Challenges and Opportunities to Sustainable Rural Connectivity

A White Paper by the
C Spire Rural Broadband Consortium

c spire
Rural Broadband Consortium

1 EXECUTIVE SUMMARY

The C Spire Rural Broadband Consortium gained practical insights into the feasibility and viability of the 3rd party enablement model for extending broadband into rural areas through research conducted by consortium partners C Spire and Facebook. Together, C Spire and Facebook conducted Wireless Internet Service Provider (WISP) interviews and several market deployments using the Established ISP engagement model with C Spire as the Operator. [1, 2] Working with the WISPs highlighted some of the differences between larger ISPs and smaller, more localized ISPs and demonstrated some of the challenges experienced when deploying in rural Mississippi markets.

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2 INTRODUCTION

The C Spire Rural Broadband Consortium was established to work with industry and community leaders, including Airspan, C Spire, Facebook, Microsoft, Nokia, Siklu, and Telesat to research ways to shrink the digital divide and make the internet a more equitable place. C Spire worked closely with Facebook on a rural connectivity trial covering several markets to better understand challenges and opportunities to bringing broadband connectivity to rural Mississippi.

2.1 WHY CONNECT RURAL AMERICA

Broadband has become an important staple in day-to-day life, making it possible for people to stay connected. Connections are important for family and friends, and everyone needs access to vital services like healthcare and banking, as well as the ability to apply for jobs, do homework, stream the latest binge-worthy TV series, and play video games. According to Broadband Now, 24 million Americans do not have access to fixed wireline or wireless broadband. [3] Broadband internet access and speeds have gradually improved for most Americans over the past several decades. However, the digital divide between urban and rural areas remains significant. According to FCC data, only 77.7% of people in rural areas have access to broadband versus 98.5% in urban and suburban areas. [4] The contrast of this digital divide has become dramatically starker with the expedited shift to remote learning, working, ordering groceries, accessing telemedicine, and automated and autonomous farming, due to the COVID-19 pandemic.

2.2 MISSISSIPPI

Mississippi is the 32nd largest state (in area) in the U.S. with nearly 3 million people. [5] Mississippi has the lowest median household income and second highest rate of poverty in the U.S. [6] Compounding potential affordability and demand issues, Mississippi is the 4th most rural state in the U.S. with nearly 50% of its population living in rural areas and is ranked 42nd in the nation for broadband access. [5, 7] Several major telecommunications companies, including C Spire, a Mississippi-based company, provide some combination of mobile and fixed, voice and data internet service with a range of speeds. However, the large land mass and rural nature of Mississippi has left significant portions under-served. While a few satellite operators provide TV and internet to rural areas, the significant need in these areas has spawned a growing cottage industry of smaller, local ISPs that typically use unlicensed spectrum to deliver internet to lower density areas.

Mississippi is a relatively flat state, with extensive farmland (nearly one-third of the land mass), waterways, and forests along with some gently rolling hills. While the relatively flat topography is not as challenging to broadband infrastructure and utility grids as more mountainous regions are, the mix of forest, farmland, small towns, and loosely scattered neighborhoods require a mix of access technologies to provide connectivity. C Spire has worked to connect the state of Mississippi via local telephone, wireless mobility, and fiber services for more than 50 years. C Spire's infrastructure assets include around 10,000 route-miles of fiber and more than 1200 cell sites. [8]

Section 3 describes the approach the Consortium used to gain insights into local WISPs. A description of the WISPs and a discussion of challenges is found in Section 4. Section 5 discusses opportunities, while Section 6 concludes the paper.

3 APPROACH

The C Spire Rural Broadband Consortium has been exploring the 3rd party enablement business model to foster faster and more cost-effective time-to-market rural broadband deployments. Part of that exploration is a deeper dive into the challenges and experiences of a particular type of local 3rd party, the Established Internet Service Provider (ISP). The Consortium used a hands-on approach to gain an empirical understanding of challenges and opportunities by working with three Mississippi-based Wireless Internet Service Providers (WISPs) to connect five under-served rural towns and unincorporated areas using the Established ISP engagement model with C Spire as the Operator. [1]

Extensive interviews were conducted with all of the WISP partners to better understand their businesses, their business models, and hurdles to expansion. The interviews pointed to a handful of issues, some unique to each WISP, and some that were generally applicable.

