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## Public Safety Grade LTE Myth or Reality?



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Photos courtesy LA-RICS

# The Challenge of Public Safety Grade LTE

Recently, there has been some debate on the meaning and definition of “public safety grade.” The recent hurricanes underscore the need for clarity on what it means and what public safety needs with regard to reliable data. A National Public Safety Telecommunications Council (NPSTC) document published in 2014 provided a definition that the overall system design enables system and service to achieve 99.999 percent availability.

What does availability of this magnitude mean in lay terms? Availability at 99.999 percent (five nines) results in net outage of five minutes per year. Availability at 99.99 percent (four nines) results in net outage of roughly 53 minutes per year. Both factors are better than the general commercial carrier availability of 99.0 and 99.9 percent availability (between 88 and 8.8 hours respectively per year). This creates a significant difference in expectations because the devil is in the details of how availability is calculated versus measured in an operational network. The First Responder Network Authority (FirstNet) is highlighting the importance of data in

## Should public safety expect LTE networks to be built to the same public safety grade standards used in LMR systems?

By Joe Ross, Steve Sidore, Scott Edson and Ted Pao

public-safety operations, and as public safety wrestles with a 25-year commitment decision with the selected vendor, it becomes one of the cornerstones of the eventual solution that will last a generation.

If FirstNet and data communications are ever expected to become “mission critical,” public safety must be able to rely on data communications as much as LMR, built to five nines availability, which is needed to achieve public safety grade. So, a definition is less material than whether FirstNet will be as reliable as public-safety radio communications. If in five or 25 years, broadband data is only slightly more reliable than existing commercial networks, the mission-critical element of broadband data will not occur. Public safety needs a concerted effort to work toward public safety grade, defined as 99.999 percent service availability. Five nines, among many other

requirements, is mandatory for broadband to replace LMR.

### Overlap and SON

Most public safety grade talk has been diverted to the cell overlap that exists in a commercial network and a feature called self-organizing network (SON) to automatically fix problems when a site is out. SON can slightly mitigate the loss of coverage from a site, but it is a far cry from solutions that completely resolve the outage.

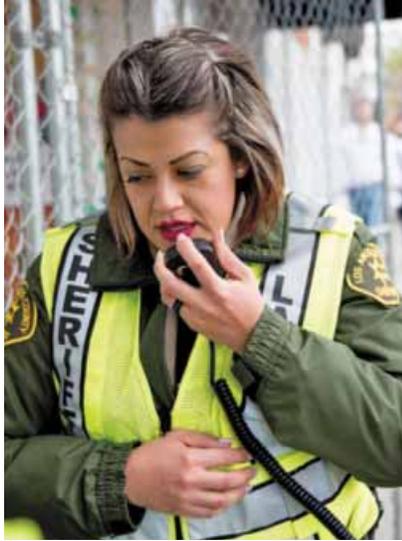
First, cell sites have been dramatically reduced in height. Carriers originally used 300-foot towers, but now towers are 30 to 50 feet tall in urban areas, allowing them to only cover so much area no matter which way you point the antennas. The SON feature can automatically uptilt an antenna, but this will only slightly increase received power at the cell edge and only slightly fill the gap for an off-air site. In urban areas where there is

substantial density because of capacity, there may be enough overlap that public safety may not notice an outdoor coverage issue, but in suburban, rural and edge-of-network areas where there is far less overlap, there will be a hole with the loss of a single site. There is no overlap at the edge of coverage where some of the biggest overall improvements are needed to deliver reliable communications in rural areas.

Second, the largest concern in urban areas from loss of a cell site is loss of capacity and in-building coverage. Steel and concrete construction, combined with LEED-compliant windows result in buildings that cause the signal to degrade 1,000-fold by the time it reaches the building interior. There are only two ways to achieve coverage in this scenario — a cell site a quarter- to a half-mile away or a distributed antenna system (DAS). It is not feasible to have a DAS in every building, so the economical approach is substantial cell density. With a cell-site density of every quarter mile, an outage will cause a hole inside the buildings in the immediate vicinity.

Third, an outage is rarely only a single site. Most outages affect more than one site in an area. This occurs because a power outage often affects a neighborhood, and with earthquakes and hurricanes, the outage can affect an entire region. This is precisely needed when a mission-critical network is needed. As demonstrated after the recent hurricanes, power outages affect many neighborhoods and many sites. Likewise, earthquakes, ice storms and other events can affect power to tens of thousands of homes for a day or more, causing outages to a dozen sites, and long after a two-hour battery pack is exhausted. Road and storm conditions often prevent deployment of portable generators at the affected sites if enough personnel and generators are even available to address the outage. Long multisite outages most certainly create large coverage holes, SON or no SON.

