WHITE PAPER / **TOWER SITE PLANNING FOR UTILITIES**

A STRATEGIC APPROACH TO NEW TOWER SITE PROJECTS

BY Jon Conway

Utilities face increasing demand for communications networks and widespread data coverage for more assets. Identified project objectives and best-practice planning guidelines help utilities execute new tower sites to meet these growing needs and prepare for future requirements.

Utilities require stable, robust communications to manage outages, energy, dynamic power flow and more. Sophisticated networks provide the needed interconnection between assets to deliver the required reliability levels to support customers across the country.

In addressing the growing needs of communities and utility responsibilities during routine and emergency operations, the Utilities Technology Council — a global association focused on the intersection of telecommunications and utility infrastructure — estimates that utilities will require a tenfold increase in bandwidth requirements over the next three to five years.

Whether to solve backhaul throughput requirements using point-to-point microwave systems, address improved two-way radio system capabilities or build out field area network strategies, planning and building new utility tower sites are often required.

TOWER TYPES

There are typically two tower types to consider for most utility projects: a self-support tower and a guyed tower. It's important to understand that tower type influences site selection.

Self-Support Tower

To support the tower load, a self-support tower has a large foundation directly below it to support all tower loads. As a result, the tower base grows wider at the bottom, nearest the foundation. The base face width — the distance between any two tower legs measured at the tower's widest point at the base of the tower — can be estimated at 10% of the tower height.

Guyed Tower

A guyed tower has a smaller face width over the entire height of the structure. To support the tower loads, a small base foundation is paired with guy wires. The guy wires extend out and down in three directions from various heights on the tower to a distance of approximately 80% of the tower height.

These general tower guidelines can be modified during the design phase, and usually at an additional cost, but utilities must work with tower manufacturers and designers early in the process to see that the project reflects the cost.

INITIAL PROJECT ASSESSMENTS

The decision to build a new tower is never straightforward and should come about only after detailed analysis and consideration. As with any well-planned project, utilities must explore a range of aspects to see that the case for a tower is sound and the supporting resources exist to proceed.

Before planning for a new tower site, utilities need to define:

- Why is a new tower needed? What systems and/or technologies will the tower be used for, such as land mobile radio (LMR) networks, field area network (FAN) systems and point-to-point networks?
- What frequencies will systems on the tower be operating under, what is the purpose of each transmitting antenna and what is the required height for each antenna to serve its intended purpose?
- Where will the general location of the tower site be?
- What is the budget for the project?
- What is the schedule? Is the timeline sufficient to address all requirements to plan, design and construct a tower?

Permitting requirements are another comprehensive area that will require dedicated time and budget. The permitting process for a new tower project can take six months and cost tens of thousands of dollars. If any concerns or issues are discovered, there can be significant extensions to the project's timeline and increases in cost. These details should be considered in the initial appraisal of the project.

NEW TOWER SITE PLANNING CONSIDERATIONS

With the essential project objectives outlined, utilities are in good shape to get underway with planning. Understanding the range of diverse factors that make up new tower site planning can help utilities better prepare to avoid stumbling blocks that could delay what can be an already lengthy process. When choosing to build a new tower site, utilities should consider these components of the process:

- Site selection
- Tower selection
- Support infrastructure
- Construction
- Maintenance

All elements of tower site planning work in harmony to help identify the right decision for each tower site and each utility.

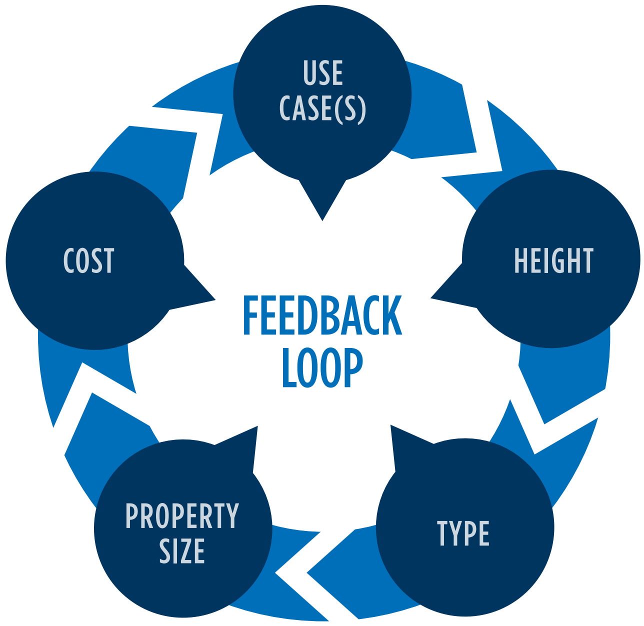


FIGURE 1: *When determining tower selection, key deciding factors create a feedback loop that help identify the best tower type for the project.*

SITE SELECTION

The site selection process typically starts with knowing that a tower is required for a particular geographic area to address a specific need. For example, the area serves as an ideal location for a new microwave link to an existing site, or a two-way radio site is needed to improve currently spotty coverage. Identifying a general area is enough to get started.

