Select Spectrum

700 MHZ A-BAND & PRIVATE LTE COMPARATIVE STUDY

Cost and Performance Comparison

A comparative analysis of 700 MHz A-Band and 900 MHz Private LTE networks assessing lifecycle cost, capacity, and suitability for modern utility field-area communications.

November 2025

Analysis and Report by: KN Utility Telecom Consulting

Contents

Background and Executive Summary

Context for Comparing 700 MHz A-Band and 900 MHz PLTE Cost, Coverage, and Capacity

As utilities move toward greater functionality, automation, and responsiveness in their electric grids, a resilient and dependable telecommunications network has become the foundation for grid modernization. Modern grid operations depend on real-time visibility, control, and coordination across thousands of field devices from substation assets to reclosers, regulators, and sensors deployed at the grid edge. These evolving operational needs are driving utilities to re-evaluate their communications infrastructure to ensure it provides the reliability, capacity, security, and flexibility required to support current and future use cases.

The electric grid has long been constructed for high reliability and black start capability. It is therefore critical that a utility's telecommunications network match that same level of reliability, resiliency, and security. Increasing data requirements, from existing devices to automation of distribution feeder devices and new applications requiring higher throughput, further underscore the need for dependable, high-performing communications networks that utilities can control and trust.

Most utilities have owned and operated their own purpose-built telecommunications networks since the 1960s and 1970s to ensure the reliability necessary for safe and continuous electric service. These networks were designed specifically to meet the unique operational and reliability needs of the electric grid. As commercial wireless networks became available, utilities began leveraging them for non-critical communications. However, commercial networks cannot deliver the availability, performance, or coverage needed for mission-critical operations. Their commercial business model, driven by serving a large number of consumer subscribers, is fundamentally different than the requirements and high levels of reliability and availability utilities have for their telecommunications networks.

Today, new spectrum allocations and modern technologies enable utilities to design networks that go beyond single-purpose applications allowing utilities to consolidate multiple operational use cases. Modern utility telecom networks can now support multiple use cases, ranging from monitoring and control to Distributed Energy Resources (DER), Advanced Metering Infrastructure (AMI), and advanced analytics, over a homogenous network. This evolution is one of the primary drivers for utilities to transition toward next-generation telecommunications infrastructure.

Because these modern telecommunications networks support multiple use cases and require greater RF spectrum, they are becoming increasingly visible within utility planning and investment decisions. Historically, utilities leased narrowband channels from the FCC for minimal cost—often $50 for a 10-year license—but modern systems must now secure dedicated spectrum, construct or lease additional tower sites, expand backhaul, and, in the case of PLTE, purchase and operate an Evolved Packet Core (EPC). These factors increase the overall cost and complexity of today's networks.

However, the cost of a multi-use, next-generation network is often comparable to or lower than maintaining multiple purpose-built systems serving individual functions. There is, nonetheless, a wide disparity in both cost and functionality among technology options. PLTE networks can support a broader range of applications, while 700 MHz wideband systems provide many of the same capabilities for fewer, but critical, use cases—at significantly lower capital and especially operational cost over a 20-year lifecycle.

Purpose of This Analysis

Finding the Balance Between Cost, Coverage, and Capability

The purpose of this analysis is to compare a licensed spectrum option widely adopted by utilities–the 700 MHz A-Band spectrum and the technologies that can operate within that band to a licensed 900 MHz LTE-capable spectrum (3 × 3 MHz block) and standard LTE technology. While LTE is a mature, widely supported technology with a global ecosystem, it may not be the best solution for every utility. Each utility must carefully consider coverage, capacity, traffic requirements, costs, pros and cons, risks and benefits, and operational requirements unique to its environment before determining the optimal technology path forward. Utilities continue to build robust telecommunications networks as the foundation for achieving their grid modernization goals, enabling increased visibility, enhanced monitoring and control of distribution feeders, and the secure integration of emerging applications. A strong, reliable telecom backbone will ultimately determine the success of these modernization initiatives.

700 MHz and 900 MHz Technologies

Overview of Technologies Supporting Utility Field-Area Communications

This analysis evaluates wireless technologies that can operate within wideband or broadband licensed spectrum suitable for utility applications. Each technology offers different tradeoffs in performance, ecosystem maturity, and deployment complexity. The comparison focuses on how these options align with electric utility operational needs such as distribution automation, SCADA, and AMI backhaul. Technologies reviewed include 700 MHz wideband systems including stand-alone NB-IoT, IEEE 802.16s/t, proprietary wideband radios, and 900 MHz private LTE (PLTE). The goal is to assess coverage, capacity, latency, interoperability, and cost factors relevant to modernizing utility field area networks (FANs) and supporting grid-edge communications.

700 MHz

A Proven Spectrum Option Offering Broad Coverage and Flexibility

The 700 MHz band provides excellent propagation characteristics and wide-area coverage, making it well suited for utility field communications in both rural and urban environments. Because of its lower frequency, it can penetrate vegetation, buildings, and terrain obstructions more effectively than higher frequency spectrum. This spectrum is especially valuable for utilities seeking reliable connectivity for geographically dispersed assets or for building a foundational layer of coverage to support wideband and lower data applications. Within this band, multiple technologies are available, from wideband proprietary radios to standards-based NB-IoT (part of the 3GPP standard) or IEEE 802.16s/t allowing flexibility in balancing performance, cost, and ecosystem maturity.

900 MHz

Broadband Spectrum Enabling Private LTE and Future 5G Evolution

The 900 MHz band also offers strong propagation characteristics and broad geographic coverage. Its 3 × 3 MHz allocation supports standard broadband technologies, including PLTE. However, incumbent users occupy portions of the band and must be cleared before it can be fully utilized by a purchasing entity. The spectrum owner, Anterix, has petitioned the FCC to permit 5 × 5 MHz channel operation if other incumbents agree to vacate additional frequencies, which would enable larger LTE channels and greater capacity. Recently, 3GPP also approved 5G operation in 3 MHz channels, making this 900 MHz spectrum capable of supporting both 4G LTE and 5G technologies.

Coverage and Capacity

Understanding How 700 MHz and 900 MHz Networks Balance Range and Capacity

A utility's Field Area Network (FAN) depends on two essential factors: coverage—how far each base station sector can communicate reliably—and capacity, or the total data that can be supported by all connected devices. Both are shaped by frequency, channel bandwidth, and the underlying radio technology.

