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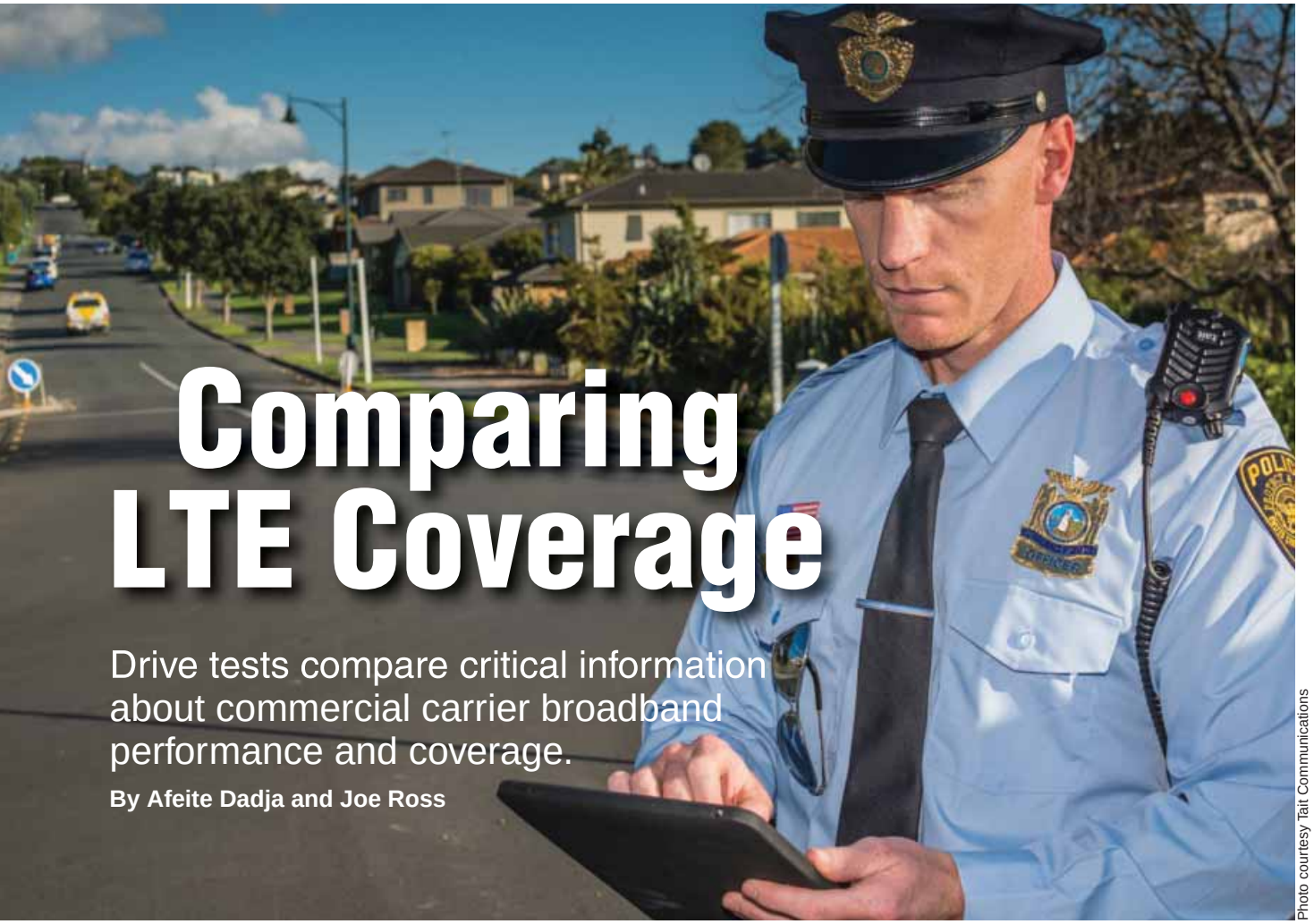


Comparing LTE Coverage

Drive tests compare critical information about commercial carrier broadband performance and coverage.

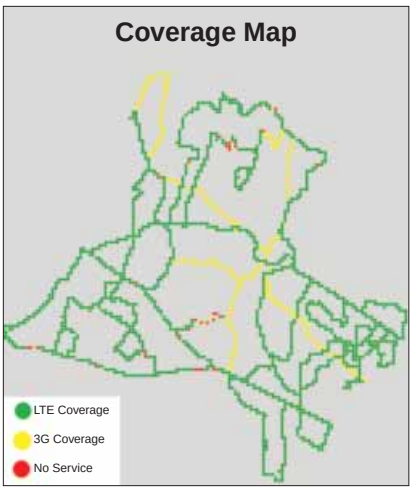
By Afeite Dadja and Joe Ross

Photo courtesy Tait Communications

Wireless carriers consistently claim that testing proves the best network, often referring to crowdsourced solutions as proof that one network is better than the competition. Unfortunately, carriers do not share any of that evidence, and the crowdsourced results depend on who downloads each vendor's app and where those subscribers use the network. In other words, it's hard to thoroughly analyze carrier claims and determine which network is truly best.

