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National Telecommunications and Information Administration (NTIA)
US Department of Commerce
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Washington, DC 20230

Subject: Response from Ligado Networks to NTIA Request for Comments on the Benefits, Challenges, and Potential Roles for the Government in Fostering the Advancement of the Internet of Things (Docket No. 160331306–6306–01 / RIN 0660–XC024)

To Whom It May Concern:

Ligado Networks thanks the NTIA for its focus on enabling the Internet of Things (IoT) and for the opportunity to comment on this topic of critical importance to United States (US) leadership in technology and innovation.

IoT represents a simple concept: interconnecting machines, devices, and end points in order to transmit information with limited human intervention. However, its applications across use cases and industries, including manufacturing, agriculture, transportation, public safety, autonomous systems, healthcare, and critical infrastructure, have the potential to create dramatic economic and social benefits for the US. These benefits can accelerate US global competitiveness, technological leadership, and economic stability well into the 21st century.[1]

US leadership in IoT requires the development of advanced networks that offer the coverage, capacity, and security essential to successfully enable a broad range of IoT

[1] Accenture: Winning with the Industrial Internet of Things, http://www.accenture.com/us-en/insight-industrial-internet-of-things

applications. Industry, with support and encouragement from the NTIA and FCC, has addressed similar challenges in the past, and is fully capable of shaping a vibrant IoT ecosystem. As the NTIA explores the role of government in fostering the development of IoT, Ligado Networks urges it to promote the development of multi-tiered, heterogeneous networks that can deliver critical capabilities to achieve the transformative benefits of IoT and serve many emerging fifth-generation (5G) use cases.

As a leading innovator in heterogeneous satellite networks, Ligado Networks offers the following comments for NTIA's consideration. First, we propose a clear definition for IoT, including its five most important characteristics, and describe the factors essential to its development. Second, we characterize the most significant technological challenges affecting US leadership in developing a vibrant IoT ecosystem. Third, we articulate a bold, yet realistic vision for IoT through a characterization of its benefits to US economic vibrancy. Our full comments are included in the following pages.

1. Defining the Internet of Things (IoT)

1.1 The Internet of Things (IoT) is heterogeneous and offers the potential to enable a diverse set of innovative solutions to improve economic and societal performance

Conceptually, IoT refers to an interconnected network of intelligent 'objects,' including communication devices, sensors, and actuators, capable of sending and/or receiving information with or without ongoing human intervention. We believe that IoT can be viewed across three dimensions, as depicted in Figure 1.

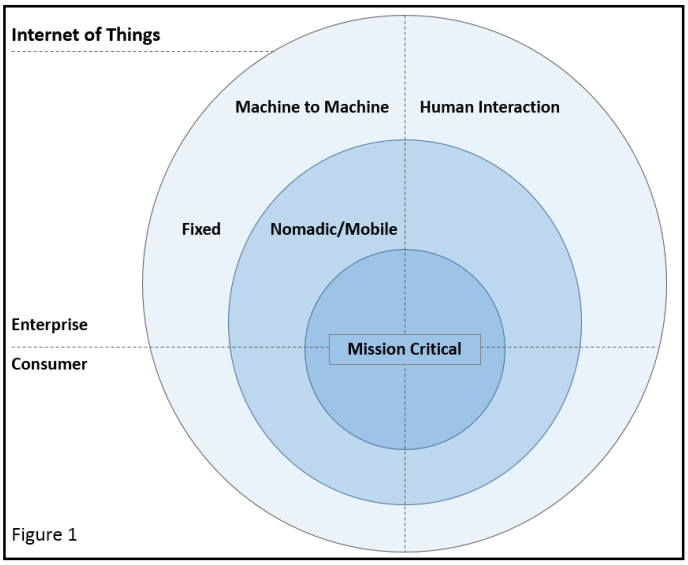

Figure 1

First, IoT encompasses both Machine to Machine (M2M) devices, which do not require ongoing human interaction, as well as other, more traditional devices which offer varying degrees of human interaction through one or more input and / or output nodes. Second, each category of IoT devices may also include either fixed devices, which are installed in a permanent location, or nomadic / mobile devices, which require a portable, often wireless connection. Third, and most importantly, the IoT ecosystem depicted in Figure 1 reflects multiple classes of devices with various levels of criticality for their communications: these include devices which are part of our everyday lives, and those which support critical elements of life, safety, and security. We believe that this latter segment of devices, which represent

'mission-critical' things, has the power to revolutionize applications related to national security and public safety, critical infrastructure security and efficiency, and economic competitiveness.

