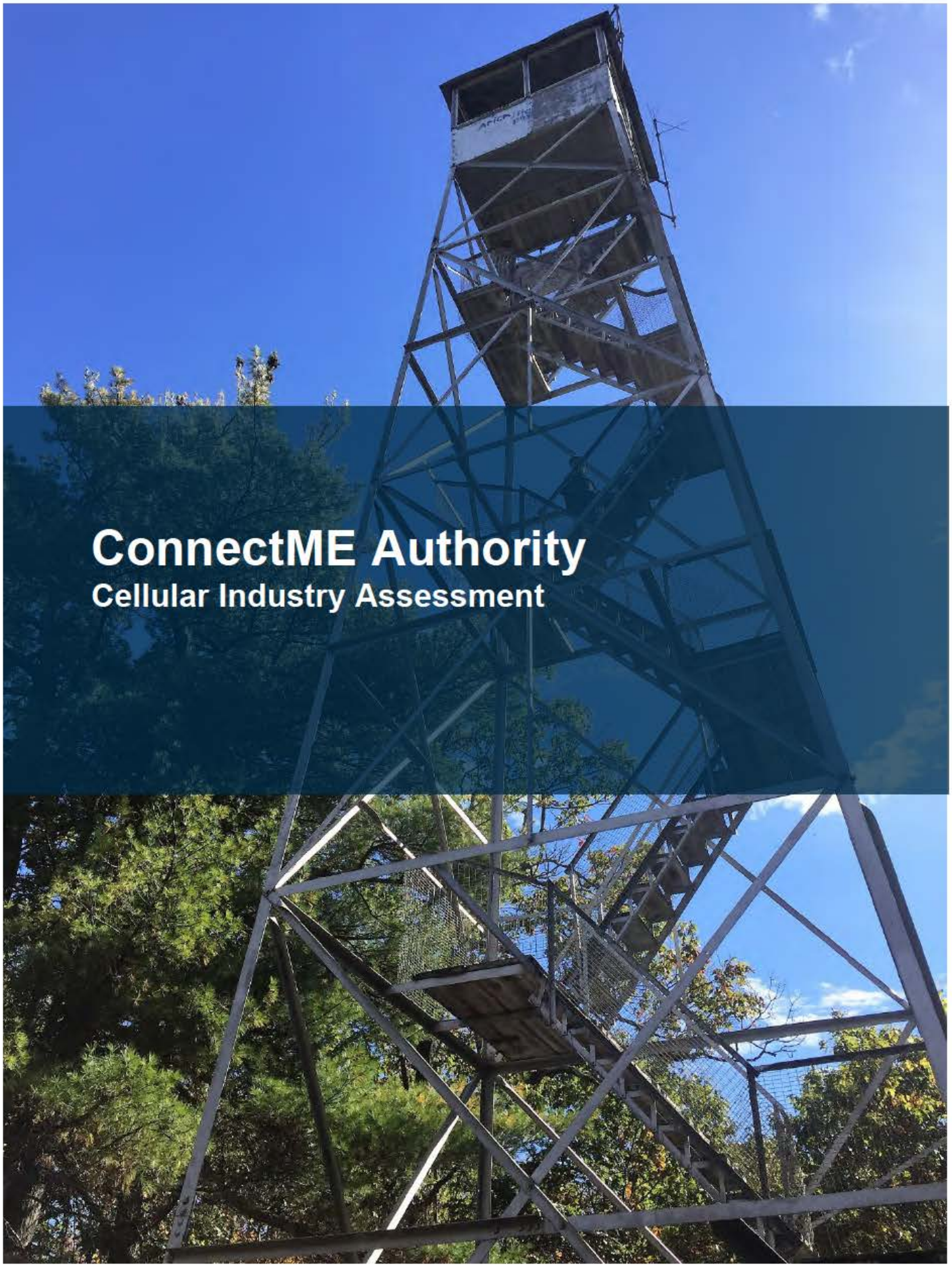


ConnectME Authority

Cellular Industry Assessment

CONTENTS

Executive Summary

The Department of Economic and Community Development, in coordination with the ConnectME Authority, the Department of Administrative and Financial Services and the University of Maine System, Networkmaine, has been charged with the development of a plan to leverage state assets to expand cellular telephone service to underserved areas of the State.[1]

Other states have moved to make available state-owned assets such as public safety radio towers, buildings, land and spectrum. Typically, the cellular site selection process starts not with what sites are available, but what coverage gaps or capacity constraints the carrier seeks to solve, and then examines what sites are available to address them. Some states have engaged professional asset managers to help make their properties more marketable to potential cellular tenants. A common model of state-owned asset management focuses directly or indirectly on maximizing lease revenue generation. A focus on prioritizing expansion of cellular coverage in rural unserved or underserved areas requires emphasizing the public benefit of expanded coverage over lease revenue.

Mobile data usage and traffic is increasing rapidly, driven by increased demand for data intensive applications such as video, and to satisfy the demands on cellular networks wireless carriers invest in network densification, installing small cells allowing limited spectrum to be divided up and reused throughout an area. This network densification trend causes wireless carriers to focus network deployment spending in heavily utilized urban and suburban areas, making them less likely to invest in expanding coverage into unserved and underserved rural areas. This increases the importance of capitalizing on carrier interest in investment on those occasions when carriers' capital budgets are allocated to a rural unserved area.

A key aspect of many state-owned communication asset management plans is shared infrastructure, allowing efficient use of limited resources. The cellular industry has always relied heavily on shared assets, for example large cell towers owned by a landlord aggregating leasing opportunities and populated by several wireless carriers and companies specializing in fiber optic and microwave backhaul. As network densification drives small cell development, this same shared asset paradigm is being pushed to the rooftop, to the street light, to the utility pole, and to state-owned assets as well. Shared use of state-owned communications assets can be utilized for network densification, and by making assets suitable for rural deployments available at low cost, to incentivize both improvements in existing service and the expansion of coverage into unserved areas.

In addition to physical state-owned communications assets, streamlined access to the public right of way for the development of distributed small cells can help address rural coverage gaps. Even though small cells are primarily used for urban and suburban network densification, they can also be used to address coverage along roadway corridors. In areas of dense foliage and difficult

[1] http://www.mainelegislature.org/legis/bills/getPDF.asp?paper=SP0509&item=3&snum=129

topography, roadside small cells sometimes provide an effective solution in rural areas where most buildings are near major through roads.

1. Industry Background

A cellular network, or mobile network, is a high-speed, high-capacity voice and data communication network. With the introduction of flat rate subscription services and a significant increase in cellular-connected device use, the volume of traffic on these networks and the level of access to them has grown rapidly over the years. Today, reliable access to mobile networks is crucial to commerce, education, public safety, community development, and other needs.

1.1. Cellular Carriers

A cellular carrier, also known as a **mobile network operator (MNO)**, is a company that provides cellular communication services to an end user. The MNO owns or controls and operates all necessary components of the network in order to sell and deliver service. To broadcast their service, MNOs must acquire a radio spectrum license, or frequency allocation, from the Federal Communications Commission (FCC).

Figure 1: The Major National Carriers

The most well-known MNOs are the larger nationwide carriers, including AT&T, Verizon, Sprint, and T-Mobile. [2] These carriers generally provide the most extensive coverage, although there are local and regional exceptions. Because most users' phones utilize these carriers' networks, the coverage of these MNOs is especially important to rural areas with tourism-dependent economies. MNOs without a nationwide footprint such as US Cellular – the fifth-largest cellular operator in the country — offer regional coverage. These smaller carriers may provide the best coverage in some rural areas across the country. In Maine, US Cellular has a significant presence.

Cellular subscribers can receive coverage outside areas serviceable by their MNO by "roaming" in regions covered by another carrier pursuant to a pre-existing roaming agreement. Not every carrier has a roaming agreement with all other carriers, and not all customer phones are necessarily compatible with all networks. Roaming agreements allow smaller carriers to access a larger carrier's coverage and allow national carriers to fill in holes within their national footprint. Prior to the consolidation of the cellular industry, roaming was a necessity for any company seeking coast-to-coast coverage. Today, MNOs with nationwide networks can be more selective about when and with whom their customers may roam. Carriers have a financial incentive to minimize roaming. However, for smaller, regional MNOs, a roaming

[2] As part of the proposed merger of T-Mobile and Sprint, the companies have proposed spinning off certain assets to DISH Network, which has proposed to build a new nationwide cellular network. However, DISH's proposal is not yet a reality and is a long way from being a practical option for expanding coverage in the near term.

agreement with one or more national MNO is essential to provide nationwide service to their customers.

