# THE TRUTH ABOUT WIRELESS BROADBAND:

## THE MYTHS AND CHALLENGES OF WIRELESS TECHNOLOGY IN RURAL AMERICA

*Rural Telecom Educational Series*

This paper was jointly sponsored and developed for the Foundation for Rural Service by John Staurulakis, Inc. (JSI), Monte R. Lee and Company and Palmetto Engineering and Consulting to underscore the challenges of wireless technology in rural America.

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### EXECUTIVE SUMMARY

Today's wireless networks would not work without a fiber or other wired network supporting them. Although wireless signals can be transmitted through the air for a few miles, they are subject to interference from buildings, hills and mountains, trees, and other obstacles that interfere with the line of sight between antenna towers and other facilities. In addition, wireless services share the air, or spectrum, with each other, and an overflow of simultaneous users can crowd out or slow down other users and cause service degradation. For these reasons, as explained more fully in this paper, new 4G wireless networks will be designed to carry a wireless signal for only a relatively short distance before transferring it (whether it be a voice call, text message, or e-mail) to the wireline network buried underground or strung across utility poles. If the call or text message is directed to another wireless user, only when the signal reaches a wireless facility near the end-user's device does the signal leave the wired network to complete its journey wirelessly.

In urban areas, a relatively few number of antennas can reach many people; for example, an array of cell phone antennas atop a downtown office building can reach not only the people in the building but also numerous others nearby. In rural America, however, people live and work much farther apart from one another. Therefore, on a per-capita basis, rural wireless requires more antenna towers and other structures. Moreover, the vast majority of wireless service providers must obtain a license from the Federal Communications Commission (FCC) and purchase the right to offer service over particular airwaves. The costs involved in obtaining those rights can reach many millions of dollars and do not include the costs of building antenna towers and other facilities. In rural areas, there are fewer customers to share the cost of the network.

This paper will explain the nature of wireless networks; demonstrate how wireless networks rely on fiber-optic or other wired networks; illuminate the persistent myths about wireless technology's application in rural settings; describe the technical and economic challenges of providing wireless broadband in rural America; and attest to the continuing importance of the national commitment to the support of rural wired networks.

## THE NATURE OF WIRELESS, OR HOW WIRELESS WORKS

Policy-makers are addressing the nation's march toward the "broadband transition." The implications of increased broadband deployment for commerce, health care, education, and national security are primary for people and communities across America. Consumers are choosing services based on their needs—robust fiber-optic or other wired connections for industrial and home use; mobile wireless for personal and business "on the go" connectivity.

The appeal of mobile wireless service is powerful, and Americans have embraced it. As cell phones evolve to smart phones, however, it is necessary to recognize the interconnected structure of wireless networks (*i.e.,* cell phones, PDAs) and wired networks (*i.e.,* fiber-optic and copper-based). Virtually all wireless networks rely upon a wired network to provide a backbone transmission path for voice, video, and data services. In sum, the wireless industry relies upon its connections to the wireline networks constructed and maintained by community based telecom providers throughout rural America. Sound public policy aimed at ensuring a comprehensive and successful broadband strategy must recognize these facts.

### WHAT IS SPECTRUM?

To address the relationship between wireless and wired networks, one should begin by explaining how wireless networks operate. The nation's experience with wireless did not begin with cellular telephones in the 1980s, but with radio (the original wireless service) and television in the early twentieth century. The devices all transmit signals across the radio spectrum. Radio spectrum, measured in units of hertz, describes the **electromagnetic frequencies** that are present in the atmosphere. They include radio waves that transmit news and music to your car radio, microwaves that cook food and carry cell phone calls, and x-rays that provide penetrating imaging of our bodies or buildings.

U.S. law controls which spectrum ranges may be used by the public and how they may be used. Some spectrum can be used only if the service provider or user obtains an FCC license, while other spectrum may be used by the general public without the need for a license. Most wireless broadband in America is offered on **licensed spectrum.**

**Licensed vs. unlicensed spectrum**
Sometimes, household devices operated by remote control (using radio waves) can interfere with or interrupt each other. That is because the frequency ranges used by the devices may be close to those used by others, or because the devices share a band of frequency. Users of early cordless telephones could often hear their neighbor's conversations; or, a remote control ceiling fan may mysteriously activate and spin, even if no one turned it on. These devices operate on unlicensed spectrum, and are subject to interference. By contrast, the FCC sets strict rules that discourage interference on "licensed" spectrum.

