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on
Exploring the Value of Spectrum to the U.S. Economy
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Chairman Wicker, Ranking Member Schatz, and members of the Subcommittee, thank you for inviting me to testify. My name is Dave Heiner, and I am Microsoft's Vice President for Regulatory Affairs. I am pleased to speak with you today about the value of unlicensed spectrum to the U.S. economy.

We all use unlicensed spectrum every day without giving it much thought. If you unlock your car with a key fob, open your garage door with a remote, make a hands-free call in the car, or buy a coffee with an Apple Pay tap, you are using unlicensed spectrum. If you are tracking your steps with a Fitbit, you are using unlicensed spectrum to communicate with your phone. And, of course, nearly everyone uses Wi-Fi. In fact, more than half of all internet traffic transits over a Wi-Fi connection. PCs, laptops, tablets, game consoles, smart TVs, mobile phones, and other devices all routinely connect to the internet via unlicensed Wi-Fi spectrum. Together, these technologies combine to create billions of dollars in economic value to the U.S. economy every year.

Licensed spectrum is important too, and Microsoft is very much in favor of a balanced policy that aims to promote the availability and efficient use of both unlicensed *and* licensed spectrum. In developing optimal spectrum policy, we think it is important to bear in mind that unlicensed spectrum is carrying 16 times more internet traffic than licensed spectrum. That is remarkable considering there is substantially more commercially viable licensed spectrum than unlicensed spectrum below 6 GHz, where the vast majority of broadband traffic resides. Wi-Fi traffic to the internet is growing very rapidly—by 2015, Wi-Fi handled more than half of all global internet traffic, wireless or wireline. That share of overall traffic continues to rise. And Wi-Fi is ubiquitous: most U.S. households have Wi-Fi and there are nearly 100 million public Wi-Fi access points around the world. Looking forward, forecasters expect the number of Wi-Fi access points to grow to well over 500 million by 2021.

Wi-Fi is only one of many uses of unlicensed spectrum. The low barriers to entry and permission-less innovation enabled by easy access to this shared resource has enabled large companies and small companies alike to innovate in a wide range of wireless technologies and even enabled the emerging category of the "Internet of Things" (devices communicating with one another, and with users, via the internet).

Unlicensed spectrum is critical to innovation at Microsoft and the technology sector

All of this is very important for Microsoft and, of course, for the technology sector as a whole. Wireless connectivity is very much at the center of the "mobile first, cloud first" business strategy that Microsoft's CEO Satya Nadella is pursuing. From cloud computing to the Xbox platform to the Internet of Things, Microsoft's ability to invest and innovate depends on the availability of broadband spectrum governed by commercially reasonable rules—so our individual and enterprise customers have a great experience at home, at work, and on the go.

When I started at Microsoft in 1994, our software was primarily delivered to customers via floppy disks or CD-ROMs. The software typically had little interaction with the internet. Those days are gone. All of Microsoft's major business lines are now dependent on continuous and reliable internet connectivity for key features and continuous updating. Those businesses—Windows, Office, and our relatively new Azure "cloud" platform—make Microsoft the third most valuable company in the world. (The first two are Apple and Alphabet, and they are dependent on internet connectivity too.) Microsoft is employing more than 70,000 people in the United States and investing close to $13 billion in R&D annually (88 percent of which is spent in the United States) to grow those businesses. The Microsoft cloud serves over 1 billion customers, generating over 1 trillion data points every day managed through more than 100 data centers around the world connected to the internet. Cloud is critical to consumers, enterprises of all sizes, and even governments—stimulating innovation and enabling economic growth.

Our cloud services include Windows, Office 365, MSN, OneDrive, Skype, Azure, Outlook.com, and more. And all of these services depend upon consistent and ubiquitous internet access for key features. For example, Windows enables customers to synchronize their files to the cloud and other devices and to "roam" settings and preferences from one device to another. Windows includes Cortana, the personal digital assistant that relies upon cloud processing to help people stay organized and get things done. Our Office 365 customers are continually getting new features, without having to wait years as in the past for major new versions to be released. For all of these efforts, last-mile connectivity is critical—and unlicensed spectrum is meeting that need for us and our customers.