This analysis compares two representative approaches for a statewide utility network:

- A 900 MHz PLTE system using 3 × 3 MHz frequency-division duplex (FDD) channels

- A 700 MHz proprietary wideband system using 2 × 1 MHz FDD channels divided into multiple 50 kHz carriers

Both systems are capable of achieving statewide coverage when properly engineered with appropriate site spacing, antenna height, and power levels. The main differences lie in how far the signals propagate, how they manage interference, deliver throughput, and scale to meet operational needs.

Coverage Comparison

How Frequency and Reuse Strategy Influence Network Reach

Coverage determines how many sites are required to reach all assets across the utility's service territory. It depends on signal propagation, interference, and device location, which is influenced by both frequency and channel bandwidth. In practice, achievable coverage is shaped not only by the radio frequency and antenna design but also by the density and placement of utility assets, topography, and how interference is managed across the network.

The 900 MHz PLTE network offers excellent mid-band propagation with an average coverage radius of about eight miles per sector (See Figure 1) under typical terrain and environmental conditions. LTE's adaptive modulation enables devices close to the tower to operate at high data rates (using 64-QAM or 256-QAM), while devices at the edge of coverage automatically adjust to more robust but lower-rate modulation schemes such as 16-QAM or QPSK. Because LTE operates with a frequency reuse of one (See Figure 3), all sectors share the same spectrum, and interference is managed dynamically through the scheduler's resource block allocation, power control, and timing coordination.

In contrast, the 700 MHz proprietary network operates at a lower frequency, which improves signal propagation and penetration—especially beneficial for reaching remote or hard-to-access assets. For this analysis, the system was modeled using 50 kHz channels, providing a typical coverage radius of about twelve miles per sector (See Figure 2).

---

700 MHz offers greater coverage per site, reducing tower and infrastructure requirements

---

Instead of sharing one wide carrier, the 700 MHz system uses discrete channel pairs organized in a frequency reuse pattern to limit interference between nearby sites. This approach allows utilities to extend coverage per site while maintaining predictable performance. A reuse factor of six (See Figure 4) provides flexibility in assigning multiple 50 kHz channels per sector for higher-density or higher-traffic locations while maintaining enough signal separation to minimize potential self-interference.

While LTE's frequency reuse of one maximizes spectral efficiency, it also demands tighter interference management. At the cell edges, overlapping coverage from adjacent sites can create inter-cell interference, which LTE mitigates by dynamically adjusting power levels and scheduling. The scheduler may reserve portions of available resource blocks for inter-sector coordination, slightly reducing usable payload capacity but maintaining reliable connectivity.

In contrast, the proprietary system's frequency-reuse pattern provides more predictable separation between sites, minimizing interference by design. This approach offers greater stability in wide-area networks and can reduce the number of tower sites needed for equivalent coverage — an advantage in both cost and operational simplicity.

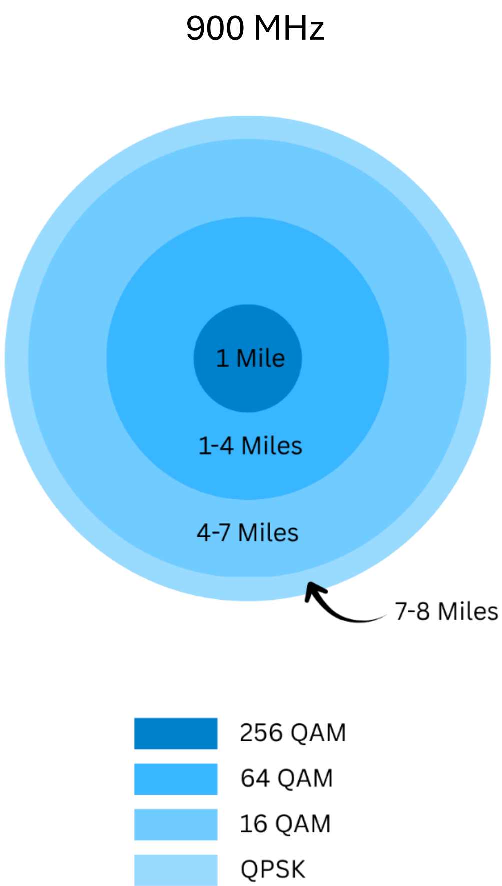

Figure 1

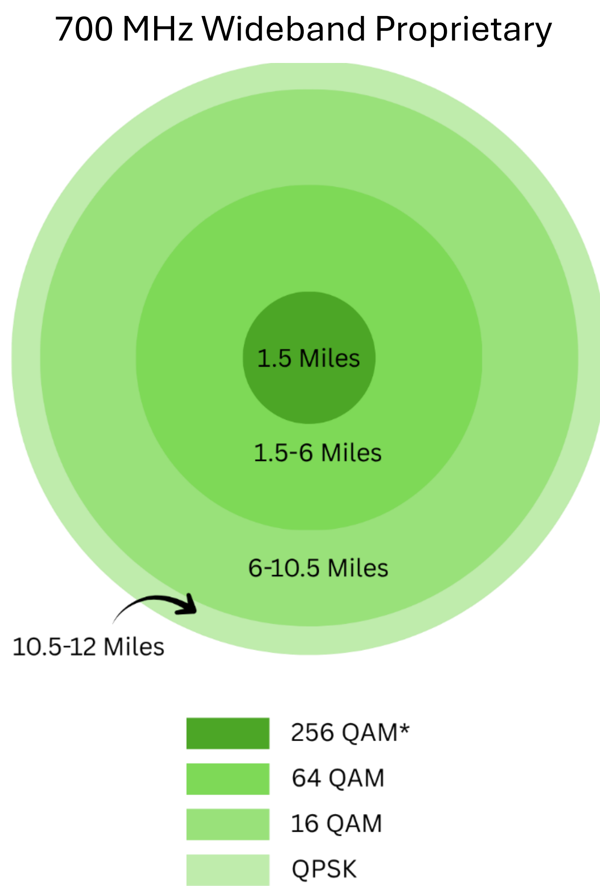

Figure 2

*Not all vendors offer 256 QAM modulation. For vendors that do not offer this modulation scheme, 64 QAM would be in its place in this diagram.