Mobile phones, including smart phones, operate on various blocks of spectrum. A block of spectrum refers to the range of frequency that it comprises. The signals of a wireless phone call, text message, or e-mail often travel across one level, or band, of spectrum frequency to transmit the message, and another band of frequency to receive it.

### WIRELESS TRANSMISSION FACILITIES

Unlike a walkie-talkie, a cell phone will not work without a network, and both the network and the device must be "tuned" to the correct spectrum. A wireless system is made up of three main components: a **cell site** antenna tower or base station; the **transport element;** and the **network core** or wireless switch. The **cell site** is located in the field close to consumers and is connected to the **network core** through fiber or other **wired transport.** Accordingly, a cell phone call or text message from one wireless user to another: (1) travels from the device to the cell site, where it (2) is passed to the fiber or wired transport element, which (3) connects to the network core where the traffic (4) is routed back using the transport facility, until the signal emerges at a cell site close to the call recipient, and (5) departs the wired network and returns to wireless mode to reach the recipient's device.

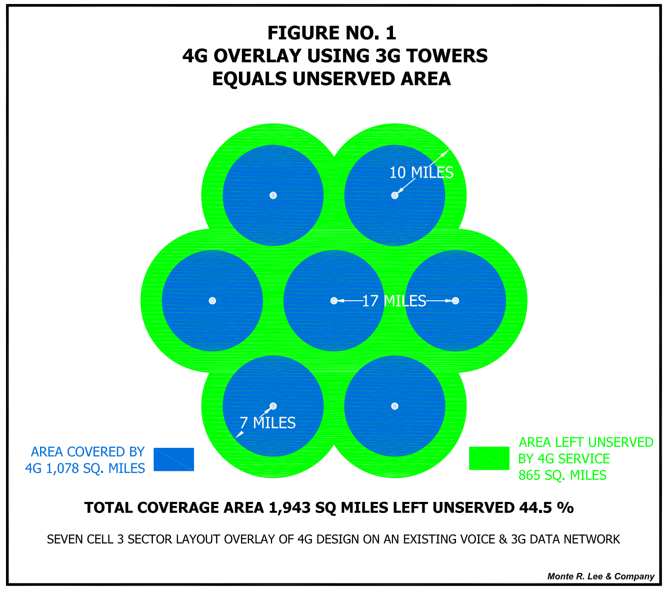


A wireless subscriber communicates with the base station/tower over the radio frequency. The size of the pipe for the transport of voice, text, or video between the two connections is the *frequency bandwidth,* or simply, *bandwidth.* The larger the bandwidth, the greater the amount of data that can be transported over the network. The distance between the cell site and the user also plays a key role in establishing the amount of available bandwidth or the volume of data a user can receive at any given time. This relationship can be likened to a soft voice in a noisy room: As the voice gets farther away, it becomes fainter, and if the person speaks faster, it becomes harder to hear or understand what is being said. In a 4G network, data signals are "loud" and pronounced at distances close to the tower and can be "heard" even at the faster speeds.

Wireless networks must also overcome limitations caused by terrain, foliage, and obstructions between the cell site and the device. Many frequencies rely on a clear line of sight between the cell site and the user; if the signal cannot "see" the end point, the signal degrades. In addition, the distance over which a signal can be transmitted is a factor in determining whether a rural subscriber can access high-speed broadband service. Given the design factors, it can be expected that rural data networks, especially when the terrain is rugged or (as is common in rural areas) customers are located far from each other, require additional cell sites to meet service objectives. In very rough and mountainous terrain, cellular-type wireless service is not practical and rarely even considered.

Currently, there are not sufficient numbers of wireless structures in necessary locations to meet 4G wireless data propagation requirements for the vast rural territories to be served. Even where cell sites have been built for the voice network, the implementation of 4G data services will require shortening the distances between the towers and customers—or, stated differently, will require a sharp increase in the number of towers/sites in rural areas. For example, if sufficient service were to depend on reducing the distance a signal must travel, on average, from ten miles to seven miles, high-speed data requirements mean that structure quantity would have to double.

**Now you know**
Wireless propagation is the dispersion of electromagnetic signals through the air or other media from a transmitter. The signal level required for a reliable 4G data service is 20 dB, or 100 times more than the signal required for a voice call.




### SHARED SPECTRUM, SHARED NETWORK

A customer's wireless broadband experience depends upon the amount of spectrum controlled by the service provider and the number of other users using the network; stated differently, a correlation exists between the amount of spectrum available and the derived amount of bandwidth delivered to the customer. Wireless service is a "shared resource" in the last mile; e.g., the last section of the network that lies between the tower and user. In other words, users of mobile wireless services share the network with others. Therefore, a wireless user's experience depends, in part, on how many others are on the network at the same time. By contrast, fiber or copper-based DSL facilities are "dedicated" resources over the last mile; *i.e.,* each user enjoys a dedicated line that is unaffected by others.

