Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band	ET Docket No. 13-49

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I. INTRODUCTION AND SUMMARY.

Wi-Fi is now central to the way Americans access the Internet. Wi-Fi networks augment and extend wired networks and relieve congestion on licensed wireless networks. Consumers rely on unlicensed Wi-Fi networks every day in their homes and businesses, indoors and outdoors, to connect with a rapidly increasing number of devices. In 2012 alone manufacturers sold 1.5 billion Wi-Fi-enabled devices. As a consequence, Wi-Fi traffic has surged in recent years, surpassing all traffic on licensed wireless networks, and will soon pass wired connections to the network as a percentage of total IP traffic. This surge will continue. Cisco estimates that Wi-Fi traffic will triple over five years, with as much as 11.1 exabytes per month of data transmission via Wi-Fi connections by 2016.

In response, Comcast has invested to provide its customers with the best in-home Wi-Fi experience, and to build the Xfinity WiFi network to serve its customers via tens of thousands of indoor and outdoor access points in cities across the country. Comcast is not alone in its investments to meet the huge expansion in demand for Wi-Fi. Other cable companies have also built tens of thousands of Wi-Fi access points in their service areas, and together these companies have created the CableWiFi network so that customers of any of these companies can access the Wi-Fi network of any other participating company.

The success of Wi-Fi, however, has placed great stress on existing unlicensed spectrum resources. The core 2.4 GHz band is already heavily saturated in a number of densely populated communities. This problem will only become more acute as Wi-Fi usage continues to grow. Furthermore, the next generation of Wi-Fi, using the powerful new IEEE 802.11ac standard, will enable the delivery of wireless broadband speeds in excess of 1 gigabit per second to consumers and businesses, but only if 160 megahertz-wide channels are available for unlicensed use. Without access to additional spectrum resources, Wi-Fi networks in the United States will be

unable to keep up with consumer demand and new global standards, and American consumers will lose out on access to widespread gigabit Wi-Fi service. Comcast, therefore, welcomes the Commission's Notice of Proposed Rulemaking on Unlicensed National Information Infrastructure ("U-NII") operations in the 5 GHz band ("NPRM").[1]

The 5 GHz band is crucial for the future of Wi-Fi and its ability to grow and meet consumer demand. To overcome 2.4 GHz congestion and to capitalize commercialization of the 802.11n standard, Comcast today includes 5 GHz radios in every new Wi-Fi access point in its network – and virtually every new consumer device is now 5 GHz capable. Looking ahead, the 5 GHz band has more potentially available spectrum for unlicensed technologies than any other band being considered for an unlicensed designation in the United States today – and, most importantly, it is the only band that could offer unlicensed channels large enough to accommodate 802.11ac gigabit Wi-Fi channels.

In its 5 GHz deployment for Xfinity WiFi, Comcast today uses only U-NII-3 channels, which comprise less than 20 percent of the spectrum authorized for Part 15 devices in the 5 GHz band. This is because of numerous restrictions that make using the other parts of the band impossible, impractical, or uneconomical. Specifically, indoor-only restrictions, Dynamic Frequency Selection ("DFS") requirements, and low maximum-power limits governing the U-NII-1 and U-NII-2 sub-bands severely hamper utilization of this spectrum while also preventing the implementation of wideband 802.11ac channels.

To optimize the use of 5 GHz spectrum to meet growing Wi-Fi demand, the Commission should designate the new U-NII-2B and U-NII-4 bands for unlicensed use and update the

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[1] *Revision of Part 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, Notice of Proposed Rulemaking, 28 FCC Rcd. 1769 (2013) ("NPRM").

technical rules that govern unlicensed operation in the band. These changes are consistent with the Administration's policy to encourage greater sharing of spectrum resources, and will maximize the value that the public derives from this spectrum. Unlicensed devices would continue to operate on a non-interfering basis, and incumbents such as government users, intelligent transportation service ("ITS") licensees, and satellite licensees would continue to be able to operate in this spectrum. As is the case today, unlicensed devices would share the 5 GHz band subject to the Part 15 rules, and would not displace current operations.

Furthermore, 5 GHz is the ideal band to advance the Administration's forward-looking policy of using spectrum sharing to address spectrum scarcity in a workable way. Unlike in other bands, many licensees have not yet built out their 5 GHz operations, and in some cases have not even settled on operational standards. This is therefore the perfect moment for the FCC to move decisively so that engineers from the various entities that will share this band can work together to develop standards and practices that will advance the Administration's spectrum-sharing vision through the efficient and intensive use of the 5 GHz band.

Comcast therefore recommends that the Commission follow these five principles as it moves forward:

- *First*, harmonized rules between adjacent bands will advance gigabit Wi-Fi by enabling operators to utilize the 160 megahertz channels necessary to achieve the full potential of the next generation 802.11ac Wi-Fi standard. The Commission should therefore harmonize the rules for the U-NII-1 and U-NII-2 bands and the U-NII-3 and U-NII-4 bands.

- *Second*, the Commission's indoor-only restrictions are impractical, difficult to police, and essentially preclude a band's use for widespread Wi-Fi deployments. The Commission should therefore remove the indoor-use restriction in the U-NII-1 band and not impose such a restriction in any other band.

- *Third*, DFS requirements undermine commercial use by increasing product development timelines and costs and, most importantly, damaging the user experience. While the Commission should update DFS to protect incumbent government users in

the U-NII-2 sub-bands where DFS rules are already in place, it should not expand DFS to cover additional bands.

- *Fourth*, higher transmit power enables the use of Wi-Fi in applications that require greater range or throughput. It can also reduce the cost of deployment and improve the consumer experience. The Commission should therefore increase the permissible power level in U-NII-1 and harmonize the power level in U-NII-4 to match that of U-NII-3.

- *Fifth*, given the intense and immediate need for additional unlicensed spectrum and updated rules in the 5 GHz band, the costs of delay are very high. The Commission should act as soon as possible to advance these recommendations, even if this means issuing rules covering portions of the 5 GHz band while it works to resolve more difficult questions in other portions of the band.

By adopting these principles, the Commission will give investors and innovators the spectrum resources they need in the 5 GHz band to help meet escalating demand, ensure American consumers have access to gigabit Wi-Fi, and enhance the benefits of Wi-Fi for the nation's economy.

II. UNLICENSED SPECTRUM ENABLES COMCAST TO OFFER WIDESPREAD ACCESS TO HIGH QUALITY WIRELESS BROADBAND SERVICES.

Comcast's Xfinity WiFi service provides fast wireless broadband access in select areas throughout its footprint at no additional charge for qualifying residential Internet and Comcast Business customers, as well as for consumers who are not Comcast Xfinity customers on an hourly, daily, or weekly basis for a nominal fee. Comcast provides Xfinity WiFi through several types of access points:[2] (1) indoor access points in a large number of retail establishments, providing Wi-Fi access for any eligible Xfinity customers who are in or near the retail location; (2) access points in key high-traffic venues, such as train stations and sports stadiums (for

[2] *See generally* XFINITY WIFI, FAQs, http://www.comcast.com/wifi/faqs.htm.

example, Comcast recently made Xfinity WiFi available at Citizens Bank Park in Philadelphia,[3] where the company provides access as an amenity for no additional fee to any guest with a Wi-Fi-enabled device); and (3) outdoor access points in thousands of locations throughout its footprint. These outdoor access points are small, weatherproof units located in areas where customer demand for wireless broadband access is high, such as public parks and main streets. Comcast also provides its customers with in-home Wi-Fi routers to extend their wired networks.

