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SMART CITIES

How 5G Can Help Municipalities Become Vibrant Smart Cities

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Executive Summary

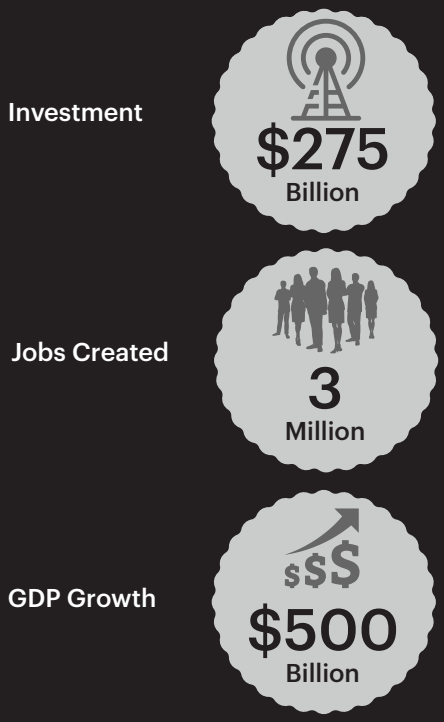
For decades, the evolution of communications technology has laid the foundation for broad economic growth across the United States benefitting towns and cities large and small. The next generation of wireless network infrastructure will be built using small-cell networks employing 5G wireless technology. The connectivity and computing capacity unleashed by these high-speed wireless networks will bring the power of Smart City solutions to municipalities across the country.

This can transform local economies. Research has suggested that Smart City solutions applied to the management of vehicle traffic and electrical grids could produce $160 billion in benefits and savings through reductions in energy usage, traffic congestion and fuel costs. These 5G attributes will enable cities to reduce commute times, improve public safety and generate significant smart grid efficiencies.

Beyond the benefits of pervasive Smart City technology, the potential gains from the deployment process for such technology are also significant since telecom operators are expected to invest approximately $275 billion in infrastructure, which could create up to 3 million jobs and boost GDP by $500 billion.

Full realization of the economic growth and cost savings from leveraging Smart City solutions built on 5G infrastructure will, however, depend on how robustly 5G networks are deployed locally, and will require different approaches from those used in the past. The network deployment build of 5G will involve 10 to 100 times more antenna locations than 4G or 3G. These cells are small – the size of a shoe box – and are critical not only for delivering the speed and capacity promised by this next generation of wireless, but also for supporting the increased number of devices that will be connected to the network in the future.

5G Economic Impacts



Smart City Technology & 5G Are Expected to Benefit All Community Sizes

	 **Saratoga, CA** 29,900 Pop.	 **Beaumont, TX** 118,000 Pop.	 **Metro Chicago, IL** 9,472,000 Pop.
Jobs Created	**300**	**1,000**	**90,000**
GDP Growth	**$50M**	**$180M**	**$14B**
Network Investment	**$20M**	**$100M**	**$8B**
Smart Grid + Transportation Benefits	**$10M**	**$70M**	**$5B**

To support the increased density of small cells that will be required to obtain both the economic and Smart City benefits enabled by 5G wireless networks, there are a number of steps municipal leaders should take to encourage telecom operators to invest in deploying next-generation infrastructure in their municipalities.

Today, many municipalities require approvals and fees based on the historical deployment of large towers that can be more than 250 feet tall. The shift from traditional large wireless towers to small-cell sites – affixed on locations from lamp posts to utility poles – will require a streamlining of the permitting process governing wireless infrastructure deployment and an appropriate adjustment in permit areas.

If municipal and regulatory leaders wish to reap economic benefits, including jobs and GDP growth, and accelerate their journey to becoming a Smart City, they should strive to be among the first to streamline permitting, change their fee structures, and reduce regulatory hurdles to support the new small-cell deployment model required for this next generation of wireless technology.

