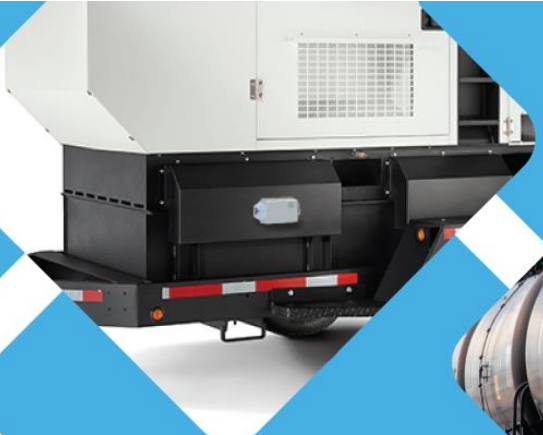

TEKTELIC
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Carrier Grade LoRaWAN® Gateways Save Network Operators Millions

Carrier Grade LoRaWAN® Gateways Key Parameters

Many Telecommunication Engineers have been trained on or are aware of Carrier Grade requirements introduced in the late 1990s to ensure that telecom equipment is developed and tested to mission-critical standards as people, businesses, and government livelihoods and operations depend on them. The initial Carrier Grade requirements were focused on public wired and later wireless telecom infrastructures. Later the same Carrier Grade requirements were applied to the critical infrastructures such as VoIP and the Internet at large.

The classic telecom Carrier Grade specifications focus on the Network **Availability** (so called 5 9s or 6 9s); **Performance** (best Key Performance Indicators for a product type); **Security** (product and network); and **Maintenance** (operation and evolution). For any product to meet Carrier Grade requirements there are many relative standards and product specifications they have to meet depending on the network and deployment condition. However, there are 12 key areas that any Carrier Grade product design must address.

The LoRaWAN developers and operators should understand the most important Carrier Grade Gateway design specifications, implementations, and their importance in order to ensure the operator LoRaWAN networks are highly reliable, have excellent Radio performance, and result in low operator upfront investment and ongoing operating costs. Figure 1 represents four LoRaWAN Gateways designs that meet Carrier Grate performance specifications mentioned above and discussed in detail further in this paper.

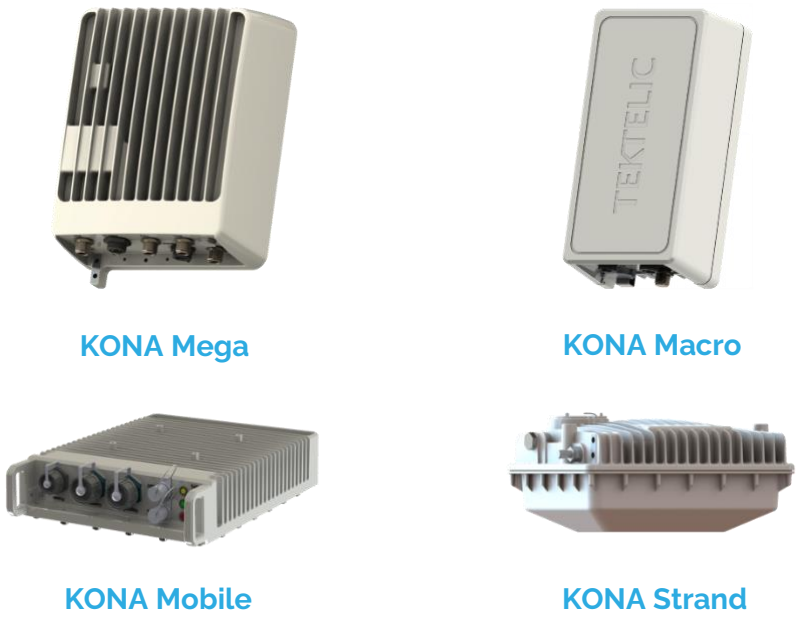

Figure 1: Mega, Macro, Mobile and Cable Strand Carrier Grade LoRaWAN Gateways

Below are listed the most important Gateway design areas and KPIs every **developer should consider** while designing and testing LoRaWAN Gateways. By the same token, every LoRaWAN operator and enterprise should seek to verify the Gateway KPIs and performance before deploying them if they intend to operate them for 8-10 years without significant downtime, numerous issues, site visits, poor Radio performance, all leading to the operator significant yearly cost increase, or outright equipment replacements well before its planned time.

