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June 19, 2017

VIA ECFS

Marlene H. Dortch, Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, DC 20554

Re: Notice of Ex Parte Presentation, *Connect America Fund*, WC Docket No. 10-90; *Universal Service Reform – Mobility Fund*, WT Docket No. 10-208

Dear Ms. Dortch:

On June 15, 2017, representatives of Mosaik Solutions, LLC ("Mosaik") met with (1) Rachael Bender, Legal Advisor to Chairman Ajit Pai, along with Jay Kaplan and Anthony Patrone, legal interns in Chairman Pai's office; and (2) Daudeline Meme and Claude Aiken, Legal Advisors to Commissioner Mignon Clyburn, to discuss the data the Commission will use to determine the availability of commercial wireless broadband services in the above-referenced proceedings.[1] Attending the meetings on behalf of Mosaik were Bryan Darr, President and CEO; Chip Strange, Vice President, Strategy & Business Development; and Michele C. Farquhar, outside counsel to Mosaik.

During the meetings, Mosaik introduced its network performance data collection and reporting software, Signal Insights, which is well-suited to support potential Mobility Fund II challenges. Mosaik has an array of datasets and data collection software options, but Signal Insights supports the industry with an operationally efficient, simple-to-use solution that will not place undue burdens on those who engage in the Mobility Fund II challenge process. Mosaik provided an overview of metadata that may be collected to determine if mobile broadband networks are available while simultaneously measuring those networks' performance. The attached presentation outlines key aspects of Mosaik's Signal Insights service.

Further, Mosaik urged the FCC to take a more aggressive and aspirational approach to broadband data analysis. Mosaik noted that technologically advanced, cost-effective network testing solutions are available in the private sector to assist the FCC's policy decisions.[2] As we look ahead,

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[1] *See Connect America Fund, Universal Service Reform – Mobility Fund*, Report and Order and Further Notice of Proposed Rulemaking, 32 FCC Rcd 2152 (2017).

[2] *See Ex Parte* Notice from Michele C. Farquhar, Counsel, Mosaik Solutions to Marlene H. Dortch, Secretary, FCC, GN Docket No. 14-28, *et al*. (filed Dec. 7, 2016); *Ex Parte* Presentation from Krista Witanowski, AVP Regulatory Affairs, CTIA, and Elizabeth Barket, Law & Regulatory Counsel, Competitive Carriers Association to Marlene H. Dortch, Secretary, FCC, GN Docket No. 12-264, *et al*. at 1 (filed Aug.

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the FCC should work with and encourage the private sector to provide, in both urban and rural areas, sensor technologies and other advanced solutions to assess the availability and quality of broadband networks. The FCC should demand more from the private market because private-sector companies are best equipped to provide scalable solutions in support of FCC analyses.

At the end of the meeting, Mosaik left behind the attached white paper from the Wireless Infrastructure Association describing how the 49 million Americans living in rural areas would benefit from improved access to mobile wireless broadband service.[3]

Pursuant to Section 1.1206(b) of the Commission's rules, I am filing this letter electronically in the above-referenced dockets. Please contact me directly with any questions.

Respectfully submitted,

Michele C. Farquhar
Partner

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Enclosures (2)

cc (via email):

Rachael Bender
Daudeline Meme
Claude Aiken
Jay Kaplan
Anthony Patrone

10, 2016) ("the Commission's mobile speed testing efforts duplicate far more robust efforts well underway by third parties, each of which gather detailed speed testing data that is more expansive and thorough than the [Mobile Measuring Broadband America]'s results").

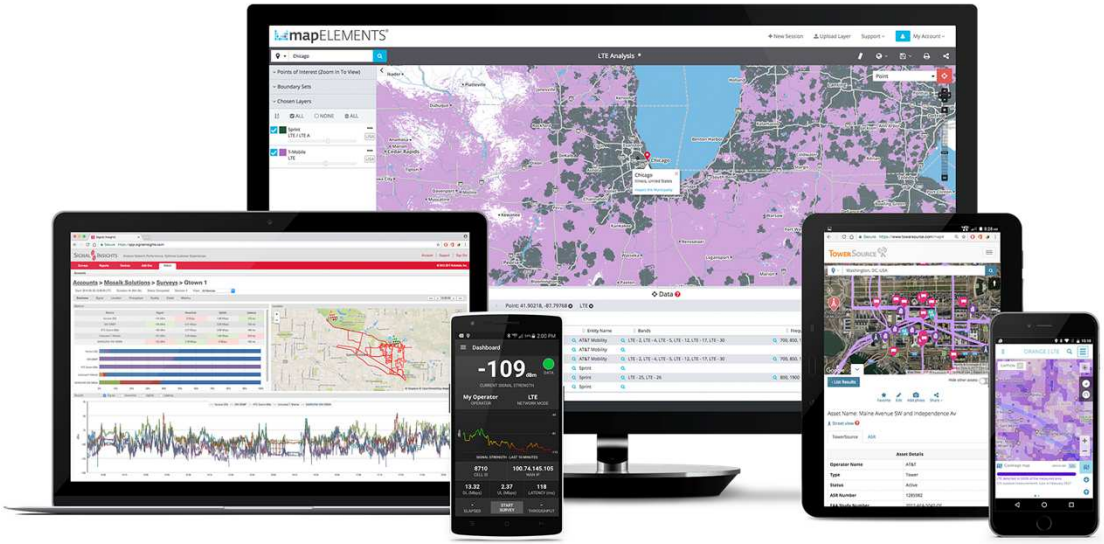
[3] *See* WIRELESS INFRASTRUCTURE ASSOCIATION, RURAL AMERICA: HOW WIRELESS TECHNOLOGIES COULD IMPACT AMERICA'S HEARTLAND CONNECTIVITY FOR PEOPLE, MACHINES AND EVERYTHING ELSE, attached hereto.

Mosaik™

As a strategic partner to mobile operators and network-dependent solution providers, we enable clients to deliver a superior network experience.

Network Experience Solutions

Performance | **Intelligence** | **Visualization**



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Network Experience Solutions Portfolio

Performance

Network QoE ("NetQ")

Visibility into the **Network Experience** from the end-user device. Measure the Network Experience on a large scale with customizable configurations for groups, geographic areas, or equipment types. Integrate with existing mobile apps via SDKs.

Signal Insights

Directly measure **Network Experience** on both cellular and Wi-Fi. Benchmark multiple networks and get test results in near real-time – No post-processing required.

Intelligence

sensorly

Available both on iOS and Android, the Sensorly app is used by consumers all over the world to find the best coverage or the best carrier for them to gain the most optimal **Network Experience**.

CoverageRight™

Gain industry visibility to compare **Network Experiences** expectations against the competition's. This is the most flexible way to consume our global wireless coverage data, including the option of integrating into your internal systems.

mapELEMENTS®

Visualize the wireless landscape from a micro- or macro- POV to determine network expansion opportunities, forge strategic alliances, respond to RFPs and understand customers' **Network Experience** expectations when on the go.

TowerSource

Visualize the U.S. wireless landscape with the addition of infrastructure assets, fiber and coverage to plan your next site acquisition and deployments.

Visualization

cellmaps

Provide consumers with visibility to the **Network Experience**. Be transparent. An effective way to communicate your global wireless footprint.

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SIGNAL INSIGHTS℠

Analyze Network Performance.
Optimize Customer Experiences.

