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United States Senate Committee on Commerce, Science, and Transportation
Hearing on "Investing in America's Broadband Infrastructure: Exploring Ways to Reduce Barriers to Deployment"

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Chairman Thune, Vice Chairman Nelson, and members of the Committee. Thank you for the opportunity to share Nokia's thoughts about ways to encourage and improve broadband deployment in the United States.

Nokia:

Nokia is a leading innovator in the technologies that connect people and things. With business activities in more than 125 countries, we are driving the transition to smart, virtual broadband networks and connectivity by creating one single network for all services. We are converging mobile and fixed broadband, IP routing and optical networks, with the software and services to manage all of these technologies. Supporting Nokia's comprehensive connectivity portfolio is a world-class research and development program led by the award winning U.S. based Nokia Bell Labs, and with additional R&D centers in the United States, Europe, and Asia. Nokia invested more than $5 billion in R&D during 2016, adding to a portfolio that now exceeds 90,000 patents. Our researchers and engineers continue to develop technologies that will transform the way people and things communicate and connect, including: 5G wireless technology, ultra broadband access, IP and Software Defined Networking ("SDN"), Cloud applications, IoT and security solutions, data analytics, and sensor and imaging technology that will be widely utilized in IoT applications.

Nokia is also a major facilitator of the emerging Internet of Things ("IoT") market through our "ng Connect" program. With Nokia's "ng Connect" program, we have built an ecosystem of more than 300 members including leading network, consumer electronics, applications, and content providers. The IoT community of the ng Connect program brings innovative companies together to collaborate on solution concepts, end-to-end prototypes, business models, and market trials that will unleash the full potential of the IoT.

Broadband Deployment in the United States:

The United States is fortunate to have very good broadband networks, particularly with respect to wireless broadband. However, as noted by many researchers, in spite of considerable federal and state policy efforts over the last decade, we have not been able to deploy truly high-speed broadband capability ubiquitously throughout the country. There are persistent, known challenges underlying this reality. Therefore, it is timely to take a fresh look at this issue as the Committee is now doing. Nokia commends the Committee for its work on the Mobile Now Act. This legislation, once enacted, makes critical changes to siting of infrastructure on federal land with improved access to rights-of-way, and further directs the FCC and NTIA to work on a range of spectrum that is critical to mobile broadband development. We see this legislation as a critical step forward and urge its prompt passage. Importantly, Congress continues to hear about spectrum policy from industry groups. The reason is that the need for a predicable, flexible supply of spectrum for broadband use, across a range of bands, is a foundational element of the connected society. It is not a subject that can be addressed in one bill and then deprioritized. We encourage you, the FCC, and NTIA to continue your aggressive work on spectrum policy.

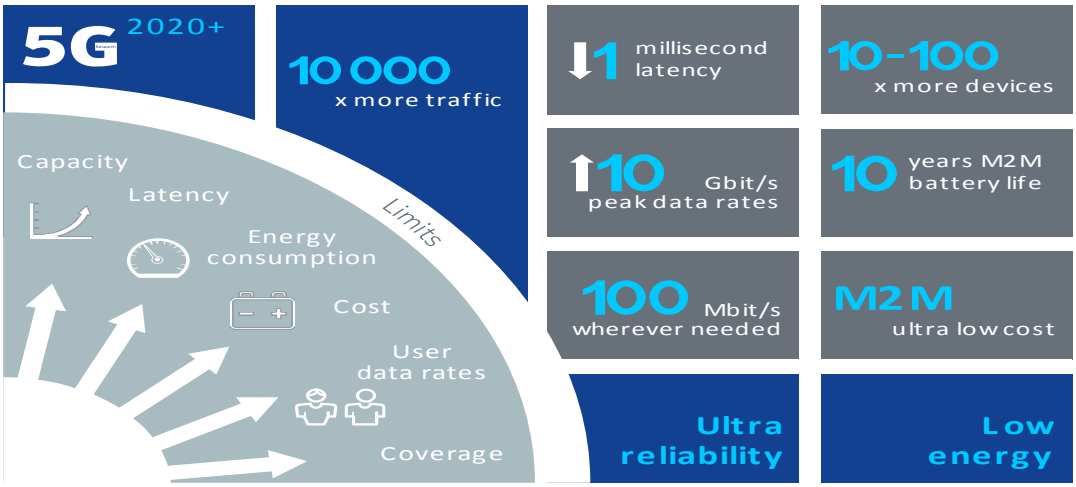
We stand at a very important moment with a huge leap forward in technology applications and services emerging at a rapid pace. Once relegated to the confines of science