Some **MNOs** specialize in rural communities. These networks often help extend the coverage of larger MNOs who have not built out network infrastructure into these less populated areas. These companies generally provide wholesale service through roaming agreements in areas where they operate. In some cases, this may be the company's exclusive business, and in other cases the company may also offer retail service to customers within the areas that it serves. As a result of industry consolidation, these rural MNOs are not as common as they once were. However, because these companies focus on covering underserved rural markets, they may be more motivated to consider building and leasing sites in rural areas. In Maine, two notable companies that cover rural territories and provide roaming service to national MNOs are Wireless Partners and Northeast Wireless Networks.

MNOs may sell access to their network services and spectrum allocation to smaller carriers called **mobile virtual network operators (MVNO)**. The brand names of MVNOs are well-known to many consumers and include Tracfone, Straight Talk, Ting, and Google Fi. However, MVNOs do not own the infrastructure needed to transmit service.[3] MVNOs lease access from MNOs in bulk and often at wholesale rates. In some cases, major national carriers have acquired companies that were formerly independent MVNOs and continued to operate them as distinct brands. Examples include Boost Mobile via Sprint and Cricket Wireless via AT&T. Since these networks do not have the cost associated with building and maintaining towers, their services may cost the consumer less compared to a larger MNO. While some MVNO brands may be recognizable, they do not independently contribute to expanding coverage.

1.2. Spectrum

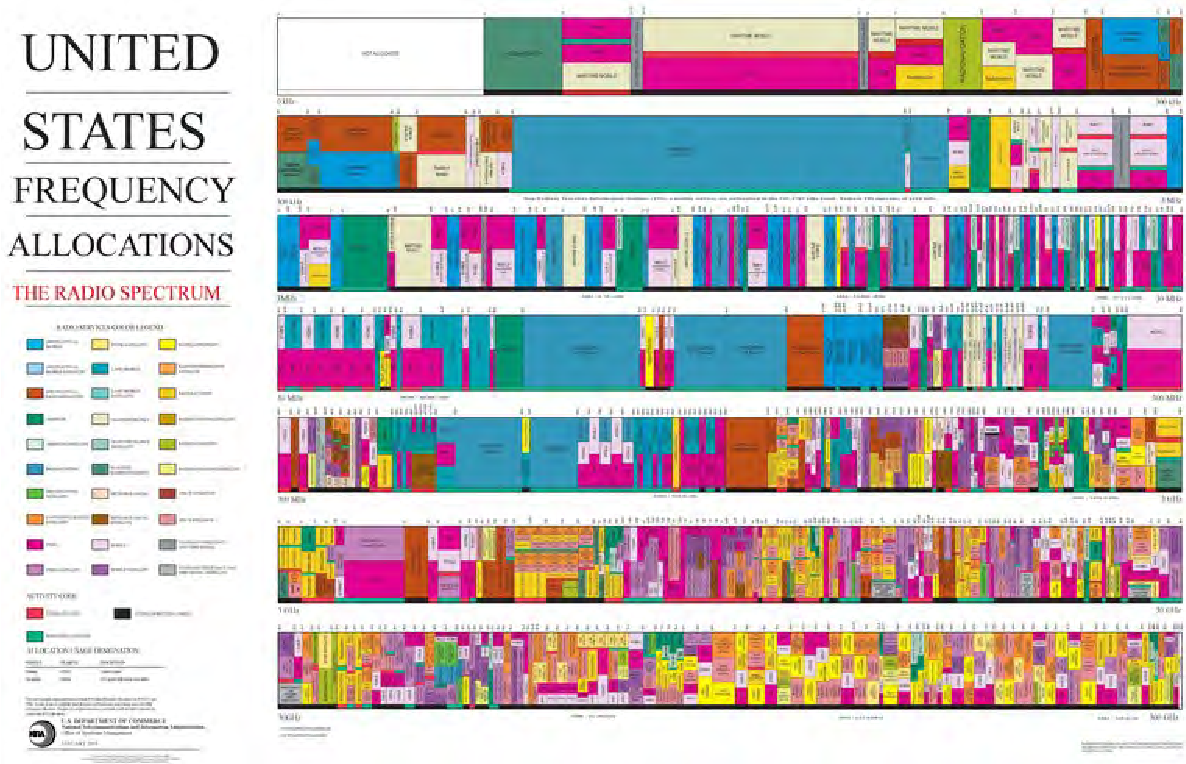
Cellular communication signals travel through the air via invisible radio frequencies ("RF"), commonly referred to as spectrum. Radios, GPS, TV broadcasts, WiFi routers, cellphones, and many other technologies utilize spectrum to send and/or receive data. Radio waves from multiple transmitters operating in an unmanaged way in the same or similar RF bands can cause interference with each other, prohibiting clear reception. Thus, many cellular systems have dedicated channels, or slivers of spectrum, on which they operate. Uses of RF spectrum are wide-ranging and subject to regulation at the federal level[4] - and, to an extent, at the international level.[5]

[3] Some cable operators have also entered the market as MVNOs, two examples of this are Xfinity Mobile or Spectrum Mobile. These cable company products typically rely on a combination of cellular networks for wide-area service and the cable operator's widely-deployed WiFi hotspots in or very close to buildings or other developed areas over very short ranges.

[4] 47 U.S.C.S. § 301

[5] For example, the International Telecommunications Union's Radiocommunication Sector "coordinates …radiocommunication services, as well as the international management of the radio-frequency spectrum and satellite orbits." https://www.itu.int/en/about/Pages/whatwedo.aspx.

Figure 2: Spectrum Allocations in the United States as of 2016[6]



A common distinction among different spectrum bands involves licensed vs. unlicensed operation. [7] Low-powered wireless applications ride over unlicensed frequencies, which are portions of spectrum set aside for the public to use. Larger, commercial operations must acquire a license to operate over specific portions of spectrum. Cellular networks operate in licensed spectrum, with different bands in a given geographic area reserved for particular MNOs. MNOs obtain their spectrum licenses from the FCC. The FCC controls who is operating on blocks of spectrum by auctioning off the licenses to blocks based on a variety of small or large geographical units. MNOs often purchase multiple blocks of spectrum in a variety of bands. These licenses may also be transferred, with FCC approval, in post-award secondary markets. FCC licenses to different blocks of spectrum used by cellular networks have build-out requirements to a greater or lesser degree. Generally, license-holders are not allowed to leave their spectrum unused

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[6] As of November 2019, the most recent chart published by the National Telecommunications and Information Administration (NTIA) was as of January 2016. https://www.ntia.doc.gov/page/2011/united-states-frequency-allocation-chart.

[7] An exception to this dichotomy is the Citizens Broadband Radio Service (CBRS) spectrum, which the FCC has designated under a new "shared spectrum" model and which is now beginning to roll out. The CBRS band is shared spectrum that will be available to both licensed and unlicensed users, with priority given to licensed users. Unlicensed users will nevertheless have access so long as their use does not interfere with licensed use. See https://www.fcc.gov/wireless/bureau-divisions/mobility-division/35-ghz-band/35-ghz-band-overview.

indefinitely. As a practical matter, few license-holders are in danger of failing to meet these requirements. It is often the case that some geographic portion of a spectrum license may remain uncovered indefinitely without running afoul of the license's build-out requirements because licenses do not require 100% build-out.

As shown in Table 1, it is possible to divide cellular spectrum used in today's current and emerging networks into three broad classes: low, mid, and high. Carriers have their own mix of spectrum licenses in a variety of bands. The bands used for 4G are diverse, as Verizon and AT&T's 5G deployments are concentrated in high-band spectrum while T-Mobile and Sprint have 5G plans in low- and mid-band spectrum. Note that all smartphones can use unlicensed Wi-Fi spectrum, which is very low power and only operates at short range.

