type: none"> • Complement Wi-Fi network • High capacity LTE services more cost-effective than DAS • Elastic, event-driven network (add capacity as needed) • Premium fan services such as in-game highlights, statistics, and other featured content
Retail	<ul style="list-style-type: none"> • Subscriber continuity of cellular • Traditional DAS solutions not suitable for most retail locations

D. MSOs as Neutral Host Provider

Historically, DAS, or neutral host systems have been deployed by mobile network operators as a way of significantly expanding coverage and capacity at a venue. Stadiums, convention centers, and corporate campuses have been the target for DAS. The cost is mainly borne by the operator.

Shared spectrum services provide the opportunity to offer a neutral host solution similar to DAS, but for far less cost than traditional DAS. As such, MSOs could play a role in a neutral host solution – potentially in partnership with enterprises or building/venue owners. As broadband or telephony providers to businesses, MSOs could act as an integrator or neutral host, offering LTE service in the same way they do broadband. In certain contexts, it could be substitutive of the fixed network; in other cases, it might complement broadband.

Clearly there are business model issues to be sorted out here. But we believe there is an interesting opportunity for MSOs to add cellular to their suite of enterprise solutions . . . without having to build a macro network.

E. As Part of an MVNO Service

Some major MSOs, namely Comcast and Charter, have announced plans to offer cellular services as MVNOs, invoking an MVNO agreement they have with Verizon. Comcast has launched Xfinity Mobile, leveraging Wi-Fi hotspots and using Verizon as a cellular provider.

We believe shared spectrum can play an important role as part of a future cable wireless service — instead of, or as a complement to, an MVNO offering. The terms of the MVNO deal are not especially favorable for high levels of data usage. The significant amount of spectrum available as part of the 3.5 GHz proceeding could offer cable MSOs an additional option for cellular coverage or capacity, perhaps at more favorable economics than what they are paying Verizon on a wholesale basis.

We can also envision a sort of hybrid cable-Wi-Fi-cellular service. For example, Comcast, which has acquired 600 MHz licenses in several markets, could then build a compelling proposition mixing and matching its assets: Wi-Fi, MVNO, their 600 MHz spectrum, shared spectrum, and perhaps even services based on MulteFire or other unlicensed service. They could also add 3.5 GHz capabilities to outdoor APs, where there have been QOS issues associated with Wi-Fi.

F. Outdoor Coverage/Capacity Boost

We were encouraged by the FCC ruling allowing higher output power for 3.5 GHz small cells. We believe that this development adds an opportunity to provide coverage and capacity augmentation in certain outdoor locations. Historically, these situations have been

addressed by DAS, or carrier Wi-Fi solutions. Now, we have a new and potentially superior option in certain contexts: neutral host, less expensive, and faster to deploy. Additionally, traffic demand in these sorts of scenarios is dynamic and changeable, which lends itself to a more flexible spectrum sharing framework.

G. Last Mile Access

We also see the potential for last-mile access. This could be used for backhaul purposes in Non-Line-of-Sight (NLOS) situations, or as a less expensive alternative for short range backhaul. For MSOs, this provides a less expensive way to increase capacity, and opens up revenue opportunities for fixed wireless type services.

4. Framework/Economics

The approach being taken for the 3.5 GHz band places the United States at the forefront of how network services will evolve. Relying on a spectrum sharing scheme and a cloud-based hosting model, MSOs will acquire network resources on an as-needed basis. Shared spectrum provides the benefits of a QOS LTE service for only a slight price premium over Wi-Fi.

The business framework being proposed by certain potential SAS vendors is for a cloud-based subscription model. The enterprise or MSO acquires the spectrum on an as-needed basis, as a complement to broadband, Wi-Fi, and even their cellular MVNO offerings.

Advantages of a Neutral Host Model
<ul style="list-style-type: none"> • Allows for multi-operator framework to be used, much like DAS, for indoor and enterprise market
<ul style="list-style-type: none"> • Improves the customer experience compared to Wi-Fi by maintaining QoS of LTE and reducing issues associated with Wi-Fi, such as interference
<ul style="list-style-type: none"> • Increases opportunities for cost sharing – enterprises, building/venue owners
<ul style="list-style-type: none"> • Greater likelihood that other parties will deploy access points: systems integrators, tower companies, building owners, enterprises
<ul style="list-style-type: none"> • Significantly lower cost of service than in a single operator environment

The cloud-based approach is necessary for effective nationwide operation of the shared spectrum network, providing scale (up or down), elasticity, processing power and data storage – all dynamically. For the operators, it allows for a subscription-based pricing model, a la AWS, so the MSO can buy only what they need on a highly flexible basis. As a result, MSOs can increase the variety of their service offerings by putting together efficient pricing structures, such as a “pay for what you use” model, for their customers.

5. Go-to-Market

We believe there are two components of an MSO go-to-market for shared spectrum. The first component is developing the business case and financials for different shared spectrum scenarios. The direction here depends on what the overall strategic direction is for the MSO. Do they plan to be in the cellular business (via MVNO or owned licensed spectrum), or are shared spectrum services principally an add-on to their broadband/Wi-Fi business?