Wireless user experience is also affected by the amount and positioning of bandwidth the provider controls. For example, a service provider needs 50-100 MHz of contiguous bandwidth to provide an efficient, long-term wireless solution without significant service restrictions even in rural areas of low density. Signals over this spectrum are distributed for use as a cell tower extends its "reach out" across three geographic areas or sectors. In such a "three-sector" configuration, standard in most installations, a carrier will be able to provide 100 Mbps of shared traffic for one-third of the area using the most advanced LTE technology currently envisioned. Today's desktop applications using fiber enjoy as much as 6 Mbps data speeds at low cost. In this sort of environment, 100

Mbps of traffic for applications requiring 6 Mbps would support relatively few simultaneous users; additional users or greater speeds would threaten to exhaust that segment of wireless network capability. As new applications increase the need for speed (with current estimates as high as 50 to 100 Mbps in the near term), wireless providers will find it extremely difficult to meet demand. With the expected growth in consumer Internet services, a handful of users watching video or movies could slow down or completely deny access for others in a given cell area. The FCC is considering ways to make more spectrum available, but small companies generally cannot obtain large segments of bandwidth.

If a carrier initiates wireless broadband service without sufficient long-term spectrum available, it should expect customers' usage demands eventually to outpace its available bandwidth. Limited spectrum means business and service problems for providers that will not be able to grow their customer base or will have to scrimp on quality with each new connection. The lack of access to contiguous spectrum is another challenge: Most rural providers do not have access to the 50-100 MHz of contiguous spectrum that would provide adequate bandwidth. In many cases, rural providers have been locked out of obtaining spectrum altogether, while others are confined to small 5-, 10-, or 25-MHz increments. And, in the FCC spectrum auctions, the licenses were limited to areas that did not overlap in a manner enabling rural providers to obtain sufficient spectrum to serve their areas. As a result, few community based companies exited the auction with sufficient spectrum to run wireless broadband in rural areas.

Even auctions of additional spectrum might not help. If the rural geographic area is included in a large block of spectrum that covers an urban market or other large expanse, rural providers will likely not have the economic means to cover the purchase price. In contrast, large carriers have successfully amassed significant blocks of spectrum either through acquisitions or the auctions. These companies need the spectrum in order to meet demand in urban markets. It is unlikely, however, that a large company would build towers and transmission facilities to provide service in rural areas, given their business focus and/or unwillingness to accept the low return on investment typically earned in rural markets. In today's business climate, spectrum owned by large carriers typically goes unused in rural settings, and the "warehousing" of spectrum adds to general shortages and limitations in rural wireless data services. With 4G on the way, this spectrum deficiency in rural communities will only increase.

**The alphabet soup of spectrum auctions**

FCC auctions for spectrum licenses limited winners to provide service over specific frequencies and in specific geographic areas. To define those areas, the FCC looked to the U.S. Department of Commerce and the Rand McNally 1992 Commercial Atlas and Marketing Guide. Spectrum licenses are defined to fit EAs (Economic Areas), BTAs (Basic Trading Areas), and CMAs (Cellular Market Areas). Since the areas are not based on telephone company service area borders, it is possible that a carrier might obtain a wireless license that permits it to serve some, but not all, of its regular service area, or that a carrier might obtain a license for an area far larger than it would ordinarily plan to serve.

Among the myths beclouding wireless broadband service is the idea that it does not matter whether blocks of frequency are adjoining or separate. In truth, a provider that cannot obtain adequate spectrum in the same frequency band faces additional investment burdens. Most network equipment is frequency-band-specific and requires separate hardware to operate. Items in this category include antennas, transmission lines, transmitters, and CPE equipment. Changes in any of this equipment cause increased inventory issues, added tower expense, and additional power requirements. The propagation characteristics also change based on frequency, causing a provider to need different designs for service within the same area. These changes are equivalent to operating two separate systems while trying to offer a transparent data service to customers.



## RURAL NETWORK DESIGN: OVERCOMING GREAT DISTANCES AND LOW DENSITY

To this point, we have addressed some of the basic network elements that enable mobile wireless services. Other factors, however, warrant attention as we tackle the myth that mobile wireless is the "technology of choice" for rural broadband deployment. Current limitations include service availability, slower speeds, and higher capital costs per user.