Public safety requires broadband networks that work everywhere because an emergency incident can occur anywhere. States and territories have opted into the First Responder Network Authority (FirstNet) network, but state, local and tribal agencies now have an important decision about whether to adopt the service. Coverage and network performance are key attributes that agencies will consider when comparing the AT&T-based FirstNet solution with those from other commercial providers.

To further investigate this challenge, Televate, a public-safety consultancy, conducted a head-to-head comparison between two nationwide cellular carriers throughout a suburban county, where the majority of the population is concentrated in one area of the county. The analysis was conducted with two off-the-shelf smartphones of the same model operating in the same location inside



a vehicle and tested in the same manner driving throughout the county. The test devices used standard commercial accounts and did not have priority service, an important feature to public safety.

The map on Page 13 depicts the route driven as well as the technology mode of one carrier's network (Carrier 1). The map shows large sections of the county operating on 3G technologies (in yellow), resulting in Long Term Evolution (LTE) service in only 82 percent of the area tested for Carrier 1. In some cases, switching to 3G occurs because the cell sites support only 3G technologies, but in others, it is because of the ability for 3G technologies to hang on to the call at lower signal levels than 4G LTE. When the LTE signal improves and is capable of providing reliable service, the network will switch the session back to LTE service. Testing demonstrated 3G service was "dragged" into Carrier 1 areas that had LTE service available more frequently. In other words, the call did not switch back to LTE despite it being available with good signal levels. And the lower speeds, higher delays and other limitations of 3G services generally can cause performance issues for public-safety operations.

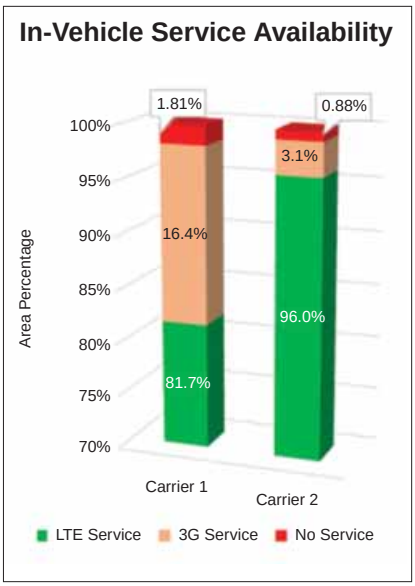
Data Quality Indicators

Ultimately, public safety wants sufficient data bandwidth to satisfy the demands of the applications in use and when public-safety operations require reliable service. FirstNet required 768 kilobits per second (kbps) downlink and 256 kbps uplink in its request for proposals (RFP). The county tests measured data bandwidth parameters, as well as signal levels to determine the degree to which a particular network would provide indoor service. They also measured the data speeds, or throughput, the networks could deliver throughout the county. The signal level, radio signal noise levels and the spectrum resources available on a cell site can affect throughput, so these measurements were of particular interest. Finally, the amount of LTE spectrum employed by the two carriers was studied. Employed spectrum affects the total capacity available for each cell site, and it can impact the peak speeds available to a single user when the spectrum resources of multiple LTE channels are combined, a feature called carrier aggregation.

Test Results

Perhaps what is most important to a user is where the various levels of service are available. In other words, can a user obtain a usable connection through the network, even at slow speeds, throughout the county? Certainly, a device displaying "out of service" is a prime example of no service availability, but if a device shows a connection, yet the connection quality is so poor that it cannot reliably pass messages through the network, public safety would not consider that location "covered." The "In-Vehicle Service Availability" chart illustrates a high-level perspective of the total test area measured and the proportion of the county where service was available. The chart shows that there was limited area where the devices were not connected, less than 2 percent for both carriers.

These tests underscore the importance of measuring system performance, not only service availability.



