# How to Meet Utility Bandwidth Requirements in Narrowband Channels

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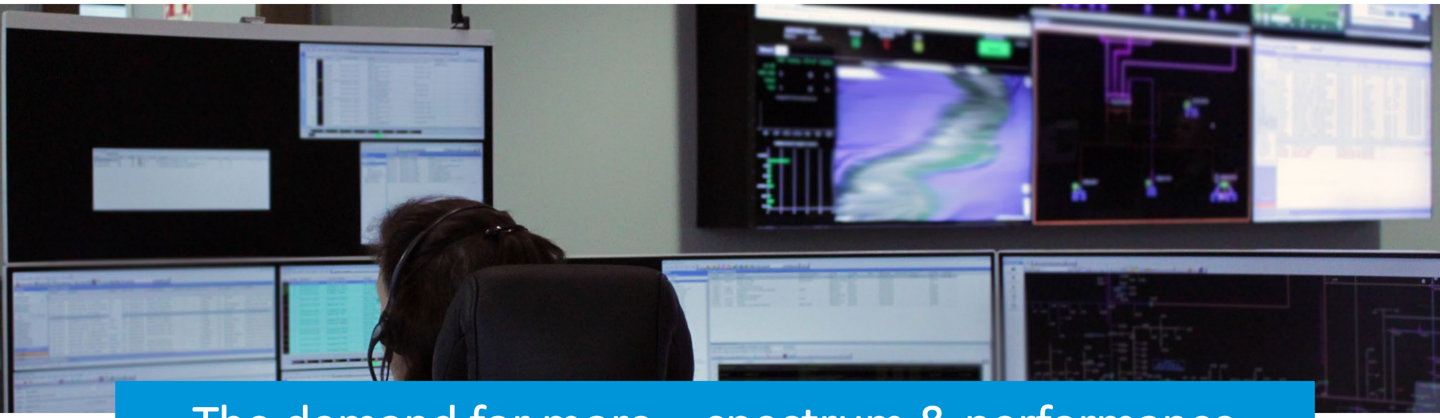


# The demand for more - spectrum & performance

## Chasing spectrum

In 1988, UTC released research detailing a shortage of spectrum and recommended an additional 1.0 - 6.3 MHz be set aside for utility operations between 2000 - 2010. Ten years later in 2009, UTC reported on a widening gap caused by decreasing available spectrum and an increasing demand for capacity to support growth and smart grids.

Given this growing demand, coupled with an increased focus on national security and more frequent natural disasters, UTC further increased their recommendation for dedicated critical infrastructure industries spectrum to 30 MHz of dedicated spectrum. Despite this recommendation, regulatory decisions between 1988 and 2009 actually **resulted in a net loss of spectrum available for utilities**. (Utilities Telecom Council, 2009, January, pg. 5)

## Technology evolves

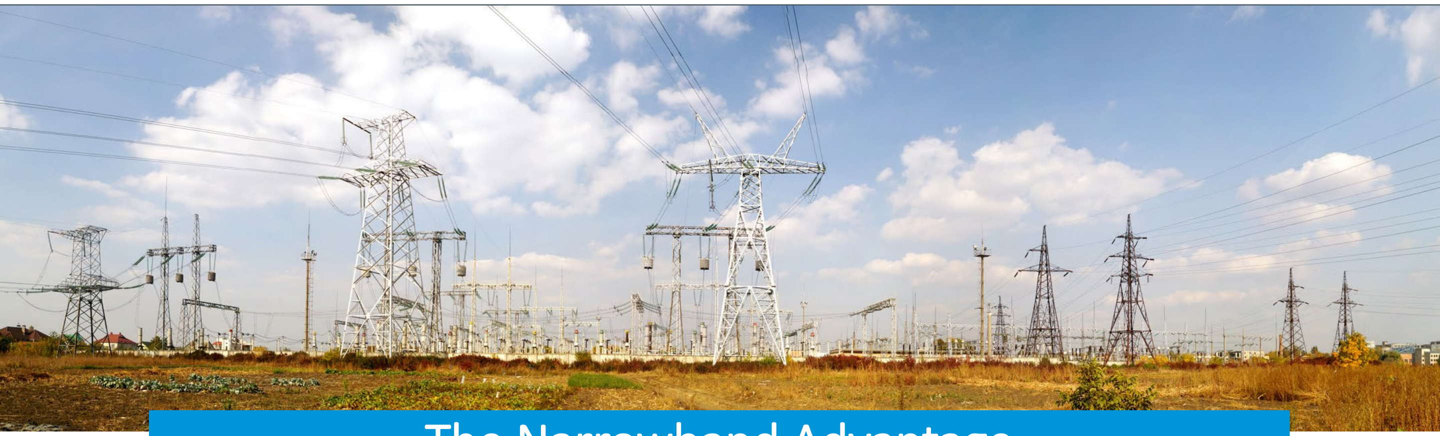
High capacity radio systems like WiFi and LTE were incorporating two of the latest technologies into their architectures to dramatically increase capacity:

1) multiple transmitters & receivers (MIMO) and

2) 256 QAM modulation.

Both offered tremendous performance benefits to a radio network's capacity. Although the independent technologies had been developed, 4G/LTE hadn't arrived on the scene yet.

Could these technologies enable utilities to overcome the spectrum availability/capacity requirement gap and achieve their long-term capacity goals?



# The Narrowband Advantage

A number of options exist for a utility to deploy a communications network – microwave, fiber, LTE/5G solutions and licensed narrowband. The solution chosen will depend on balancing coverage and capacity with cost.

Each option obviously offers pros and cons which need to be balanced against each other during the decision-making process. One solution which offers ultra-high data capacity, for example, may also involve a lengthy deployment with high capital costs. Terrain and climate may also be significant determining factors which immediately rule out one approach in favour of another.

In the following pages we will examine how narrowband wireless communications could be an ideal solution for your utility communications.

## Key Narrowband Advantages

- Lower rollout costs
- Private, licensed network
- No requirement for line-of-sight
- Better immunity to weather events and natural disasters
- Lower OPEX

*"...a private network with a known capital and operational expenditure may present a stronger financial case than relying upon carrier-provided services."*

2019 Utility Network Baseline Survey, Utilities Technology Council

# Will narrowband meet your requirements?

## How much data for the FAN?

Over the years, various models for Field Area Network (FAN) bandwidth requirements were developed by industry leaders including IBM, Bell Labs and other research institutions such as EPRI. These models showed that the enterprise data consists of data from the FAN, video surveillance, mobile data, enterprise data, synchrophasors and other applications.

In these models, FAN data represented about 40% of the total amount of enterprise data.

## The Steps

The following pages outline three steps you can take to determine whether a narrowband communications network could deliver the capacity you estimate your utility will require.

1. Get the lay of the land – carry out internal and external research

2. Estimate the number of sites required for your service territory

3. Calculate the amount of bandwidth you will require to support your applications

4. Calculate the bandwidth available using narrowband radios

*"Without reliable and sufficient [telecommunications] bandwidth, grid modernization is impossible."*

Read on to find out how to calculate your network requirements

# Step 1: Get the lay of the land

## Fact-finding

Before embarking on any large-scale project, you will need to spend some time in research and fact-finding. There may be pain points in other business units of your organization that you need to learn about. Or possibly your organization has new technology coming online with specific requirements in terms of data flow in multiple directions or near real-time visibility.

Here are some starting points to research internally:

- Current costs for annual truck rolls
- Annual outage stats
- Any penalties relating to SAIDI or SAIFI
- Costs for training staff
- Introduction of new field devices and their requirements
- Causes of pain points across your organization