Microsoft's Azure cloud platform enables software developers to quickly and inexpensively build new cloud services. More than 90 percent of Fortune 500 companies are using Azure today to efficiently deliver enterprise solutions. GE Healthcare is an example. Microsoft Azure powers mission-critical patient care applications for GE Healthcare, including solutions that streamline communication between clinicians, patients, and hospital administrators with secure, centralized, real-time access to the diagnostic scans and reports that physicians need to make decisions. And it is unlicensed spectrum—which links the data to tablets, smartphones, and a wide variety of connected devices—that makes all of this possible.

Microsoft's cloud also supports our new "mixed reality" platform, HoloLens. Unlike virtual reality, "mixed reality" merges people, places, and objects from the physical and virtual worlds together, allowing users to interact with content and information in far more accessible and intuitive ways. Developers have created apps for HoloLens that range from games to art museum tours to simulated lab experiments. Enterprise users can benefit from HoloLens too, with architecture tools, power plant monitoring, and aircraft maintenance training. Microsoft's HoloLens headset relies on unlicensed spectrum to connect our customers to the worlds—physical and online—around them.

Microsoft's Xbox game console is dependent on unlicensed spectrum too. Game consoles serve as central hubs not only for multi-player gaming, but also for making calls on Skype, watching TV on Netflix, and controlling home IoT devices. Advanced game consoles depend on Wi-Fi-linked internet access for all of these features, and they use unlicensed Wi-Fi and Bluetooth technologies to distribute data to different devices throughout our customers' homes, and to link game controllers—including guitars and steering wheels—to consoles.

The businesses and consumers we serve expect every application to work both in the office and on the go, and they expect access to the same cloud applications on laptops, smartphones, tablets, and wearables.

The unlicensed bands are the workhorses that make this happen. *Our telemetry shows that ninety-eight percent of Windows 10 devices are connected to Wi-Fi and nearly half of all data flows over the Wi-Fi connection.* This is the case because consumers and enterprises overwhelmingly use Wi-Fi to link to their fixed wireline broadband service, whether that service is delivered by cable or a telco.

Unlicensed spectrum fuels economic growth

Of course, the importance of Wi-Fi is not limited to Microsoft, or even to internet firms generally. Wi-Fi access points serve an ever-growing ecosystem of devices, including not only laptops, smartphones, and tablets, but also doorbells, irrigation systems, thermostats, refrigerators, lighting systems, and wearables.

Two relatively recent economic studies help to quantify the value of unlicensed spectrum.

In 2014, Raul Katz, a professor at Columbia University, estimated that by this year unlicensed spectrum would contribute $547.22 billion in economic surplus annually and nearly $50 billion to the annual GDP.[1] He arrived at that estimate by building on his

[1] Telecom Advisory Services, LLC, Assessment of the Future Economic Value of Unlicensed Spectrum in the United States at 4 (Aug. 2014),

historical assessment of unlicensed spectrum's economic value in 2013 ($222.4 billion in total economic value and $6.7 billion contributed to the GDP)[2] and analyzing two key drivers of growth in the area. First, Professor Katz analyzed growing adoption of then-widely deployed technologies and applications, including Wi-Fi-cellular off-loading, residential Wi-Fi, Wireless Internet Service Providers, Wi-Fi-only tablets, wireless personal areas networks, and radio-frequency identification devices. As Professor Katz explained, research from a wide variety of industry resources anticipated very rapid growth in adoption of those technologies. For example, Cisco estimated that between 2013 and 2017 the number of tablets in use in the United States would grow by more than 300 percent and the internet traffic generated by each of those units would increase nearly five-fold. Dr. Katz also accounted for increased economic value generated by the "deployment of emerging innovations, such as machine-to-machine communications and agricultural automation." Though his estimate attempted to account for those future developments, Dr. Katz underscored that "estimates of economic value of future technologies are extremely conservative."