900 MHz LTE

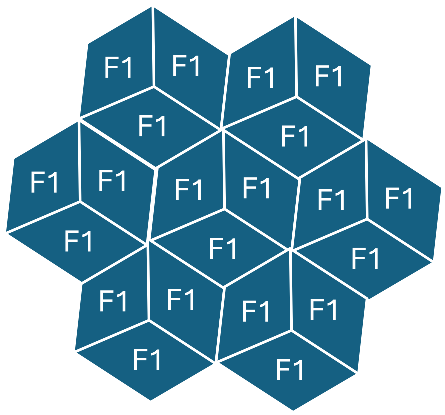

Figure 3

700 MHz Wideband Proprietary

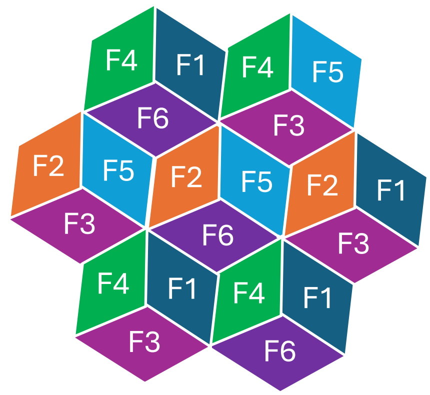

Figure 4

Capacity Comparison

Balancing Capacity, Complexity, and Operational Needs

While coverage defines where communication is possible, capacity defines how many devices can operate effectively within that area and how much data these devices can transmit. The two systems take very different approaches to achieving this balance.

The 900 MHz PLTE network, with a 3 MHz uplink channel per sector and a reuse factor of one, achieves roughly 2.7 megabits per second (Mbps) of usable uplink capacity after accounting for LTE overhead (control signaling, synchronization, and interference management). Downlink capacity is somewhat higher and typically not a limiting factor for grid operations. This level of throughput provides headroom for thousands of devices per sector, depending on their specific use cases. The network can also support broadband and other data-intensive applications, though continuous video streaming is generally discouraged due to capacity considerations.

PLTE delivers flexible, high-capacity broadband performance; 700 MHz systems deliver deterministic, low-overhead reliability.

The 700 MHz proprietary system operates with much narrower 50 kHz channels, providing about 75–150 kilobits per second (kbps) of usable uplink capacity per channel, depending on modulation and coding efficiency. Though an order of magnitude smaller than LTE, this capacity is sufficient to support hundreds of field devices, including reclosers, voltage regulators, capacitor bank controllers, and AMI collectors—all of which transmit small packets. Additionally, with a frequency reuse of six and 50 kHz channel sizes, additional radios can be added to sectors where additional capacity is required, and some manufacturers offer radios with higher bandwidths which would also provide additional capacity.

In most utility FAN environments, these devices send control or telemetry data measured in tens or hundreds of bytes every few minutes. This low-duty, predictable traffic pattern makes the proprietary system's deterministic scheduling model particularly effective. It ensures consistent latency and reliable delivery without dependence on an LTE core.

By contrast, LTE's broadband framework supports a wider mix of applications and form factors and can dynamically adjust bandwidth based on network demand. While this adds flexibility, it also introduces greater complexity and cost—factors that may not be necessary for basic automation and telemetry use cases.

Parameter	900 MHz PLTE (3 x 3 MHz)	700 MHz (2 x 1 MHz FDD, 50 kHz Channels)
Channel Bandwidth (UL/DL)	3 MHz / 3 MHz	50 kHz / 50 kHz per radio[1]
Reuse Pattern	1	6
Sector Radius	~ 8 mi	~ 12 mi
Useable UL/DL Capacity	~ 2.3 Mbps	~75/150 kbps
Estimated Devices per Sector (assuming 100% FAN devices, at 70% capacity)	92,000 (theoretical)	3,750 (theoretical)
Capacity Utilization (FAN Traffic)	70%	70%
Network Control	Standard LTE core	Deterministic polling, no EPC

1 - Assuming maximum radio channel size is 50 kHz

- PLTE device count is a theoretical upper bound from average-throughput calculations; practical limits and CQI/interference reduce real maxima, but DA at 5-minute polling leaves a lot of headroom. PLTE would typically not be used just for DA and SCADA, but for comparison purposes it was used in this table.
- 700 MHz count assumes conservative usable capacity (~75 kbps) for one 50 kHz channel; capacity and device counts scale ~linearly with additional 50 kHz radios per sector.

Comparison and Tradeoffs

Balancing Scalability, Simplicity, and Cost Across Spectrum Options

Both the 900 MHz PLTE and 700 MHz proprietary systems meet the performance requirements of a modern utility FAN, but they do so through different design philosophies.

- 900 MHz PLTE emphasizes scalability and versatility, providing broadband capacity capable of supporting advanced applications, limited video, mobile users, and future 5G integration. It offers higher throughput but requires more complex network management, including LTE core functions.
- 700 MHz proprietary solutions prioritize coverage, predictability, and cost efficiency. Their deterministic operation simplifies performance engineering and ensures consistent latency for SCADA and automation traffic. They are also less expensive to deploy and maintain, making them ideal for utilities focused primarily on distribution automation and grid monitoring.

LTE provides more capacity than most current utility applications require but offers flexibility for future use cases, whereas the proprietary system delivers what many utilities need today—secure, reliable connectivity with minimal overhead.

Both systems also incorporate strong security frameworks. LTE embeds encryption and authentication directly into the air interface, while proprietary systems typically apply encryption at the transport or application layer. The resulting overhead is minimal in both cases and has little effect on overall throughput.

Example Capacity Analysis

Illustrating Real-World Differences Through a Modeled Utility Case

For this analysis, a fictitious statewide utility was modeled serving roughly 42,775 square miles and 8.6 million people, with a mix of rural, suburban, and urban areas. About 57,000 field devices and substations were assumed to require connectivity. Under these conditions, estimated device density equates to 304 devices per sector for 700 MHz and 135 devices per sector for 900 MHz, both well within their respective capacity limits.

The 700 MHz A-Band proprietary network provides a cost-effective, purpose-built solution for wide-area utility communications, offering predictable performance and extensive coverage at a lower cost. The 900 MHz PLTE system delivers higher capacity and greater flexibility, suitable for utilities anticipating broader integration of advanced applications or mobility.

Both represent viable, forward-looking options—each optimized for a different balance of coverage, capacity, and complexity depending on a utility's operational goals.