In order to deploy an IoT ecosystem capable of supporting these critical things, Ligado Networks believes IoT-centric networks must deliver five key characteristics: pervasive connectivity, ultra-reliability, peer-to-peer connections, precision location, and end-to-end security.

Pervasive Connectivity: Seamless network connectivity across geographies and populations is essential to the success of IoT deployment. Supporting this connectivity across a wide variety of economic and social applications requires flexible networks that are multi-tiered and heterogeneous. Hybrid satellite-terrestrial networks – supporting both broadcast and unicast satellite services in parallel with terrestrial operations / augmentation – are ideal to ensure pervasive and highly reliable connectivity.

Ultra-Reliability: Mission-critical IoT applications require constant network communication, making ultra-reliability crucial to their success. Objects communicating real-time military, air traffic control, and healthcare information, to name just a few critical applications, will be limited in their usefulness by the dependability of their connections. Interference and latency are examples of issues that could affect networks, and providers must overcome or mitigate these issues to provide ultra-reliable service.

Peer-to-Peer (P2P) Communications: As IoT applications unfold and the number of connected objects grows, device-to-device communication is essential for automated

information exchange, enhanced connectivity, and mesh network reliability. These capabilities may also help reduce network congestion and latency.

Precision Location: Centimeter-level accuracy is an important characteristic for a wide array of IoT applications including construction, healthcare, transportation, precision agriculture, and disaster relief. Advanced, IoT-centric networks must overcome known constraints within current GPS technology, including precise location identification and poor coverage when devices are located indoors or subject to inclement weather conditions. IoT networks can achieve this level of precision by augmenting current GPS systems with hybrid satellite and terrestrial networks.

End-to-End Security: Security is critical to information transmission. The IoT ecosystem will include an increasingly dense network of connected objects, and it is essential to protect the network from security issues, such as spoofing and hacking, which could lead to catastrophic consequences. The implementation of identity management and predictive analytics technologies are useful for recognizing potential breaches before they can be exploited.[2] In addition, certain types of networks are more naturally suited for secure transmissions; for instance, satellite networks, with fewer access points for breach, are inherently more secure than most terrestrial networks.[3]

The proliferation of IoT represents a paradigm shift for society and commerce in the United States and around the globe. The dramatic increase in the visibility and connectivity of

[2] IBM, Stay ahead of cyber attacks and fraud with predictive analytics, http://www.ibmbigdatahub.com/blog/stay-ahead-cyber-attacks-and-fraud-predictive-analytics

[3] iDirect : Satellite Basics, http://www.idirect.net/Company/Resource-Center/~/media/Files/Corporate/iDirect%20Satellite%20Basics.pdf

objects in our midst will create an unprecedented level of transformation in both the public and private sectors, improving quality of life, enabling new services, increasing economic productivity and efficiency, and addressing societal challenges.[4]

Next-generation, IoT-centric networks, including Ligado's hybrid satellite network service offerings, can enable some of the most transformative next-generation/5G use cases. However, policymakers must support efficient use of existing spectrum assets, particularly those in the mid-band, to develop the 5G network capabilities that will allow providers to deliver the full potential of IoT.

Advanced hybrid terrestrial-satellite networks, optimized for IoT, can start to address next-generation/5G connectivity requirements across the ecosystem of mission-critical things. We are developing the leading hybrid satellite-terrestrial network architecture and optimizing it to deliver ultra-reliable, highly secure, and pervasive connectivity. Our unique capabilities allow us to provide service in regions that aren't covered by traditional operators, which overlook regions of low population density where much of the ecosystem of mission-critical things will originate. Although 4G wireless networks provide service to 98% of the US population, they cover just 20% of the nation's geographical area.[5] Critical IOT endpoints, both mobile and infrastructural, are more widely distributed than is the population and the transformative utility of IOT will require pervasive connectivity that only hybrid networks can deliver.

