Before the
DEPARTMENT OF COMMERCE
National Telecommunications and Information Administration
Washington, DC 20230

In the Matter of	)	
	)	
Developing a Sustainable Spectrum Strategy for America's Future	)	Docket No: 181130999-8999-01
	)	

COMMENTS OF NOKIA

Nokia submits these comments to the National Telecommunications and Information Administration ("NTIA") in response to the above-captioned Notice; Request for Comments ("Notice") on development of a sustainable spectrum strategy.

I. NOKIA'S TRACK RECORD OF INNOVATION IN COMMUNICATIONS TECHNOLOGIES

Nokia offers unparalleled leadership in the technologies that connect people and things. Nokia is leveraging its strengths to create a new type of network that is intelligent, efficient, and secure, and which will serve as a critical enabler of many capabilities and use cases associated with 5G and the Internet of Things (IoT). We are weaving together the networks, data, and device technologies to create the universal fabric of our connected lives. Nokia brings together, in one company, mobile broadband with fixed line access, and the underlying IP routing and optical technology that connects them.

Nokia has a strong track record of pioneering research and technology development in the area of shared spectrum use in wireless networks. With an annual spend of approximately $5 Billion on -- and approximately 40,000 employees dedicated to -- R&D, Nokia is well-positioned to lead the industry into the next generation of communications. Nokia Technologies and Bell Labs have been actively performing advanced research in spectrum

sharing for well over a decade and have developed transformational technologies protected by approximately 80 patents.

Of significance to Nokia's work to enhance efficiency of spectrum use and spectrum sharing, in June 2016, Nokia announced industry-first Citizens Broadband Service Devices (CBSDs) in the form of new micro and indoor pico cells that are part of its industry leading, innovative Flexi Zone small cell product portfolio for the Federal/non-Federal shared Citizens Broadband Radio Service (CBRS) band covering the 3.55-3.7 GHz range. In October 2018, our commercial CBSD was certified by the Federal Communications Commission (FCC). Nokia has participated in dozens of spectrum-sharing projects across the globe, and Nokia's Bell Labs research team was the first to publicly report on the design of an end-to-end CBRS testbed and Spectrum Access System (SAS) prototype culminating with Nokia applying to the FCC to operate a SAS for the CBRS band in 2017.

Nokia serves in leadership positions in the Spectrum Sharing Committee of the Wireless Innovation Forum (WInnForum) developing the specifications for the interfaces between the SAS and the radio networks. Nokia actively participates in spectrum proceedings at the FCC, including participating at all stages in the FCC's 3.5 GHz proceeding as well as other standards bodies relevant to spectrum sharing in other regions around the world. As a founding member of the CBRS Alliance, Nokia's expertise is unmatched in designing and building Neutral Host and private LTE networks that maximize the benefits of the shared spectrum,[1] and has the industry expertise and award-winning networks to help the U.S. Government and commercial entities connect their people, equipment and information.

[1] Ongo: Easy to install wireless for Enterprises, Industries, and Public Spaces, available at https://networks.nokia.com/products/OnGo.

II. THE RIGHT U.S. GOVERNMENT POLICY CHOICES ARE CRITICAL TO THE GLOBAL COMPETITIVENESS OF U.S. INDUSTRIES

For the next generation of wireless and IoT to meet the lofty ambitions policymakers frequently cite, and for the U.S. to maintain leadership in both network capability and the development of applications and use cases, policymakers must continue supporting prudent actions that facilitate deployment of new infrastructure needed to add capacity, increase peak data rates, and reduce latency. Continued U.S. leadership in networks and capabilities is not guaranteed. Additional steps are necessary to bring critical spectrum bands to the market on timelines that are competitive with other global markets, to encourage investment in research and development and testing of new network equipment, and to reduce barriers to infrastructure deployment. Attached to these Comments is a Nokia Policy Paper: "U.S. Needs to Act to Secure 5G Leadership."

The Policy Paper describes the high stakes of the U.S. meeting its 5G goals in the areas of jobs, economic growth and investment as well as the major positive impacts 5G and IoT will have across the U.S. To achieve these goals, U.S. policymakers should ensure a regulatory environment that can propel technology development and deployment. Specifically, we highlight the need for: (1) an intellectual property rights policy that rewards innovators to justify R&D costs; (2) a spectrum policy that keeps the pipeline primed, in particular in the much-needed mid-band spectrum range; and (3) infrastructure policies that facilitate deployment in communities throughout the Nation and on Federal lands. We also urge that the Federal government encourage participation in international standards bodies, increasing the number of participants overall as well as from a broader cross-section of U.S. industry.

