A Field Guide to the North American Communications Tower

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By Kristina Panos April 5, 2016

The need for clear and reliable communication has driven technology forward for centuries. The longer communication's reach, the smaller the world becomes. When it comes to cell phones, seamless network coverage and low power draw are the ideals that continually spawn R&D and the eventual deployment of new equipment.

Almost all of us carry a cell phone these days. It takes a lot of infrastructure to support them, whether or not we use them as phones. The most recognizable part of that infrastructure is the communications tower. But what do you know about them?

What Is a Communications Tower?

Communication towers are all around us in various shapes and forms. Some towers serve several kinds of signals. They transmit one-way broadcasts like AM/FM radio and television signals while also handling two-way cellular traffic using various protocols.

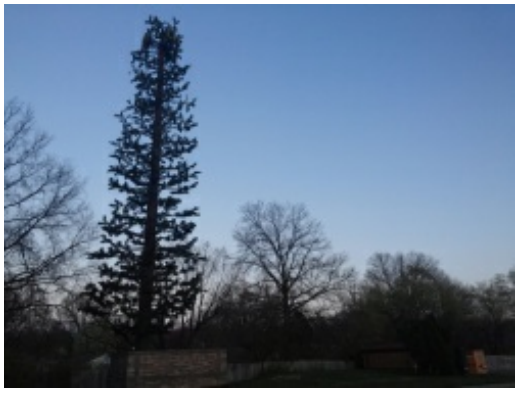
Most towers simply elevate and support communication antennas, but there are some called mast radiators that actually act as the antenna themselves. AM radio and other low-frequency towers fall into this category. In this article, I'm going to focus on a particular species of communications tower — the cellular kind.

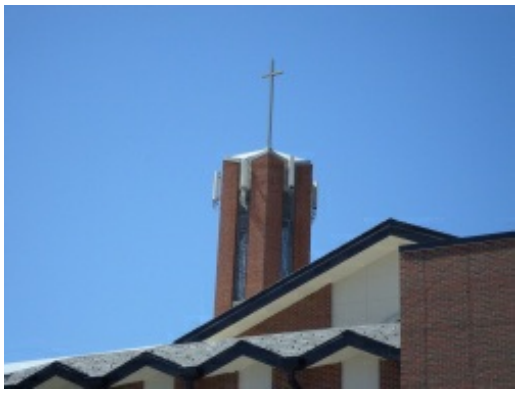
Cellular antennas on a lattice tower.

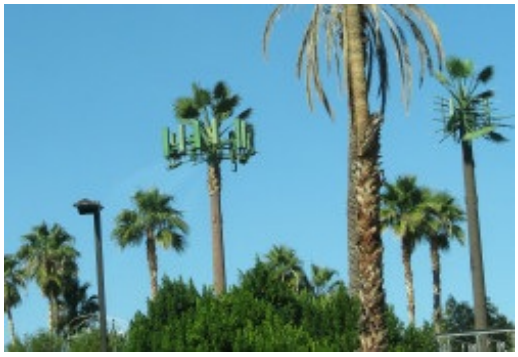
A cell site is mainly two things: arrays of two-way antennas that operate on cellular frequencies, and the equipment that makes that possible. Technically speaking, they are called Base Transmitter Stations (BTS). You might see 'cell site' and 'cell tower' used interchangeably, but these terms are not synonymous. A cell site or BTS encompasses all the equipment needed to transmit and process cellular signals between devices. This includes the antennas that cover different cellular frequency bands, the signal amplifiers, the on-site processing equipment, and the backhaul connection to the core network. A cell tower is just the structure that elevates the antennas and supports equipment.

The tower itself may be shared by one or more carriers that each has their own cell site. This arrangement is called collocation. Whatever carrier got there first takes the highest elevation for their antennas. Each one that comes after takes the next highest slot. The tower may not be owned by any cell carrier, however. Many of them are owned by companies like American Tower who lease out the space.