Mosaik

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In Today's Connected World, Experience Matters

With Signal Insights, enterprises can analyze customer experience on cellular or Wi-Fi networks, indoor and outdoor

Test
Perform drive tests, site surveys, or in-building evaluations

Measure
Capture signal and throughput quality KPIs

Benchmark
View results from a single device or benchmark multiple networks

Visualize
View survey data in graphs, charts, and maps

Report
Create rich PDF reports or export all data to CSV

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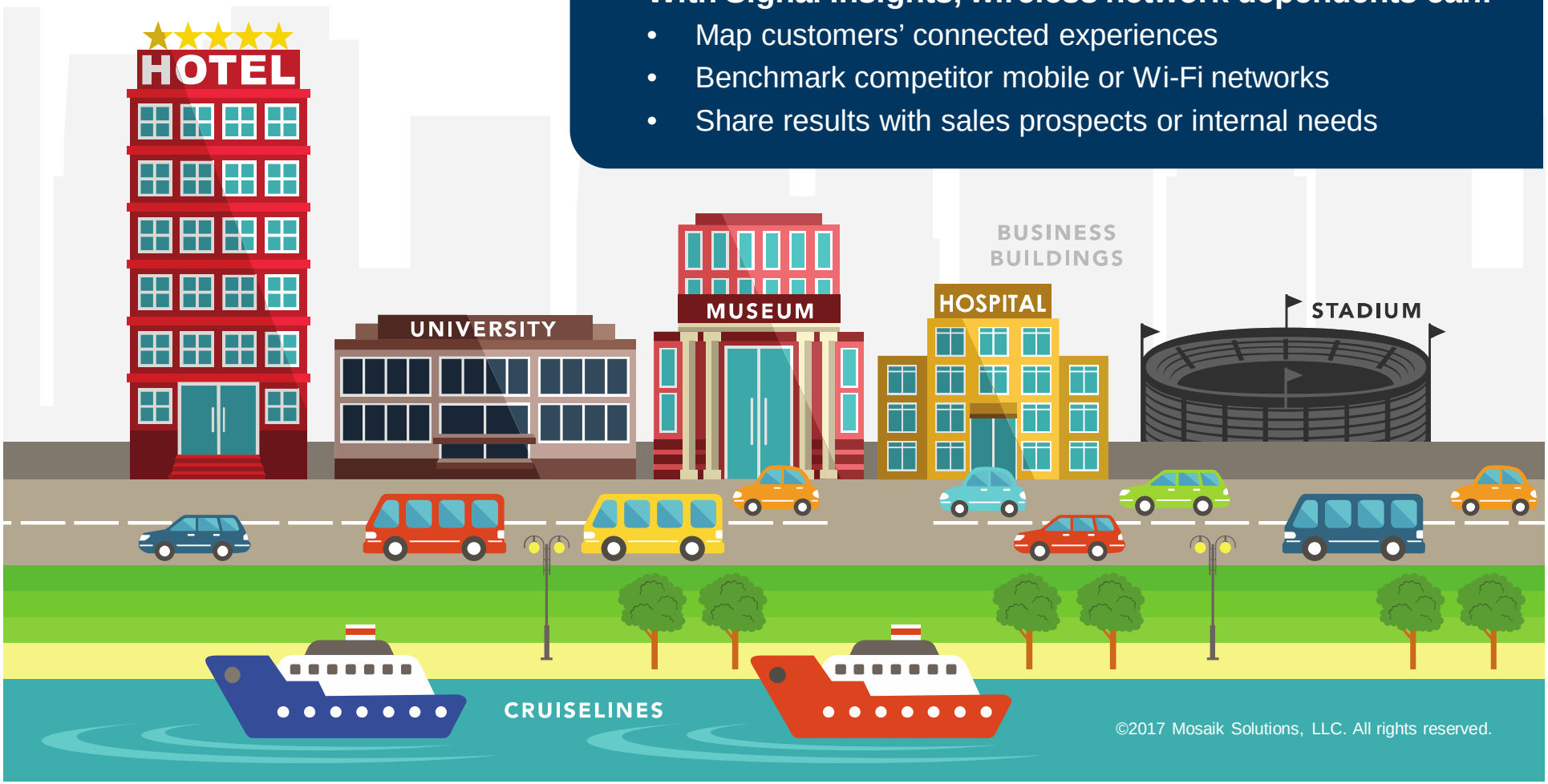
Wireless Network Dependents

Businesses and venues are reliant on quality wireless networks as a part of their operations and customer's overall experience. We call these organizations Wireless Network Dependents.

With Signal Insights, wireless network dependents can:

- Map customers' connected experiences
- Benchmark competitor mobile or Wi-Fi networks
- Share results with sales prospects or internal needs



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Signal Insights = Stronger Challenges

Nearly every comment from the industry supports the utilization of a mobile application-based software solution to evaluate FCC unserved census block results

1

Simple, efficient, cost effective

Fulfills the objectives of providing an independent, cost-effective, operationally efficient solution for determining whether census blocks are served or unserved by mobile broadband networks.

2

Download the app directly from Google Play

Provides a consumer device-based network validation service via an unrooted Android mobile app and synchronize with the Signal Insights Dashboard.

3

Easy to use

Reduces costs by delivering test results and associated KPIs in near real-time to the dashboard, while ensuring you have the best information to determine whether you should challenge.

4

No post-processing required

Download reports from the dashboard and limit the operational overhead required by the challenge process.

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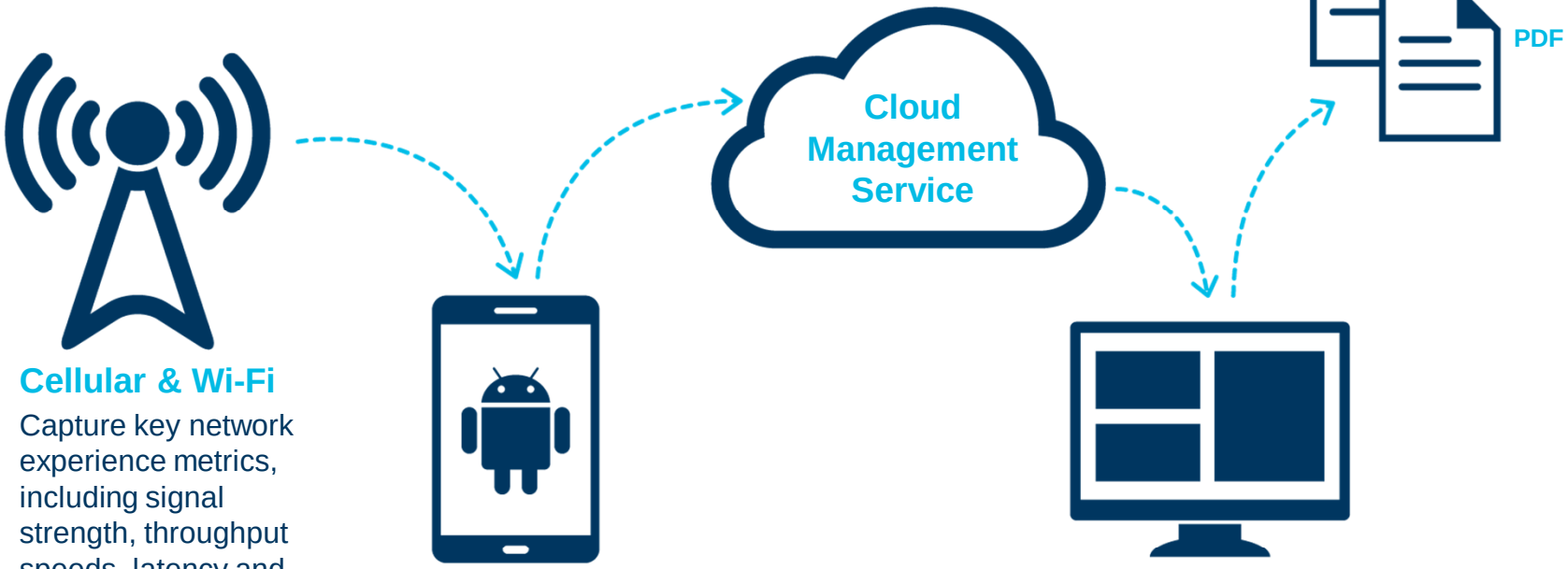
How it Works

No Complicated Software.
No Expensive Hardware.