1. Does the Network with the deployed Gateways support minimum 5 9s or 0.99999 availability (maximum 5 minutes/year down time)?
2. Does the Gateway meet 15+ year Mean Time Between Failures (MTBF) based on its design and Failures in Time (FIT) analysis?
3. Does the Gateway support all SW & FW Updates and Upgrades, Configurations and Provisioning remotely and autonomously without ever visiting the Gateway site (a single visit can be more expensive than the Gateway itself and take days due to location, accessibility and weather conditions)?
4. Does the Gateway monitor its Digital, Radio, 3G-4G Modem, Backhaul and Power Supply subsystems to ensure they function normally and if not, do they raise an alarm and indicate what subsystem generated the alarm, or failed, and what are the remedial next steps?
5. Does the Gateway cause interference to other types of wireless systems, especially in the licensed bands because the Gateway does not have proper RF Band Pass filter at its Antenna (which runs the risk having the entire LoRaWAN® network shut down by FCC or other regulatory bodies until the interference is addressed)?
6. Do other wireless systems (3G, 4G, 5G, FM Radio, Digital Public Radio, TV Broadcast, GPS Re-transmit etc.) cause interference to the Gateway because it does not have proper RF Band Pass filters at its Antenna and effectively reduces the LoRaWAN® network coverage, reception reliability, overall network dependability and in many cases damage the Gateway LNA circuits?
7. Does the Gateway and the LoRaWAN® network incorporate security to ensure the network performance and security cannot be compromised at any level and the collected data is secured?
8. Is the Gateway design, features and performance optimized for a customer specific deployment and operation (or it is “one size fits all”) to save significant deployment and yearly Operating Costs as the Gateway cost is only 5% to 15% of Total Operator Cost when amortized over 5-7 years?
9. Does the Gateway design, Backhaul, 3G, 4G and 5G Modem support standard and product evolution for 5-10 years? In particular, are the 3G, 4G and 5G modems certified

by the global cellular operators and will they support operator LTE releases for the next 5-10 years? It is for this reason vendors producing outdoor LoRaWAN Gateways should use 4G CAT-6 Modems to ensure the optimal LTE Rx and Tx performance with MIMO and LTE operator long term support with LTE upgrades to Releases 14, 15 and 16.

10. Does the Gateway have all of its external interfaces ESD, and Lighting protected? Does the Gateway meet country and regional Regulatory and Safety Requirements (Safety requirements could carry criminal liability and void operator commercial insurance if the Gateway causes damages)?
11. Does the Gateway meet IP67, 5% to 100% condensing humidity, operate from -40˚C to +60˚C without any degradation and support -40˚C Cold Start (power up after -40˚C for 4+ hours)? Also, does the Gateway operate normally and meet its specifications across the entire input voltage range and at "four corners" that are defined as combination of Min and Max operating Voltage and Temperature?
12. Does the Gateway support comprehensive network level Operation, Administration & Maintenance (OA&M) at the entire LoRaWAN® network level to guarantee Operator lowest Operating Cost or Total Cost of Ownership?

If the selected LoRaWAN Gateways do not meet the above KPIs and specifications, then those Gateways will result in much higher yearly operator network cost, and worse even increasing their yearly cost as the Gateways age, becoming less reliable, causing more equipment downtime.

LoRaWAN® Network Operators Cost Drivers

The traditional cellular operators, unlike many LPWAN operators, have over 30 years of wireless network deployment and operation experience. They have optimized the network deployment and cost models to ensure the selected Basestations guarantee high Radio performance, network availability, and low operating cost. They never select sub-optimal performance Basestations even if they are lower priced than the Carrier Grade Basestations because the cellular network performance will suffer and the yearly operating cost as well as the total network cost will increase. This will not only make them less competitive, but also result in losing customers to competition, and not able to reinvest into growing and improving the network. For this reason, all wireless operators protect their true network costs and how they optimized it. It is one of their key metrics that determines not just their profitability, but also future growth, market expansions, partnerships and M&A activities.

