Utility Uses for Wireless Spectrum

Evaluating the Importance of Spectrum in the Utility Sector

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Executive Summary

Utilities transmit and process enormous amounts of data. Those data volumes increase almost daily, as utilities deploy more sophisticated grid management and as consumers install more residential energy generation. Both those applications need data to balance grids and to give utilities situational awareness of their grids. Utilities rely upon both wireline and wireless data transmission, depending upon many factors. Where fiber optic cables are already in place, such as in high-voltage transmission lines, then that fiber is a natural candidate for data transmission. Other use cases may not be suitable for wireline data transmission.

Wireless telecommunications solve a plethora of utility communications problems. Wireless is typically slower than wireline and with lower bandwidth, but wireless telecommunications can reach into areas where wireline is expensive or impossible to build, or where a wireline build-out would take too long to satisfy a use case. In short, wireline can solve many utility data transmission problems, but not all of them. Some problems have only wireless as their solution. Utilities must have reliable wireless telecommunications to meet their data transmission requirements. Otherwise, those utilities cannot keep their grids balanced, and they lose situational awareness of their grids.

Reliable wireless telecommunications require reliable wireless spectrum, clear and free of interference. Spectrum is reliable when it remains available to utilities for decades, not requiring utilities to migrate out of a spectrum due to regulatory or other factors. Such migration is expensive, time-consuming, and fraught with the possibility of service disruption to utilities' customers.

This report examines the current state of play for utility spectrum access: what spectrum is available, how utilities use it, and recent trends in utility spectrum needs. Detailed case studies look into the telecommunications approach at two large and sophisticated utilities.

Reliable energy delivery is fundamental to all critical infrastructures. Energy delivery can only be reliable if the telecommunications are reliable. And utilities need a stable and clear spectrum to achieve their telecommunications, without which reliable energy delivery will become nearly impossible.

Overview of Wireless Spectrum

Wireless spectrum typically refers to the full frequency range from 3 kHz to 300 GHz that may be used for wireless communication. Demand for wireless broadband has soared due to technological innovation and the rapid expansion of wireless internet services. Increasing demand for services has required changes in the philosophy of spectrum management.

The Federal Communications Commission (FCC) determines the use cases for specified spectrum portions in the U.S., as well as the parties who will have access to them. Licensed spectrum devices operate within the portion of the radio spectrum designated by the FCC to be reserved for organizations that have been granted licenses. With exclusive rights, a license holder operates without interference or spectrum crowding. The FCC provides legal protection and enforcement to prevent other operators from transmitting over the same frequency in the same geographic area. The FCC also regulates the physical layer technologies to be employed.

The U.S. electrical grid today consists of approximately 55,000 transmission substations, 642,000 miles of high-voltage lines and 6.3 million miles of distribution lines. Utilities underpin this infrastructure with information and communication technology (ICT) networks and devices to monitor the grid and maintain reliability. These ICT networks rely on spectrum, and as the grid gets "smarter" and modernized, utilities' reliance on spectrum will only grow. The grid is now undergoing a revolution due to the introduction of system automation devices and distributed energy resources.

In order to maintain control of these new systems and resources while properly balancing the load of electricity on power lines, utilities need to radically increase the number of control points on the grid while minimizing security vulnerabilities presented by automation and interconnectivity. As owners of critical infrastructure networks, utilities operate their own extensive wireline and wireless communications systems. While utility wireless systems are generally highly reliable, they typically use licensed spectrum that is allocated in narrowband channels (typically less than 50 kHz wide). Unfortunately, the spectrum typically utilized by utilities is often limited in capacity and subject to congestion and/or interference from competing and often incompatible radio frequency operations on the same or adjacent channels.

As owners of critical infrastructure networks, utilities often own and operate private telecommunications networks, comprising extensive wired and wireless communications systems. The spectrum typically utilized by utilities for wireless telecommunications is often limited in capacity and subject to congestion and interference from the same or adjacent channels. Because there is no spectrum dedicated for use by utilities, different utilities operate their communications systems in different spectrum bands. Furthermore, the FCC has from time to time reallocated spectrum to other users, forcing utilities to relocate some of their wireless communications systems to other bands.