Report Export
Built-in reporting capabilities allow users to export data into file formats to support FCC filing requirements

Cellular & Wi-Fi
Capture key network experience metrics, including signal strength, throughput speeds, latency and quality

App For Android
Data gathered by Signal Insights app is securely uploaded to the cloud near real-time

Analytics for Cloud
Users can view and analyze the data in a web-based interactive dashboard

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Network Metrics Collected

Signal Insights provides key network performance information throughout each survey

Network Type
LTE, UMTS, HSPA, HSPA+, 1xEV-DO, W-Fi

Network Identification
MCC, MNC, CID, LAC

Signal Connection
dBm, RSSI, RSRP, ECIO, SNR

Data Connection
Downlink, Uplink, Latency, Packet Loss, Jitter

Other
Time Stamp, Notes, Number of Samples

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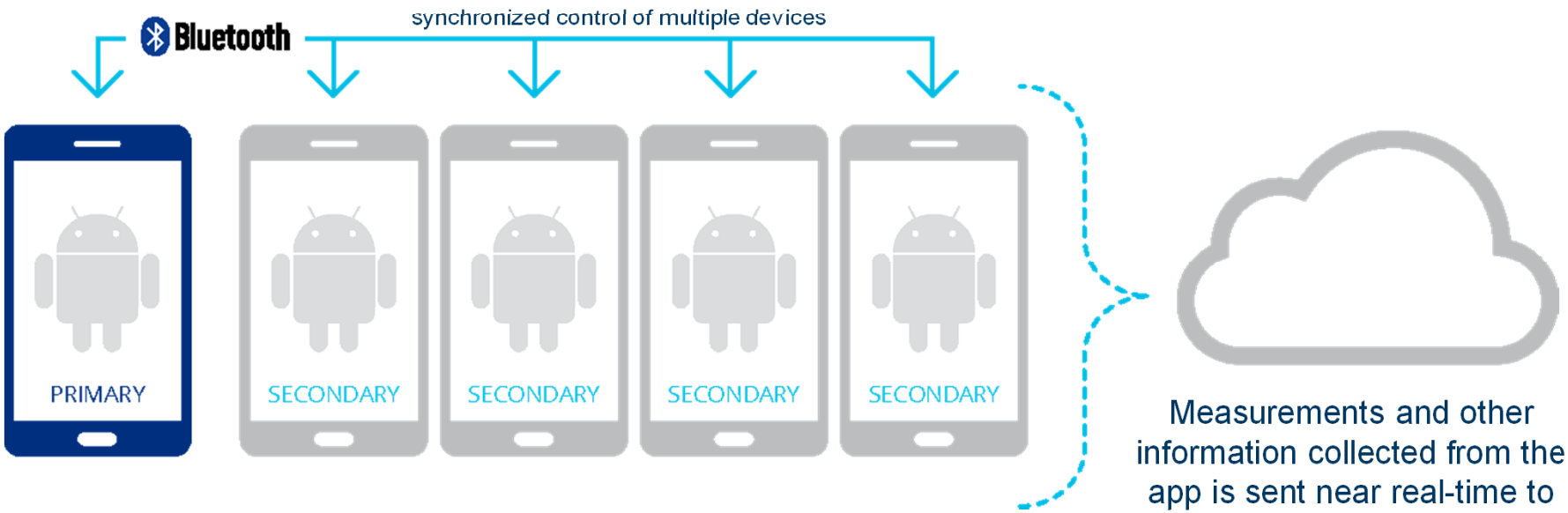
Benchmarking

Measure multiple networks concurrently using several Android devices



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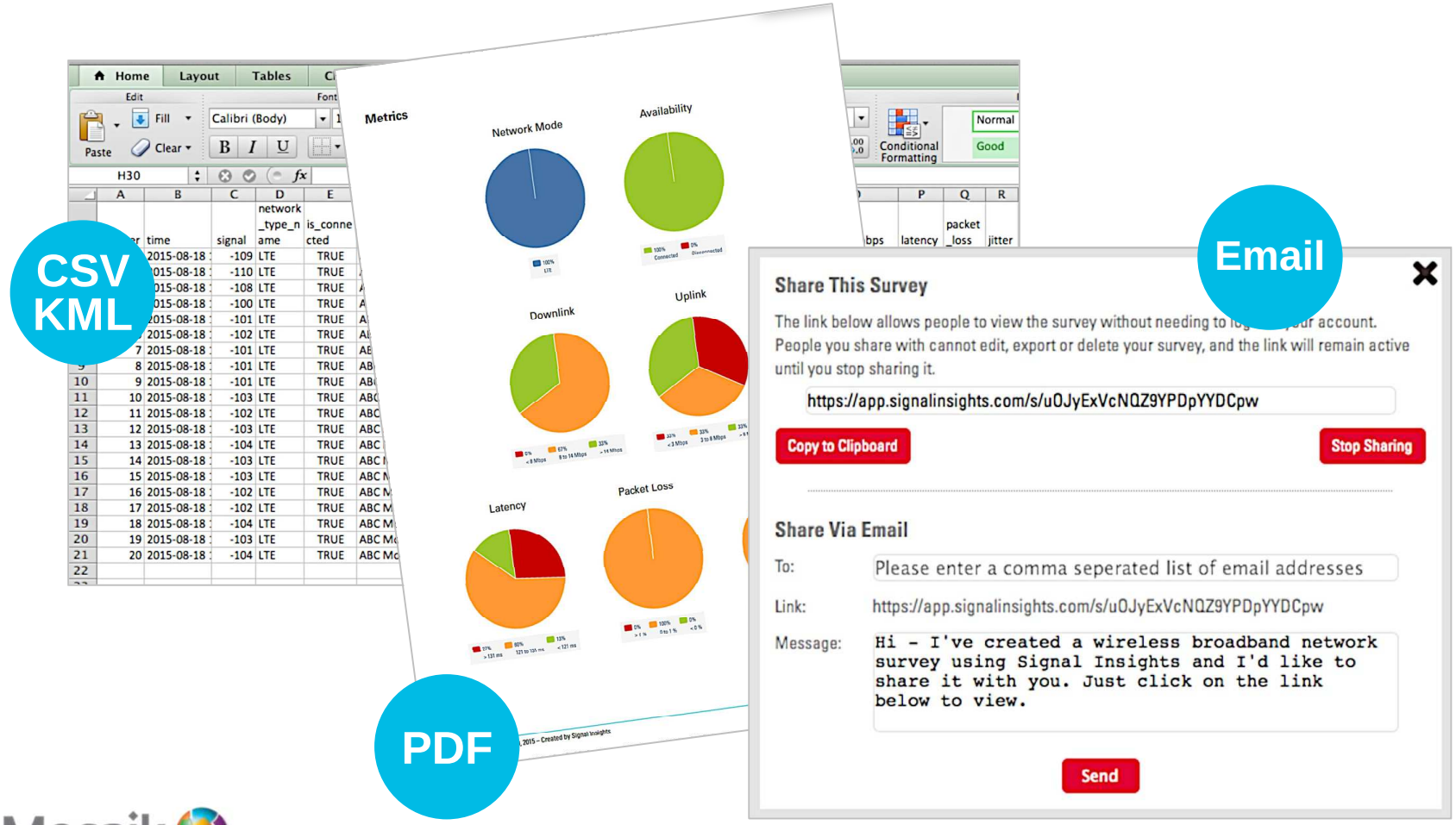
Report & Share

***PDF** – Easily download pre-packaged reports*
***CSV and KML** – Quickly share directly from Signal Insights to efficiently support FCC filing requirements*



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Signal Insights | Features Summary

- Android mobile application easily distributable to field-based personnel
- A fixed number of surveys with a maximum duration of 60 minutes
- Test results viewable in near real-time with a web-based dashboard featuring data visualization, mapping and KPIs
- .CSV and .KML data download capability
- Pre-packaged PDF Downloaded Reports
- Centrally controlled data outputs that may be restricted from personnel if needed
- Points of Interest (POI) Upload enabled

A Mosaik MFII kit may include national operators' devices and battery backups – lease or purchase options are available

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Rural America: How Wireless Technologies Could Impact America's Heartland

Connectivity for People, Machines and Everything Else

Wireless Infrastructure Association

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Rural America: How Wireless Technologies Could Impact America's Heartland Connectivity for People, Machines and Everything Else

This white paper is meant to be an educational tool and does not reflect Wireless Infrastructure Association policy.

Abstract

The United States relies on the 49 million Americans living in rural areas for most of its food, energy and water.[1] Yet while most Americans benefit from today's advanced wireless networks that allow them easy access to their community and content, the most advanced technologies have not been widely deployed in rural communities. It is difficult for mobile operators to justify the low Return on Investment (ROI) based on the number of people living in those communities with so many demands elsewhere on limited capital budgets. Connectivity will allow rural communities to realize the many benefits of the Internet of Things—enabling farmers to further advance precision farming, bringing healthcare advances to rural communities, and empowering local businesses to better compete with their urban counterparts. Everything is better with added connectivity. With increased wireless access, Americans living in rural areas would realize the same benefits of broadband services as the rest of the nation, including public-safety advancements such as the ability to call 911 and be assured that the call will be connected to their Public Safety Answering Points (PSAPs). This report explores initiatives that can influence how wireless infrastructure can be deployed in rural America.

Introduction

Over the past several decades, technological innovations have been catalysts for tremendous positive changes in the world, impacting every aspect of people's daily lives. The Internet, mobile communications, social media, smartphones, and many other inventions have brought access to instant information and communications to the highest levels in human history.