fiction novels, ideas like autonomous driving vehicles are no longer distant aspirations. As we look at the near and mid-term, Nokia believes that there will be substantial advancement in the areas of connected health care, intelligent transportation and infrastructure, and Smart Cities among others. Augmented and virtual reality, machine-to-machine communication, remote diagnostic medicine and perhaps even a tactile Internet, with instantaneous feedback to a user enabling things like remote surgery, being among the possibilities. More of our learning, commerce, health care delivery, and daily living will take place via a broadband connection, making the availability of high quality, affordable broadband a necessity for modern living now more than at any time in our history. We have not fully addressed the so-called digital divide with current generations of technology, so there is a danger that the divide will not only persist, but could actually widen. If more commerce, learning, and quality of life enhancing activities like health care take place in a digitized context, and people in some areas of the country lack access to a connection, the divide between users in different geographies and socio-economic strata will grow. Fortunately, there are opportunities to engage this challenge.

To place the technical challenges ahead of us in context, consider that Nokia believes that we will see a more than 10,000 fold increase in the amount of traffic on networks over the next 5-10 years resulting from deeper penetration and uptake of mobile broadband, dramatic increases in connected devices and machines, the expansion of the industrial Internet, and connected transportation and health care among other applications. On the mobile broadband side, we believe that in order to accommodate the increase in traffic and the sensitivity of many emerging applications like autonomous driving cars and connected healthcare, network peak data rates will need to increase to more than 10 Gbit/sec (gigabytes per second) with at least 100 Mbit/sec everywhere in the network. For perspective, reaching that type of peak data rate

would require a jump potential a hundred or more fold from where we are today in many deployed networks.

The massive increase in capacity, and in coverage, needed to create a network environment capable of the foregoing will require substantial investment in infrastructure, particularly small cells and distributed antenna systems to "densify" network deployments. Densification of networks is a core strategy to elevate capacity and capability of wireless networks in order to reach latency (delay in packet transmission) levels below 1 millisecond, which will be necessary for many future use cases. For context, reported latency rates in US wireless networks during 2016 ranged from a low of 60 milliseconds in LTE networks to a high of 163 milliseconds in older 3G networks.[1] These are fast networks, and they do a great job of providing reliable wireless broadband service to consumers that support the voice, text, and video services for which they were designed. But, it is clear that significant upgrades are needed to reach a reality where zero fault tolerance applications like autonomous vehicles can be widely deployed.



Nokia view of 5G wireless network conditions and requirements

[1] See e.g., Comparisons of networks drawn from mobile subscribers at https://opensignal.com/reports/2016/02/usa/state-of-the-mobile-network/. Industry figures vary, and in many cases suggest even lower latency figures that continue to improve as additional investment is made.

The good news is that wireless carriers, large and small, in the U.S. are prepared to make the necessary investment and meet the challenge. In fact, broadband providers of all kinds including cable companies, utilities, municipalities, and cooperatives (which are an essential part of the rural broadband strategy) all stand ready to invest significantly in broadband infrastructure to support the foregoing vision of a connected society. However, the decisions made by regulators and legislators at the state level, and here in Washington will have a significant impact on their collective ability to deploy and continuously upgrade broadband infrastructure. Based on our experience as a major partner for companies and communities that deploy broadband technology, Nokia believes that there are three key things that policymakers need to be mindful of in fashioning regulatory and legislative actions if the true objective is to create an environment conducive to robust investment:

1) Regulatory policy impacts the ability of providers to monetize infrastructure investment and can be a major driver of costs and delays in broadband infrastructure deployment;

2) The relative health of the investment environment for broadband infrastructure is heavily influenced by regulatory activities as noted, but also by fiscal policy actions Congress may undertake such as an infrastructure bill and comprehensive tax reform; and

3) Emerging use cases are both a driver of broadband network requirements and consumer interest in, and adoption of the technology. Adoption rates are a key component of the business case for major infrastructure investment, particularly in rural and underserved areas. Industry and policymakers can do more to shape consumer expectations and uptake of the technology.