A. Comcast Has Invested to Deploy Xfinity WiFi Access Points in Several States and the District of Columbia.

Comcast is investing in Xfinity WiFi, and the service has grown dramatically since its launch. In 2012, the company expanded its Wi-Fi network from 5,000 access points to more than 25,000 access points. Thus far in 2013, that number has grown to over 55,000 access points. Because of these investments, Xfinity WiFi is available today in Pennsylvania, New Jersey, Delaware, Massachusetts, Washington, D.C., Maryland, Virginia, West Virginia, and the San Francisco metro area, as shown in Figures 1-4. In addition, Comcast recently announced the launch of Xfinity WiFi in the Chicago and Atlanta areas.

[3] Press Release, *Xfinity WiFi Now at Citizens Bank Park*, COMCAST CORPORATE (Mar. 18, 2013), http://corporate.comcast.com/comcast-voices/xfinity-wifi-now-at-citizens-bank-park.

Figure 1:
Pennsylvania, New Jersey, New York, and Delaware

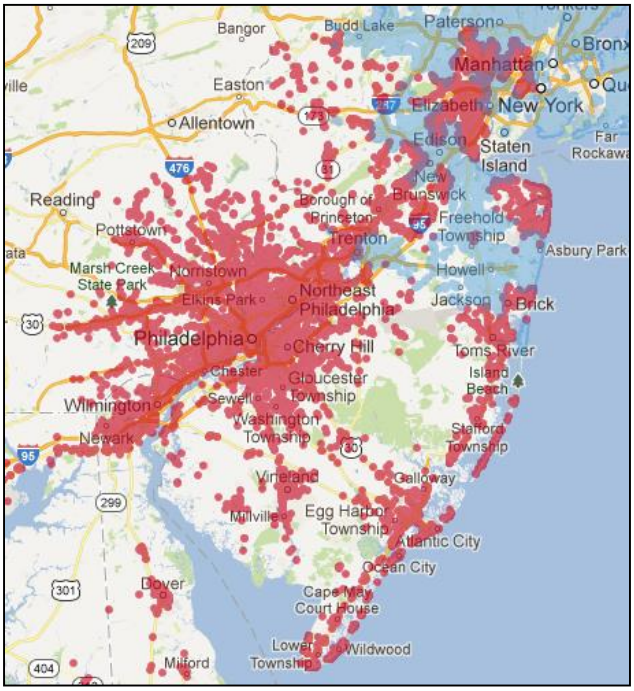


Figure 2:
The Greater Boston Region, Including Massachusetts, Maine, New Hampshire, and Vermont

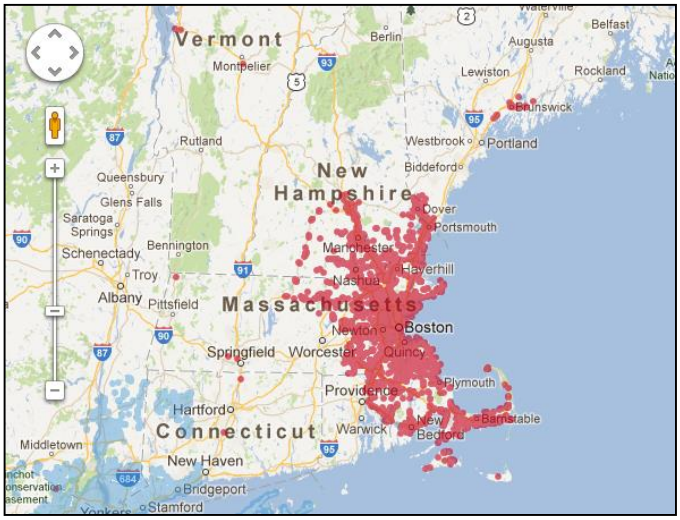


Figure 3:
The Washington, D.C. Region, Including Delaware, Maryland, Virginia, and West Virginia

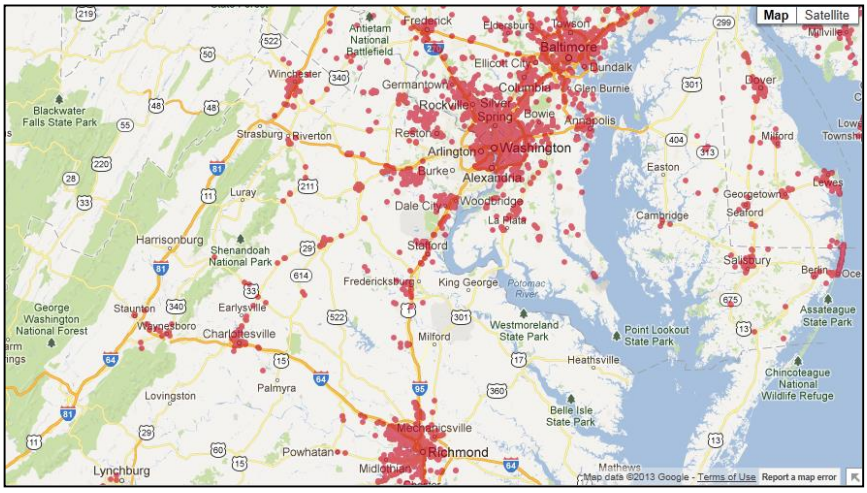
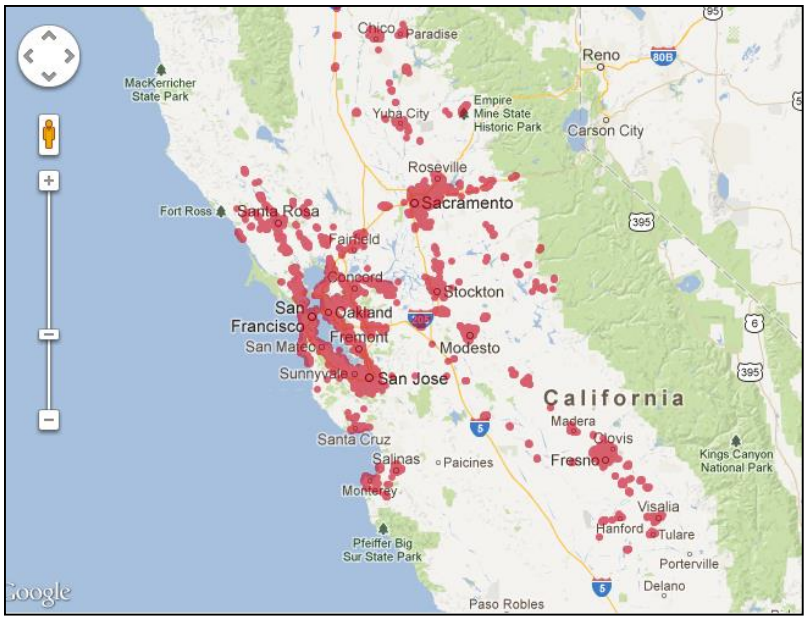


Figure 4:
The California Region



In the next phase of its build out, Comcast will expand Xfinity WiFi into several new regions, at which time Comcast anticipates that the service will be available in parts of almost all of the states in which it operates.