Rural areas have fewer residents than urban areas, but who are spread out over areas that are generally as large as, if not larger, than many cities. As one departs large urban centers and travels to more remote, less crowded towns, one experiences the differences in size and scope that factor into all aspects of the infrastructure scale needed to maintain civic and social continuity. A similar contrast exists and must be taken into account in the design of wireless data networks. Two of the most significant differences among urban, suburban, and rural network designs are the distances separating the cell sites/towers and building penetration.

Within an urban grid, cell sites are mere blocks apart; in suburban areas, the towers may be a mile or two apart; in rural areas, they are most often separated by many miles. The urban layout supports abundant coverage with consistently strong signal levels that create high-quality wireless service and great data speeds. In the suburbs, with tower sites farther apart, wireless coverage is relatively good but less reliable within building structures. With the added distance between sites, a customer can use the service in most areas, but may need to be near a window to get quality calls or available 3G data service. Coverage may be more sporadic in interior rooms, with little or no signal the norm in basements and cellars. In rural areas, farther from the cell site, data coverage is best outdoors, while coverage in the home is usually limited to an upper floor near windows facing the tower.

**Population density and telecom costs**

In a suburban area, one linear mile of telephone facilities (poles, wires, etc.) may pass 100 houses on quarter-acre lots; in an urban area, the number of users served by the same plant could increase exponentially if that mile included apartments or high-rise office buildings. When the costs of a network can be shared by more users, the per-customer cost decreases. In rural areas, the costs of a wireless network can be contained by building fewer towers and other facilities. The consequence, however, is lower service quality.

Suburban and rural customers who live close to the cell site likely experience an acceptable level of service for today's bandwidth requirements, similar to residents in urban areas. When one considers the vast amount of area covered by each site, it can easily be seen that most rural customers do not reside *within close proximity* of the towers. For today's wireless providers, it is simply not economically feasible to add a sufficient number of towers/sites in rural areas to offer customers urban-like wireless services. Besides the obvious cost and investment reasons, tower placement, network facility, and environmental concerns also make construction/placement a complex and difficult endeavor.

Wireless service has changed significantly over the past three decades. At the start, wireless voice service was available in New York City, Chicago, Dallas, Washington, D.C., and other urban centers long before it reached most rural areas. With the advent of 2G data service, customers in urban markets began to enjoy texting and other device-to-device services, such as meter reading. With 3G development came the opportunity for urban users to take advantage of an explosion of application-based services, music downloads, and Internet access. The accompanying build-out of 2G and 3G (*i.e.,* slower speeds) data services throughout much of rural America has trailed what was achieved in metro areas, though most of the tower/infrastructure designs and locations are similar to the voice network. For rural providers, the 2G and 3G build-outs have hinged on the economics of customer usage and **data roaming.**

**Data roaming**

Data roaming refers to the ability of customers to use their mobile devices in areas where another company provides service; FCC rules require companies to work with each other in order to ensure that users can "roam" the country, and still use their phones.

The idea that 4G (*i.e.,* high-speed) wireless broadband service, such as LTE, can be easily overlaid onto the existing network to be readily available in rural areas, however, is largely a myth that belies current design constants governing wireless networks. Most segments of the wireless high-speed data network will not be easily upgradable to meet future bandwidth demands. Also, the laws of physics do not allow for the use of smart phones and other Internet devices; *e.g.,* iPhones, Droids, Kindles, iPads, that must be able to span the long distances between towers located in rural areas.