Also in 2014 Richard Thanki conducted a study for the Consumer Electronics Association focusing on retail sales attributable to products that depend upon unlicensed spectrum.[3] To estimate the economic value generated by that spectrum, Thanki collected sales data for the wide variety of devices that use it—Wi-Fi devices, but also less obvious parts of the unlicensed ecosystem, such as broadcasting hardware, medical devices, and baby monitors. Thanki concluded that unlicensed spectrum generates more than $62 billion in "incremental retail sales value," a number that he cautions is overly conservative because it focuses solely on "the sale of devices using unlicensed spectrum to end-users" and does not attempt to quantify "indirect contributions in terms of savings, productivity, and utility" that "greatly exceed" the study's assessment of direct benefits.

These indirect benefits, including the innovation gains described above, should not be overlooked. In addition to its direct value in driving the adoption of new devices and technologies, unlicensed spectrum yields a wide range of indirect economic spillover benefits that prove more difficult to quantify. These indirect impacts reverberate throughout the economy in job growth, wage gains, and productivity.

Unlicensed spectrum fuels innovation

Congress and the FCC had great foresight in enabling use of unlicensed spectrum decades ago, and, in particular, the release of the ISM band for unlicensed spread

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http://www.wififorward.org/wp-content/uploads/2014/01/Katz-Future-Value-Unlicensed-Spectrum-final-version-1.pdf.

2 *Ibid.*

3 Consumer Electronics Association, Unlicensed Spectrum and the American Economy: Quantifying the Market Size and Diversity of Unlicensed Services at 2 (Aug. 4, 2014), https://ecfsapi.fcc.gov/file/7521751149.pdf.

spectrum use in 1985. Today this spectrum is powering our cloud economy. The unlicensed bands produce the exceptional economic value discussed above because anyone can use them as long as they follow basic FCC rules on power limits and emission restrictions that are designed to protect other users from harmful interference. Today, innovators of all types—incumbents as well as start-ups—recognize this powerful combination of light regulations and low barriers to entry. And this advantage has helped make the Internet of Things a reality. But the growing number of IoT applications will require access to enough low-, mid-, and/or high-frequency spectrum to succeed. A variety of protocols operating in unlicensed spectrum have been developed to enable IoT devices, including Wi-Fi, zigbee, Bluetooth, WirelessHART, and z-wave.

Smart home technologies are already bringing unlicensed IoT technologies into millions of American homes through devices like Sonos connected speakers, which form their own mesh networks using the 2.4 GHz and 5 GHz unlicensed bands. Many other IoT devices rely on radio-frequency identification, commonly known as RFID. RFID tags most often use unlicensed spectrum to communicate with everything from container cars to lost luggage. These popular devices are already on their way to becoming ubiquitous. Ericsson has estimated that, by 2018, IoT devices will surpass mobile phones as the largest category of connected devices.

As you can see, unlicensed spectrum is critical to a wide variety of technologies and applications, and the numbers tell the story of just how much value this creates:

- Innovators have seized on the opportunities created by unlicensed spectrum to develop a wide range of new devices. In January 2015, the Wi-Fi Alliance announced that the industry had shipped its 10 billionth Wi-Fi device.[4]

- Unlicensed frequency bands support more traffic than any other band. In the United States 54.9 percent of total internet traffic transited a Wi-Fi network. (By comparison, just 3.4 percent of total internet traffic transited a mobile network using licensed spectrum.)[5]

- We've seen tremendous investment in unlicensed access points. To carry the huge wave of data I've described, the number of public Wi-Fi access points

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[4] WI-FI ALLIANCE, Total Wi-Fi® device shipments to surpass ten billion this month (Jan. 5, 2015), http://www.wi-fi.org/news-events/newsroom/total-wi-fi-device-shipments-to-surpass-ten-billion-this-month.

