Private Wireless Networks vs Public Cellular for Utility Smart Grids

by MiMOMax Wireless, Inc.

Our Objective

This whitepaper will compare the advantages and disadvantages for utilities considering a private wireless network vs public cellular to address the need for increased communication capacity that arises from distribution grid advancements, i.e. grid modernization, smart grid, and Field Area Network plans.

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Problem Summary – Private vs Public

When tasked with identifying a Field Area Network (FAN) to support a grid modernization strategy, utilities are faced with deciding between purchasing their own private communication system or paying monthly fees to use a public carrier's system.

> *"Other key decision criteria such as security, reliability, latency, and support costs all weighed into the decision to choose the [private] FAN."* (Reimer, 2016)

Private vs Public - The decision to go private or public is an important decision as utilities and other Critical Infrastructure (CI) industries have extensive telecommunications requirements that can only be met through their wireless networks. Utility companies have historically favored building their own private wireless networks for three main reasons that still hold currently. They include:

1. State regulatory structures that encourage utilities to build their own networks.
2. Utilities' skepticism that carriers will provide reliable connectivity during emergencies.
3. Carriers' lack of ubiquitous coverage, especially in rural areas.

- (Weinschenk, 2018)

However, some argument is beginning to surface that the above is changing given, for example, the IoT-style networks that public carriers and others are building based on technologies like LoRa, NB-IoT and LTE M. Theoretically, these networks might be able to support millions and millions of low-cost devices and connections. This is balanced by the cautious pace of utilities in adopting IoT trends. (Weinschenk, 2018).

> *"Going forward, I don't think we will see U.S.-based utilities relying on [carrier provided] NB-IoT or LTE Cat M1 any time soon,"…"Longer term, I do think we see that for apps that are not critical, things more along the lines of asset monitoring and management. But that's not imminent in my opinion."*

- **Richelle Elberg**, principal analyst, Navigant Research.

While there are significant differences in the technologies used in both approaches, this paper focuses on the business factors that utilities need to consider when evaluating a private spectrum solution vs using public cellular services.

Critical Infrastructure - To boil it down, the decision to go public or private comes down to how much risk a utility can take on giving up control of their communication needs. As a Critical Infrastructure industry, utilities face key tactical issues that are not planned for in other businesses that must be considered when deciding on a private vs public Field Area Network.

The key tactical issues can be organized under a 7C's approach including:

Table 1: The 7C's For Deciding on a Private vs Public Field Area Network	
Key Decision Factors	Descriptions
Critical Infrastructure Grade	• Does the system meet your organization's availability requirements to minimize downtime? • Do all sites have the amount of back-up power your organization requires? • Are you able to prioritize your specific data above all others on the network
Coverage	• Can the coverage be tailored to your territory & customer needs? • Can additional coverage be added to areas where there is little or no coverage?
Capacity	• Is the capacity tailored to your application's specific needs? • Can additional capacity be added to areas when it's needed?
Control	• Is your organization able to dictate when outages occur for upgrades? • When performance issues arise, can your organization prioritize what areas should be addressed first?
Capabilities	• Do you have direct influence on the roadmap for the infrastructure and devices? • Is your organization able to take on the role of an integrator between the device provider, infrastructure provider & application providers?
Cost	• Does the solution fit your cost structure (O&M vs CapEx) • Can you afford to change your network hardware as frequently as public carriers and emerging standards elicit change.
Cyber-Security	• Do you have control of the data on your network 100% of the time?

The 7C's approach has been used in various industries to help distinguish the value one solution has over another type of solution. A similar 5C's approach has been used by many industries when deciding between owning a private land mobile radio (LMR) system or using a public cellular system for its mission critical voice communications. CI industries need consistent and immediate access to their resources lest disruptions threaten public safety and affect millions of people. Utilities and other Critical infrastructure industries depend on both having spectrum available plus protection from interference and encroachment by other users whose operations generally do not have the same urgent need. It's for this reason that these industries have consistently selected private radio systems for their critical voice communications over public networks.