Table 1: Low-, Mid- and High-Band Cellular Spectrum

Frequencies		AT&T		Verizon		T-Mobile		Sprint		US Cellular	
		4G	5G	4G	5G	4G	5G	4G	5G	4G	5G
Low Band	600 MHz					Band 71	Band n71				
·Long range	700 MHz	Bands 12, 14, 17, 29		Band 13		Band 12				Band 12	
·Best for rural coverage	850 MHz (original cellular band)	Band 5		Band 5				Band 26		Band 5	Band 5
	1700 / 2100 MHz (AWS)	Bands 4, 66		Bands 4, 66		Bands 4, 66		Bands 4, 66		Band 4	
Mid Band	1900 (PCS)	Band 2		Band 2		Band 2		Band 25		Band 2	
·Medium range	2300 MHz	Band 30									
·Higher speeds in rural areas	2500 MHz							Band 41	Band n41		
	3500 MHz (CBRS)	Band 48 (expected)		Band 48 (expected)		Band 48 (expected)		Band 48 (expected)			
High Band ·Short range	28 GHz				Band n261		Band n261				
·Very high speeds in urban and suburban areas	39 GHz		Band n260								

Generally, there is a trade-off in spectrum between the reach (*i.e.*, coverage) of the spectrum and the amount of information that it can support (*i.e.*, capacity). Typically, more spectrum is allocated to higher frequency bands. [8] Lower bands propagate further than higher bands and are less impeded by obstacles such as trees or buildings. Higher band spectrum can better support higher speeds and be used by more users simultaneously, albeit over shorter distances. In rural areas, users are spread out over greater distances and fewer people use the same frequencies simultaneously, so network planning in these areas relies more on lower bands. In a rural network, it is often best to focus on the deployment of networks supporting low-band services for basic coverage, with mid-band spectrum providing extra speed and capacity over shorter ranges.

[8] There is a greater amount of spectrum the higher one goes up the radio spectrum (e.g. mathematically, there is only 1000 MHz of spectrum at or under 1000 MHz, but another 4000 MHz of spectrum between 1000 MHz and 5000 MHz). Therefore, higher frequency channels tend literally to have more band-width: channels are assigned a wider frequency range, allowing them to carry more information than the smaller channels that are used in lower-band services where there is simply less spectrum available to assign.

1.3. Cellular Network Generations

Cellular network advertising and the news often tout the benefits of service provided by “4G” or “5G” networks, where the “G” in 1G, 2G, 3G, 4G, and 5G stands for Generation. First-generation networks were the original analog mobile networks and phones. Subsequent generations of network technology, summarized in Table 2, are faster and offer improved or new features. 4G is the primary version in current use, but 5G deployment is underway.

Table 2: Cellular Network Generations

Network	Description	Status
1G	The original analog voice cellular service	Retired
2G	Digital voice service and low-speed data	Nearly Retired
3G	Moderate-speed data	Mostly Retired
4G	Higher-speed data, lower latency, voice as data	Widely Deployed
5G	Designed for a wide range of very high-speed to lower-speed data applications, low latency	Deployments Starting

Long-Term Evolution, known as LTE, is the universal language that 4G radios use to communicate. “4G-LTE” is the most broadly supported technology currently available and will continue to be for the near future.

2. Cellular Network Technology and Development

Cellular services depend on two key components: spectrum and infrastructure. Spectrum fuels cellular communications, and infrastructure – towers, poles, and other structures that support cellular antennas, as well as the other network infrastructure attached and connected to them – expands coverage and increases capacity. Increasing demand for mobile broadband requires carriers to find more spectrum and build more cellular infrastructure.

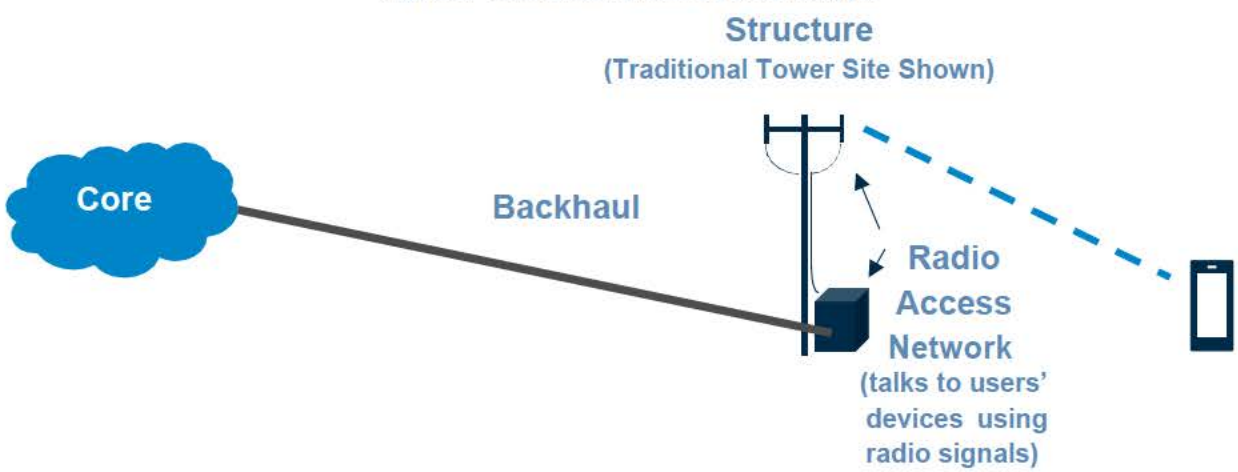
2.1. Cellular Network Infrastructure Overview

A cellular network consists of a constellation of sites which communicate to mobile user devices and are handed off from site to site. There are related communications facilities that connect this constellation of sites back to a central network, which is connected to other networks such as the Internet and public telephone network. In a simplified form, the major parts of a cellular network include:

- **Radio Access Network:** Creates the RF links between user equipment and a cellular network's transmitting and receiving equipment.
- **Core Network:** Provides control and routing functions between cell sites and other networks, including the Internet and other cellular networks.
- **Backhaul:** Connects individual cell sites to the core network through telecommunications links, most commonly fiber optic but sometimes microwave.
- **Towers, Poles, and Support Structures:** Provide support as the physical facilities on which components of the Radio Access Network attach to better communicate with user equipment.

These parts, especially the Radio Access Network and Core Network, contain multiple component parts which are omitted in Figure 3 below for simplicity.

Figure 3: Conceptual Parts of a Cellular Network



The construction of – or access to – structures and backhaul contribute to the overall costs of adding sites, as well as the equipment that is part of the Radio Access Network.

2.2. Macro Towers, Small Cells, and Network Densification

While the common perception of a "cell site" is a tower with an array of antennas attached, cell sites now include diverse forms such as "macro sites" and "small cells".