While almost everyone recognizes the critical role of these technology evolutions, the fact remains that like any other invention, there are substantial costs and expectations of ROI tied to deploying these services and solutions. As such, the digital revolution has led to a digital divide. While residents of almost all major metropolitan areas have experienced the full benefits of the digital revolution, the lack of availability of these services in rural areas has left too many of those living and working in such locations behind and excluded from the progress that most people in major cities have come to take for granted.

These benefits are no longer nice-to-have services, but are part of the fabric of society. Moving forward, fifth-generation (5G) technology deployments will increase the chasm dividing networks in rural and urban areas. Indeed, in its report "The 5G economy: How 5G technology will contribute to the global economy," IHS Economics & IHS Technology note that 5G deployments are part of an "elite class of socio-economic mainsprings known as General Purpose Technologies (GPTs)."[2] When pervasively adopted around the globe, these technologies redefine work processes and rewrite the rules of competitive economic advantage. Other game-changing technologies of the past included the printing press, electricity and the steam engine, IHS noted.

The ensuing content in this report is designed to provoke and invite further actionable thoughts and ideas to cut through this digital divide to provide true ubiquitous access to broadband services for all U.S. citizens. While advanced wireless networks have a ubiquitous impact on all facets of society and business, this report will focus on its potential impact on public safety, agriculture, healthcare, the automotive industry and general productivity.

The State of Connectivity in Rural America Today

The digital divide between rural and urban areas is well known and documented, and is at risk of becoming a wider gap going forward. Data shows that unemployment is higher where broadband adoption is lowest. Household income suffers, along with education rates.[3]

Through the years, the federal government has launched programs to try to close this gap. The Universal Service Fund (USF) is the umbrella program aimed at providing universal connectivity services, including the Connect America Fund,[4] which includes Mobility Fund initiatives, aimed at getting mobile connectivity to more Americans. The results of these efforts have been mixed. As government continues to try to improve these programs, it has recognized technology advances. For example, the Federal Communication Commission requirements for fixed broadband speed have increased as a prerequisite for funding assistance. About 15 years ago, the requirement for broadband connectivity was 200 kilobits per second (kbps) in at least one direction. In 2015, the FCC increased the threshold for fixed broadband to mean download speeds of at least 25 megabits per second (Mbps) and upload speeds of at least 3 Mbps.[5] In February 2017, the FCC's Mobility Fund II order specifies that participating carriers must be willing to provide mobile service with median speeds of 10 Mbps download and 1 Mbps upload.

The FCC continues to try to address how to get more rural Americans broadband access.

In April 2017, FCC Chairman Ajit Pai announced plans to reduce Title II regulatory burdens that have stifled broadband investment in rural communities, among other areas. "When businesses cut back on capital expenditures, the areas that provide the most marginal returns on investment are the first to go. And in the case of broadband, that means low-income rural and urban neighborhoods. As a result, Title II has kept countless consumers from getting better Internet access or getting access, period. It is widening the digital divide in our country and accentuating the practice of digital redlining—of fencing off lower-income neighborhoods on the map and saying, "It's not worth the time and money to deploy there."[6]

If getting broadband connectivity to rural underserved Americans had an easy solution, it would be resolved by now. Rather, it is a dilemma with several prongs. First, distance matters. Copper does not scale over a few miles, and speeds degrade as the distance increases. Rural areas that get some sort of copper broadband connectivity likely must rely on it for a long period, often until federal subsidies such as universal service, Rural Utility Services (RUS) grants or stimulus funds enable fiber buildout. As the world's communications backbone gets faster over time, copper-based networks will become slower by comparison. Future programs should not place a band-aid on outdated networks but rather provide the impetus for scalable fiber and other advanced infrastructure.

However, technological advancements may be able to bridge the digital divide. While years ago the cost of deploying broadband services would have been prohibitive, today's various delivery-technology solutions make broadband deployment more feasible. The expansion of fiber networks combined with the existing Wi-Fi and cellular network services – and even the potential launch of new low-earth orbiting satellite constellations for broadband services – provide more options to make the goal of deploying additional broadband services to rural areas a reality during the next several years.

Lack of Coverage, Lack of Data

Although there is consensus that rural broadband connectivity is lacking, determining where dead spots exist is another source of frustration. Existing data that has been compiled by available sources is dated and largely lacking the detail necessary to establish policy decisions required to rectify rural connectivity issues. The problem is well known but not specifically defined.

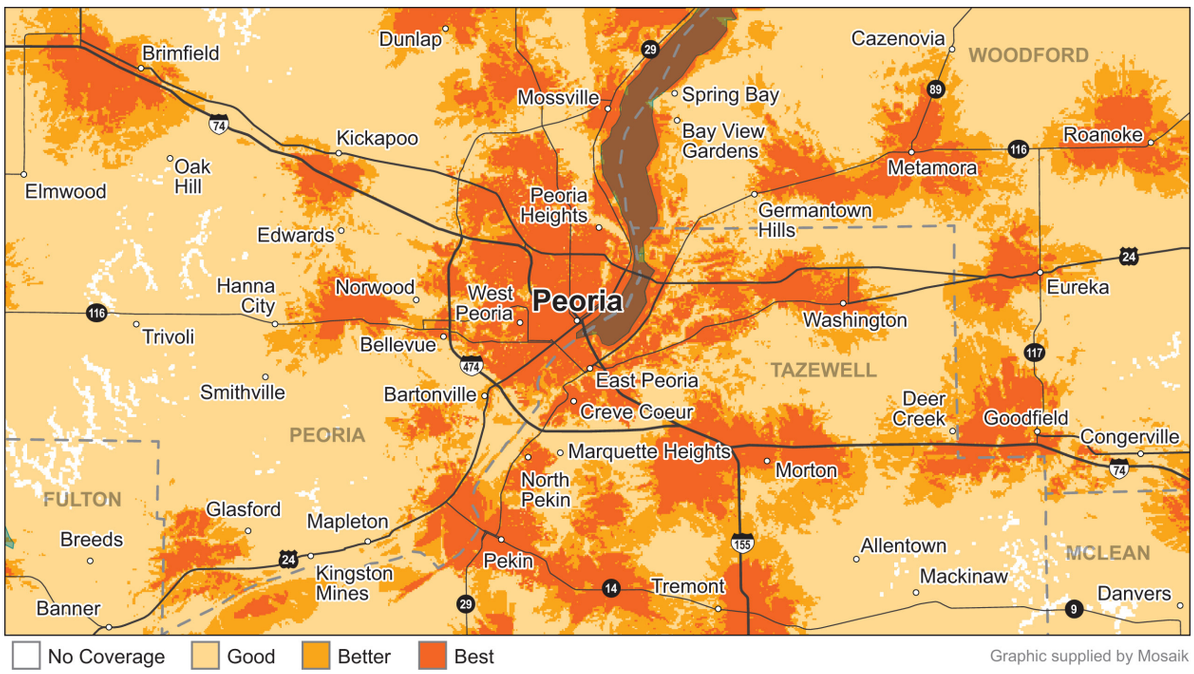
In February 2017, the FCC adopted an order establishing Phase II of the Mobility Fund.[7] This fund will provide $453 million per year for the next 10 years to support the expansion and preservation of wireless broadband services into unserved areas. Of the yearly total, $34 million will be earmarked for deployment of services to Tribal lands. The number of people ultimately served by Phase I of the Mobility Fund fell far short of the program's original intentions. There is keen interest in Washington to make certain that the dollars spent on Mobility Fund II go to areas where they will accomplish the most.

In preparation for this expanded federal program, on March 21, 2017, the House Subcommittee on Communications and Technology held a hearing entitled "Broadband: Deploying America's 21st Century Infrastructure." The purpose of the hearing was "to discuss barriers at the federal level that hinder private-sector investment in broadband infrastructure and to examine legislation intended to remove these barriers. Additionally, the Subcommittee will discuss the challenges of collecting, aggregating, and making available accurate data relating to the availability of broadband service across the United States."[8]

During the hearing, there was a clear recognition that wireless coverage in many areas, particularly rural areas, is inadequate to the task of providing throughput speeds high enough to be defined as mobile broadband. Subcommittee members also recognized that the federal government needs more and better data to make the best decisions. A significant challenge to this process is the lack of industry consensus for measuring the quality of existing network deployments to ensure that federal subsidies are spent wisely.