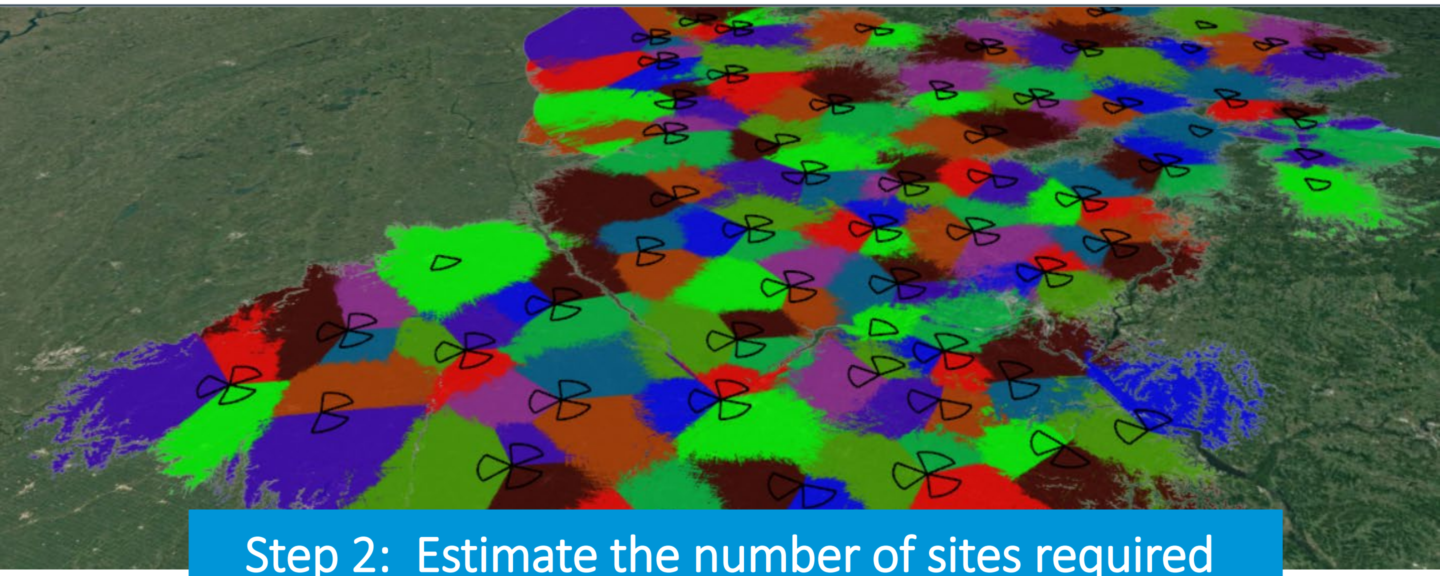
## Now look to the vendors

The next step in your research mission is to become familiar with vendors, their products and their customers.

Compare product specifications, paying specific attention to **data throughput** and **latency** – both of which will significantly impact your ability to a) run multiple applications across the same network and b) run applications which need near real-time grid visibility.

Read case studies to find other utilities who are using wireless narrowband to upgrade their grid and use industry associations to form connections with employees at those utilities who may have experience in deploying narrowband networks.

In our experience, members of the North American utility sector take a collegial approach and are happy to share their expertise and advice. Don't ignore the value you can gain through engaging with utility employees who have already taken this journey before you.



# Step 2: Estimate the number of sites required

## Sites Required

As the starting point to determine whether narrowband can meet your bandwidth needs, you will need to estimate the number of radio sites required to cover your service territory.

Below is an outline of a range of Mimomax-designed networks for urban, rural and statewide rural/urban mix environments. While it is difficult to provide a definitive number of base station sites, the examples below may give you a high-level idea of what to consider for your service area.

| Type of network | Number of base stations | Square miles service area |
|---|---|---|
| Urban | 50 | 3000 |
| Urban/Rural* mix | 90 | 5000 |
| Rural/Urban* mix | 50 | 50,000 |
| Rural | 60 | 80,000 |
| Rural | 50 | 40,000 |

As you can see from the table above, the number of base stations can vary widely for different territories. This results from the fact that each utility's network design needs to support different terrain, environment and population density.

# Step 3: Calculate your bandwidth requirements

In order to ascertain whether narrowband could support your communications network, you will need to determine details such as the data throughput and latency required for the various applications you run.

At this point you may also want to **rank your applications in terms of criticality**. This can be helpful for phased deployments where you will scale a network upwards, adding additional applications and devices as funding becomes available for deployment.

You may need assistance from colleagues in other business units to ascertain these details.

## Application bandwidth examples

While there are no standard industry quoted rates for the bandwidth required for each application, the table below outlines some of the most common utility applications and their associated stats.

| Application | Total Frame (Bytes) | Polling rate |
|---|---|---|
| Reclosers | 350 | 5 seconds |
| Switches | 350 | 5 seconds |
| Commercial Solar | 150 | 20 seconds |
| Advanced Metering | 350 | 900 seconds |
| Capacitors | 350 | 5 seconds |

# How to calculate bandwidth requirements:

1. Ascertain which applications you will run over your network
2. Determine number of devices to be connected
3. Determine the bandwidth required by your devices
4. Multiply the device bandwidth by the number of devices

# Equation to determine your application bandwidth

- Take the general quoted bandwidth rate per meter
- To translate bytes to bits, multiply by 8
- Then take this total and divide by the polling rate in seconds (i.e. 15 minutes equates to 900 seconds)
- Finally, multiply the number you calculated directly above by the number of endpoints for your application.