Comcast's Xfinity WiFi network is also part of the larger CableWiFi network, a collaboration of the five largest cable operators that enables each operator's subscribers to access all the other participating cable operators' Wi-Fi networks.[4] The CableWiFi platform currently provides access to more than 150,000 Wi-Fi access points throughout the country, and that number is growing.[5] Comcast's qualified subscribers can use access points managed by other CableWiFi operators for no additional charge, just as they access Xfinity WiFi hotspots in their home markets. Furthermore, once a customer registers with a CableWiFi partner network, he or she will be able to use any access point in that network again without having to re-register.

B. The Exceptional Growth of Xfinity WiFi Customer Usage Demonstrates That Wi-Fi Demand Is Accelerating.

As the Xfinity WiFi network has grown, customer usage of the network has increased dramatically by every key measure. In 2012, total unique users of the service increased by over 110 percent, megabytes per user by over 50 percent, sessions per user by over 35 percent, devices per user by over ten percent, and average minutes per session by over ten percent. In the last 12 months, the system has experienced triple-digit growth in both unique users and "tonnage" (measured in GBs of traffic). Significantly, all of Xfinity WiFi's eligible user groups are using the service more frequently and intensively, including Comcast subscribers, non-subscribers accessing the system via pay-per-use, amenity users, and CableWiFi users who are customers of partner companies.

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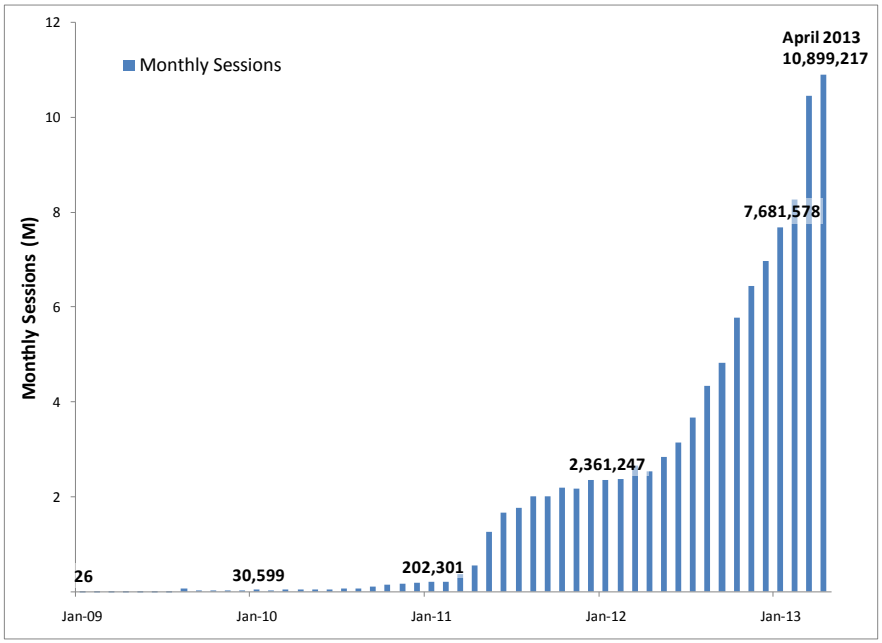
4 *See generally* CABLEWIFI, http://cablewifi.com.

5 *See id.*

Another indication that Wi-Fi use is growing as rapidly as companies are able to build out facilities is that Comcast now hosts as many Xfinity WiFi sessions in one month as it did in the service's entire first two and a half years, as shown in Figure 5 below.

Figure 5: Xfinity WiFi Usage Growth



Simply put, Xfinity WiFi users are doing much more, more often, with more devices, and for longer periods of time. Comcast is working hard and investing to expand its network to meet its customers' increasing demand.

C. Wi-Fi Networks Create Significant Value for Fixed and Mobile Networks and in Emergency Situations.

Comcast's experience with Xfinity WiFi is consistent with broader industry trends. A growing amount of data shows that unlicensed technologies have generated enormous dividends for the country in terms of economic growth and investment. Since the Commission's first action in 1985 to allow unlicensed technologies to use the Industrial, Science, and Medical

("ISM") spectrum band,[6] use of wireless technologies operating on unlicensed frequencies has exploded. While a diverse group of these technologies serve a wide variety of consumer and business needs, the development and rapid adoption of Wi-Fi technologies is probably the most important part of this success story.

In the short period since the adoption of the 802.11b and 802.11a standards in 1999 and 2000, the shipments of products that utilize Wi-Fi have grown to an astonishing 1.5 billion devices in 2012.[7] This enormous number of connected consumer devices has driven extremely rapid growth in Wi-Fi traffic. Cisco estimates that 37 percent of all U.S. IP traffic reached consumers via Wi-Fi in 2011, and that this number will jump to 45 percent by 2016.[8] By contrast, traffic carried by licensed wireless networks constituted only two percent of total U.S. IP traffic in 2011.[9] Cisco also estimates that Wi-Fi volume will equal even that of wireline volume by 2016.[10]

This meteoric growth has made Wi-Fi a major contributor to the national economy. According to a 2012 study, "[a] variety of approaches all point toward economic benefits [from

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6 *See generally Authorization of Spread Spectrum and Other Wideband Emissions Not Presently Provided for in the FCC Rules & Regulations*, First Report and Order, 101 F.C.C.2d 419 (1985).

7 *Wi-Fi Enabled Device Shipments will Exceed 1.5 Billion in 2012, Almost Double that Seen in 2010*, ABIRESEARCH (Oct. 11, 2012), http://www.abiresearch.com/press/wi-fi-enabled-device-shipments-will-exceed-15-bill.

8 *Virtual Network Index Forecast Highlights, 2011-2016*, United States – Network Connections, CISCO SYSTEMS, http://www.cisco.com/web/solutions/sp/vni/vni_forecast_highlights/index.html#~Country (last visited May 28, 2013) ("CVNI Forecast").

9 Mark Cooper, *Efficiency Gains and Consumer Benefits of Unlicensed Access to the Public Airwaves*, at 13 (Jan. 2012).

10 CVNI Forecast.

unlicensed technologies] at least in the tens of billions of dollars a year."[11] Additionally, a 2009 study that used consumer survey data to derive the incremental demand for broadband services attributable to Wi-Fi estimated that "Wi-Fi usage in the home, for only the purpose of broadband extension, may be generating anywhere between $4.3 and $12.6 billion in annual economic value for consumers in the United States."[12] And that was even before introduction of the first iPad. Estimates go on to show that the value of in-home Wi-Fi, hospital Wi-Fi, and RFID tags "together may generate $16-37 billion per year in economic value for the U.S. economy over the next 15 years."[13] By some accounts, unlicensed services contribute upwards of $50 billion in annual economic growth.[14]

Unlicensed spectrum also adds value as a key complement to licensed wireless technologies, particularly as part of the solution to addressing the rising demand for licensed spectrum caused by increased mobile wireless broadband traffic. According to Cisco, traffic on licensed mobile wireless networks increased 70 percent in 2012, rising from 520 petabytes per month in 2011 to 885 petabytes per month in 2012.[15] Cisco explains that the tremendous rate of annual growth outstrips the pace at which mobile network operators can increase the capacity of

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11 Paul Milgrom *et al.*, *The Case for Unlicensed Spectrum*, ¶ 42 (Oct. 12, 2012), *available at* http://siepr.stanford.edu/?q=/system/files/shared/pubs/papers/pdf/10-036_Paper_Milgrom.pdf.

