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Low Power Wide Area Technologies for IoT Use Cases

Technology Assessment for MSOs

A Technical Paper prepared for SCTE•ISBE by

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Executive Summary

IoT is set to expand at a very rapid pace over next few years. While the majority of IoT connections in the United States of America are based on Wi-Fi and other short-range technologies, Cellular (2/3/4G) and LPWA currently account for ~20% of the IoT connections and are expected to grow at a CAGR of 37% between 2018 to 2023. The LPWA segment is set to grow at an astounding 58% CAGR and touch 512 million connections by 2023, while cellular IoT connections will grow at 16% CAGR and rise to 206 million – accounting for less than half of LPWA connections. As operators race to compete with new models to serve LPWA connections, the connectivity revenue per connection will also continue to decline at over 13% CAGR, thanks to the range of options on the table.

Within LPWA category, the licensed technologies are set to grow faster than unlicensed technologies. Licensed LPWA market is forecasted to grow at 49% CAGR ('18 – '23) reaching $1,836 Million (based on 306 Million connections) in 2023, while unlicensed LPWA market will grow at a slower pace - 37% CAGR – to capture $718 Million (based on 206 Million connections). Customers will look to deploy LPWA solutions as either Public or Private network depending on use case requirements, addressable market, ecosystem maturity, security, and regulatory considerations. While the unlicensed Private networks will remain favorable for certain enterprise verticals, nearly 80% of the growth will come from licensed public connections once LPWA scales.

To select the right LPWA technology for a given use case, MSOs should evaluate technologies across three key areas: Technology Fit, Operational Impact and Business Relevance.

• Within technology fit, the major evaluation factors include throughput (or payload size), battery, mobility, and tracking requirements.

• Operational Impact attributes to be considered are Quality of Service, deployment type (private vs public networks), coverage, and topology (urban vs. rural).

• Finally, the business relevance criteria encompass time-to-market and operator incumbency.

Based on the above framework, critical applications requiring high QoS and accurate tracking deplete battery life and will need licensed technologies like NB-IoT. Non-critical and delay-tolerant applications will likely prefer non-licensed technologies like LoRaWAN. The middle market applications will accommodate both technologies; however, NB-IoT is considered a favorite. Segments with low operator presence, like agriculture, have initial propensity for unlicensed technologies. Thus, LoRaWAN can carve out a market niche in rural, smart-city, and utility sectors, while the price sensitive middle-market and the premium critical apps market will likely be NB-IoT's home turf.

Ongoing 3GPP standardization of licensed LPWA technologies – LTE-M, NB-IoT, EC-GSM – will continue to increase the applicability and robustness of these technologies to a wide variety of use cases. Engineering advances will continue to reduce module prices. With Operator subsidies, module prices for licensed LPWA technologies will likely be at par with unlicensed LPWA technology modules in the next 3 to 5 years. Similarly, improvements in battery technology and form factors will not only drive adoption of existing use cases but also enable new use cases.

Cable operators (MSOs) deploying LoRaWAN have a window of two to three years to monetize it before wireless operators (MNOs) deploy nationwide NB-IoT and/or LTE-M networks with enabled devices/modules. MSOs should consider building a regional NB-IoT network as well as evaluate means to provide nationwide IoT coverage via roaming and / or wholesale agreements.

Content

1. LPWA Market Overview

1.1. LPWAN Set to Overshadow Traditional Cellular IoT Connections 2X

The Low Power Wide Area (LPWA) market is a fast-growing market with some wide array technologies available to address the multitude of IoT use cases. Majority of the IoT connections are Wi-Fi and short-range technologies like Zigbee, Bluetooth, etc. Cellular and LPWA together make up less than 20% of the IoT connections. In 2017, the total number of Cellular and LPWA IoT connections in the United State of America were about 108 million. These connections are expected to be 722 million by 2023, growing at a CAGR of 37%. The LPWA subset will proliferate at an 58% CAGR to reach 512 million connections by 2023, while cellular IoT connections will grow at 16% CAGR and rise to 206 million – accounting to less than half the number of LPWA connections. Factors like reduction in module costs, improvement of battery form factor, increased clarity on technology applicability by use case, and demonstration of Return on Investment (proof points) will likely be the key drivers of this growth.