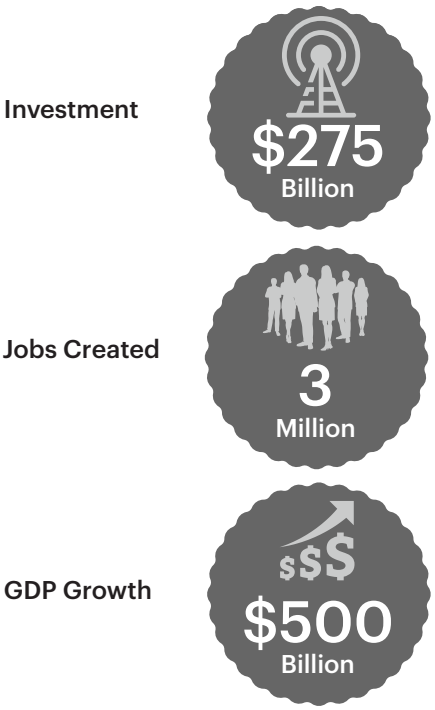
The Next Generation of Wireless Technology Will Fuel Economic Growth

The full potential of Smart Cities will be unlocked by 5G networks and small cells, creating jobs as well as entire new industries. Communities that support 5G wireless technology will see significant economic and community benefits. This next generation of wireless technology is expected to create 3 million new jobs and boost annual GDP by $500 billion, driven by a projected $275 billion investment from telecom operators.

Direct Economic Benefits

As telecom operators build out their networks, they are expected to invest across the country. Our analysis indicates that U.S. telecom operators could invest approximately $275 billion over seven years to deploy next-generation wireless technology, with trials beginning as early as 2017 in select cities.[1] Of that $275 billion, $93 billion is expected to be spent on construction, with the remainder being allocated for network equipment, engineering, and planning.

5G Economic Impacts



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Deploying the infrastructure required for 5G will also create jobs. We estimate that approximately 50,000 new construction jobs will be created each year over the 7-year buildout period. When we consider the effects on suppliers and other partners, and their spending in the economy, the full impact from construction spending alone could be approximately 120,000 jobs created each year during the first seven years of deployment.[2]

Broader Economic Benefits

Though the direct jobs and investment to be expected from deploying 5G are significant, the broader economic benefits associated with an improved wireless communications network are even greater. Based on research into the benefits of adopting the next generation of wireless technology,[3] we expect 5G could help create 2.2 million jobs, and approximately $420 billion in annual GDP, spread across small, medium and large communities in the U.S.[4]

Another of 5G's contributions to generating jobs and economic growth will be providing the benefits of high-speed broadband to the 5% of Americans who currently do not have access. Because faster Internet connections allow users to utilize video applications for telecommuting, or participate in e-learning courses that give them additional skill sets or certifications, their employability and earning power increases, thus creating a more competitive workforce in different localities – which would, in turn, attract higher-paying jobs to these communities. If localities embrace 5G, and citizens who are not already online become adopters, we could see an additional $90 billion in GDP, and 870,000 in job growth.

Communities of all sizes are likely to see jobs created. Small to medium-sized cities with a population of 30,000 to 100,000 could see 300 to 1,000 jobs created. In larger cities like Chicago, we could see as many as 90,000 jobs created.

On a state level, there will also be significant economic benefits. Analyzing a sample of different-sized states across different regions, the number of jobs created in the short-term as a result of network deployment is expected to be significant for both large and small states, with California seeing more than 11,000 jobs created.

While the deployment of 5G wireless networks will bring near-term economic benefits, it will also help to ensure that U.S. communities remain competitive over the longer term by allowing them to fully leverage Smart City technology, and ensuring the latest wireless communications technology is available to citizens and businesses. The job impact for larger states could be considerable; California could see as many as 375,000 long-term jobs created.

Expected Number of Jobs Created by State

State	Network Deployment	Increased Competitiveness
California	11,000	375,000
Florida	6,000	195,000
New York	5,000	190,000
Oregon	1,100	39,000
South Dakota	200	8,000

Smart City Growth Will Be Accelerated by Next-Generation Wireless

The Smart City applications currently leveraging today's wireless networks are already showing significant benefits to communities. Building on the foundation of 4G LTE, 5G will accelerate these Smart City benefits.