12 Richard Thanki, *The Economic Value Generated by Current and Future Allocations of Unlicensed Spectrum*, Final Report, Perspective Associates, at 35 (Sept. 28, 2009), *available at* http://spectrumbridge.com/Libraries/White_Space_Primer/whitespaces-microsoft-study.sflb.ashx.

13 *Id.* at 42.

14 NPRM, Statement of Commissioner Mignon Clyburn, 28 FCC Rcd. at 1822.

15 *See Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2012-2017*, CISCO, at 1 (Feb. 6, 2013), http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.pdf.

their licensed spectrum networks, and this growth is expected to continue for at least the next four years.[16] Many mobile wireless broadband providers have come to embrace Wi-Fi as a complementary technology and necessary to avoid or relieve congestion on their networks. As Sprint has explained, "[o]ne of the most effective methods of increasing the capacity of wireless data systems is moving data traffic, whenever possible, from the licensed spectrum of commercial mobile carriers to unlicensed spectrum, such as that now used for Wi-Fi."[17]

This offload strategy is possible because, as the Commission explains, "[u]nlicensed communication links are included in a wide variety of devices which are increasingly mobile or portable in nature."[18] For example, as of the start of 2013, 55 percent of all mobile phone users owned a smartphone, up seven percent from October 2012.[19] Indeed, "[l]ast year, 96 percent of U.S. traffic associated with portable devices was carried on Wi-Fi networks at some point."[20] Smartphone users are turning to Wi-Fi in greater numbers to access wireless data, complementing their cellular data plans with Wi-Fi.

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16 *See id.* at 3.

17 Comments of Sprint Nextel Corporation at 5, 7, WT Docket No. 12-4 (filed Feb. 21, 2012).

18 NPRM ¶ 37.

19 *See* Press Release, *comScore Reports December 2012 U.S. Smartphone Subscriber Market Share*, COMSCORE (Feb. 6, 2013), http://www.comscore.com/Insights/Press_Releases/2013/2/comScore_Reports_December_2012_U.S._Smartphone_Subscriber_Market_Share (noting that 125.9 million people in the U.S. owned smartphones).

20 NPRM, Statement of Commissioner Robert McDowell, 28 FCC Rcd. at 1820-21 (citing *Virtual Network Index Mobile Forecast Highlights, 2012-2017*, United States – Network Connections, CISCO SYSTEMS, http://www.cisco.com/web/solutions/sp/vni/vni_mobile_forecast_highlight/index.html#~Country).

The value to cellular offload from Wi-Fi is substantial, with one study estimating a current savings of up to $26 billion per year in infrastructure costs alone.[21] A 2012 economic study by Richard Thanki further estimated that the economic value of cellular offload could reach $250 billion worldwide over the next four years.[22]

Finally, there are also positive externalities associated with unlicensed services that are not as easily quantified, but are readily apparent. This was demonstrated by Comcast's experience during the aftermath of Hurricane Sandy and, more recently, after the tragic events at the Boston Marathon. Following Sandy, mobile wireless service was unavailable for large portions of the affected areas,[23] but Comcast and others made their Wi-Fi access points available to anyone who needed them to communicate with family or friends, or otherwise get important recovery information. Likewise, in the immediate aftermath of the recent attacks at the Boston Marathon, commercial mobile wireless networks were at times overloaded,[24] but Comcast opened its network to anyone with a Wi-Fi-enabled device, allowing many individuals – including non-Comcast subscribers – to establish communications. Wi-Fi assists in such challenging scenarios for several reasons: its use of non-exclusive and globally available spectrum; the highly effective interference avoidance protocols native to the 802.11 family of

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21 Cooper at 22.

22 Richard Thanki, *The Economic Significance of Licence-Exempt Spectrum to the Future of the Internet*, at 9 (June 2012).

23 *See, e.g.*, Brendan Sasso, *FCC Says Hurricane Sandy Knocked Out 25 Percent of Cell Towers in Its Path*, THE HILL (Oct. 30, 2012), *available at* http://thehill.com/blogs/hillicon-valley/technology/264915-fcc-hurricane-sandy-knocked-out-25-percent-of-cell-towers.

24 *See, e.g.*, *Cell Networks Overloaded in Boston Marathon Bombing*, ENTERPRISE MOBILITY TODAY (Apr. 16, 2013), *available at* http://enterprisemobilitytoday.com/cell-networks-overloaded-in-boston-marathon-bombing-aftermath/.

technologies that allow them to operate in the same bands as other users; the carrier-agnostic interoperability between end-user devices and network infrastructure; the natural resilience of a distributed, small-cell architecture; and the pervasiveness of the wired broadband networks that connect Wi-Fi access points to the Internet.

During emergencies such as these, Wi-Fi networks offer consumers an important opportunity to communicate and stay connected because of the interoperable nature of Wi-Fi. Almost every mobile device is now equipped with a Wi-Fi radio, so almost everyone can access a Wi-Fi network, regardless of his or her underlying mobile operator. Mobile wireless providers simply could not offer access to everyone, even if they wanted to, because of incompatibility between GSM, LTE, or CDMA technologies or supported frequency bands. In a sense, Wi-Fi has become the interoperable communications standard for consumers.

III. COMMISSION ACTION IS NEEDED TO PRESERVE THE FUTURE OF WI-FI BECAUSE OF 2.4 GHZ SPECTRUM EXHAUST AND THE EMERGENCE OF THE 802.11AC STANDARD.

Identifying additional unlicensed spectrum and improving the rules that govern existing unlicensed bands are critical to preserving and expanding broadband deployment, economic growth, and the public safety benefits of Wi-Fi described above. This is the case because: (1) the core 2.4 GHz unlicensed band is becoming saturated; and (2) no existing unlicensed band can fully accommodate the powerful new 802.11ac standard, which will enable widespread "gigabit Wi-Fi" unlicensed networks.

A. There Is a Looming Spectrum Shortage in the 2.4 GHz Band.

According to Cisco's Virtual Networking Index, Wi-Fi traffic will triple between 2011 and 2016, with as much as 11.1 exabytes per month of data traveling via Wi-Fi connections by

2016.[25] Comcast's own experience with the enormous growth in consumer demand of its Xfinity WiFi service is consistent with this prediction.

Today, most operators deploy Wi-Fi networks in the 2.4 GHz band, which, from a practical perspective, has only three 20-megahertz non-overlapping channels available for unlicensed use.[26] This band is not exclusively available for wireless broadband, however. Vast numbers of other wireless devices, including microwave ovens, garage door openers, and cordless phones, use this band. In densely populated areas, increased use of Wi-Fi – as well as those myriad other unlicensed devices that accompany urban populations – has created congestion in the 2.4 GHz band, reducing the utility of this spectrum particularly for high-throughput and latency-sensitive applications.[27]

Although the 2.4 GHz band has allowed Wi-Fi to flourish, this band is reaching capacity in larger, high-penetration markets.[28] Even in less-crowded markets, the 2.4 GHz band may be congested by 2015.[29] Operators are working hard to try to augment capacity by adding access points where the demand is greatest; in fact, operators will most likely double the number of

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25 CVNI Forecast.