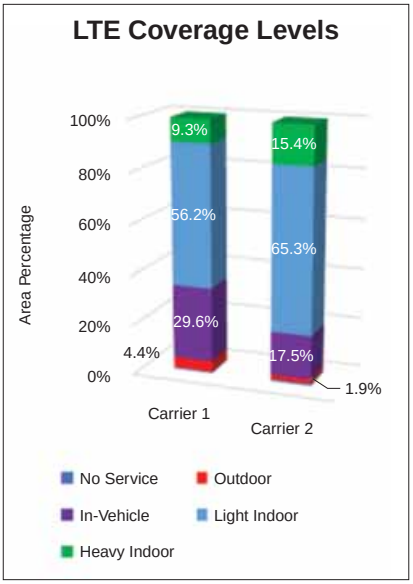
However, especially for Carrier 1, a substantial portion of the area tested used 3G, and the performance on the 3G networks was lower than on LTE. Carrier 1 served only 82 percent of the area with LTE, while Carrier 2 served 96 percent of the area with LTE. Despite these results, both carriers' published coverage maps indicate they serve virtually the entire county with 4G LTE service. Both carriers also depict 100-percent coverage of the county on their published maps. However, these maps may depict outdoor coverage, while our tests were conducted inside a moving vehicle. While the phones were connected for more than 98 percent of the measured area during the test, the test revealed that a far smaller area achieved reliable broadband service.

Coverage Levels

Signal level has a major impact on the type of service available at any given location. At higher signal levels, data speeds are likely to be higher, and high signal levels will penetrate more walls and deliver more reliable indoor service. The "LTE Coverage Levels" chart depicts the various levels of LTE service in the areas tested for both carriers. Carrier 2 has stronger signal levels overall throughout the county, enabling the carrier to provide greater in-building service levels —

15 percent more of the area tested — and in-vehicle service levels — 3 percent more of the area tested.

Carrier 1 covers 99 percent of the areas measured with outdoor service, but this would require vehicles installed with modems and roof-mounted antennas — adding substantial cost for more expensive equipment and installation to achieve a comparable level of service. Carrier 2 provided 98 percent of the LTE service area with signal levels sufficiently strong enough to achieve reliable in-vehicle service. These percentages are based only on the areas where LTE service is available from both carriers.



Data Speeds and Throughput

High signal levels do not guarantee good broadband performance. Network congestion, total spectrum available and carrier interference are factors in the amount of capacity and data speeds available to an individual user at a given location. If a major incident occurs at one of these locations, hundreds of public-safety users could seek resources. The tests used as many resources as the network would allow to help gain greater perspective on the total throughput available to users throughout the county in case of an emergency incident impacting network capacity. The "HTTP Download Speeds" chart depicts downlink (download) performance for the tests. Carrier 1 provided service speeds of at least 768 kbps to the user — a speed capable of rich web browsing, CAD, AVL and most applications except high-definition video — to 95 percent of the measured area. Surprisingly, although Carrier 2 had larger LTE service availability and stronger signal levels, it had decreased downlink throughput performance. Carrier 2 provided download broadband levels of service to only 79 percent of the measured area. Carriers 1 and 2 provided data rates capable of high-definition video — speeds higher than 2 Megabits per second (Mbps) — real-time streaming video in 85 percent and 68 percent of the area, respectively. Clearly, signal levels alone do not predict the performance of a broadband network.

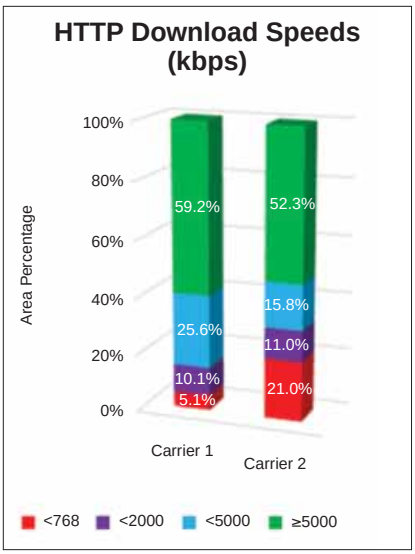
The "HTTP Upload Speeds" chart depicts the uplink (upload) test results for the two carriers. The uplink performance is similar for the carriers, but both provided "broadband" speeds far less than the typical 95-percent coverage objective of mission-critical public-safety systems. Both carriers provided broadband upload speeds — at least 256 kbps — to only 80 percent of the service area. And speeds capable of high-resolution streaming video — more than 1 Mbps — were possible in roughly half of the area tested.

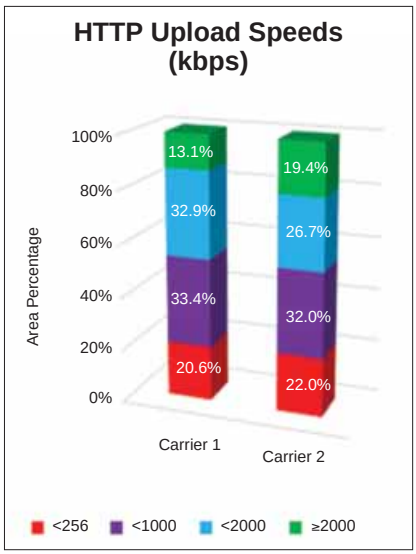
These speeds would accommodate, for example, video from an ambulance or a police cruiser in the field. Speeds of 2 Mbps needed for reliable high-definition video from the field were achieved in less than 20 percent of the area tested. Clearly, while the network did provide some service to most of the county, the uplink speeds did not achieve broadband speeds at the reliable levels of service typically required of public-safety networks.

