UK OFCOM SPACE SPECTRUM STRATEGY CONSULTATION

RESPONSE OF
BOEING UK LIMITED

Boeing UK Limited ("Boeing") provides these comments in response to Ofcom's Consultation regarding Space Spectrum Strategy. As Ofcom acknowledges, satellite services already deliver important services to UK citizens and consumers, and are poised to deliver greater benefits in the future. Boeing is a world leader in the development, manufacture, and deployment of advanced satellite space and ground systems, and is keenly aware of the opportunities offered by satellite communications and the challenges in crafting regulatory policies that keep pace with advancing technology.

As explained below, Boeing is developing next-generation, high throughput satellite systems to provide unprecedented data rates, coverage, and spectrum efficiency. These systems rely on spectrum in current commercial fixed-satellite service ("FSS") bands—such as C-, Ku-, and Ka-band—as well as FSS allocations in higher frequencies such as V-band and above. Advanced satellite technologies employed in these next-generation systems, as well as the unique propagation characteristics in higher frequency bands, will expand the potential for sharing between satellite and terrestrial services. Boeing urges Ofcom to adopt regulatory policies that not only maintain existing satellite services, but unlock the potential of higher-frequency, higher-bandwidth satellite services available from next-generation satellite systems coming online in the near future.

Question 2

Do you agree with the industry and technology trends we have identified for the satellite sector? Are there other trends that could have implications for spectrum use?

Boeing confirms Ofcom's observation that there is increasing use of the Ka-band, particularly for broadband applications.[1] Higher frequencies offer inherently greater potential data rates, as well as the use of spot beams, which further enhances satellite frequency re-use and geographic targeting. These factors hold true for frequencies above the Ka-band, including the V-band, which will see increasing use for satellite services as lower bands reach capacity and demand for higher data rates continues to increase.

The near-term ability to operate very high capacity satellite networks in higher frequency bands is being facilitated by important advances in satellite communications technology, such as beam-forming satellite payloads, phased-array satellite and earth station antennas, robust modulation and frequency re-use schemes, and advanced NGSO system architectures. Employing these technologies in the commercial sector, the satellite communications industry will be able to introduce transformative increases in satellite system capacity, coverage, and spectrum sharing capabilities of next-generation broadband satellite systems. Ofcom should therefore ensure that its spectrum strategy enables growth in the satellite sector, including broadband and other satellite-delivered services, not only at Ka-band and below but also at V-band and above.

[1] *Consultation* at 49.

Question 3

Do you agree with the application specific trends we have identified for the satellite sector? Are there other trends that could have implications for spectrum use?

Ofcom notes four application-specific trends that could have implications for spectrum use by the satellite sector: broadcasting (video distribution and contribution), broadband connectivity, positioning, and machine-to-machine (M2M) / Internet of Things (IoT). Ofcom appears to suggest, however, that only broadband connectivity may drive an increase in demand for non-positioning satellite spectrum. Even then, Ofcom suggests that it does not anticipate that spectrum availability is likely to be a barrier to the growth of satellite broadband and therefore does not propose to prioritise new bands for satellite broadband capacity.

Boeing respectfully suggests that video distribution and M2M, as well as broadband connectivity, will drive increased demand for advanced satellite communications applications which, in turn, will drive the need for additional satellite broadband spectrum. For example, increasingly higher-resolution programming and additional content production will likely result in increased bandwidth requirements for video distribution. Moreover, the growing trend towards "on demand" video distribution will result in a disproportionate (indeed exponential) need for additional satellite broadband spectrum as content is downloaded independently by many users at various times rather than "broadcast" to all potential viewers. In addition, as Ofcom notes, automotive and similar high data-rate M2M and IoT applications may drive demand for satellite services – particularly services provided by next-generation NGSO satellite systems using higher bands where smaller antennas and shorter transmission paths enable deployment of affordable user terminals for fixed and mobility applications.