26 The 2.4 GHz band was the first band made available for Wi-Fi use, and the most commonly used Wi-Fi standards (802.11b, g, and n) all operate in 2.4 GHz. 802.11n also operates in 5 GHz, but because of constraints in that band, discussed in more detail below, *infra* Sections IV and V, most 802.11n deployments are dual-band, operating in both 2.4 GHz and 5 GHz.

27 *Cf.* Cooper at 22; Mass Consultants Limited, *Estimating the Utilisation of Key Licence-Exempt Spectrum Bands*, Final Report, Issue 3, at 2, 27 and 80 (Apr. 2009), *available at* http://stakeholders.ofcom.org.uk/binaries/research/technology-research/wfiutilisation.pdf.

28 NPRM, Statement of Commissioner Mignon Clyburn.

29 *See* Rob Alderfer, *WiFi Spectrum: Exhaust Looms*, CABLELABS, at 11-12 (May 28, 2013) (included as Attachment A to Comments of The National Cable & Telecommunications Association, ET Docket No. 13-49 (filed May 28, 2013)) ("*WiFi Spectrum: Exhaust Looms*").

deployed access points by 2015.[30] And the transition to 802.11n may yield improvements in wireless efficiency.[31] However, the organic growth of traffic transmitted over Wi-Fi networks will consume nearly all of this additional capacity.[32]

The Commission has recognized this risk. Acting Chairwoman Clyburn has stated, "The 2.4 GHz band, while critical to the success of Wi-Fi and other unlicensed technologies, is increasingly congested particularly in major cities."[33] Additionally, as former Chairman Genachowski explained, "Wi-Fi congestion is a very real and growing problem."[34] Furthermore, former Commissioner McDowell noted, "The spectrum that is used for unlicensed Wi-Fi is also experiencing congestion, which will only increase in the coming years if we do not make appropriate bands, like the 5 GHz band, more attractive for investment and innovation."[35]

A recent CableLabs study corroborates these warnings, finding that

> [A]ny reasonable extrapolation of known trends leads to the conclusion that WiFi spectrum exhaust is a matter of "when", not "if". In light of the substantial time typically required to release new spectrum, this finding serves as a guidepost for spectrum policy. In the absence of new WiFi spectrum, it is likely that wireless broadband consumers will experience reduced performance. This poses a risk to

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30 WIRELESS BROADBAND ALLIANCE, GLOBAL DEVELOPMENTS IN PUBLIC WI-FI: WBA Industry Report 2011, *available at* http://www.wballiance.com/wba/wp-content/uploads/downloads/2012/07/16_WBA-Industry-Report-2011-_Global-Developments-in-Public-Wi-Fi-1.00.pdf.

31 *WiFi Spectrum: Exhaust Looms*, at 8-9.

32 *Id.* at 7. In addition, although adding access points can increase capacity, that capacity is not additive, as access points deployed with higher density must transmit at reduced power to avoid co-channel interference. *See* RF Solutions, *20 Myths of Wi-Fi Interference*, CISCO, http://www.cisco.com/en/US/prod/collateral/wireless/ps9391/ps9393/ps9394/prod_white_paper0900aecd807395a9_ns736_Networking_Solutions_White_Paper.html.

33 *Id.* at 1822, Statement of Commissioner Mignon Clyburn.

34 NPRM, Statement of Chairman Julius Genachowski, 28 FCC Rcd. at 1818.

35 *Id.* at 1820-21, Statement of Commissioner Robert McDowell.

> continued growth of the wireless broadband ecosystem, a central element of technology and economic policy in the United States.[36]

The study estimates that, within the next few years, there will be a Wi-Fi spectrum shortage in the 2.4 GHz band. This shortage will negatively impact consumers in a variety of ways, including by reducing throughput and shrinking coverage areas for each access point, making Wi-Fi less valuable, particularly for bandwidth-intensive uses.[37]

B. The Next Generation Wi-Fi Standard Will Require Wider Bandwidths to Achieve Gigabit Wireless Broadband Speeds.

Additional unlicensed spectrum also will be necessary to enable the next generation of Wi-Fi, called IEEE 802.11ac, which promises to deliver substantial benefits to consumers, businesses, and providers alike. Most notably, the new standard will allow for wireless broadband speeds potentially in excess of 1 gigabit per second, dramatically exceeding the speeds enabled by current wireless technologies.[38] With 802.11ac, consumers will be able to upload and download more data more quickly and more reliably than ever before. As Cisco has explained, "802.11ac is about delivering an outstanding experience to each and every client served by an [access point], even under demanding loads."[39]

The enhancements enabled by the 802.11ac Wi-Fi standard translate into tangible benefits for consumers, above and beyond the obvious appeal of faster throughput. Wireless networks operating on the 802.11ac standard will support multiple, simultaneous data-intensive

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36 *WiFi Spectrum: Exhaust Looms*, at 5.

37 *Id.* at 10-12.

38 *802.11ac: The Fifth Generation of Wi-Fi*, Technical White Paper, CISCO at 3 (Aug. 2012), *available at* http://www.cisco.com/en/US/prod/collateral/wireless/ps5678/ps11983/white_paper_c11-713103.pdf ("Cisco White Paper").

39 Cisco White Paper at 4.

uses, such as several users streaming HD videos, without any appreciable degradation in quality.[40] In addition:

- The new standard will increase wireless network capacity, increase spectral efficiency, and improve reliability;[41]
- Consumers will experience improved energy efficiency, as their devices will consume less battery power due to faster and more efficient data transfers;[42]
- In areas where user density is high, such as at universities and in office spaces, 802.11ac will deliver enhanced performance because of its superior ability to handle data traffic over multiple spatial streams;[43]
- The new standard will deliver relatively high data rates over a larger area than current generation Wi-Fi standards are capable of delivering, improving in-home and in-office Wi-Fi networks as well as significantly bolstering the coverage and usability of shared, public Wi-Fi access points, such as the rapidly developing Xfinity WiFi and Cable WiFi networks.[44]

As data usage skyrockets and consumers expect networks to handle ever-increasing levels of demand without degradation in quality, the nation's broadband ecosystem would greatly benefit from the network enhancements that will be made possible by 802.11ac. Some

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40 *See id*.

41 *See* John Cox, *Q&A: What the FCC's Wi-Fi Expansion Means for You*, NETWORK WORLD (Jan. 23, 2013), *at* http://www.networkworld.com/news/2013/012313-expanding-wifi-266058.html; *What You Need to Know About 802.11ac*, MOTOROLA SOLUTIONS at 4-5 (July 2012), *available at* http://www.motorola.com/web/Business/_Documents/White%20Paper/_Static%20files/80211ac_White_Paper_0712-web.pdf ("Motorola White Paper").

42 *See, e.g.*, Dong Ngo, *5G Wi-Fi (802.11ac) Explained: It's Cool*, CNET (May 18, 2012), http://news.cnet.com/8301-17938_105-57437317-1/5g-wi-fi-802.11ac-explained-its-cool/ ("The fact that [802.11ac] WiFi clients can finish transmitting the same amount of data in just around 1 third of the time, compared to [802.11n] clients, translates into less energy being used.").

43 *See* Motorola White Paper at 4.

44 *See id.* at 4-5.

studies forecast that there will be nearly *one billion* 802.11ac-enabled devices in use by 2015.[45] But additional, usable unlicensed spectrum is the key missing ingredient in the United States.