The same 7C's factors hold true when considering the type of network to consider for a Field Area Network to support the critical applications involved in grid modernization initiatives. Each of the applications can have a direct impact on reliability and financial performance. In the August 2, 2016 testimony to the Public Utilities Commission of the State of Colorado on the matter of granting a certificate of public convenience and necessity for a private Field Area Network to support distribution grid enhancements, the Director of Advanced Grid Intelligence and Security for Xcel Energy replied to the commission's question on if alternatives [public networks] for the FAN were considered by stating *"Other key decision criteria such as security, reliability, latency, and support costs all weighed into the decision to choose the [private] FAN."* (Reimer, 2016)

As many utilities have achieved their AMI goals to empower the consumer with their individual usage information, utilities are now shifting their focus directly to the grid. Improved quality, availability and performance are key drivers behind grid modernization efforts and the field area network. Because it must provide the visibility for operators to monitor, control and protect the grid and those who rely on it at the most critical times, including during disasters, the FAN is considered a mission critical network. It's in these critical moments when safety and lives can be affected as crews work to get the operations restored and power flowing again.

The Grid Modernization Laboratory Consortium was sponsored by the US Department of Energy to understand "The Impact of 5G Telecommunications Technology on US Grid Modernization 2017-2025." Under the heading "Why 5G is Not the Answer to Utility Communication Dreams" the authors summarized that "Even as the mobile telecommunication service providers are completing their rollouts of 4G/LTE, the industry is hard at work developing and finalizing standards for 5G that will pave the way for early pilots by 2020. As is typical of this stage of high-tech development, many discussions around 5G describe everything it *might do* as what it *will do.* And since the industry is at the stage of throwing features against the wall to see what might stick, any new brainstorms are promptly added to the "well, it might be able to do that" list which almost instantly gets repeated out of context as the committed feature list". The Grid Modernization Laboratory Consortium paper then goes on to examine the reason for the following conclusion, however we'll examine pros and cons in this paper:

"Despite the present conversation suggesting that 5G will massively transform electric utilities, there are a number of reasons why it will not be significant for electric utility operations until after 2025 and therefore will not play a major role in the current phase of grid modernization." (Taft, 2017, p. 1)

Read on to explore all our 7 C's areas you should consider when researching deployment of a private wireless network vs public cellular for your grid modernization, smart grid, or Field Area Network projects.

Discussion of the 7 C's issues for utilities

Following is a discussion of the individual critical infrastructure issues to consider when comparing the value of private Radio systems over public communication-based systems. They are organized with the 7C's categories as explained in the opening summary and include:

1. Critical Infrastructure
2. Coverage
3. Capacity
4. Control
5. Capabilities
6. Cost
7. Cyber-Security

Critical Infrastructure

The importance of the electric utility market as a Critical Infrastructure industry cannot be overstated. Their operations have a direct impact on our economy, quality of life and safety – and is a driving factor behind why utilities are investing hundreds of millions if not billions in grid modernization efforts – to improve their reliability. Therefore, the FAN must be as resilient and reliable, if not more, than the electrical grid itself. Critical Infrastructure requires wireless networks that are mission critical.

When evaluating a network's ability to be mission critical, several key questions should be asked to determine if the network can meet the critical needs as a FAN:

- Can the system be designed to meet your desired availability (4-nines, 5-nines…, etc.)?
- Does the network have enough backup power to meet the needs of your organization?
- Are you able to have total control on how the data is prioritized on the network?
- Does the federal government give you control on use of the spectrum across your defined service area and enable you to prosecute anyone who interferes with your communications?

Public Cellular Strengths in relation to CI - Given their poor history of performance, carriers have been slowly adding battery backup to key sites improving their uptime, but typically not to the level that a utility requires. For example, FirstNet is intended to be a parallel cellular network targeted at public safety and first responders. It's not built yet and to date FirstNet does not consider utilities as first responders and have no intention to prioritize their communication needs on the network.