The market deployments were intended to connect rural communities that might not have been served otherwise. Several approaches were considered for market selection and service, including using community anchor institutions (CAIs) to provide free Wi-Fi to the general public, matching markets to different technologies, and using markets within reach of Operator infrastructure, all while leveraging publicly available data sources to understand levels of connectivity, the market areas, and other relevant context.

With the help of the WISP partners, the final criteria for market selection included markets that 1) either had fiber running through them or were within 10 miles of C Spire towers, 2) were within or near the WISP territories, and 3) had local officials willing and able to work quickly and easily with the WISP. The WISPs had a locally focused approach to market identification based on their experience and likely customer prospects. The WISPs were able to also identify underserved areas that are unincorporated; these areas have little to no information available in standard databases, such as the United States Census. [9] Ultimately, five markets were selected and used to test the 3rd party enablement approach.

4 LEARNINGS

4.1 WISP INTRODUCTION

Two of the three WISPs who acted as the customer-facing ISPs in the 3rd party enablement model are similar in customer count (~400), number of employees (3 full-time), service area (~1 county), and number of years in business (~10 years), while the third is a bit larger and has been in business nearly twice as long. Two of the WISPs were started because the founders were trying to get broadband to their homes and could not find good options. One of the WISPs is purely a family business; each family member learned the skills needed to build and run the network and business. All of the WISPs serve both residential and business customers, and all offer additional throughput tiers that are below broadband speeds (<25/3 Mbps downlink/uplink).

When asked about their biggest challenges, all three discussed access to infrastructure and funding. Grants were considered challenging and expensive to apply for, while two of the three cited an inability to get access to capital (i.e., bank loans). Two of the WISPs also discussed the trade-off in costs for wireless technologies to serve challenging morphologies (i.e., unlicensed line-of-sight [LOS] technologies vs. LTE non-LOS [NLOS]), while two also mentioned the challenge of finding qualified employees. Other mentions include low population density, demographics, political barriers, time, and knowing when and where to expand next.

The WISPs had widely different ideas about opportunities, although all three could see the growth potential in the large number of underserved areas, replacing DSL, and the widespread clamor for the internet during the COVID-19 pandemic. At least one is looking at how to be more than just an internet service provider.

Their business models differ somewhat too, as each has a different customer-to-tower break-even point, though all look for a payback timeline of 12-18 months. The typical rollout timeline for a new site is 1-2 months.

All three WISPs look at different technologies to see if there are better ways to serve existing and future customers, either through solutions that have higher throughput or customer counts, or those that can better serve more challenging morphologies.

4.2 GENERAL CHALLENGES

The macro challenges to serving rural areas include lower population density, potentially lower incomes, and greater distances (often with varied terrain to be spanned or covered), resulting in lower total revenue potential, higher costs, and less attractive business cases than higher density, more affluent urban areas. Because of the comparative advantage of urban areas, the industry has spent fewer resources trying to address rural areas, hence most of the available technology, tools and most common methods were developed with urban settings in mind. [1, 10]

Building broadband infrastructure involves market assessment, planning, technology choice, funding, permitting, site acquisition, construction, customer acquisition, maintenance and repair, and customer service. [1] Interviews and experience working with local WISPs and community stakeholders highlighted a few key micro-level blockers to expanding rural coverage: access to 1) high speed backhaul, 2) vertical infrastructure, 3) funding, and 4) resources to facilitate recruiting and training technicians.

4.2.1 HIGH-SPEED BACKHAUL

Last-mile connectivity is only as good as the upstream connectivity. In rural areas, the biggest challenge is the lack of proximity and access to regional fiber, assuming it exists. The U.S. has millions of miles of fiber weaving across the country like interstate highways, but for data. Unlike highways, however, many of these fiber networks pass through nearby rural towns without any local on-ramp. Long-haul fiber networks are optimized for capacity with the latest equipment capable of carrying petabits (1 million gigabits) of data per second on a single fiber pair, while small towns may only need 1 gigabit per second or less. The cost of breaking out a long-haul fiber network to pick-up and drop-off local traffic can be upwards of $100,000 per break-out, which can be a barrier and requires a thoughtful architecture and design to prevent the loss of long-haul transport capabilities, which would introduce an untenable opportunity cost.