Seven people were invited to speak, including Ted Carlson, Chairman of United States Cellular Corporation. In his testimony, he suggested that a minimum signal strength standard of -85 dBm (decibel in reference to 1 milliwatt) be set to define where an LTE network could effectively deliver broadband services to subscribers. A signal strength of -85 dBm commonly (but not always) represents the mid-range of what many operators use to represent the "better" coverage when they represent their network with a "good, better, and best" footprint.

In the map shown below, an unnamed wireless operator uses the middle shade of orange to represent this "better" coverage. Not surprisingly, the highest concentration of the "best" coverage, is in the most densely populated community of Peoria, Illinois. The "better" or mid-range service extends the network to the next level. Note that in more rural areas, the mid-range coverage would extend the defined broadband area further than within the urban area. Rural transmit power is typically higher as there is greater distance between neighboring sites.



Graphic supplied by Mosaik

Should the FCC adopt this typical second-tier pattern as the minimum defined broadband service, it should be noted that there is almost as much area in the lightest orange (good) and white (no coverage) as there is within the two strongest signal patterns. Of course, only one operator is shown in this example and no two network patterns are identical.

Indeed, much of the country that may have been thought of as being adequately covered may no longer be looked upon that way. Peoria is one of the largest cities in Illinois. The 2010 U.S. Census found the Peoria Metropolitan Statistical Area (MSA) to have a population of 373,590. That is more than half of the entire population of Wyoming. Yet, as noted in the example map above, one can see that throughout this section of Illinois, wireless customers living in and traveling to neighboring rural communities do not have access to wireless broadband with this particular carrier.

LTE Without Speed Is Not Broadband

LTE is a wireless communications standard but LTE coverage does not, by itself, provide the kinds of speeds expected from a mobile broadband connection. Most U.S. wireless operators have launched 4G LTE over a significant part of their existing footprint. Signal strength is usually where the coverage conversation begins, but many other factors can impact throughput speed. Network congestion can slow speeds significantly in areas where the signal may be quite strong. Population density, time of day, available spectrum, and carrier aggregation all can play a part in a network's metrics. Access to fiber at each cell site is necessary to sustain a high-speed connection; otherwise it is like putting a Volkswagen engine in a Porsche. It may look great, but stepping on the pedal brings nothing but disappointment.

The FCC's February Mobility Fund II order specifies that participating carriers must be willing to provide mobile service with median speeds of 10 Mbps download and 1 Mbps upload. The order also specifies the median latency should be less than 100 milliseconds. Census blocks currently not covered with a minimum advertised download speed of 5 Mbps will be eligible for the program. A defined decibel level will assist in identifying likely areas of concern, but it cannot predict what speed will be experienced there.

The Need for Empirical Data

Operators rely upon radiofrequency (RF) propagation modeling to design and engineer their networks but depend upon measurements taken from the field to judge a network's performance. Drive-testing with equipment capable of analyzing the quality of that network has been an important part of the process to ensure that it is performing as expected.

If federal dollars are used to subsidize network expansion, the federal entity providing those funds must be provided with empirical data, not just theoretical RF propagation maps, to ensure that the taxpayers are receiving proper value for their investment. The challenge here is that the cost of driving through rural America is often economically unfeasible. In some instances, the cost of drive-testing a subsidized area may even exceed the subsidy offered by the federal government.

There has been much discussion of crowd-sourced data being able to fill the gap. Data that can provide trends and averages can be extremely valuable to operators allowing them deeper visibility into how their networks perform over time. Drive-testing provides only one moment in time, a snapshot, of each location tested. With crowd-sourced data, carriers could accurately benchmark their signal levels against their competitors as data can be gathered across all networks. However, crowd-sourced speed test data is unreliable because it is not random. Wireless users typically launch speed tests when they are experiencing a problem with throughput. That provides an unfair and inaccurate view of how a network is performing overall. This type of testing is valuable to carriers troubleshooting problem areas, but it should never be used by regulators to judge whether an operator is providing a given average level of service.

Ultimately, the experience of those individuals and companies paying for use of the network should determine whether they are receiving the level of service for which they have paid. Collecting performance data from consumer devices in the background is one method. But many rural areas may still not generate enough data to provide the necessary volume and geographic scope to file the documentation needed to validate subsidized infrastructure. To avoid the expense of drive-testing, operators must be proactive to ensure that some portion of the already small number of devices traveling these rural areas are capturing as much data as possible. In addition, regulatory authorities, such as the FCC, must be willing to work with the operator community to embrace newer data-gathering technologies and methods to accomplish their shared goals.

A Vision of the Impact Wireless Infrastructure Could Have on Public Safety, Farming, Healthcare and More

Education, agriculture, online training, health services, financial services, news and information, security, and many other vital tasks and services are now delivered through fixed and mobile broadband wireless communication networks whether using Wi-Fi or via a commercial cellular carrier's network.

As the economy continues to evolve, like their urban counterparts, people in rural areas will need retraining and should be able to upgrade their educational and vocational skills to keep up with changing times and source new-economy jobs that will sustain them and their families.

Public Safety

As the digital divide segments the population into those with robust wireless service and those without, the reality is that lack of robust infrastructure can lead to a significant disparity of available emergency services for rural residents. Without significant investment in rural wireless connectivity, this disparity will only widen with the near-term public-safety benefits of 5G wireless technology. Difficulties with indoor coverage are not limited to the big city. People in rural areas with poor signal strength are at heightened risk if their phones do not work inside their homes or other structures.

Society has embraced cellular connectivity for public safety. Over the past decade, the percentage of 911 calls made via wireless devices has increased compared to those made on landline phones every year. About 80 percent of consumers used cellular phones to make 911 calls, according to 2015 data from reporting states, while about 16 percent used wireline phones. This is similar to 2014 data, which showed that 76 percent of consumers used cellular phones to make 911 calls and about 21 percent used wireline phones. Furthermore, Voice over Internet Protocol (VoIP), Multi-Line Telephone Systems (MLT), and text-to-911 are being used in increasing volumes. Wireline phones were the only method of emergency contact that decreased in usage volume from 2014 to 2015.[9]

Because the overwhelming majority of Americans rely on wireless networks to contact public-safety personnel, it will be critical for people living in rural areas to have the wireless infrastructure necessary for next-generation emergency services to function. In addition to basic emergency services requested today via wireless devices (ambulance requests, police and fire calls, traffic accidents, reports of criminal activity, etc.) the future of wireless technology will provide a more robust suite of emergency services and safety features. 5G cellular technology will be able to provide enhanced location-based services for indoor 911 calls, where most 911 calls originate. Software providers and equipment companies are developing solutions that aim to provide for an accuracy of two meters from a caller's location, including height location for calls made from high-rise buildings.[10] Next-generation network solutions also will provide a more robust coverage footprint versus current Global Positioning System (GPS) protocols as well as a lower latency time to help provide exact caller location. These solutions will be vital in improving location-based accuracy for first-responders, therefore dramatically improving response time during life-threatening situations.

In addition to location-based services to improve emergency response time, 5G advancements also will enable enhanced communication between first responders and emergency service personnel providing information to their coworkers at the scene. 5G will provide the technology for significant amounts of data to be transferred at low latency and high quality. The first responders to an emergency can have wireless access to building drawings or other critical information within seconds of a request. It also will allow first responders to send back video or pictures via helmet cameras or other wireless devices to personnel at command centers who are organizing ground efforts and working to coordinate resources and ensure emergency personnel safety.

Healthcare

In ambulance-based telemedicine, time is a critical component in achieving successful outcomes in life-threatening situations. Next-generation EMT services will use mobile communications technology, aimed at providing a significant time advantage, expediting critical treatment, and improving patient outcomes. Vital signs of patients being transported by ambulance can be measured and transmitted to the hospital instantly via a wireless network, and videos taken by digital cameras installed in the ambulance can be sent to the hospital in real-time. While the patient is in transport, emergency room doctors and nurses can receive and review the incoming data and assess the patient's condition while directing the EMTs toward the best course of action for that patient. Hospital staff can prepare for surgery prior to arrival or direct an ambulance or medivac helicopter to a more suitable hospital for the patient's condition. For many common life-threatening situations (heart failure, stroke) time is of the essence and wireless connectivity will be critical to all patients receiving the best care possible. This connectivity for information exchange between the EMTs and hospital staff is especially critical for residents in remote areas who are, many times, long distances from hospitals and clinics. Residents benefitting from these advancements will only be possible with robust connectivity in all areas of the country.

