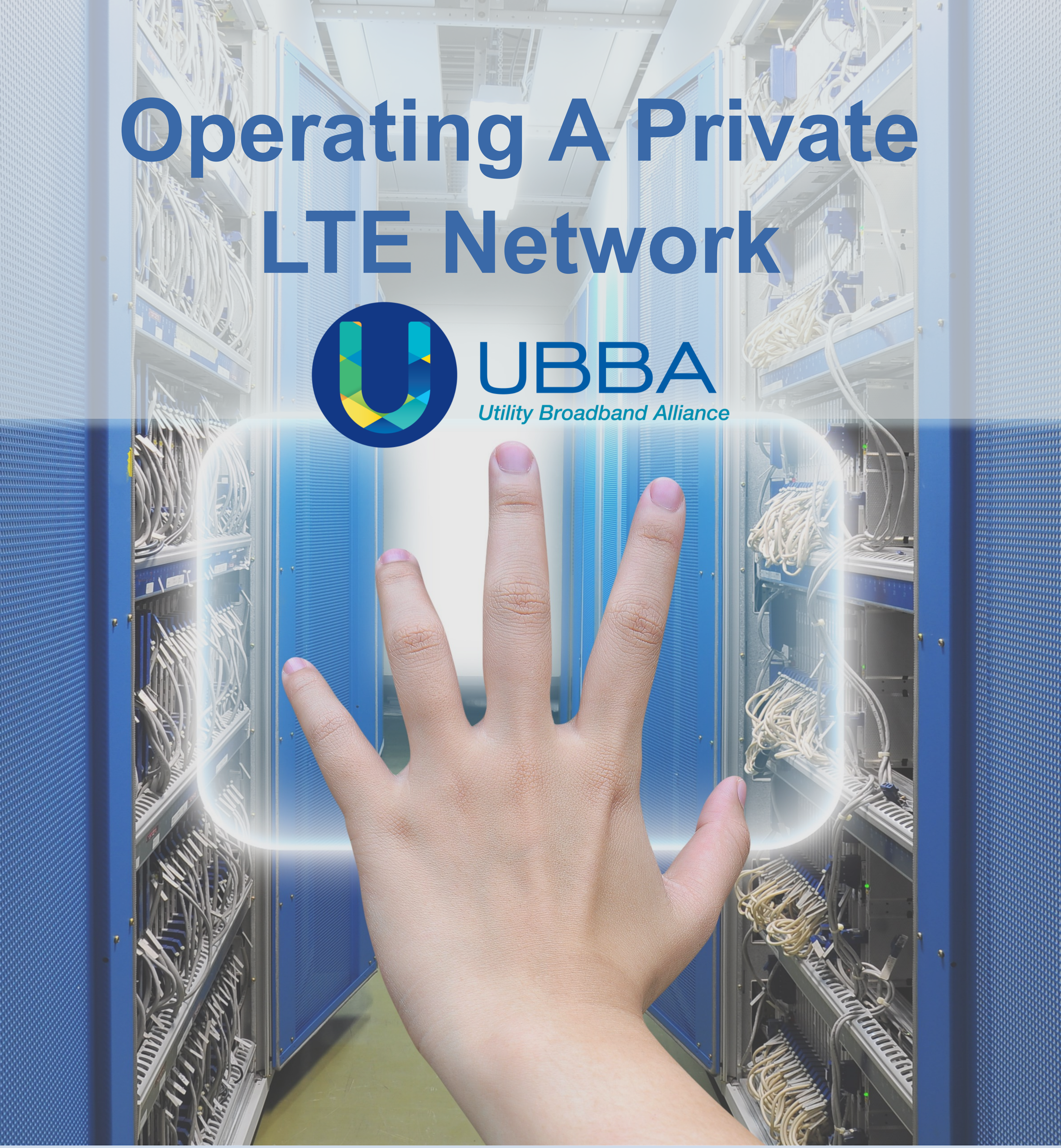
Operating A Private LTE Network



The purpose of this paper is to provide an electric utility some variables to consider when it comes to the planning, design, setup and then running of a private LTE network. Although some utilities already have experience with operating legacy communications, there is a lack of exposure to LTE. We hope that you find this paper useful in your consideration of deploying & operating a private LTE network.