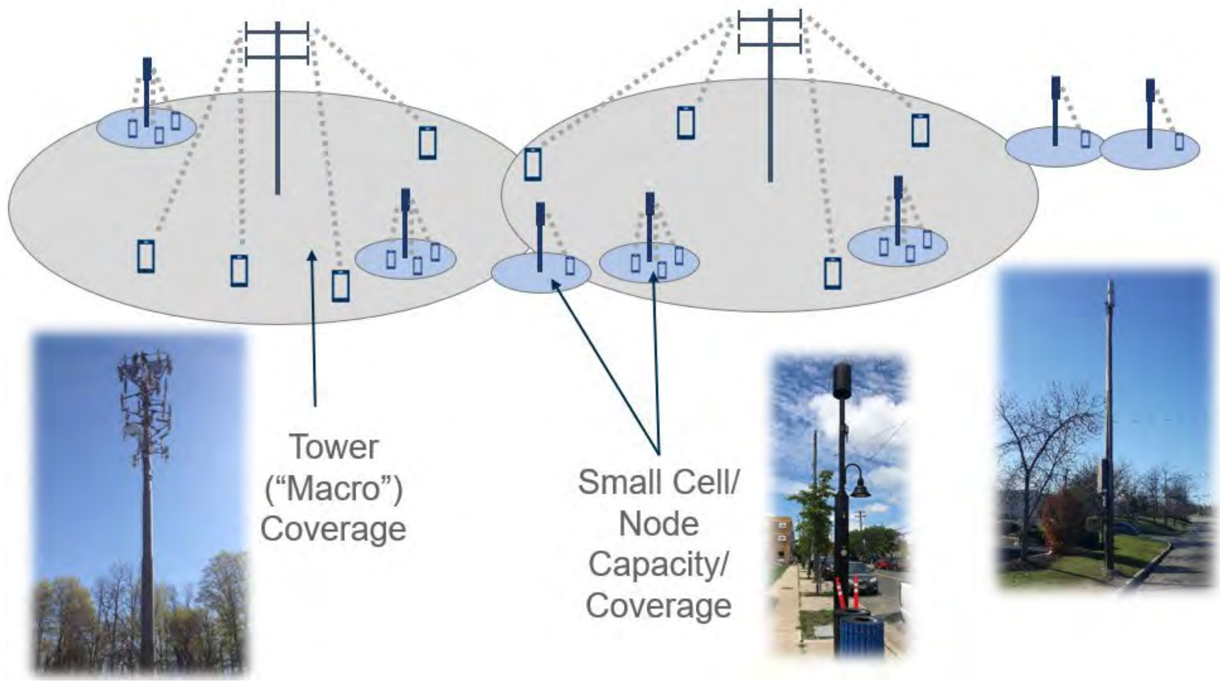
Antenna installations on towers and collocations on tall structures such as rooftops are often referred to as **"macro"** sites. Macro sites are often but not always located on tower structures. These traditional cell sites form the core of a cellular network and are effective for covering large geographic areas by delivering signals miles away. Macro towers are the typical "cell towers" recognized by the general population and almost always the type of facility used to provide an area with initial cellular coverage. The average cost for a typical rural macro tower installation is about $275,000, plus land costs.[9] However, the cost of macro sites can vary substantially at different sites, with some sites being much more expensive. Cost factors not only include the tower structure (or reinforcements to an existing structure) and the equipment placed on the tower, but also road access, power, and fiber optic lines to connect the tower. For towers placed in remote locations, these less-visible elements can be major factors that can drive costs at some sites past $1 million.

Small cells[10] are lower-powered cellular base stations that function much like traditional cells in a mobile cellular network but are a fraction of the height of a macro tower and located in close proximity to the coverage target. Small cells are frequently deployed to add capacity to the cell network, offloading users concentrated in a small area from what would otherwise be an overloaded macro site, as depicted in Figure 4 below. This type of deployment is common in more densely developed areas. Less commonly, small cells can be used as a targeted coverage solution to fill gaps in limited coverage areas that would be difficult or expensive to address with a macro cell. Small cell growth is expected to be significant in the coming years as carriers are deploying tens of thousands of small cells to increase capacity in heavily populated regions.

[9] https://www.costquest.com/uploads/pdf/2017/cs_4g-unserved-areas.pdf

[10] A more technical discussion would distinguish between several types of facilities which, while they share common elements of a small form factor and coverage area, have differences in how they organize and deliver the elements of a Radio Access Network. This includes Distributed Antenna Systems (DAS), Remote Radio Heads (RRHs), Centralized Radio Access Networks (C-RANs), and stand-alone small cell base stations. For the purposes of this discussion, these differences are not important, and they are grouped here under the single heading of "small cells."

Figure 4: Macro Sites and Small Cells



Typical Macro Sites

- Antennas affixed > 100' support structure
- Monopoles, rooftops, water tanks, and lattice towers
- Radius > 1 mile; 3 or more sectors; each sector equipped with 1 or more frequencies
- Provide base-level system coverage
- Used to cover roads, commercial areas, and residential areas
- Can support three carriers on one structure
- Requires power and fiber

Typical Small Cell

- Antenna affixed to < 50' support structure
- Utility poles or decorative street lights
- Radius < 0.5 miles; 1 or more sectors; each sector equipped with 1 or more frequencies
- Augment macro coverage or offload traffic from macro network
- Used to cover topographically challenged roads and high traffic commercial areas
- Can support multiple carriers on one structure
- Requires power and fiber

The first cellular networks typically deployed macro sites designed to cover very large areas. There were fewer users, usage came at a significant price per minute, and user devices often transmitted at higher power than today's typical mobile phone. Over time, both the number of users and intensity of use have substantially increased. Although macro sites are still especially important in rural areas, they are more likely today to be located on secondary ridgelines and moderately high spots closer to potential users, instead of higher and more remote peaks.

Carriers have also added more site density in their networks. In this scenario, each cell site is designed to cover a smaller area addressing a more limited set of users typically utilizing data-intensive applications such as streaming services. Today, carriers typically deploy both macro sites and small cells in a “heterogeneous network.” This network densification is greatest in urban areas and least pronounced in rural areas.

2.3. Carrier Network Investment Patterns

As national carriers expand their networks, they do so primarily for network densification within urban and suburban areas to accommodate the increased bandwidth demands of current cell phone usage patterns. The national carriers have achieved a relatively high level of population coverage. Although their footprints still leave substantial gaps in coverage when measured by landmass (including substantial gaps in parts of Maine), the carriers have relatively extensive coverage in areas with the highest density of users.

The needs of users within these carriers’ existing footprints are now the principal driver of carrier investment. Users are consuming ever-increasing amounts of mobile data, but each site can only accommodate so much usage at once. Even when a cell site has the reach to cover an area adequately, high usage levels by many people can cause customers to experience slow or unreliable service, which can be experienced as a complete lack of coverage. This problem is most acute outside of rural areas. Carriers respond to this trend by investing in new sites for capacity, not coverage, in a bid to keep existing customers happy and avoid defections to competitors. While investment in new coverage has not completely disappeared, the capital for new coverage sites competes in carriers’ investment budgets with demands to maintain, upgrade, and densify networks in their existing coverage footprints. This pattern is likely to remain for the foreseeable future. Focus on network densification in urban and suburban markets occurs at the expense of carriers expanding into rural areas where there are fewer users, as they allocate their finite capital investments into more densely populated areas.

This pattern is reinforced by the weak link between new coverage and new revenues for cell carriers. New cell sites in uncovered areas do mean additional capital and operating expenses, but do not necessarily lead directly to significant amounts of new revenue since most customers tend to be on plans with a pool of usage for a flat monthly rate. Cell phone subscription rates may be somewhat lower in areas with poor cell coverage, but a substantial fraction of possible users still subscribe to cell service in rural areas. Gaining and retaining market share among the much larger numbers of urban and suburban users is for many carriers the more compelling business imperative.

2.4. Cell Site Development Process and Requirements

In order to expand coverage and increase capacity, cellular carriers are always researching means to locate new network infrastructure. Budget, population size, geography, and market incentives ultimately drive the placement decision. Generally, a carrier's process will begin with identifying areas of need, then proceed to considering sites that can address that need. A carrier's marketing department and engineering department determine priority sites they believe will provide the most benefit to their customers and their financial bottom line.

Search rings are used to determine areas where cell phone coverage or capacity is lacking. The search ring is displayed as a map point centered within a defined area. The goal is to identify a new build location inside that ring, but if a site cannot be found within the ring, a spot will be chosen as close as possible to the ring. It is becoming increasingly difficult to find viable locations inside search rings as they are getting much smaller and the areas where new rings appear may have zoning issues and other restrictions.

Once the area for the search ring is determined, it is then given to a site acquisition specialist. The site acquisition specialist typically works for the carrier or a subcontracted company and performs a field visit, which involves driving through the search ring area looking for land or structures suitable for equipment placement. For new site builds, the site acquisition specialist oversees completing site candidate identification, leasing packages, and any necessary zoning, permitting, and regulatory filings. The site acquisition specialist creates detailed reports on viable locations for sites and negotiates leases with owners and property managers.

If a Radio Frequency Engineer approves the chosen site and technical parameters, they will design schematics used for leasing, zoning approval, and construction of new towers, if necessary. This may involve surveying the acquired land for optimal positioning of the towers. These data are then analyzed and used to create a custom plan for bringing the carrier's vision to reality.

Once the tower is constructed, utility coordination begins, and equipment is affixed to the tower. Wires run from the tower antennas to the base station equipment, usually concealed at ground level. The base station equipment includes amplifiers, multiplexers, system controls, and transceivers that transmit and receive radio signals through the antennas. The radio equipment must have backhaul signals to and from a mobile switching center. Local power and fiber companies determine utility routes to the new location, which is typically costly in rural areas.