A lower-cost option is to access fiber through microwave backhaul via the nearest fiber-connected tower (see Figure 1).

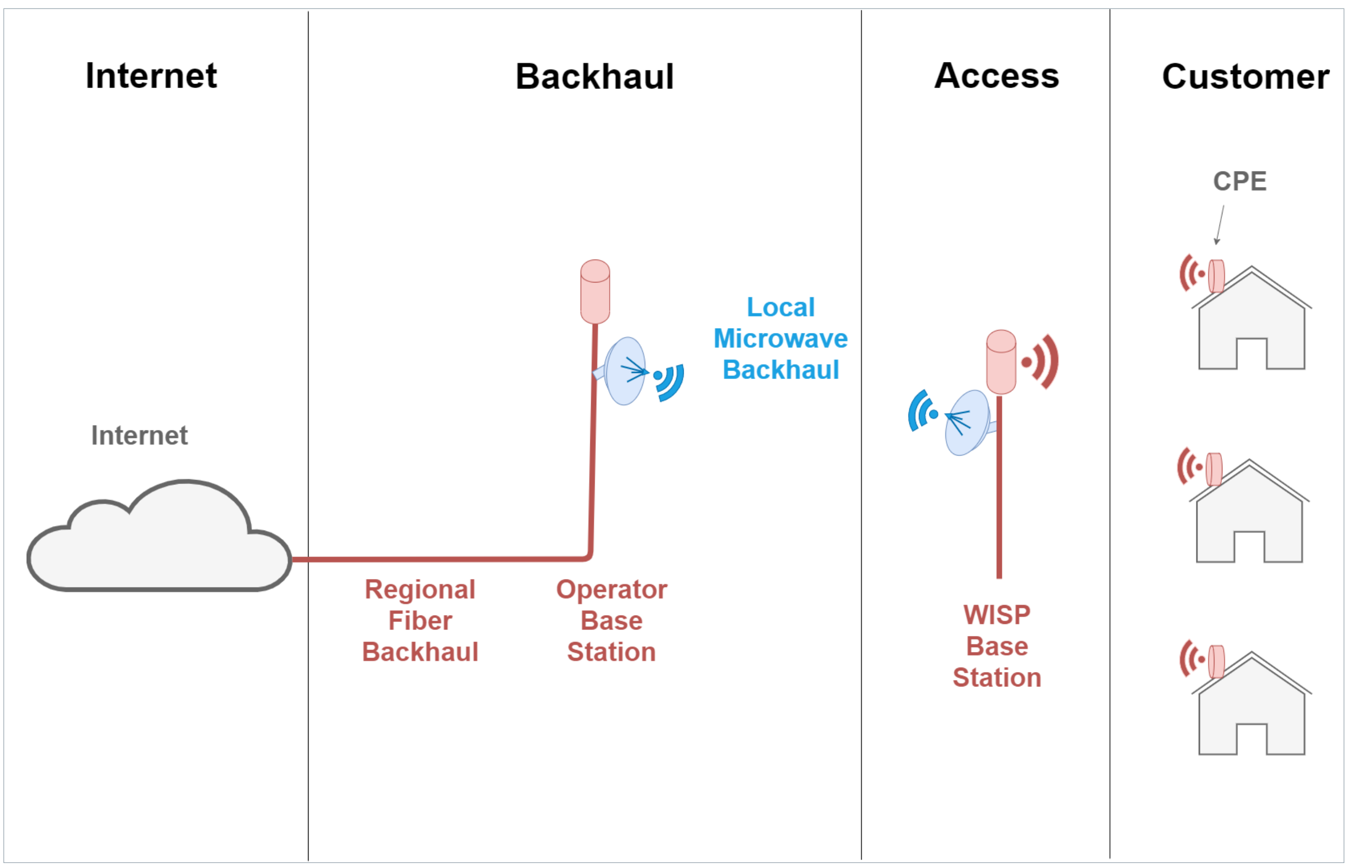

FIGURE 1:
Local microwave backhaul to WISP FWA tower

4.2.2 VERTICAL INFRASTRUCTURE

Expanding networks requires site identification to support backhaul and access infrastructure. Microwave backhaul and fixed wireless access (FWA) can cover the greatest distance with the highest throughput when they have clear line-of-site which generally means they need to be mounted to some form of vertical infrastructure and/or on top of hills. While towers can be reused (on-going rent) or built (upfront capital), because rural business cases are very cost-sensitive, it is important to take advantage of existing vertical infrastructure whenever possible, including water towers, church steeples, barns, and small towers built for precision agriculture telematics.