The tests were conducted during a weekend, and there were no special events identified in any part of the county during the tests. So, the demand experienced during these test periods is likely similar to ordinary traffic periods. Throughput measurements were conducted to and from the same internet-based server for both carriers, so the results should isolate the performance differences of the two carriers. Given that Carrier 2's signal levels were 4 dB stronger and the interference levels were lower (2 dB lower interference) in areas where both carriers provide LTE, the primary drivers of performance suggest that Carrier 2's performance is because of issues outside of the quality of the radio channel.

One potential differentiator could be the amount of spectrum allocated to LTE in this area. A spectrum scan for LTE services in the populated area of the county found that Carrier 1 used 20 megahertz of downlink spectrum, and Carrier 2 used 30 megahertz of downlink spectrum. This additional spectrum could affect data speeds in two ways. First, more spectrum results in greater overall capacity. Second, higher downlink speeds can occur as a result of carrier aggregation. This feature allows the LTE system to allocate more than one LTE channel to individual subscribers. However, the test revealed that despite Carrier 2's 50 percent advantage in LTE spectrum availability, it allocated less downlink spectrum resources to users than Carrier 1, especially at lower signal levels. The quantity of spectrum resources, over time, is fundamental to providing high levels of throughput to an individual user. As a result, Carrier 2's downlink performance suffered. There is no evidence that congestion (lack of available resources) occurred to cause this effect, but if so, priority and pre-emption may alleviate these resource allocation issues for Carrier 2.

Carrier 2 was superior in terms of LTE service availability. However, the testing showed that Carrier 2 did not translate that advantage to downlink performance.





These tests underscored the importance of measuring system performance, not only service availability. The analysis demonstrated substantial differences between two carriers in regards to service availability and coverage levels, as well as a substantial difference between the availability of any service versus the availability of broadband services. Clearly, Carrier 2 was superior in terms of service availability and coverage penetration. Carrier 2 was also superior in terms of LTE service availability. However, the testing showed that Carrier 2 did not translate that advantage to downlink performance. Given Carrier 2's advantage in signal levels and LTE service availability, it was surprising to see Carrier 1's better downlink throughput results. And, while uplink performance was similar between the two carriers, both carriers did not provide broadband service levels at the coverage reliability levels expected by public safety.

Looking Forward

As agencies move forward and consider adoption of the FirstNet network, they need to carefully analyze the performance of the various options available to them. Carrier coverage maps are not useful when it comes to conducting a realistic comparison. Tests such as these will help agencies fully understand the real-world performance of the networks within their respective operational area. Uncovering issues, such as Carrier 1's service area, frequent transitions to 3G technologies and lower signal levels, as well as Carrier 2's downlink throughput, will help begin a dialog on the important enhancements necessary for providers. Which carrier is best in this county depends on the most important attribute for the service — is it the largest footprint or the higher download data speeds?

The tests underscore the importance of an agency fully understanding its operational requirements. In this case, a substantial amount of the county does not achieve 768 kbps downlink and 256 kbps uplink speeds for both carriers. An agency would need to assess its applications and determine what data throughput speeds are required to fulfill its mission. Perhaps, far lower speeds are acceptable. If an agency expects to stream video applications countywide, that raises the bar. In this case, only half the area for both carriers achieved uplink data speeds of 1 Mbps or higher.

The coverage measurements tool used to conduct these tests is out of reach for most public-safety agencies. It is expensive and requires cellular network engineering training to use. Most agencies can't afford to have engineers drive around their service area to test in this fashion. In addition, a carrier's performance can change dramatically over time. Carriers are adding new sites, migrating to LTE, adding new bands and otherwise optimizing their networks.

An ideal coverage testing solution is an "agency-sourced" collection method whereby an agency's own users collect data as needed. This approach enables agencies to test performance in the locations most important to them, in the configuration that best suits their environment, and when and as often as they'd like.

A new mobile application, Pinpoint, collects coverage and performance information using off-the-shelf smartphones with no formal training required. The tool delivers much of the capability of expensive engineering software to a public-safety agency. Agency personnel can travel around their normal or otherwise defined areas, by vehicle or foot, to automatically collect data at intervals frequent enough to qualify network performance. Armed with this information, an agency can engage in a more robust discussion with a carrier to address important coverage and performance gaps as well as to understand the seasonal factors, such as the effects foliage has on signal levels and data throughput.

As data becomes more mission critical, the broadband networks that deliver information needed to provide lifesaving services to the public become essential. It is important for agencies to understand their broadband data needs, now and in the future, and how the coverage and performance of commercial carriers fulfill these requirements. ■

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