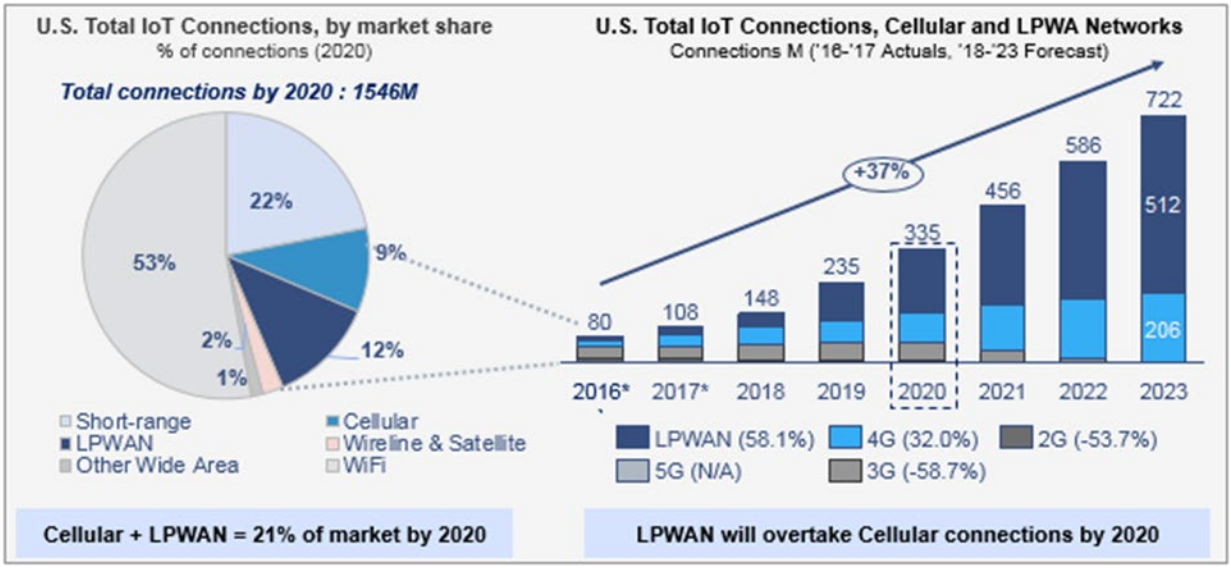


Figure 1 - U.S. IoT Connections Breakdown By Technology

1.2. Licensed LPWA to attain a rapid growth at 49% CAGR; Unlicensed growth will prevail, but slower

The LPWA market can be segmented by the type of spectrum a technology uses, resulting in two segments; i.e., licensed and unlicensed technology markets. Technologies like LoRaWAN, Sigfox, RPMA, and Telensa operate in the unlicensed spectrum, whereas LTE-M, NB-IoT, and future 5G IoT technologies will leverage the licensed spectrum.

On the other hand, the use cases can also be segmented based on expected level of service for a given application, resulting in non-critical, middle ground, and critical applications. Applications like Smart Meters are generally classified as non-critical as the mobility and latency requirements are not stringent, while applications like people or pet tracking are considered critical applications as they require a high

degree of QoS. An example of a middle ground application is commercial automation which has moderate QoS requirements and delay tolerance.

We expect the Unlicensed LPWAN market to grow at 37% CAGR from 2018 to 2023. In year 2023, the unlicensed technologies are expected to connect about 206 million connections and generate revenues of $718 million. In comparison, the licensed technologies will grow at 49% CAGR during the same period and reach 306 million connections and $1,835 million in revenues by 2023.

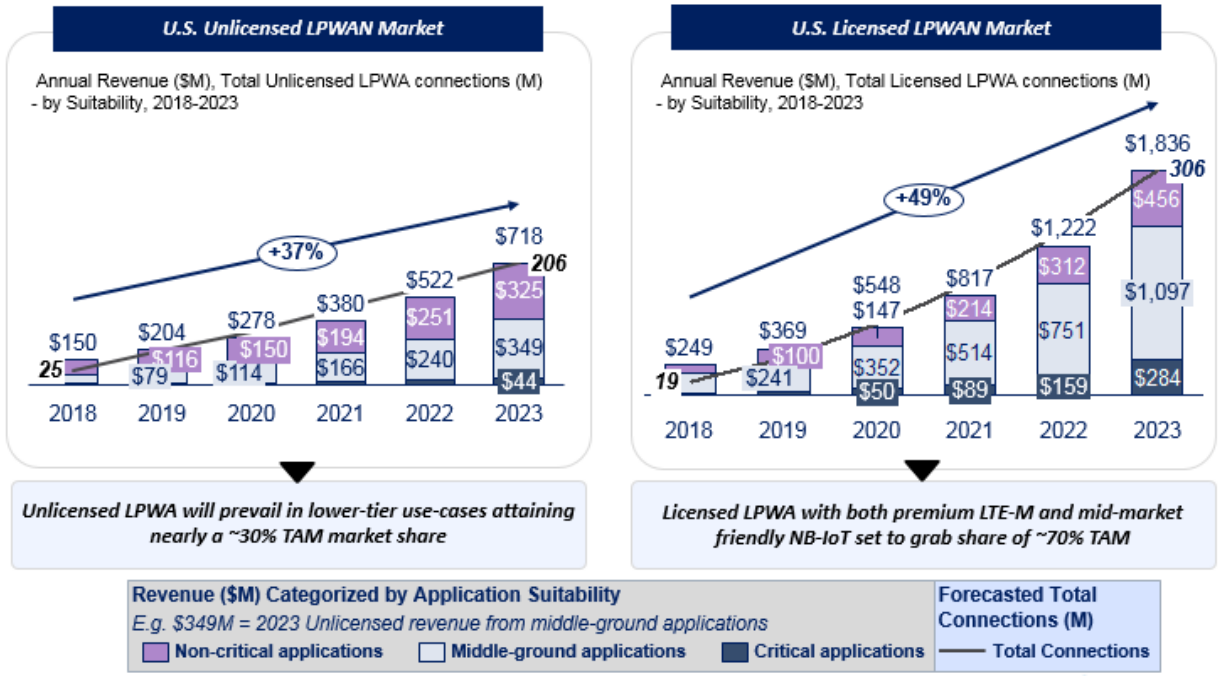


Figure 2 - U.S. LPWAN IoT Connections Breakdown By License Type

1.3. Unlicensed will sustain a niche for Private networks, however Licensed Public deployments will far outpace

Enterprises will choose between private and public LPWA networks based on addressable market, ecosystem maturity, use case requirements, security, and regulatory considerations. Based on the current state of the ecosystem and the hurdles in the realization of "Private LTE" networks, it is expected that Unlicensed LPWA will be more favorable for these enterprise private networks.
Some enterprises will choose to leverage Private networks driven by:

1. **Lowest cost of service**: Private networks will continue to have lower Total Cost of Ownership (TCO) at least for next few years, especially for sectors with built-in long-term business case needs like Utilities. It is critical that these networks are easy to deploy and operate.
2. **Security / Regulatory**: Increased focus on security and need for regulatory adherence for private network deployment.

