Response of Boeing UK Limited

UK Ofcom Call for Input
3.8 GHz to 4.2 GHz Band: Opportunities for Innovation
9 June 2016

Introduction

Boeing UK Limited (Boeing) is pleased to respond to Ofcom's Call for Input on potential new opportunities for more intensive sharing of the C-band spectrum between 3.8 GHz and 4.2 GHz. That band is used extensively in the UK as a downlink band for space-to-earth transmissions. The Call for Input reflects statistics showing that there are 28 sites with satellite earth stations currently in the UK,[1] with a total of 201 active downlink connections at those sites.[2]

Despite this usage, and perhaps because portions are already also used for Fixed Links and Mobile/Wireless Access Applications, Ofcom's recently-published *Spectrum Sharing Framework*[3] identifies the upper part of the C-band (3.8 GHz to 4.2 GHz) as its first candidate for exploration of new sharing opportunities.[4]

The satellite service providers using this downlink band already deliver important benefits to UK citizens and consumers, such as broadcast TV, broadband communications, and connectivity to ships, off-shore platforms, cars and aircraft. There is potential for still greater benefits from this spectrum in the near future. Boeing supports the development of a strategy to maximise those benefits. Our response focuses on the issues related to satellite communications, as well as protection of the adjacent frequency band utilized for critical aviation purposes, the band 4 200 MHz to 4 400 MHz.

Boeing has concerns regarding the feasibility of sharing the 3.8-4.2 GHz band with new terrestrial services because, unlike higher frequency bands where unique propagation characteristics and advanced antenna technologies can facilitate sharing, C-band terrestrial transmissions cause harmful interference within a considerable distance of C-band earth station receivers.

In addition, as discussed below, new C-band non-geostationary satellite orbit (NGSO) systems are under development that will further expand the use of the 3.8-4.2 GHz satellite downlink band in the United Kingdom and around the world. These next-generation NGSO satellite systems will provide a variety of advanced communications services including data access, remote monitoring, Internet of Things (IoT) and other broadband applications. This additional array of services will enable new levels of connectivity and communications applications in urban and rural areas alike.

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1 Call for Input, § 1.9.

2 Call for Input, § 2.14.

3 *A Framework for Spectrum Sharing*, Statement, 14 April 2016 (http://stakeholders.ofcom.org.uk/binaries/consultations/spectrum-sharing-framework/statement/statement.pdf).

4 *Id.* at § 1.18.

In addition, Boeing is concerned with potential out of band emissions from terrestrial services impacting radio altimeters which utilize the adjacent radio frequency band 4.2-4.4 GHz. Radio altimeters are used to provide highly accurate measurements to determine the height an aircraft is above the Earth's surface during the approach, landing, and climb phases of aircraft operations.

Question 1: Given the nature of the incumbents and their use of the spectrum, what new types of applications do you foresee could access this spectrum on a shared basis? Please provide details on the potential applications and their characteristics of use as identified in the spectrum sharing framework.

Boeing can see little room for new terrestrial applications for this band in the UK, particularly high density ubiquitous cellular users, given the current range of incumbent uses and services, and planned new satellite uses. In preparation for WRC-15, the ITU-R prepared an analysis summarising and synthesising the results of eleven separate spectrum sharing studies between terrestrial mobile and geostationary fixed-satellite services (FSS) operating in the 3.4-4.2 GHz and 4.5-4.8 GHz bands, and concluded that, "[t]he sharing between IMT-Advanced and FSS is feasible only when FSS earth stations are at known, specific locations, and deployment of IMT-Advanced is limited to the areas outside of the minimum required separation distances for each azimuth to protect these specific FSS earth stations."[5]

The minimum required separation distances identified in the ITU-R analysis are sufficiently large that they would appear to preclude any practical deployment of typical terrestrial mobile service in the 3.8-4.2 GHz band. Specifically, with respect to "suburban/urban macro-cell deployment scenarios," the ITU-R analysis concluded that both a long-term interference criterion requiring "separation distances . . . at least in the tens of km," and a short-term interference criterion requiring separation distances that "exceed 100 km for most of the cases," and up to 525 km, would need to be met.[6] Even in small-cell outdoor deployment scenarios, both a long-term interference criterion requiring separation distances "in the tens of km," and a short-term interference criterion requiring separation distances of "around 30 km in typical IMT-Advanced small-cell deployment using low antenna height in urban environment," but that can exceed 100 km, would need to be met.[7]