Private Network Strengths in Relation to CI–

Uptime - If up time is crucial for compliance, then having a highly reliable wireless communication network for the FAN is mandatory. Public cellular networks were not designed for mission critical operations and often do not support much more than a few hours of backup power. Compounding the problem during a critical event public networks can be quickly overloaded causing disruptions in communications. Events such as the Boston Marathon bombing and most recently reports of outages and lack of communication from Hurricane Michael continue to show the inadequacies of public cellular and their inability to provide communication services during critical times. Private networks on the other hand can be designed to support the levels of uptime required by the utility. From battery backup solutions to generators with fuel to last several weeks, power backup solutions can be tailored to the needs for each specific area, and application in the service territory.

Compliance – As a heavily regulated industry where rising costs, and outages caused by natural and manmade disasters are becoming more frequent, utilities are now in the crosshairs of government regulation more than ever. Utilities face fines for downtime making reliability and control ever more important for the wireless network. In addition, NERC (North American Electric Reliability Corporation) compliance standards have become more stringent and discussions around their Critical Infrastructure Protection (NERC-CIP) protocols being extended from the bulk electric transmission systems to the distribution systems is becoming a real possibility. This will raise the level of performance that will be required from a FAN. With such non-governmental fines also more likely, the increased reliability and security of the FAN is imperative.

> *"Massachusetts Court Upholds Penalties On Utilities For Storm-Induced Electric Outages."* - **Forbes, Apr 14, 2014, 08:25pm:** (Pentland, 2014)

Dedicated - Another advantage that private networks have over public networks is control of the data on the network. When emergencies happen, the public networks become flooded with users calling, texting and streaming video – making accessing the network nearly impossible. Private systems, on the other hand, only handle your traffic. Owners of private networks therefore can prioritize traffic and redirect bandwidth as required to support critical applications.

Availability - One of the most important aspects of a radio system is its reliability. Even in the best conditions where both power and capacity are available, a networks reliability greatly effects a utility's ability to communicate with its assets. The most standard unit of measurement for network availability is the NINES (9's) rating. The system and each of its links can be designed to support the availability and reliability the organization requires from 2-nines reliability (99%) to 5-nines (99.999%) reliability. This reliability translates to the number of minutes per year that can be tolerated when the system is not operating.

Table 2: Nine's Reliability Chart

Reliability	Percentage	Downtime per year
2-nines	99%	3 days 15 hours 40 minutes
3-nines	99.9%	8 hours 46 minutes

4-nines	99.99%	52 minutes 36 seconds
5-nines	99.999%	5.26 minutes
6-nines	99.9999%	32 seconds

System availability is where private networks excel as they can be designed for almost any level of reliability that a utility requires. Higher availability comes at a higher cost, but over the long run the costs are justifiable when lives, safety and security are on the line.

With the number of natural disasters and manmade disasters seemingly increasing each year, imagine if the increased outage from lesser public cellular availability was in your organization's service territory or worse yet, due to your technology choice? The net result is that cellular networks become a highly risky proposition for a utility to support their mission critical Field Area Network communications.

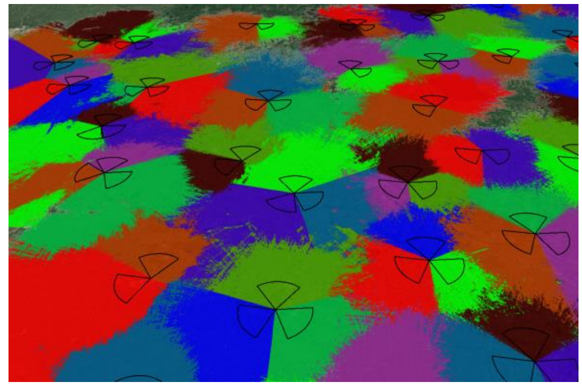
- https://www.bostonglobe.com/business/2013/04/16/cellphone-networks-overwhelmed-blast-aftermath/wq7AX6AvnEemM35XTH152K/story.html (Farrell, 2013)
- http://fortune.com/2017/08/30/hurricane-harvey-cell-backup-power/ (Shields, 2017)
- http://floridapolitics.com/archives/281814-next-gen-radios-aced-hurricane-michael-stress-test (Schorsch, 2018)