The majority of enterprises will prefer Public networks, primarily for two key reasons:

1. **Use Case Flexibility**: Public networks can support a wide variety of use cases.
2. **Industry Momentum & Ecosystem**: Globally, the majority of the networks deployed are forecasted to be public as the number of vendors, devices, and systems proliferate.

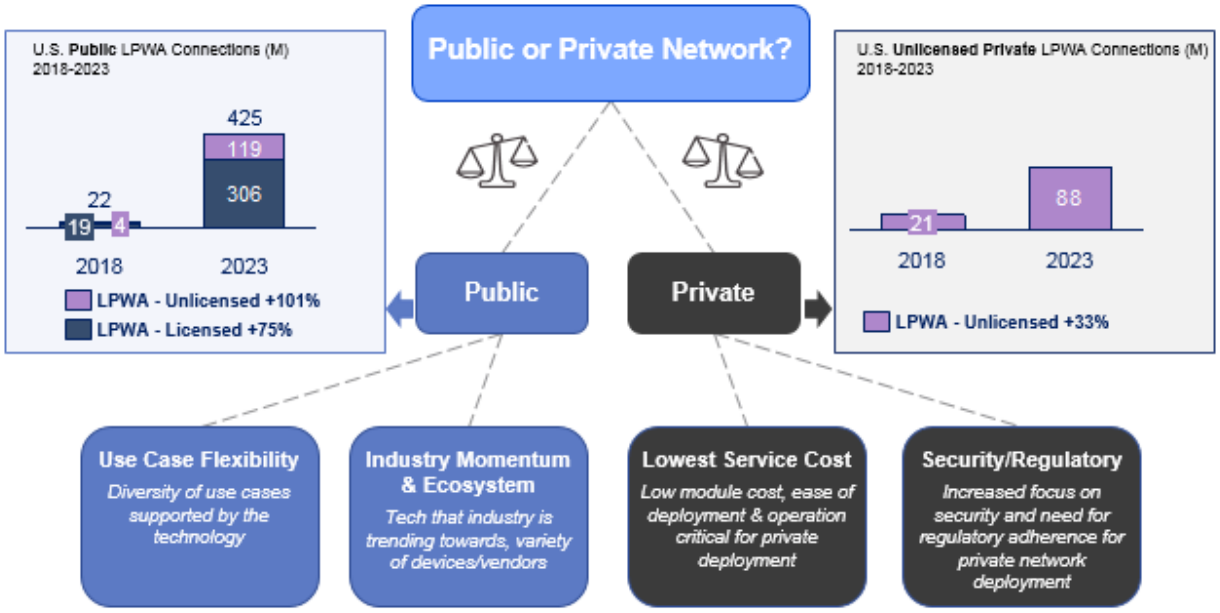


Figure 3 - U.S LPWAN IoT Connections Breakdown By Network Type

1.4. All Operator roads lead towards NB-IoT, though approaches may vary

Cable MSOs have entered the IoT market but have mainly focused on unlicensed technologies. Comcast launched LoRaWAN-based machineQ in late 2016 and has acquired spectrum to launch any cellular IoT service, if it wishes to do so. Cox has launched an asset management solution under the Cox2M brand. Cable operators face a critical decision on technology choice between the unlicensed and licensed technologies, as well as between NB-IoT and LTE-M, if pursuing licensed technologies for their IoT network.

Wireless carriers (MNOs) like AT&T and Verizon initially launched LTE-M service. Given the global industry momentum of NB-IoT, MNOs have now announced NB-IoT launches, while T-Mobile already has launched NB-IoT and is planning for an LTE-M network too. MNOs are also launching their connectivity management and application enablement platforms; e.g., ThingSpace by Verizon and M2X Flow by AT&T, as well as partnering with other ecosystem players for analytics and services. Similarly, Sprint is building an "operating system" in partnership with its sister-company and chip manufacturer, Arm, to manage device connectivity across cellular, Wi-Fi, and LoRaWAN networks.

Overall, all mobile and cable operators are leaning towards NB-IoT as it enables them to uniquely and efficiently address several of the IoT use cases, has a broad ecosystem, strong support for roadmap development, robust security, and module costs will almost be at par with unlicensed technologies in next few years (at least enabled through bundled pricing models).