Cost Analysis

700 MHz A-Band Offers Long-Term Cost Advantages Over PLTE

This fictitious statewide electric utility was created to represent a realistic deployment scenario for advanced distribution automation and grid monitoring and control. Use cases include downline feeder automation—such as capacitor bank controllers, voltage regulators, reclosers, and line sensors—as well as substations and (AMI) backhaul collectors and concentrators.

The cost evaluation compares representative network technologies capable of supporting these operational requirements. Costs were developed using representative market estimates to illustrate typical capital and operational cost profiles for each technology class, including spectrum, Radio Access Network (RAN) equipment, user end devices (UEs), implementation, and ongoing support. Results are presented in aggregated and relative terms to highlight general cost trends and trade-offs rather than detailed procurement-level pricing.

This analysis indicates that the total cost of ownership over a 20-year period is lower for the 700 MHz A-Band deployment. The primary drivers are lower infrastructure costs—due to the lower frequency—no requirement for an Evolved Packet Core (EPC), which is necessary for PLTE systems, and lower spectrum costs. Infrastructure accounts for the majority of total project cost. This is not necessarily because LTE equipment is more expensive, but rather because higher frequency deployments typically require more sites—each with associated costs for towers, buildings, civil work, and backhaul. Additionally, there is typically higher ongoing support costs for LTE equipment than for 700 MHz A-Band equipment making for a higher OpEx cost.

That said, spectrum and EPC costs, while not insignificant on their own, are small relative to overall RAN and infrastructure costs. The cost of end devices (User Equipment, or UEs) is roughly equivalent between PLTE and 700 MHz A-Band systems for comparable SCADA, DA, and other FAN applications. For this reason, UE costs were excluded from Figures 6, 8, 11 and 12. In many utilities, the UE cost is borne by the business unit owning the use case and is considered part of the device itself (e.g., a radio integrated with a capacitor bank controller is treated as part of the controller cost). Because this cost is nearly the same across technologies—and represents the largest single cost element regardless—it was excluded from some the comparative figures.

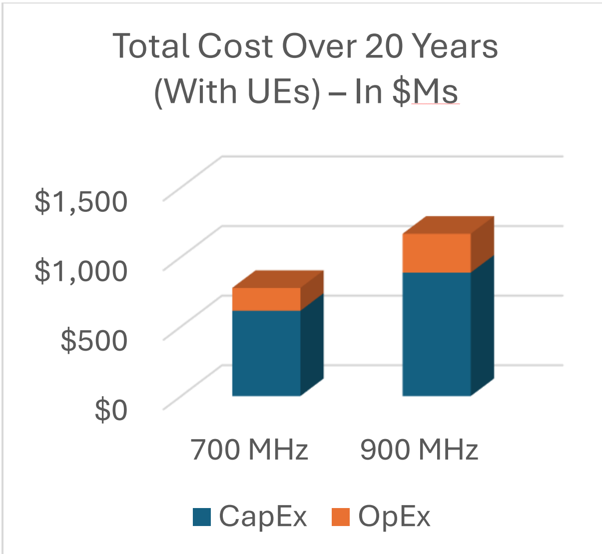

Figure 5

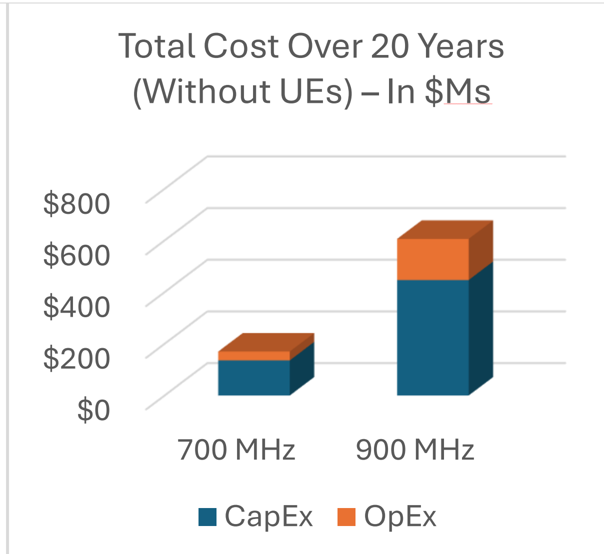

Figure 6

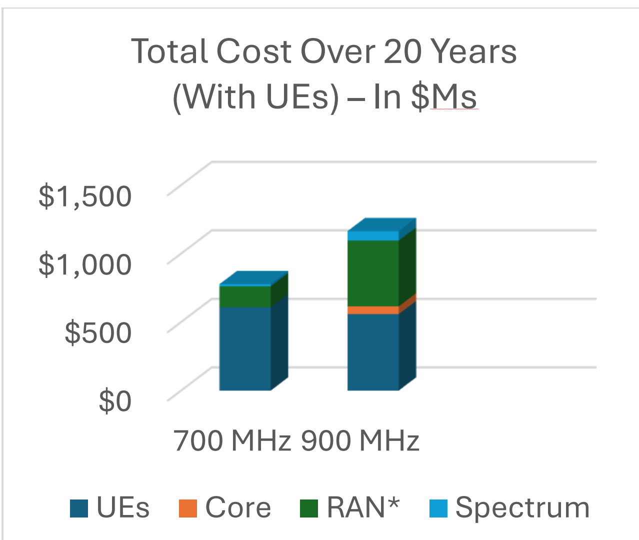

Figure 7

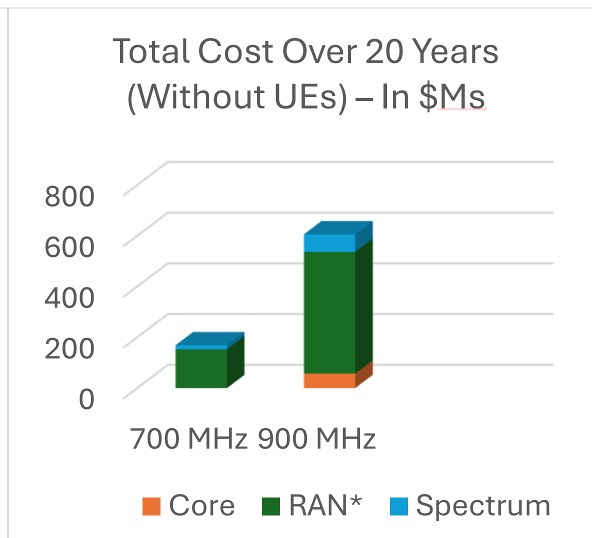

Figure 8

*RAN includes backhaul and site work costs. Assumptions can be found in the Appendix.