## GETTING THE TRAFFIC FROM THE TOWER TO THE INTERNET

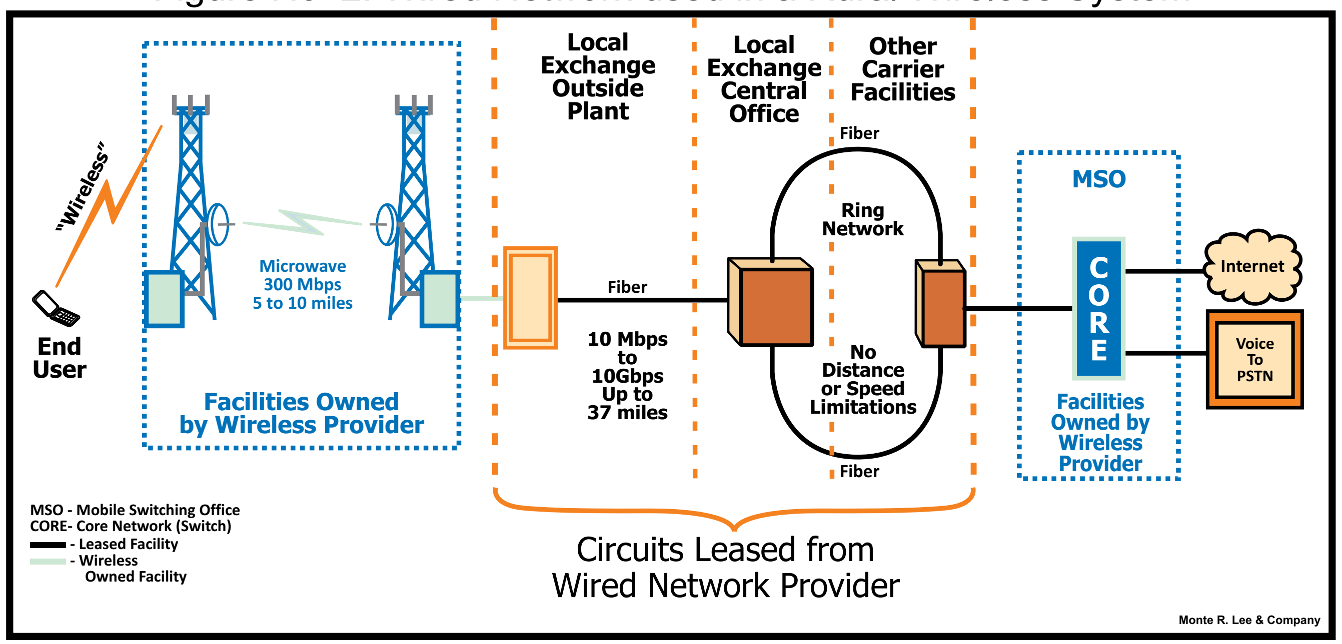
### WIRED NETWORKS CRITICAL FOR BACKHAUL CONNECTION

Perhaps the most persistent wireless myth is the assumption that wireless systems can operate *without* the use of the existing wired network. Wireless providers, in truth, rely heavily on wired networks built and maintained by local exchange carriers (LECs) to connect their cell sites/towers to the core switch and to transport data traffic back to the network core and on to the Internet. The transport of this broadband traffic is often referred to as backhaul. There are two parts to wireless backhaul: transporting the signal from the cell site to a central location, and then to the Internet.

**At the core of the network**
The core manages the traffic and switches calls and data across the network. At this central point, several cells' voice and data messages are combined and sent to the wired network and the Internet. The core switch is the "brains" of the system, handling billing, voice mail, texting, Internet connection, roaming on other systems, and support functions.

In some instances, wireless providers transmit data from their towers to the core switch using wireless (microwave) technology. A microwave connection, however, is now almost always designed to provide service between a maximum of only two sites before having to jump to the wired network. The alternative backhaul method, wireless microwave, uses point-to-point RF (radio frequency) transport and operates with limited capacity. With the deployment of 3G data services and the large data applications that followed, wireless providers had to off-load their traffic to the wireline network as soon as possible. Now, 4G network reliance on wired facilities is necessitated by backhaul (transport) requirements that exceed the bandwidth capabilities of current wireless microwave technology. The microwave facilities used for 4G service cover only a single hop, which is then connected to the wired network. Without a LEC or other wired provider to connect to, a wireless carrier would have to build fiber connections to all sites with the exception of the last one, at the network's end. At start-up, a wireless operator likely would use its own microwave network as much as possible to minimize its backhaul expense. In rural areas, it is common for wireless providers to request that LECs connect their tower sites for data services, and given current tariff structures, wireless providers can obtain these connections from rural LECs at a very economical cost.

Figure No. 2: Wired Network used in a Rural Wireless System






### BACKHAUL: MOVING INCREASING LOADS OF DATA

Another wireless myth is the assumption that ample bandwidth is available to handle wireless data customers once they are connected to the network. We have discussed the backhaul of traffic between individual users and the cell site. In this section, we discuss the transmission of signals from the cell site to the *Internet backbone.*

**Internet backbone**
The Internet refers to the collection of computer systems and servers connected by telecommunications networks that crisscross and span the country. Certain segments of the network are larger than others, much the way roadways can be described as highways, arterial roads, and neighborhood streets. In Internet parlance, the largest parts of the network are referred to as the backbone.