It is important to understand that this site development process takes place within the context of a budget allocation and management process which, in turn, determines the regions that will receive the greatest number of new sites. National cellular carriers' operations and site development activities are broken down into regional teams. Each region requests funding from company headquarters for sites to build in the next year. These requests are broken down between coverage and capacity solutions. Regions are allocated capital to spend on these sites, generally on a first come, first served basis. Regional teams have site goals and must spend all allocated capital to meet those goals. Regions that cannot spend their allocated budgets quickly and predictably have a difficult time holding on to their allocated budgets and sites. Budgets unspent in one region in a year are liable to be re-allocated to regions that do have the ability to put the capital to work. This dynamic creates a risk for regions and communities where site acquisition and permitting is lengthy, expensive, and/or unpredictable, resulting in less investment over time. While core, “non-optional” markets are less likely to lose funding, rural areas are more vulnerable. Regions and communities that can create fast and predictable paths for carriers to acquire, permit, and build sites stand to benefit when capital is re-allocated.

3. Shared Infrastructure and the Key Vendor Ecosystem

National carriers rely on a blend of internal and contracted resources to develop and operate cellular infrastructure. This vendor ecosystem includes a range of carriers who work with these companies to build their networks and, in some cases, own and operate key elements of the overall network.

Cellular carriers often rely on outside vendors to perform work related to site acquisition, permitting, and architectural and engineering services (other than RF engineering). Major cellular carriers regularly use vendors that own and provide access to infrastructure elements needed for the cellular networks. In many cases, this provides the opportunity for vendors to develop common infrastructure shared by multiple carriers as shown in Figure 5. At traditional tower sites, the most common vendor-supplied infrastructure includes the tower and the fiber backhaul. Space on the tower is leased from a tower company, and the fiber backhaul may be leased from a telecommunications company such as the incumbent telecommunications company, a cable company, or other competitive telecommunications companies.

Figure 5: Shared Infrastructure at Traditional Tower Sites

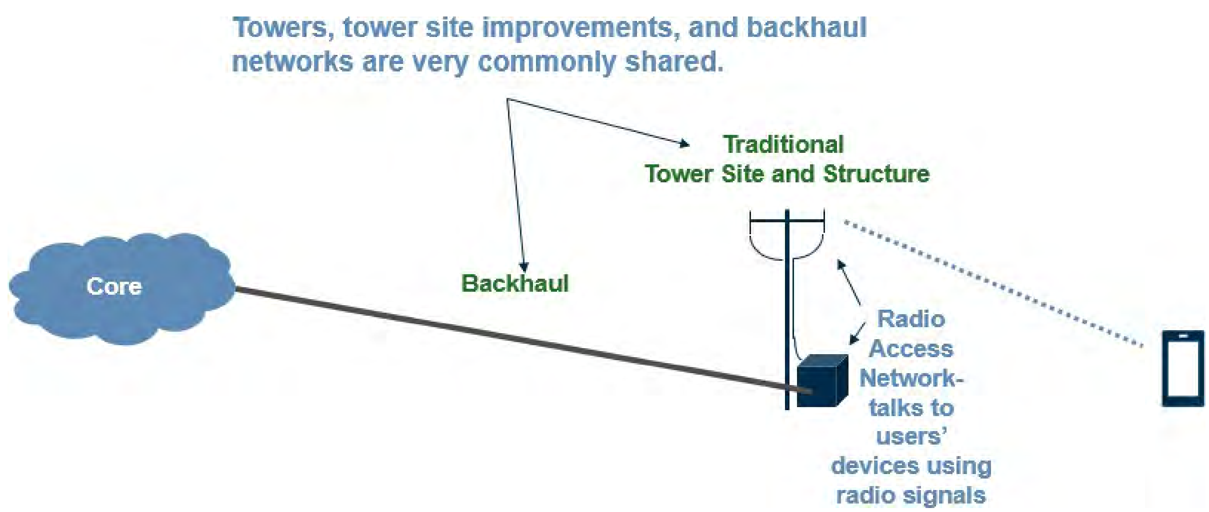
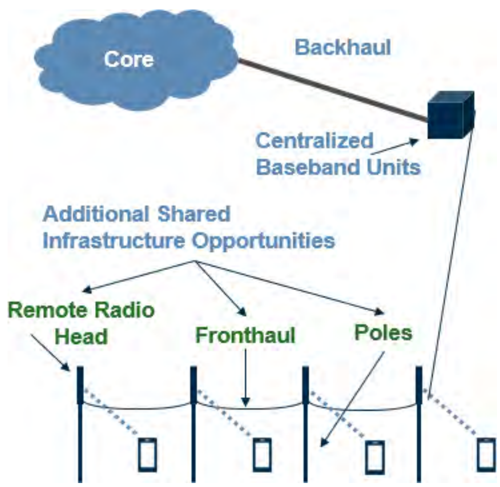


Figure 6: Shared Infrastructure Example in Distributed Radio Access Networks



In traditional tower sites, the components of the Radio Access Network sit on or at the base of the tower and are typically provided by the carriers using the tower. In the case of some types of small cell networks, this Radio Access Network is distributed at multiple cellular "nodes" connected back via "fronthaul" fiber to centralized network equipment. This form of infrastructure, shown in Figure 6, opens additional opportunities to develop shared infrastructure in the "fronthaul," poles for the nodes, and even the node equipment itself.

Historically, national carriers have relied heavily on tower sites owned by vendors such as American Tower or Crown Castle, specializing in aggregating the leasing opportunities at tower locations limited in availability by topography, accessibility and proximity to population.

To accommodate network densification in urban and suburban areas, locations with proximity to carriers' customer bases have become commonplace for small cell installations. Network densification has driven cell deployment from traditional macro tower sites, down to small cell deployments on building rooftops, streetlights, utility poles and other privately and publicly owned vertical assets. Access to public-rights-of-way for poles and "street furniture" that can be used to deploy small cells has become critical to efforts to deploy small cells at the density needed for 4G and 5G sites. Use of these public rights-of-way has in some communities been contentious. Shared infrastructure vendors can create opportunities to minimize duplication of facilities. Generally, carriers and their vendors are more likely to persist in efforts to site such facilities in areas with large concentration of users. Long or expensive processes to obtain access may limit the investments carriers are willing to make in smaller markets.

4. State-Owned Telecommunications Asset Management

Policies and practices among states and other public bodies regarding leasing of assets for cellular network use vary widely. Agencies may in some cases actively encourage access to assets such as government-owned towers, land, and rooftops, or they may limit them. In some cases, property or funding restrictions limit commercial use, in other cases these factors are not barriers. Some public bodies directly manage the process of handling inquiries and entering into leases. As a general matter though, the missions of public agencies typically do not make them specialists in the business of leasing sites for commercial wireless networks.[11] This, plus the fact that there can be a diversity of site restrictions on public property, and sometimes a lack of key site data can sometimes combine to discourage cellular carriers from developing towers (especially macro sites) on public property in areas where there are viable sites on private property. That said, wireless carriers can and do use state and other assets in a range of jurisdictions.

To better encourage carriers to use public assets for cellular networks, some states utilize a leasing aggregator, or an asset manager. This is typically a private company with specialized expertise in dealing with commercial wireless companies. These managers may collect and organize information about state properties, assess which properties may be most useful for wireless networks and market them, respond to inquiries, and negotiate leases. In some cases, they may participate in investments in site improvements that increase the attractiveness of a site for commercial wireless networks. In many cases these agreements are structured in such a way that focuses implicitly or explicitly on maximizing revenue from leased sites for the state and/or the leasing agent. This objective does not necessarily further the goal of rural expansion, and in some cases may actually hamper it by discouraging the manager from developing leases for sites where the market value of a site to a carrier is low but the public benefit of increased coverage is high. A model where an asset manager works under a fee-for-service based system rather than a revenue share model and is incentivized to maximize increased coverage rather than revenue could be an alternative where leveraging state assets as a tool to expand coverage is desired.

Below are examples of relevant models of telecommunications asset management of state-owned resources, most emphasize a revenue generation component in addition to a policy of coverage expansion.