Thank You to the Members of the UBBA

Cybersecurity & Technology Architecture Working Group

What problems are the Utility trying to solve?

As a first step, it is important for the utility to consider the potential uses of the LTE network. This will help in the definition of operations requirements. Not only understanding the types of applications such as SCADA, AMI, and Meter Reading but also working with the application owners and understanding their throughput, latency, and polling requirements. Putting together a data call model for each application will help formulate your spectrum and site requirements which will in turn drive the complexity for your RF design team. A lesson learned from the Southern Linc deployment was that many of the application owners grossly overestimated their throughput and polling requirements. Defining a minimum set of use cases required to support your LTE business case will help you determine the size and scope of your network deployment and in turn extrapolate your utility operation needs.

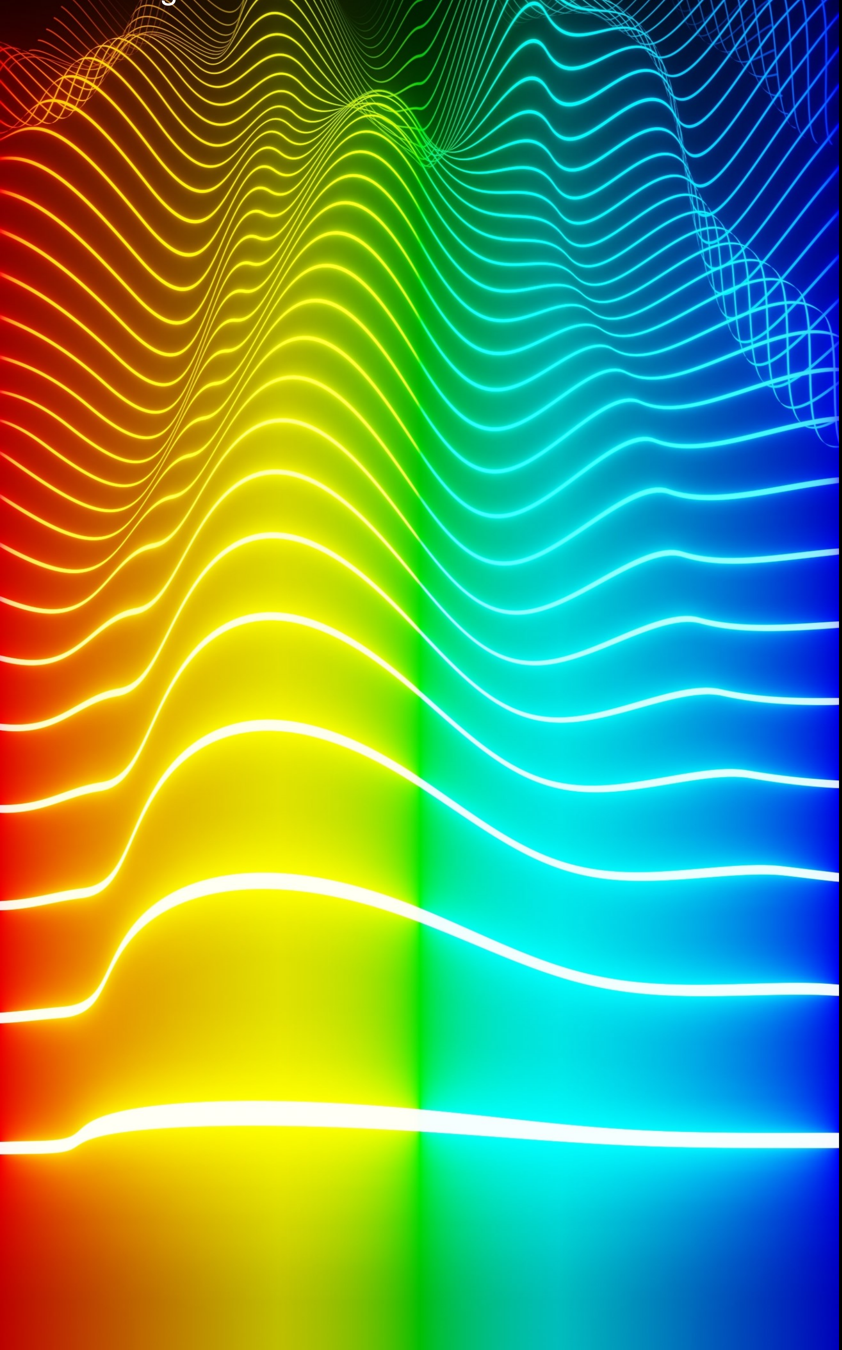
Fixed Versus Mobile UE Support

Fixed User Equipment (UE) support means that a data device is installed at a permanent location for data services such as SCADA and Metering. One way to manage fixed device installations is to have an RF engineer model each fixed device's location and expected RF environments prior to deployment. Specific instructions can be given to the installer in terms of antenna type and orientation. From an ongoing operations support perspective, the fixed devices need to be monitored and managed. Fixed devices out in the elements can stop working for many reasons. Talking with your application owners and clearly defining who is responsible for the monitoring and field support is critical.

Conversely, mobile UE services include applications such as mobile computing, mobile hotspot, and Over The Top (OTT) voice services. Mobile applications add operations support from an optimization standpoint as there are greater demands on RF planning and optimization. Tier 1 carriers have set a high bar for mobility and handovers especially on major interstates and urban areas. Understanding these expectations will help define the workload for your RF and optimization teams. Depending on the size of your mobile UE fleet, you may need to consider staffing for device management as well as end user technical support.

Bands and Bandwidth Available