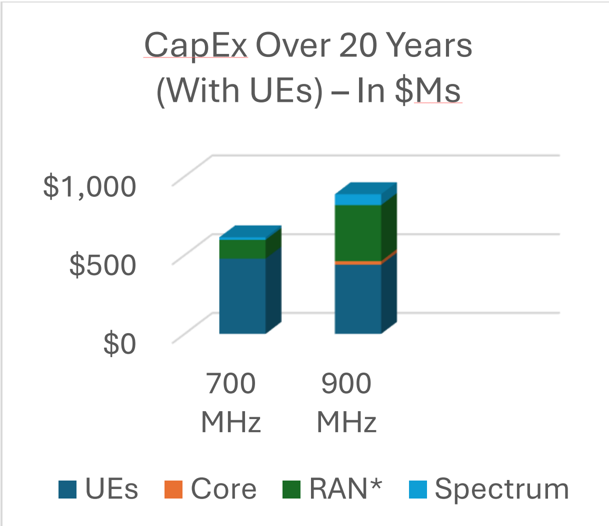

Figure 9

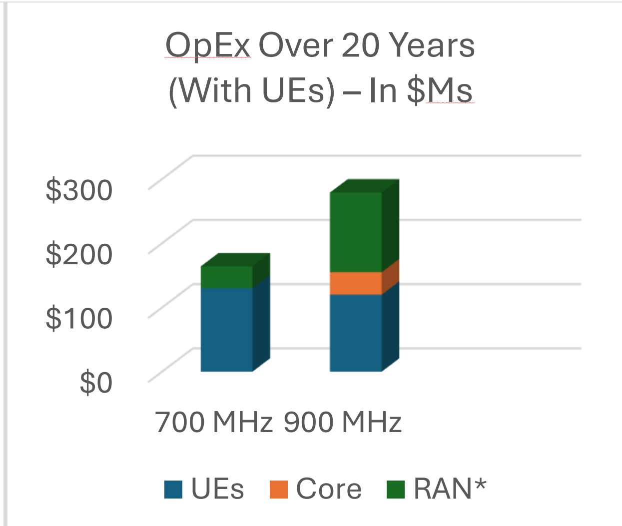

Figure 10

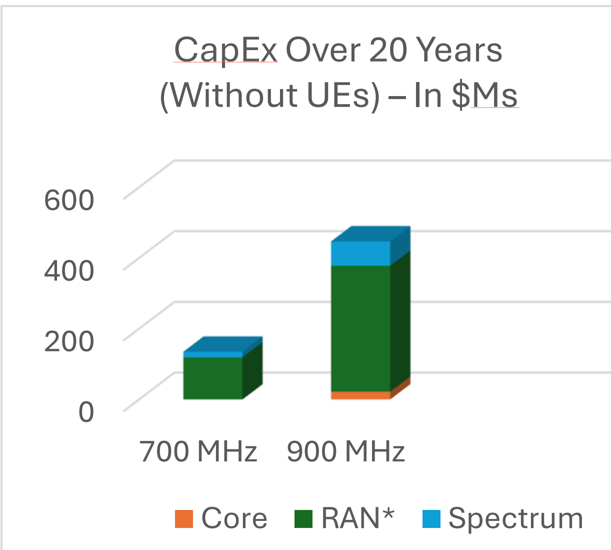

Figure 11

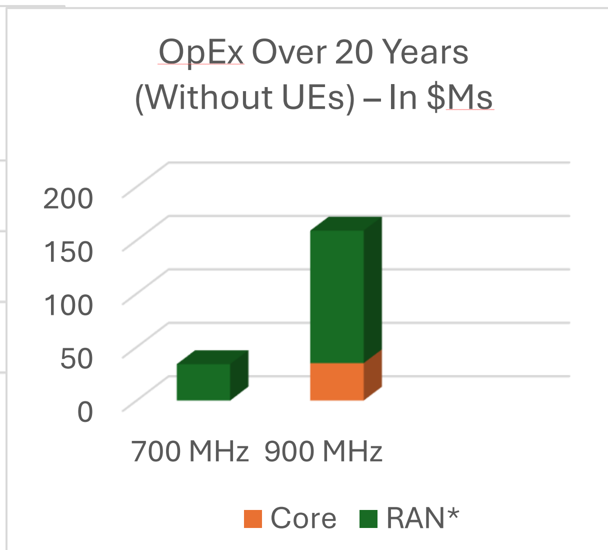

Figure 12

*RAN includes backhaul and site work costs. Assumptions can be found in the Appendix.

Use Case Evaluation

700 MHz A-Band Applications and Device Ecosystem

This section focuses on use cases and device ecosystems specific to 700 MHz A-Band networks as part of this analysis. While 900 MHz PLTE provides a broader ecosystem and higher-capacity capabilities, this evaluation concentrates on the range of utility applications that can be effectively supported within the wideband 700 MHz A-Band channels.

The use cases included in this analysis are primarily FAN devices, consisting mainly of distribution feeder automation equipment such as capacitor bank controllers, voltage regulators, and reclosers. These devices typically transmit small data payloads and do not require stringent latency performance, making them well suited to operate within the available capacity of wideband 700 MHz channels. Traffic from these assets is generally periodic or event-driven status updates, setpoint changes, or alarms, rather than continuous, high-throughput communication.

While these were the primary focus of the capacity evaluation, other potential use cases for 700 MHz A-Band networks include AMI backhaul, substation SCADA and RTUs, Distributed Energy Resource (DER) interconnections, remote-controlled sectionalizing and tie switches.

From an end-device perspective, most current 700 MHz A-Band implementations rely on industrial-grade radio modems or integrated routers housed within control cabinets. These devices are typically larger and more expensive than modules designed for high-volume commercial markets, limiting their suitability for smaller form-factor applications such as fault circuit indicators (FCIs), AMI endpoints communicating directly from the meter, or smart streetlight controllers. The spectrum's narrower channel bandwidth also makes it less appropriate for broadband or video-based applications such as substation physical security or AMI 2.0 high-data-rate communications.

---

700 MHz A-Band networks are well suited for utility field-area use cases requiring reliable communications with lower cost and complexity.