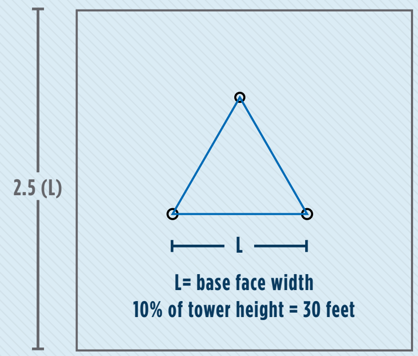
To further evaluate a site and narrow down the selection, utilities should:

- **Understand the topography:** Find high spots around the planned site location using a GIS database or topographical data as an overlay in satellite imagery to learn the topography. Isolate favorable locations for identified tower project needs.
- **Establish and engage with property ownership:** Using identified site selections, establish land and property ownership for each option. Develop a high-level statement to contextualize the project and begin querying landowners to determine interest and discuss selling or leasing options. Some lands are maybe owned by people who live out of state, so starting the process early is essential.
- **Determine local planning and zoning rules:** Many utilities have internal site acquisition and real estate groups who can help understand planning and zoning jurisdictions for each site option. Be thorough in identifying what the area is zoned for, the neighboring landowners, setback requirements and nearby roads. Find out whether permitting requires a preliminary site design or sealed engineering documents, whether variances to codes will be needed or if attendance is required at county or city planning and zoning meetings to defend your proposed site.
- **Consider site access:** Evaluation is necessary to learn how a vehicle will access the site, how easy the site will be to get to and maintain once it is operational, if a new access road must be built, and how difficult it will be during construction for large equipment to get to the site. Study what will be required both inside and outside the fence line to construct, access and maintain the site and all associated components.

A TALE OF TWO TOWERS

In determining whether a self-support tower or guyed tower will be used, utilities should consider the different land size needs. Overall land requirements depend on tower type and what will be contained within the fence, in addition to the tower. The example below reflects the land requirements for a simple, 300-foot tower:

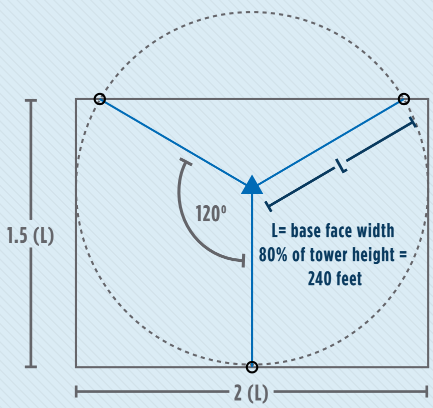
Self-support tower land requirements for a 300-foot tower can be calculated as:



2.5L = 75 feet
Squared off = 75 feet x 75 feet of land, or slightly more than 1/8 acre

FIGURE 2: *Self-support tower. This example shows the tower centered but it would typically be placed in a corner or to accommodate ancillary equipment.*

Guyed tower land requirements for a 300-foot tower can be calculated as:



Because the tower requires only the land out to the guy wire anchors (and not the entire 240-foot radius around the tower), a good rule of thumb is 2L x 1.5L. Therefore, 2L x 1.5L = 480 feet x 360 feet of land, or slightly less than 4 acres.

FIGURE 3: *Guyed tower.*

TOWER SELECTION

It's clear that site selection and tower selection go hand-in-hand for new tower site projects. The decision-making process to determine tower selection becomes a feedback loop that, when evaluated against overall project goals, can help identify the best tower type for the project (Figure 1).