The key attributes of 5G that will benefit Smart Cities include higher speeds; more connections – thus enabling wireless connectivity in unprecedented locations, ranging from street lights to sewer holes; quicker, more adaptive response times that support time-sensitive applications, such as vehicle-to-vehicle communications; and ultra-low-power connections, such as sensors for leak detection in water mains, since, in many cases, the replacement cycle is directly related to battery life.

We have picked three areas – energy/utilities, transportation, and public safety – to showcase what is possible when municipalities welcome next-generation wireless technology. These examples also illustrate how wireless connectivity is already creating jobs, generating municipal efficiencies, and increasing government revenue.

5G: Technology to Meet the Growing Demands of Smart Cities

Energy & Utilities

Smart Grid. 5G technology will help unleash the next wave of Smart Grid features and efficiency. Across the U.S., Smart Grid benefits are estimated to be as high as $2 trillion dollars over 20 years.[5]

By allowing many unconnected, energy-consuming devices to be integrated into the grid through low-cost 5G connections, 5G enables these devices to be more accurately monitored to support better forecasting of energy needs. By connecting these energy-consuming devices using a smart grid, demand-side management will be further enhanced to support load balancing, helping reduce electricity peaks and ultimately reduce energy costs.

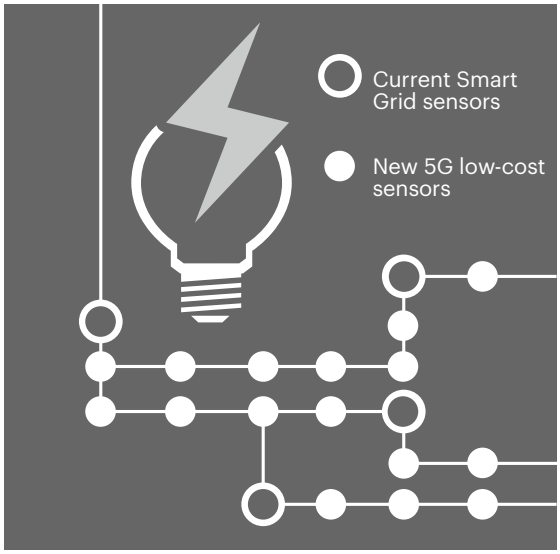
Capturing this data through 5G connections will further enable larger cities, or even state-level jurisdictions, to plan expensive energy infrastructure spending more efficiently and reduce downtime. In the event of power failure, smart grid technology enables precise, real-time diagnosis, down to the specific pole or transformer affected by an outage, which speeds up repairs and reduces downtime. For example, by installing smart grid technology, Chattanooga, TN, a medium-sized town, reduced the duration of outages by over 50% during a severe windstorm and saved the utility $1.4 million* in operational costs for just one storm.[6]

Last but not least, 5G is itself more cost effective and energy efficient than past generations of wireless technology, thus making its own contribution to energy savings.

Smart Lighting. By automatically dimming public lighting when no pedestrians or vehicles are present, smart lighting can save power and reduce light pollution while still keeping neighborhoods safe. Smart lighting has begun to be rolled out in cities such as San Diego and Barcelona[7] as part of a larger Smart City initiative. Through its system, San Diego will save an estimated $1.9 million[8] annually through the installation of these street lights. Across the U.S., the potential savings from this approach are estimated to be more than $1 billion per year.

Smart lighting connected to a city's broadband network can also monitor local air quality. Adding this level of connectivity to smart LED lighting can also reduce the lighting system's maintenance costs.

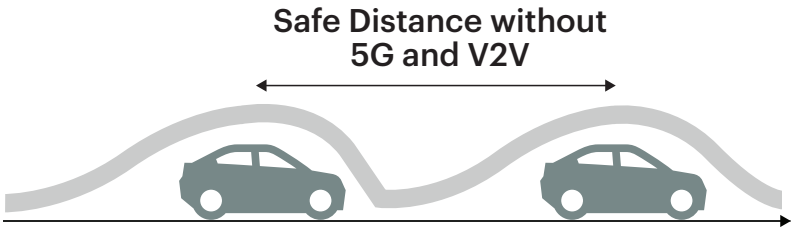
Smart Energy Grid



5G enables additional low-cost connections to provide comprehensive coverage of the energy grid.