4.1. New York

In 1997 New York State entered into a long-term agreement with Crown Castle to lease, operate and maintain state owned telecommunications assets such as towers and rooftops. Crown Castle is responsible for marketing and leasing these assets to carriers, and revenue from the leases is shared between Crown Castle and the state.

[11] However, in the case of the California, described in this section, the state created an office with that specialty.

Since 1997, Crown Castle has leased over 1,250 antenna installations and developed more than 72 wireless infrastructure sites on state land, including 27 new state-owned towers. The revenue share agreement is 50/50 for existing telecommunications infrastructure. For new structures and locations that Crown Castle has to substantially modify, the state receives 30 percent of the revenues for the first 10 years of individual lease agreements, and 50 percent after, to compensate Crown Castle for their capital investment. New York State owns the new and modified infrastructure, and nets over $10 million in revenue annually.[12]

New York State's objectives for this asset management model were to ensure the communications needs of state agencies were met while providing private carriers access to the state's resources, as well as to generate revenue for the state, both objectives independent of expanding coverage.[13]

4.2. Ohio

The state of Ohio entered into an agreement with Agile Networks for Agile to develop the state-owned Multi-Agency Radio Communications System (MARC), a high capacity, 800 MHz wireless broadband mesh network carrying the data and voice traffic of over 50,000 Ohio public safety personnel. The MARC system utilizes 250 towers overall, 151 of which are state owned. The state paid Agile $2.2 million in 2015 for their work on the MARC system, and in the same year authorized Agile Networks to sublease space on dozens of state-owned communications towers to other carriers, with no revenue share agreement.[14]

The state's stated reason for entering into the subleasing agreement was to avoid exceeding a 10 percent private use limit the IRS puts on government owned assets built with proceeds from the sale of tax-exempt bonds, and to fulfill a policy goal of extending internet access coverage into Appalachia. The agreement does not give Agile exclusive subleasing rights, the state retains the right to sublease tower space on state-owned towers.[15]

Agile Networks pays the state about $700,000 annually for the right to locate their own equipment on or at the base of 146 of the 151 state-owned towers.[16] This enables Agile to sell backhaul service to other carriers using its fiber optic network and microwave dishes. Agile also provides

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[12] https://system.suny.edu/media/suny/content-assets/documents/capital-facilities/campus-let-/CLC-12-Crown-Castle-Telecommunications-Agreement-8.1.pdf

[13] Ibid

[14] http://www.dispatch.com/content/stories/local/2016/08/14/1-company-helps-state-skirt-rules.html

[15] Ibid

[16] Ibid

backhaul services to tenants at state sites, thereby realizing an additional revenue stream for itself.[17]

Agile has subleased tower space, and sold backhaul services, to numerous carriers, including T-Mobile. It is unclear how many of the towers Agile has the right to sublease T-Mobile has collocated on, and all the revenue from the deal with T-Mobile goes to Agile. Agile makes the argument that T-Mobile would not have collocated on the towers if it wasn't for the presence of Agile's backhaul services, and the retail services provided by T-Mobile would not have been deployed otherwise.[18]

4.3. Pennsylvania

The Commonwealth of Pennsylvania also has adopted a two-pronged policy approach when it comes to state-owned telecommunications asset management. In late 2019 Pennsylvania announced they were entering into 20-year agreement with Agile Networks to be its wireless asset manager. "We realize the revenue-generating opportunity the commonwealth has in renting extra space on communications towers and assets to third-party wireless providers. In addition to creating a revenue stream, we have the opportunity to contribute to more accessible and reliable wireless coverage across the Commonwealth."[19]

The Commonwealth's Department of Public Services created the Office of Enterprise Wireless Management to oversee the asset management agreement, and over the 20-year contract the Commonwealth will earn an estimated $100 million. Agile Networks will inventory and analyze the Commonwealth's assets, determine fair market value and market the assets to carriers. Under the agreement Agile can also propose new tower locations on Commonwealth owned land for development, based on their market analysis. [20]

4.4. Florida

The Florida Department of Management Services (DMS) entered into an agreement with the Harris Corporation to develop the Statewide Law Enforcement Radio System (SLERS). Harris received a $40 million advance payment and received certain state-owned tower assets. DMS

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[17] It's worth noting that the asset management agreement the state of Ohio has in place with Agile networks allows Agile to utilize the state's 800MHz spectrum in a similar way as AT&T can utilize FirstNet's 700MHz spectrum, as a shared spectrum with public safety applications having priority access to the network. This arrangement allows utilization of not only physical state-owned assets such as tower sites, but spectrum as well.

[18] http://wirelessestimator.com/articles/2016/hugely-profitable-state-wide-tower-deal-most-likely-will-never-be-bested/

[19] Pennsylvania Department of General Services Secretary Curt Topper
https://www.dgs.pa.gov/wireless/Pages/News.aspx

[20] Ibid

received $26.4 million in credits for radio equipment Harris installed, as well as additional credits for replacement of 6,000 State mobile and portable radios. [21]

Harris is paid $15 - $18 million annually to operate and maintain the SLERS network, an amount based on motor vehicle and boat registration surcharges. Under state law, DMS receives $3 per criminal offense and moving traffic violation to update the SLERS system, which is approximately $1.5 million annually. In turn, as part of a revenue share agreement, Harris pays DMS 15% of all net revenues received from SLERS users on communications towers and 5% of net revenue for each SLERS user radio on the network. [22]

Harris does not lease excess tower capacity or tower assets to private enterprise carriers on SLERS towers. The network is for state government users such as city and county governments, school districts, universities, community colleges, and non-profit organizations. The infrastructure is based on a Multi-Protocol Label Switching technology providing a highly available and highly reliable statewide communication infrastructure. [23]

Harris has done work for the state of Maine, including developing the P25 Maine State Communications Network (MSCommNet), completing the project in 2015. The VHF 144-175 Mhz wireless system serves more than 2,000 state employees using over 4,500 mobile and portable radios.[24]

4.5. California

Unlike the four examples above, the state of California decided to take state-owned telecommunication asset management in-house. Under the California Department of Public Services, the Asset Management Branch of the Real Estate Services Division acts as telecommunications asset manager for the state's vast network of assets.[25]

"The Asset Management Branch (AMB) oversees leasing, space planning and interior design, sales, appraisal, and acquisition services. AMB is also responsible for maximizing the performance of state real estate assets by identifying and implementing value enhancement solutions for unused and underutilized state-owned properties."[26]

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[21] https://www.dms.myflorida.com/business_operations/state_technology/public_safety_communications/radio_communications_services/statewide_law_enforcement_radio_system_slers/slers_funding

[22] Ibid

[23] https://www.dms.myflorida.com/business_operations/state_technology/suncom2/data_services/myfloridanet_2

[24] https://www.cisa.gov/sites/default/files/publications/Funding_and_Sustainment_Methods_11242015.pdf

[25] https://www.dgs.ca.gov/RESD/Resources/Page-Content/Real-Estate-Services-Division-Resources-List-

[26] https://www.dgs.ca.gov/RESD/About#@ViewBag.JumpTo

Folder/Telecom-Lease-Rate-Guideline#@ViewBag.JumpTo

[26] https://www.dgs.ca.gov/RESD/About#@ViewBag.JumpTo

The state leases state-owned land for the development of new wireless installations, the rooftops of state-owned buildings, antenna space on state-owned towers and poles, and space within state-owned communications vaults.

The state publishes detailed, itemized rates based on three population-based location tiers, with areas of lower population density being less expensive, and can include services such as road maintenance to tower sites, commercial and emergency power for an additional fee.[27]

4.6. Michigan

Recently passed legislation in Michigan represents a good example of a state telecommunications asset management policy that prioritizes expanding coverage into unserved areas over revenue generation. In 2019 Michigan passed House Bill 4237, allowing collocation by both public and non-public entities on Michigan Public Safety Communications System (MPSCS) tower infrastructure. The legislation allows government agencies to collocate on MPSCS towers immediately, while private enterprise entities have to wait three years to collocate equipment for any commercial purpose.