III. NTIA SHOULD PROVIDE AND UPDATE A SPECTRUM ROADMAP OF BANDS BEING CONSIDERED FOR COMMERCIAL USE

Nokia applauds the Administration's directive asking Federal departments and agencies to assess their spectrum needs and develop a spectrum strategy. NTIA's request for comments is an integral part of that process. The Spectrum PM recognizes that, "the Nation requires a balanced, forward-looking, flexible, and sustainable approach to spectrum management."[2] Nokia emphasizes the importance of transparency and predictability in this process. There are several examples of the U.S. Government undertaking such initiatives to provide such transparency and predictability to stakeholders, with substantial success.

For example, in 2010, the Administration published a "Ten Year Plan and Timetable to Make Available 500 MHz of Spectrum for Wireless Broadband."[3] During this effort, numerous bands were identified for "Fast Track" assessment, including bands that are now part of the shared commercial-Federal ecosystem. Nearly 10 years later, the Spectrum PM is a welcome refresh of that effort.

On a similar note, the FCC's mmWave proceedings started with a Notice of Inquiry that considered numerous bands at once,[4] resulting in service rules for multiple gigabits of high-band spectrum over the course of just a few short years. With the 28 GHz auction entering its final stages, the FCC has announced its intention to auction the 24 GHz, 37 GHz, 39 GHz and 47 GHz bands, all in 2019. These are the types of best practices that provide the

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[2] Memorandum for the Heads of Executive Departments and Agencies, *Developing a Sustainable Spectrum Strategy for America's Future*, at 1 (Oct. 30, 2018), available at. https://www.whitehouse.gov/presidential-actions/presidential-memorandum-developing-sustainable-spectrum-strategy-americas-future/ ("Spectrum PM").

[3] *See* Ten Year Plan and Timetable to Make Available 500 Megahertz of Spectrum for Wireless Broadband (President's Spectrum Plan Report) (October 29, 2010), available at https://www.ntia.doc.gov/report/2010/ten-year-plan-and-timetable-make-available-500-megahertz-spectrum-wireless-broadband-pre.

[4] *See* Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, Notice of Inquiry, GN Docket No. 14-177 et al., FCC 154 (rel. Oct. 17, 2014).

"balanced, forward-looking, flexible and sustainable" spectrum outcomes for which the Spectrum PM strives.

Identifying potential bands to be made available for commercial use has several benefits. Providing a spectrum roadmap focuses the scarce engineering resources of both government and industry on discrete bands. Through industry-government collaboration, bands can be assessed more efficiently and in a manner that promises to bring the latest technologies and value to both government and the commercial marketplace. Moreover, a spectrum pipeline roadmap provides the commercial market with a greater ability to plan research and development and deployment plans.

To meet the future needs for cellular applications, U.S. industry needs more low-band spectrum for coverage, mid-band spectrum for wide area capacity, and high-band spectrum for extreme capacity. Below, Nokia highlights bands in each category that the Federal government should prioritize:

410-430 MHz and 450-470 MHz (low band).[5] 3GPP defined a Frequency Duplex Division (FDD) LTE band to cover the range 450-470 MHz (Band 72) and is now defining a new band to cover the 410-430 MHz range (Band 126). There is interest in these bands from utilities in Europe and the U.S. to meet electric, gas, and water utility spectrum requirements. In the U.S., the 410-420 MHz band is used by Federal agencies primarily for conventional and trunked land mobile radio communication systems. Maritime mobile communication systems also operate in this band. The 420-450 MHz band is used by the military and other Federal agencies for a number of important radar applications, multi-function position-location communications systems, and test range telecommand and flight termination systems

[5] Federal Government Spectrum Use Reports 225 MHz – 7.125 GHz, available at https://www.ntia.doc.gov/page/federal-government-spectrum-use-reports-225-mhz-7125-ghz.

making the band essential to national security. We encourage NTIA in coordination with the Department of Defense ("DoD") and other federal agencies to study the 410-430 MHz and 450-470 MHz bands for repurposing to commercial use, considering the ongoing ecosystem being developed for these bands globally.