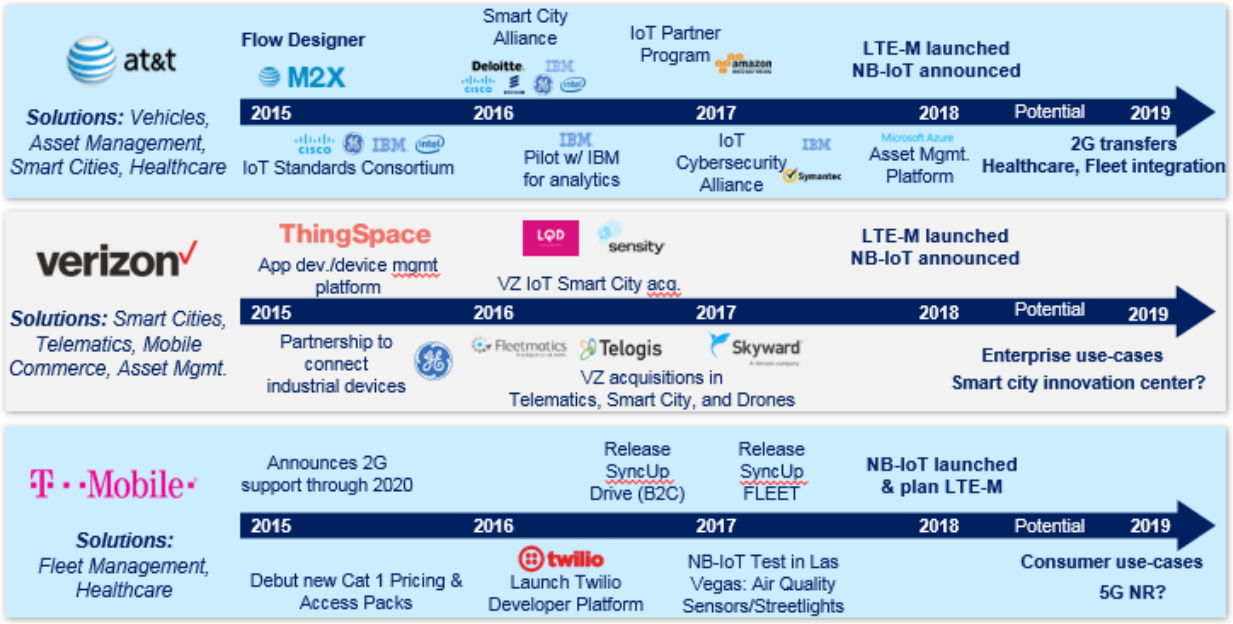


Figure 4 - U.S. MNOs IoT Evolution

2. Technology Selection by Use Cases

2.1. Framework for LPWAN Technology Analysis

To better understand which technologies are best suitable for a target use case, one needs to analyze the use cases across three key criteria – Technology Fit, Operational Impact, and Business Relevance.

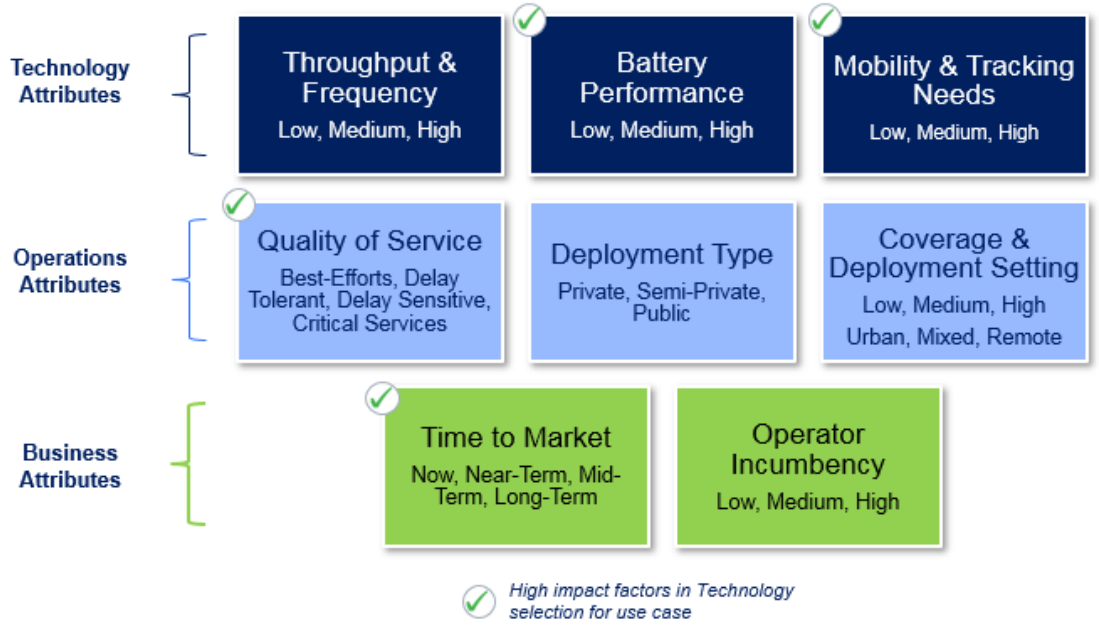


Figure 5 - Factors for Comparing LPWAN Technologies

(1) **Technology** requirements like *throughput (or payload size), frequency of transmission, spectrum used, battery performance, and mobility*. Applications like smart meters and agriculture sensors have small payload and infrequent message transmission requirements which can be served by LoRa. Whereas NB-IoT is better suited for public safety or ride sharing apps which require frequent broadcast of sizeable payloads and mobility support. Applications with acute needs to maximize battery performance are most serviceable by LoRaWAN.

(2) **Operations** requirements like *Quality of Service, deployment type, and coverage*. Given that unlicensed technologies are best-effort, they can't guarantee a QoS level. So, delay-sensitive / critical applications characterized by real-time low latency needs are better served by licensed, cellular technologies like NB-IoT or LTE-M. In terms of deployment type, private networks leverage unlicensed technologies. Utilities and Industrials are likely to prefer private networks. Additionally, coverage and distribution impacts use case addressability and level of service. Cellular technologies generally have good urban coverage and have coverage holes in rural, sparsely populated areas, indoors or underground locations. Such areas are sweet spots for LoRaWAN (and other unlicensed technologies). Utilities, agriculture, industrials settings are where LoRA can maximize their advantages, closely followed by home security and assisted living apps.