[4] GSMA Report: The Impact of the Internet of Things:
http://www.gsma.com/newsroom/wp-content/uploads/15625-Connected-Living-Report.pdf
[5] US Department of Homeland Security, Tech Note, http://www.firstresponder.gov/SAVER/Documents/4G-Routers_TN_1215-508.pdf

1.2 The correct balance of industry and government leadership is essential to the development of a vibrant IoT ecosystem

The IoT ecosystem in the United States today is in the early stages of its development. Its emerging status presents industry and government with unique opportunities and challenges to shape further development and deployment. Despite an unstructured environment and uncertainty around the way forward, many elements of the IoT ecosystem are beginning to materialize. Current projections predict 21 billion IoT devices will be installed globally by 2020,[6] with over $6 trillion invested in IoT infrastructure over the same period.[7]

Past generations of communications network deployments provide strong evidence of industry's ability to anticipate and satisfy demand for products and services. This success is predicated on government's successful development of forward-looking regulatory frameworks that provide flexibility and enable industry's innovation and development of new technologies. Evidence of this successful collaboration is reflected in clear US leadership in the development and deployment of 4G. In fact, CTIA recognizes that the US was "one of the first countries to deploy 4G LTE starting in 2010 and has expanded coverage, deployed advanced technology, and enabled high speed broadband networks to stay at the forefront."[8]

Through a well-developed regulatory framework that supports efficient and flexible use of spectrum, including sharing in some bands and advanced planning for auctions, US industry

[6] Gartner, Gartner Says 6.4 Billion Connected "Things" Will Be in Use in 2016, Up 30 Percent From 2015, http://www.gartner.com/newsroom/id/3165317
[7] PwC, The Industrial Internet of Things, http://www.pwc.com/gx/en/communications/pdf/industrial-internet-of-things.pdf
[8] CTIA, The U.S. is a Global Leader in 4G LTE, http://www.ctialatest.org/2015/09/25/the-us-is-a-global-leader-in-4g-lte/

has led globally in technology innovation and service development. In addition, NTIA and FCC encouragement of a competitive marketplace and a neutral approach towards individual technologies and architectures has resulted in service provider experimentation, the evolution of a heterogeneous and multi-layered 4G network, and widespread availability of compatible devices. Likewise, the success of the US IoT ecosystem will depend on continued collaboration between industry and government to encourage the formation of competitive markets and support the efficient use of spectrum for IoT applications.

Industry must take the lead, with strong support from government, to develop networks that offer pervasive and ultra-reliable access to services and address cybersecurity and privacy concerns. Industry and government have faced similar challenges in the past and, through partnership, are well-equipped to respond in order to carry this momentum forward, once again positioning the US to maintain its leadership position and capture the extensive benefits of a vibrant telecommunications sector.

1.3 IoT offers the opportunity to enhance US global competitiveness and economic growth

IoT is unquestionably the next evolution in telecommunications, offering the potential to fundamentally change both industry and society. Through efficient and flexible use of our nation's existing spectrum allocations and position as a technology innovator, IoT can create new, high-value jobs across industries and regions. Just two decades ago, US investment in the proliferation of the Internet stimulated far-reaching benefits, increasing manufacturing incomes and creating jobs in industries such as semiconductors, computing, and information services.[9]

[9] McKinsey, Internet Matters: The Net's Sweeping Impact on Growth, Jobs, and Prosperity

IoT is expected to yield similar benefits; in fact, Industrial IoT applications alone are expected to add $14.2 trillion to the US economy by 2030.[10]

The US must act quickly to maintain its position as a global leader in Internet technology, as the world universally embraces and implements IoT. Industry and government must be proactive and expeditious in bringing more licensed spectrum to market and incentivizing greenfield network deployments to enable the US IoT ecosystem to reach its full potential.

2. Technical Initiatives Required to Enable US Leadership in IoT

2.1 Existing licensed spectrum should be efficiently used for maximum utilization

The NTIA and FCC should be commended for proactively managing processes to efficiently and effectively put spectrum to highest social and economic use. The successful development of a vibrant IoT ecosystem will hinge on similar planning to make current spectrum assets available for next-generation/5G networks that will serve the growing IoT market. Pervasive, reliable, secure, and cost-effective connectivity is critical to satisfy coverage and capacity demands from IoT objects in both enterprise and consumer applications, and government must prioritize efficient use and promote spectrum-sharing for of this increasingly scarce resource to shape a thriving IoT ecosystem.