With FSS earth stations "distributed widely across the UK"[8] and many located near London,[9] it would be difficult or impossible to enforce this required separation with respect to typical mobile user terminals or handsets. Indeed, the analysis reflected in the Call for Input reinforces the difficulty of sharing, even among terrestrial services. Observing that fixed links operate primarily at the upper and lower extremes of this band, the Call for Input

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5 International Telecommunication Union, Radiocommunication Sector, "Sharing studies between International Mobile Telecommunication-Advanced systems and geostationary satellite networks in the fixed-satellite service in the 3 400-4 200 MHz and 4 500-4 800 MHz frequency bands in the WRC study cycle leading to WRC-15," Report ITU-R S.2368-0 (June 2015), at 32 ("*ITU-R Sharing Summary*").

6 *Id.* at 31.

7 *Id.*

8 Call for Input, § 2.7, Table 1.

9 *Id.*, § 2.13, Figure 2.

explains that "[t]his is partly driven by the fact that fixed links observe a centre gap in Range 3 and that Ranges 4, 5, and 6 are prioritised for UK Broadband."[10]

Question 2: Based on information provided in this Section, can you identify any barriers to enhanced sharing in the 3.8 GHz to 4.2 GHz band? Please use the Spectrum Sharing Framework, which identifies four types of barriers to spectrum sharing: lack of information; market barriers; technology barriers; and authorisation barriers.

There are significant technological barriers to enabling new terrestrial uses in the radio frequency band 3.8-4.2 GHz. No studies have been conducted proving harmful interference to critical aviation safety systems will be avoided. Such studies must be performed prior to any allocation changes. Significant work has been done internationally to develop proper protection criteria. The results of this work can be found in ITU-R Recommendation 2059 (2014).[11]

In addition to sharing difficulties with incumbent users, new NGSO satellite systems are under development for use in this band that, when deployed, will significantly complicate the sharing calculus that the Call for Input describes. At WRC-15, Resolution 157 was adopted recognising that new NGSO satellite constellations with circular orbits have "the potential to augment substantially the capacity, spectrum efficiency and benefits derived from GSO and non-GSO systems operating in" this band, among others.[12] Resolution 157, therefore, called for studies to examine operational issues associated with the use of this band for NGSO constellations with circular orbits, because the current power flux-density (PFD) limits, developed for NGSO satellites with highly-elliptical orbits (HEO), may not be suitable.[13] Satellite-based service providers and manufacturers are actively pursuing efforts to assist with these studies, as well as to design and deploy C-band NGSO constellations that would be compatible with the new ITU-R rule revisions, when available.

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[10] *Id.* at § 2.19-2.20.

[11] Recommendation ITU-R M.2059-0 (02.2014) Operational and technical characteristics and protection criteria of radio altimeters utilizing the band 4 200-4 400 MHz (available https://www.itu.int/dms_pubrec/itu-r/rec/m/R-REC-M.2059-0-201402-I!!PDF-E.pdf).

[12] World Radiocommunication Conference, WRC-15, Resolution 157, *Study of technical and operational issues and regulatory provisions for new non-geostationary-satellite orbit systems in the 3700-4200 MHz, 4500-4800 MHz, 5925-6425 MHz and 6725-7025 MHz frequency bands allocated to the fixed-satellite service* (2015), at 1 ("Resolution 157").

[13] *Id.* at 2 (calling for ITU-R to conduct studies with the purposes of, first, "in the frequency band 3700-4200 MHz (space-to-Earth), identification of possible revision of Article 21, Table 21-4 for non-GSO FSS satellites, with a view to enabling new non-GSO systems to operate in these FSS frequency bands, while ensuring that existing primary services, i.e. the mobile service and fixed service, are protected and maintaining the existing Article 21 pfd limits for GSO networks"; and second, "in the frequency bands 3 700-4 200 MHz (space-to-Earth) and 5 925-6 425 MHz (Earth-to-space), the Article 22 epfd↓ limits and epfd↑ limits applicable to non-GSO systems with a view to enabling additional non-GSO systems to operate in these frequency bands, while ensuring that GSO networks are protected from unacceptable interference pursuant to No. 22.2 and existing protection criteria."