Building on existing vertical infrastructure such as mobility towers typically means monthly rent. While a cellular company typically pays thousands (even tens of thousands) of dollars a month in rent per tower, this tends to be too expensive for the average rural WISP business model. However, identifying the right location and locating other types of existing vertical infrastructure to serve the desired under-served communities can be like finding the proverbial "needle in a haystack." What's more, once a location has been identified, the WISP needs to identify the landowner and agree on the pricing, terms, and other conditions to acquire or rent the land to build a new tower or find space on some existing structure, which can take time and be hit or miss.

4.2.3 FUNDING

The business case rural WISPs use to determine whether to expand into new markets is highly impacted by the up-front capital investment (CAPEX) in infrastructure and equipment. Recurring operating costs (OPEX) are relatively low, so a WISP typically calculates its break-even on a new site by dividing its deployment CAPEX by monthly customer revenue (i.e., the average price of service multiplied by the number of expected subscribers). Service price can range from $40 to $120 per month depending on the service speed. Expanding into a new area can require $25,000-$100,000 of CAPEX depending on how much new infrastructure is required (e.g., fiber laterals, towers, microwave radios, etc.).

WISPs, especially small established ones, have some of the lowest site deployment costs in the entire industry. However, the biggest challenge remains CAPEX costs for new deployments. While new entrants will need to establish transport circuits to deliver service to new customers, established WISPs are often able to get backhaul from their existing sites until new customer demand requires additional capacity or circuits. This creates a scenario where CAPEX costs are the primary costs and considerations that hold back new deployments.

The costs to deploy a new site from the CAPEX side can vary from around $15,000 on the low end to $100,000 on the higher end. The primary driver for CAPEX costs on a deployment is the radio technology, with more economical and medium range 802.11 based equipment coming in around $20,000 to $30,000 and a licensed LTE deployment coming in around $70,000. Generally, the more expensive equipment allows for higher speeds and larger coverage areas.

The secondary CAPEX cost comes from how many new towers are needed to support both the radio transmission and the delivery of backhaul. In the most ideal scenarios, fiber is available at an existing structure that can be collocated on, such as a water tank, grain silo or municipal tower. As these businesses are hyper local, it is common for WISPs to negotiate collocation on these structures for free in exchange for providing new service to an area or free service to the structure owner.

In the most common scenarios in rural America, existing structures do not necessarily exist in the same areas that have fiber. Fiber is incredibly expensive to deploy, but an absolute requirement for new Fixed Wireless Access (FWA) sites. The best solution is to build a tower near existing fiber to support radio access equipment. Generally, a 180-foot guyed tower costs at least $15,000 plus minimal costs for zoning and permitting when applicable. Commonly, the land for these sites is provided for free by landowners in exchange for free internet service. When the land is not provided entirely for free, it is generally rented for a few hundred dollars a month, which ranges widely across the country depending how much the real estate is worth.

When trying to expand to even more rural areas where fiber does not exist, there are several other potential solutions. One is to obtain backhaul through a microwave dish from an existing cell tower that has fiber (Figure 1). This would typically have a several thousand-dollar capital cost to attach to the tower as well as a several hundred-dollar monthly rent to have a microwave dish on the tower. This dish can then be used to bring backhaul to another site or structure in an area that does not have fiber. This model typically allows a WISP to bring backhaul to a new location 5-10 miles off the existing fiber network. Another potential scenario is in more rural locations where fiber is available in a nearby area but an existing tower is not. In this case, two new towers would need to be built: one near the existing fiber (to put one end of a microwave backhaul link on) and one for access to the service area. Other solutions for even more rural areas that are dozens to hundreds of miles from the nearest fiber include multiple microwave hops and satellite backhaul. These, however, are much more expensive, making it a high-cost CAPEX build (and drastically increasing OPEX as well).