A non-public entity wishing to collocate on MPSCS towers for a commercial or business purpose can do so only in a “service needs area.”[28] A “service needs area” is an area “determined to be unserved by the Connect Michigan Broadband Service Industry Survey for the State of Michigan regarding advertised speeds of at least three megabits per second downstream and 768 kilobits per second upstream as of October 1, 2014.” [29]

Fees to collocate on MPSCS towers are comparable to the costs charged to public safety agencies or entities, even for installations for commercial purposes. All costs associated with planning, installation, operation and maintenance of equipment is the responsibility of the entity collocating on an MPSCS tower. Revenue collected from leasing MPSCS tower space will be used for construction and maintenance of the system, and to pay the debt service on bonds used to finance the construction of the MPSCS towers.[30]

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[27] https://www.dgs.ca.gov/RESD/Resources/Page-Content/Real-Estate-Services-Division-Resources-List-Folder/Telecom-Lease-Rate-Guideline#@ViewBag.JumpTo

[28] https://legiscan.com/MI/text/HB4237/2013

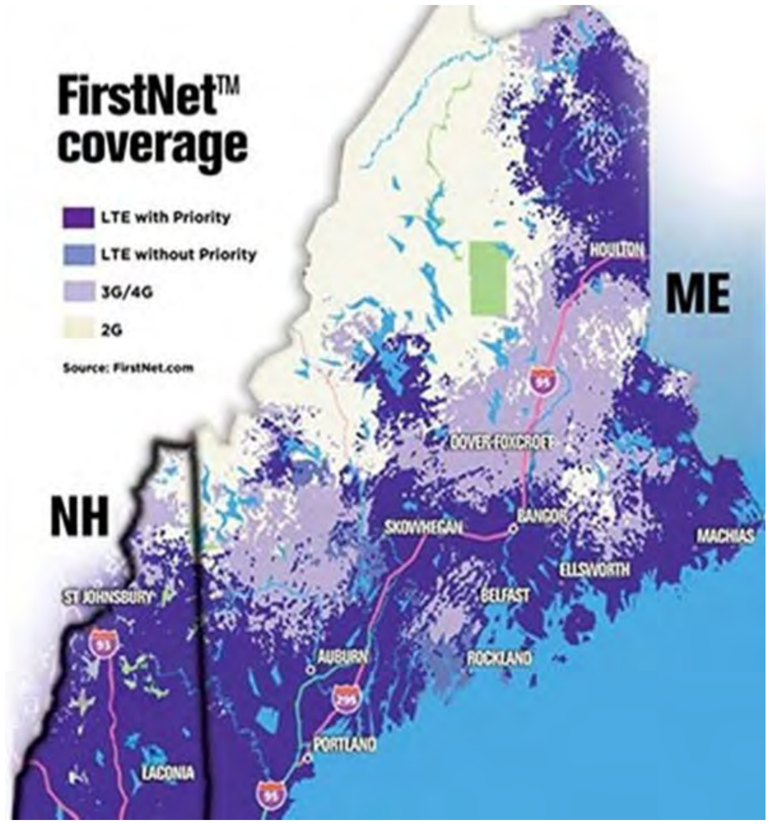
[29] http://www.legislature.mi.gov/documents/2013-2014/billanalysis/Senate/htm/2013-SFA-4237-L.htm

[30] https://www.cisa.gov/sites/default/files/publications/Funding_and_Sustainment_Methods_11242015.pdf

5. AT&T FirstNet

In 2017, AT&T was selected by FirstNet, the First Responder Network Authority, to deploy and operate the nationwide public safety network under a 25-year contract. AT&T will receive $6.5 billion over five years and 20MHz of spectrum in the 700MHz band, which is also used for consumer-based LTE networks.[31]

Figure 7: [Projected Maine FirstNet coverage]



FirstNet, which operates within the US Department of Commerce, was authorized by the federal government in 2012 and funded with $7 billion from an FCC spectrum auction in January 2015. AT&T competed in that same spectrum auction and placed $18.2 billion in winning bids.[32]

AT&T will invest about $40 billion of its own money over the 25-year term to build, operate and maintain the network. While AT&T can utilize the FirstNet spectrum for commercial use as well as public safety - with public safety usage having priority access to the network – AT&T will also connect FirstNet users to the company's existing network. "We're going to use the FirstNet build,

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[31] https://arstechnica.com/information-technology/2017/03/att-gets-6-5-billion-to-build-us-wide-public-safety-network/
[32] Ibid

and as we touch the towers to build FirstNet, we're going to put [other spectrum] to use. That's going to put a lot of capacity into the network. When you touch the tower, you're not just touching it for FirstNet, but you're touching it to put other bands of spectrum…in service as well."[33]

FirstNetME is the statewide program to optimize the design, deployment and operation of the FirstNet public safety network in the state of Maine. Working under the guidance of the Maine Interoperable Communications Committee (MICC), FirstNetME is working with FirstNet and the Maine Emergency Management Agency to develop a state plan based on Maine's coverage challenges and the requirements of Maine's public safety and first responder communities.[34]

FirstNet awarded $135 million in funding to states through the State and Local Implementation Program (SLIGP) to aid with initial project implementation. Maine was allocated $1.04 million of SLIGP funds to develop network coverage and user requirements, and to develop a plan based on these requirements.[35]

FirstNet provides a national carrier, AT&T, with a reason to look at sites to provide coverage in areas beyond those which it would cover as part of "business-as-usual." If the state provides properties that help meet these objectives, the FirstNet development window is an enhanced opportunity to help AT&T meet its coverage objectives for public safety users and also enhance service to all Mainers and visitors.

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[33] AT&T Senior Vice President of Technology Planning and Engineering Scott Mair - https://www.rcrwireless.com/20170623/carriers/att-svp-shared-spectrum-firstnet-tag17
[34] https://firstnetme.gov/
[35] https://firstnetme.gov/about/index.html

6. FCC Mobility Programs

In 2017, as part of a multi-stage transition of its Universal Service programs, the FCC adopted the framework of a 10-year $4.53 billion Mobility Fund-II ("Mobility Fund") to expand rural cellular coverage, which has yet to be implemented. The FCC announced that funds would be awarded to companies through a reverse auction process – funding qualifying applicants who seek the lowest amount of federal support. This is a similar mechanism to the one used by the FCC to award rural broadband funds through its Connect America Fund Phase 2 (CAF-II) program. The dollars available through the Mobility Fund program would be more than twice that of the CAF-II program. On December 4, 2019, FCC Chair Ajit Pai announced the launch of a $9 billion 5G Fund that would replace the planned Mobility Fund Phase II. The timeline for the launch of this initiative and most of its details are not available at this time.

The 5G Fund represents a possible major opportunity to draw on federal funding to support expansion of cellular service in Maine. However, it is uncertain which areas in Maine will be eligible and when the funding will be available.

For the Mobility Fund Phase II, the FCC released a map of "Initial Eligible Areas" provided in Figure 7 below which shows that Maine contains large uncovered areas.[36] However, this map was widely criticized for understating coverage gaps in many rural areas. The FCC developed its nationwide coverage map and an initial map of uncovered areas eligible for the Mobility Fund (the 'Initial Eligible Areas Map'), through a special, one-time data collection effort from cellular carriers in 2017. The data collected was based on propagation model-predicted availability of 4G LTE coverage supporting download speeds of 5 Mbps or greater.[37] The FCC used the collected data to produce the map shown in Figure 8. The FCC then subjected the data to a "challenge" process, in which challengers were invited to collect field measurements to validate the information carriers had provided. A total of 21 entities submitted valid challenges. [38] Due to the magnitude of challenges encountered during the process, the FCC opened an investigation into the accuracy of one or more carrier-submitted maps in December 2018, delaying the Mobility Fund's implementation.[39] The investigation concluded that there were, in fact, significant overstatements in coverage from some carriers.[40]

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[36] Federal Communications Commission, *Mobility Fund II Initial Eligible Areas Map, (Aug. 8, 2018), https*://www.fcc.gov/reports-research/maps/mobility-fund-ii-initial-eligible-areas-map/

[37] "Each polygon shall represent outdoor 4G LTE coverage, as defined by download speeds of 5 Mbps at the cell edge with 80 percent probability and a 30 percent cell loading factor. The terrain and clutter data used to generate the coverage boundaries must have a resolution or BIN size of 100 meters or smaller." In re Instructions for Filing 4G LTE Coverage Data for Mobility Fund II Support, 32 FCC Rcd 7023, 7024 (F.C.C. Sept. 22, 2017).