The U.S. electrical grid today is undergoing a revolution due to the introduction of more sophisticated grid automation capabilities and distributed energy resources. Managing the new grid automation is much more data-intensive than in the past. The increased data needs drive a correspondingly increased need for telecommunications, to deliver all that data where it is needed, when it is needed.

Utility Uses of Spectrum

Utilities need reliable telecommunications to monitor and control systems. Interference to existing communications systems like power line carrier or microwave frequencies reduces utilities' situational awareness of their grids, with the potential for developing problems to go unnoticed. Interference to utilities' two-way communications systems, or a lack of available capacity due to a lack of spectrum, can cause serious delays in restoring power. When outages occur, these two-way wireless networks are the primary means of communicating with crews engaged in the dangerous activities associated with electrical service restoration.

Utility telecommunication standards are quite demanding:

- Utilities require telecommunications coverage to read sensors and meters across their entire service territories. Utilities cover as much of their service area as possible using their private networks, but may rely on leased circuits from the carriers in remote areas that are not otherwise cost effective to be served by a private network.

- Some utility applications do not require high bandwidth capability, but utilities must cover the telecommunications needs of all systems, even during outages or other emergencies.

- Communication networks provide sufficient levels of low latency and high security as demanded by critical applications such as protective relaying.

- Networks must deliver the services cost-effectively. Investment in communication networks – as with any other element of the utility network – must be prudent.

Commercial communications networks are challenged to meet the requirements that utilities have with respect to reliability, coverage, capacity, latency, security, and cost effectiveness. Utility needs in the area of critical command and control grid applications require the presence of real-time or near-real-time response, especially in such areas as phasor measurement monitoring, remedial action schemes, and protective relaying.

Recent Trends

Utilities' need for interference-free spectrum has been well documented, and the need has become more acute in recent years due to increasing use of automation. Some of the objectives that drive increased communications needs are:

- Increased customer benefits by improving grid reliability, enhancing customer communications, and supporting greater degrees of customer choice and control.
- Reducing peak demand via time-of-use tariffs and demand management.
- Reduced operating expenses by simplifying planning and support functions.
- Deferred capital investments through increased capacity utilization and peak demand reduction.
- Increased worker safety by providing tools to perform work functions in a safer manner.
- Increased grid resiliency and reliability by predicting outages before they occur using data analytics.
- Increased integration of renewable energy resources, which require additional data to keep distribution grids stable.
- Better situational awareness via video surveillance and video streaming from unstaffed sites such as substations.

Significantly more end-points, of greater sophistication, will communicate through utilities' future networks. There will be greater need for inter-utility connectivity for wide-area-situational awareness. Cybersecurity requirements will increase both in scope and control standards.

Case Studies

Experiences at two large UTC member utilities demonstrate the industry's need for fast and reliable wireless telecommunications. Each of these utilities uses a mix of telecommunications technologies to meet its needs: wired, wireless, privately-owned, commercial carrier service, and satellite communications. No two business scenarios are alike and each grid project with a telecommunications component must identify the best solution for its use cases.

Southern California Edison

Southern California Edison (SCE) serves 15 million people over a service territory of approximately 50,000 square miles. They deliver nearly 90 billion kWh of electricity to their customers each year. SCE's network is truly huge: over 12,000 miles of transmission lines, more than 90,000 miles of distribution lines, nearly 1.5 million electric poles, over 700,000 distribution transformers, and nearly 3,000 substation transformers.

SCE's current communication use cases include: telephony, data, video, voice dispatch, mobile data, grid monitoring and control, teleprotection, load management, smart metering, and internal collaboration. To meet these needs, SCE uses a mix of private, leased, and shared telecommunication networks, based on use cases. Applications that require high availability, low latency, and stringent security rely on a private telecommunications network, SCEnet.