(3) **Business** requirements like *Time to Market and operator incumbency*. MSOs looking to deploy LPWA networks and go-to-market quickly initially chose LoRaWAN or other unlicensed technologies as these had a head start over licensed technologies. As 3GPP standards are completed and ecosystem matures, the time-to-market advantage of unlicensed technologies is degrading quickly. Finally, existing client relationships will affect MSO's offerings and technology selection. Applications like Fleet Management have a strong wireless operator incumbency and MSOs may find it difficult to penetrate. On the other hand, agriculture, industrials, and smart cities are some of areas offering great potential for MSOs to launch IoT offerings.

A simplified summary of technology suitability by LPWA's likely target applications is presented below:

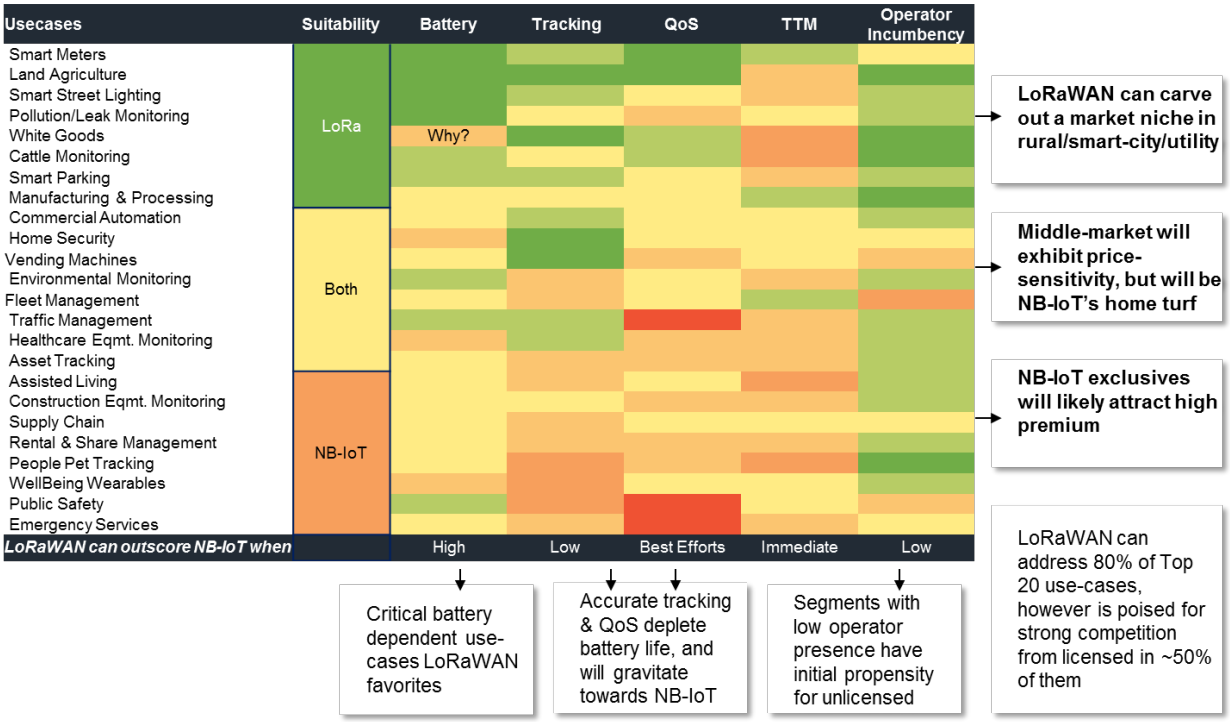


Figure 6 - Technology Suitability for Top 20 LPWAN Applications

As seen, while LoRaWAN can potentially carve out a market niche, it will likely fall behind NB-IoT in broader market addressability.

2.2. Competitive boundaries between licensed and unlicensed set to settle at 60-40 split of applications

By 2023, licensed LPWAN connection will account for 60% of LPWAN connections, while all unlicensed LPWAN technologies will account for 40%. A simplified view of top twelve applications and corresponding forecast of technology connections is show below:

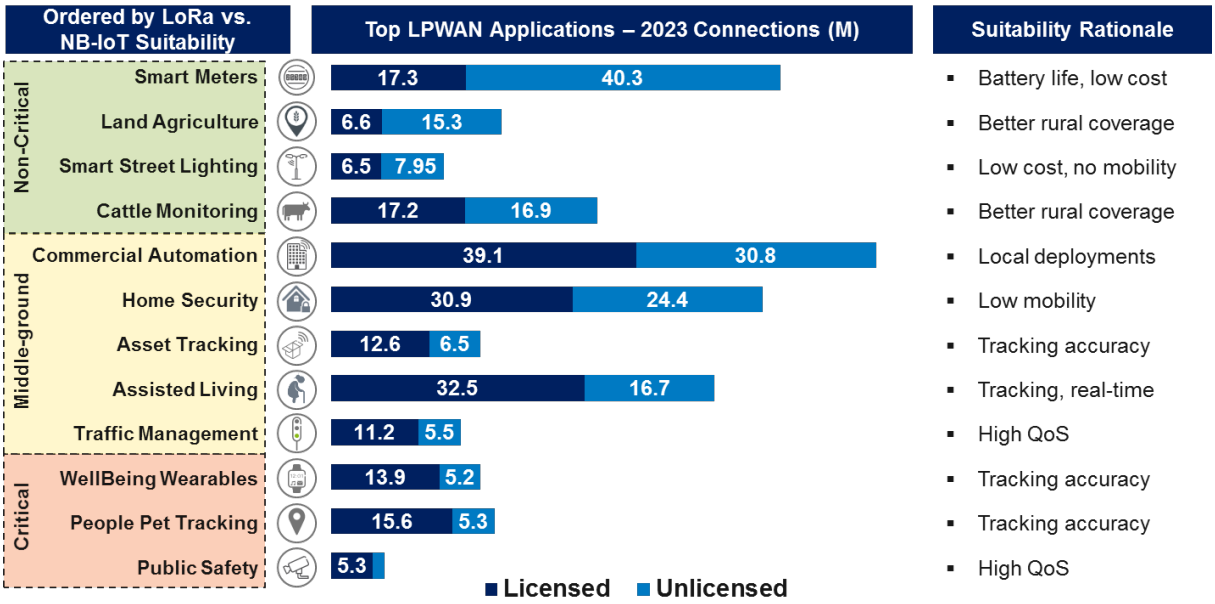


Figure 7 - Technology Suitability for Top 20 LPWAN Applications

2.3. Case Study: Smart Bike

Service providers globally are leveraging a combination of LPWA technologies to address unique customer painpoints while setting new benchmarks for innovation. For example, Ofo, a leading Chinese bike sharing company, offers what is termed docking-free pushbikes for rent, meaning bikes can be collected and deposited from any legal parking spot. Users can locate bikes using their smartphone and unlock it by scanning a barcode. Ofo developed an IoT smart lock based on NB-IoT technology that lowers power consumption, enables wide-area coverage, and slashes system resource delays at low cost. NB-IoT lets Ofo ensure it has bikes located at key locations when commuter demand is highest. Meanwhile, bikes can be unlocked in less than 5 seconds. Both improvements have greatly boosted user satisfaction and enabled Ofo's transformation from a new startup to global bike-rental company with over 10 million bikes and a valuation of over $2 Billion in under 3 years.

The company has even gone a step further to begin equipping its bicycles with LoRa devices and wireless RF technology (LoRaWAN) to complement its licensed connectivity option to achieve full network connectivity even in remote areas and dense buildings. As clearly seen, unlicensed and licensed LPWA technologies can co-exist and even be complementary in enabling the art of the possible. As "sharing economy" heavyweights Lyft and Uber both jump into bike-sharing (with Lyft's purchase of Citi Bike reportedly for over $250M in July 2018), it's clear that when it comes to LPWA, it's still Day One!

3. Roadmap and Deployment Options

3.1. LoRaWAN will have an opportunity to gain a foothold in the US however global momentum for 3GPP will tilt ecosystem development

LoRaWAN has been growing in the US as it has low module and servicing costs, strong battery performance, and does not require licensed spectrum. Additionally, with an early start in 2015, it has been deployed and has a strong ecosystem, that is likely to thrive for the next several years.

However, when looking long term, it seems that the balance will tilt in favor of licensed, 3GPP technologies. Operators can leverage their existing infrastructure to deploy and expand the licensed LPWA technologies. 3GPP has successfully developed many Mobile technology standards and has structure processes to define, simulate, adapt and launch global standards. These consistent standards spur innovation as well as interoperability with other devices and systems. Security, a critical aspect of IoT connectivity, is greater in 3GPP licensed technologies. Thus, while LoRAWAN will continue to thrive, 3GPP LPWA will grow significantly and overtake LoRaWAN ultimately.