- Start with the **use case** for the tower: Evaluate what the immediate needs are for the tower, what the near- and long-term benefits of building the tower are and what the tower could be used for in the future.
- Determine the general **height range** for the tower: Identify whether the tower is for high-frequency, point-to-point microwave systems where line of sight is critical or if the tower will expand or add coverage for existing communication systems. The outcome becomes a variable in the most suitable tower type.
- Consider the **property size** required or any site size limitations to inform tower selection, as outlined in Figures 2 and 3.
- Evaluate **cost considerations** based on tower selection inputs for each tower type. Costs include land acquisition, design, procurement, construction and maintenance. Self-support towers and guyed towers have different land, material and erection cost advantages for utilities to consider. For example, self-support towers require more steel and concrete, increasing initials costs and guyed towers are flexible when it comes to potential future enhancements and structural modifications.
- While the emphasis of this paper is on self-support and guyed towers due to their scale and complexity, utilities should also **consider monopole towers**. These towers are generally the least intrusive and easiest communications towers to erect because of their small footprint and relative size. This convenience, however, comes at the expense of rigidity, stability and height. Monopoles should be considered in the initial tower selection analysis, but be sure to verify the application's requirements for height and beam width stability when considering monopole towers.

As utilities evaluate tower selection options and identify a suitable choice, comprehensive procurement specifications are needed when going to bid to see that the tower is manufactured to requirements. Proposals should include soil and geotechnical reports, structural and mechanical specifications, feed line routing, safety requirements and any required appurtenance information.

SUPPORT INFRASTRUCTURE

Regardless of tower type or location, support equipment is necessary for new utility communication tower sites. These assets should be included in overall planning from the early stages of planning, through design and into construction.

- **Obstruction lighting:** File early with the Federal Aviation Administration (FAA) to determine what is needed and include this in tower procurement or separately with a tower obstruction lighting supplier. Consider LED lighting with smart or Ethernet-enabled alarm capability, as those systems can deliver long-term operational savings and require less maintenance.
- **Equipment enclosure:** This critical asset involves evaluation and consideration of both exterior and interior layout and configuration options.
  - **Exterior:** Thoroughly consider the enclosure and how it will be located, including its orientation in terms of other equipment on the site. Determine whether there will be a generator and on-site fuel source, what utility services are needed, where the tower is in relation to the enclosure and how large of a radio frequency (RF) port entry is required. Go far as to consider heating, ventilation and air conditioning (HVAC) unit sizing and location, and long-term service maintenance accessibility.
  - **Interior:** Determine what will be included inside the enclosure, both for immediate and long-term needs, and consider the necessary support equipment such as a backup battery system and transfer switches. Establish requirements upfront such as standardizing where every rack will be placed, where the backup battery will go, how cables will be routed, where antenna line feed will be routed, and more to save on future costs should additional enclosures be required for other sites.
- **Ice bridge:** Plan for appropriate spacing to accommodate an ice bridge to get from the tower to the building. Sections are typically available in 10-foot pieces. Enough distance needs to be left from the tower to the enclosure to route cables with appropriate bend radius sweeps and drip loops.
- **Emergency backup power:** Backup power and on-site fuel sources often are designed for and installed during a new tower site build to provide emergency support to the site in the event of a utility service outage. Understand all on-site loads required to remain in service during an outage to help with generator sizing. Be aware of the electrical and fire protection codes for distances between equipment and structures, such as spacing between enclosure, generator and fuel source. Lastly, consider how technicians and service personnel will enter, drive around and park on the site to guide the layout of this equipment in relation to the tower and enclosure.
- **Electrical service:** For remote installations, request electric service early in the project to understand, plan for and coordinate the route from the distribution service transformer to the meter and then into the building. When installing near an existing substation, consider the complexities of acquiring power from the station service transformer.
- **Perimeter protection:** Protecting a new tower site and the critical infrastructure that is contained also requires planning, but typically involves a gated fence line around the perimeter of the site. While the linear feet of a fence line depend on many factors, gate access and parking space inside of the fence should reflect the long-term plans for a site. Consider larger gates (e.g., 20-foot width) if long-term plans include drive and park access inside the fence line. Smaller gates (e.g., 3-4-foot width) should be used if only foot traffic is planned. For added protection, consider barbed wire in addition to nontraditional fence fabric with tighter mesh patterns that prevent cutting and climbing.
- **Site signage:** Don't overlook tower site signage, as it serves as a security warning, alerting others of potential harm and providing general site identifiers. Signage includes owner name, address and site name; a security contact number for site entry and exit; RF hazard signs; the FCC antenna structure registration (ASR) number; no trespassing signage; and any other hazard signs. Consult Occupational Safety and Health Administration (OSHA) and telecommunications site standards for site signage and location guidance.