The final flaw in the argument that a commercial network can withstand an individual site outage is that the system was designed to include the failed site. Engineers assume it is in



From top to bottom: A deputy uses the LMR system during the Rose Parade; a steel cage designed to provide the necessary strength per code-REVG for the monopole foundation; and the steel cage with anchor bolts used in preparation for drilling the pier foundation

service, and when it is out of service, problems occur. The initial problem is that signal levels from the neighboring sites are probably similar and are all low. Therefore, the signal to noise ratio in the area will be poor, along with performance. Next, the missing site is likely to cause a substantial traffic load on neighboring sites, further increasing interference levels. And while first responders will have priority on the network, if the signal levels do not sufficiently exceed the noise levels, public-safety performance will suffer.

While power outages are frequently the cause of wide-scale cell service outages, they are not the only source. A major transmission line that affects many sites without a truly redundant path — a fiber cut of redundant lines in the same conduit — can be cut. As the NPSTC document points out, the need for hardening is not limited to long-term power supply; multiple forms of redundancy for power, transmission, path and space diversity must be deployed to achieve 99.999 percent availability across the service area.

### No Four Nines Without Hardening

While not the desired level of reliability, four nines of availability simply is not achievable without substantial network hardening. Network transport services — the connection between cell sites and the core network — generally have service level agreements (SLAs) that only guarantee 99.9 percent service availability. For higher service availability, multiple unique connections to the cell site are required. A connection that uses the exact same path is not unique and is likely to experience outages at the same time. The most common outage for leased-line connections is fiber/cable cuts. Improving the availability of transmission circuits requires both path and space diversity through the use of bidirectional ring topologies connecting multiple RF sites with multiple paths to connect to the core. The RF sites must have physically diverse facilities entering and exiting the site location, and use separate routes back to the core. That

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means separate and distinct manholes and conduit paths entering and exiting the site that have more than 25 feet of physical separation with each route heading north or south from the facility. For this reason, public safety builds truly redundant microwave links and rings and uses diversity to achieve five nines of availability on its own, as well as creating fiber rings to achieve public safety grade reliability.

Likewise, a power-related event caused by equipment failures or major weather events is not going to deliver four nines. These events frequently have average downtime durations of a full day. A single event could then cause an entire region to experience less than 99.9 percent reliability. It is not feasible that a commercial carrier could achieve nationwide 99.99 percent availability without hardening the majority of its network.

### Local Public Safety Grade

When public safety builds systems to public safety grade, the availability applies to the system itself. Not every site is guaranteed to achieve 99.999 percent availability, but overall, across all aggregated sites, the construction and commitment are generally 99.999 percent. Each site, connectivity and core that support each other must be designed collectively for greater than 99.999 percent availability. So, a purpose-built network for a city or county achieves 99.999 percent availability in that city or county. A nationwide commitment, on the other hand, could mean that areas where it is difficult to achieve a high degree of availability — areas that experience frequent hurricanes, for example — could be sacrificed because of expense. For example, if AT&T's network in Los Angeles County failed for an entire day, it would have little impact on AT&T's nationwide compliance but would result in, at best, 99.7 percent availability in Los Angeles County. AT&T and FirstNet might consider

this a success, but an outage affecting Los Angeles County serving 10 million residents for a day would cause major problems and put lives at risk.

While many tout the just 5 percent of cell sites knocked out by Hurricane Harvey as a success, a more detailed look is not so encouraging for some counties. Aransas County, Texas, for example, had 95 percent of its cell sites out for three consecutive days. Refugio County had 85 percent of its cell sites out for two days. And while Harris County, where Houston is located, experienced outages of only 5 percent of sites in the worst case, those outages could have been clustered in an area that had dramatic needs for public-safety communications.

Hurricane Irma knocked out 27 percent of cell sites in the affected Florida counties on day one, but the counties at the southern tip of the peninsula had more than 50 percent of their cell sites out, while 80 percent of the sites in Monroe County, home of the Florida Keys, were out. A whopping 739 of 1,435 cell sites in Miami-Dade County were out. And while cell density in built-up Miami may help with some overall service availability, large pockets were without cellular service.

While it may be difficult and challenging to achieve four nines, much less five nines of availability, public safety needs most sites for each region, city and county to be hardened to ensure that local public-safety officials can rely on FirstNet wherever they live and work. Los Angeles Regional Interoperable Communications System (LA-RICS) asked AT&T and FirstNet to provide hardening details for this reason. Public-safety stakeholders in Los Angeles County need to make sure that all portions of the county have sufficient hardening to be survivable.

### Different Backups

LMR networks are not only more

survivable and available, they have better backups. Because public-safety radios come with simplex or talk-around capabilities, when the network fails, public safety can still communicate. In addition, LMR networks have failure modes that allow for a graceful degradation of service. For example, multiple transceivers can be used as a control channel in a trunked radio network or sites can be configured to operate in stand-alone mode, separate from the core network if necessary.