From a regulatory standpoint, the 700 MHz A-Band allocation permits both fixed and mobile operations under FCC rules. However, most current utility implementations are fixed wireless networks. Vendor support for mobile-capable equipment in this band is limited at present but may expand as utilities signal demand for mobility features and as the ecosystem matures.

The vendor ecosystem for 700 MHz A-Band remains smaller than that of 900 MHz PLTE. Available offerings are concentrated among a limited number of manufacturers providing proprietary radio systems and ruggedized industrial modems tailored to utility and critical-infrastructure environments. Broader device diversity including embedded modules, gateways, and integrated routers, will depend on continued regulatory stability, growing market demand, and alignment with emerging utility IoT standards.

As utilities expand the integration of distributed generation, Electric Vehicle (EV) charging, and energy storage systems, 700 MHz A-Band networks could serve as a reliable and cost-effective backhaul option for supervisory control and telemetry in areas where fiber deployment is impractical. For the foreseeable future, the 700 MHz A-Band can provide a solid, utility-owned solution for field automation and monitoring. Over time, as network requirements evolve, this same spectrum could be repurposed or transitioned to support NB-IoT or complementary LTE-based architectures, ensuring that the spectrum investment retains long-term value and can be leveraged as part of a broader grid-modernization strategy.

Use Case	Typical Data Profile	Latency Sensitivity	700 MHz A-Band Suitability	Comments
Feeder Automation (Reclosers, Regulators, Cap Bank Controllers	Low data rate, periodic/event-driven	Low-moderate	High	Ideal fit, small payloads and modest latency requirements
AMI Backhaul	Moderate, aggregated	Moderate	High	Supports aggregated meter data; not suited for direct-to-meter
Substation SCADA/RTUs	Low-moderate	Moderate-high	High	Effective for telemetry and supervisory control
Remote-Controlled Switches	Low data rate, real time	High	High	Adequate for control
Distributed Energy Resources	Moderate	High	High	Suited for telemetry, status, control
Transformer Monitors / Power Quality Sensors	Low-moderate	Low	High	Suitable for continuous monitoring and data trending
Fault Circuit Indicators (FCIs)	Very low, event-based	Low	Low	Limited by form factor and current radio size/cost
Substation or Field Video	High, continuous	High	Not suitable	Bandwidth insufficient for broadband or video applications
Mobile Field Applications	Variable	Moderate=high	Limited	FCC allows mobility, but few mobile-capable devices currently available

Risks and Considerations for 700 MHz A-Band Networks

Evaluating Standardization, Interoperability, and Future Bandwidth Needs

While 700 MHz A-Band utility deployments have been in place for more than two decades and have demonstrated long-term stability, several factors should be considered when evaluating future use.

The primary risk is the lack of a standardized technology framework—apart from NB-IoT and IEEE 802.16s/t, both of which have limitations as noted in the Appendix. Each manufacturer uses proprietary implementations, meaning devices from different vendors are not interoperable. This limits flexibility and creates dependency on individual vendors for ongoing product support and technology evolution. Although this introduces potential long-term risk, the three primary vendors serving this market have been in operation for many years and maintain strong installed bases across utilities and other critical-infrastructure sectors. Given their established customer base and continued product investment, it is unlikely that support for these systems will end in the near future.

Because the 700 MHz A-Band is wideband spectrum, it cannot support the same number of devices or throughput levels achievable with broadband systems such as private LTE. It is not designed for high-data-rate applications such as video or broadband field connectivity. However, most manufacturers support quality-of-service (QoS) features and can deliver low, deterministic latency suitable for SCADA, DER, distribution automation and other FAN use cases.

As utilities continue advancing grid modernization and integrating more bandwidth-intensive applications, they may eventually require additional spectrum or complementary technologies. This does not diminish the long-term value of 700 MHz A-Band. The spectrum can continue to serve lower-data applications and can also be leveraged for NB-IoT deployments as part of a PLTE deployment, ensuring the spectrum investment remains valuable. In a hybrid architecture, 700 MHz A-Band could continue supporting existing FAN and SCADA applications, while higher-throughput or latency-sensitive functions migrate to PLTE in the future.

Summary

Balancing Reliability, Cost, and Future Scalability

This study compared two licensed spectrum options—700 MHz A-Band and 900 MHz PLTE—to evaluate their ability to support modern utility communications, focusing on coverage, capacity, cost, ecosystem maturity, and operational suitability.

Both 700 MHz and 900 MHz provide viable paths for utilities to modernize their FANs and support grid automation. However, their strengths and tradeoffs differ.

The 700 MHz A-Band offers exceptional coverage, signal penetration, and predictable performance within wideband channels. Its deterministic operation, lower cost, and simplified deployment make it particularly well suited for distribution automation, SCADA, AMI backhaul, and other lower throughput applications where reliability and latency are more important than raw bandwidth. The primary limitations are its proprietary, vendor-specific implementations and the absence of a unified technology standard, which limits interoperability and long-term flexibility. Still, the technology has demonstrated decades of stable utility operation, and the spectrum can be repurposed for NB-IoT in the future to protect the investment and align with emerging LTE-based architectures.

The 900 MHz PLTE network provides a standards-based, broadband platform with higher capacity, broader device ecosystem support, and stronger long-term scalability. It can support a wider range of use cases, including mobile field applications, advanced analytics, and other data-intensive operations. However, it comes at a higher capital cost, requires more infrastructure and engineering complexity, and may be underutilized for utilities whose near-term needs are limited to lower data FAN applications.

From a cost perspective, estimates show that 700 MHz A-Band deployments require lower capital and operational investment compared to LTE-based solutions. In contrast, 900 MHz PLTE systems involve higher upfront costs driven largely by denser site requirements, EPC infrastructure, and integration but may deliver greater long-term value for utilities anticipating bandwidth growth and with use cases which cannot be supported by 700 MHz A-Band solutions.

Both spectrum options have clear roles in supporting grid modernization. 700 MHz A-Band provides an economical, multi-use case, and proven foundation for FAN and SCADA communications. 900 MHz PLTE establishes a scalable, standards-based framework capable of supporting a broader scope of applications. Utilities pursuing grid modernization efforts should carefully consider their requirements and business case when evaluating which spectrum solution is the right fit.