3.45-3.55 GHz (mid band). In the U.S., military radar systems operate in the 3.45-3.55 GHz band. NTIA and DoD are studying this spectrum for potential repurposing to commercial use. We encourage NTIA to expedite their study so that this 100 MHz of spectrum could supplement the CBRS band by 2022 and leverage a global 5G ecosystem being developed for that spectrum range.

37-37.6 GHz (high band). The FCC has identified the 37-37.6 GHz band for commercial Shared Access Licenses (SALs) which will share the band with Federal operations. The FCC determined that this shared band "can be used by a wide variety of Federal and non-Federal users, by new entrants and by established operators – and small businesses in particular – to experiment with new technologies in the mmW space and innovate."[6] We encourage NTIA to work with the FCC and other stakeholders to expedite completion of the sharing framework so that 5G can be deployed in this band just below the important 37.6-40 GHz spectrum range.

IV. INTRODUCTION OF NEW, AUTOMATED AND DYNAMIC SHARING MODELS CAN UNLOCK GREATER SHARED SPECTRUM ACCESS

The Spectrum PM emphasizes the importance of technologies that will allow more efficient use of spectrum, and in particular asserts that the "United States Government shall continue to look for additional opportunities to share spectrum among Federal and non-Federal entities."[7] While there are many situations where it is impractical to clear Federal uses

[6] Use of Spectrum Bands above 24 GHz, GN Docket No. 14-177 et al., Report and Order and Further Notice of Proposed Rulemaking, Appendix E, at ¶ 6 (rel. July 14, 2016).

[7] Spectrum PM at 3.

completely, such Federal bands may very well offer valuable opportunities for sharing. The 3.55-3.7 GHz band is one example of such a band where there are critical government operations that are prohibitively expensive to move and must be protected, but those operations are limited both temporally and geographically. Below, we discuss automated spectrum sharing as a prime example of technologies and business models that should be considered.

5G technologies will also enhance our ability to share spectrum and infrastructure. One such technology enabled by 5G is network slicing, which provides the ability for a service provider to divide spectrum into infinite "slices" with an unprecedented level of flexibility, security and quality of service differentiation.

An additional model for unlocking greater value from Federal spectrum, public-private partnerships (PPP) should be considered. For example, FirstNet's partnership with AT&T, allows commercial access to 20 MHz of low-band spectrum allocated to Public Safety in return for substantial value. That PPP will allow FirstNet to achieve its public safety mission more efficiently and more rapidly than it could ever do on its own.

We discuss each below.

Automated Spectrum Sharing. Automated spectrum sharing can play a critical role in making spectrum available for commercial use while preserving the spectrum access necessary to satisfy the mission requirements and operations of Federal entities. An example of such an automated federal/non-federal automated sharing arrangement was developed for the CBRS 3.55-3.7 GHz band, currently allocated for use by DoD for Navy ship-borne and ground-based radar systems. Sharing is enabled by a SAS, which serves as an advanced, highly automated frequency coordinator providing Federal users interference protection from commercial users and optimizing frequency use to allow maximum capacity and coexistence for commercial users.

Initially, NTIA defined very large exclusion zones that would have made the spectrum unavailable along the coastline where a majority of the U.S. population is concentrated and where the spectrum is most valuable. With the development of a SAS, the spectrum will become more widely available, including along the coastline. In addition, the SAS has opened the spectrum to a wide variety of commercial users, deployment models, and business cases, including some that are not adequately served by licensed or unlicensed rules frameworks in other bands. Educational institutions, transportation hubs, healthcare facilities, stadiums, convention centers, and retailers are some of the verticals showing interest in the band to facilitate their own private LTE networks using the CBRS band. Mobile Network Operators also show strong interest in the band to augment service to their customers. The 3.5 GHz band offers good propagation characteristics, a large amount of spectrum, and the band is seen as key mid-band spectrum range for 5G.

It is important to note that, while the 3.5 GHz band is an important reference that will inform future sharing, it is just one example to draw from for future bands. Not all aspects of the 3.5 GHz band framework should be replicated wholesale for other bands. That said, it is a great policy and technical achievement that can pave the way for more commercial-Federal automated sharing.