Regulatory policy impacts:

Over the last several years we have seen a major focus on regulatory policies like privacy and network neutrality here in Washington. These are important issues with a real need for clear standards and rigorous, predictable enforcement to provide consumers critical

protections. Unfortunately, they have also become a source of considerable uncertainty for markets. Nokia is not a broadband service provider, so when we look at issues like these it is to discern how rules and restrictions will shape the scope of our ongoing research and product development (such as research demand for additional computing power and analytics capabilities in our infrastructure solutions), and the market for broadband infrastructure more generally. And, there is a clear impact in our experience.

In the case of the FCC's now repealed broadband privacy rules, limitations on broadband service provider access to, and utilization of data that is routinely available to other technology companies in the ecosystem directly limited the capability of broadband providers to realize potential value creation opportunities in the future. And, that alters the value calculation that providers make in determining whether, and how much to invest in certain technologies. In the same way, the *ex ante* prohibition of innovative pricing models (for example fee based prioritization directly at the consumer's direction) under the net neutrality rules, and the inclusion of a nebulous "general conduct standard," in our judgment created a significant risk to broadband provider investment. The prohibition on new pricing options and the general conduct rule make any significant deviations from current practices in traffic management, data plan pricing, or creation of specialized services risky from a legal and regulatory standpoint. Those risks have been a regular discussion point between broadband providers and their suppliers, and have directly impacted product discussions including whether to continue developing specific features in new products and whether to move forward with specific deployment plans. Along with an observable decline in capital expenditures in the last two years, these developments are a clear indication of a negative impact on investment from the regulation.

My purpose in raising these two issues, which I understand to be the subject of very passionate debate, is not to make a normative judgment about what the FCC did, or should do, or even what Congress should do. Rather it is to bring the conversation to a point where there is an understanding that regulatory choices directly impact the decision making of private actors, and ultimately how capital expenditure decisions are made. To put a finer point on this, we note that there is a frequent focus on profit and loss statements of telecommunications providers in these debates: wherein we hear that profits are healthy therefore investment will continue to happen and regulatory factors have not impeded capital deployment. In our experience, profit is frequently not an accurate, or at least not a complete, barometer of the health of the investment environment. Indicators like average revenue per user (ARPU) and return on capital employed (ROCE) are more tightly linked to the investment decisions of broadband providers because they are measures of how well a provider is monetizing prior capital investment and what the returns on planned investment will be. When policy shocks occur, they directly impact the forecasts that providers have relied on in making capital decisions, and those decisions are then altered. Since the adoption of the network neutrality order in 2015, the ARPU of all but one US wireless carrier has declined as opportunities to introduce new sources of revenue were constrained.[2]

Whatever position one takes on the issues of privacy and net neutrality, and we take none here; restrictions on the ability to generate marginal revenue through certain innovative activities like data analytics and prioritization invariably impact the capital expenditure decision making because they limit the ability to fully and flexibly monetize marginal infrastructure investment. There is a range of very reasonable opinion about these issues. Our

[2] See https://www.statista.com/statistics/283513/arpu-top-wireless-carriers-us/

hope is that as Congress considers these issues moving forward, it will do so with careful deliberation on how a legislative solution (which we strongly favor) will balance consumer protections with the impact to the capital decision making of the very providers we want to invest in improving connectivity.