Storms - **Resilience Needed:** Power outages from natural disasters (hurricanes, earthquakes and tornados) and man-made disasters (bombings, car accidents, terrorism) can happen at any time. It's been reported for years that when a disaster strikes private communication systems performed, but the public cellular systems were overloaded or failed after a day or so of operation. In 2013, the Boston Globe published an article titled "Cellphone networks overwhelmed after blasts in Boston". Fortune published an article talking about how cellular systems performance had been improving because of the FCC's imposed power backup requirements after Hurricane Katrina took out over 1,000 cell sites. But the cell companies fought in court and prevented this requirement from being mandated.

Storms - Increase: Hurricane Michael in November 2018 was the latest reminder of the value private systems provide over public networks during a disaster. One of the reported stories (see Availability above) from floridapolitics.com described how well recovery and help could be provided to those in need because the private system continued to operate.

- *"Initial Reports of 264K Out of Service and 19% of Cell Sites Down, Telecom Carriers Respond to Hurricane Michael."* **Telecompetitor** (Britt, 2018)
- *"Can we count on cell networks in disasters?"* **CBS News** (Reardon, 2011)
- *"Mass. Imposes $24.8M Penalty on Utilities for Storm Response."* **Green Tech Media** (Tweed, 2012)

Coverage



Public Cellular Strengths in relation to Coverage - Public networks, on the other hand, take a different approach as their focus is on population areas, not individual customers or industry applications. One advantage public cellular provider's offer is they already have coverage in most areas. The quality of the coverage may not be to the level that a utility needs, but the existing coverage makes it easy for implementing pilots and systems.

Private Network Strengths in relation to Coverage - A field area network is only as good as the coverage it provides to the endpoints. The value of a private system is that the provider will work with you and tailor the coverage to your organization's needs and provide the necessary levels of redundancy so it's there when you need it. Utilities and other critical infrastructure organizations work wherever people are – even in remote areas. Private network providers can place sites in locations to ensure the coverage and reliability required at the system level and link level are met for each application. Furthermore, if your service territory changes, sites can be added as needed.

Capacity

In today's world where we are relying more heavily on data, having a system with the capacity you need for today and tomorrow is imperative. Capacity is more than just the data rate a device provides and includes the performance at the site level and across the entire system. Although capacity may be viewed as being independent from coverage, in truth capacity and coverage are interlinked. As you near the edge of a cell and the coverage begins to degrade the capacity also degrades. Just because the system is displaying good coverage doesn't mean that the system has capacity available. Many of us have experienced this when our phone displays that it has 4-5 bars of service, yet you can't seem to make a call or get a response from a web page you are attempting to access.

Public Cellular Strengths in relation to Capacity - Cellular networks were designed with capacity in mind and their strength is that need to support millions of users. Their use of broadband channels provides raw capacity considerably larger than what can be offered in a narrowband private channel, both from a site and system perspective. However, that capacity is shared with all users in the area and the net effect may be more, less or equal to what can be delivered in a private narrowband system.

Private Network Strengths in relation to Capacity - As much of a benefit as it may seem, it's a cellular system's sharing of capacity and the inability to prioritize users on the network that makes it an Achilles heel. Cellular providers don't provide service level agreement (SLA) with a guaranteed amount of bandwidth or guaranteed minimum latency to levels a utility required for critical applications on the grid. Public networks use one large broadband channel to provide services to millions of customers at any given time. The ability to have any of the capacity dedicated to an application or specific user group is outside of your control. During a disaster or events where lives are at stake, cellular systems have routinely become overloaded with loved ones trying to connect with each other. It's in these times that utilities must have communications to their grid to ensure their employees are safe, the public is safe, and the grid is safe.