Advanced broadband satellite systems provide a fast, flexible, and cost-efficient way to bring high-speed connectivity to unserved and underserved areas, and also to mobile platforms

such as ships and aircraft. Satellite-based broadband provides not only a ubiquitous option for the most hard-to-reach places, but also a genuine competitor to terrestrial wired and wireless services, helping keep broadband prices affordable and service reliable from the countryside to the city center. In order to realize these benefits for all UK citizens, the investment being made in next-generation satellite systems must be supported by access to additional high-frequency spectrum. Thus, Ofcom can and should include V-band and higher FSS bands among the spectrum available to bring high speed affordable broadband to customers across the nation.

Question 8

Are there other areas where spectrum liberalisation could enable better satellite broadband services and what specific actions should we be considering?

Boeing applauds the recognition in the Consultation that action by Ofcom will help promote new technologies to make FSS an increasingly powerful and flexible communications service. In particular, earth stations in motion ("ESIMs") and NGSO satellite constellations will benefit from liberalization of spectrum rules to promote investment and growth in these technologies.[2] As Ofcom notes, growth of these services depends not only on revising the relevant regulations in the UK, but also on updating the relevant regional and international agreements. To that end, Boeing urges Ofcom to support the studies undertaken pursuant to ITU Resolution 157 (a review of the technical and operational issues relevant to new NGSO

[2] *Id.* at 57.

systems in the C-band)[3] and Resolution 159 (a review of the technical and operational issues relevant to new NGSO systems in the V-band).[4]

Resolution 157 addresses the outdated power flux density ("pfd") limits that exist in the Radio Regulations for the protection of C-band GSO networks from NGSO systems. The pdf limits were based on the unique orbital configuration of the highly-elliptical orbit systems that were proposed more than a decade ago when the limits were first adopted. As a result, the C-band pfd limits appear to be much more stringent than necessary to ensure the protection of GSO networks from modern NGSO satellite systems.

Given the prior assumptions that were employed regarding the orbital configurations of NGSO systems that may operate in the C-band, Resolution 157 calls for ITU-R studies of the power limits applicable to NGSO systems in the bands 3,700-4,200 MHz and 5,925-6,725 MHz and the addition of power limits applicable to NGSO systems in the bands 4,500-4,800 MHz and 6,725-7,025 MHz, while ensuring that all existing services are adequately protected. Individual country administrations are invited by the Resolution to participate in the studies by submitting contributions to the ITU-R. Boeing urges Ofcom to move forward with the revision of the relevant NGSO regulations within the UK and to submit any data developed during this process to the ITU in support of modernizing the international C-band NGSO rules.

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[3] RESOLUTION 157 (WRC-15) Study of technical and operational issues and regulatory provisions for new non-geostationary-satellite orbit systems in the 3 700-4 200 MHz, 4 500-4 800 MHz, 5 925-6 425 MHz and 6 725-7 025 MHz frequency bands allocated to the FSS (available at http://www.itu.int/dms_pub/itu-r/oth/0c/0a/ R0C0A00000C0021PDFE.pdf).

[4] RESOLUTION 159 (WRC-15) Studies of technical, operational issues and regulatory provisions for nongeostationary fixed-satellite services satellite systems in the frequency bands 37.5-39.5 GHz (space-to-Earth), 39.5-42.5 GHz (space-to-Earth), 47.2-50.2 GHz (Earth-to-space) and 50.4-51.4 GHz (Earth-to-space) (available at http://www.itu.int/dms_pub/itu-r/oth/0c/0a/R0C0A00000C0006PDFE.pdf) ("*Resolution 159*").

Resolution 159 initiates similar studies to examine the technical and operational issues and regulatory provisions for the operation of NGSO FSS satellite systems in the V-band frequencies (37.5-42.5 GHz (space-to-Earth) and 47.2-48.9 GHz (limited to feeder links only), 48.9-50.2 GHz and 50.4-51.4 GHz (all Earth-to-space).[5] In comparison to the intensively-used C-band, the V-band is comparatively greenfield for both GSO and NGSO FSS systems, and the development of, and investment in, NGSO FSS systems would benefit from greater certainty in the measures that will be required to protect GSO FSS and broadcast satellite service ("BSS") satellite networks. The studies initiated under Resolution 159 will be completed in time for consideration at WRC-19. Boeing recommends that Ofcom support the development of favourable international regulations for high-throughput NGSO V-band operations by submitting to ITU-R any relevant data developed during the UK deliberation on V-band NGSO systems.