If the MSO plans to be in the cellular business via an MVNO or hybrid owned/leased/shared spectrum model, a key next step is to determine how shared spectrum fits into the strategy. For example, shared spectrum could have a fairly significant effect on how network traffic is apportioned between “on-net” (MSO Wi-Fi and owned/shared spectrum) and “off-net” (MVNO partner). If shared spectrum fits into the strategy, the MSO will need fewer resources to acquire licenses as part of the company’s overall approach to mobile.

The second component is related to the MSO’s shared spectrum business that leverages its broadband/Wi-Fi assets. Here, the MSO is adding 3.5 GHz to Wi-Fi APs and is talking with enterprise customers about coverage/capacity/premium service benefits of shared spectrum. The MSO will need to:

- Develop the business case and financials for different shared spectrum scenarios. The direction here depends, in part, on whether the MSO plans to be in the cellular business (via MVNO or owned licensed spectrum), or whether shared spectrum services are principally an add-on to their broadband/Wi-Fi business.
- Equip the sales organization to have shared spectrum discussions with enterprises. There will be opportunities to expand coverage and capacity, and/or offload traffic from cellular services. The discussions might also include enterprises/venues sharing in some of the cost of deployment, or making their facilities available for deployment of APs.

MSOs are going to have to get comfortable with three game-changing elements enabled by spectrum sharing: the idea of a neutral host solution (which they have already done for DAS); an expanded ecosystem of potential partners, such as SIs and building owners; and new/alternative business models combining fixed and mobile services (cloud/subscription based). They will need to take into consideration the following:

- **Test/Trial spectrum sharing in 2H 2017/1H 2018.** The first SASs have become operational. Test-ready vendor equipment and early devices equipped with 3.5 GHz capabilities are already available. We believe MSOs should consider testing some shared spectrum services in the latter part of 2017 and 2018, keeping an eye on MNO activities. Testing would be:

- With enterprise customers, and/or building or venue owners. Pick a key target vertical, such as hospital or hospitality
- Possibly in cooperation with other MSOs, if shared spectrum is to be part of the “cable Wi-Fi” regime
- Possibly with MNOs, especially if shared spectrum is going to fit into an MVNO type relationship
- **Determine primary use case on a per opportunity basis.** What is the mix of coverage vs. capacity, and how is traffic shifted between Wi-Fi and LTE on an AP?
- **Build a sales and business development organization.** Determine which types of customers will be acquired via direct sales and which will be through partners, such as tower companies and systems integrators. The partner development organization will forge relationships with SIs, venue owners, and so on. This organization will need to be knowledgeable about the economics and have business models at the ready.
- **Build business cases,** to determine which types of opportunities are appropriate for shared spectrum vs. alternatives, such as Wi-Fi, MVNO, and other emerging opportunities, such as MulteFire.
- **Business cases and models should also delineate how cost responsibilities shall be shared,** depending on the opportunity, between MSO/enterprise/venue owner.
- **Develop business models/cases to classify type of opportunity (internal)**
 - Customer retention?
 - Revenue enhancement?
- **Develop a pricing model** for different situations/customers/contexts
 - As an extension of broadband/Wi-Fi—no extra charge
 - Premium charge for enhanced capacity/coverage, where customers share in the cost of deployment
 - Are any charges for hardware passed on, or are charges only for services?

It will also take some time and experience with spectrum sharing to determine what types of opportunities are PAL vs. GAA, and how to value the spectrum and temporary licenses.

Conclusion

We are particularly excited about the shared spectrum and 3.5 GHz band opportunity, for three reasons. First, it unleashes a game-changing amount of spectrum, allowing for a new way of thinking about capacity and coverage. Second, it provides a potentially viable solution to what has heretofore been an intractable problem: in-building wireless coverage.



Third, this represents true business model innovation, vaulting the U.S. to a global leadership position.

The network of the future will have a mix of Wi-Fi (fixed) and mobile assets, combining licensed and unlicensed services. Traditional boundaries between fixed and mobile operators, between licensed and unlicensed services, and between Wi-Fi and mobile, will be eroded.

MSOs have the opportunity to consider shared spectrum as an option for greater coverage and capacity, as well as for premium services, leveraging their broadband/Wi-Fi assets. Over time, this can be an important element of their broader mobile/cellular strategy. Shared spectrum could prove to be an important customer retention and revenue enhancement tool, opening up new opportunities in the enterprise segment and potentially other partners in the communications and digital media ecosystem.

Disclaimer: This White Paper is authored by Mobile Ecosystem, with the objective of promoting thought leadership with regard to shared spectrum opportunities. The White Paper is underwritten by Federated Wireless, Inc. In no way does this White Paper represent an endorsement of any particular vendor's products or solutions.

*Please contact Mark Lowenstein, Managing Director, Mobile Ecosystem, with any questions.
mloenstein@m-ecosystem.com www.m-ecosystem.com [@marklowenstein](https://twitter.com/marklowenstein)*