Private networks, on the other hand, are designed to provide both the coverage to the areas where it's required but also to deliver the capacity where it's needed and to meet required SLA's. Applications can truly be prioritized over one another on a private network. As a utility's needs grow, additional capacity can easily be added to the site or sites where it's needed. As the only consumer of resources on a private system, the utility is in total control over how their capacity is allocated.

"..the private network solution allows Public Service [Company of Colorado] to utilize the network's full bandwidth and all capacity is dedicated to the Company's use, which is particularly critical during emergency and outage situations." (Reimer, 2016)

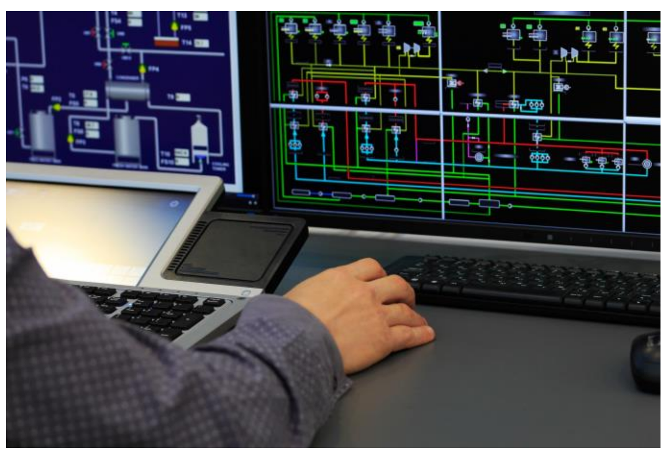
Finally, the architecture of all public cellular systems should be considered given it effects capacity. Public networks use sharing or multiplexing over a limited number of RF channels to be able to serve millions of consumers. This underlying structure of queuing and allocation over available channels means a utility's data must be first routed through the service provider's packet data network (PDN) gateway before reaching the utility's control center. This results in latency. Gateways are typically at the service provider's central office, and could possibly be outside your state, exacerbating the latency. And, if multiple PDN routings are allowed, the latency could worsen or be unpredictable.

"Even data services presented as "always on" or "always connected" have the underlying structure of queuing and allocation over available channels. This entails variable channel setup and queuing delays." (Taft, 2017, p. 16)

Control

Utilities and critical infrastructure markets require control over many areas of their operations. Without control, chaos can occur – and when you are dealing with providing energy services to customers a lack of control can result in disaster.

When using a public cellular system, the organization willingly hands over total control to the carrier. The carrier determines which areas will have coverage and how much capacity will be assigned to that area. The public carrier also determines when the system will be down for maintenance, when they will upgrade their network and if they should adjust their antennas to modify coverage – without your consent. The public carrier will do their best to minimize the effect to their customers, but in the end, they have total control over the system's maintenance, operation and performance.



Private networks give the control back to the utility. The utility decides where it wants coverage, what level of coverage and capacity should be at each area and the service level to deliver to each application. The utility is also in control of managing outages for system upgrades to occur. Control is one of the leading reasons why utilities have always deployed their own communications networks.

"In addition to needing access to wireless communications, CI entities have a separate requirement: control over the communications system, to ensure safety and reliability. This control can be satisfied only through the use of private radio spectrum." - NTIA Spectrum Use Study." (Joint Commenters, 2001)

Many of the components that comprise the grid are custom and would take months to years to have a new replacement unit built. In addition, in order to protect these sensitive pieces of equipment that can be easily damaged when a fault occurs, tight controls to monitor the performance of the network are required to ensure the equipment isn't damaged when a fault occurs.

Capabilities

IOUs, MUNIs, Coops, Water, and Railroad all have unique wireless communications needs. Consequently, private radio systems are often customized to meet these specialized needs. On the other hand, public wireless networks serve the general population.

While utilities may appear to be extremely similar, each one is unique in their operations. From the equipment utilities use in the field and the types of interfaces they support to whether they want their radio network to support layer 2 or layer 3 services – they all approach the same problem in different ways. Because of utilities' uniquenesses, they are best served by a flexible wireless manufacturer providing a roadmap that is comprehensive and open to modification when utilities need it.

