Response to Ofcom Spectrum Sharing Consultation

About Google

Consistent with our mission of organizing the world's information and making it universally accessible and useful, Google's products and services span the entire wireless economy, including mobile operating systems, mobile applications, phones, and tablets. Google's business depends on users having access to robust licensed and licence-exempt spectrum resources.

General Response

Usage of wireless networks in Europe is skyrocketing. Some forecasts predict that demand for mobile data will increase at a compound annual growth rate of 66% between 2012 and 2017.[1] Meeting this demand is essential to promoting technological innovation and economic growth.

I. Ofcom should enable robust access to both licensed and licence-exempt spectrum

Enabling access to both licensed and licence-exempt spectrum is key to meeting increasing spectrum demands. In the past, a balanced approach has fueled the wireless economy, benefiting consumers, innovators, and investors. Exclusive access to licensed spectrum provides the certainty major operators need to make large investments in their wide-area networks, while broad eligibility for access to licence-exempt spectrum fosters widespread contributions to innovation and investment in emerging technologies. For instance, because licence-exempt devices are "free from the burden of normal delays associated with the licensing process," manufacturers can design equipment to "fill a unique need [that can] be introduced into the market quickly."[2] Thousands of new licence-exempt devices are certified each year. Of these, Wi-Fi devices are the most well known, but Bluetooth,[3] Zigbee,[4] and RFID[5] devices have all also experienced rapid growth in the last several years.

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[1] European Commission, *Study on the Importance of Wi-Fi & the Socioeconomic Benefits of Using Small Cell Infrastructures* 1, Aug. 1, 2013, http://ec.europa.eu/digital-agenda/en/news/study-importance-wi-fi-socioeconomic-benefits-using-small-cell-infrastructures (EC Study).

[2] Kenneth R. Carter, Ahmed Lahjouji, & Neal McNeil, FCC, *Unlicensed and Unshackled: A Joint OSP-OET White Paper on Unlicensed Devices and Their Regulatory Issues*, OSP Working Paper Series at 5 (May 2003).

[3] Bluetooth is a standard facilitating hands-free operation of music players, mobile phones, and other devices.

[4] Zigbee is powers technologies that benefit from ad hoc and mesh networking solutions, such as home automation.

[5] Radio Frequency Identification (RFID) technologies are used in a variety of industries to track inventory or other objects.

In addition, licence-exempt use complements licensed use. As Ofcom recognizes, Wi-Fi "offer[s] the opportunity to offload traffic from mobile access networks."[6] The European Commission recently concluded that offloading traffic has saved European mobile network operators approximately 35 billion euros in network deployment costs and projected network savings of 200 billion euros by 2016.[7] The Wi-Fi experience also makes clear that greater availability of licence-exempt spectrum increases demand for and the utility of licensed spectrum. Most obviously, increased Wi-Fi availability and ubiquity has enabled consumers to use their phones and tablets more intensively to access a variety of online content and services. In turn, adoption and development of these services drives demand for licensed and licence-exempt network access, creating a virtuous cycle of investment in content and access.

II. Ofcom should adopt spectrum-sharing policies as a critical strategy for meeting increased demand.

Given the rapid increase in demand for spectrum to support wireless services, it is unlikely that Ofcom will be able to meet that demand solely through a policy of clearing and repurposing spectrum. To make additional spectrum available for use, Ofcom should adopt spectrum sharing policies.

Spectrum sharing is attractive for several reasons. First, spectrum sharing allows more efficient use of a finite resource. For example, enabling licence-exempt use of the television white spaces will allow new devices and services to take advantage of spectrum currently lying fallow without displacing existing users.

Second, spectrum sharing can make additional spectrum for wireless services available very quickly. In contrast to the often lengthy and complicated process of clearing incumbents and auctioning exclusive licenses, spectrum sharing minimizes delays by leaving incumbent operations in place. Further, spectrum sharing can be used in times of transition between clearing and auctioning—for example, databases can enable temporary access to available spectrum before auctions are conducted and licensed services become operational.[8]

Third, spectrum sharing works. Networks relying on shared spectrum have been deployed successfully in the United States.[9] And Google's trial network in Cape Town, South Africa, delivered broadband to 10 secondary schools with a minimum data rate of 2.5 Mbps and peak data rates of 10 Mbps at distances between 3 and 6 kilometers from a base station, without causing harmful interference to incumbent services.