Appendix

Technology Details

NB-IoT

Stand-alone NB-IoT can offer broad coverage and low operational costs for monitoring small, low-data devices spread over large areas. Its 200 kHz channel, heavy coding, and message repetition allow signals to reach vaults, basements, and rural assets that are often difficult to cover with other wireless technologies. For water and gas utilities, the long battery life of NB-IoT devices can be a real advantage where power isn't readily available. In contrast, most electric utility devices already have power, so NB-IoT's strength is really in extending visibility to remote or hard-to-reach assets that only need to send small packets infrequently.

There are, however, several factors that limit its usefulness for broader grid applications. NB-IoT uses only QPSK modulation and relies on repetition and retransmission rather than adaptive modulation or higher-order constellations like 16-QAM or 64-QAM. While that improves coverage, it comes at the cost of latency and network capacity. Every retry or coverage enhancement repetition consumes additional airtime, so even though messages are small, network throughput drops sharply when devices operate in poor signal conditions.

NB-IoT can technically register tens of thousands of devices per cell, but in practice only a few hundred to a few thousand can actively transmit without collisions or excessive delays. The overall cell capacity is shared across all active endpoints. When many devices transmit frequently or when CE1 (medium coverage extension) or CE2 (deep coverage extension) coverage modes are used, effective capacity can fall by an order of magnitude. For electric utilities, that means NB-IoT works well for low-duty applications like line sensors, fault indicators, or vault alarms that may communicate for a short amount of time on an infrequent basis, but not for distribution automation or SCADA where many devices are or in higher bandwidth applications or where latency is critical. In short, stand-alone NB-IoT can fill a niche for wide-area, low-data telemetry, but it cannot meet the performance requirements of real-time grid operations or dense device networks.

Additionally, an LTE core is required making this an expensive solution when not deployed in conjunction with LTE. For this reason, NB-IoT was not included in further analysis.

IEEE 802.16s/t

IEEE 802.16s was developed as a wireless standard specifically for private, licensed networks that operate in narrower channel sizes than traditional broadband systems. Unlike earlier WiMAX versions that required wide channels, 802.16s was adapted for industrial and utility environments where available spectrum might be limited to 100 kHz, 500 kHz, or 1 MHz. The standard was designed to provide a reliable, IP-based platform with a deterministic MAC layer and strong coverage in lower frequencies, giving utilities an alternative to proprietary narrowband radio systems. The goal was to establish an interoperable standard that could support SCADA, distribution automation, and other critical infrastructure applications over wideband spectrum.

In practice, however, IEEE 802.16s has seen limited commercial adoption in the utility industry but is seeing increasing adoption in the freight rail sector. While it exists as an open standard, there is effectively only one manufacturer currently producing radios compliant with it, and that supplier's focus has been primarily in the rail and drone communications sectors rather than in electric utility automation. That makes 802.16s more of a theoretical standard than a broadly supported ecosystem. Its successor, IEEE 802.16t, extends the same technology to narrowband channels (down to 12.5 kHz) and adds features such as channel aggregation and improved deterministic scheduling.

These capabilities have strong potential for mission-critical control applications in theory, but without multiple equipment vendors, 802.16s and 802.16t are not yet practical options for large-scale utility deployments. For now, they remain niche technologies whose adoption is limited by vendor availability rather than by technical capability. For this reason, this technology is not included in further analysis.

Proprietary Technologies (Industrial Radio Solutions)

Proprietary radio systems continue to play a major role in utility communications because they are built around practical performance and operational reliability rather than formal standards. The GE MDS Orbit platform is a good example. It combines licensed narrowband, unlicensed 900 MHz, and cellular technologies within a single, modular platform. It supports narrowband channels as small as 6.25 kHz and provides backward compatibility with GE's legacy radios, which allows utilities to expand or migrate networks without replacing existing equipment. Because the system is proprietary, GE has full control of the MAC, compression, and link management, which helps optimize performance for SCADA and automation applications. The tradeoff is that interoperability is limited to the GE ecosystem, so long-term support and lifecycle planning are tied to the vendor's roadmap.

Mimomax Tornado focuses on high throughput and spectral efficiency in narrowband licensed channels. It uses full-duplex MIMO and adaptive modulation up to 256-QAM, providing aggregate data rates over 1 Mbps in a 50 kHz channel with low latency in optimized protection mode. Like most proprietary systems, it delivers strong performance within its own ecosystem but does not have interoperability with third-party radios.

Aviat's Aprisa SR and SR+ radios have been widely deployed in utility SCADA and DA networks for years. The SR+ supports adaptive coding and modulation, operates in licensed wideband channels up to 100 kHz. It is ruggedized for substation environments and integrates well with existing utility networking architectures. While Aprisa radios are also proprietary, they are among the most established and trusted solutions in the utility market today.

In general, proprietary technologies like Orbit, Tornado, and Aprisa provide high performance, reliability, and strong vendor support, but they come with vendor lock-in and limited interoperability. They remain a solid option for utilities looking to build multi-purpose, mission-critical private radio systems in environments where spectrum availability or cost are limiting factors, and in certain applications they may deliver a superior technical solution. All three solutions have seen wide adoption by utilities that have deployed networks on the 700 MHz A-Band frequencies beginning in the late 2000's.

Private LTE (PLTE)

PLTE provides a standards-based broadband communications platform that allows utilities to support a wide range of operational applications on a single network. It offers greater capacity and flexibility than legacy narrowband systems and benefits from a mature global ecosystem based on 3GPP standards. Because of that global foundation, utilities have access to interoperable equipment, strong vendor support, and long-term technology continuity. PLTE enables utilities to integrate SCADA, distribution automation, field workforce, and other applications using a unified, secure, and scalable architecture while maintaining control of their own networks and data.

At the same time, PLTE comes with design and operational challenges that utilities must consider. LTE uses a frequency reuse of one, which means all sectors operate on the same frequencies. Interference is managed within the LTE scheduler and resource blocks through timing, power control, and interference coordination, but it cannot be eliminated completely. A well-engineered design with thoughtful antenna placement, sectorization, and frequency planning is critical to maintain reliable performance. PLTE networks also require more spectrum, infrastructure investment, and integration effort than wideband or point-to-multipoint systems.