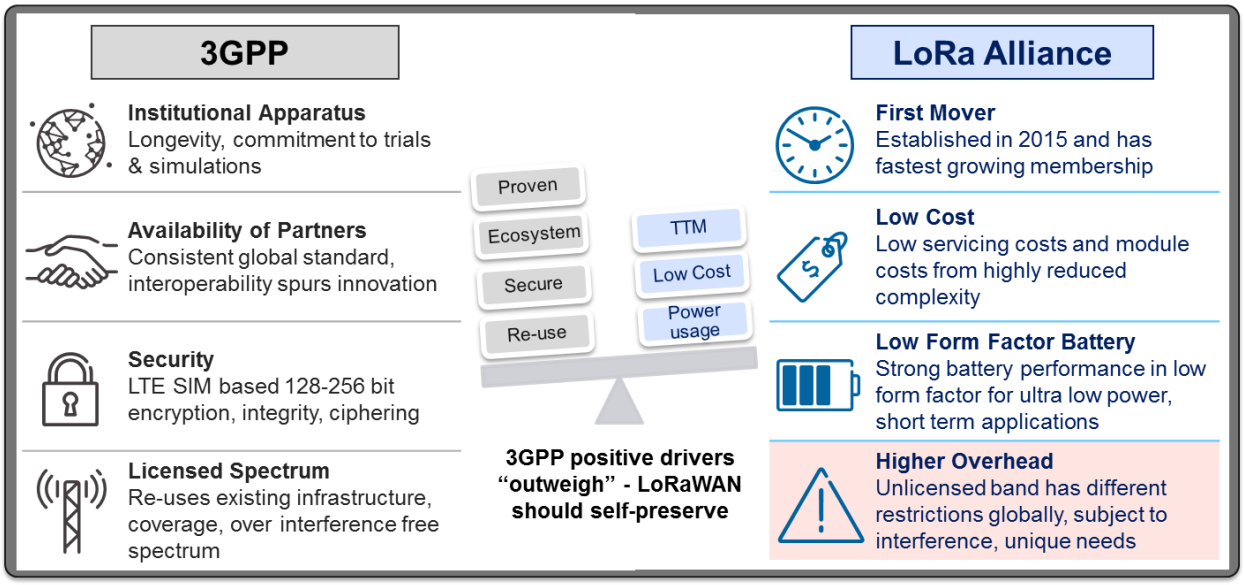


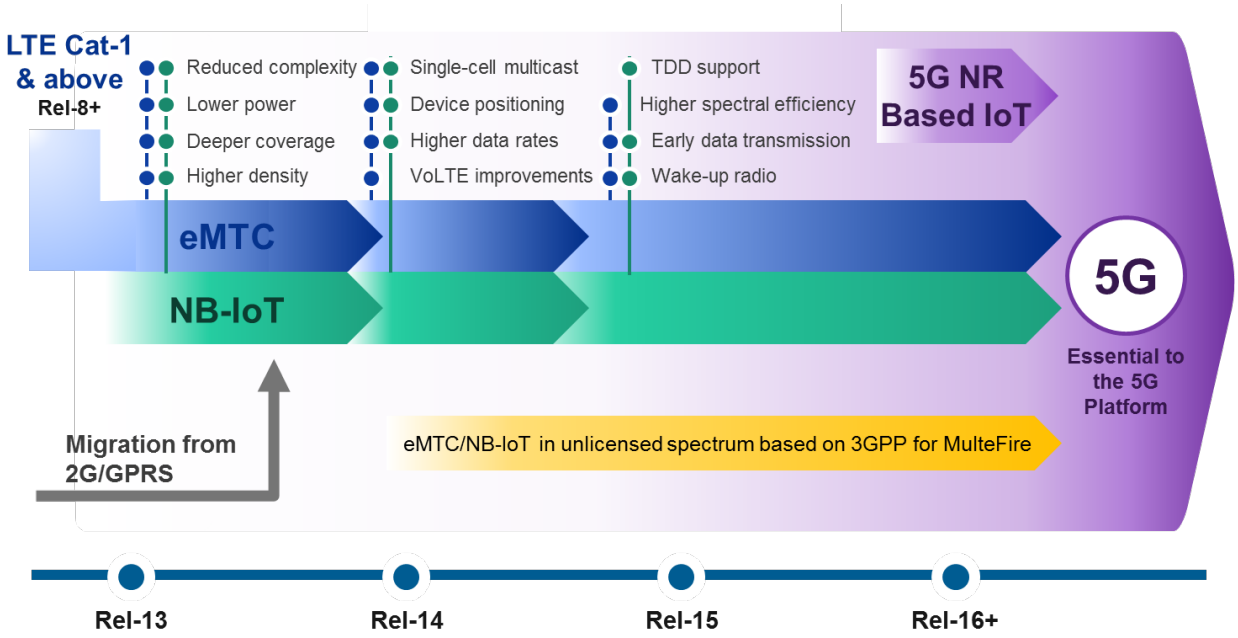
Figure 8 - 3GPP vs LoRaWAN Development

3.2. 5G aligned developments will fortify NB-IoT's future and further bolster the ecosystem development

LTE-M and NB-IoT were introduced in 3GPP Release 13 and provide a complementary cellular solution to enable all IoT use cases by efficiently and cost effectively connecting a wide variety of devices. 3GPP continues to evolve these technologies and bring new capabilities and efficiencies.

Release 14 introduced positioning, broadcast, VoLTE improvements, and two new device categories — Cat-M2 and Cat-NB2. Release 15 will add TDD support for NB-IoT, higher spectral efficiency and power-optimizing features such as wakeup radio and early data transmission. Both, LTE-M and NB-IoT, are agnostic to core networks; i.e., they will work in 5G Non-standalone (EPC) and Standalone (5G Core) modes. There is support for both LTE-M and NB-IoT in-band deployments with 5G NR. Release 16 will further increase device density and network efficiency using non-orthogonal multiple access (NOMA),

enabled by resource spread multiple access (RSMA). Grant-free uplink will allow IoT devices to send sporadic small data bursts to the network without scheduling, thereby reducing overhead signaling.



Source: Qualcomm

Figure 9 - 3GPP IoT Standards Development

3.3. Module costs & batteries will continue to decline, spurring innovation and opening LPWA to new use cases

When deploying large scale IoT devices, module and battery cost become major considerations from a CapEx perspective. However, these are one-time costs and when compared to recurring revenues from connectivity and professional services (e.g. installation, analytics), these constitute a small portion of the customer's TCO (under 5-8% as estimated for a sample asset-tracking use case). Hence, operators or solution providers should consider exploring bundled pricing plans subsidizing device (module, battery, MCU, casing etc.) costs for price sensitive customers who are hesitating to go forward with their IoT plans or looking for cheaper alternatives.

Range of batteries are available for LPWA like LiPo, Alkaline, Lithium-Thionyl-Chloride (LTC), Coin cell (Wearables), and Ultra-thin wireless nanotag. Form factors continue to be reduced and eventually some apps my not even rely on a battery. E.g. Fujitsu Laboratories has developed the world's smallest LPWA sensor device which is powered by a single solar cell.