During its April 2016 meeting, ITU-R WP 4A considered a Working Document towards a preliminary draft new Recommendation (WD-PDNR) on technical and regulatory provisions for GSO/NGSO FSS sharing in this band. The result was a new Working Document contained in Annex 5 to the April 2016 WP 4A Chairman's Report (Doc. 4A/63). That document provides the first steps for the required analysis work to properly address the issues identified in Resolution 157 (WRC-15). This work involves studies of frequency sharing between NGSO systems and GSO FSS, MSS and BSS networks. The objective is to identify new epfd limits for Article 22 applicable to circular-orbit NGSO systems that will ensure appropriate protection of GSO networks while enabling use of the same FSS spectrum by new circular-orbit NGSO systems, thereby significantly enhancing spectrum use.

Thus, as Ofcom examines the potential for new and more intense sharing of this band with terrestrial services, any such sharing scheme must also take into account the additional impending band sharing already contemplated as a result of the deployment and operation of new circular-orbit NGSO satellite constellations. Indeed, Ofcom should defer consideration of more intense sharing of this band by terrestrial services until the ITU-R completes the studies described in Resolution 157 with respect to sharing already under examination by new satellite-delivered services.

New circular-orbit NGSO constellations are likely to utilise ubiquitously-deployed user terminals for IoT and related broadband connectivity applications. Such deployment will raise sharing issues that are even more challenging than those presented by the existing FSS earth stations and other services in the band. As the ITU-R Sharing Summary concluded: "When FSS earth stations are deployed in a typical ubiquitous manner or with no individual licensing, sharing between IMT-Advanced and FSS is not feasible in the same geographical area since no minimum separation distance can be guaranteed."[14]

The uncertainty of new terrestrial services, the need to protect critical aviation safety, and the emergence of new NGSO constellations have implications for all four types of barriers identified by Ofcom in its *Spectrum Sharing Framework*, as follows.

First, with respect to lack of information, there is not yet sufficient information available regarding new terrestrial system characteristics or applications contemplated in this proceeding, and sharing between terrestrial and new NGSO satellite systems is under study at the ITU. As Ofcom recognised, "potential sharers have examined the feasibility of sharing bands by carrying out studies based on publicly available information (such as ITU-R documentation)."[15] However, no studies have been conducted at the ITU with respect to studying adjacent frequency bands used by safety services.

Second, there are clear market barriers. The emergence of new C-band NGSO constellations that will use this band create uncertainty, which constrains providers' ability to commit development resources to new terrestrial services. In addition, Ofcom efforts to introduce new terrestrial services in this band may hamper the development of circular-orbit NGSO systems, which may ultimately offer even better services to the public. As the *Spectrum Sharing Framework* recognises, "uncertainty about security of spectrum access and long term

[14] ITU-R Sharing Summary at 32.

[15] *Spectrum Sharing Framework* at § 5.15.

availability to guarantee a quality of service makes the funding of innovative services and applications challenging."[16]

Third, there are technology barriers to the introduction of more intense sharing of this band with terrestrial services at this time. As the *Spectrum Sharing Framework* recognises, "coexistence challenges are a potentially significant barrier to sharing and . . . these issues are relevant both when private parties are trying to strike a sharing deal; by spectrum trading, and when Ofcom is considering a specific sharing opportunity."[17] Here, the ITU-R is still studying coexistence issues in this band, including for new circular-orbit NGSO constellations now under development.

Fourth, there are authorisation constraints, which derive from the uncertainty described above. As the *Spectrum Sharing Framework* recognises, "the steps needed to understand coexistence issues, and in some cases the need for us to consult before issuing a licence" can create delay in authorising additional services in a given band.[18] This is particularly so when multiple potential new services are emerging simultaneously, such as here, with respect to both new NGSO constellations and potential new terrestrial services.

Question 3: Do you agree with our initial assessment of a potential application of a tiered authorisation approach in this band?