In the United States to date, the 900 MHz (3 x 3 MHz) broadband segment has been the primary band targeted for private LTE deployments in the utility sector. The FCC permitted the reconfiguration of this spectrum in 2020 to enable broadband operations for utilities and other critical infrastructure entities. Since that time, Anterix has worked closely with utilities and vendors to develop a strong device and equipment ecosystem specific to the 900 MHz band. While other spectrum options such as CBRS and other frequencies are now available for PLTE, 900 MHz remains one of the primary foci for many utilities because of its favorable propagation characteristics, nationwide availability, and established industry support.

Assumptions

Population Data

- All population data based on 2020 census data
    - Urban: 1,000+ people/Mi^2
    - Suburban: 200-999 people/Mi^2
    - Rural: 0-199 people/Mi^2

Device Type	Urban	Suburban	Rural
Cap Bank controller	1 per feeder	3 per feeder	4 per feeder
Reclosers	2.5 per feeder	2.5 per feeder	2.5 per feeder
Voltage Regulator	0 per feeder	0.5 per feeder	1 per feeder
FCIs	5 per feeder	5 per feeder	5 per feeder
Substations	8,000-20,000 meters	4,000-12,000 meters	2,000-6,000 meters
AMI Collectors/ Concentrators	3,000 meters	2,500 meters	1,500 meters

Meters: 1 meter/3 population

Feeders: 6 feeders/substation

All feeders are 3 phases

Propagation Data

Based on flat earth. No terrain or clutter data used or assumed for high-level modeling.

700 MHz A-Band wideband proprietary propagation: 12 miles

- 256 QAM: < 1.5 miles
- 64 QAM: 1.5 – 6 miles
- 16 QAM: 6 – 10.5 miles

- QPSK: 10.5 – 12 miles

900 MHz LTE propagation: 8 miles

- 256 QAM: < 1 miles
- 64 QAM: 1 – 4 miles
- 16 QAM: 4 – 7 miles
- QPSK: 7 – 8 miles

Cell size limited to practical limitations to limit QPSK devices and cell edge devices in order to minimize cell degradation to extraneous retries, etc.

Cost Analysis Assumptions:

Backhaul assumes $500k/site and assumes no sites have existing backhaul.

RAN Site Work assumes $750k/new site, $250k/lease site and assumes 50% new towers, 50% lease towers.

RAN O&M assumes $1,200/month lease cost.

EPC O&M includes 3 additional staff at a $200k/annually loaded rate.

Spectrum costs are estimated based on publicly available information.

Capacity Assumptions:

700 MHz A-Band, 50 kHz channel conservative useable capacity: 75 kbps

700 MHz A-Band, 50 kHz channel moderate useable capacity: 150 kbps

LTE (3 MHz FDD uplink) useable capacity: 1.84 Mbps

100% DA devices with 500-byte message size transmitting every 5 minutes

References

3GPP

- ETSI TS 136 300 V18.4.0 (2025-01): LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (3GPP TS 36.300 version 18.4.0 Release 18); https://www.etsi.org/deliver/etsi_ts/136300_136399/136300/18.04.00_60/ts_136300v180400p.pdf
- ETSI TS 136 211 V17.1.0 (2022-05): LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation (3GPP TS 36.211 version 17.1.0 Release 17); https://www.etsi.org/deliver/etsi_ts/136200_136299/136211/17.01.00_60/ts_136211v170100p.pdf
- ETSI TS 136 213 V17.6.0 (2024-02): LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer procedures (3GPP TS 36.213 version 17.6.0 Release 17)

https://www.etsi.org/deliver/etsi_ts/136200_136299/136213/17.06.00_60/ts_136213v170600p.pdf

- ETSI TS 136 212 V18.1.0 (2025-01): LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Multiplexing and channel coding (3GPP TS 36.212 version 18.1.0 Release 18) https://www.etsi.org/deliver/etsi_ts/136200_136299/136212/18.01.00_60/ts_136212v180100p.pdf
- ETSI TS 136 331 V17.8.0 (2024-05): LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (3GPP TS 36.331 version 17.8.0 Release 17); https://www.etsi.org/deliver/etsi_ts/136300_136399/136331/17.08.00_60/ts_136331v170800p.pdf
- https://www.3gpp.org/news-events/3gpp-news/nb-iot-complete

IEEE 802.16s / 802.16t

- IEEE 802.16s-2017; https://standards.ieee.org/ieee/802.16s/6813
- IEEE 802.16t-2025; https://standards.ieee.org/ieee/802.16t/10450
- Carrier Aggregation explained; https://www.3gpp.org/technologies/101-carrier-aggregation-explained
- ETSI TS 136 321 V15.11.0 (2021-01): LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification (3GPP TS 36.321 version 15.11.0 Release 15); https://cdn.standards.iteh.ai/samples/62354/8f9d6afd173f4132985b4f04b38d843c/ETSI-TS-136-321-V15-11-0-2021-01-.pdf
- ETSI TS 136 214 V15.4.0 (2019-10): LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements (3GPP TS 36.214 version 15.4.0 Release 15); https://www.etsi.org/deliver/etsi_ts/136200_136299/136214/15.04.00_60/ts_136214v150400p.pdf

Glossary

Term	Definition
ACM	Adaptive Coding and Modulation
AMI	Advanced Metering Infrastructure
Broadband Spectrum	Spectrum greater than 1.4 MHz channel size
CBRS	Citizens Broadband Radio Service (Spectrum in the 3.55–3.7 GHz range)
CE	Coverage Enhancement: • CE0 – Normal coverage: Devices close to the base station, few or no repetitions needed • CE1 – Moderate coverage: Devices farther away; moderate number of repetitions used to improve reliability • CE2 – Deep coverage: Devices in poor signal conditions; highest number of repetitions and strongest coding required
CQI	Channel Quality Indicator
DER	Distributed Energy Resources
EPC	Evolved Packet Core
FCI	Fault Circuit Indicator
HARQ	Hybrid Automatic Repeat Request
IoT	Internet of Things
LTE	Long Term Evolution
MAC Layer	Medium Access Control Layer. A sublayer of the data link layer that controls how devices share and access the communications channel
NB-IoT	Narrowband Internet of Things
Narrowband Spectrum	Spectrum less than 25 kHz channel size
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
QoS	Quality of Service
RAN	Radio Access Network
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
WiMAX	A wireless broadband technology based on the IEEE 802.16 standard, designed to provide high-speed internet access over long distances for fixed and mobile users
Wideband Spectrum	Spectrum greater than 25 kHz and less than 1.4 MHz channel size