The benefits delivered by the 802.11ac standard result primarily from wideband channels, higher-order modulation and coding schemes, an extension of MIMO to enable concurrent multi-user transmissions, and the use of enhanced channel-bonding techniques that allow flexible and efficient use of spectrum resources. The result is a potentially much "wider pipe" that can transmit more data more efficiently to achieve higher speeds that will support simultaneous data-intensive uses and unleash a new generation of wireless innovation.

To realize its full potential and deliver gigabit service, however, the 802.11ac standard requires 160 megahertz contiguous channels – far wider than channels currently available in any of the spectrum bands commercially usable for unlicensed services in the United States. Through this proceeding, however, the Commission has the opportunity to provide sufficient usable 5 GHz spectrum to support the next generation of Wi-Fi. Other nations are already moving forward with spectrum band plans for this gigabit Wi-Fi technology. The Commission too should seize this opportunity without delay.

IV. THE COMMISSION SHOULD ADOPT RULES THAT PROMOTE WIDESPREAD ADDITIONAL USE OF THE 5 GHZ BAND TO ADVANCE WI-FI.

This proceeding is critical both to addressing the challenge of 2.4 GHz exhaust and seizing the opportunity of gigabit Wi-Fi. This is the case because the 5 GHz band has more spectrum potentially available for unlicensed devices than any other band being considered in the United States today – and it is the only band that could offer unlicensed channels large enough to

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[45] *See* Press Release, In-Stat, *Zero to a Billion*; *802.11ac-Enabled Device Shipments to Soar by 2015, Says In-Stat* (Feb. 8, 2011), *available at* http://www.marketwire.com/press-release/zero-to-a-billion-80211ac-enabled-device-shipments-to-soar-by-2015-says-in-stat-1391854.htm.

accommodate the 802.11ac standard. Furthermore, IEEE has already created Wi-Fi standards for this band, and many consumer devices in the U.S. and around the world already have 5 GHz capability. And all of this can be done consistent with the spectrum sharing policies espoused by the Administration to facilitate the highest and most effective use of the spectrum without harming incumbent users. As Commerce Secretary Nominee Penny Pritzker recently emphasized, the government must "look harder" at opportunities such as spectrum sharing in order to "find more spectrum that can be made available for commercial use."[46] By initiating the 5 GHz NPRM, the Commission has begun the process of achieving this important goal.

Wi-Fi network providers like Comcast could make additional 5 GHz spectrum resources available to consumers very rapidly and without the need for specialized devices or chips. But without Commission action in the near term, there is a substantial risk of stagnation in the development of Wi-Fi as a broadband delivery mechanism in the United States. Comcast therefore strongly supports the Commission's proposal to designate the new U-NII-2B and U-NII-4 bands for unlicensed use. Opening these bands for Wi-Fi devices would represent a major step forward towards addressing the oncoming unlicensed spectrum shortage. Comcast agrees with the Commission that unlicensed devices should operate on a non-interference basis relative to incumbent licensees in these bands, as is the case in each of the 5 GHz U-NII bands already open for unlicensed technologies. Moreover, the Commission's U-NII rules should continue to prohibit unlicensed operations from creating harmful interference to incumbents such as

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[46] U.S. Senate Committee on Commerce, Science, and Transportation, Nominations Hearing, "Nomination of Ms. Penny Pritzker to be Secretary of Commerce" (May 23, 2013), *available at* http://www.commerce.senate.gov/public/index.cfm?p=Hearings&ContentRecord_id=33632e00-0ba4-4e3f-b08d-325962fa7217.

government users, ITS licensees, or satellite licensees, each of which would maintain their protected status.

But for this proceeding to succeed, the Commission must not only designate these two new bands for unlicensed use, it must also update the technical rules that govern the existing 5 GHz U-NII bands to reflect substantial changes in circumstances, technology, and the marketplace that render obsolete the Commission's 15-year-old assumptions about this band.

The existing technical rules for the U-NII-3 band set a 1 watt maximum transmit power limit, permit indoor or outdoor operation, and do not impose DFS listen-and-avoid technology. These rules make the U-NII-3 band attractive for investment and deployment; consequently, U-NII-3 is the only 5 GHz band that Comcast currently can use in all locations where it deploys Xfinity WiFi. But the U-NII-3 rules govern access to just 100 megahertz of the 555 megahertz potentially available for use in the 5 GHz band. In each of the other existing U-NII bands – the vast majority of the frequencies – a combination of indoor-only restrictions, low power levels, and/or DFS requirements limit the bands' usefulness for many Wi-Fi operations, including cable Wi-Fi systems. As a consequence, there has been far less investment in and development of these other bands.

As the Commission reviews how to increase investment and deployment in the 5 GHz band, updating these technical rules is as important as identifying new bands for unlicensed use. Comcast therefore respectfully requests that the Commission adopt the following five principles:

- *First*, consistency between adjacent bands will advance gigabit Wi-Fi by enabling operators to take advantage of the 160 megahertz channels contemplated by the next generation 802.11ac standard. The Commission should therefore harmonize the rules for the U-NII-1 and U-NII-2 bands and, separately, the U-NII-3 and U-NII-4 bands.
- *Second*, indoor-use restrictions preclude a band's use for widespread Wi-Fi deployments, including cable Wi-Fi systems. They are also inconsistent with the current Wi-Fi

marketplace. The Commission should therefore remove the indoor-use restriction in the U-NII-1 band and not impose such a restriction in any new band.

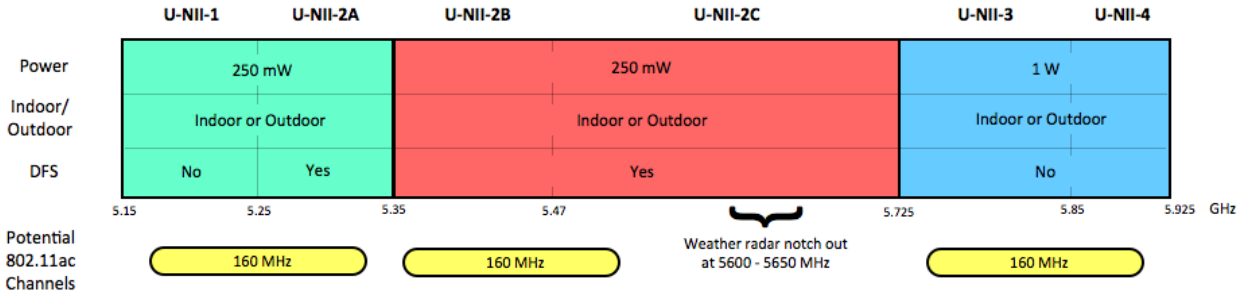
- *Third*, DFS requirements undermine commercial use by increasing manufacturing costs and undermining the user experience. While the Commission should update DFS to protect incumbent government users in the U-NII-2 bands, it should not expand DFS to cover any additional bands.

- *Fourth*, higher transmit power enables the use of Wi-Fi in applications that require greater range, coverage, or throughput, and in other cases can reduce the cost of deployment and improve the consumer experience. The Commission should therefore increase the allowed power level in U-NII-1 and set the power level in U-NII-4 to match that of U-NII-3.