Availability of licensed, mid-band spectrum is particularly critical to accelerate the delivery of mission-critical services for national security and public safety, infrastructure, and

http://www.mckinsey.com/industries/high-tech/our-insights/internet-matters

[10] Accenture, Growth game-changer drives progress and prosperity, http://www.accenture.com/us-en/insight-industrial-internet-things-growth-game-changer

mission-critical applications. The NTIA should collaborate with other government agencies to prioritize flexible use of mid-band spectrum across multi-layered networks thereby accelerating the growth of critical IoT applications, which depend on ultra-reliable, highly-secure, and capacity-rich connectivity. Delays in permitting terrestrial use of mid-band spectrum will only impede the development of greenfield networks optimized to deliver mission-critical IoT services.

2.2 Addressing cybersecurity concerns is critical to support widespread adoption of IoT

As the IoT ecosystem scales, especially around mission-critical applications, proactive and well-designed cybersecurity standards will become essential to overall ecosystem stability. Data risks in next-generation IoT will increase, due to the diversity and volume of devices and networks that can be breached. Hybrid satellite terrestrial networks with advanced technology will enable more secure transmissions. Satellite systems inherently have fewer access points for breach, while terrestrial network augmentations are greenfield deployments that can more readily implement advanced end-to-end security architecture.

Cybersecurity is especially significant as IoT is adopted across multiple industries. Objects performing mission-critical tasks in high-stakes environments are prime targets for attacks, and the consequences of a breach in national security and critical infrastructure applications could be dire. Conservative estimates of the economic impact from cyber-attacks put the losses at $100 billion annually, and could increase significantly with the growth of IoT devices.[11] Industry

[11] AFCEA International Cyber Committee, The Economics of Cybersecurity, http://www.afcea.org/committees/cyber/documents/CyberEconfinal.pdf

and government, with support from NIST, NTIA, and FCC, should continue to collaborate to develop security standards for next-generation IoT.

Standards for end-to-end security, including data encryption, integrity, and source authentication, as well as pervasive connectivity are critical components of building a secure and robust IoT ecosystem. Greenfield deployments, where key cyber and privacy considerations are factored into the original design, can prioritize implementation of such new security standards. Establishing standards in the early stages of IoT proliferation will accelerate adoption across industries and minimize the potential for damage from incidents along the way.

2.3 Networks should possess the capability to prioritize devices, applications, and services to manage increased demand

IoT objects that support mission-critical applications rely on pervasive and ultra-reliable connections. As billions of objects, many of which require uninterrupted and pervasive connectivity, join IoT networks, greenfield deployments can successfully optimize for capacity, coverage, security, and latency requirements and prioritize across application and service needs. Ligado Networks agrees with industry and government stakeholders on the importance of dynamically managing service demands for mission-critical users based along the following prioritization:

1. **National Security:** Protect the US homeland from internal and/or external threats; enable priority access for national intelligence, military, and law enforcement users
2. **Public Safety:** Enable first responders to provide law enforcement, disaster response, and emergency services to regional and local populations

3. **Critical Infrastructure:** Support national, regional, and local infrastructure integrity, including the power grid, hospitals, and roadways / bridges
4. **Transportation and Commercial:** aviation, automotive, commercial transportation, rail, maritime, and UAS enablement – aerial or terrestrial

Industry also needs to develop and support solutions for offloading data based on demand and category of use. Optimizing for data compression, buffering, filtering, and transmission is crucial. For example, national security applications cannot experience delays without losses, whereas consumer applications such as home temperature controls can tolerate elevated buffering and filtering of data transmissions. IoT networks must scale with demand and utilize a flexible architecture to enable truly ubiquitous coverage. As greenfield deployments emerge, industry should prioritize and government should encourage the networks best suited to prioritizing / offloading information, such as hybrid terrestrial-satellite networks.

3. Economic Benefits of US Leadership in IoT

3.1 Industry and government should shape the IoT ecosystem by leading in spectrum allocation, policy creation, innovation, and collaboration

US leadership in developing and deploying a vibrant and state-of-the-art IoT ecosystem is an essential element of maintaining our nation's global competitiveness in the 21st century. The NTIA and FCC should collaborate with industry and play a significant role in four critical areas that will shape the IoT environment – spectrum, policy, innovation, and collaboration.

Efficient use of spectrum is critical to meet IoT network demands: The NTIA and FCC have been remarkably proactive in finding innovative ways to allocate spectrum through auctions and spectrum sharing to providers who can make the most effective use of these assets. Government should continue to promote flexible spectrum use and encourage the proliferation of advanced networks required for the 5G future. Simply put, next-generation mobile networks need new real estate – greenfield spectrum not currently in use – if we are to successfully build advanced IoT networks.