The spectrum and bandwidth that you will have available can impact the workload for your RF and optimization teams. Many utilities are investigating deploying 3Mhz of spectrum. This will work fine for many applications. With this amount of spectrum, areas with a high-density of UEs like plants or large offices can cause more planning and work for your RF and Optimization teams. Understanding your expected UE density and locations ahead of time will help you determine your problem locations, and you can plan for extra workload in the RF design in those areas.



SLA Per Application or Use Case

It is important to understand the service levels and availability that your end users expect. One of the main reasons that utilities consider owning their own private network is not only for security and control but having a “utility grade/ mission critical” telecommunications system in terms of reliability and availability. Having agreement with your end users on their SLA expectations will be key in determining the number of FTEs needed. The more aggressive you are with your availability requirements, the higher the number of FTE’s that will be needed. From a field perspective the faster you need sites restored, the more it is going to impact the number of sites per FTE that can be supported. From a core network perspective, it is critical to make sure you have the talent in place to respond 24X7 for issues. Thankfully, the core LTE network is very stable. Unfortunately, there are constant upgrades on component software, so having the staffing to test and fix any upgrade issues is key. Please see Service Assurance and Network Management section for a life cycle wheel describing steps that can be taken to help build out the private wireless environment.

Number of Sites

The number of sites, density of sites, driving time to the sites, and expected restoration time are factors that can be used to help determine how many field technicians will be required.

Tier One carriers have high density of sites to provide in-building coverage with mobile devices, as well as to be able to manage a high density of users that are running high data throughput applications such as streaming video. With a high density of sites there is much less drive time to each site. Utilities will likely have a more dispersed deployment of LTE sites many of which that are in rural areas. The drive time to sites is a big variable when determining the number of technicians needed to be able to get to a site within your SLA with your end users. Depending on the criticality of your end user applications, a reasonable expectation is to have a technician on site to repair a service impacting issue within two hours. A technician in a metro area with a high density of sites will be able to manage more sites than a technician that is taking care of rural areas.