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[6] Ofcom, *Consultation on the Future Role of Spectrum Sharing for Mobile and Wireless Data Services*, Aug. 9, 2013, at 2.

[7] EC Study at 5.

[8] *See* Michael Calabrese, *Use it or Share it: Unlocking the Vast Wasteland of Fallow Spectrum* (2011), at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1992421 (last visited Nov. 8, 2013).

[9] Amar Toor, *North Carolina Launches FCC-approved TV White Space Network in Wilmington*, ENGADGET, Jan. 30, 2012, at http://www.engadget.com/2012/01/30/north-carolina-launches-fcc-approved-tv-white-space-network-in-w/ (last visited Nov. 8, 2013).

In developing spectrum sharing approaches, Ofcom should consider geolocation databases as important tools. A geolocation database enables sharing by receiving location information from a device and transmitting information regarding spectrum that is available for use by that device at its stated location. For example, in the context of database-enabled sharing of the television broadcast bands, a licence-exempt device sends its location to a database, and the database provides information about the television channels available for use at the device's location, as well as the technical rules (e.g., maximum transmit power or out-of-band emission restrictions) associated with operation in those channels.

Ofcom should also investigate both two-tier (incumbent/licence-exempt) and three-tier (incumbent/licensed/licence-exempt) approaches to spectrum sharing. Whether a two or three-tier approach is employed, Ofcom should allocate sufficient spectrum to secondary users—both licence-exempt and licensed, if applicable. The amount of spectrum needed to support an ecosystem will vary by frequency range. For example, in the spectrum below 1 GHz, tens of MHz of licence-exempt spectrum may support a viable ecosystem of chips, devices, and database, but above 5 GHz, hundreds of megahertz of available spectrum likely will be needed to support investment and deployment. Importantly, because adequate spectrum is a critical precondition for successful deployment, device and chip manufacturers will hesitate to commit resources to new bands and technologies until there is certainty that sufficient spectrum will be available. For example, the European Commission noted earlier this year that uncertainty regarding which spectrum will be available for mobile broadband across the continent has hindered the deployment of next generation networks.[10] These principles apply equally to licensed and licence-exempt technologies.

Finally, spectrum sensing holds potential to enhance sharing substantially. Spectrum sensing, whether used alone or in combination with a geolocation database, may enable access to spectrum that a database alone cannot achieve. Ofcom accordingly should adopt flexible policies allowing multiple sharing methodologies.

Responses to Specific Questions

Question 1: How is demand for indoor wireless data connection speeds and capacity likely to develop over the next 5–10 years?

Demand for indoor Wi-Fi is rapidly increasing.

- Wi-Fi device sales have seen double-digit growth in recent years, with growth in 2011 alone estimated to be between 25% and 30%.[11]

[10] European Commission, *Working Document: Impact Assessment on the Measures Concerning the European Single Market for Electronic Communications and to Achieve a Connected Continent* (2013), at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2013:0331:FIN:EN:HTML (last visited Nov. 8, 2013).

[11] Comments of Edgar Figueroa, CEO, Wi-Fi Alliance, at Center for Internet and Society at Stanford Law School, "The Power and Potential of the Unlicensed Economy" (July 11, 2012), *available at*

- On an annual basis, the sale of Wi-Fi routers "has sustained a compound average growth rate over 30% for almost a decade."[12]

- Global shipments of Wi-Fi enabled devices are expected to increase from 1.5 billion units in 2012 to 3 billion units in 2016.[13]

- A recent EU study estimated that 71% of all wireless data traffic that was delivered to smartphones and tablets in the EU in 2012 was delivered via Wi-Fi.[14] It is estimated that this figure will grow to 78% by 2016.[15]

Although these data points encompass both indoor and outdoor use of Wi-Fi, many devices that use Wi-Fi, from laptops to smartphones to tablets, are often used indoors, suggesting that indoor usage is growing explosively along with overall usage.

Question 2: Will an extension of the 5 GHz band be required if Wi-Fi is to play a sustainable role in meeting the growing demand for indoor wireless connectivity?

