making communications work
for everyone

Space Spectrum

Statement

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About this document

This document sets out our strategy for space spectrum, covering the satellite and space science sectors, and including meteorological and earth observation satellites.

These sectors already deliver important benefits and our strategy sets out the priorities we will focus on to enable further growth.

Delivery of these priorities sits alongside our on-going activities in these sectors, including management of satellite filings and earth station licensing. Our aim is to deliver these in a high quality and efficient way and we will seek to further improve our processes.

In addition, through our international representation work we support wider UK interests as appropriate.

Contents

Section 1

Executive summary

Overview

1.1 This document sets out our strategy for space spectrum, covering the satellite and space science sectors and including meteorological and earth observation satellites. These sectors already deliver important benefits and our strategy identifies how we will enable further growth.

1.2 We will focus our policy efforts on enabling growth in satellite broadband and earth observation. We will do this by providing greater access to spectrum for these areas. This will include negotiating international agreements to free up spectrum for new uses, and by facilitating access to spectrum used by the public sector. We will monitor growth in other applications, such as the Internet of Things, to understand where we may need to take further action in the future.

1.3 We also recognise the benefits of existing satellite and space science use, and will carefully consider the impact on these benefits when exploring spectrum sharing opportunities.

1.4 We will deliver our on-going work, including licensing satellite earth stations and managing satellite filings, in a high quality and efficient way. We will look to make further improvements to these processes and welcome feedback from stakeholders on how to do this.

1.5 We represent the UK at international bodies relating to spectrum. Through this we support as appropriate the wider UK interest.

Enabling growth in satellite broadband

1.6 We will, where appropriate, help to enable growth in satellite broadband communications. This will support our goal of making communications work for everyone, by enabling:

- Better fixed broadband options for residential consumers and businesses in the hardest to reach locations in the UK, which terrestrial broadband technologies may not serve well at the moment; and
- Better broadband connectivity (e.g. Wi-Fi) for passengers on aircraft and on ships.

1.7 We will achieve this by:

- Liberalising spectrum use to enable greater exploitation of new technologies (such as non-geostationary satellite constellations) where possible;
- Where necessary, considering action to ensure efficient use of bands already available for satellite communications in the UK; and
- Considering making additional spectrum available in the future if and when this becomes appropriate.

1.8 Our future work will also be informed by monitoring of satellite broadband take-up and on-going work on the development of a universal service obligation (USO) for broadband.

Enabling earth observation growth

1.9 We will help to enable growth in the quality and quantity of information about the earth collected by satellites. This information can bring benefits such as improved weather forecasting, more efficient public services, new commercial applications and more informed policy making (for example in relation to climate change).

1.10 We will support this growth by:

- Taking action to ensure long-term predictability of access to bands used for sensing, particularly passive sensing of frequency specific physical phenomena (for example used for monitoring of soil moisture);
- Supporting the growing numbers of small and nano-satellites by facilitating access to suitable spectrum (including spectrum used by public sector users where appropriate) for Telecommand, Tracking and Control (TT&C); and
- Enabling access to spectrum for downlinking data from earth observation satellites.

1.11 In addition, we will support innovation in this sector by engaging particularly with smaller and/or newer organisations to ensure regulatory information is as easy to access and understand as possible.

Existing benefits and new uses

1.12 We recognise the wide range of benefits delivered as a result of satellite and space science use of spectrum. There are competing demands on this spectrum from other services which can also deliver growing benefits. Therefore, we will consider opportunities for enabling new uses in, and adjacent to, bands used for satellite and space science use. However, we will carefully consider the impact of any changes, including ensuring that we understand the ability of different services to coexist. We will take appropriate action to deal with interference problems should they arise.

1.13 In addition, we will support more general work that proactively looks at identifying and facilitating sharing opportunities between different users.

Monitor other important areas

1.14 There are several other satellite applications which, whilst important, do not need significant (spectrum related) regulatory action in the short to medium term.

1.15 These areas include the move towards higher resolution broadcast TV content, safety-related communications, satellite navigation and positioning. We will pay particular attention to developments relating to machine-to-machine (M2M) and ‘Internet of Things’ (IoT) applications. This is because the nature of these applications and their use of spectrum is still subject to some uncertainty.