State and local: Regulatory issues at the state and local level will also impact the ability to deploy broadband infrastructure at levels necessary to realize the vision for a connected society. As I noted earlier, the next generation networks will depend on a massive deployment of new infrastructure. The need for this increased wireless infrastructure, and other necessary broadband infrastructure investment, has already reached a critical level. Unfortunately, Nokia has experienced first-hand the frustration of local coverage needs being thwarted by local siting practices. Common problems fall into several related, and overlapping categories, as follows:

- Undefined laws and processes and/or a lack of personnel;
- Redundant, fragmented procedures; and
- Onerous and prohibitive fees

In our experience, many jurisdictions have ill-defined processes for receiving and processing requests to site infrastructure. The lack of defined procedures leads to inefficiencies and haphazard results. We have found that jurisdictions that lack defined procedures are often not familiar with the legal landscape intended to remove barriers to deployment. As an example, although some larger cities are experienced with Section 6409(a) of the Spectrum Act, even those jurisdictions typically have not revised their processes to incorporate that law. Actions that qualify for 6409(a) streamlined treatment, nevertheless can be delayed by localities seeking modified lease terms, for instance, when attempting to negotiate a master agreement or franchise license prior to requesting regulatory siting approvals. Many local governments are using these master agreements as a substitute for a more comprehensive legal framework (effectively creating a de facto zoning ordinance via contract).

The lack of clear procedures makes the application process much more difficult from the beginning – it can be hard to know where to even start – let alone ultimately obtaining the required authorization to move forward. It is therefore not surprising that jurisdictions that suffer from ill-defined, haphazard processes also lack the employee resources to process siting requests. We understand that local jurisdictions often face budgetary constraints, however, lack of employee resources exacerbates a number of other impediments. Each unnecessary extra step (or steps) in the process that should result in modest delays can clog the deployment pipeline entirely when coupled with a lack of government personnel. In most cases, the overwhelming majority of the time necessary to deploy a small cell has nothing to do with the process for acquiring the equipment, installing it, or connecting it to power and backhaul: it is time spent obtaining review and approval.

In addition to process and personnel limitations, Nokia often experiences multi-layered review processes involving several agencies within a jurisdiction. This leads to review and approval timelines that are not easily discernable from one authority or interdepartmental agency to the next. In one major city example, the process is fairly well defined, but involves three or four different phases, which occur in seriatim instead of concurrently. While review times should be in the 90-day range, approval often takes double that, layering delay on top of delay. Depending on the number of site applications that are under review with the government, at any given time, the timelines to approval for the initial application can challenge the viability of the entire deployment.

Fees that are assessed for initial access, recurring access, and things like regulatory site inspections can threaten the economics of an entire deployment. Nokia, and our partners, have experienced site "inspection fees" of $3,000 or even $4,000 applicable to each location. These

per-location fees are particularly outrageous when put in the context of hundreds, or even thousands, of small cells planned for a single deployment. Many localities lack personnel to inspect individual macro-cell (large, frequently tower based) sites; so, the timeframes and expense that would be applied to small cell deployments under the current approval framework is a major concern. Notably, the $3,000-4,000 fees do not include other application fees and recurring fees associated with accessing the location.

The fee problem is further exacerbated by an emerging cottage industry of third party consultants who see the complexities of citywide deployments as a business opportunity, becoming a middleman. The goal of the consultant is often *not* to maximize connectivity, but rather to maximize city revenues. Consulting agreements also frequently provide broad marketing and management services rights that include revenue sharing options with the locality based on the lease terms that the third party is able to negotiate with the carrier. Nokia has recent experience with this problem. Consultants frequently enter the mix in preparation for major events that lead to short-lived local economic development initiatives. From a business perspective, a service provider may plan to build for the longer term, with infrastructure intended to benefit a community long after the event is over. Yet consultants often push for higher fees for these temporary high profile projects, and the result is we do not achieve the type of long-term economic development that would better serve residents and businesses.

Once higher fees are charged due to an event-specific deployment, those rates then become precedent, and set a rate floor for future deployments, not just in that particular city, but also in other locations where the consultants are working. In multiple cities where Nokia has participated in preparations for a short-lived event, we have found the elevated fees to be

prohibitive and backed away from participation only later to see those elevated fees cited by consultants to localities as a benchmark for other longer term deployment projects.