Studies suggest future requirements per cell site will be a minimum of 100 Mbps capacity. This means that 10-15 cell sites covering an area of 1,300-1,500 square miles will require as much as 1 Gbps Ethernet for backhaul capacity. Using our roadway analogy, the capacity of an arterial road connecting to a major highway must be able to accommodate the traffic emerging from connected residential streets. So, even if a rural market would have a sufficient number of cell towers or other facilities (residential streets), it would still require a sufficient capacity of Ethernet pipes (arterial roads) in order to connect to the Internet backbone (major highway). Many rural market areas, however, still have limited Ethernet pipes and will require significant network expansion before wireless broadband services can be offered. If a local wireline carrier is not able to expand its network, or opts to charge high rates for connectivity, the wireless network operations that depend on the LEC network will suffer and may never reach its potential of offering reliable data service.

Many wireless providers request transport with backhaul speeds of approximately 50 Mbps, with additional capability to adjust to more than 100 Mbps. Due to the increasing data bandwidths available with emerging 4G technologies, current projections estimate that, to meet wireless system needs, each tower site will require as much as 300 Mbps, which may not be available in rural areas. In urban settings, a wireless company usually can count on multiple wired providers from which it can obtain a connection at *any* speed and short "lead time" because of its proximity to the wired provider's fiber coax or copper facilities. Among the wired carriers that urban wireless companies can call on include: LECs, competitive LECs (CLECs), cable TV companies, and metropolitan WANs. By contrast, due to the nature of the service territory and sparse populations, most rural communities have access to wired networks operated by a single provider (the LEC) only, using either fiber or DSL copper facilities. All other factors being equal, wireless carriers prefer to connect to the wired network with fiber, since it offers easy bandwidth expansion and lower maintenance costs.

**Fiber vs. copper**
Until fiber-optic cable emerged, telephone plant was connected using copper wire. Copper has remarkable transmission capabilities, and the addition of various devices to the copper-based network can be used to obtain reasonable broadband service. In contrast, fiber has exponentially greater capabilities that can be exploited with the addition of economical electronic upgrades. Ironically, fiber is a less expensive option when deploying new facilities. Since glass is cheaper than copper, and since the labor costs associated with both are fairly equal, deploying fiber is less expensive than deploying copper.

In addition to the underlying network, wireless providers also must address other facilities placement issues. Wireless towers are strategically placed to maximize area coverage while still being relatively accessible to power and data transport. Unlike in urban settings, power lines and communication facilities in rural areas are not placed on every corner or drive. Some facilities are miles from the proposed tower site, significantly increasing system construction costs.

## WIRES FOR THE WIRELESS

It is widely assumed that wireless technology will hasten the deployment of advanced broadband services across the nation. Before that happens, however, difficult questions remain, focusing on the investment, financing, and payment for critical underlying network infrastructure necessary to support mobile (and fixed) wireless broadband services. As described earlier in this paper, the wireless systems used for almost all rural broadband access depend on wired connection to the Internet. In fact, as a result of a variety of interconnected issues, not the least of which is the shortage of spectrum (a condition not likely to change in the foreseeable future), it is in wireless carriers' best interest to *maximize* the use of wired facilities for their transport needs to the Internet.

To their benefit, wireless providers currently enjoy the fact that rural LECs serving vast expanses of the national geography are fully capable of meeting their transport needs. Community based LECs serve approximately 7 percent of the U.S. population; however, the service territory of these providers makes up close to three-quarters of the land mass in the continental United States. The availability of this infrastructure is critical for wireless carriers. Rural LECs maintain robust a wireline network they have built and maintained in the most challenging rural areas. It is these rural carriers' wired networks, traditionally copper and more increasingly fiber, that make backhaul connection possible for wireless carriers in the high-cost, sparsely populated stretches of America.

The interconnected relationship between wireline networks and wireless backhaul service affects the universe of wireless and wireline users. Public safety and homeland security, for instance, have been promoted and achieved through the jointly provisioned telecommunications infrastructure in rural areas. Wireless providers rely on more secure wireline networks for transport and other critical functions in order to reach all parts of the nation.

This mutually beneficial relationship and the synergies between wireless cell sites and wireline networks beg the question: How and why are rural providers able to meet wireless needs in rural America? The answer focuses largely on rural LECs' long record of commitment and delivery of a wide variety of quality services in high-cost, hard-to-reach areas. These service territories span the nation: from Hoodsport, Washington, in the Pacific Northwest... to Metter, Georgia, near the Atlantic coast... to the heartland-defining Red River Valley, in the North Dakota expanse... to the southernmost bend of the Rio Grande, on the Texas-Mexico border. It is important to note that these areas are *not* first-, second-, or even third-tier markets. Rather, these are areas for the most part forgotten, neglected, even ignored by the large investor-owned companies as they built and maintained their regional networks across the country.