Figure 2 includes scenarios that illustrate the variability in access and backhaul. All scenarios assume a single tower can provide access to the entire market area being served. Scenario 1 is where a new access tower can be built where fiber is already available. Scenario 2 is where a new access tower is built, but it must obtain backhaul through a microwave link from another existing tower or structure. Scenario 3 is where a new access tower is built that obtains backhaul through a microwave link to a second new tower to feed the microwave link from existing fiber. The “a” and “b” in each scenario are the low-cost 802.11-based access equipment and the high-cost LTE-based equipment respectively. Note that this is only the WISP side of the equation; the fiber provider would be responsible for the fiber breakout costs, either in the ground or at an existing tower or structure.

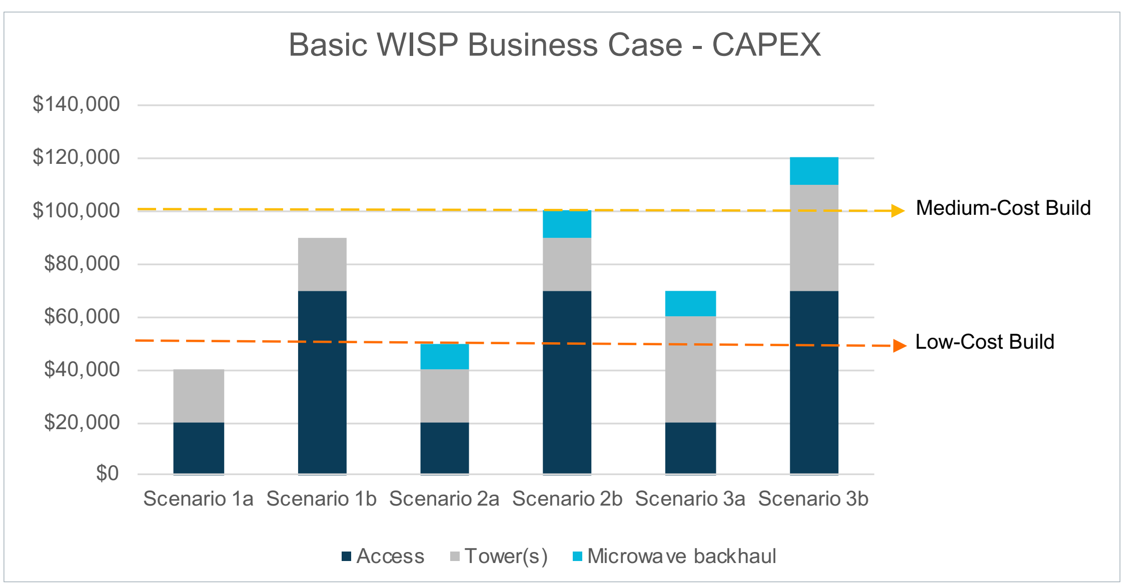

FIGURE 2:

WISP CAPEX models for various rural build scenarios

The primary driver for OPEX costs is transport (i.e., backhaul). For new entrants this will likely be the largest cost as one can expect to pay at least $1000 per month for a new circuit with reasonable capacity. Established WISPs are often able to increase capacity to existing circuits to serve new markets, which is generally much lower cost than adding a new circuit.

Established WISPs typically budget transport costs of $1-$2 per user per month. Outside of transport costs, a WISP can expect to pay about $1 per user per month for a billing / customer relationship management (CRM) system. Because sites have low power usage, electricity costs are generally negligible. Electricity is either provided by the landowner of the site or is the minimum the utility can charge if the site is sub-metered. The partner WISPs for this project mostly do not consider customer service as an OPEX expense as it is generally provided directly by the owner/operator of the WISP.

Figure 3 shows the OPEX cost per month for the same three scenarios as in Figure 2 with the exception that Scenario 2 requires rent on a non-WISP owned tower (e.g., a cellular/mobility tower). None of the scenarios assume a new backhaul circuit, so the costs for transport are negligible (i.e., based on subscriber count). If a new circuit were necessary, monthly OPEX for each scenario would increase dramatically.