CONSTRUCTION

The costs associated with new tower construction are a substantial portion of the overall project budget and require dedicated planning to see that execution is controlled. These elements are critical to efficient and effective construction.

- Selecting a **qualified construction contractor** is essential and evaluation should include general contractor safety records and climbing certifications, such as the National Association of Tower Erectors (NATE) standard, for each climbing crew member to be working on the project.
- Be sure to understand **crew experience** in tower erection, antenna and line work and civil and electrical work specific to what will take place at the site.
  - **Civil work** experience involves site grading, foundation construction including drilled piers and large mat foundation, offloading of large materials delivered to the site — often using a crane — and ancillary support infrastructure foundation experience.
  - **Exterior electrical** experience involves subgrade grounding, subgrade trenching and conduit installation and subgrade piping for the on-site fuel source.
- **Tower erection** planning — best done early and with the contractor — includes determining whether a crane will be used, identifying the heaviest tower section and determining the proper crane size to support the load, locating where a crane will be sited and detailing the crane lift safety plan.
- **Antenna and line work** crews must be familiar with the type of antenna that will be installed and the nuances of different RF systems. Microwave installation requires special consideration for mounting and waveguide routing and the contractor should have an execution plan. Experienced workers must perform and understand the results of sweep testing for each antenna and feed line.
- **Site grounding** must be identified in the design, follow industry best practices and require a qualified contractor to avoid safety risks and poor connections. Grounding installation audits should also be completed during construction.
- **Ancillary equipment** is often part of the construction process and includes generators, tower obstruction lighting, backup battery systems, transfer switches, waveguide pressurization systems and more. Plan to include testing of devices upon delivery and after final connections.
- **Permitting notifications** are important to complete during the process and the contractor and construction personnel should be responsible for notifying when critical milestones are achieved so the permitting process can be completed.

FENCE IT IN

In addition to specific tower type, general land requirements are also influenced by what will be included within the fence line. Self-support towers and guyed towers offer different possibilities for utilities to consider and design in the site plan to optimize land use.

- **Self-Support Tower:** At a minimum, the land required will encompass the entirety of the tower. Support infrastructure, such as a building or generator, will be contained inside the fence, resulting in needing more land than just the tower footprint.
- **Guyed Tower:** There are two approaches to determine land requirements for a guyed tower:
  - Fencing the minimum amount around the tower to include ancillary support infrastructure, like a building or generator and also around each guy anchor to prevent vegetation growth or vandalism. The result is unused and unfenced land between the tower and guy anchors that could be part of a lease agreement with the landowner or, more likely, is retained in the utility lease agreement.
  - The other option is to fence the much larger, total area around the tower and all guy anchors, which increases fencing, gravel and maintenance costs.

MAINTENANCE

Owning and operating a tower requires ongoing maintenance to preserve operational performance and raise awareness of necessary enhancements as towers are used and new objectives for the asset arise.

- **Regular inspections and maintenance** help to prevent failures over time. Following the American National Standards Institute (ANSI)/ Telecommunications Industry Association (TIA)-222 standard provides a useful checklist to inspect and maintain towers. Often, items include:
  - Structure conditions
  - Tower finish
  - Lighting
  - Grounding
  - Antennas and lines
  - Guy wires
  - Foundations
  - Tower alignment
- **Future structural analysis** is needed when an appurtenance will be added to the tower that was not in the original plan. Simplify the process by keeping all records from the tower manufacturer and installation, including tower design details, erection details, foundation details and all appurtenance assumptions and structural loading calculations. A loss of those records can be the difference in spending $1,500 on an updated calculation with the actual structural steel and foundation records to $10,000 for an updated calculation full of caveats and assumptions
- **Structural modifications** are sometimes required as a result of new antennas being added to the tower after it was originally designed and constructed. The details of the modifications are specific to the tower type and new loads being added to the tower. Plan for time and costs to design and install such modifications as they frequently require a field visit and precise fabrication during design and then must be carefully installed by an experienced crew.

Utilities that define project objectives upfront, follow best practices guidelines and work with a qualified, experienced contractor can expect success for new tower site planning, design and execution.

BIOGRAPHY

JONATHAN CONWAY is a senior electrical engineer and project manager specializing in telecommunications and network engineering with over 15 years of experience. He serves as project manager and lead engineer on various utility projects related to radio frequency design and construction, communications tower construction, network architecture and design, supervisory control and data acquisition (SCADA), and systems engineering/integration.

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