Acknowledging both the harsh environment and unfavorable economic prospects faced by America's communications pioneers, Congress designed and enacted policy objectives aimed at supporting the financial and operational viability of rural LECs. Without such federal support, many rural communities and small towns could not have attracted the network infrastructure needed to bring service to residents—many for the first time—and, eventually, to wireless providers venturing into marginal markets.

### A WIRELINE-WIRELESS HYBRID BROADBAND NETWORK

Rural LECs continue to grow and evolve their networks. No community based provider would devise a business plan today focusing on voice service alone. Most rural carriers have upgraded their networks and facilities to deploy high-speed, broadband-based data and video services across much, if not all, of their areas, regardless of the obstacles in getting the technologies to rural customers. The services offered today by rural LECs include voice as a foundation, but also package long-distance, high-speed Internet access, transport, cable and IPTV video, and other information access services. Rural carriers' networks are dynamic, built with the future in mind. Rural LECs have planned and invested in scalable networks capable of bringing today's services on platforms that will accommodate new technologies to meet tomorrow's demands.

Wireless systems and coverage demand ever more diverse and sophisticated transport services in rural America. Going forward into the broadband era, it would not seem a wise economic or investment decision to ignore the significant, state-of-the-art wireline networks constructed and maintained by community based telecom providers. It is critical to leverage the legacy networks that rural carriers maintain today to offer wireline and wireless broadband services to residents of all parts of our nation. Without robust wireline <u>and</u> wireless networks, Americans in rural communities will be at significant disadvantage and will continue to suffer from the digital divide between the urban and rural way of life.

### GLOSSARY OF TERMS

*Glossary Source: FRS Glossary of Terms; FRS Rural Telepedia*

**2G**
Second-generation mobile wireless telephone technology.

**3G**
Third-generation mobile telecommunications; it is a generation of standards for mobile phones and mobile telecommunication services fulfilling the International Mobile Telecommunications-2000 (IMT-2000) specifications by the International Telecommunication Union. Application services include wide-area wireless voice telephone, mobile Internet access, video calls and mobile TV, all in a mobile environment.

**4G**
Fourth generation of cellular wireless standards; a 4G system is expected to provide a comprehensive and secure all-IP based mobile broadband solution to laptop computer wireless modems, smartphones, notebooks and other mobile devices. Facilities such as ultra-broadband Internet access, IP telephony, gaming services, and streamed multimedia may be provided to users.

**Backbone**
A larger transmission line that carries data gathered from smaller lines that interconnect with it. On the Internet or other Wide Area Network (WAN), a backbone is a set of paths that local or regional networks connect to for long-haul interconnection. The connection points are known telecommunications Data Switching Exchanges (DSEs).

**Backhaul**
The original definition of backhaul was to transmit a telephone call or data beyond its normal destination point and then back again in order to utilize available personnel (operators, agents, etc.) or network equipment not available at the destination location. For example, depending on distances and service arrangements, it might be cheaper to send a telephone call on a private line to a location way beyond the destination and then dial up the destination, which is back in the other direction. The term evolved to a more generic meaning and often refers to transmitting from a remote site or network to a central or main site. It implies a high-capacity line; for example, to backhaul from a wireless mesh network to the wired network means aggregating all the traffic on the wireless mesh over one or more high-speed lines to a private network or the Internet.

## GLOSSARY OF TERMS, CON'T

**Bandwidth**
The capacity of a telecom line to carry signals. Bandwidth is both the total frequency spectrum, in Hertz or cycles per second, which is allocated or available to a channel, as well as the amount of data that can be carried by a channel, in bits per second (bps). Also called a "communications pipe".

**Cell site**
Also called a base station, the central radio transmitter/receiver that maintains communications with a mobile telephone with a given range. A cellular network is made up of many cell sites, all connected back to the Mobile Telephone Switching Office (MTSO) via landline or microwave.

**CLEC (Competitive Local Exchange Carrier)**
A telecommunications provider (also known as a "carrier") that competes with other, already established carriers (generally, the incumbent local exchange carrier [ILEC]).

**CPE equipment**
The terminal, equipment, and/or inside wiring located at a subscriber's premises, which are connected to a carrier's communication channel(s) at the interconnection point.

**Data roaming**
Using a wireless phone outside of your service provider's local coverage area or home calling area is referred to as roaming. Roaming arrangements between service providers expand the potential area for phone use. Service providers can charge higher rates for data sent from outside their home calling or coverage area. International roaming means that you can use networks other than your own when traveling abroad.

**Electromagnetic frequencies**
Refers to the part of the electromagnetic spectrum corresponding to radio frequencies—that is, frequencies lower than around 300 GHz (or, equivalently, wavelengths longer than about 1 mm).