Almost certainly yes. As discussed above, demand for Wi-Fi is skyrocketing, but licence-exempt allocations have not changed substantially since 2003. Industry has made significant strides in enabling improved Wi-Fi access in the 5 GHz bands. For example, the recently developed IEEE 802.11ac standard makes use of 80 and 160 MHz channels. This standard allows extremely high-speed data transfers at rates of up to 1 gigabit per second. Previous iterations of Wi-Fi could not have supported these transmission rates, and, if Ofcom designates sufficiently wide licence-exempt channels, innovators will use the 802.11ac standard to improve short-range video streaming and two-way, real-time video delivery, as well as other high-bandwidth consumer applications.

Moreover, although 2.4 GHz licence-exempt spectrum is being used very efficiently,[16] it has become saturated during certain times of day in heavily trafficked areas such as city centers, apartment buildings, and public venues. This congestion leads to diminished throughput and creates frustration for Wi-Fi users because the 2.4 GHz band is the core Wi-Fi band today. Improved licence-exempt access to the 5 GHz band has notable potential to help alleviate congestion in 2.4 GHz band and quickly improve the Wi-Fi experience for users, particularly given the existence of established Wi-Fi standards for the 5 GHz band.

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http://stanfordvideo.stanford.edu/stream/saapanel.html (last visited Nov. 8, 2013) ("Stanford Unlicensed Economy Conference").

[12] Mark Cooper, *Efficiency Gains and Consumer Benefits of Unlicensed Access to the Public Airwaves* 10 (Jan. 2012) *available at* http://www.markcooperresearch.com/SharedSpectrumAnalysis.pdf.

[13] Wi-Fi Alliance, Press Release, *New Wi-Fi Alliance Technologies Shine at CES*, Jan. 28, 2013, http://www.wi-fi.org/media/press-releases/new-wi-fi-alliance%C2%AE-technologies-shine-ces-2013.

[14] *See* EC Study.

[15] *Id.*

[16] *See, e.g.*, Richard Thanki, *The Economic Significance of License-Exempt Spectrum to the Future of the Internet* 14 (June 2012), *available at* http://www.wirelessinnovationalliance.org/index.cfm?objectid=DC8708C0-D1D2-11E1-96E9000C296BA163.

Question 3: Are there other types of indoor wireless applications [that] will require access to alternative spectrum other than that provided by the licence-exempt 2.4 and 5 GHz bands used by Wi-Fi?

Yes. First, Wi-Fi in the home can be improved by making spectrum below 1 GHz available on a licence-exempt basis. Using such spectrum, Wi-Fi can offer indoor coverage that better penetrates through interior walls and serves the outer reaches of larger structures. Given increasing demand for in-home video, improved Wi-Fi access in the home will provide critical consumer benefits in the coming years. Second, emerging machine-to-machine (M2M) technologies will likely rely heavily on low-frequency, low-power licence-exempt access. Many of these types of devices, such as smart meters and inventory control systems, have utilized the 900 MHz band in the United States. The growth of such systems will likely increase demand for access to licence-exempt spectrum below 1 GHz.

Question 4: What role do you think Wi-Fi will play in providing wireless broadband connectivity outdoors over the coming 5-10 years?

Wi-Fi can play a significant role in improving outdoor connectivity if Ofcom opens up sufficient spectrum—especially spectrum under 1 GHz—for licence-exempt use. Outdoor Wi-Fi often can deliver high-capacity services at lower cost than traditional services.

Demand for outdoor use continues to increase. According to the *International Business Times*, the global market for outdoor Wi-Fi services will grow from $15.41 billion in 2013 to $37.2 billion in 2018, a compound annual growth rate of more than 15%.[17] Anecdotal evidence supports these predictions, as Wi-Fi has become increasingly pervasive in outdoor cafes, on public transportation, and at outdoor sporting events. During the London Olympics, for example, the average spectator using Wi-Fi consumed 40 MB of data.[18] In order to meet increased demand associated with the 2012 games, BT managed more than 500,000 hotspots across greater London.[19]

In addition, standards are being developed to exploit the benefits of Wi-Fi in different bands. For example, the IEEE 802.11af standard is designed to maximize throughput on broadcast television channels, even if they are discontiguous. Licence-exempt use based on 802.11af can be particularly important in delivering low-cost broadband to hard-to-serve areas. By contrast, 802.11ac maximizes high-bandwidth transmissions over short distances. Freeing up spectrum with varying rate/range characteristics for licence-exempt use will unlock significant benefits.