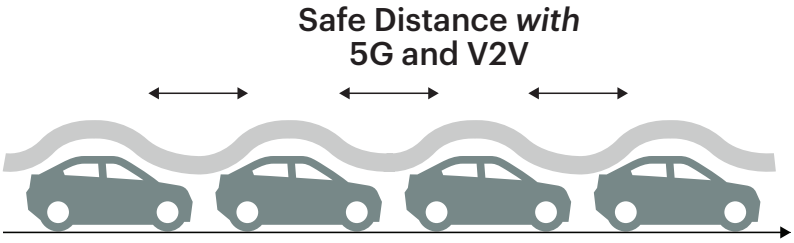
Smart Car Convoys

Fuel Savings of 25%[9]



Air flow - drag constitutes 50-75% of highway energy

Self-Driving Cars - 2020



Air flow – car convoy can reduce drag by 20-60%

Autonomous Cars w/5G - Future

5G vehicle-to-vehicle communications (V2V) could allow lead cars to communicate hazards to following cars, increasing reaction time and safely allowing car convoys.

Transportation

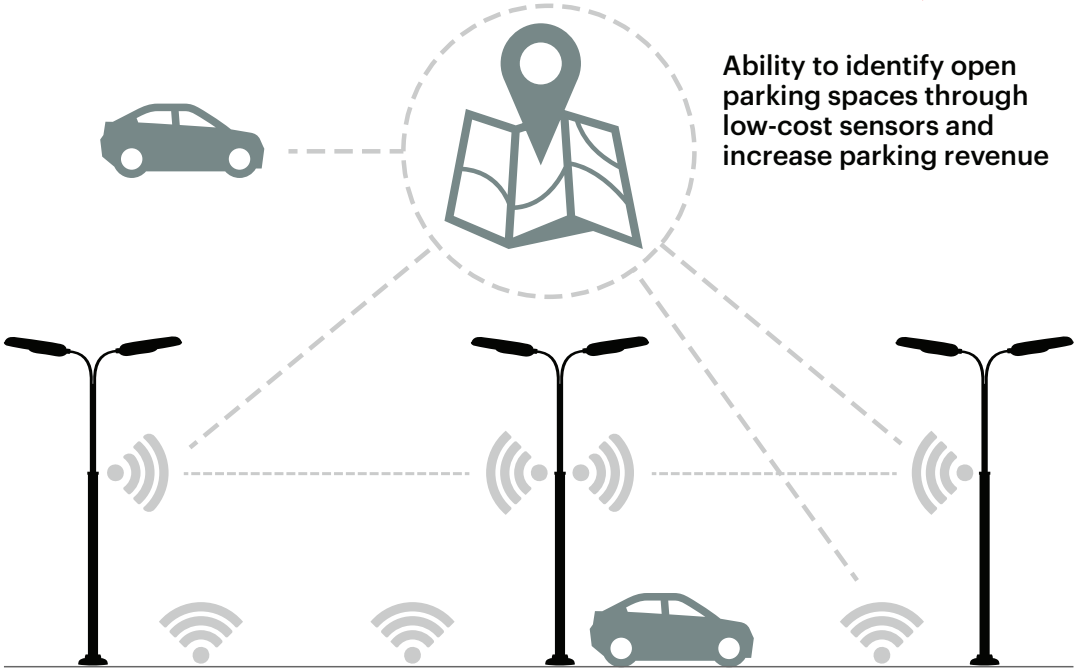
By leveraging next-generation wireless technology, communities can improve their transportation systems – enhancing public transportation, reducing traffic congestion, and generating revenue from public parking efficiencies.

Public Transportation. With increased wireless connectivity, communities with a public transit system can reduce rider wait times while also optimizing bus inventory. Giving transit operators minute-by-minute information on the number of users who are currently using the system, or who intend to use the system at a specific time, will help increase system utilization, and allow for dynamic bus routing.