A combination of transport media support varying bandwidth requirements in the network – fiber optic, microwave, satellite, and wireless mesh network. Similarly, voice dispatch capability needed for routine and emergency communication relies on a private land mobile radio (LMR) system to insure no congestion during emergencies, and ubiquitous coverage throughout its vast territory. Being a mobile use case, LMR is obviously wireless.

LMR systems are critical during and after natural disasters, when commercial carrier services may be unavailable or overloaded, and when utility field workers are sent to potentially dangerous areas where electric infrastructure may have been damaged or destroyed. LMR ensures reliable communication with the field force, which results in faster service restoration and reduced personnel safety risk to those working in the field.

SCE's strategy to improve its network is:

- Upgrade the capacity and functionality of the SCEnet high-speed backbone network to effectively manage the expected explosive growth of traffic for Smart Grid and other enterprise needs.
- Upgrade SCEnet transport and expand the reach of broadband to another additional 100 distribution substations.

- Build a next generation, secure, high-speed substation Local Area Network.
- Leverage 4G wireless Field Area Network to replace legacy systems, significantly expand distribution automation capability, and enable mobile broadband.
- Build a high-speed inter-utility network to support wide-area-situational awareness.
- Leverage smart meter capabilities to communicate with devices on the Home Area Network (HAN).

Executing this strategy demands reliable and fast wireless telecommunications. Grid protection technologies require network latency under 10 milliseconds. By comparison, energy consumption readings from smart meters have a latency requirement measured in days. Thus, commercial networks can meet some use cases but not all of them.

In its response to the U.S. Department of Energy, regarding the National Broadband Plan of 2010, Southern California Edison explained when existing commercial networks can and cannot satisfy its communications needs:

> Commercial networks are capable of meeting some SCE needs. For example, SCE plans to leverage commercial networks to provide cost-effective backhaul for approximately 5.3 million meters in its AMI [Advanced Metering Infrastructure, that is, smart metering] system, known as Edison SmartConnect™. Commercial networks may also be suitable for routine communications with small, dispersed distribution systems, or the monitoring of certain grid devices in the field.
>
> However, most current commercial communications networks do not meet the reliability and coverage requirements for applications such as Land Mobile Radio (LMR). Also, they do not meet the latency, availability, and security requirements for critical command and control grid applications that must have real-time or near-real-time response, such as phasor measurement monitoring, remedial action schemes, and line differential protective relaying. The uncertain rollout timeframe of new generation carrier services is also a concern for utilities.
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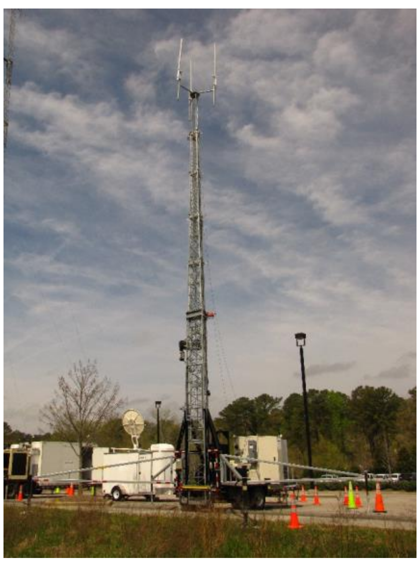
> In sum, the use of commercial networks for critical grid control applications is limited because they currently lack adequate coverage, power supply backup, latency control, congestion management, quality of service, Service Level Agreements, and dependable rollout timeframes.

Southern Company

Southern Company serves 9 million customers in the southeastern U.S. with 46,000 MW of generating capacity and 1,500 billion cubic feet of combined natural gas consumption and throughput volume. Operations include nearly 200,000 miles of electric transmission and distribution lines and more than 80,000 miles of natural gas pipeline. Southern Company is the holding company for four traditional electric utilities serving more than 4.5 million retail customers. Southern Company Gas is an energy services holding company whose primary business is the distribution of natural gas to 4.5 million retail customers through utilities in seven states in the Midwest, Southeast, and Mid-Atlantic.