Not all cell sites are on towers. Many of them are built on rooftops, and some are perched atop streetlights. Some are designed to go unnoticed, lurking behind facades. They pose as indigenous trees, cacti, steeples, or even art installations. Click to embiggen the disguised sites below.



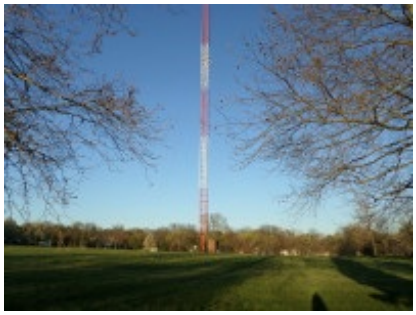




Masts, Cell Towers, and Cell Sites

There are several types of towers and sites out there. The way that towers look and the heights they reach are determined by the area they occupy and the needs of subscribers on the ground.

A guyed mast is technically not a tower at all. It's a narrow latticed structure that is held upright and centered with guy wires that are anchored to the ground. Guyed masts are fairly cheap to construct, but they have a broad footprint and require a lot of land. Because of the way they're built, guyed masts can reach 2,000 feet tall. Masts over a certain height are usually painted in alternating bands of aircraft orange and white for increased visibility.



A guyed mast in the suburbs

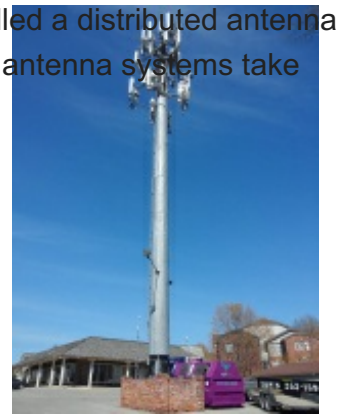
Lattice towers are self-supporting structures that have three or four sides. These are easy to build, easy to climb, and provide a lot of space for mounting equipment.

A lattice tower with four cell sites.

Suburban tower cell site installations are often found on monopole towers. These are sleek poles that look like soaring streetlights with foot pegs. Monopoles are more expensive to build than lattice towers and guyed masts, and they are more difficult for workers to climb. Some of the monopoles in my town have the antennas mounted directly to the pole, which seems like a waste of space.

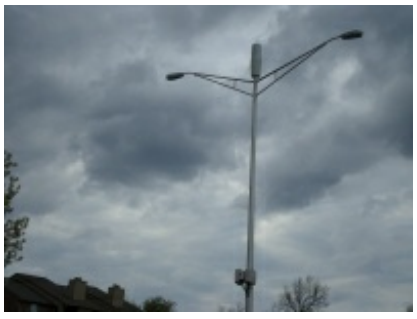
Temporary sites called cells on wheels (COW) are used to handle short-term increases in network traffic. They are often wheeled out for heavy attendance at events like the Super Bowl. COWs are also used in remote rescue and coordinated operations in low or no-coverage locations. These sites are built into vehicles or towed on trailers and come in several shades of functionality.

If an area has spotty coverage but the gaps don't warrant a full-blown cell site, you might spot some street light cell sites. These are part of something called a distributed antenna system, but they are often referred to as small cells. Distributed antenna systems take the power and coverage of a regular cell site and distribute it among several small ones. If a cell site is a cake, a distributed antenna system is a batch of cupcakes. Distributed antenna systems and small cells are also used indoors, usually in busy places like offices, hospitals, and sports arenas.



A monopole planted in the back of a shopping center.

A Nextel COW parked outside the 2005 Rose Bowl. Image via Wikipedia



Street light cell site above a major thoroughfare.

Bass Drums in the Sky

Tower components will vary based on the location and needs of the area's subscribers, but there are a few things you will see pretty consistently from tower to tower. Most obviously, a cell tower has several types of antennas that handle different frequencies and cellular technologies. These are the thin, vertical bars that are mounted parallel to the tower. Generally speaking, the longer the antenna, the lower the frequency it's built for. But the physical size of a single antenna says nothing about the traffic capacity of the tower. It's the number of antennas that determines the amount of traffic a cell site can

handle.