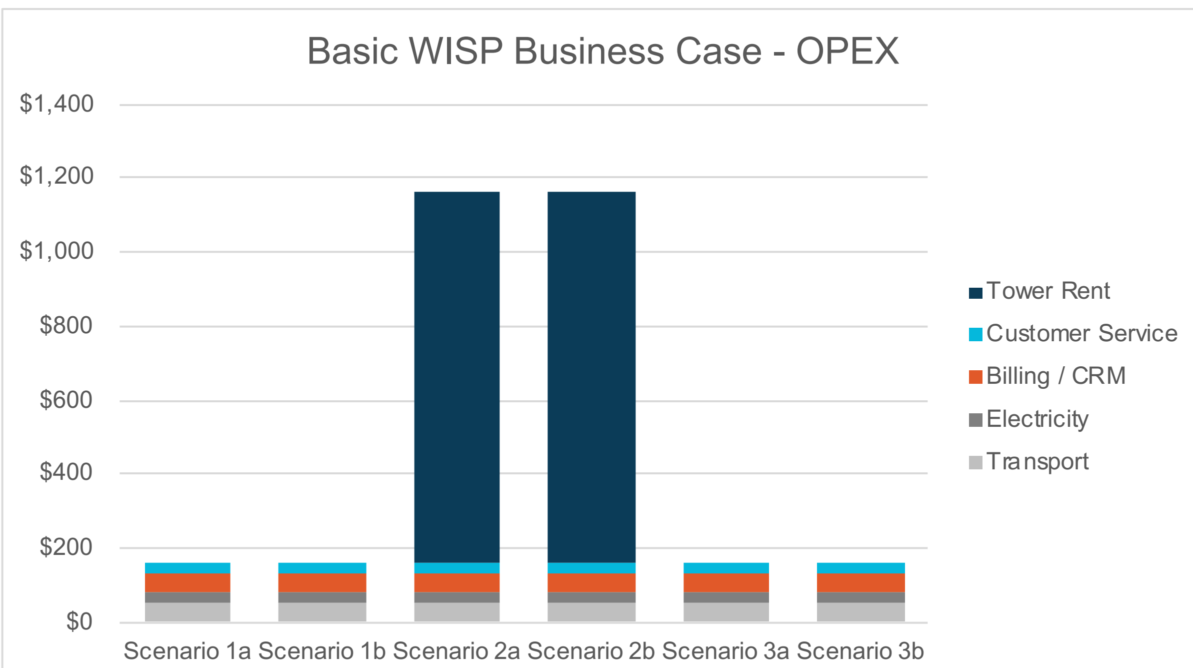

FIGURE 3:
WISP monthly OPEX for various rural build scenarios

Many local ISPs are small businesses with as few as 3 employees. These small businesses often do not have large cash balances, fixed assets that can be collateralized for a loan, or sufficient accounts receivable to justify factoring. In addition to not fitting with traditional lending products, local banks and credit unions were disinterested in creating new products to meet small ISPs' needs. While the federal government has various programs to help fund rural expansion, some of the small ISPs interviewed felt like they would not meet the qualification criteria, such as providing a bank letter of credit, and could not effectively support the ongoing reporting requirements. As a result, small ISPs remain largely self-funded, able to grow only when they can save enough to build the required new infrastructure.

4.2.4 RECRUITING & TRAINING

Building and operating sustainable last mile broadband networks requires a range of capabilities including civil works, manual labor, business, and technical support/engineering. Two of the WISPs indicated it is challenging to find people with the skills needed to design, build, configure, and maintain broadband networks. In some cases, they rely on family, friends, and even out of state contacts that provide technical support virtually.

4.3 DEPLOYMENT-SPECIFIC CHALLENGES

4.3.1 MARKET AREA DESCRIPTIONS

The five market areas ultimately selected for deployment represent a range of morphologies from clustered towns to loosely scattered neighborhoods and farmland. Three of them are named (incorporated) towns that can be found on a map; the other two areas are outside of towns, identified during the project by nearby roads. The market areas likewise range in size from ~200 people to tens of thousands of people. The poverty rate is relatively high for the three towns, ranging from ~30% to ~50%. [9]

Access technologies selected to serve these markets were all wireless, ranging from unlicensed 5 GHz micro-cellular and macro-based technologies to LTE using the CBRS band. Most local WISPs utilize Wi-Fi-based technologies over unlicensed spectrum due to the wide general availability and low equipment costs. However, these bands are prone to interference and somewhat limited in terms of coverage. A mobility option such as LTE can be more robust but is typically much more expensive and more complicated to deploy and use. The market areas' morphologies helped drive the technology used, including how densely clustered the targeted customers were and how heavily wooded the area was. [10]

Backhaul for four markets was provided via a 1 Gbps microwave link from a C Spire macro tower to a WISP-controlled structure. The remaining market was served via a direct C Spire fiber breakout.