Critical to the efficient use of spectrum is that different frequencies are deployed in ways that exploit their comparative advantages. Longer distance communications (over many miles) should take place on lower band spectrum that is best used in coverage type networks. Shorter distance communications (over several miles) should utilize mid-band spectrum best suited for flexible coverage and capacity use. Very short distance communications (well under a mile) should take place on very high frequencies with wider channels that support the greatest capacities. Only by utilizing such network architecture will spectrum be put to its most efficient uses.

Thanks to the leadership of the NTIA and FCC, policy makers have already begun to open the new frontier of very high frequencies for millimeter wave length radio waves. And the first-ever auction of low-band broadcast spectrum is now underway offering as much as 100 MHz of spectrum currently used by television stations for wireless use. The missing piece in all this is the creation of ample new mid-band spectrum to be used for mission-critical IoT applications and 5G. Ligado Networks envisions using its mid-band spectrum across terrestrial

and satellite architectures to develop heterogeneous, multi-layered networks that are optimized for IoT capacity and coverage requirements.

Set open, constructive policy to foster IoT growth: An open regulatory environment and favorable policy guidelines are essential to advancing large scale IoT adoption across industries. The NTIA and FCC should work with stakeholders from industry, consumer protection, and other groups to define appropriate standards for data privacy and information security. By establishing a regulatory framework to address these challenges, the development of the IoT ecosystem will accelerate through industry's investments in and deployment of critical IoT applications.

Encourage network innovation to support IoT development: A broad range of technologies are essential to evolving the networks that underlie the IoT ecosystem. Industry has a proven record of developing and deploying technologies that meet end user needs through market-based dynamics. The NTIA and FCC should encourage this experimentation across technologies and allow the market to determine the best solutions to serve end user needs.

The evolution of the networks that support IoT will be unlike those that evolved to support voice and data wireless communications. Not only will IoT networks serve devices, not people, but they also can serve all geographies broadening the availability of new, differentiated network capabilities uniquely delivered by a hybrid satellite-terrestrial network. Existing wireless carriers are likely to prioritize existing terrestrial assets on their current footprints, which do not currently reach all geographies. The NTIA and FCC can encourage the advancement

of hybrid network technology to accelerate the deployment of next-generation/5G IoT solutions across high-potential applications in the near future.

Promote collaboration among industry and government: Long-term success for the US IoT ecosystem requires partnership between industry, the NTIA, and the FCC. Industry must lead in identifying and executing on an IoT vision that results in a robust ecosystem, capable of harnessing intelligent analytics and big data. Simultaneously, a public policy framework developed by NTIA and the FCC must promote critical capabilities, including privacy and security.

3.2 The proliferation of IoT will fuel economic growth across a wide range of industries

The arrival of IoT represents a transformative shift for the economy. Through mission-critical IoT applications across a wide range of industries, the US can reap significant economic benefits, including increased competitiveness in domestic manufacturing, improved natural resource utilization in agriculture, and the creation of higher value jobs that rely on academic backgrounds in STEM: science, technology, engineering, and math.

While IoT connectivity in both enterprise and consumer settings will likely become pervasive in the next decade, the most significant value for the US economy will result from enterprise IoT applications, particularly those that focus on industrials such as manufacturing, agriculture, and infrastructure. The pace of change across industries will be rapid, with analysts predicting IoT hardware spending in excess of $2.5 million per minute by 2016.[12] Similarly, the number of discrete devices connected to the IoT ecosystem is projected to reach 21 billion by

[12] Gartner, Gartner Says It's Not Just About Big Data; It's What You Do With It: Welcome to the Algorithmic Economy, http://www.gartner.com/newsroom/id/3142917

2020,[13] with two-thirds representing “things” that monitor, control, analyze, and optimize the world.[14]