Each antenna is connected to the base station by several cables. Monopole towers have a conduit down the center to house the cables, but on a lattice tower, the cables run down the outside. Depending on the installation, they will run over an ice bridge so they are elevated. Base stations can range in size from simple all-weather cabinets to equipment bunkers the size of a small house.

You will often see a parabolic dish or two on a cell tower. It will likely be a grid style or a solid dish, but you might see something that looks like a big bass drum. These are all species of microwave antennas, and they are being used to backhaul traffic to the mobile switch sitting in the central office. If you don't see any dishes, the backhaul is routing over fiber or copper.

Bass drum in the sky, courtesy of CommScope

Microwave backhaul antennas come in a couple of flavors. Some are simple, unshielded parabolic dishes like those dark gray ones that receive television signals. Others are shielded with a round radome that protects the antenna from dirt and snow and reduces wind loading. My personal favorites are the ones that look like a bass drum. These are high-capacity, high-performance antennas that can reach 15 feet or more in diameter and weigh hundreds of pounds. Without the drum skin and the rim, they would look like solid parabolic antennas. Those extra things are just a different kind of radome that's usually made out of fiberglass or Teflon.

Ice bridge or waveguide bridge. Image via Wireless Estimator

Small Boxes, Big Impact

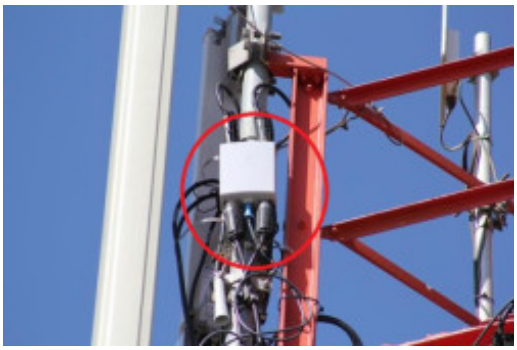
On newer cell site systems, you'll see a piece of equipment called a Remote Radio Head (RRH). These are used to distribute the base station equipment between the tower and the ground. The RRH itself is a small rectangular box on the tower that is connected to the base station by a fiber optic link. These remote radio heads increase efficiency and free up space on the ground, but there are tradeoffs. They are complex pieces of

equipment and they must be built to withstand the elements.

In order to improve the uplink gain, carriers will often mount another small rectangular box called a Tower Mounted Amplifier (TMA). Uplink gain is the transmission of the signal from a subscriber's handset to the base station. TMAs are great for you and me because our phones are able to communicate with the tower using less battery power and less data. They also give us greater coverage.

Last but not least is the lightning arrester. You can probably guess what this does — it absorbs lightning strikes and offloads them safely to an earth ground. Static dissipative brushes are just one type of lightning protection.

Remote Radio Head unit. Image via CommScope



Tower Mounted Amplifier. Image via Foresite Group

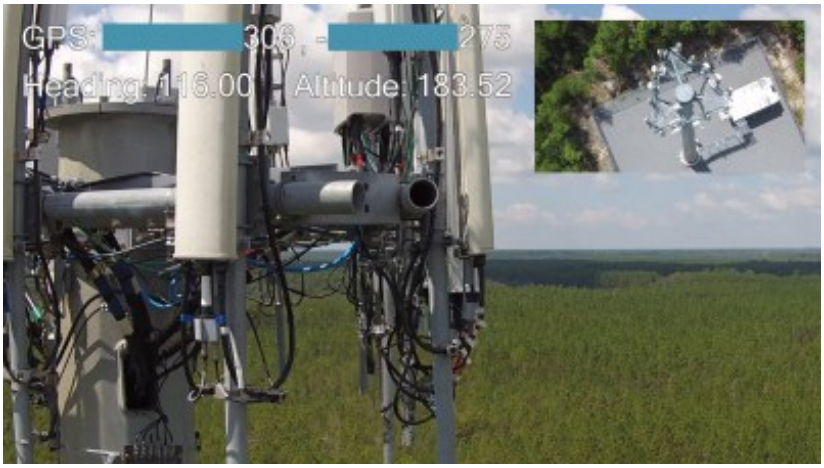
Static dissipation brushes. Image via Tower Beacon