The business model for each market is reflective of the technologies used, with initial build costs ranging from small to medium ($34 - $97k). Initial build costs were related primarily to the technology chosen, with LTE proving more expensive. Other cost drivers included using two frequency bands to serve a loosely scattered neighborhood with lots of trees and installation costs for a water tower (which requires significant welding) versus building a less expensive guyed tower.

As of the publication of this paper, four markets were completely built, three of which are actively serving customers.

4.3.2 DEPLOYMENT CHALLENGES & LESSONS LEARNED

The challenges for these specific 3rd party deployments were wide ranging, including lack of interest or focus by town governments, bureaucratic delays, technical challenges, and operational ones.

The Consortium looked at a variety of technologies to fit the variety of morphologies. WISPs (as with most ISPs) tend to stick with technologies they have tested and trust. The WISPs were willing to experiment with the Consortium in some instances. One technology experiment, TV white spaces, did not prove successful in the desired area and was abandoned for a more reliable technology in another market. [11]

One theory explored was the availability of fiber running through small towns that can be surfaced or broken into to serve that small town. 70% of Mississippi's ~350 incorporated cities, towns, and identifiable areas are within 0.5 miles of C Spire fiber. An additional 26% are within 10 miles (e.g., a single microwave link distance) of C Spire fiber. This would indicate that it should be relatively easy to find underserved markets in WISP territory with C Spire fiber running close to them. Instead, it was easier to find an underserved (and desirable, from a WISP point of view) market within 10 miles of a C Spire tower than along a C Spire fiber route. Whether this was unique to the territories of the WISPs involved or is a more general rule of thumb has not been determined. It is possible that C Spire's fiber routes are primarily through towns that are already well-served; that could be generally true of most fiber routes. This would indicate, however, that a different way of cost-effectively breaking into fiber and then distributing it over long distances (e.g., with a microwave hop) is necessary.

Fiber breakout for rural deployments is typically a challenging problem in two ways. One way is that breaking into fiber typically means making that fiber strand (or pair of strands) unusable for anything else. This appears to be lost revenue to a fiber provider, as the strand(s) could have been used to serve a major metropolis with much higher resulting revenues. The other way is that breaking into the fiber is typically expensive, requiring large, high-capacity cabinets installed. While the second problem was solved in this scenario using a low-cost passive solution, the first problem still needs work.

Another challenge was obtaining [FCC] approval for the microwave backhaul links. While a 30-day approval process is standard, the COVID-19 pandemic created much longer delays. One of the links took more than 4 months to be approved; another took just over 5 months.

Another set of challenges were related to local government. One market was less interested in a fixed service than in improving mobility service as the town is about 10 miles from the nearest cell tower. The town offered free access to their infrastructure for both services, as long as cellular service was improved. There were two structures the town indicated were possible, a radio tower and a water tower. However, thorough research uncovered that the radio tower (that would have been more cost effective to build on) was not actually owned by the town. The water tower was owned by the town, but the land on which it was built was owned by the county. Further research uncovered that the town's land lease with the county had expired long before, and it took months for the town to renegotiate and sign a new lease with the county. As a result, while this market had been selected nearly a year before the others were, this market was built around the same time as the others.

While WISPs have more localized knowledge and local contacts, local government support is critical. Some of the market options identified were down-selected when local government officials appeared uninterested in the possibility of a low-cost WISP provider serving their market. One market, however, welcomed both C Spire and the local WISP, working with both to enable new structures in the most convenient spots, either on town or private property. Even modest support from local authorities for access and permitting can make or break the business case for bringing in new broadband connectivity.

Another business challenge was the cost to deploy on a water tower versus a typical cellular tower or a typical WISP-built tower.