Network Slicing. Network slicing, enabled by 5G, offers network operators a way to provide services to multiple customers at guaranteed quality of service from fields as diverse as public safety, industrial automation and healthcare. Specifically, network slicing capabilities use virtualization to partition the access network into virtual network slices. This allows running separate services or traffic types on different slices completely independently from one another. The resulting sliced infrastructure provides the control and flexibility

necessary to run innovative broadband services that differentiate in customer experience and invites convergence in networks for faster time-to-market and improved capital efficiency.

Network slicing allows a single network provider to securely connect more users, more segments and more entities that would otherwise use parallel networks. The network operator can create a dedicated network slide for government users. Cooperative models between private and government users should be incentivized for the best possible spectrum and economic efficiency. Notably, security can be designed and differentiated for each slice to meet the unique characteristics and security needs of the user.

Some examples of benefits of Network Slicing for network operators include:

- Slicing allows networks to scale over more users and market segments, hence improving take rates and ROI.
- Converge separate networks for internal organizations and customer segments onto a single network infrastructure.
- Target new business segments, such as vertical markets, government users and enterprise services, by creating dedicated virtual slices.
- Reduce risk, accelerate time-to-market and improve capital efficiency via co-investment with partners who want to operate their own dedicated network slice.

Network slicing customers, which could include Federal users, benefit from:

- Reduced investments and lower operational costs.
- Enhanced service differentiation.
- High flexibility and easy integration on infrastructure and service provisioning.
- Full autonomy in customer care and network operations.
- Reduced ping-pong escalations due to a clean separation of connectivity and service.
- Increased agility by separating infrastructure and service layers.

In sum, network slicing could enable government operations to continue in a given band while providing access to robust commercial services on the same infrastructure and spectrum range.

Sharing Based on a PPP model. Another cooperative model is the PPP model, wherein Federal users can be served by commercial networks, while being guaranteed spectrum access at guaranteed quality of service (QoS). The FirstNet agreement with AT&T provides a useful example. FirstNet has a spectrum allocation of 20 MHz in the 700 MHz band (Band 14) to use for a nationwide public safety broadband network. By entering into an agreement with AT&T that includes allowing AT&T to share Band 14, FirstNet has access to a multiband solution that provides public safety with expanded capacity beyond Band 14, with end-to-end security, along with priority and preemption capabilities to ensure reliability of its mission-critical operations. This arrangement is a useful model for the for a Federal user to allow access to a third-party operator that can, in turn, offer substantial benefits to the Federal user in terms of cost of ownership, flexibility, etc.

V. INVESTMENT IN RDT&E IS IMPORTANT TO IMPROVE SPECTRUM-UTILIZATION METHODS, AND SPECTRUM-SHARING TOOLS AND TECHNIQUES

Nokia believes that the Federal government would benefit by investing in RDT&E to improve spectrum-utilization methods and develop spectrum-sharing tools and techniques. This will help share the burden with commercial investment and allows the Federal government to have their own tools that would allow more independent assessment of new approaches. Government investment in RDT&E will also help bring new spectrum for commercial use to market more quickly if NTIA can do their own assessment in parallel to efforts by commercial entities.

Collaboration between Federal and non-Federal entities can go beyond what was done in WInnForum for the CBRS band. For collaboration in WInnForum, the Federal and non-Federal entities worked together on defining requirements but then the non-Federal entities developed the SAS which NTIA Institute for Telecommunication Sciences (ITS) is now testing.

If NTIA also did its own research and development on SAS or automated spectrum sharing technology in parallel, the Federal government could have gained more confidence in the end-product sooner, which would have helped with expediting the commercial SAS products. An automated spectrum sharing system could perhaps even be used for Federal coordination in relevant bands where various Federal systems need to coexist. This would improve the efficiency of spectrum usage by Federal agencies and in turn make available valuable spectrum for commercial use either through clearing or sharing.

The Federal government can also invest in RDT&E to better understand commercial systems, especially 5G, as proper modeling of the unique advanced features of 5G such as beamforming is important as NTIA studies coexistence of 5G with Federal systems in various bands. Finally, as the Federal government develops future systems, they should consider the systems being developed by the non-Federal entities. This could be done jointly and would allow more efficient spectrum usage if Federal and non-Federal systems could use technologies that are developed to be compatible from the start as a key requirement.