The type of work for which the technician is responsible is another variable to consider. In addition to antennas on the tower, some deployments have LTE radios and filters on the tower top. These repairs will require a tower crew which is a different talent than your typical telecommunications technician that will work on your ground equipment. Another consideration is backup generation at the site. Backup generators and fuel cells require regular exercising and maintenance. Will you have your own telecommunications technicians take care of this work, or will you outsource it? Although LTE sites can run in cabinets that do not require air conditioning, the utility deploying LTE may have existing telecom shelters that have extra space in which LTE can be installed. Will your technicians be responsible for existing telecom equipment as well as the HVAC and power systems at the site? If the utility has existing technicians already familiar with operating legacy telecom infrastructure, the training curve is not overly complex in getting them ready to support LTE.

Finally, the quality of the LTE site installation is a key component into how much field support will be needed. Bad connectors or grounding can play havoc with operations, so making sure the site is installed properly from the beginning is important.

Different Types of UEs

The number and variety of User Equipment (UEs) will impact your needs for product engineering (device certification and support). Although LTE is a standards-based technology, UEs are not plug and play. There is a considerable amount of work needed to make sure that the LTE modem/module in the device will work well with your network configuration, device management, roaming, and provisioning needs.

There are plenty of third parties that provide certification and testing services if this type of talent is not in-house. Also, consider who will be responsible for supporting Fixed UE deployments in the field. Some utilities may expect their field telecom technicians to not only take care of LTE site infrastructure, but also the UE deployments that are connected to critical applications in the field.

VoLTE/IMS

Offering Voice over Long Term Evolution (VoLTE) services is a big consideration for a utility. The IMS infrastructure is considerable and complex and is similar in scope and complexity to the LTE core so a similar amount of FTE's will be needed to support. VoLTE services also add complexity with regulatory requirements E-911, E-911 Location Requirements, FCC reporting requirements, CALEA (lawful intercept), number management, and others all need to be considered. Having employees that can navigate the regulatory requirements of offering phone services is required.

In addition to the infrastructure and regulatory support, offering phone services brings on added complexity for your RF optimization team. End users are accustomed to being able make mobile phone calls without interruption while traveling. External vendor support for text messaging interop, roaming, local and long distance, MMS, WPS, etc. are all additional considerations for support. A deep dive into VoLTE and IMS services is recommended prior to going down this path.

Reliability Requirements (Day-to-Day, Storm or Emergency)

Emergency & storm restoration SLA is a consideration on the number of FTEs needed. Having 24X7 technicians available to setup mobile assets such as Cell-On-Wheels (COWs), Generator-On-A-Trailer (GOAT's), and Satellite-On-Wheels (SOW's) is a consideration when planning your workforce. Tornados, hurricanes, and other disasters can cause large outages despite efforts for your LTE network hardiness. Having field technicians to maintain and trained to quickly and safely deploy your mobile assets to restore LTE communications in a fast manner is critical. An emergency response plan with expectations for pre-deployment, restoration, and then decommissioning activities and expectations will help you factor in the number of technicians needed. Having a bare minimum number of field technicians may work fine for sunny day routine maintenance, but don't forget to plan for emergency response staffing requirements. The utility that is investing in the significant capital into the deployment of LTE, is expecting to have the network up and running in the worst of times.

In the telecommunications industry there is a term FIVE 9s (99.999% uptime) which equates to no more than 5 minutes and 15 seconds of down time per year. This type of reliability comes at a cost. One way to help achieve this level of reliability is to deploy geographic redundancy with two separate data centers. This will not only offer redundancy from a data center disaster standpoint but also allows the utility to move data traffic to one data center for upgrades or isolated equipment issues.

The reliability of the RAN network is more difficult to maintain compared to the core network due to several variables that can impact availability which are outside of a controlled data center environment. The cell site connectivity (backhaul) and tower top electronics and antennas are susceptible to impacts from severe weather, fiber cuts, and theft/vandalism just to name a few. With diverse and redundant transport connections to the cell site, three 9s (99.9x Uptime) is very achievable with a goal towards four 9s (99.99% uptime) which equates to no more than 52 minutes and 16 seconds of downtime per year per site.