- *Fifth*, because of the intense and immediate need for additional unlicensed spectrum and updated rules in the 5 GHz band, the costs of delay are very high. The Commission should therefore act as soon as possible where it is able to do so, even if this means issuing rules covering portions of the 5 GHz band while it works to resolve more difficult questions in other portions of the band.

If the FCC follows these principles, it will produce a 5 GHz band that is best able to support the efforts of innovators and investors to address the fast-approaching unlicensed spectrum shortage and to deliver gigabit Wi-Fi. Figure 6 below illustrates the recommended changes as applied to the 5 GHz band.

Figure 6: Recommended 5 GHz Changes and Larger Wi-Fi Channel Sizes



A. Harmonization of Technical Rules that Apply to Adjacent Bands Will Enable Access to Multiple 160 Megahertz Gigabit Wi-Fi Channels in the 5 GHz Band.

The Commission should harmonize the technical rules across the 5 GHz band whenever possible in order to advance gigabit Wi-Fi. Although the 5 GHz band may appear to have sufficient spectrum to accommodate the larger channels contemplated by the new 802.11ac Wi-Fi standard, inconsistent rules across the U-NII bands make it impractical to develop networks and products that can actually use these wider channels.

Under the Commission's rules, any unlicensed device spanning two U-NII bands must operate within the "lowest common denominator" rules that apply to each band – including DFS, power, and indoor-only restrictions that apply to any of the bands used by a channel.[47] If, for example, an unlicensed device used a channel that overlapped the U-NII-1 and U-NII-2A bands, the device would be subject to (1) the low 50 mW power limit in U-NII-1, (2) the indoor-only restriction in U-NII-1, and (3) the DFS requirements in U-NII-2. In short, such a device would be subject to the worst of both worlds, and using such a channel would mean "forfeit[ing] opportunities for new broadband applications that may be permitted in other bands."[48]

Dissimilar U-NII band operating parameters will become increasingly problematic as network operators seek the larger 160 megahertz channels needed to achieve the full potential of the 802.11ac standard. For example, while the available spectrum could in theory accommodate

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47 FCC, Office of Engineering and Tech. Laboratory Division, *Guidance for IEEE 802.11ac and Pre-ac Device Emissions Testing* at 3 (Apr. 8, 2013) (noting that "[a]ll operational requirements for each band of operation must be satisfied"); NPRM ¶ 46 ("When devices are designed to operate across multiple frequency bands, the Commission's rules require that applicants demonstrate compliance with the rules for each of the individual frequency bands in which they intend to operate in order to be certified for operation in each band.").

48 NPRM ¶ 19.

up to twelve 40 megahertz channel blocks in 5 GHz, two of those are restricted to indoor use only,[49] two more are eliminated from use because of current guidelines prohibiting Wi-Fi transmission in the band used by Terminal Doppler Weather Radar systems, and some equipment manufacturers do not support use of the remaining channels in U-NII-2 because of the DFS requirements, thereby eliminating four more 40 megahertz channels.[50] Harmonizing the technical rules between U-NII bands therefore will be critical to enabling full access to next generation Wi-Fi technologies and to promoting continued Wi-Fi investment.[51]

Establishing consistent and reasonable operating parameters across various sub-bands in 5 GHz is particularly important because, although the 802.11ac standard allows aggregation of non-contiguous spectrum for certain bonded channel modes, the technology benefits from a contiguous 160 megahertz channel for maximum performance.

Applying this principle to the NPRM, the Commission should harmonize the technical rules for the U-NII-1 and U-NII-2A bands by eliminating the indoor-only restriction and increasing maximum power in U-NII-1. The Commission should also extend the technical rules for the U-NII-3 band to the U-NII-4 band, as well as to the 25 megahertz between these bands.

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[49] The U-NII-2 band accommodates an additional four channels, but many device manufacturers do not support those channels because of the DFS requirements in that band. *See* 47 C.F.R. § 15.407 (h)(2); *see also Understanding 20 MHz Versus 40 MHz 802.11n Channel Configuration*, CONNECT802, http://www.connect802.com/80211n_channels.htm. ("Connect802").

[50] *See* Connect802.

[51] NPRM ¶¶ 26-28.

These actions would produce two contiguous 160 megahertz 802.11ac channels that could be used for widespread, indoor/outdoor Wi-Fi networks.[52]

B. Indoor-Only Restrictions Stifle the Development of Widespread Wi-Fi Networks and Are Inconsistent with the Current Wi-Fi Marketplace.

The Commission should remove the indoor-only restrictions in the 5 GHz band. As the Commission recognizes, "the assumptions made in 1997 [when indoor-only restrictions were first introduced] may not be valid for today's market."[53] Rather, today's "devices are increasingly mobile or portable in nature, not easily limited to indoor locations."[54]

Today, virtually every consumer communications device uses Wi-Fi – including the smartphones and tablets that consumers use outdoors every day. As the popularity of mobile phones, tablets, and other portable devices with Wi-Fi capability has soared, demand for outdoor Wi-Fi access has exploded. Comcast deploys substantial portions of its Xfinity WiFi network outdoors to accommodate these important uses. This means, however, that Comcast and others cannot use any spectrum with indoor-only restrictions in their outdoor Wi-Fi deployments. Indoor-only restrictions therefore severely limit WiFi network operators' ability to use a band. In the 5 GHz band, Comcast does not use the U-NII-1 band at all because of the indoor-only restriction (as well as the 50 mW power level limitation). As utilization of the 5 GHz band increases, the U-NII-3 channels, the only 5 GHz channels not encumbered by DFS or indoor-only restrictions, will not be sufficient to address the demand for service.

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52 The U-NII-1/U-NII-2A channel would have a DFS requirement. It would therefore be less useful and flexible as the U-NII-3/U-NII-4 channel. But it would be useful for a sub-set of applications.

53 NPRM ¶ 37.

54 *Id.*

Applying this principle to the NPRM, the Commission should eliminate the indoor-only restriction in the U-NII-1 band, and not adopt such a restriction in any other band.

C. The Commission Should Impose DFS Requirements Sparingly, Because They Undermine Commercial Use.

DFS requirements increase equipment costs and delay commercialization timelines while undermining the Wi-Fi user experience. The Commission's third principle therefore should be to limit any DFS requirements to cases where they are absolutely necessary. DFS requirements drive up device costs by introducing complexity, delay, and expense to the testing and certification process. Device manufacturers that bear these costs pass them along to consumers, raising the price of devices that include DFS capability. Furthermore, manufacturers are more likely to produce DFS-capable devices only for enterprise markets, where customers are willing to pay for more costly equipment with longer life cycles.

DFS requirements undermine a consumer's experience by causing significant service delays and interruptions. When a DFS-capable device boots up, it takes an extended period of time to scan channels for the protected government users that it must avoid. Additionally, even in the middle of a transmission, a DFS-capable device will vacate a channel after sensing a protected user. This can disrupt a consumer who is downloading or streaming data.