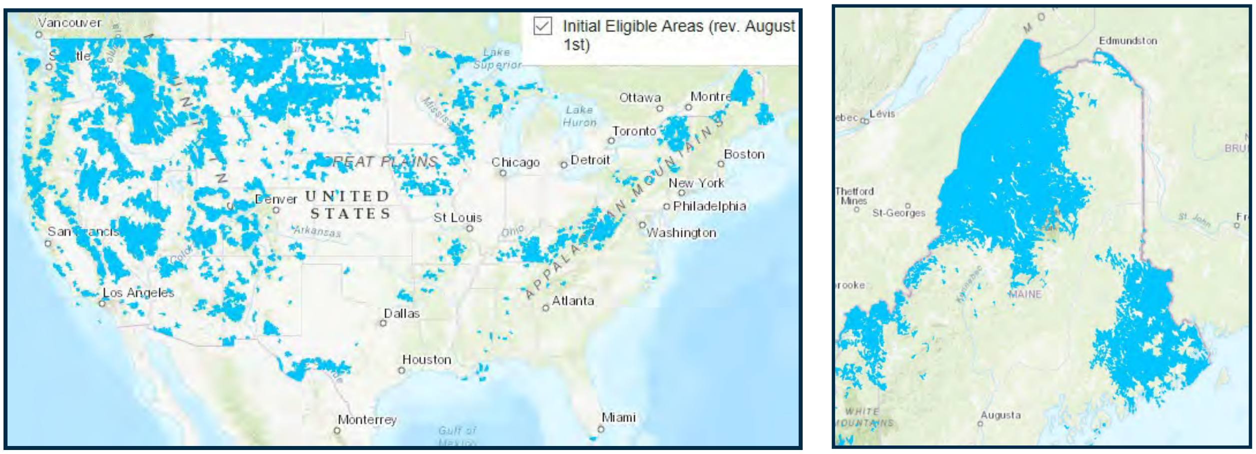
[38] In re Mobility Fund Phase II Challenge Process Portal Update: November 2018, 33 FCC Rcd 11706 (F.C.C. Dec. 3, 2018).

[39] Federal Communications Commission, "*FCC Launches Investigation into Potential Violations of Mobility Fund Phase II Mapping Rules,"* (December 7, 2018) https://docs.fcc.gov/public/attachments/DOC-355447A1.pdf.

[40] Federal Communications Commission, "*Mobility Fund Phase II Coverage Maps Investigation Staff Report,"* (December 4, 2019), para 4. https://docs.fcc.gov/public/attachments/DOC-361165A1.pdf

Given the concerns raised about the accuracy of the FCC's Initial Eligible Areas Map, it would not be prudent to rely on these maps as a definitive representation of coverage gaps in Maine.

Figure 8: FCC Mobility Fund Initial Eligible Areas



While this report is not intended to provide a comprehensive overview of the Mobility Fund program, it is worth understanding a few key elements as context for this report.

The FCC targeted the Mobility Fund to address areas lacking 4G LTE Coverage. The FCC adopted an area-based framework, using square miles to measure coverage, and stated that it would require carriers to bid for areas encompassing at least a census block group or tract. Winning bidders would have been required to cover 85% of supported areas in a state within six years, along with interim milestones. Winning bidders would also have been required to provide voice and data roaming and provide collocation space on any newly constructed towers.[41] These bidding and coverage requirements may have presented significant challenges to those competing to cover areas encompassing northern Maine. It remains to be seen how many of these requirements will be present in the 5G Fund.

[41] FCC-17-11A1 (V)(D)(101)(102)(103)(104) - https://docs.fcc.gov › public › attachments › FCC-17-11A1

7. Key Federal Regulatory Policies

The FCC has taken affirmative steps to issue regulations and rulings that require State and local permitting agencies to act on telecommunication permit applications within specific periods of time. Section 704(c) of the Telecommunications Act of 1996 requires that a:

> State or local government or instrumentality thereof shall act on any request for authorization to place, construct, or modify personal wireless service facilities within a reasonable period of time after the request is duly filed with such government or instrumentality, taking into account the nature and scope of such request. [42]

In 2009, the FCC issued what is commonly referred to as the "Shot Clock Order" to define a "reasonable period of time," stating that a state or local government should act on a new telecommunications tower permit application within 150 days of receipt, and a vertical collocation application within 90 days.[43]

In 2018, the FCC took additional steps to use its authority to coordinate siting regulations across federal, state, and local jurisdictions. The FCC explicitly stated that it was taking these additional steps for the advancement of a national strategy to promote the timely buildout of new telecommunications infrastructure across the country. The primary goal of the 2018 Declaratory Ruling (2018 FCC Ruling) was to eliminate regulatory impediments that may add delays and costs to cellular deployment.

Specifically, the 2018 FCC Ruling sought to streamline deployment of small cellular facilities by:

- Setting timeframes for application review and processing of small cell facilities to 60 days for collocations;
- Restricting state and local permitting fees to no greater than a reasonable approximation of the cost;
- Establishing greater uniformity of siting standards;
- Expanding access to municipal infrastructure in the ROW;
- Defining permissible aesthetic and undergrounding requirements; and

[42] 47 U.S.C.S. § 332(c)(7)(B)(i)(I).

[43] In re Petition for Declaratory Ruling to Clarify Provisions of Section 332(c)(7)(B) , 24 FCC Rcd 13994 (F.C.C. November 18, 2009).

- Clarifying that failure by a state or local permitting agency to act on a permit application constitutes a presumptive prohibition on service as defined by the Telecommunications Act of 1996.[44]

The FCC also aimed to limit environmental and historic reviews for telecommunications facilities pursuant to the National Environmental Policy Act (NEPA) and the National Historic Preservation Act (NHPA).

In practice, the impact of these recent rulings, especially in hard to serve areas such as rural Maine, have been inconsistent at best. Permitting timelines shared by industry often do not meet FCC shot clock requirements, and little progress has been made at the local level to improve uniformity of design, aesthetic, and siting restrictions. This is in part the result of ongoing legal challenges by municipal, state, environmental, and other stakeholders. Notably, efforts to streamline applicability of NEPA and NHPA requirements were invalidated by federal courts after challenges by environmental and tribal stakeholders.[45]

Also in 1996, to implement the requirements of section 704(c) of the Telecommunications Act passed that same year, an Executive Memorandum was released entitled "Facilitating Access to Federal Property for the Siting of Mobile Services Antennas.'' The Memorandum recognized the importance of wireless infrastructure deployment on the nation's roadways and facilitated access to federal property for antenna installations.[46]

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[44] In re Accelerating Wireless Broadband Deployment by Removing Barriers et al. , 30 FCC Rcd 9088 (F.C.C. September 27, 2018).

[45] United Keetoowah Band of Cherokee Indians in Oklahoma. v. FCC, 933 F.3d 728 (D.C. Cir. 2019).

[46] Federal Register, Vol. 61, No. 62, March 29, 1996 - https://www.govinfo.gov/content/pkg/FR-1996-03-29/pdf/FR-1996-03-29.pdf

Conclusion and Recommendations

Cellular coverage is no longer a luxury but a necessity. It is essential for public safety, tourism, and economic development. It is woven into the fabric of everyday life, and necessary for communities in Maine to thrive. Gaps in coverage are a fact of life across many rural communities in Maine.

As described above, closing coverage gaps should include pursuing a state-owned telecommunications asset management policy that prioritizes expanding coverage into unserved and underserved areas. If expanding coverage is the primary goal, generating revenue from state-owned telecommunications assets can be considered on a sliding scale, with assets that could be utilized to expand coverage into unserved or underserved areas offered at a reduced cost, but assets that can be utilized for urban and suburban network densification having a fair market value.

The recently passed Michigan legislation is perhaps the best example of a policy that incentives coverage expansion over revenue generation. By making available state-owned tower assets only in areas defined as unserved or underserved, at incentive rates, the legislation addresses the specific policy goal of coverage expansion.

In addition to prioritizing access to state-owned tower assets capable of serving rural and underserved areas, enabling rapid and low-cost access to public rights of way for the development of shared telecommunications assets not only enables network densification in urban and suburban areas, but along some roadways in rural areas as well.