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[17] Angelo Young, *Demand For Outdoor WiFi Expected To More Than Double Value Of The Market By 2018*, INT'L BUS. TIMES, June 20, 2013, at http://www.ibtimes.com/demand-outdoor-wifi-expected-more-double-value-market-2018-report-1315839 (last visited Nov. 8, 2013).

[18] BT, *Case Study: Wi-fi Access at London 2012*, http://www.btwifi.co.uk/Media/pdf/london2012-case-study.pdf (last visited Nov. 8, 2013).

[19] *See id.*

Question 5: Will the increased deployment of Wi-Fi access points outdoors create a risk of reduced quality of service performance over the longer term and, if so, will approaches to co-ordinate access point performance be able to mitigate this risk?

Increased deployment of Wi-Fi access points will likely improve the overall user experience. If deployed as a complement to mobile wide area networks, outdoor Wi-Fi can augment connectivity and improve overall quality of service. Many of the outdoor deployments are managed Wi-Fi, where multiple access points are coordinated using a controller to ensure coexistence. In many cases smaller cells can be used to add capacity and, if needed, those smaller cells can operate at higher frequencies than larger cells require. In addition, IEEE is working on standards to improve coordination of independently deployed access points (IEEE 802.19).

Question 6: Will improved approaches to accessing spectrum in licence-exempt bands be needed in the longer term to maintain the quality of service achievable for outdoor public mobile broadband and/or M2M services? If so, which approaches are most likely to be adopted and how likely do you think they are to be successful in improving access to spectrum?

Google has no comment on this question.

Question 7: Which frequency bands are most likely to be best suited to providing geographical shared access, including via a geolocation database approach, for use by mobile broadband, for example small cells and M2M applications?

Sharing enabled by geolocation databases can be applied to any frequency band. If a device has the capability to transmit and receive signals in the band(s) at issue, a database can dynamically authorize or prohibit operation. In the United States, for example, the Federal Communications Commission (FCC) has authorized use of geolocation databases to enable sharing across the television broadcast bands (54–60 MHz, 76–88 MHz, 174–216 MHz, 470–608 MHz, and 614–698 MHz)[20] and has initiated a proceeding to consider allowing consumer devices dynamic access to the 3550-3700 MHz band.[21]. Other jurisdictions, including Singapore, Canada, and South Africa, are actively exploring the possibility of allowing shared access to the television bands.

In general, sharing will be most useful in bands where incumbent operations are difficult to relocate, but are limited in either time or geographic scope and predictable.

Question 8: Would access to these bands best be realised through licensing or licence-exemption?

Google's experience suggests that both three-tier (incumbent/licensed/licence-exempt) and two-tier (incumbent/licence-exempt) approaches can offer significant benefits. In

[20] *See* 47 C.F.R., Part 15, Subpart H.

[21] *See Amendment of the Commission's Rules with Regard to Commercial Operations in the 3550-3650 MHz Band*, GN Dkt. No. 12-354, 27 FCC Rcd. 15594 (2012).

both cases, however, devices and chipsets will be built only if there is sufficient access to spectrum for non-incumbent users.

Choosing the best framework for a particular band may depend on the characteristics of the incumbent users and uses, whether there is interest in licensed access to the band, and international developments. For example, the United States has adopted a licence-exempt model for access to TV white spaces in the broadcast bands, and there is clear momentum around a licence-exempt model for those bands in the United Kingdom and Canada. The establishment of a licence-exempt model for those bands in additional jurisdictions will establish a global market for chips and devices, allowing consumers to take advantage of the economies of scale that accompany widespread deployment. Other bands may be better suited to a three-tier solution.

Question 9: Do you believe that tiered shared access to a range of spectrum bands has a role in meeting demand for mobile and wireless data and, if so, which applications and devices do you think will be particularly suited to this access model?

Google believes that making licence-exempt access available at a variety of frequency ranges enables innovation and investment in wireless technologies. Because propagation characteristics vary across bands, Ofcom can maximize innovation and investment by ensuring that there is spectrum available for licence-exempt use both above and below 1 GHz.

Question 10: Do you believe DSA could play an important future role in the future in enabling a better quality of service and low barriers to spectrum access alongside conventional licensed and LE spectrum approaches?

Google strongly believes that Dynamic Spectrum Access (DSA) can play a critical role in improving efficiency, allowing improved quality of service, and removing barriers to spectrum access.