Traffic/Commuting. Imagine being able to reduce traffic congestion in your community by 40%, saving drivers and operators in medium-sized cities approximately $100 million annually.[10] Traffic management systems can help deliver these benefits and, thanks to 5G's ultra-fast speeds, cars will be able to "convoy" or "platoon" in groups,[11] increasing road vehicle capacity, while providing substantial energy savings for vehicle owners. And if autonomous cars are supported by Smart Traffic Management systems, congestion could decrease and deliver additional productivity and quality-of-life improvements to residents.

Smart Parking + Metering

↑27%
Parking
Revenue



Ability to identify open parking spaces through low-cost sensors and increase parking revenue

Reduce time to find parking and congestion benefits all commuters and encourages traffic to commercial areas, boosting economic activity.

Public Parking. With real-time information available about empty on-street parking spaces, vehicles will no longer need to circle the block, but instead go directly to an open space, identified as such by a low-cost 5G sensor on a street lamp.

Combined with the smart metering systems that are already deployed in some areas, advanced wireless connectivity could increase parking revenue by 27%[12] while also helping reduce congestion and idling.

Gun Shot Detection

Real-time monitoring of gunshots provides police and first reponders with exact location, speeding up response time.

Public Safety

Smart City innovations in public safety are just beginning to take hold, and wireless connectivity is the driving force behind these innovations.

Chicago currently uses its 4G network to provide real-time video which allows first responders to assess a scene before arriving.[12] Deployment of 5G in a Smart City will enable the integration of all video surveillance, with access to specific locations, pole by pole, in ultra-high definition. This capability would allow responders to use facial recognition to identify known criminals or spot missing persons before arriving on the scene.

Thanks to wireless sensors, San Francisco is already able to generate detailed, real-time, location-based information when a firearm is discharged. This allows authorities to be immediately alerted, and has helped reduce gun crime by up to 50%* in neighborhoods where the technology has been deployed.[14] When a gun is fired, the sensors can triangulate the location, and sometimes even identify the type of gun. That information is sent to authorities to speed up deployment of personnel to the location.

In many communities, emergency warning systems are already providing alerts about tornados and other life-threatening weather events. Building on such warning systems, 5G flood sensors could also provide motorists with route guidance, helping reduce one of the primary causes of death during flooding: people choosing routes that pass through flooded areas.[15]

Deploying Next-Generation Wireless Infrastructure

Smart City benefits, along with the significant economic growth and job creation described, depend on the deployment of 5G. But this next generation of wireless connectivity will require a wireless infrastructure that is significantly denser than that required by 4G.

The key to this new wireless infrastructure is the small cell. Telecom operators are already using 4G small-cell technology in limited deployments today to support increased capacity for new users and Smart City sensors. But the full promise of Smart Cities and 5G requires a robust deployment of small cells.

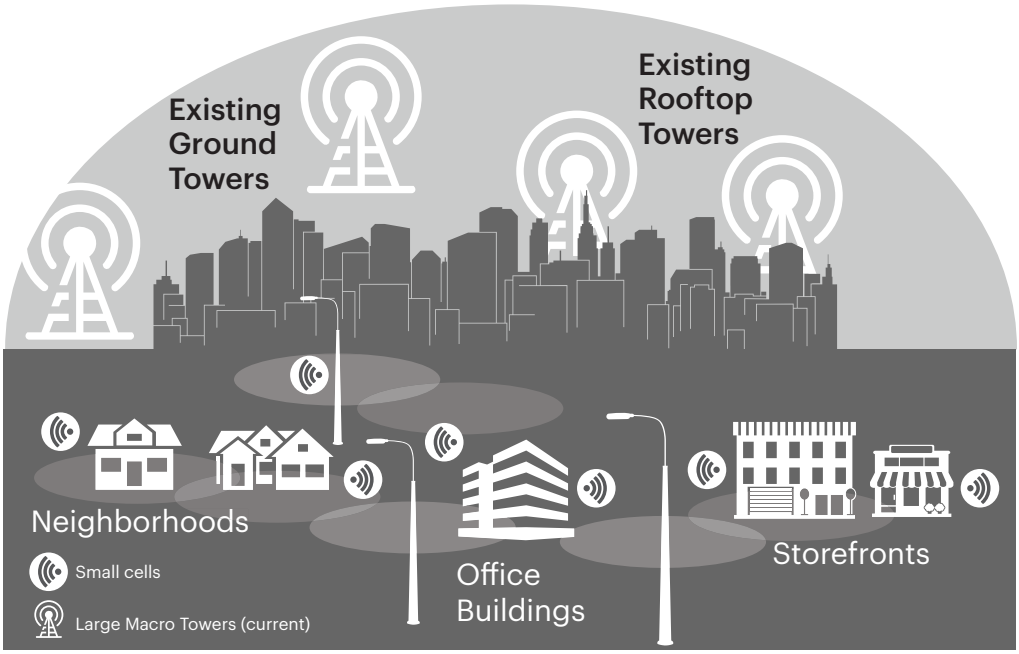
That is because tomorrow's wireless networks will require hundreds, or even thousands, of small cells, densely deployed across a city or town, instead of traditional macro cell towers, which are hundreds of feet tall and transmit wireless signals for miles. Complementing the existing macro cell sites, these small cells can be the size of a shoe box and discretely deployed nearly anywhere – from street lamps and utility poles to the sides of buildings.