IoT deployment will catalyze the advent of Industry 4.0 and promote US economic competitiveness in the industrials sectors: manufacturing, transportation, infrastructure, energy, and agriculture, among others. The term ‘Industry 4.0’ refers to the combination of several major innovations in digital technology, all now coming to maturity, poised to transform the energy and manufacturing sectors.[15] These technologies include advanced robotics and artificial intelligence; sophisticated sensors; cloud computing; data capture and analytics; digital fabrication; software-as-a-service and other new marketing models; platforms that use algorithms to direct motor vehicles; and the embedding of all these elements in an interoperable global value chain, shared by many companies from many countries. While these technologies are often thought of separately, when joined together they integrate the physical and virtual worlds. This change enables a powerful new way of organizing global operations: bringing speed of software to large-scale machine production. The tangible benefits of IoT, including lower production costs, higher crop yields, and reduction in traffic accidents, are significant. Several examples, which can be applied through advanced networks, include:

IoT applications in manufacturing are projected to create $2.3 trillion in global value by 2025:[16] This value is primarily driven by data generated and collected through smart sensors

[13] Gartner, Gartner Says 6.4 Billion Connected "Things" Will Be in Use in 2016, Up 30 Percent From 2015, http://www.gartner.com/newsroom/id/3165317
[14] Strategy + Business, A Strategist’s Guide to the Internet of Things, http://www.strategy-business.com/article/00294?gko=a9303
[15] Strategy + Business, A Strategist’s Guide to Industry 4.0, http://www.strategy-business.com/article/A-Strategists-Guide-to-Industry-4.0
[16] Intel, A Guide to the Internet of Things, http://www.intel.com/content/dam/www/public/us/en/images/iot/guide-to-iot-infographic.png

installed across the production value chain, which will enhance operating practices, detect maintenance issues, automate procedures, and safeguard workers.

Through these advances, US manufacturers will gain a significant competitive advantage by lowering costs and enabling production efficiencies, reinvigorating domestic production, and allowing US manufacturers to compete with low-cost manufacturers globally. Further, the deployment and management of IoT in manufacturing will create demand for next-generation high-skilled jobs. Nearly 25% of all manufacturers have begun implementing IoT technologies, and the number of participants is expected to reach 80% by 2025.[17]

IoT applications in agriculture are anticipated to generate $100 billion in benefits by 2025:[18] Improvements in smart farming, applied through sensors to gather detailed data ranging from soil moisture and nutrient level to optimal harvest times, will provide higher crop yields and improved resource conservation. Because less than two percent of the US population now works in agriculture, these benefits are amplified by enabling ever-greater output from very finite field space.

IoT applications through autonomous vehicles are anticipated to create $871 billion in social benefits annually: The scope of automation is broad, including the calculation of a score that warns of bad drivers nearby to real time, navigation systems that suggest safer alternative routes, real-time traffic management to alleviate traffic jams, and P2P-enabled automation that helps vehicles avoid traffic accidents altogether, potentially eliminating the $871 billion annual

[17] U.K. Government Office for Science, The Internet of Things Report, http://www.intel.com/content/dam/www/public/us/en/images/iot/guide-to-iot-infographic.png

[18] McKinsey, Disruptive Technologies, http://www.mckinsey.com/business-functions/business-technology/our-insights/disruptive-technologies

cost of vehicular crashes in the US.[19] Ultimately, IoT-enabled automation will allow cars to operate completely independently to transport people and things, serving as taxis, buses, and delivery vehicles.

As a pervasively-connected IoT ecosystem enables autonomous vehicles, additional revenue opportunities will emerge for businesses that are willing to subsidize the cost of a car in order to capture the lifetime value of a connected driver, as well as for local municipalities that capture usage data to assign taxes based on consumption. Society stands to benefit a great deal from these new applications, providing greater safety and productivity.

While industry is leading the effort to make this vision a reality, government has the opportunity to lay the groundwork through investment in smart highway infrastructure and roadway electronics. The construction of NRTK (Network Real Time Kinematic) can add an enhanced level of precision to this "smart" infrastructure. An RTK network provides superior precision location, using a network of reference stations to send correction information to devices that allow for refinement of an object's position, correcting for minor errors due to weather and signal distortions. Government encouragement of this technology can support a variety of IoT applications that will require precise location to function properly.

The advent of smart cities will allow municipalities to share information across departments and services: Smart cities refer to advanced urban developments that will share information among public assets, including emergency response teams, water facilities,

[19] U.S. Department of Transportation, NHTSA, The Economic and Societal Impact of Motor Vehicle Crashes: http://www-nrd.nhtsa.dot.gov/Pubs/812013.pdf

libraries, and many others. Smart cities will evolve at different rates and in manners unique to their geographic locations. Like cities today, smart cities will be heterogeneous. Deployments in densely populated urban centers such as New York and Los Angeles will require vastly different infrastructure than those serving suburban and rural geographies. Objects providing information to emergency responders, utilities providers, and transportation operators should be using connected networks of different types to ensure pervasive, ultra-reliable, and secure connections. The US can take a proactive approach in preparing for smart cities to ensure the proper infrastructure is deployed to support their growth.