[5] Cisco, VNI Forecast Highlights Tool: 2020 Forecast Highlights, http://www.cisco.com/c/m/en_us/solutions/service-provider/vni-forecast-highlights.html, (accessed Feb. 23, 2017).

around the world will grow six-fold from 2016 (94.0 million) to 2021 (541.6 million).[6]

In addition to delivering direct value to consumers and enterprises, unlicensed networks are also valuable because they sustain licensed networks. Mobile traffic is asymmetric: considerably more data (especially video) is downloaded than uploaded. Licensed network providers and device makers increasingly choose to offload downlink traffic from licensed networks to Wi-Fi, harnessing the power and pervasiveness of unlicensed access points. And, as data caps and speeds become more of a concern, smartphone users now take advantage of Wi-Fi as an option for their most data-intensive applications. By one estimate, 85 percent of the traffic generated by smartphone video apps goes over Wi-Fi—one of the reasons that "although cellular data usage on smartphones is growing, Wi-Fi data growth is dramatically outpacing it."[7] By 2021, 64 percent of the traffic from smartphones will be offloaded from mobile devices to fixed networks via Wi-Fi or small cells. For tablets, that number is projected to be 72 percent.[8]

The flexibility in the FCC's unlicensed rules is also clearing the way for innovators to take advantage of underutilized spectrum, such as television white-spaces (TVWS). Certified TVWS devices allow consumers, internet service providers, local governments, and others to access unassigned and unused spectrum that exists between television stations. At these frequencies, a signal can travel over much larger distances than conventional Wi-Fi, making it perfect for providing broadband access to unserved and underserved rural areas. There are many potential uses for such technology. As described in a recent article in the The Economist,[9] Microsoft researchers are using TVWS to collect data from far-flung sensors on a farm in Washington state. The sensor data, once analyzed in the cloud, enables the farmer to engage in "precision farming," to minimize both irrigation and pesticide use. And because FCC rules ensure that white-spaces devices will protect over-the-air broadcasters and other licensed services from harmful interference, they will add economic value without causing any harmful interference.

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6 Cisco, Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2016-2021 (Feb. 9, 2017), http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html.

7 Ericsson, Ericsson Mobility Report: On the Pulse of the Networked Society at 25 (June 2016), https://www.ericsson.com/res/docs/2016/ericsson-mobility-report-2016.pdf.

8 Cisco, *supra* note 6.

9 The Economist, TV Dinners: Unused TV Spectrum and Drones Could Help Make Smart Farms a Reality (Sept. 27, 2016), http://www.economist.com/news/science-and-technology/21707242-unused-tv-spectrum-and-drones-could-help-make-smart-farms-reality-tv-dinners.

Microsoft has invested significantly in white-spaces technologies, and is committed to their success. Even though the Incentive Auction created uncertainty among white-spaces users and the developing ecosystem, Microsoft has continued to invest in white spaces to ensure that this technology lives up to its transformative potential once the auction and repack is concluded and the FCC's updated rules are finalized. We have spearheaded white-spaces projects in the United States and around the world.

In southern Virginia, for example, Microsoft has partnered with Mid-Atlantic Broadband Communications and the Commonwealth of Virginia to use white spaces to bring high-speed internet access into the homes of previously unconnected students. In these areas, as many as 50 percent of school children lack access to high-speed internet at home, making it hard for them to do their homework, and excluding them from the revolution in education that the internet has brought for students in many wealthier areas. Using white spaces, we are able to leverage the fiber connections that run to these schools, allowing students in surrounding areas to access school networks wirelessly from home. With this single project, Microsoft and its partners will serve 7,500 primary and secondary school students when the system is fully deployed. If deployed statewide, this approach could help to connect a quarter million unconnected students in Virginia alone.

Microsoft has also worked to deploy white-spaces networks in previously unserved parts of rural Africa, proving that this technology will play an important role in U.S. and international communities where infrastructure challenges are even greater. In Kenya, Microsoft and its partners have used white spaces to deploy internet access points in areas that do not even have access to an electrical grid. We have used white-spaces technologies to connect these rural access points to distant fiber connections, and used conventional Wi-Fi to bring these connections to individual devices. These access points are solar powered, allowing them to be completely isolated from any other physical infrastructure.

These projects are just the beginning. We are committed to taking on more investments with partners around the United States this year, with a focus on supporting connectivity, skills, and local innovation in rural and underserved communities. We strongly support action at the FCC to ensure that enough TV white-spaces channels remain available for unlicensed use, and hope the FCC will finalize commercially reasonable white-spaces rules soon so we can move ahead.