Question 9

Do you agree that existing bands are likely to provide sufficient capacity for considerable growth in satellite broadband and that we do not need to prioritise the identification of new bands? Do you have any comments on the analysis we have undertaken of supply and demand?

The existing bands FSS (*i.e.*, Ka-band and below) simply will not be able to keep pace with the constantly increasing throughput demanded by consumers and enterprises. The massive growth of satellite broadband to date will only continue to increase in the future, and the satellite industry will need assured access to adequate spectrum to serve the future needs of citizens wherever they are.[6]

To meet these needs in the UK and internationally, Boeing is developing a next-generation NGSO system, which will represent a dramatic increase in the state of the art of

[5] Resolution 159 at 3.

[6] *Id.*

satellite broadband. Therefore, it remains critically important for Ofcom to prioritise the preservation of additional higher spectrum bands, including V-band, for satellite services as part of its plan for satellite broadband growth.

The Consultation correctly notes that use of the Ka-band is increasing,[7] but the analysis does not project this trend of increasing usage far enough forward to encompass increasing use of the V-band, which will become a key satellite band in the relatively near future. The near-term need for V-band spectrum is the inevitable outcome of two factors. First, the end user demand for higher data rate communications services is ever increasing, as users incorporate the reliability and power of new communications capabilities into their daily life and work. Second, satellite communications networks provide unparalleled flexibility and reliability in extending service to rural and remote areas of the UK, across adjacent seas, and in support of mobile connectivity aboard aircraft and ships. Satellite communications networks are also a primary means of providing broadband service to hard to reach operations such as oil platforms, disaster relief, and remote IoT devices.

Unfortunately, the UK does not fully commit to high bandwidth V-band FSS in its domestic spectrum allocation table. The International Allocation Table provides a total of 5 GHz of V-band downlink spectrum in the 37.5-42.5 GHz band. By contrast, the UK follows the International Table in providing for 3 GHz of FSS downlink spectrum from 37.5-40.5 GHz, but does not include the additional 2 GHz from 40.5-42.5 GHz. Thus, V-band FSS operations in the UK will have access to only 3 GHz of dedicated downlink spectrum as compared to the 5 GHz envisioned under the International Table.

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[7] *Id.* at 57-58.

For uplink spectrum, the UK table identifies five GHz of spectrum available for uplink (42.5-43.5 GHz, 47.2-50.2 GHz, and 50.4-51.4 GHz). This 5 GHz block, however, is subject to international footnote 5.516B, which specifies that several bands within this uplink spectrum have been identified for use as *downlink* bands (47.5-47.9 GHz, 48.2-48.54 GHz, and 49.44-50.2 GHz) in Region 1. These carve-outs amount to 1.5 GHz of uplink spectrum potentially repurposed for downlink, apparently resulting in an effective V-band allocation in the UK of 4.5 GHz of downlink (space-to-Earth) spectrum and 3.5 GHz of uplink (Earth-to-space) spectrum.

Although the use of these carve outs would result in a useful increase in downlink spectrum and a more symmetric allocation of spectrum between uplink and downlink, ultimately this arrangement still results in only 8 GHz of total spectrum available for V-band satellite operations. The International Table provides a better model for FSS growth in V-band in the form of a full 10 GHz co-primary spectrum, split symmetrically between uplink and downlink bands (37.5-42.5 GHz (space-to-Earth) and the 42.5-43.5 GHz, 47.2-50.2 GHz, and the 50.4-51.4 GHz (all Earth-to-space)), and Ofcom should consider adopting this symmetric 5 GHz plan in the UK.