3.3 Industry and government can effectively encourage IoT innovation by fostering a competitive market for network services

The sustainable vibrancy of the IoT ecosystem requires a competitive market for network services that encourages innovative new architectures and solutions to support an ever-increasing number of connected objects. The NTIA and FCC can encourage the development of a competitive and innovative market for services through the development of heterogeneous and multi-layered networks, optimized for IoT capacity and coverage requirements. Specifically, government can foster a competitive market by supporting diverse technology architectures and encouraging market entrants of all sizes and types.

Employ diverse technology architectures: Industry has a demonstrated track record of developing and evolving technologies that satisfy demand. The present IoT ecosystem is in the early stages of development, and government can foster the natural development of this market by enabling the efficient application of existing spectrum assets across terrestrial and satellite

architectures. Through terrestrial networks, providers can satisfy bandwidth-hungry streams, while satellites will efficiently provide ubiquitous “command and control” coverage to enable critical network functionality in underserved rural geographies.

Encourage IoT network innovation through competitive service providers: Innovation in IoT network services will be led by competitive providers who are focused on the development of a vibrant IoT ecosystem. While incumbent providers will play an important role in scaling networks, these developments are largely incremental add-ons tied to ongoing 4G network upgrades. To capture the full growth and transformative benefits of next-generation/5G IoT, policymakers should encourage the presence of small, dynamic providers focused on developing and deploying greenfield capabilities that optimize services for IoT and ultra-reliable 5G use cases.

4. Enabling IoT Will Support US Leadership

The Internet of Things offers an unprecedented opportunity to improve quality of life, enable new services, increase economic productivity and efficiency, and address a wide range of societal challenges. Additionally, US leadership in IoT will enable U.S. economic competitiveness and reinvigorate a range of industries, including the manufacturing, transportation, infrastructure, energy, and agriculture sectors, among others. The expected economic benefits, technological advances, and social impacts of IoT are significant and warrant the attention and consideration of the NTIA, FCC, and US government at large.

Both industry and government must be expeditious in allocating resources and addressing challenges to enable the US IoT ecosystem to achieve its full potential. Important initiatives that the government must support include:

- **Making available new sources of licensed spectrum:** Existing network operators are continuing to invest in newly-available spectrum and network infrastructure to meet the growing demand from existing mobile broadband customers. The challenge comes when we ask those same operators to dedicate those same frequencies to next-generation/5G IoT. The NTIA should collaborate with other government agencies to prioritize spectrum sharing for flexible terrestrial and satellite use especially in mid-band which is ideally suited for high-quality and reliable mobile coverage.
- **Providing for mission-critical support:** Mission-critical IoT applications offer some of the most striking opportunities for the US economy and society. Government has a vested interest in ensuring that the mission-critical IoT is properly provisioned with licensed, mid-band spectrum in order to ensure pervasive connectivity regardless of location.
- **Encouraging a competitive and innovative environment:** A competitive market is essential to realizing the full potential of IoT. Dynamic, innovative network service providers are focused on developing next-generation IoT optimized architectures that enable some of the most promising 5G use cases today, and which will accelerate the broader development of a vibrant IoT ecosystem.

- **Addressing technical challenges:** Initiatives to address obstacles with cybersecurity, privacy, and network flexibility should be a top priority for both industry and government stakeholders.

The US must act quickly to maintain its global leadership position as the world universally embraces and implements IoT technology. The successful development of a vibrant IoT ecosystem will preserve US global competitiveness and economic stability well into the 21st century, and catalyze a variety of direct and indirect societal benefits.

Ligado Networks appreciates the opportunity to submit comments to the NTIA on fostering the advancement of IoT. We believe that with industry leadership and strong government support, next-generation IoT will transform the US economy and society, allowing enterprises and individuals to enjoy the accompanying benefits. Many impactful IoT applications are available today, and Ligado Networks stands ready to support the development and deployment of a vibrant and dynamic IoT ecosystem.

Respectfully submitted,

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