Redundancy Requirements

In the telecommunications world when talking about redundancy there are various levels that can be instituted:

- Local redundancy
- Geographic redundancy
- Connectivity Redundancy

First is local redundancy whereby within a data center deployment there are redundant components. For example, for a 4G LTE solution there would be at least two MME's, two SGW's and/or two PGW's. It is highly recommended that this level of redundancy be built into the network design.

Second is geographic redundancy whereby the electric utility has at least two data centers where core components can be placed. These data centers should be sufficiently far apart such that if a major event occurs at one data center the other data center will not be impacted by the same event (i.e., fire or tornado). With geographic redundancy each of the core components has a geographically separate instance so if one data center is impacted the other can take over and manage all the network traffic.

Finally, one of the most susceptible components to outages is the cell site connectivity. Microwave and Fiber connections can be subject to outages especially due to extreme weather and fiber cuts. Having redundant connections to the LTE site can help a utility achieve the availability they require especially for critical sites.

Service Assurance

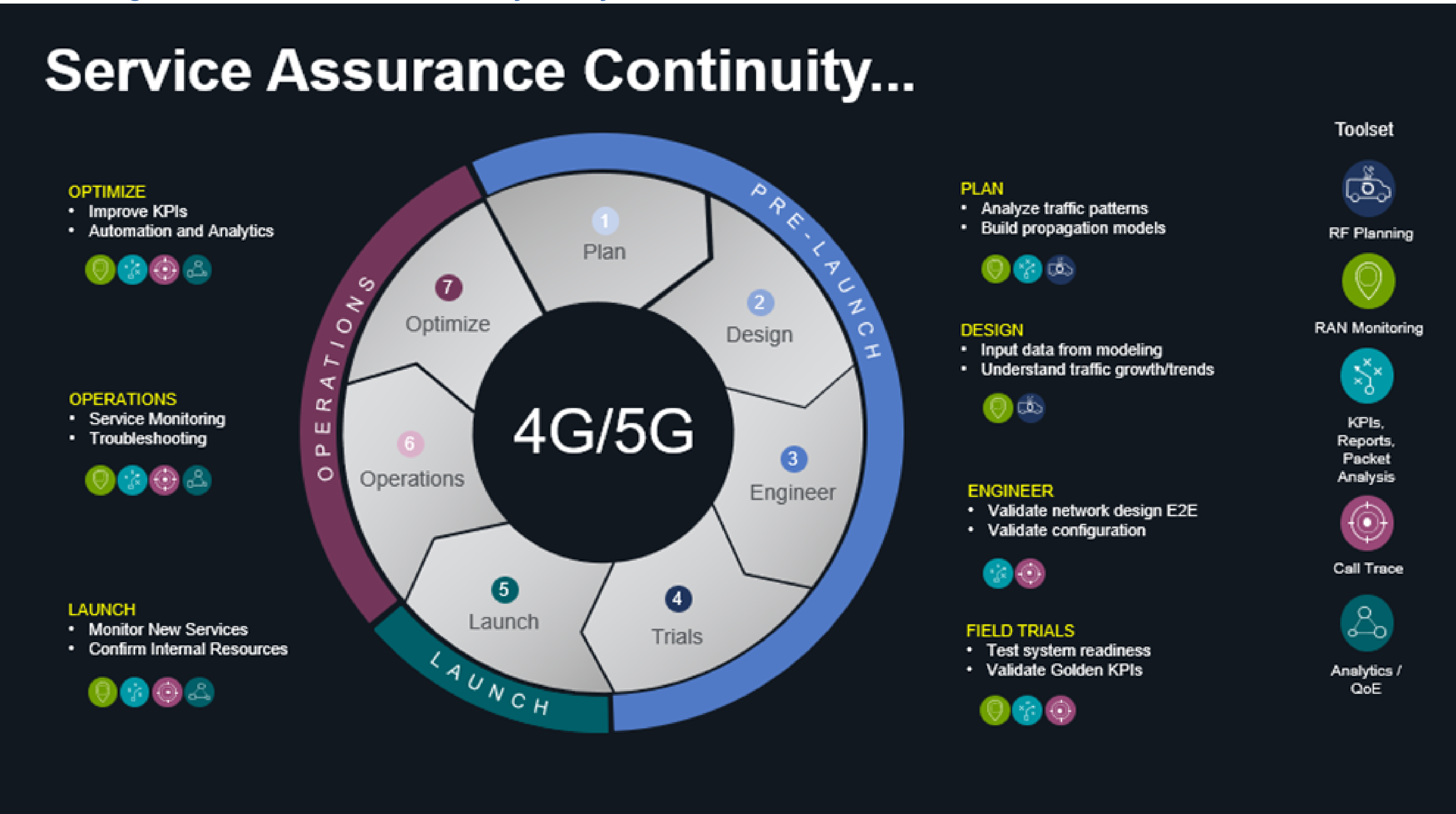
Modern wireless communications technologies be they 4G or 5G are much more complex than the older wired methodology. Network Equipment Manufacturers are moving more towards virtual based and/or cloud-based technology to deploy these private wireless solutions. This virtual and/or cloud-based technology and the decision on the placement of both the equipment and software adds a further layer of complexity to providing a wireless infrastructure that is robust, reliable, redundant, secure and is up somewhere between 99.9% and 99.999% (Five 9s) of the time. Due to this rise in complexity, it is imperative that as electric utilities consider implementing private wireless solutions moving forward that consideration is made to how to:

1. Plan
2. Design
3. Engineer
4. Trial
5. Launch
6. Operate
7. Optimize

Providing service assurance at all steps of this process is essential to ensuring that the quality of the network is as high as it can be and problems that will arise can be resolved quickly. It is especially important that the owners of this wireless network plan and build in the necessary tools from the start to make sure that when issues arise the mean time to knowledge to find these issues is as small as possible, because time is money. Wireless network owners who have little to no tools can spend valuable resources and time watching network equipment manufac-turers and cloud-based vendors work to try to determine where the problem is in the network.

With the right tools, gathering and analyzing the actual packets the wireless network can be restored to service much quicker. Clearly, it is essential to properly plan for tools at the outset of the project, otherwise when problems arise the owner/operator of the wireless network will spend valuable time trying to get to the root cause of the problem.

Fig. 1 - Service Assurance Continuity Life Cycle



Network Management

In addition to the Service Assurance functionality described above, it is especially important for the electric utility to setup and monitor the network management which is typically done with Simple Network Management Protocol (SNMP) traps or telemetry sent from the Network Elements (NEs).

This is different than service assurance in that the individual NEs provide information on the status of the nodes to a centralized management system versus looking at the packets that are traversing from client to server and back. Some of the things that are gathered from a Network Management system are:

1. CPU utilization
2. RAM usage
3. Disk usage
4. Network usage (summarized)

In addition to these KPI's the NEs can provide telemetry data via a software agent to allow for automatic transmission of KPIs in real time to a centralized network management system.

Having the network management system in place in addition to the service assurance platform helps to identify issues that are occurring with the network elements that are part of the private wireless solution.

Timeline for deployment

Although this paper is focused on operating an LTE network, the timeline for deployment will certainly impact the number of FTE's needed especially if the same personnel are expected to be involved with both operations and deployment. Outsourcing deployment or hiring contractors is a consideration to help supplement staffing.

If you choose to outsource the build out which others have done, make sure that your FTE's are working side by side with the outsource partner so that learnings about the network operation can occur while the build out is happening.

Differences Between Private and Carrier LTE

Today many electric utilities are relying on the large service providers to provide carrier LTE for their IOT devices in the field so the number of FTEs to manage this business relationship is low (say one or two key people). However, the cost to the electric utility is high and when issues occur (weather events, network outages, fiber cuts, etc) it can sometimes take weeks to restore service.

When electric utilities implement private LTE, the number of FTE's will rise however the utility is able to control its own destiny and can maintain "utility grade" network support.