The approach is similar to the supply-operations concept of distributing dispatch centers across a geographic area to serve customers more efficiently than one main, central warehouse. The approaches have similar benefits:

1. **Speed to deliver:** Just as numerous small dispatch centers can be located closer to the ultimate destination, and thus provide faster delivery, widely distributed small cells also deliver higher speed, and enable large amounts of data to be more readily delivered to users.

2. **Capacity to serve:** When a given dispatch center does not have the capacity to serve a certain client within the required timeframe due to the shortage of available resources/products, other nearby centers are able to provide service. Likewise, if a small cell experiences too much traffic demand due to a major event (e.g., an emergency situation in the area), other small cells can help meet demand, preventing the communication interruption that usually occurs with current technology.

Macro and Small Cells



Existing towers will provide coverage for miles, while small cells will support the increased needs of a Smart City.

Small cells could be discretely installed on lamp posts, utility poles or sides of buildings.

3 **Specialization and diversification of fulfillment:** Just as small niche centers can provide specialized service to a local area, a "small cell" can also provide specialization of service to a large, diversified number of users. With the availability of sufficient numbers of small cells, wireless networks will support both specialized transportation solutions (e.g., vehicle-to-vehicle communication) and specialized public safety solutions (e.g., gunshot detection sensor communication), all while ensuring the best quality of service to other highly critical applications, such as a nearby hospital which requires highly reliable communications (e.g., for remote surgery).

Small cells are already beginning to supplement the operations of existing 4G macro towers, and will initially be the central strategy by which telecom operators deal with this ongoing growth in demand for mobile capacity and coverage ultimately leading to the full-scale 5G deployment that will be required by Smart Cities.

While the benefits of pervasive small-cell 5G technology are highly significant, the real-world logistics of deploying small cells on a large scale must also address the cost, complexity and time involved in deployment. Many municipalities continue to rely on regulations and processes that were created to handle the rollout of existing and previous wireless technologies, but which are likely to be inadequate for the rollout of 5G technology.

The challenges in this area are threefold: local permitting and regulations; access to public rights of way; and fee structures.

Local Permitting and Regulations

Currently, applications for small-cell implementations can take up to 18 to 24 months for approval, which is similar to the time required to approve one large macro cell tower. Recognizing that the density of small cells is up to 100 times greater than for macro towers, such an approval cycle will pose a tremendous challenge to both telecom operators and municipalities. In certain cases, slow turnaround/approval times have not only caused delay, but have resulted in approval of only part of the submitted plan. If approval for a full cluster of small cells is not supported, and fewer small cells are deployed as a result, the full benefits of this wireless technology will not be realized.

In many cities, the approval cycle requires several separate tribunals for approval. Committees such as a neighborhood association, a planning commission, a zoning commission, the county council and others may each require a separate decision-making process.