Today many LPWAN network operators do not have the same level network deployment and operation experience as their cellular counterparts. And many LoRaWAN Gateway vendors also do not have the experience designing, developing and manufacturing Carrier Grade LoRaWAN

Gateways. There are some LoRaWAN® operators that had to fix or replace their LoRaWAN Gateways only after 1-3 years of operation. It is important to note that a Gateway replacement cost, in most cases, is more expensive than the Gateway cost itself as is provided further in this paper. In addition, the incremental costs due to the LoRaWAN Gateway suboptimal performance and low reliability will further increase the yearly operator network cost from minimum 25% to well over 100%.

Figure 2 indicates how most outdoor LoRaWAN Gateways are deployed and the telecom towers they are mounted on. The installation team consists of 3 people and a large Boomer Crane. An experienced crew can deploy an outdoor Gateway in 3-4 hours, or 2 Gateways per day. Typical North American loaded labor rate is min $120/h to over $200/h, and Boomer Crane costs is min $180/h. And these costs do not include the antennas, cables, surge protection, other material, and engineering planning and support costs.

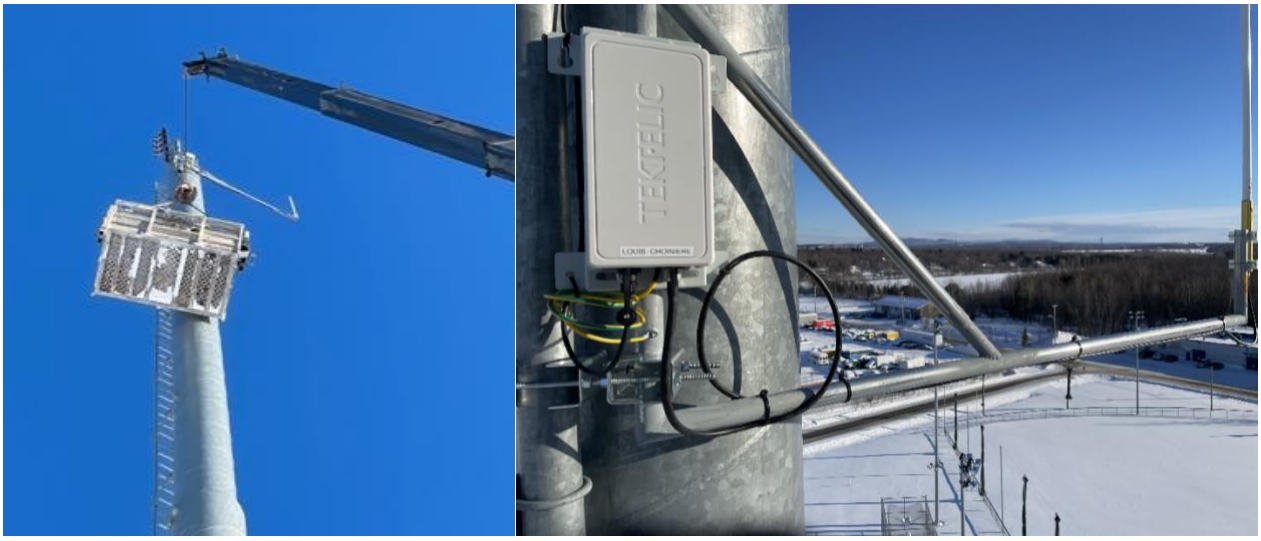

Figure 2: LoRaWAN Gateways Deployment at 110 foot Telecom Tower using a Boomer Crane

To understand how the operator Total Network Cost is affected by the Gateway itself, let's us consider only two Gateway parameters: a) Radio Performance, and b) Reliability. A typical LoRaWAN® network cost for a mid-size city with 1.25 million people such as Calgary, Canada, is provided in the table below.