Remote Monitoring, Wearable Sensors and Tracking Services

Remote health monitoring systems are commercially available for several illnesses that have medication schedules and identifiable symptoms. This includes some major common illnesses such as heart disease, diabetes, and asthma. The system can be a medical device, such as a scale, blood pressure cuff, or fingertip-oxygen meter, and wireless connectivity enabled in the patient's home. The devices collect patient information and send the data to the doctor. The doctor can adjust the patient's treatments based on data received. Remote monitoring mitigates the inconvenience and expense of an office visit, not to mention trips to the hospital or emergency room.

Since 2012, Vidant Health, a network of medical facilities in North Carolina, has used remote monitoring for hundreds of patients with illnesses such as congestive heart failure, high blood pressure, and diabetes. In that time, hospital readmission rates have fallen 74 percent for those patients using remote monitoring because doctors are often able to adjust doses or recommend physical activities.[11] Proactive monitoring helps to prevent additional medical issues, assuming the patient is compliant.

Remote monitoring is especially important for seniors who may have mobility issues or live alone. Wearable gadgets can now report vital signs to a health center, which can warn patients of potential health risks. Going forward, doctors could be able to perform minor procedures from remote location by using medical robots and the 5G network.

In addition to remote monitoring, many hospitals are also using wireless technology to improve patient care, operational efficiency, safety, and regulatory compliance. Many hospitals have implemented radiofrequency identification (RFID) tags to help operate their businesses and improve patient outcomes. These RFID tags work in conjunction with the hospital's third-party or proprietary wireless systems and can provide machine-to-machine (or Internet of Things) connections as well as tremendous amounts of critical data for patient care and operations. This cutting-edge wireless technology is used to track nurse workload and efficiency, locate and track expensive and specialized medical equipment, provide location and accurate data for drug reporting requirements, ensure hygiene protocols are met, and to prevent child abductions via wireless infant protection systems. Hospitals without these wireless advances will be behind in operational improvements and patient results.

The ability to deploy any of these remarkable technologies completely depends on seamless and a dense wireless network to retrieve and send the data.

Automotive Industry

The automotive industry also continues to use wireless technology to improve passenger safety in the United States. Increasingly, automobile manufacturers are installing automatic crash notification (ACN) as a safety feature in their vehicles.[12] When an incident occurs in a vehicle equipped with ACN (for example, an airbag deploys), the system can send an instant notification to an operator, who then will try to contact the driver. If no one in the vehicle responds, the operator will notify 911. Many car manufacturers offer some level of ACN services, often using Bluetooth-enabled handsets to sync the vehicle to the ACN notification system.

The National Highway Traffic Safety Administration (NHTSA) said ACN systems can reduce death and disability by decreasing the time it takes for Emergency Medical Services personnel to arrive at a crash scene. "ACN is especially beneficial to crash victims in rural areas, where there are typically fewer or no witnesses to call emergency responders," NTSHA noted.

These advancements are available in the near-term, but only possible with robust cellular coverage in all areas of the country. As technology improves, the future of wireless connectivity to improve public safety is limitless. However, until programs and investments are established that provide wireless coverage in rural areas, many residents will not be able to benefit from this progress.

Agriculture

While nearly every industry segment will benefit from broadband access, one industry that can be revolutionized by connectivity in rural America is the Agriculture industry.

Precision agriculture uses information and technology to manage site-specific inputs to reduce cost and increase yields for maximum profitability, as well as for improved sustainability and environmental protection. Precision agriculture relies on GPS and geospatial data techniques for reducing inputs and increasing outputs, resulting in increased productivity to allow producers to feed more people using the same amount of land and export U.S. agriculture around the globe. Improvements in yields benefit consumers of goods produced on croplands, while improvements in chemical applications benefit the environment.

Both high-accuracy positioning and broadband connectivity are becoming integral components of daily agricultural operations in the U.S. and globally. These technologies are revolutionizing agriculture by improving productivity, minimizing input usage in the field, and reducing fuel usage and costs. Without the infrastructure necessary to deploy these critical technologies more widely, U.S. agriculture will fall short of its potential to feed, fuel, and clothe growing global populations in the years ahead.

Modern agricultural operations increasingly require high-speed broadband in the nation's rural areas, and other areas of agricultural activity. Enabling farmers to use machine-to-machine data fully requires significant improved communications capacity and access to high-speed mobile broadband. However, today many farmers face a lack of cellular coverage in the fields where agricultural machines work. The lack of coverage needed for these solutions to transmit data from the machines is already a concern, but will grow as data volumes increase.

Farming is the lifeblood of rural communities and does not exist without people to support and tend to it, such as in:

- Planning (agronomists, co-ops, landlords, hired hands);
- Planting (seed suppliers, plow and tillage equipment);
- Protecting (insecticides, herbicides, and fertilizing); and
- Production (contracting combines, grain storage, transport, and milling).

Modern Farming

High-quality mobile broadband connectivity in cropland is important to ensure ongoing U.S. leadership in precision agriculture to feed the growing U.S. and world population. The U.S. population is projected to reach 417 million in the year 2060, an increase from 319 million today. Worldwide, farmers must double the food supply in the next 40 years, and do so in a sustainable manner if we are to feed tomorrow's global citizens. Modern farming using machines-with-modems involve an operator who is communicating separately by cellphone and often using a tablet in the machine's cab.

Production agriculture does not exist in urban or suburban areas where mobile broadband coverage tends to be focused, because it cannot. Rather, farms are captive to the geographies, soils, climate, water, and available land required for growing food. Agriculture happens where the geology and climate are favorable, not where other business factors or broadband conditions are favorable. Farms cannot move to areas of better broadband coverage; mobile broadband must move to farms, where people live, work, and grow crops. Farms and fields can be dependent on whatever public infrastructure is made available to croplands.

Telematics Solutions

Much of the future of enhanced farming efficiency and productivity turns on the grower's ability to gather, process, and transmit data using advanced information and communications technologies. Wireless broadband service is a necessary technology (in addition to fixed broadband) to achieve cost-effective coverage for farm-intensive rural areas with significant tracts of cropland. These data-gathering and data-transmitting processes, better known as telematics systems, use machine-to-machine and machine-to-network data transmission systems. Technology-equipped machine solutions enable agronomic decision-making to advance productivity, improve producer profitability and global competitiveness, and optimize inputs for continuous environmental improvement.

As machine populations continue to grow and farmers look to technology solutions that require real-time, high-speed machine connections, the demand and reliance on rural broadband will increase. Bringing wireless broadband connectivity to cropland will provide farmers the ability to make real-time data transfers and design prescriptions that minimize the amount of necessary seed, fertilizer, and pesticides; reduce costs for fuel, labor, water; and dynamically identify best practices for fields in each location. With superior, precise, site-specific data, a farmer can analyze and carefully adjust farming practices to be the as efficient, economic, and environmentally friendly as possible, thus improving productivity and sustainability.

In this regard, Darrington Seward, Managing Partner, Seward and Son Planting Company, explained to the Senate Subcommittee on Communications that his family farm could not manage their 22,000 acres of cotton, corn, soybeans and rice productively or profitably without extensive use of precision agriculture technologies.[13] Mr. Seward receives information wirelessly from tractors, sprayers, combines, cotton pickers, and fuel trucks that are essential to day-to-day operations. Machines that cannot send or receive data wirelessly are unable to capture the productivity gains and cost savings that innovative technologies provide.

Mr. Seward also explained how precision agriculture allows farmers to deploy "variable rate nutrient application to deliver in each part of the field the exact amount of nutrients called for." As a recent *New York Times* article recognized, using "location-specific information about soil nutrients, moisture, and productivity of the previous year, new tools, known as 'variable rate applicators,' can put fertilizer only on those areas of the field that need it (which may reduce nitrogen runoff into waterways)."[14]

These techniques are also key to environmental sustainability and responsible stewardship of rural lands and waters. The economic impact of today's agriculture technologies is significant. According to recent reports, data-driven decisions about irrigation, fertilization, and harvesting can increase corn farm profitability by $5 to $100 per acre, and a 6-month pilot study found precision agriculture improved overall crop productivity by 15 percent.[15] But significant portions of rural areas do not have the same access to wireless broadband and therefore are being denied the full benefits that modem agricultural technology makes possible. Without wireless broadband on croplands, the significant public benefits of increased yield and decreased environmental impacts cannot be realized.