If yes, please provide as much detailed information as possible of how you consider any tiered authorisation approach may enable greater spectrum sharing and how it could be implemented in practice.

If no, please describe the spectrum access method that you consider may best meet any requirements you have to access spectrum in the 3.8 GHz to 4.2 GHz band. Please give specific details of how you would envisage this working in practice, where appropriate with reference to the tools and enablers identified in the Spectrum Sharing Framework.

In concept, a tiered approach could be feasible, but the design of the tiers should require any new services to accommodate and protect (1) those services that are already operating in the band, including FSS earth station downlinks, fixed links, and the UK Broadband service; and (2) circular-orbit NGSO satellite constellations, which are already contemplated and now under development for this band.

These recommendations have certain implications for the specific tiers proposed in the Call for Input. Tier 1, as proposed, would "comprise the bands' incumbent services" and "spectrum access rights would fall within a given range of frequencies and geographic areas not accessed by other tiers."[19] Future services from circular-orbit NGSO constellations should be accommodated within Tier 1. The long lead time to develop and deploy such constellations, as well as their nationwide –even global – footprint and substantial benefits to

[16] *Id.* at § 5.30.

[17] *Id.* at § 5.33.

[18] *Id.* at § 5.34.

[19] Call for Input at § 3.7.1.

the public, mean that it is impractical to relegate them to a lower tier, where interference concerns might degrade or even preclude delivery of service.

For example, ITU-R Resolution 157, when calling for study of the operation of circular-orbit NGSO systems in this band, explicitly protects incumbent services in these bands. For example, Resolution 157 requires that "enabling GSO networks and non-GSO systems to make the most efficient use of satellite orbits and frequency bands allocated to the FSS *shall take into consideration* the other services to which those frequency bands are also allocated on a primary basis," and recognises the existence of additional regional allocations to terrestrial fixed and mobile services in this band.[20] In the same way, Ofcom should avoid precipitous action that would foreclose the availability of new services from circular-orbit NGSO systems in this band before the constellations, literally, have gotten off the ground.

Therefore, the presence of new circular-orbit NGSO constellations will also affect the design of Tier 2, proposed as new geographic licences that would "allow the same spectrum to be used simultaneously in different locations," essentially through regional licences that carry "a set of defined technical conditions."[21] NGSO constellations, however, will have nationwide coverage, meaning that the technical conditions would need to be developed such that any such regional Tier 2 licences do not cause harmful interference to these satellite services.

Opportunistic spectrum access under Tier 3, which would permit use on a secondary basis of devices that are "able to determine whether or not a particular frequency is available and determine that its use will not cause undue interference to incumbent users" would similarly need to detect and accommodate use of the band by circular-orbit NGSO constellations.

Question 4: Should a potential future tiered authorisation approach to spectrum access in the 3.8 GHz to 4.2 GHz band accommodate changes from incumbent services of the spectrum? I.e. should new licences or variations to existing fixed link and satellite earth station licences be allowed to continue on a first-come-first-served co-ordinated basis?

Boeing believes that existing services – including GSO and NGSO FSS earth station receive operations – should be given primary status throughout the 3.8 GHz to 4.2 GHz band and the nation. Both geographic Tier 2 and opportunistic Tier 3 should be required to modify their systems and services, if required by to accommodate expanded service from these existing and contemplated services and licencees. As the Call for Input recognises, "if we proceed with a multi-tiered authorisation approach then we should also continue to allow Tier 1 licencees to grow their businesses in this band, and on the continued basis of first-come-first-served coordination mechanisms that these licences are currently subject to."[22] Satellite development and deployment costs are extremely high and satellite operators should be

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[20] Resolution 157 at 2 (emphasis added). Similarly, Resolution 157 further resolves that the studies it describes shall "in no way change the protection criteria and protection levels defined in those criteria for the GSO FSS, the fixed service and the mobile service" and "ensure protection of the existing non-GSO FSS systems with highly-elliptical orbits," *Id.* at 3.

[21] Call for Input at § 3.5.1.

[22] *Id.* at § 3.10.

permitted to construct earth stations and deploy user terminals throughout their licenced footprint on a primary, first-come-first-served basis vis-à-vis other Tier 1 licencees.