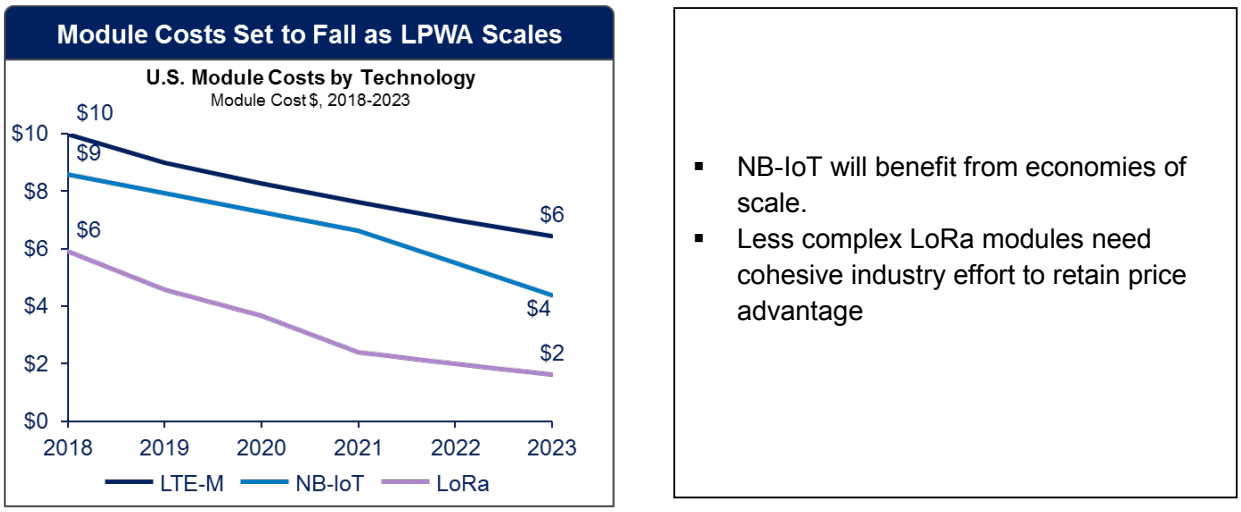


Figure 10 - Module Cost Forecast

3.4. NB-IoT can complement LoRaWAN and enable MSO to win mega deals

Cable operators (MSOs) deploying LoRaWAN have a window of two to three years to monetize it before wireless operators (MNOs) deploy nationwide NB-IoT and/or LTE-M networks with enabled devices/modules. MSOs who wish to address the full span of use cases or meet diverse customer needs, should consider either deploying NB-IoT network in their footprint or negotiate a wholesale deal with another NB-IoT network provider. Additionally, as the LPWAN battleground matures and connectivity price drops, a nationwide footprint will become table-stakes. To remain competitive, MSOs can evaluate means to provide nationwide IoT coverage via roaming and / or wholesale agreements.

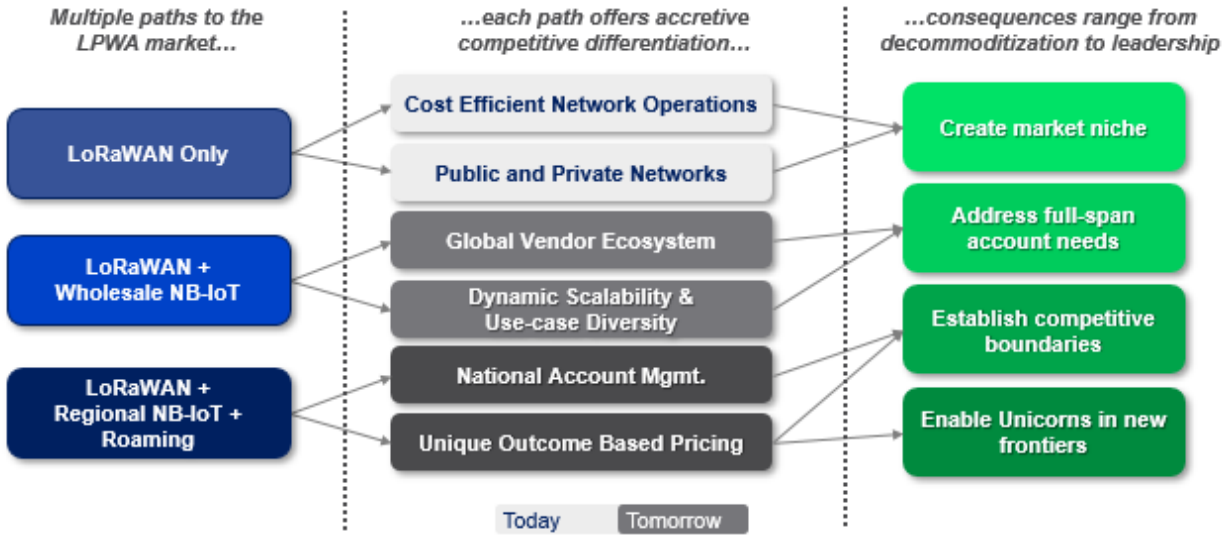


Figure 11 - Potential LPWA Market Options and Consequences

Abbreviations

IoT	Internet of Things
LPWA	Low Power Wide Area
CAGR	Compound Annual Growth Rate
MSO	Multiple Service Operator
QoS	Quality of Service
NB-IoT	Narrow Band – Internet of Things
LoRaWAN	International Society of Broadband Experts
LTE-M	Long Term Evolution For Machines
EC-GSM	Extended Coverage Global System For Mobile
MNO	Mobile Network Operator
RPMA	Random Phase Multiple Access
TCO	Total Cost of Ownership
LoRa	Long Range
3GPP	3rd Generation Partnership Project
VoLTE	Voice over LTE
TDD	Time Division Duplex
EPC	Evolved Packet Core
NOMA	Non-Orthogonal Multiple Access
RSMA	Resource Spread Multiple Access
MCU	Multipoint Control Unit
LTC	Lithium-Thionyl-Chloride

Bibliography & References

1. ABI Research: https://www.abiresearch.com/
2. Analysys Mason: http://www.analysysmason.com/
3. GSMA: https://www.gsma.com
4. Machina Research: https://machinaresearch.com/
5. Ofo: https://www.ofo.com/us/en
6. 3GPP: http://www.3gpp.org/
7. Qualcomm: https://www.qualcomm.com/
8. LinkLabs: https://www.link-labs.com/
9. Gartner: https://www.gartner.com/en