Deliver our on-going activities in a high quality and efficient way

1.16 In addition to the above areas where we have identified aspects for particular regulatory focus, we will continue to aim to deliver our on-going activities in a high quality and efficient way, wherever possible seeking improvements to the service that we offer stakeholders. Our work includes facilitating commercial access to spectrum that is used by public sector users. We welcome feedback and suggestions from stakeholders that helps us to further improve our processes.

1.17 Our on-going activities cover:

- Licensing of satellite earth stations and provision of Recognised Spectrum Access (RSA) for receive-only earth stations. We have an on-going programme of work to both update the licence products we offer and improve the efficiency of our processes for licensing earth stations and issuing RSAs.

- Management of satellite 'filings' for companies or other organisations registered in the UK, the British Overseas Territories, the Channel Islands and the Isle of Man. Satellite filings are the process for obtaining internationally recognised orbital positions and spectrum frequency assignments for satellite networks. We are continuing to look at ways to further improve this process to make it as efficient as possible for stakeholders.

- Provision of information on spectrum regulation and use. We will keep the existing space spectrum interactive tool but not update this going forward. Instead we will enhance our existing Interactive Spectrum Map[1], and potentially a new interactive data tool that could bring together a number of different existing data sources. We will focus on maintaining two areas that we believe provide the most benefit to stakeholders: frequency allocations with corresponding licence products; and details of licensed earth stations (for known, permanently sited earth stations).

- Representing the UK at international bodies relating to spectrum. We have an on-going process to engage with stakeholders in preparation for relevant international meetings.

Next steps

1.18 Our strategy will inform the planning and prioritisation of our work over the coming years. Although we anticipate that it will remain relevant for a number of years, we will update it if and when appropriate. One area that we may update sooner is the strategy for our work on satellite broadband.

[1] http://static.ofcom.org.uk/static/spectrum/map.html

Section 2

Introduction

2.1 This document sets out Ofcom's strategy for the management of spectrum used by space applications. The strategy includes spectrum used by:

- Satellite communication, broadcasting and positioning applications. We refer to these throughout as the 'satellite' sector.
- Space science, earth observation and meteorological satellite applications. We refer to these collectively throughout the document as the 'space science' sector.

Background and aims

2.2 In order for us to be as effective as possible at managing the use of radio spectrum, it is important for us to have an up to date and thorough understanding of the trends influencing spectrum use, particularly given the increasing and competing demands for spectrum from different sectors. In 2013 we published our overall Spectrum Management Strategy and have progressed more detailed reviews of a number of sectors and/or bands since then.

2.3 The purpose of our strategy is to inform how we focus our work in the satellite and space science sectors over the coming years. The strategy is relevant to aspects of our work where we have choices about how we prioritise our efforts, in particular to our spectrum licensing role and our work influencing international rules. For example, the strategy will inform the priority we attach to developing new options for authorising satellite earth stations, and how we prioritise our work on different agenda items in preparation for the International Telecommunications Union (ITU) World Radio Conference 2019 (WRC-19).

2.4 We published a consultation on our proposed strategy in March 2016.[2] Our proposals were informed by an earlier Call for Inputs[3] and our analysis of spectrum use and the benefits and trends associated with the satellite and space science sectors. We received 24 responses to the March consultation, of which one was confidential.

2.5 This statement sets out our conclusions on our strategy in light of stakeholder responses. It also provides an update on some of our on-going work such as the provision of improved information for stakeholders.

2.6 A summary of the responses we received and our response to points not covered in the main body of the document is contained in Annex 1.

[2] https://www.ofcom.org.uk/consultations-and-statements/category-1/space-spectrum-strategy
[3] https://www.ofcom.org.uk/consultations-and-statements/category-1/space-science-cfi

Ofcom's role

Ofcom's spectrum management role in the space sector

2.7 Ofcom has a range of different legal functions to carry out in relation to the satellite and space science sectors, reflecting their complex and international nature. These fall into three broad categories.