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Public Cellular Strengths in relation to Capabilities - Public cellular providers deploy standards-based solutions created by the 3GPP. Being standards based, many devices and suppliers exist to feed the ecosystem – hence lots of options, which is a benefit. Another benefit is that public carriers can reduce supply risk given that there's a choice between multiple vendors.

Private Network Strengths – in relation to Capabilities

The 3GPP (3rd Generation Partner Project) consists of representatives of the carriers who actively promote the standards for the network. If a utility wants a feature to be supported by the network, the providing carrier must present that feature to the 3GPP in hope they agree that it's worthy. Similarly, the utility would have to work with each of the device manufacturers to get them to support the desired functionality. The challenge comes in that 1) the utility may or may not get the approval from each group to include the requested feature(s) in their product, 2) the utility becomes the integrator making sure that the way each manufacturer implemented the feature is consistent with one another and 3) that the solution works end-to-end. That's a lot of risk and ownership on the utility. Since public carriers get their revenue from their existing services, they are less inclined to want to support customer specific features.

Private network manufacturers are traditionally very flexible in supporting unique features for an individual customer. Because they are focused on each utility and their reputation and business depends on their support, private network manufacturers are incentivized to support custom features for each client. Better yet, as the manufacturer's reputation is on the line, they are more likely to go the extra mile to ensure the system works. In addition, the manufacturer usually takes on the integrator role - making sure the specifications are clearly spelled out, the risks are known, the schedule is published, and the test plan is agreed to by all parties. By managing the integration, the private network manufacturer reduces the risk associated with implementing a custom feature for a utility.

Cost

Costs are one area which is usually black and white, but ultimately how a FAN is sourced depends on your company's financial preferences.

Public Cellular Strengths in relation to Cost - Public cellular networks have the advantage that their costs are amortized across millions of users paying fees every month. They offer lower upfront cost as the network is already deployed. Because they can offer what seems like a low monthly cost per user, a public carrier's subscription model can seem incredibly attractive at first. Utilities should evaluate each of the 7 C's to weigh up the possible lower upfront cost.

Private Network Strengths in relation to Cost –
Primary Revenue Source - In a public network, the transition from one generation of technology to another is heavily weighted toward public demand and those millions of users. In 2015 the revenue generated by public carriers in the utility vertical was only 0.2%. It is apparent that Mission Critical operations may not be the primary motivator of the public carrier when assessing the bottom line.

Rapid Standards Turnover - As commercial demand is continuing to be driven by new features and alluring standards, public carriers are motivated to rapidly upgrade networks to remain current and competitive. This drives potential for an increased rate of standards turnover, or G-attrition. We have seen carriers announce end of life not only for 2G but also 3G at the same time. This effectively signals 3G as having half the life of 2G.

4G is now deployed and stable, however has already been around for 9 years. Given the absolute best case it is likely 4G will only be around for another 10 years, however 5G is already on the horizon. When considering a significant 4G deployment a burgeoning question must be, "how likely is it that we would be planning a 5G upgrade prior to completing our 4G deployment?"

Total Cost of Ownership - When evaluating the costs properly, all the costs associated with the project must be considered over the lifecycle of the system in a Total Cost of Ownership (TCO) model. A cellular carrier may offer a pricing of $2.00/mo./device pricing for a certain amount of data each month. Seems great, right? If the customer has 500,000 devices that they are implementing in a FAN, the result is $1M/mo. or $12M per year. Utilities traditionally look at 10 to 20 year lifecycles for their radio networks which would result in a FAN costing $120M to $240M! That's a lot of money that utility organizations would have to cover for a system for which there was little control. This figure also doesn't take into account any hardware upgrades required during the 10 to 20 year life cycle in order to meet the pace of carrier technology evolution

> "Public Service [Company of Colorado] determined that device costs were fairly similar [between private Field Area Networks and public cellular] but monthly and annual expenses were considerably higher with the use of public cellular." **Public Service Company of Colorado's response to the Public Utilities Commission of the State of Colorado hearing, August 2, 2016** (Reimer, 2016)

Additional costs will also impact the TCO including the costs to integrate the devices into the system, or the costs to resolve issues when there is a problem. In a public carrier system, the utility becomes the integrator and takes on a significant burden. In complex systems such as integrating wireless communications across multiple applications, a situation can arise where the application provider blames the hardware provider and the hardware provider then blames the application provider and the network provider. This type of messy finger pointing generally must be resolved by the utility resulting in delays and additional costs.