Some cities also require a discretionary review of each installation, or else classify every small-cell installation as a new installation that requires its own separate environmental assessments and approvals, even if the location has an existing small-cell site operated by another telecom operator.

Access to Public Rights of Way

One potential option for telecom operators deploying small cells on Public Rights of Way is to work with a partner that offers a database of already-approved sites, and manages relationships with operators through efficient, mutually beneficial processes.

Immediate access to these types of qualified sites and assets makes it quicker and easier to find locations to deliver 5G services to users and enable Smart Cities. It also shortens the time spent negotiating with site owners, and reduces the effort required to secure the necessary permissions and approvals.

One example of a partner would be the local public utility which manages utility poles. The FCC has supported wireless deployment by clarifying rules related to the use of utility poles, specifying that pole attachment laws should also cover wireless attachments, thus removing any ambiguity about how wireless attachments should be treated by utility pole owners. The FCC has also specifically required that any denial must be on a "case-by-case" basis.[16]

While many owners of public utilities poles have embraced small-cell attachments from the beginning, others remain less enthusiastic. Without Public Rights of Way, the deployment of next-generation small-cell technology will continue to suffer – and communities will not be able to enjoy its benefits.

Fee Structures

In many instances, fees imposed on small cells are comparable to those imposed on macro cells without regard to their differences. The application fees and other acquisition fees (including rental) of macro-cell sites are applied to each of the 50 to 100 small cells required resulting in costs being multiplied and deployment becoming financially unfeasible. Communities that apply previously used processes and regulations to small-cell rollouts, rather than updating their approach, can end up discouraging small-cell deployments.

Such challenges, coupled with concerns about return on investment, will cause delays for the deployment of wireless infrastructure, potentially leading to the loss of projected benefits in the affected communities, and shifting those benefits, including economic development and increased competitiveness, towards communities that have developed plans to support faster deployment of next-generation technology. Such delays are also likely to have consequences for certain types of Smart City benefits that depend on having the 5G infrastructure in place.

Cost is one of the most significant challenges that telecom operators face when deploying small cells. Small-cell equipment itself typically accounts for 10% or less of a site's total cost of ownership, with a much larger part of the investment instead going to the services through which each site is selected, assessed, acquired and approved for implementation. Considering the large number of small cells required, the cost structure makes the total cost of installing small cells many times higher than the costs for existing infrastructure.

These regulatory and operational challenges are just a fraction of the issues telecom operators will face when implementing the small-cell technologies. There are other challenges they need to handle in parallel, such as acquiring new frequency spectrum; making sure there is high-capacity connectivity, such as fiber optics, to each of the small cells, and development of 5G know-how and expertise.

Next Steps to Unlock Economic Growth

To build a 21st Century Smart City and reap the resulting economic benefits, municipal leaders must support an environment that cultivates smart innovations for all of their citizens. By facilitating 5G infrastructure deployment, they can make their communities more efficient and attractive to investments by telecom operators as well as other industries.

Keeping in mind the telecom operators' expected infrastructure investment of $275 billion for 5G deployment over seven years, and the opportunity to create up to 3 million new jobs, there are a number of steps that municipal leadership can take to improve the rollout process and save time, thus helping the prompt evolution of their community towards a Smart City and reaping the associated economic benefits. These steps address three main areas of challenge previously outlined: streamlined permitting and processes, right-of-way applications, and fee structures.

Streamlined permitting and processes:

- **Batch approvals** – By pre-approving cell antenna types and providing approval for specific areas, as opposed to pole by pole, approval processes can be streamlined, saving the city significant time and resources that would otherwise be spent processing repetitive permits.
- **Accelerated timelines** – To allow for efficient deployment of small cells, permits should have a reasonable approval time.

Right-of-way applications:

- Given the pervasive yet non-intrusive nature of small- cell technology's footprint, municipalities would benefit from providing access to sites or assets such as government-owned utility poles, streetlights and other street fixtures, wherever possible.