The negative effects of the DFS restrictions will be amplified in the context of the new 802.11ac standard. The 160 megahertz channels necessary to achieve the full potential of the 802.11ac standard will often span multiple bands, and FCC rules will require users of such bands to comply with the most restrictive requirements of any band used. Imposition of DFS

requirements in U-NII-4, for example, would therefore affect channels stretching back into the U-NII-3 band.[55]

Applying this principle to the NPRM, the Commission should restrict DFS to where it currently exists, the U-NII-2 sub-bands. Existing DFS requirements have permitted commercial and government users to share spectrum in the U-NII-2 sub-bands that otherwise would be unavailable for wireless broadband use. In addition, reasonable updates to DFS requirements in the U-NII-2 sub-bands would be appropriate if such changes are the only way to protect existing government incumbents. And the FCC's equipment certification process may be updated, such as by including a requirement that manufacturers make it more difficult or impossible to turn off DFS in a device using a U-NII-2 sub-band, in order to protect government users.

By contrast, extending DFS into any new band would greatly reduce investment and undermine performance in that band. In order to maximize the utility of 5 GHz spectrum to meet exploding Wi-Fi demand, the Commission should decline to extend DFS into these other U-NII bands.

D. Higher Transmit Power Enables Wi-Fi Networks with Greater Range, Coverage, and Throughput.

The Commission should strive to increase power limits where possible, because doing so will increase the range and throughput of Wi-Fi connections – thereby reducing the cost of network deployment and improving the consumer experience. These considerations are particularly important for devices that transmit in the 5 GHz band where signals tend to attenuate

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[55] This would also be the case for a 160 megahertz channel stretching from U-NII-1 through U-NII-2A. Comcast does not oppose DFS in U-NII-2A, despite this problem, because incumbent users already operating in the band depend on an existing DFS requirement. However, the continuation of DFS in U-NII-2A results in there being only one possible contiguous 5 GHz band that does not have DFS – a potential U-NII-3 to U-NII-4 channel.

faster with distance and suffer higher building penetration and foliage losses.[56] In the presence of these environmental factors, higher transmit power levels ensure higher signal-to-noise ratio at the receiving devices, thereby improving link reliability, performance, and range.

Higher power levels are beneficial for both indoor and outdoor use. Indoors, additional power allows signals to penetrate interior walls and floors within a home or office, thereby providing more ubiquitous coverage. Outdoors, higher power helps to overcome penetration, diffraction, and absorption losses, which can otherwise reduce range, particularly for point-to-point links and mesh networks. Importantly, consumers will realize the benefits of authorizing higher transmit power for access points regardless of whether their terminal device transmits at the maximum power limit because a higher signal-to-noise ratio at the user device will improve downlink throughput, i.e. faster download speeds.

Applying this principle to the NPRM, Comcast suggests that the Commission increase the power of the U-NII-1 band and allow 1 W operation in the U-NII-4 band. The U-NII-1 band's current limit of 50 mW is too low for the band to be of practical use for widespread Wi-Fi networks; therefore, the FCC should increase it to at least to 250 mW. The FCC should harmonize the U-NII-4 band with the U-NII-3 band by adopting a 1 W power limit.

E. Delay in Designating Additional Unlicensed Spectrum and Updating Technical Rules Will Impose Large Costs on Consumers and Businesses.

The Commission should resolve the need for additional Wi-Fi spectrum as expeditiously as possible. As demonstrated above, consumer demand for Wi-Fi is growing rapidly. This growth has pushed the 2.4 GHz band to its limit – it is already highly congested in many densely

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[56] *See Amendment of the Commission's Rules to Provide for Operation of Unlicensed NII Devices in the 5 GHz Frequency Range*, Report and Order, 12 FCC Rcd. 1576 (1997) (stating that signals at higher frequencies "have propagation constraints that will reduce the communication distance of devices operating at equal powers").

populated areas and will not, alone, be able to support the expected growth of the Wi-Fi ecosystem. Furthermore, the new 802.11ac standard, which requires larger channels than are practically available in existing unlicensed bands, will in the near future become the dominant industry standard. Soon, millions of consumers in the United States may expect gigabit Wi-Fi, but without Commission action domestic spectrum designations will not allow spectrum supply to meet this demand. Applying this principle to the NPRM, the Commission should therefore find that additional unlicensed designations and updated rules in the 5 GHz band are critical to addressing both of these rapidly approaching challenges. The Commission should adopt an order consistent with its proposals in the NPRM as soon as possible, even if this means issuing rules covering portions of the 5 GHz band while it works to resolve more difficult questions in other portions of the band.

The Commission should also recognize that there will never be a better time to empower sharing of the U-NII-4 band than today, or a better band to actualize the Administration's forward-looking policy of advancing spectrum sharing. 5 GHz ITS technologies are in their infancy. In the 14 years since the Commission granted ITS use of the band there has been research into potential ways to use the spectrum, but no licensee has deployed a commercial system.[57] Various interests have only recently coalesced around the emerging 802.11p standard, and the first pilot study is only now underway. In recent testimony before Congress, the President and CEO of the Alliance of Automobile Manufacturers made clear that widespread

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[57] *See, e.g.*, Doug Newcomb, *Why Your Next Car Should – and Shouldn't – be a Wi-Fi Hotspot*, POPULAR MECHANICS (Oct. 18, 2012), *available at* http://www.popularmechanics.com/cars/news/industry/why-your-next-car-should-and-shouldnt-be-a-wi-fi-hotspot-13852868 (quoting an industry analyst explaining that "[t]he reality is that adoption of DSRC technology is at least 10 years away and will require investments that federal and local governments may be unwilling to make, while the resistance of carmakers will also be strong").

deployment of ITS technology is still "a very long time away," and it could "take forever to get to a point where [the technology] has permeated the stream."[58] If the Commission acts now to require sharing, engineers from ITS licensees and Wi-Fi equipment manufacturers can build sharing into their technologies and networks from the beginning, rather than as a difficult retrofit. The result would be a far more intensively and efficiently used band than otherwise would be possible. Comcast stands ready to engage with the incumbent licensees to work together to make the U-NII-4 band a model that demonstrates how the Administration's vision of spectrum sharing can work in practice.

V. CONCLUSION.

Comcast's Xfinity WiFi network, as well as its customers' first-rate in-home Wi-Fi experience, demonstrates both the great value of unlicensed networks and consumers' soaring demand for more and better Wi-Fi services. With adequate spectrum resources and technical rules that support build out, Wi-Fi can continue to be an engine for economic growth, fertile ground for innovation, and an important part of emergency response. But 2.4 GHz exhaust, and the need for 160 megahertz channels to deliver gigabit Wi-Fi, mean that the future of Wi-Fi is uncertain without Commission action. This will slow down investment and innovation. Comcast therefore strongly supports the FCC's 5 GHz NPRM, and urges the Commission to act as expeditiously as possible to issue rules that designate the U-NII-2A and U-NII-4 bands for unlicensed use – and, critically, that update its technical rules for the existing U-NII bands. Comcast also respectfully requests that the Commission not delay action on specific parts of the

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[58] *See The Road Ahead: Advanced Vehicle Technology and its Implications: Hearing Before the S. Comm. on Commerce, Science, and Transportation*, 113th Cong. (2013) (testimony of Mitch Bainwol, President and CEO of Alliance of Automobile Manufacturers), *available at* http://www.commerce.senate.gov/public/index.cfm?p=Hearings&ContentRecord_id=f228343f-36b3-4517-b01f-9f15624eb05d.

band, even if this means segmenting the proceeding. The need for additional unlicensed spectrum resources is so strong, and the cost of delay is so high, that the Commission should act as soon as possible where it is able to do so.

Respectfully submitted,

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