Nokia certainly understands that thinly staffed localities would turn to such consultants with promises of generating additional revenue for city activities. And, there is some value in the temporary use of third parties to process applications and negotiate rates in reducing delays from personnel shortages, provided that the third parties have experience in the issues involved and are truly temporary to deal with the short-term expected surge in applications for small cell deployments. The risk, however, is that the ultimate beneficiary of this arrangement is the consultant, and the citizenry loses through less robust deployment and higher subscription fees needed to support the expensive rights-of-way fees the consultant extracts. The introduction of a new layer of participant, the contracted consultant, with their own profit motivations skews the charges assessed against network operators and equipment vendors even further from the "cost recovery" level. Taken with the sheer number of small cells and distributed antenna systems ("DAS") that are planned for 5G network densification efforts, the consultant-driven costs provide an almost insurmountable barrier to deployment in many jurisdictions.

The use of consultants has moved well beyond the events context, and is now proliferating across a widening geography. As noted, these consultants have an incentive to drive up the fees assessed in each subsequent jurisdiction to leverage ever increasing fees for their own financial gain due to the nature of their retention agreement compensation terms. Each locality becomes the new benchmark for the next consulting contract, driving rates ever higher. Nokia believes that the FCC and Congress should view the hiring of such consultants to negotiate siting rates skeptically. This type of retention becomes counter to the objective of

facilitating broadband deployment when win bonuses or other fee level based compensation are utilized. Nokia therefore has told the FCC in written comments to find that this type of compensation is not appropriate and may be a basis for applicants in impacted jurisdictions to obtain relief from the Commission. We have attached an example of marketing materials representative of the kind these consultants send out to cities as an exhibit. Revenue sharing and the maximization of revenues are featured prominently, to further our point.

There are several additional challenges Nokia sees in the deployment of infrastructure, many of which have been noted to, and are being examined by, the FCC. These include: 1) total moratoria on deployments in some jurisdictions, 2) severe restrictions on the size of new equipment or the imposition of restrictions or new fees on modifications to existing deployments, and 3) utterly uneconomic per site access fees (initial and recurring charges) in many cases assessed on a per pole or point basis. Just some examples cited to the FCC in its previous proceeding looking at these issues:

> Moratoria: An Illinois city has denied all permits to locate small cells along ROWs. Another city in that state is refusing to process permit applications until it can enact a new ordinance on small cells. A Florida county has a moratorium blocking all ROW installations. There could be as many as 17 other city or county moratoria in Florida.
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> Partial restrictions and arbitrary conditions:

- Texas city is refusing to allow any wireless facilities in ROWs;
- New Jersey city requires a public bidding process to attach facilities to utility poles but has failed to seek bids for more than six months;
- Several California cities require providers to demonstrate gaps in service coverage as a condition of ROW access;
- Florida city limits the number of small cell installations (regardless of the number of providers) to 13 sites in one square mile;
- Several Illinois jurisdictions impose minimum distance requirements of up to 1,000 feet between small cell installations, even when the installations serve different wireless providers;
- Other jurisdictions impose limitations on the height of poles that can house small cell infrastructure.

> Fee examples:

- California city is demanding up to $20,000 in annual ROW fees. Two other California cities charge ROW fees per pole of over $1,000 per month and $2,300 per month respectively;
- A Massachusetts city requires a $5,000 up-front fee before it will negotiate an ROW use agreement. Another city in that state is demanding a $6,000 per pole annual fee;
- A Minnesota city is demanding a $6,000 annual per pole fee;
- An Oklahoma city charges more than $2,500 per year per small cell;
- A company that holds a contract with New York to manage wireless facilities is demanding fees of $9,000 per year for small cells;
- The New Jersey Department of Transportation is requesting $37,000 per year per for each new facility located in state highway ROWs; and
- The Virginia Department of Transportation charges $24,000 per year for each new structure in state highway ROWs.