Fee structure update:

- The fees typically charged for macro towers, when applied to small cells, will deter telecom operator investment. Given the increased number of cells required for a 5G deployment, a new, rational fee structure – one that does not compromise revenues of the city – should be considered in light of the economic opportunity such a deployment represents. A city will benefit much more from the increased jobs and prosperity that 5G Smart City technology brings, than from the revenue the city generates from pole fees or permits.
- Additionally, municipalities should consider more efficient fee administration. Rather than establishing a different price for each type of lamp post or streetlight, cities could create simple asset classes based on location, power requirements, maintenance requirements and engineering charges, thus providing optimal terms and conditions for each small-cell deployment, while reducing unnecessary paperwork.

In addition to specific policy recommendations, municipalities should consider ways to ensure departmental coordination on decision-making. Given some of the time-consuming situations that telecom operators have faced as a result of piecemeal approval from the required city departments, it is clear that providing operators with a single point of contact for inter-departmental approvals would save time for both operators and city officials.

The evolution of 5G wireless technology, which will create the advanced infrastructure needed for Smart Cities, has reached a very promising juncture – yet also a critical one. The Smart City concept is real, and is starting to take shape in a number of municipalities in the U.S. and abroad. To reach its full potential, and unlock the full benefits of Smart Cities, communities now need to support small-cell deployments to enable a 5th generation of communications infrastructure. Cities and towns which are first to facilitate the wireless infrastructure evolution will see the greatest benefit, while slow adopters may be the equivalent of turn-of-the-century towns that were not supported by infrastructure, and slowly became less competitive and lost jobs while their populations shrank.

Given the large investment that telecom operators plan to make in the coming decade, and the 5G trials that are expected to start in early 2017,[17] municipal leaders should position their communities to take advantage of this investment and all of the other benefits that accompany it, including improving citizens' lives, creating jobs and increasing their economic competitiveness.

Appendix – Methodology, Assumptions and Caveats Around Estimated Economic and Other Impacts

- Network investment costs are based on our knowledge of current estimates of expected costs, and assume adoption and coverage requirements will be similar to previous generations of technology. Technological advances, regulatory frameworks, and the availability and cost of wireless spectrum are examples of factors that may impact these estimates.
- Construction jobs directly created from the network investment were calculated using industry average costs.[18]
- Indirect and induced employment figures as a result of construction were calculated using industry-specific employment multipliers.[19]
- The impact of next-generation wireless technology on employment was estimated using research that studied the impact of previous generational shifts in wireless technology – specifically, the economic impact of 3G technology in the U.S.[20] The number of jobs created increased over time as the technology is adopted and the figures in this document represent the number at the end of the 7-year buildout.
- GDP growth related to jobs created from the next generation of wireless technology was determined using estimates of the elasticity of employment with respect to growth for the U.S.[21]
- The estimates of jobs created by providing broadband access to consumers through 5G wireless assumes the share of the population that currently doesn't have access to broadband internet will be the same at the time of 5G deployment, and that 5G will be a substitute for wireline broadband. It also assumes consumers who don't have access to the technology will adopt it at the same rate as those who do have access. Estimates of the economic impact are based on previous studies of the economic benefits of broadband covering employment[22] and GDP.[23]
- The estimates of long-term jobs created through adoption of 5G technology for different city sizes assumes the jobs are evenly distributed across city sizes based on population since the technology has benefits for people in all sizes of cities. This is assumed to be the case for broadband access as well: while households which do not have broadband internet access are predominantly in rural areas, the estimates of total jobs created by city size are distributed evenly across different city sizes based on population since there will be an indirect and induced impact affecting others beyond those who gain access to broadband connectivity.
- Though 5G is expected to deliver significant economic benefits, it is also important to reflect that delays in rollouts caused by technological, legal, or financial costs can significantly limit the deployment and adoption of 5G. The numbers may also vary considerably from city to city depending on the local environment, including the difficulty and cost of deployment. The benefits of the buildout, including the number of jobs created over time, will also vary, depending on adoption and usage of the technology.

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[4] 5G will provide businesses with access to more information, a broader supplier base, technology that lowers transaction costs and makes them more competitive both nationally and internationally, and a wider range of customers. Consumers will benefit from expanded access to training, increasingly available online, that helps them learn new skills and become more productive, while also helping them to reduce the cost of finding new jobs.

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