## Example: AMI Metering

Here's an example using the equation above. Take a large AMI system with 500,000 meters, polled at 15-minute intervals, the equation would look like this:

- 350 bytes x 8 = 2800 bits or 2.8kbits
- 2800 / 900 seconds = 3.111 bits/s
- 3.111 x 500,000 endpoints = 1,555.5 kbps or **1.5Mbps**

# Step 4 - Calculate available data capacity

## Aiming for higher spectral efficiency

The next step is to calculate the amount of data that can be delivered at each site. In order to get the highest data throughput, you need to start with a radio which delivers better spectral efficiency.

Spectral efficiency is the optimized use of spectrum allowing for the maximum transfer of data with the lowest amount of errors.

In terms of spectral efficiency, a radio running at 64 QAM modulation can deliver a maximum of 6 bits of data in every 1 hertz of spectrum (6 bits/sec/Hz) in the channel size used. Therefore traditional radios that use 1 transmitter and 1 receiver in each radio would have a theoretical spectral efficiency of 6 bits/sec/Hz and, in a 50 kHz channel, would be able to deliver up to 300 kbps.

Narrowband radio technology, however, has advanced significantly over the last decade. Using a 2x2 MIMO system that uses 2 transmitters and 2 receivers would provide a spectral efficiency of up to 12 bits/Hz (6 bits/Hz for each transceiver) at 64 QAM.

## Increase modulation to increase capacity

Obviously, the aim is to boost your data throughput via the technology you deploy. In addition to selecting a MIMO solution, using a higher modulation rate will also boost your data capacity significantly. As you will see from the table on the following page, increasing the modulation rate from 64 QAM to 256 QAM gives a notable boost in the data capacity in each channel.

## Modulation Rates Table

| | 12.5 kHz | 25kHz | 50kHz |
|---|---|---|---|
| 64 QAM | 120 kbps | 240 kbps | 480kbps |
| 256 QAM | 160 kbps | 320 kbps | 640 kbps |

(Note - the figures above are the half duplex rates for Mimomax radios. The full duplex rates are double the rates above.)

## Minus Overheads

In all wireless data systems, you can expect to have to account for overheads. Forward Error Correction (FEC) rates generally range from 1/2 through to 7/8.

Mimomax, for example, uses a 7/8 rate which equates to a 12.5% overhead. This will need to be removed from your gross aggregate data rate. There will also be other overheads such as IP protocols associated with headers. If your data is highly compressible, it is possible you can claw back some of the overhead associated with TCP/IP.

Depending on the level of compression you can achieve, you may be able to get back to a baseline that mainly only needs to account for FEC.

## Per Site Data Capacity

To further increase site data capacity, you can look to use a variety of advancements including:

- MIMO
- Full Duplex
- Higher orders of modulation, and
- 3-sector base sites with directional antennas.

## Example:

Using a **MIMO** radio running at **64 QAM** in a 50 KHz channel could achieve a gross, aggregate, full duplex rate of:

- **2880 kbps per 3 sector site (using directional antennas)**

Boosting that same radio up to **256 QAM** in a 50 KHz channel would give a gross, aggregate, full duplex rate of:

- **3840 kbps per 3 sector site (using directional antennas)**

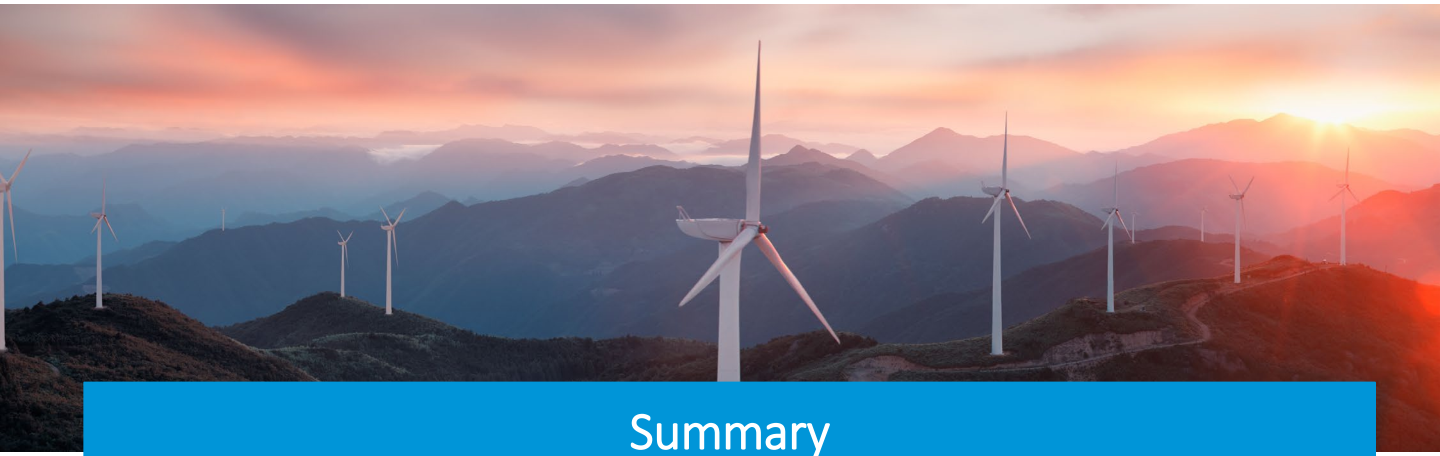
## Account for Overheads

This rate above will drop to **3360 kbps** once you have accounted for a **12.5% Forward Error Correction** as discussed on the previous page. Depending on the protocols used, the repeatability of the data and the method of compression, there will be other overheads which will also need to be taken into account.

Note: a traditional SISO radio would be unable to achieve these rates. Please see specifications from individual manufacturers for data rates to carry out these calculations.

If the quoted rates are raw data rates, we recommended reducing the total by 1-FEC rate and to also allow for additional overheads.

For example: 7/8 FEC rate equates to 1 - 7/8 = 1/8 or 12.5% data reduction. TCP/IP overheads could consume an additional 20-30% of the capacity. However, depending on the data, the impact of overheads can be mitigated with the use of robust header and payload compression.



# Summary

Utilities can now deploy a common platform for their FAN applications which is scalable, private and operates on licensed spectrum in frequency bands to which they already have access.

Radio platforms like the Tornado from Mimomax which uses the same advanced radio technology found in 4G, WiFi, 5G and WiMAX can deliver the performance utilities need but on licensed narrowband spectrum. These platforms also offer excellent line of sight and non-line of site coverage.

Unlike 4G, 5G and WiMAX which use a centralized core architecture, some narrowband radio architectures are coreless (including Mimomax) which allows the radios to operate in both point-to-point and point-to-multipoint modes.

*"...A private network with a known capital and operational expenditure may present a stronger financial case than relying upon carrier-provided services."*

2019 Utility Network Baseline Survey, Utilities Technology Council

## Want help with planning a Field Area Network?

If you would like to schedule an appointment with the Mimomax Regional Sales Manager for your area

Click here

# Bibliography


Gungor, Sahin, Kocak, Ergut, Buccella, Ceati, & Hancke (2012). *A Survey on Smart Grid Potential Applications and Communication Requirements.* IEEE

Madden, Mark (2011). *Grid Application Traffic Requirements:* Bell Labs FAN Grid Study Presented at Metering America

RIYAZUDDIN, K. and SANKARNATH, V. (2016, August). *QR Code Modulation for Data Transmission in Mobile Devices* Using OFDM-DWT Technique: International Journal of Advanced Technology and Innovative Research Volume. 08, IssueNo.09, August-2016, Pages: 1757-1760. http://www.ijatir.org/uploads/435162IJATIR10508-297.pdf

Robinson, Michael B (2008). *Wireless Alternatives for the Intelligent Distribution Grid*, Presented at UTC Next-Generation Summit

Utilities Telecom Council (2009, January). *The Urgent Need for a Licensed Broadband Spectrum Allocation for Critical Infrastructure.* Washington, DC: Utilities Technology Council: https://ecfsapi.fcc.gov/file/6520194487.pdf

Utilities Telecom Council (2019, April). *Utility Network Baseline Survey results.* Washington, DC: Utilities Technology Council: https://utc.org/wp-content/uploads/2019/04/UTC-Utility-Network-Baseline-Final.0419.pdf


## About Mimomax

Mimomax develops wireless communications solutions for narrowband channels which enhance visibility and control – right to the edge of our customer's networks.

Our award-winning radios utilize Multiple Input, Multiple Output (MIMO) technology combined with full duplex communications and ultra-low latency to provide our customers with communications solutions which optimize data throughput and provide rapid feedback and control of their mission-critical assets.

Winner of the 2018 UTC IMPACT Award for Mimomax Tornado Radio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