Even with the greater V-band spectrum available to FSS under the 5 by 5 GHz plan, satellite operations in this band remain encumbered by various spectrum sharing requirements with other services, including radio astronomy and fixed point-to-point services. To compensate for anticipated losses in available capacity, the ITU-R, pursuant to Resolution 162, is currently studying the allocation of the 51.4-52.4 GHz band for the FSS.[8] In addition to

[8] RESOLUTION 162 (WRC-15) Studies relating to spectrum needs and possible allocation of the frequency band 51.4-52.4 GHz to the fixed-satellite service (Earth-to-space) (available at http://www.itu.int/dms_pub/itu-r/oth/0c/0a/R0C0A00000C0025PDFE.pdf).

aligning the V-band portion of the UK table with the International table, Ofcom should strongly support these efforts to make 51.4-52.4 GHz available for FSS.

Of even greater concern is ITU Resolution 238, which proposes to include the entirety of the V-band FSS allocation as a candidate for studies on potential future use by terrestrial-based International Mobile Telecommunications ("IMT") systems using "5G" technologies.[9] Although some potential may exist for sharing between FSS and IMT in portions of the V-band, next-generation satellite networks will require unencumbered access to the vast majority of V-band capacity in order to meet the very high data rate expectations of end users. Further, Resolution 238 identifies other bands as alternative potential candidates for IMT services, and Boeing encourages Ofcom to support consideration of these alternative bands in the ITU-R study process.

Question 17

Are there any improvements we should consider in how we enable existing benefits to continue, whilst exploring sharing / new uses?

The continued development of higher frequency satellite technologies has dramatically increased the ability of satellite operators to shape coverage areas for maximum performance and minimum interference. More so than in the lower bands, there is tentative but growing agreement that sharing between satellite and terrestrial wireless services is feasible in parts of the V-band and other high bands through the use of advances in antenna technologies and the unique propagation characteristics of the band (e.g., high directivity, relatively short communication

[9] RESOLUTION 238 (WRC-15), Studies on frequency-related matters for International Mobile Telecommunications identification including possible additional allocations to the mobile services on a primary basis in portion(s) of the frequency range between 24.25 and 86 GHz for the future development of International Mobile Telecommunications for 2020 and beyond (available at https://www.itu.int/dms_pub/itu-r/oth/0a/06/R0A0600006C0001PDFE.pdf).

ranges, limited building penetration, etc.). Thus, Ofcom's space spectrum strategy should establish a regime that provides the regulatory certainty required for the growth of both satellite and terrestrial services in the higher bands, making the most of the available spectrum by promoting the possibility of sharing where feasible.

As the UK Spectrum Policy Forum recently noted, even though space services have global primary allocations touching 82 percent of spectrum between 1 GHz and 100 GHz, only 3 percent is available on an exclusive basis for space/satellite services. Satellite operators have thus far made an extraordinary effort to share spectrum between competing satellite systems using highly-directional receivers and polarization to achieve substantial spectrum re-use. These inter-service sharing measures have resulted in very efficient use of satellite spectrum and have also facilitated spectrum sharing with other services in non-exclusive bands. To the extent that FSS and terrestrial-based mobile networks may be required to share spectrum in the higher bands such as the V-band, Ofcom should ensure that its policies take into account the most recent advances in spectrum sharing techniques as it evaluates the potential for satellite and terrestrial-based users to co-exist.

The most difficult sharing case is likely to be co-frequency sharing between satellite receive user terminals and 5G operations in urban environments. Even in such dense spectral environments, however, applying phased-array antenna characteristics and other reasonable operational assumptions (*e.g.*, 5G base station height and down-tilt), locations within a 5G deployment area may be usable for V-band FSS earth station operations.

By thoroughly considering spectrum sharing opportunities and additional options for accommodating 5G services (*e.g.*, channelization, indoor versus outdoor deployments, spectrum beyond V-band FSS allocations, etc.), Ofcom can maximize the availability of new services to

citizens regardless of their location and can make the most efficient use of limited spectrum to facilitate the deployment of advanced broadband satellite systems in upper mmW frequencies.

Conclusion

Satellite services are a key resource in bringing reliable, affordable broadband to citizens wherever they are, and technology advances are already being applied to deliver greater benefits in the future. To facilitate the continued growth of satellite broadband, Ofcom should set its sights beyond Ka-band by including V-band and above in its space spectrum strategy, and by carefully considering how and where spectrum sharing between satellite services and terrestrial services may be feasible.

Respectfully submitted,

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