Federal efforts to bridge digital divide

The urgent need to address this shortfall was expressed in a July 2016 letter to former FCC Chairman Tom Wheeler by U.S. Senators Roger Wicker (R-Miss.) and Joe Manchin (D-W.Va.), and a bipartisan group of 24 other senators representing states with significant rural areas and in which agriculture is a major generator of economic activity.[16] Those 26 senators joined in highlighting the growing unmet demand, and urged the FCC to do more to address the needs of rural Americans in the agricultural sector for high-speed broadband, including particularly mobile services, stating:

> Croplands and ranch lands have lagged behind in adequate mobile coverage, even as demand for coverage has grown. To address this coverage gap, we urge you to consider a metric of broadband access in croplands (and farm buildings), or some other geographic measurement, in addition to road miles, to identify these areas of greatest need. "Cropland" coverage can be assessed using United States Department of Agriculture data for crop operations, the United States Geological Survey's Land Use classification, or other databases.

For many Americans in rural America, work is closely tied with the agricultural sector; specifically, for farm owners and workers, the areas with a need for wireless coverage are croplands.

The Universal Service Fund (USF)

The statutory principles that govern the FCC's USF include 47 U.S.C. § 254(b)(2), which states that "access to advanced telecommunications and information service should be provided in all regions of the Nation."[17] Just as consumers living in urban areas enjoy 4G LTE coverage where they live and work, so too should rural citizens have access to 4G LTE coverage where they live and work.

Beyond people, industries will benefit from broader advanced communications as well. Precision agriculture depends on stable, reliable high-speed connections to equipment operating in remote locations. Although there have been small pockets of success for those few customers with the financial and other resources to create and maintain their own infrastructure, high-powered, macrocell-based LTE continues to be the only technology that provides the bandwidth, reliability, and affordability that are required by today's farmers.

Other Industries

Local governments benefit from increased broadband access for many of the same reasons described above, such as improving communications and efficiency in their own workforce. The Brookings Institution has estimated that "for every 1 percentage point increase in broadband penetration in a state, employment is projected to increase by 0.2 to 0.3 percent per year."[18]

Rural broadband services improve education opportunities in many of the same ways as healthcare. By connecting rural schools to remote classes via telepresence, additional subjects can be taught cost-effectively and schools can expand the scope of existing class offerings. Classes from metro community colleges, online universities, and conventional universities can be available to rural communities through broadband. For example, Starbucks recently announced a program to offer free online classes from Arizona State University to its employees throughout the country — a program that rural Americans could take advantage of, provided their community has sufficient broadband availability. Finally, the availability of broadband Internet service improves student test scores and engagement.[19]

Remote worker training via improved broadband connectivity would enable companies to train workers without the need to travel to a metro area office or facility. Further, companies can conduct online training classes, increasing remote worker engagement and improving workplace efficiencies. Indeed, the benefits of increased broadband availability in rural markets go- far beyond agriculture — it is needed to maintain quality of life and increase economic opportunities in rural areas. As society finds more ways to use — and benefit from — broadband connectivity, the need to provide the same level of service to rural communities will increase.

Available and Soon-to-be Available Technology Solutions that can Aid Rural Broadband Deployments

As indicated earlier in this report, enhancing broadband services in rural areas is not necessarily a technological issue, but rather a business challenge. With that in mind, several recent technology advances have made the business case for deployment of broadband services in rural areas more feasible. Some of these options are highlighted below:

- While traditional wireless networks initially were designed and deployed to cover roads and vehicular traffic (then pedestrian and ultimately indoor connectivity), current data usage patterns indicate it would be more feasible to provide fixed mobile broadband services in rural areas – first to indoor locations and then outward toward a macro network once traffic increases. Some mobile operators are delivering fixed wireless broadband services that eliminate the need for last-mile fiber runs and fiber-to-the-home requirements in these less-dense areas. Long-term plans call for using 28 GHz – 33 GHz spectrum for line-of-sight fixed wireless services.
- Another option could be deployment of small cells inside these indoor locations with a combination of microwave backhaul solutions to eliminate the need for delivering fiber to each location. Microwave backhaul links could be aggregated at a point-of-presence and from there hauled back to a carrier's core network. Several non-line-of-sight backhaul platforms are under development, which could make this approach feasible in the near future.
- A third option, which would require a significant effort to foster collaboration between several major competing companies, would be to design and deploy a shared, neutral-host network. Such a network initially could be designed, deployed, and expanded as needed. A combination of unlicensed and available licensed spectrum could be used, and service providers that would agree to use the network would share the cost of deployment. As more companies signed on to be part of the system, the cost to deploy such a network would be reduced, allowing broadband expansion into rural areas without the need for multiple network buildouts and their associated deployment and ownership expenses.
- Moreover, there have been recent announcements related to the design and launch of new low-orbit satellite constellations that would be used solely for delivering broadband services. While this approach will take time before it is entirely in place, it presents yet another technology solution, where the sheer ability of satellite constellations to cover mass areas would be useful to provide coverage and services to rural areas that today are out of the reach of terrestrial networks. Existing satellite-technology companies also are working on improving coverage and latency as well.

- The FCC recently reallocated 3.5 GHz spectrum, which presents another promising alternative. Commonly known as Citizens Broadband Radio Service, 3.5 GHz consists of 150 megahertz of spectrum to be used in three tiers. There are two major components to the division of spectrum. Up to 50 percent of the spectrum is designated for general authorized access, open to the largest variety of users. The creative-use cases and technology advancements that this open market will likely provide may cast a positive outcome for rural America in the future. The Priority Access License would assign 10 megahertz of spectrum to licensees exclusively for one year, and the Incumbent Access tier would include the federal government and satellite services that use the spectrum today. Companies engaged in this initiative include some of the largest and most influential in the market: American Tower Corp., AT&T Corp., Boingo Wireless, CommScope, Crown Castle Inc., ExteNet Systems Inc., SpiderCloud Wireless, T-Mobile USA and Verizon, among others. The Wireless Internet Service Providers Association has come out in favor of the FCC's new proposal for favorable rules that can provide up to 100 megahertz of spectrum in the 3.5 GHz band for rural broadband use.[20]

Creative Solutions

Some communities have used some creative solutions to bring broadband access to their constituents. For example, in south central Minnesota, 17 townships and 10 cities formed a telecommunications cooperative called RS Fiber Cooperative, which is building a $45 million telecom network to serve more than 6,000 households, farms, and other businesses in a 700-plus square-mile area with both wireless and universal fiber-optic service.[21]

Ten cities raised bonds to pay for more than half of the estimated $15 million Phase 1 development. The cooperative partnered with Hiawatha Broadband Communications (HBC), an Internet Service Provider (ISP), to operate the network. Everyone who uses services from RS Fiber automatically becomes a co-op member. The co-op is hopeful the network can meet its financial targets to avoid using taxpayer funding to pay for the network. However, if funding falls short, taxpayer funds will make up the difference.

Phase 2 plans call for the co-op to spend roughly $30 million to build the rest of the network to the 17 townships, where many of the area's farms are located. The Minnesota College of Osteopathic Medicine said the fiber deployment was one reason it chose to set up its school in one of the towns included in the co-op.

Axcess Ontario is another nonprofit entity formed in 2005 to build fiber infrastructure in its community. Ontario County is in upstate New York with a population topping 100,000 (as of 2000) and a total area of 662 square miles. Axcess Ontario completed its 200-mile fiber ring around the county at a cost of $5.5 million. The entity has signed master agreements with eight telecom and broadband companies, including Verizon Wireless and national broadband

provider TW Telecom. Axcess Ontario is in ongoing discussions with other service providers, and is working aggressively on its next goal of luring a fiber-to-the-home (FTTH) service provider to Ontario County. With the fiber ring complete, businesses and municipalities now have access to faster and less expensive broadband, as well as bandwidth equal to global broadband leaders. Businesses can gain access to the ring simply by contacting any of the eight service providers that work with Axcess Ontario," according to the entity.[22]

Policy Considerations

Other infrastructure policies that will promote expansion of wireless broadband include:

- Uniform cell siting legislation: streamlined siting regulations, a predictable and timely process for applicants, and reasonable fees are required to speed the deployment of additional cell sites and small-cell solutions.
- Federal lands process reform: The Middle Class Tax Relief Act of 2012, Executive Orders from the Clinton and Obama Administrations, and agency guidance has made clear that the siting of mobile broadband infrastructure on federal lands and properties is a priority to deliver broadband service and efficiently use the nation's resources. The federal government owns or administers nearly 30 percent of all land in the United States, including thousands of buildings, and provides funding for state and local transportation infrastructure. However, national and regional carriers face significant challenges when working to secure access to federal rights-of-way and buildings to deploy broadband infrastructure. Both legislative and internal agency solutions are needed to effectively leverage federal property to meet national public policy and broadband deployments goals. Many of the lands and properties that would benefit from streamlined siting are in rural areas.
- Demand-based collocation: Some public/private organizations need mobile coverage based on geography (and not population density) and public/private "partnership" collocation on cell towers should be encouraged. For example, public safety (such as FirstNet), transportation, utilities, and agriculture organizations all could share infrastructure.
- Supply-based collocation: Encourage infrastructure sharing between cellular carriers providing mobile broadband and wireless ISPs that provide fixed broadband service to households and businesses.
- Dig once notifications: Notify providers of any utility trenching project to deploy fiber, or partner with neutral-host fiber providers, for mobile backhaul if the right-of-way is already opened for a gas, water, or power project.