- DSA improves spectral efficiency by freeing up spectrum that otherwise could not be used because it is occupied by incumbents in limited locations or at intermittent times. In essence, DSA allows use of vacant spectrum by flexible secondary users. Moreover, because dynamic sharing approaches do not require clearing incumbents or conducting complicated auctions, DSA techniques can be implemented quickly.

- DSA can improve quality of service. For example, using DSA techniques to increase the number of bands available for Wi-Fi use improves both the reliability and range of Wi-Fi technologies.

- DSA can reduce overall spectrum scarcity by bringing previously unavailable spectrum online.

- Where DSA approaches are accompanied by a licence-exempt or lightweight licensing framework, spectrum can be accessed relatively quickly and at low cost, reducing barriers to market entry.

Question 11: What barriers still remain to the realisation of cost-effective sensing appropriate for low-cost consumer devices and what activities are ongoing to try to address them?

Beyond our general comments on sensing above, Google has no comment on this question.

Question 12: Over what timescales could DSA become a mass market proposition?

It is clear that dynamic sharing technology works and, with access to significant spectrum, substantial operations are expected to be deployed quickly. Numerous databases and devices have been certified by the FCC in the United States,[22] and the first commercial TV white spaces network has been deployed in Wilmington, North Carolina.[23] Google's Cape Town trial has conclusively demonstrated that dynamic spectrum access can deliver wireless broadband over significant distances (between two and six kilometers) at average speeds of between 2 and 9 Mbps, without harmful interference to incumbent users. At this point, the primary impediment to significant investment and large-scale deployment of DSA technologies is certainty regarding the availability of spectrum.

Question 13: What role should Ofcom play, if any, to support the development of DSA and relevant technologies?

Broadly speaking, Ofcom can support sharing by making enough spectrum available to support investment in sharing and by developing flexible, straight-forward rules for secondary users that encourage investment, innovation, and use.

Specifically,

- Ofcom should finalise its work on enabling licence-exempt access to the TV white spaces and should make spectrum usage data as fully available as possible.

- Ofcom should add all unused spectrum to the geolocation database as quickly as possible as soon as the capacity is available.

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[22] *See, e.g.*, Office of Engineering and Technology, Public Notice, *Office of Engineering and Technology Announces the Approval of Google, Inc.'s TV Bands Database System for Operation*, ET Dkt. No. 04-186 (June 28, 2013).

[23] Amar Toor, *North Carolina Launches FCC-approved TV White Space Network in Wilmington*, ENGADGET, Jan. 30, 2012, at http://www.engadget.com/2012/01/30/north-carolina-launches-fcc-approved-tv-white-space-network-in-w/ (last visited Nov. 8, 2013).

- Ofcom should work with the industry to clear the way for DSA to be applied more generally across all bands, with priority being given to those bands where there is a prospect of international harmonisation.

- Ofcom should prioritize developing simple rules for use of shared spectrum. Regulatory complexity is a key obstacle to deployment of new services. For example, in the United States, licence-exempt access to the 5 GHz band (5.150-5.925 GHz) is encumbered by a patchwork of different requirements, including varying power levels, restrictions on outdoor use, and DFS mandates. Avoiding this kind of patchwork will encourage investment in and improve the utility of shared bands.

Question 14: Do you have any other views on any of the issues discussed in this consultation?

Google has no comment on this question.

Question 15: What are the frequency bands that would be of most value for R&D purposes?

Google has no comment on this question.

Question 16: What are the potential benefits of using a geolocation database approach for short-term access to spectrum for R&D and how would you see this working from a practical perspective? Are there alternative approaches that could deliver similar benefits?

Using a geolocation database to manage access to spectrum is a proven way to allow temporary use of spectrum. So long as experimental equipment can communicate with a database, the database can allow use and terminate it on a very dynamic basis. For example, in the United States, the FCC's rules provide for reliance on geolocation databases to afford temporary channel reservations to some wireless microphones.[24] Currently, U.S. database operators update their protection information every 24 hours, but shorter intervals are technically feasible and could enable dynamic access for short-duration research purposes if the benefits exceed the operational costs.

Question 17: What characteristics do you view as important to researchers in arrangements to facilitate temporary access to spectrum for research and development purposes?

Google has no comment on this question.

[24] 47 C.F.R. § 15.713(h)(8).