The data provided in Table 1 is a good approximation of a real LoRaWAN network performance and costs. Anyone who would like to adjust any of the parameters or data in Table 1 can download the XLS enclosed at the end of this paper from the TEKTELIC website under KNOWLEDGE, WHITEPAPERS, https://www.tektelic.com/downloads/

Total Network Coverage Area (Calgary Area)	**1150**	**sq km**
Dense Urban percentage	7%	Enter
Urban percentage	40%	Enter
Suburban percentage	53%	Calculated
Dense Urban Gateway Radius (in km)	0.50	Enter
Urban Gateway Radius (in km)	0.95	Enter
Suburban Gate Radius (in km)	2.70	Enter
Effective Gateway Radius	100%	100% Max
Total Number of Gateway	291	Calculated
16 Channel Outdoor Gateway Cost	$1,100	Market Price
Installation Cost (antenna, cables, other and labor)	$2,069	Market Rate
Amortization Period (in years)	7	Min 5 Max 10
Average Yearly Site Visits (Failure, Alarm or Maintenance)	0.5	Target 1 per 24 month
Average Cost per Site Visit (3h $175/h)	$ 525	Market Rate
Yearly Operating & Maintenance Cost per Gateway	$ 4,283	Calculated
Total Yearly Cost per Gateway site (CAPEX and OPEX))	$4,735	Calculated
Gateway percentage Cost of Total Yearly Cost per Gateway site	3.3%	Calculated
Total Yearly Network Cost (CAPEX and OPEX)	**$ 1,380,304**	**Yearly**

Table 1: Typical Simplified LoRaWAN Network Cost Numbers

The yearly cost to deploy and operate a LoRaWAN® network, for a city similar size and density to Calgary, is estimated $1.38 million as provided in Table 1. This cost assumes all equipment, initial deployment, and yearly operating costs. It is important to note in real life the total yearly cost is higher for most public operators, what makes the argument for high quality Gateways even stronger. In Table 1 we assumed all deployed Gateways meet telecom Carrier Grade performance KPI and specifications previously discussed in this paper. In particular, we assumed the LoRaWAN Gateway Radio performance is not degraded because of its suboptimal Receiver sensitivity, or Transmitter linearity, or lack of Adjacent Channel Selectivity, or Band Pass Filtering, or many other radio impairments. We also assumed the collocated wireless systems do not interfere with the LoRaWAN Receive signals and the LoRaWAN Gateways are reliable and do not require additional site visits other than a typical maintenance visit every 24 months.

It is worth noting the LoRaWAN Gateway cost as a percentage of the site cost is only 3.3% on a yearly basis when amortized over 7 years. For some LoRaWAN network this number can be even a bit less, but it rarely exceeds 10%. In other words, the Operating Cost of a LoRaWAN network is highly dependent at the quality and reliability of the deployed LoRaWAN Gateways, but the is not that sensitive to the actual cost or the LoRaWAN Gateways itself as it represents a small percentage of the LoRaWAN network cost.

Indeed, the amortized LoRaWAN Gateway cost is very low compared to the total LoRaWAN network cost, even if it is amortized over 5 years instead of 7 years. However, the total LoRaWAN network cost is highly dependent at the LoRaWAN Gateway Radio performance and its reliability.

Just to show how dependent the total LoRaWAN network cost is on the Gateway performance itself, let's reduce the effective LoRaWAN Gateway radius due to poorer Radio performance and at the same time increase the number of site visits due to poorer LoRaWAN Gateway reliability (alarms, failures, Gateway replacement free of charge, manual SW Upgrades, and other cost drivers) and incremental labor costs.

Table 2 below clearly indicates how sensitive the LoRaWAN® network cost is to the Gateway Radio performance and its reliability. If the LoRaWAN Gateways radius is reduced by 30%, what is insignificant reduction in dB terms, the total LoRaWAN Network Cost will approximately double to $2.8 million per year! And if each LoRaWAN® site requires a visit every 5 months, or 2.5 visits per year, then the LoRaWAN total network cost will further increase by $430 thousand per year! These are significant yearly cost increases that provide no incremental value to the operator or its customers. One could think of a courier service such as FedEx where only half the vehicles are working and the other half are always being fixed, but payments are being made consistently for the entire fleet.