- Conduits along highways: Require that broadband conduits be installed along and under highways as part of certain construction projects.
- Directing resources at RUS programs: RUS has a sizeable portfolio of loans to borrowers that derive a significant portion of their revenues from the Universal Service Fund, which means there must be a predictable level of support so carriers can plan, borrow, and invest in infrastructure, including neutral-host fiber backhaul.[23]

Conclusion

As a society, we must enable and enact policies that support the rapid deployment of advanced mobile broadband services. Many local communities have outdated permitting processes that create barriers to building robust wireless infrastructure. Capacity demands will increase exponentially and place tremendous pressure on spectrum availability and existing infrastructure.

Federal infrastructure policy should recognize the needs of agriculture production, public safety, healthcare and other industries to find ways to promote private and public investment toward this important but unmet need. Policies also should allow access to existing federal resources (i.e., through the USF CAF and "Dig Once" programs) to third parties willing to make these infrastructure investments, on reasonable rates, terms and conditions that support the goals of universal service and competition.

Cropland areas where farming occurs still lag far behind in adequate fixed and mobile broadband access. The significant public interest benefits of broadband deployment that lie at the heart of USF and the FCC's many other efforts to facilitate such deployment cannot be made fully available to the nation's rural communities without expanding wireless broadband availability across croplands. This is consistent with the USF principle that advanced telecommunications and information services should be available in all areas of the nation. Rural communities should benefit from the same public-safety, social, and business technology advances as their urban counterparts. In part, this depends on their access to robust mobile broadband infrastructure.

About the Authors

Tom Kane, NB+C

Tom Kane has served as president of NB+C since 2003. Under his leadership, the company has experienced significant growth, launched several new business units and expanded its geographic reach. During his tenure with NB+C, Tom has held several key positions. Success as a program manager led to his heading up the Real Estate Department in 1999. In 2001, Tom was promoted to vice president of operations for the entire organization. As a principal in the startup of NB+C's tower subsidiary, Network Towers, LLC, a tower development company that successfully built 90+ communications towers, Tom was a part of the team who sold the portfolio in 2006 to a public tower company. In 2007, Tom utilized the firm's tower development capabilities and backlog to lead a successful management buyout, creating a 100% management-owned LLC. Since 2007 the organization has opened four new regional offices and launched new divisions offering engineering, technical, and construction services to the wireless industry. He is currently treasurer of the MD-DC Wireless Association and serves on the board of directors for the Juvenile Diabetes Research Foundation (JDRF) – Maryland Chapter. Tom is also a member of the Young Presidents Organization (YPO) Washington, DC/Baltimore chapter and volunteers as a youth football coach in Crofton, Maryland. Tom received his bachelor's degree in English literature with a minor concentration in business management from the University of Maryland.

Bernard A. Borghei, Vertical Bridge

Bernard A. Borghei is Senior Vice President of Operations and one of the Co-Founders of Vertical Bridge, the largest private owner and operator of wireless communications infrastructure in the United States.

Prior to co-founding Vertical Bridge, Mr. Borghei served as Senior Vice President and partner at Global Tower Partners, the largest privately-held tower company in the United States, where he oversaw domestic and international market operations, including over 6,500 towers and 12,000 managed properties.

With over 22 years of experience in the telecommunications industry, Mr. Borghei has held executive and senior management positions of increasing responsibility in operations, engineering, sales, supply chain, site development, and customer care. He had held positions with wireless operators and service providers including SkyBitz, Wireless Facilities, Inc., Western Wireless International, and Triton PCS, successfully running operations across 24 different countries in Europe, the Middle East, Africa, North and South America.

Mr. Borghei earned a Bachelor's degree in Electrical Engineering from Villanova University and an MBA in Global Management from the University of Phoenix.

Bryan Darr, Mosaik

Bryan Darr, founder of Mosaik, serves as President and CEO. Bryan leads the company's growth as a strategic partner to mobile operators, infrastructure professionals and network-dependent solution providers, enabling clients worldwide to deliver a superior network experience. Bryan has spent most of his professional life in the wireless industry and has been an active participant in the industry's evolution. He leads his team in leveraging technology that helps clients make better business decisions on a daily basis, through innovative data visualization solutions that provide more accurate tower site evaluations, increased visibility into customer behavior and interactions with wireless networks, and improved customers' network quality of experience.

Bryan was born and raised in Chattanooga, Tennessee, and moved to Memphis in 1980 to attend Rhodes College where he majored in International Studies. Bryan has served in multiple capacities within many leading industry organizations, and currently serves on the Innovation & Technology Council for WIA and the CCA Associate member committee.

Ray Hild, JMA Wireless

Ray Preston Hild is an accomplished senior management and strategic partnership professional with over 26 years of experience in the wireless industry. He has consulted on several major government and enterprise initiatives and co-authored several industry white papers. Ray has been a member of the WIA Innovation and Technology Council for several years. In addition, he has served on a variety of wireless committees and boards for major industry associations on such topics as: Unified communications, DAS in mid-tier markets, oDAS, mobile broadband, wireless as the 4th utility, enterprise wireless systems and network densification. Lastly, Ray has created the Public Safety Code Guidebook which is meant to track the changing landscape of first responder wireless requirements across the U.S. Ray has held management and leadership positions with several prominent corporations over the years. Those include Sprint-Nextel, Corning, Galtronics, Kavveri Telecom and most recently JMA Wireless. He has won dozens of awards over several decades for service and performance. Ray is involved in the Johns Hopkins Mentorship Academy working with teenagers needing guidance in their career choices. He is also invested in supporting those who served through 185 for Heroes, an organization that hosts events for Operation 2nd Chance to help our warriors when they return from duty. Currently Ray is an Area Vice President for JMA Wireless, a global supplier of world class telecommunications equipment.

Keith Kaczmarek, Public Safety Ventures

Keith is a general partner at Public Safety Ventures, a private equity firm focused on the public safety and critical industry markets. Keith has more than 30 years of wireless telecommunications experience. He has held prominent business, technology and operations leadership roles at inPhase Wireless, Intrado, Powerwave, Cyren Call, FiberTower, inOvate Communications Group, Teligent, Nextel, AirTouch, PrimeCo and GTE. Keith was a co-founder of Cyren Call Communication, focused on supporting public safety in the creation of a nationwide public safety broadband network. He was also a general partner at inOvate Communications Group a venture fund focused on early-stage wireless companies. Keith is a Radio Club of America Fellow, holds an MBA degree, a M.S. in Electrical Engineering and a B.S. in Electrical Engineering from the University of Illinois.

Mark Lewellen, John Deere & Company

Mark Lewellen is the Manager of Spectrum Advocacy for Deere & Company. In this capacity, Mr. Lewellen represents the interests of John Deere and its Navcom Technology, Inc. and Intelligent Solutions Group business units on technical and policy developments related to the electromagnetic spectrum. As production agriculture is today driven more and more through deployment of technology, Mark plays a lead role for Deere to ensure that telecommunications policies reflect the growing importance of satellite spectrum and rural broadband to John Deere customers. Rural broadband is a key enabler to Deere's large self-propelled machines, which now have data modems installed as a standard device. He also represents John Deere in the Agriculture Broadband Coalition (ABC), a group of producer groups and equipment manufacturers dedicated to improving telecommunications policy to reflect the growing economic impact of, and potential for, technology integration in U.S. agriculture.

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Rural America: How Wireless Technologies Could Impact America's Heartland
Connectivity for People, Machines and Everything Else

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