**End-users**
Customers who directly use, rather than provide, telecommunications services.

**Ethernet**
A frame-based computer networking technology for local area networks (LANs). The name comes from the physical concept of ether. It defines wiring and signaling for the physical layer, and frame formats and protocols for the Media Access Control (MAC)/data link layer of the OSI model. Ethernet is mostly standardized as IEEEs 802.3.

**Fiber-optic**
Communications technology that uses thin filaments of glass, laser technology or other transparent materials. Fiber optic technology offers extremely high transmission speeds, allowing for data-intensive services such as video-on-demand.

**Frequency range**
The frequency range over which a system is considered to provide a useful level of signal with acceptable distortion characteristics.

**Internet backbone**
The principal data routes between large, strategically interconnected networks and core routers in the Internet. These data routes are hosted by commercial, government, academic, and other high-capacity network centers, the Internet exchange points, and network access points that interchange Internet traffic between countries and continents, and across the oceans of the world.

**Last mile**
The final leg of delivering connectivity from a communications provider to a customer. The phrase is often used by the telecommunications and cable television industries. The actual distance of this leg may be considerably more than a mile, especially in rural areas. Because the last mile of a network to the user is also the first mile from the user to the world in regards to sending data (such as uploading), the term *"first mile"* is sometimes used.

**LEC (Local Exchange Carrier)**
A company (carrier) that provides local (exchange) telephone service.

**LTE (Long Term Evolution technology)**
An all IP wireless broadband technology designed to support roaming Internet access via cell phones and handheld devices. Because LTE offers significant improvements over older cellular communication standards, it is sometimes referred to as a 4G (fourth generation) technology.

**Network core**
The central part of a telecom network that provides various services to customers who are connected by the access network. One of the main functions is to route calls across the PSTN (public switched telephone network).

**Network**
Any connection of two or more computers that enables them to communicate. Networks may include transmission devices, servers, cables, routers, and satellites. The telephone network is the total infrastructure for transmitting phone messages.

**Pipe**
See Bandwidth

**Spectrum**
The range of electromagnetic radio frequencies used in the transmission of voice, data, and video.

**Three-sector configuration**
Standard reach of a cell tower into three sectors, or geographic areas.

**Transport element**
The device, such as a wire or fiber, used to transport a signal from one cell site to another.

**WAN (Wide Area Network)**
An Internet or network that covers an area larger than a single building or campus.

**Warehousing**
The storage, and subsequent shortage, of unused spectrum by large carriers.

**Wireless propagation**
The dispersion of electromagnetic signals through the air or other media from a transmitter.

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**Your business is our business.**

Established in 1962, John Staurulakis, Inc. (JSI) is a full-service consulting firm representing hundreds of independent telecom providers across the nation. JSI's corporate headquarters are in Greenbelt, MD, with regional offices located in Minneapolis, Austin, Atlanta, and Salt Lake City. The firm's founder, John Staurulakis, is recognized as a pioneer in developing the use of company-specific cost studies as the cornerstone of the industry's financial settlements process for the independent telephone companies on which rural Americans have depended for connection to the national network.

For more information on JSI,
see www.jsitel.com

MRL

Monte R. Lee and Company is a Consulting Engineering Firm providing wireless and wireline service to rural communication companies. MRL over the last 33 years has specialized in all facets of Radio Frequency Engineering design for microwave, mobile voice and data, BRS/EBS, FM radio, LPTV and SCADA systems. MRL also offers FTTH, softswitch design, IP and SONET transport, OSP staking and design services for the telephone, video and CATV industries. MRL assists clients with RUS loans, FCC filings and environmental analysis.

For more information on MRL and Company,
see www.mrleng.com

Palmetto™ Engineering & Consulting

Palmetto Engineering & Consulting, LLC. is a professionally licensed consulting firm specializing in telecommunications and electrical engineering. Currently licensed to practice in twenty-two states, PEC provides professional and technical services to the independent telecommunications industry in the areas of inside plant, wireless, outside plant, and facilities mapping & fiber records management. Established in 2007, the firm has eight licensed engineers and over 250 years of key man telecom experience. With its home office in Greenville, SC, the staff of PEC is committed to providing value and custom solutions for independent telcos across the country.

For more information on Palmetto Engineering & Consulting,
see www.palmettoeng.com

Foundation for Rural Service

The Foundation for Rural Service, in cooperation with the National Telecommunications Cooperative Association, seeks to sustain and enhance the quality of life throughout Rural America by advancing an understanding of rural telecommunications issues.

For more information on FRS,
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RTFC

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