Southern Company has experienced a multitude of events threatening service to its customers. Although it largely dodged Hurricane Irma in 2017, Southern Company dealt with Hurricane Matthew in October 2016 that resulted in widespread outages across its network. By leveraging its wireless subsidiary, SouthernLINC, it was able to deploy its own cellular stations on wheels to provide telecommunications services to its linemen and women in the field after the carrier-based networks went down during the storm. SouthernLINC Wireless serves as a communication network with a 127,000-square-mile coverage area across the Southeast. Because its networks stayed functional during and after the storm, Southern was able to deliver needed communications services not only to its own regulated utilities, but also to the public sector.

SouthernLINC's Incident Response Team is deployed to support customers in the face of weather adversity. For these events, SouthernLINC mobilizes satellite cell sites to assist with communications as needed. The "COW" or "cell on wheels" is housed and mobilized as needed. SouthernLINC has positioned COWs as well as generators and microwave dishes at multiple storage locations inside its footprint so they can deploy the closest equipment when a particular geography is in need.



The SouthernLINC Wireless Storm Response Team uses a mobile cell tower to assist in storm response.

As a dedicated carrier that is configured for the needs of utilities and public safety, SouthernLINC builds its network differently than traditional commercial carriers do, with a focus on availability of existing services, rather than the revenue focus of carriers. This build approach enables SouthernLINC to sell unused bandwidth and network management to other industrial users. SouthernLINC deploys generators at strategic locations in advance of a storm.

SouthernLINC can prioritize repair functions based on its needs rather than depending on commercial carriers' priorities. For example, when generators fail during storms, Southern is capable of addressing the issue themselves or with their own contractors.

The benefits of this approach are dramatic. On April 27, 2011 the Birmingham-Tuscaloosa tornado had a maximum width of 1.5 miles and a track 80 miles long, with winds up to 190mph. Although the company lost two cell tower structures, the SouthernLINC network operations team was swift to respond to outages caused by severe weather and quickly restored communications for customers.

During and immediately after that tornado, SouthernLINC experienced a surge of calls as engineers dealt with area power outages and damaged equipment:

- More than 3 million Push-To-Talk (PTT) 2-way radio calls were placed in Alabama—a 59% increase over the prior day's PTT call volume.
- Another one million PTT calls were made in other areas of the footprint.
- Cellular usage increased by more than 56%.

SouthernLINC Wireless network operations technicians placed additional base radios at cell sites in strategic locations to accommodate the increased call volume following the tornados. SouthernLINC Wireless also deployed its fleet of mobile cellular sites, mobile power generators, and satellite and microwave network connection units to support communications in areas where first responders worked to assist victims, restore power and establish safe travel routes. Some of these deployments filled gaps where third-party fiber connections failed.

Less than 48 hours after the storms moved through the area, SouthernLINC Wireless had only 2% of its cell tower sites experiencing service issues. In addition to the significant network operations efforts to support SouthernLINC Wireless subscribers, more than 1,000 phones and batteries were provided to first responders and support teams involved in restoration efforts.

SouthernLINC illustrates how utilities survive natural disasters with private networks. Its LMR network enabled field technicians to remain in touch with central offices during service restoration, critical to expedited restoration and crew safety. These critical needs cannot be met by commercially offered services.

Conclusion

Utilities operate extensive private internal communications to support the safe, efficient and reliable delivery of essential services to the public at large. Commercial carrier services can meet some utility use cases that have less stringent requirements for latency and reliability. However, those systems cannot support high-speed grid control and grid protection applications, and they are not suitably resilient during and after a natural disaster.

Utilities will continue to deploy and use their own private communication networks, to ensure reliable delivery of electricity at all times, and to ensure fast and safe recovery from natural disasters and other outages. Those private networks will be a mix of wired and wireless technologies, depending upon the diverse use cases of each utility.

Utilities cannot operate their generation, transmission, and distribution networks without fast and reliable telecommunications. In the case of wireless telecommunications, utilities must have continued access to spectrum that is free of interference and that will remain available to the utility for the lifetime of its networks. Spectrum where utilities operate must not be crowded with other users or interference for adjacent spectrum ranges. Only then can utilities offer the service that customers and governments expect, in good times and bad.