The pandemic and a particularly active hurricane season slowed market deployment and then customer acquisition by quite a few months. Expanding into new markets during an extended period of unexpected repair (hurricane recovery) and existing market growth challenged the smaller WISPs especially. The remaining market to be built is struggling with equipment availability due to the ongoing COVID-19 pandemic.

5 OPPORTUNITIES

Identifying and understanding challenges is often rooted in hands-on experience, whereas discovering opportunities requires the combination of experience, trends, and some creativity. Working with local partners provides a distinct advantage, particularly in rural areas. For example, local WISPs know the physical landscape (which helps in network planning, design, and deployment) and have relationships with local officials and landowners (which helps with permitting and access to rights of way and certain vertical infrastructure). Because local WISPs live in or near the areas they serve, they know many of the community members, which can help sales (often driven by word of mouth) and customer service calls. All of this translates into local ISPs having a lower cost structure and a comparative advantage in serving rural areas over larger, regional ISPs.

What local ISPs lack, however, a larger regional or national partner can provide, particularly infrastructure such as fiber and towers. As a result, local ISPs and larger, regional ISPs may find benefits in partnering. Local ISPs may be able to extend broadband more sustainably into rural areas, but they can also sell additional services like mobile voice and data, television, over-the-top content, and security. The larger partner gains additional revenue from the local ISP partner with limited additional capital and operating expense, while the local partner can expand more easily into new areas through the use of its larger partner's resources. This is the essence of the 3rd party enablement model. [1]

There are a variety of ways the partnerships could work, including wholesale, resale, and agent with different commercial structures based on monthly and/or usage-based service charges, revenue share, or commission. The partners must work through how to play to each of their strengths while balancing each other's weaknesses.

6 SUMMARY/CONCLUSIONS AND NEXT STEPS

Consortium partners C Spire and Facebook collaborated on research into the challenges and opportunities of the Established ISP enablement model with three WISP partners. The study included interviews with the WISPs and deployments in five rural market areas. To facilitate the deployments connecting these rural areas, C Spire and Facebook provided access to infrastructure and funding.

It is clear from these deployments and interviews that access to infrastructure at more reasonable rates are key to enabling new rural market expansion, while a partner with local knowledge can help make the deployment more successful. New methods and processes to support regional-local ISP partnerships that enable more cost-effective infrastructure access and faster time-to-market builds for rural connectivity are also critical for sustainability.

Facebook has developed the **ISP Toolbox** which provides ISPs in Mississippi and beyond with free business and network tools and resources to evaluate attractiveness and feasibility of new markets and customers. [12]

The equipment used to provide wireless backhaul is relatively small, with minimal impact to towers and loading. However, the typical cost to perform a structural analysis for a tower and then rent tower space to put a microwave dish is typically well beyond business case limitations for a WISP. New tower-related processes need to be considered, such as more efficient structural analysis techniques and more reasonable rental rates appropriate to the actual equipment being used.

C Spire and Facebook are also studying cost-effective longhaul fiber breakout methods as part of one of the market deployments.

Funding mechanisms that could improve with a partnership model that still need exploring include the following:

- **Larger operators helping smaller WISPs obtain and use grant money**
- **Larger operators and companies lending WISPs money, which is paid back as part of a monthly service charge and/or when the market turns profitable**
- **WISPs gaining access to partner's new technology expertise and applicability**
- **Ways to make new technology less expensive for WISPs**

While the interaction between local, experienced WISPs and regional infrastructure operators such as C Spire seems obvious, there are other types of organization that can also participate in the 3rd party enablement model, including nascent ISPs and local stewards. [1] The challenges and opportunities for those 3rd parties and potential partnerships need to be explored further.

For this project, the Consortium only worked with established WISPs, whose skills, resources, and experience are substantially similar to mobile network operators, just on a smaller scale. Other types of 3rd parties with less network experience or different types of resources such as utility companies or co-ops, local governments, or other organizations who would like to bring broadband internet access to their communities have different challenges, including their ability to design, install, operate, and maintain networks. Enabling these types of 3rd parties will take a whole new array of tools and start-up funding.

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The C Spire Rural Broadband Consortium is made up of various partner companies interested in finding new ways to bring broadband Internet to rural communities. To learn more, go to:

www.cspire.com/rural-broadband-consortium

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