Respectfully submitted,

Nokia

/Brian Hendricks/

Prakash Moorut
Bell Labs & CTO

Brian Hendricks
Jeffrey Marks
Government Relations

Nokia
601 Pennsylvania Avenue, NW
South Building, Suite 900
Washington, DC 20004

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Attachment

Nokia Policy Paper: U.S. Needs to Act to Secure 5G Leadership

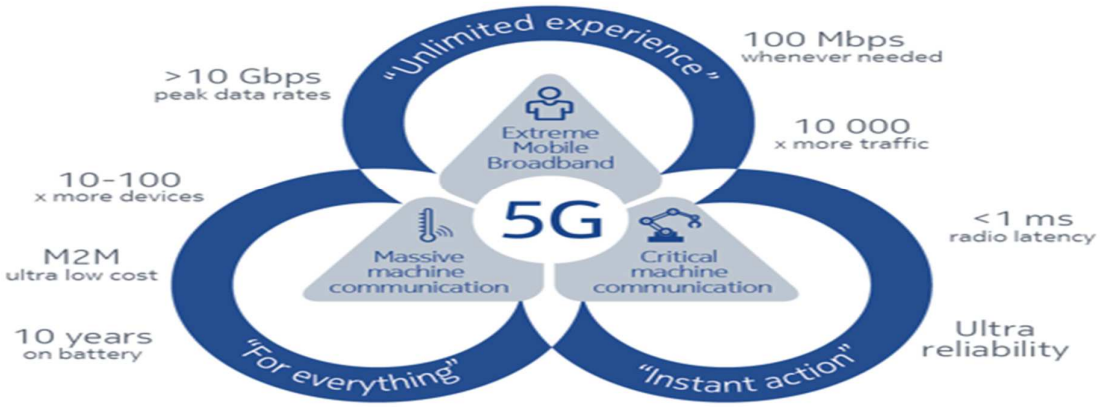
U.S. Needs to Act to Secure 5G Leadership

BACKGROUND

The current generation of wireless networks (4G) enabled rapid advancement in mobile applications and services, and that, in turn, has fed the appetite of consumers for a new generation of capabilities. The United States remains at the leading edge in developing these new capabilities and use cases including: connected healthcare, intelligent transportation and technologies to control the home environment while on the move. These, and many other uses will increasingly challenge the capacity and performance of current networks necessitating an upgrade and evolution to the fifth generation (5G) of wireless networks. For the Internet of Things (IoT) to meet the lofty ambitions policymakers frequently cite, and for the U.S. to maintain leadership in both network capability and the development of applications and use cases, policymakers must continue supporting prudent actions that facilitate deployment of new infrastructure needed to add capacity, increase peak data rates, and reduce latency. U.S. leadership in networks and capabilities is not guaranteed. Additional steps are necessary to bring critical spectrum bands to the market on timelines that are competitive with other markets, to encourage investment in research and development and testing of new network equipment, and to reduce barriers to infrastructure deployment.

What is at stake?

- **Jobs & growth:** 5G is an enabling technology for many growing business sectors including healthcare, software, video, data analytics, and machine-to-machine (M2M) communications.
- **Investments:** Early investments have helped to close the gap in ultrafast mobile broadband between the U.S. and other countries. However, projections for deployment of fully evolved, national 5G networks indicate the U.S. may be falling significantly behind Asia. The U.S. cannot allow a sustained gap to open without corresponding impacts on investment and leadership in IoT verticals like connected healthcare, intelligent transportation, and smart communities.



WHY 5G MATTERS FOR CITIZENS?

Demand. Consumers generate an increasing amount of mobile traffic, which necessitates more capacity and lower latency. 5G will offer an expected peak data rate higher than 2 Gbit/s initially and ultimately as high as 10-20 Gbit/s compared to the 300 Mbit/s LTE can offer today. Combined with virtually zero latency, this means that the radio interface will not be the bottleneck even for the most challenging use cases.

Societal innovations. 5G will support applications and industries of the future such as innovative health care services to include remote diagnostic capability, self-driving cars, and the next generation of industrial automation. 5G will mean stepping away from best effort networks towards truly reliable communication.

Internet of things. 5G will be designed for use cases expanding from humans to machines. 5G supports the huge growth of machine-to-machine communication (or, IOT), through flexibility, low costs and lower consumption of energy. This will facilitate the connection and networking of billions of devices and sensors across sectors and use cases including intelligent transportation, networked infrastructure, utility operation, healthcare and logistics. At the same time, 5G will be reliable and quick enough for mission-critical wireless control and automation tasks such as self-driving cars.