Types of Talent Needed to Operate the Utility LTE Network

- ⇒ **Operations Center Technicians** – Responsible for keeping the overall end-to-end network up and running. This team of technicians monitors network alarms, completes a first level triage of the issues, and escalates appropriately. For a 24x7 365 operation and considering sick time a vacation, a minimum of six technicians would be needed for up to a network size of about 250 sites. The complexity of the network could impact these numbers.
- ⇒ **RAN (Field Technicians) –** Responsible for the radio access network to keep it functioning properly. Depending on variables such as end device (UE) support, backup power responsibilities, density of sites, and SLA's, the number of sites that each technician can support varies from 20 to 100+ sites per tech.
- ⇒ **Warehouse Technicians for Spares / Inventory –** Responsible for making sure that spares are readily available and pulling equipment from the inventory when required. Depending on the number of sites supported, this workforce can vary and for a small operation could be combined with existing utility warehouse support responsibilities.
- ⇒ **Network Management and Operations Tools –** This team is responsible for supporting the network fault management applications tools needed to effectively monitor and troubleshoot LTE issues. This is a hard group to estimate as the complexity of network as well as how robust of network monitoring and notification tool suite is needed can impact the level of effort. A minimum of four people would be needed for a small LTE deployment.
- ⇒ **Core Engineering Engineers & Analysts –** Responsible for engineering the core network, two third-level core LTE operations support, and firewall maintenance. Minimum of eight people. Supporting VoLTE services will increase this amount.
- ⇒ **Security –** Responsible for ensuring that security is designed and engineered into the system and ongoing threat detection and mitigation is implemented. Minimum of one person.
- ⇒ **Product Engineering –** Responsible for evaluating, selecting, and testing devices (UE's) and SIMS to go onto the network. Minimum of two people.
- ⇒ **Provisioning Support –** Responsible for working with the core engineering, security, product engineering and product management teams to support the needs of the business by implementing the provisioning required to sustain and grow the business. Minimum of two people.
- ⇒ **RF Optimization –** Responsible for evaluating and improving the radio network by being able to geo-locate the subscriber and evaluate the RAN environment throughout the RF footprint. Minimum of one person for a small LTE deployment.
- ⇒ **RF Design –** Responsible for evaluating the RF environment and deciding where the best places are for antenna placement, tilt, carriers, etc. Minimum of one person for a small deployment.
- ⇒ **IT Server Support –** Responsible for setting up and maintaining the servers for the 4G LTE network over time. As virtualization of the LTE Core progresses, this is a big need. Minimum of two people.
- ⇒ **VoLTE and PTT Support –** Responsible for setting up the VoLTE and PTT functionality for end users and maintaining good quality of experience moving forward as the service grows. Minimum of five people.
- ⇒ **Regulatory Support –** Responsible for monitoring the standards (3GPP) and bringing changes to the team as the standards evolve so that the team can decide to add new functionality to the system. Minimum of one person.
- ⇒ **Data Center/Environmental Support –** Responsible for setting up the data center and maintaining the environment for the 4G LTE network over time. Minimum of one person but could be shared if utility already has this function.

Reference Appendix

Acronyms used in this paper:

- CALEA - Communications Assistance for Law Enforcement
- COAM - Company Owned and Maintained
- COW - Cell site On Wheels
- FCC - Federal Communications Commission
- FTE - Full Time Equivalent
- GOAT - Generator On A Trailer
- IMS - Internet Protocol (IP) Multimedia Subsystem
- IT - Information Technology
- KPI - Key Performance Indicator
- LTE - Long Term Evolution – 3GPP standards based 4G technology
- MME - Mobility Management Entity
- MMS - Multimedia Messaging Service
- NE - Network Elements
- OSS - Operations Support System
- PTT - Push To Talk
- RAN - Radio Access Network
- RF - Radio Frequency
- SCADA - Supervisory Control And Data Acquisition
- SGW - Serving Gateway
- SIMS - Subscriber Identity Module
- SLA - Service Level Agreement
- SNMP - Simple Network Management Protocol
- SOW - Satellite on Wheels
- UE - User Equipment – LTE Handset
- URLLC - Ultra Reliable Low Latency Communications
- VoLTE - Voice over Long Term Evolution – 4G network
- WPS - Wireless Priority Service

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