		LoRaWAN Gateway Effective Radius					
		100%	90%	80%	70%	60%	50%
Site Visits per Year	0.5	$ 1,380,304	$ 1,704,079	$ 2,156,726	$ 2,816,948	$ 3,834,179	$ 5,521,217
	1	$ 1,456,823	$ 1,798,546	$ 2,276,285	$ 2,973,107	$ 4,046,729	$ 5,827,290
	1.5	$ 1,533,341	$ 1,893,013	$ 2,395,845	$ 3,129,267	$ 4,259,280	$ 6,133,363
	2	$ 1,609,859	$ 1,987,480	$ 2,515,404	$ 3,285,426	$ 4,471,830	$ 6,439,435
	2.5	$ 1,686,377	$ 2,081,947	$ 2,634,964	$ 3,441,586	$ 4,684,381	$ 6,745,508

Table 2: LoRaWAN® Network Cost as a function of Poorer Radio Performance and Reliability

Table 3 indicates the LoRaWAN® incremental network cost as a function of poor Radio Performance and Reliability when compared to optimal Carrier Garde LoRaWAN Gateway performance. Both tables clearly indicate the value of Carrier Grade Gateway and their performance considering two parameters, but there are more than 15 that impact the operator Total Network Cost or Ownership.

		LoRaWAN Gateway Effective Radius					
		100%	90%	80%	70%	60%	50%
Site Visits per Year	0.5	$ -	$ 323,775	$ 776,421	$ 1,436,643	$ 2,453,874	$ 4,140,913
	1	$ 76,518	$ 418,242	$ 895,981	$ 1,592,803	$ 2,666,425	$ 4,446,986
	1.5	$ 153,036	$ 512,709	$ 1,015,540	$ 1,748,962	$ 2,878,975	$ 4,753,058
	2	$ 229,554	$ 607,176	$ 1,135,100	$ 1,905,122	$ 3,091,526	$ 5,059,131
	2.5	$ 306,073	$ 701,643	$ 1,254,660	$ 2,061,281	$ 3,304,076	$ 5,365,204

Table 3: LoRaWAN® Incremental Network Cost as function of Poorer Radio Performance and Reliability

Is 25%, 50%, or 100% increase of the operator yearly network cost significant or detrimental to the LoRaWAN® operator's success? The answer depends if the LoRaWAN network is small and used for a Proof of Concept (POC), or large and commercial. For example, if a LoRaWAN® network is small and used for a POC with no real customers, does not need to support certain Service Level Agreement (SLA), and has only a handful of LoRaWAN Gateways, then there is no

real customer impact even and the incremental yearly cost to run such a POC network is very low. There even could be a good reason to do so - one could procure lower cost LoRaWAN Gateways, or a complete solution, to test a use case, conduct customer demos, or run the network while still selecting or negotiating with other Gateway vendors. In most cases, a trial or POC network does not cost a lot to deploy and does not put significant risk on the operator or enterprise future business.

However, if the operator or enterprise deploys a large commercial LoRaWAN network with 100s or even 1000s of LoRaWAN® Gateways, then the operation should ensure the selected Gateways meet most Carrier Grade KPI and specifications to ensure the network yearly Operating Cost and total yearly Network Cost (OPEX and amortized CAPEX) are as low as possible for given SLA the end customs expect. To do so the operators need to deploy the most reliable and best performance Carrier Grade LoRaWAN® Gateways as was provided in Tables 1, 2 and 3. Deployment of Carrier Grade LoRaWAN Gateways will result not only in the operator lowest total Network Cost, but these Gateway will also result in the best practical outdoor and indoor coverage, high network reliability and availability, low interference, fewer device re-transmissions, and longer device battery life just to name a few.

A typical cellular operator success depends on the best wireless coverage, most reliable level of services, and lowest network Total Cost of Ownership. It has been the winning formula for most global cellular operators over 30 years, and it still applies to the cellular operators today. Most telecom professionals believe it also applies the LoRaWAN® operators and enterprises.

LoRaWAN® Network Cost Calculation

The below link allows to download the XLS calculation used to derive Tables 1, 2 and 3 used in this paper:

Link to download

If you need more information, would like to discuss how you can use the XLS for your LPWAN network cost estimate, improve the estimate calculation, or share your experience, please reach out to info@tektelic.com – TEKTELIC team will be more than happy to help any way we can and learn from you.