From Nokia's perspective, it is quite clear that major federal action is required to alleviate these barriers to deployment. The form of that action is no doubt going to be a contentious give and take with some preferring broad federal preemption of state and local time, place and manner regulation and others suggesting we need to respect local autonomy. Nokia's view is that neither extreme is a good policy solution. It is quite true that states and localities have an interest in public health and safety and the use of their local regulatory authority to advance those interests. However, it is also quite clear that many practices, including those that I have cited, are conspiring to create an environment that is deeply adverse to the Committee's stated interest of broadband deployment. And, these practices are not isolated; they are spread across many states and localities of all shapes and sizes. So, what can be done about this? Nokia suggests the following:

- Highlight the broad benefits to the public that will come with the densification of infrastructure deployments, things that are not possible today but can be a reality in a connected society. There is an excellent report from Accenture attached to my testimony that further highlights this;
- Allow the FCC's refreshed proceeding on these issues to proceed, and encourage the Commission to look at ways to highlight not just the practices noted above, but also best practices of local authorities. There are some that have been very forward leaning in streamlining regulatory processes. Some states have adopted comprehensive legislation and some localities interested in Smart City

deployments have worked to streamline bureaucratic process. These should be examples that we highlight;

Notably, while Nokia supports state level legislation, we do not believe that this is the optimal solution as a stand-alone strategy. Network deployments are not planned on a city-by-city, or even state-by-state basis. Uniformity, efficiency, and economic viability of broadband deployment likely require a federal solution;

- Congress should consider changes to the Communications Act, particularly in Sections 253 and 332 that further clarify and strengthen the FCC's authority to provide a backstop to unreasonable local rules. Whether the result of the FCC's process will be broadly applied shot clocks, fee limitations, and other restrictions, or more of a model template of practices backed by a case-by-case review and approval in the event of unreasonable and non-compliant practices, it is clear that something must be done.

Investment environment

While awareness of how regulatory actions can impact the incentive and opportunity to invest is crucial, these are not the only policy considerations currently before this Congress that could impact the future of broadband deployment in the United States. The House of Representatives will consider comprehensive tax reform, likely later this year, and two proposals in particular that are part of those discussions could have lasting negative consequences for broadband investment. First, there is a policy proposal to limit or even eliminate interest deductibility for businesses. Second, there is also a policy proposal to impose border adjustment (so called import) taxes. Each of these would have a major impact on the financial decision making of broadband providers.

The House suggestion to limit interest deductibility is married to another proposal, to change the period of so-called "expensing" or depreciation such that companies could expense 100 percent of the equipment up front rather than depreciating it over a longer period (typically 5-7 years in our industry). It is important to note that while beneficial, the move to the 100 percent expensing model does not change how much money a company may receive in a tax benefit, it simply shifts the money into an upfront time period. Companies will get the

same tax benefit as under current law, just faster. By contrast, limiting or eliminating interest deductibility would eliminate billions of dollars worth of current tax benefit (and therefore money available for investment) *permanently*. Put in very simple terms, any entity that relies primarily on debt instruments to finance capital expenditure would see their net cost of borrowing increase due to the loss of interest deductibility. And that means less dollars, billions of them, for broadband infrastructure deployment.

Critically, there are many entities currently involved in providing broadband services, from cable companies and utilities to cooperatives and privately held telecommunications companies that borrow to build. And when they borrow they do not do so for a single deployment, they do so for each capital deployment be it for upgrades or expansion of their network to cover new areas. Therefore, the loss of interest deductibility will impact those companies each time they tap the debt market. For many of these providers, funding investment entirely out of current revenues is not an option, nor is tapping the equity market by offering additional stock for sale. Many are not publicly traded, and among those that are, some cannot realistically dilute the value of their stock by releasing more shares. Debt financing has emerged as a widely employed, rational business approach. Upending that through tax reform will drain tens of billions of dollars out of future investment in broadband networks across utilities, cooperatives, small and mid-sized telcos and many cable providers. While Nokia understands tax reform is a complex undertaking with many tradeoffs, we feel strongly this should **not** be one of them.