Next steps toward meeting the growing demand for unlicensed spectrum

As this Subcommittee has long recognized, radio spectrum is an essential input to economic growth and innovation. Under the Subcommittee's and full Committee's leadership, the United States has adopted a set of core spectrum policies that can guide effective decision-making by federal agencies. Central among these are that agencies should find additional spectrum resources to support affordable broadband for all

Americans and to meet the seemingly insatiable consumer and enterprise demand for wireless data services. Agencies should free new spectrum bands for commercial service and find ways to use underutilized spectrum bands more efficiently through sharing. And agencies should continue to advance a balanced spectrum policy that identifies potential spectrum bands for licensed and unlicensed use—in low, mid, and high frequency bands.

While the unlicensed ecosystem has produced exceptional economic value and innovation to date, our existing unlicensed bands will not be able to support the continued growth of wireless data produced by consumers, enterprises, and the Internet of Things. Last month, the Wi-Fi Alliance released the *Wi-Fi Spectrum Needs Study*. It concludes that an additional 500 MHz to 1 GHz of spectrum is required to satisfy expected growth in busy-hour demand for Wi-Fi through 2025.[10] Importantly, the analysis also found that unlicensed spectrum should be "assigned with sufficient contiguity such that wide channels of 160 MHz, or perhaps even wider in the future, can be constructed."[11] Wider channels would enable greater throughput, which will result in faster downloads for users.

Based on our analysis of the nation's spectrum bands, Microsoft believes that spectrum sharing will be required to meet the demand for unlicensed spectrum. Depending on the specific frequency range, sharing may involve federal or non-federal spectrum users. So we are strong supporters of the MOBILE NOW Act, which would kick-start this process by initiating proceedings on sharing mid-band spectrum for licensed and unlicensed use.

We close with three recommendations.

First, the Subcommittee, both through MOBILE NOW and more broadly, should continue to promote a balanced spectrum policy that includes adequate unlicensed frequencies. Future spectrum needs will likely be met through heterogeneous networks where different spectrum bands—some licensed, some unlicensed—will be mixed and matched over the communications path to provide the necessary bandwidth for a given device at a given location at a given time. This means that Congress and the FCC should act to free up new licensed, unlicensed, and shared spectrum for wireless broadband at low, mid, and high frequencies. We therefore support the MOBILE NOW Act, reported out of the full Committee, and hope that the Committee will aggressively push agencies to free new bands for commercial licensed and unlicensed services.

Second, the Subcommittee should oppose efforts to over-protect incumbents through onerous technical regulations when the FCC permits unlicensed users to access underutilized bands on a shared basis. Under the Commission's rules, unlicensed devices

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[10] Quotient Associates, Wi-Fi Spectrum Needs Study: Final Report (Feb. 2017), https://www.wi-fi.org/download.php?file=/sites/default/files/private/Wi-Fi%20Spectrum%20Needs%20Study.pdf.

[11] *Id* at 2.

cannot cause harmful interference and cannot claim protection from interference. Yet some incumbents seek far more than this. They ask Congress and the FCC to impose technical rules that would hobble unlicensed technologies by making investment uneconomic and creating a perpetual state of regulatory uncertainty. Committee oversight of the FCC should therefore ensure that the Commission adopts only reasonable technical rules that support economically rational investment for growth in unlicensed bands.

Third, the Subcommittee can lend its support to voluntary industry standard-setting efforts. Standards bodies such as the IEEE have been critical for decades in developing industry consensus standards for unlicensed devices. Engineers from Microsoft work hard with their peers at other companies to develop standardized techniques for sharing the unlicensed bands. Given all the demand for access to unlicensed spectrum, it is more important than ever that companies work together at IEEE and in other appropriate standards organizations to ensure new technologies share effectively and equitably with existing users. These consensus-driven efforts can often obviate the need for costly government regulation.

Thank you for addressing these important issues today. As I've noted above, unlicensed spectrum plays a critical role in innovation and our economy. We look forward to finalization of the TV white-spaces rules, resolution of outstanding dockets relating to unlicensed spectrum, and successful passage of the MOBILE NOW Act. At Microsoft, we are committed to working with you to ensure that a balanced spectrum policy continues to produce value for the American economy, support innovation, and increase access to the internet.