LTE sites have some backups. There are generally multiple transceivers per sector to support multiple bands and other technologies, and there are multiple sectors for each site that may provide some coverage in the event of a sector failure. But an LTE eNodeB will generally have one or more single points of failure that present a risk on top of other hardening factors for the site itself. There has been little to no dialog on this aspect of hardening sites, and commercial LTE infrastructure providers are not likely to enhance eNodeBs this way.

We have heard that if 4G access fails, the 3G network will fill in the gaps. This presents two problems. The 3G networks will not provide the required data throughput, will not support future IP-based push-to-talk (PTT) systems, and are dependent on the vehicle modems installed. LTE-only modems can't fall back to 3G. Also, a fallback to 3G generally will fail because if the LTE site fails, the entire site fails (loss of power or connectivity), 3G and 4G included. However, entire technology and core network failures that would cause such a scenario are rare. This is a welcome backup but certainly will not help get to public safety grade availability. The greatest factor to achieving 99.999 percent availability occurs at the site level, not at the core. The carriers generally do a good job of achieving more than five nines of availability at the core and the network backbone that connects the cores and major arteries.

On the talkaround front, there is an LTE standard called proximity services (ProSe) that allows direct mode. However, the range of ProSe is only a fraction of an LMR radio, and

commercial interest in developing the capability is unclear. Though the standard exists, it may never make it into public-safety devices. There is industry chatter that other solutions are under consideration, but it will take years to develop devices, get them into the marketplace, and provide the kind of networking environment that mimics what Project 25 (P25) direct mode does for voice communications. As a result, an outage on the FirstNet network is more impactful than an outage on the LMR network, amplifying the effects of applications and capabilities that become mission critical.

Finally, network subscribers must use best operational practices. Many outages are caused by human error. LMR systems are not immune to this, but often, human error on commercial networks can cause major outages. A major 9-1-1 outage recently occurred because of an incorrect whitelist that restricted traffic for 9-1-1 call routing. With a nationwide public-safety broadband network, more is at stake than thousands of local LMR networks. Strong change management, robust testing, solid interdepartment communications and other network operations best practices are mandatory to achieve high levels of system availability. As integration of network systems and elements increases, the complexity level of broadband systems skyrockets and so must the level of scrutiny of changes to a nationwide broadband system.

### No Caveats

The NPSTC document highlights the particular challenges associated with different regions of the country. Mother Nature cannot be a caveat in the design.

Public-safety communications are needed the most during hurricanes, earthquakes, ice storms and major power outages. Public safety grade systems are built to withstand these events. They have more robust towers, are built to higher wind speeds and higher loads, have generators with sufficient fuel to last several days, and many other characteristics that make them survivable during these events. There simply cannot be any “force majeure” or similar caveats in the calculation. We need systems that can withstand flooding with elevated platforms outside of the flood plain and high winds and for AT&T to be accountable for availability during such events.

In addition, upgrades, modifications and preventative maintenance work should be planned to least impact the system and cause minimal outages. These upgrades and other maintenance efforts need to be performed without affecting service availability. Public safety works 24/7 and needs a 24/7 network. Outages that occur because of maintenance should be considered as any other outage. AT&T needs to make such events rare and short.

There are no easy answers to these problems. There is often not enough space to harden every site, and truly redundant backhaul is problematic at many sites. AT&T and FirstNet should seek out-of-the-box solutions to these problems. Perhaps a low earth orbit (LEO) broadband satellite option could serve as a backup to the primary fiber link? While it may not be hundreds of megabits per section, it could provide a lifeline of communications for public safety. Perhaps, a fully redundant solution direct from LEO

satellites to a handheld device would take the process one step further by making the terrestrial infrastructure irrelevant to 24/7/365 service. Iridium, OneWeb and O3b have commercial solutions that combine low-profile antennas, high speed and low latency under development or deployment. On the power front, perhaps fuel cells, solar or other enhancements could be pursued where permanent generators are not possible.

Sharing situational awareness information among first responders at an incident scene needs to be as pervasive in five to 10 years as PTT voice communications is today. Public-safety professionals put their lives on the line every day to serve the public; delivering rock-solid communications solutions is the least we can do for them and benefits the public in the worst of times. ■

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Joe Ross is a senior partner at Televate, a consultancy specializing in system engineering and program management for public-safety communications. He has nearly 25 years of leadership in designing and operating LMR and commercial cellular systems.

Steve Sidore is a senior subject matter expert with Televate. Sidore has 36 years of industry experience.

Scott Edson is the executive director of the Los Angeles Regional Interoperable Communications System (LA-RICS). He is the former chief of special operations for the Los Angeles County Sheriff's Department.

Ted Pao leads the LA-RICS team to deploy its public-safety Long Term Evolution (LTE) system and is the lead technical engineer to deploy the Project 25 (P25) system. Email feedback to editor@RRMediaGroup.com.