There has likewise been significant discussion about the imposition of an import tax as much as 20 percent. As Congress considers tax reform, it is important to recognize how the current supply chain for broadband components and finished products is constructed. While

the United States is home to many research facilities (including some of Nokia's), software development centers, and even component manufacturing, it is also true that many of the thousands of components that make up broadband infrastructure solutions originate outside the U.S. Current ITA agreements and other exemptions have limited the duties assessed against these components, and the result has been lower cost equipment. If Congress imposes a border adjustment tax and/or eliminates the exemptions for electronics and broadband components, the result will be much higher prices for equipment either through duties, or through changes to supply chains to work around those country specific duties that impose higher costs. In turn, the ability of broadband providers to execute their broad deployment plans will be impacted. Again, we understand that tax reform is complicated; we are highlighting the impact to the stated equity of the Committee to improve broadband deployment. While the tax code is not a current barrier to deployment, it could quickly become so if members are not cognizant of the impact of these proposals.

Use cases and adoption

In today's world, we cannot have a discussion on how to encourage and improve broadband deployment in the United States without taking into consideration the growing Internet of Things ("IoT") ecosystem and the transformation of the global economy into the Digital Economy. These are fundamental to demonstrating value and generating enthusiasm among consumers that will further encourage adoption of broadband technology. A core consideration of broadband deployment in rural areas is how many potential users will actually adopt and use the technology if network investment is undertaken. It is a key metric in the business case for deployment, and industry must do a better job of both developing the use cases that create interest and value for consumers, and raising awareness of the same.

The growing demand for connectivity and the digitalization of our day-to-day activities will require policy makers to think differently. At Nokia, we are working to build proven IoT use-cases around the world, particularly in the digital health, transportation, public safety, and smart cities areas. For example, Smart City use-cases require expertise that spans many different fields including finance, planning, transport, energy, safety, telecommunications and more. They also require public–private partnerships (PPPs) that embrace all of these different dimensions. The IoT smart city concept, as other verticals, is a holistic and layered framework that addresses the needs of multiple aspects of smart city projects and allows cities to use urban data to boost economic competitiveness, and build more effective, workable solutions to many city challenges. Along the way, we have seen numerous challenges including some of the regulatory issues I cited previously and others: difficulty in figuring out how to replicate and scale IoT Smart City solutions to different sized cities; layers of stakeholders; lack of technical expertise at the local level; and very challenging procurement environments.

Solutions:

1. Encourage Increased Innovation and Investment**:** policies should seek to encourage innovation and investment through such tools as: collaboration with industry, academia, and other key stakeholders; empowering CIOs and senior city government leadership; R&D investment across vertical sectors; and review of existing laws and regulations before adopting new ones;
2. 5G wireless networks will be a key element in realizing the Internet of Things' promise – Congress can enable test beds in the U.S. Infrastructure – The Federal Government should make additional spectrum available for mobile broadband, implement effective spectrum management programs, and incentivize investment in network infrastructure;
3. Public-Private Partnerships – The Federal Government should incentivize the use of public-private partnerships as a means to accelerate IoT development and adoption, and US global leadership;
4. Funding IoT/connectivity: As Congress considers an infrastructure bill and future funding legislation, we are mindful of the challenges. However, to the extent funding may be available either through redirecting current program activities or creating new ones, Nokia suggests:
    - Funding local government efforts to implement connected technologies and services;

- Funding large-scale national pilot projects for smart cities that focus on integrating multiple smart city applications with scalable and replicable solutions;
- Establishing national challenges with prizes to spur the development of IoT applications with high social or economic impact;
- Funding R&D for key underlying technological challenges relevant to the Internet of Things, such as improving cyber security and reducing power consumption;

We are supportive of many existing federal programs such as the FCC's CAF program, the rural utility service and others (even those we think need reform). To the extent Congress considers an infrastructure bill, we are supportive of additional funding through grants or tax policy that can lead to additional, targeted broadband infrastructure investment. But, to be clear, in an environment of scarce fiscal resources we believe priority should be given to the priorities we listed.

Thank you again for the opportunity to testify before the Committee.