Energy and cost. 5G will lower costs and the consumption of energy. Energy efficiency is an integral part of the design paradigm of 5G. Virtualized and scalable technologies will further facilitate global adoption. Taking these factors together, 5G could bring Internet access to a larger group of people and things while taking important steps towards a more environmentally responsible network architecture.

TECHNOLOGY CHALLENGES AND POLICY ENABLERS

Research, development, and testing by mobile broadband equipment companies like Nokia to bring 5G into reality is well underway. Multiple generations of technology already deployed must work seamlessly together under the 5G umbrella, which requires new approaches and capabilities, all with lower power consumption and lower deployment costs as key demands. This research and development is a massive financial and logistical undertaking, which requires a policy environment that supports this effort and provides the critical inputs to reduce risk and facilitate deployment and adoption.

Intellectual property rights policy: 5G research activities become much higher risk when genuine innovation is neither protected nor rewarded. Robust protections for intellectual property are an essential ingredient to the successful realization of 5G and the IoT. Congressional patent reform discussions and Administration policies should not make it more difficult for innovators to protect these rights, which are essential to the business case for undertaking the research and development risk.

Spectrum needs: Additional radio spectrum for mobile networks needs to be allocated and put into use quickly to meet the increased capacity and coverage demands of 5G. While U.S. operators currently hold significant spectrum, and will begin deployments in a range of bands including 600 MHz and mmWave bands, there are questions whether the amount of spectrum available will allow the evolution from early 5G (2 Gbit/s data rates) to fully evolved 5G that Nokia expects will have data rates upwards of 20 Gbit/s. Several countries have, or will, make large blocks of mid-band spectrum available to operators (80-100 MHz each) including China, S. Korea, Japan, and Italy with several more countries to follow. For the U.S. to enable a truly national 5G deployment that allows for an evolution to fully cable 5G, operators in the U.S. will require substantially more spectrum particularly in mid-band ranges (roughly 2-6 GHz).

Network densification and siting reform: 5G we will need to use many more base stations to meet the performance needs of future applications. These dense networks will be deployed as heterogeneous networks, combining macro sites with smaller base stations that will collectively utilize a range of radio access technologies including LTE-A, Wi-Fi and any future 5G technologies. The Federal Communications Commission (FCC) and the Administration have taken substantial action to reduce the disparities in local siting rules for infrastructure. Legal certainty regarding the FCC's reforms is a key unresolved challenge and further efforts to facilitate rapid access to federal lands will be an important consideration.

Recommendations for policy makers

- Make more mid-band spectrum available:
    - With rules finalized for the 3.5 GHz band, it is critical to move rapidly toward an auction of Priority Access Licenses (PALs) by 2020 and to facilitate deployments in the General Authorized Access (GAA) band in 2019. Completing the spectrum access system (SAS) testing and equipment certification process is critical to keeping on schedule and driving innovation in devices and use cases;
    - Adopt an order in the rulemaking proceeding for the 3.7-4.2 GHz band. The FCC needs to be more aggressive with this band. The goal should be to provide clear as much spectrum as possible, as quickly as possible. Doing this will likely require the FCC to approve allocation of spectrum via secondary market or private sale. With Asia moving quickly to deploy mid-band spectrum, the U.S. will remain at a key disadvantage until it provides significant mid-band spectrum to the market, which provides both coverage and capacity essential to serving the bulk of the U.S.
    - Complete NTIA review of the lower-3-GHz band to make more Federal spectrum available for commercial use.
- Auction the remaining mmWave bands previously identified by the FCC, including holding auctions for the 24, 37, 39 and 47 GHz bands in 2019;
- Encourage broad participation in standards bodies. Rising participation levels from other regions and increased politicization risks diminishing the ability of standards bodies to produce standards based on engineering rather than country or company specific interests. Policymakers should explore options to increase participation in standards bodies by a broader cross section of U.S. industry, including promoting lower membership fees in organizations that provide voting memberships in standards bodies and increasing participation by small and mid-sized businesses.

For further information, please contact:
Brian Hendricks, Head of Policy and Government Relations, Americas Region, +1-703-638-0954,
brian.hendricks@nokia.com