Meter collectors are another great example. While not mission critical they are certainly business critical and as utilities become more responsive to customer needs, near real time meter reads are proving to be a customer centric service. Now that 2G and 3G are sunsetting, utilities are forced to move to 4G-compatible devices. Unfortunately, we are already quite a way through the 4G life cycle meaning a further upgrade will be required in the medium-term future.

The costs soon mount up. As an example, if a utility has 5000 collectors, consider 5000 truck rolls or touch points. Given a truck roll equates to an average $375 then $1.875MM is consumed in deployment. The radio hardware also needs to be upgraded. If, on average, this sits at $500 per modem plus antenna, this equates to $2.5MM. Now we need to consider monthly fees per meter. Because there is a higher throughput at collectors, a larger amount of data is required so this may reach $7 per month per meter. Over 5 years this equates to $2.1MM. And because deployment has started late in the 4G life cycle, it is likely that this exercise would need to be repeated within a 10-year period.

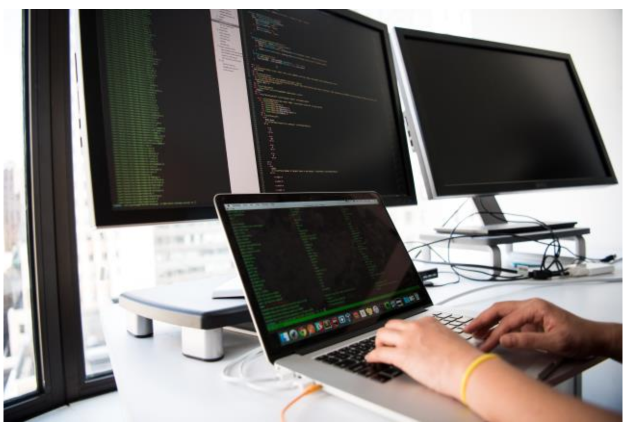
With management overheads included, expect to spend in the region of $7.5MM per generational upgrade for 5000 collectors. By the way, don't forget to pay your bill, and don't have a disagreement with your carrier, as you then risk stranding your revenue generating technology. This is a challenging environment for business-critical services, which makes it orders of magnitude more challenging for mission critical services.

In a private system, the costs are known, fixed and capitalized. The roles of who is responsible for each component/sub-section of the solution are identified along with the associated cost. Also, the utility is able to outsource whatever aspect of the project they want to the providing manufacturer along with a SLA and/or performance guarantee.   Because so many of the costs are known upfront in a private solution, the ask to the PUC/management board is known and the ROI is clear. The ROI is enhanced when multiple disparate communications systems can be consolidated into a single modernization strategy that may not only accommodate Mission Critical but can also take on Business Critical aspects.

Lastly, utilities need to consider what their company's preferred financial acquisition structure is. Today, many IOUs want to keep their purchases as a capital expenditures (CapEx) rather than a reoccurring monthly operation expenditure (OpEx). As a monthly expenditure, public cellular companies are viewed as an OpEx cost where as private network providers provide their solution as a capital expenditure. With the rate of return set for many utilities and governed by public utility commissions (PUC) for investor-owned utilities, a roadblock to commercial cellular OpEx expenses exists. During the cycle, a utility wanting to add opex expenses can't go back to the PUC (Weinschenk, 2018).

- *"U.S. utilities are much more driven to invest in their own networks. They use the rate of return business model. If they use capex, they get money for that … They make money when they build their own network, but opex eats into their profit margins."* - **Richelle Elberg**, principal analyst, Navigant Research.