Ground-Level Components

The stuff you see on the tower only makes up half the story. A lot of equipment is necessary to actually route calls and provide the signal in the first place, not to mention the power supply and line rectification. All of this is on the ground at the foot of the tower in cabinets and shelters.

The main components on the ground are the base station transceivers. These are the counterparts for the remote radio heads. Older technologies like 2G and 3G will have their own transceiver, separate from 4G/LTE. A cell site router manages the traffic between the base station transceivers and the mobile switches at the central office. If the backhaul is done over microwave, the shelter will have a baseband microwave processor to handle the signaling.

The rest of the ground equipment is power related—rectifiers that provide either -48VDC or +24VDC and generators to keep things going in times of trouble. Many sites also have battery backup that can last for a couple of hours.



Inspection footage from a drone. Image via YouTube

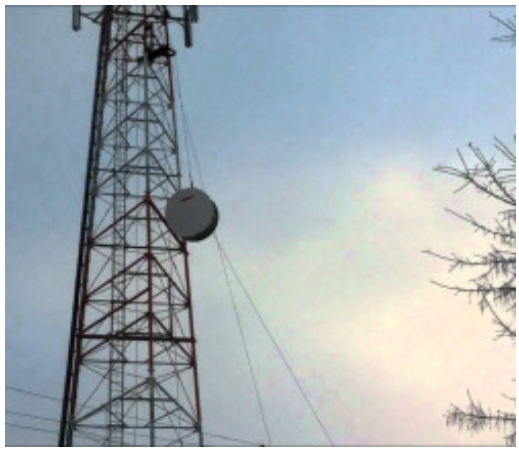
Installation, Maintenance, and Removal

There are hundreds of thousands of cell towers in the United States, and they all have to be inspected regularly. In the past few years, firms have been using drones to take video and high-resolution pictures that can be used to audit the state of the equipment. Installing and maintaining towers is a dangerous job that is both mentally and physically demanding. It's not uncommon for a technician to start the day on one tower and then drive for several hours to work on another one.

Once a tower is built, the antennas and other equipment are raised up slowly on a rope and pulley system as you can see in this video. If a dish needs to be replaced on a guyed mast, it can't just be unbolted and dropped. If the dish were to snag a guy wire on the way down, the whole mast could collapse. Here's a video that shows just how tedious it can be to remove one of those bass drum antennas.

Communications towers are often erected on hills and mountaintops, especially for long-range microwave relay. This height helps ensure that there is a clear path for the line-of-sight propagation required by microwave transmission. If a cell site is already on a

mountain or hill, it may not have to be very tall. Unfortunately, this makes the antennas and equipment more vulnerable to the whims of wildlife. Here's a video showing the damage that an industrious acorn woodpecker or two can cause to a shielded antenna.



Removing a 6′ microwave dish. Image via YouTube

The Future of Cell Sites

One way that cell technology is changing is the advent of Device to Device (D2D) technology, also known as LTE Direct. This turns every D2D-enabled device into a part of the transmission network. Essentially, if two D2D-enabled devices are within ~500 line-of-sight meters of each other, they can communicate directly without the need for a base station.

This technology basically turns phones into walkie-talkies that can operate in full-duplex mode. This is great for disaster recovery situations when coverage is crowded or completely compromised. It's also useful for geofencing, augmented reality, and beacons in retail stores that invite your targeted patronage.

D2D is less battery-intensive than discovery over Bluetooth or WiFi because it takes place at the service layer. And D2D's privacy is better than cloud-based methods because it's not continuously tracking your device's location. In that case, the future looks pretty good.