Cyber-Security



There are many similarities between public cellular and private networks in terms of cyber-security - specifically encryption and authentication. Advanced encryption algorithms such as AES256 are commonly available and would be considered table stakes in a radio communications network today.   Similarly, authentication protocols and supporting authentication services from a RADIUS server are also very common among both public and private networks.

The real difference in cyber-security between private and public networks is around control of the information. In a public network, the utility's data leaves their network and goes to the public carrier's network, gets processed then returned to the utility and sent to the appropriate device. In addition, public cellular networks use open standards which give hackers and criminals easy access to cellular devices to use for hacking attempts.

A private communication network has a security advantage in that the manufacturer is the only provider of that radio equipment. The private manufacturer may use publicly available techniques, but how they used them in their protocol is confidential and incredibly difficult information to obtain. In order to get access to a network, a thief would have to literally steal a radio from the utility that was already configured, provisioned and authenticated on the network. Since utilities use a network manager, theft of the device would be known in a very short amount of time and it's use suspended until a technician was able to go to the radio's last known location to verify its presence and operation.

""The most significant advantage of a Company-owned FAN is security. A private network allows Public Service to better control the integrity of the devices on its network and the data exchanged with those devices. The alternative—a public network—would expose the devices and Public Service to increased risk because the Company would not be in control of the network."

- Public Service Company of Colorado's response to the Public Utilities Commission of the State of Colorado hearing, August 2, 2016 (Reimer, 2016)

Summary

Public communication networks and private communication networks both have their advantages and disadvantages. Understanding your application needs and your organization's financial model is crucial in determining which network type is best for your company. Public networks have the advantage that they are easy to deploy, standards based, and can provide incredible amounts of capacity. The disadvantage to public networks is that they are not designed to be mission critical thus increasing your organization's risk. Risk is increased by giving up control over your coverage, capacity, capabilities, and cyber-security for what may appear to be a lower initial cost. When considering a Utility Networking Technology Selection Map, Navigant (Elberg, 2018) summarizes that if public wireless infrastructure is considered the downsides are: ongoing OPEX, inadequate SLA/QoS, lack of control, interference potential, capacity limits, and security concerns (Elberg, 2018, p. 7)

Private communication networks have the advantage that they are customized to your organizations requirements by delivering coverage and capacity to where you need it and offer higher levels of cyber-security in that their design is proprietary. Another advantage of a private network is that it typically is acquired as a capital expenditure, which is favorable when considering rate cases. However, that said, many private radio manufacturers can provide their radio offering as a service in a low monthly O&M fee.

Below is a table summary of the private wireless network capabilities vs Public cellular to handle common threats, risks, and needs of utilities as addressed in this paper.

Table 3: Summary - Private Wireless vs Public Cellular Network Capabilities	
Private Wireless Network Capability	Public Cellular Capability
Uptime - Battery Backup Requirement: Days	Uptime - Battery Backup Requirement: Only hours
Uptime – Compliance Requirement: Secure and controlled	Uptime – Compliance Requirement: Controlled by carrier
Capacity: Designed to accommodate requirements	Capacity: Greater than narrowband, however falls off at the edge and dependent on users
Storm resiliency: Excellent and proven	Storm resiliency: Poor and prone to overload during emergency
Expense Structure: Favors a CapEx model – Upfront investment required however more predictable cost in the long term.	Expense Structure: Favors an OpEx model – long term costs are greater and unpredictable against upgrades.
Low latency requirement: Excellent ability	Low latency required: Poor ability
Input to Key Features needed: Excellent	Input to Key Features needed: Poor – caters to general public
Interference Control: Excellent due to private ownership	Interference Control: Poor due to public use (see examples)
Security: Excellent – under control of utility	Security: Poor – public sharing of assets and descriptions
Protection against RF Network Changes (Carriers): Yes – due to private ownership	Protection against RF Network Changes (Carriers): No – due to public carrier control

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