2.8 Firstly, Ofcom authorise, under the Wireless Telegraphy Act 2006 through licences and through grants of recognised spectrum access, satellite earth stations in the UK. These earth stations can be on the ground or on aircraft or ships. For example, we license satellite news gathering vans which are used to broadcast live video from events around the UK. (These types of function are referred to in this document as our "licensing functions");

2.9 Secondly, Ofcom represents the UK at the ITU; the European Conference of Postal and Telecommunications Administrations (CEPT); the Radio Spectrum Committee (RSC) and Radio Spectrum Policy Group (RSPG).[4] In this role we influence the international rules that govern satellite use of spectrum, for example to encourage harmonisation of its use. (In this document we refer to this as Ofcom's "international negotiation functions".)

2.10 This is particularly important given the international nature of satellite communications and regulation, and because:

- Satellite and space science applications are typically provided on an international basis;
- The benefits that the UK gets from satellite and space science often depend on use of spectrum outside the UK;
- Spectrum use by these sectors is significantly influenced by international processes and decisions. These include the ITU rules governing satellite filings and spectrum allocation decisions at World Radio Conferences.

2.11 Thirdly, Ofcom manage satellite 'filings'[5] for companies or other organisations registered in the UK, the British Overseas Territories, the Channel Islands and the Isle of Man. Filings in respect of satellite orbital positions and operational radio frequencies are made on behalf of the United Kingdom to the ITU in Geneva. In this document we refer to this as Ofcom's "satellite filing functions".

Ofcom's legal duties and powers in relation to spectrum management

2.12 These functions which are exercised for the satellite and space science sectors are subject to differing legal requirements under UK law, European law and international law.

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[4] See Annex A to Memorandum of Understanding at: http://stakeholders.ofcom.org.uk/binaries/international/mou/MoU_2004_International_Rep.pdf. We also represent the Channel Islands, the Isle of Man and the British Overseas Territories at the ITU, see http://stakeholders.ofcom.org.uk/binaries/international/mou/MoU_OTs_2007.pdf

[5] Satellite filings are the process for obtaining internationally-recognised spectrum and orbital resources for satellites networks and systems, which is administered and overseen by the ITU.

2.13 The nature of this work means that it is undertaken in the context of the particular facts and circumstances of each case. These facts and circumstances can be very different from one case to another, even when exercising the same type of function. In assessing facts Ofcom applies an evidence based approach. Differing facts can result in some rules having greater weight in some cases than in others.

2.14 There are also some specific overriding rules which have to be applied in certain situations. This is because there are detailed international legal obligations which have been created to support particular satellite systems and networks. For example, EU obligations require protection of the spectrum used by the European satellite positioning system 'Galileo'. There are also specific rules which apply in the space science sector.

2.15 Broadly speaking, the different legislation which applies to the different functions is as follows:

2.15.1 For the "licensing functions" there are key rules which are set out in EU law, the Wireless Telegraphy Act 2006 and the Communications Act 2003;

2.15.2 For the "international negotiation functions", international law, the Communications Act 2003 and directions from the Secretary of State to Ofcom are relevant; and

2.15.3 For "satellite filing functions" there are relevant rules in the Communications Act, the directions from the Secretary of State and under the body of ITU treaty rules which are principally contained within the ITU Constitution, the ITU Convention and the ITU Radio Regulations.

2.16 For these reasons it is difficult to set out an overarching general legal framework in this document which applies across each of these functions in every case. However, the document aims to provide some clarity on Ofcom's approach and thinking in relation to this sector by setting out some general policy principles (in paragraphs 2.21 to 2.23 below) and priorities for our work (in section 3). Before moving to discuss these policy principles, we highlight the following points.

2.17 Ofcom has a principal duty in carrying out its functions to further the interests of citizens in relation to communications matters and of consumers in relevant markets, where appropriate by promoting competition.

2.18 Among other duties, Ofcom is required to secure, in the carrying out of our functions, the optimal use for wireless telegraphy of the electro-magnetic spectrum, which is of particular relevance when undertaking our spectrum functions. We consider that, in general, the optimal use of spectrum is most likely to be secured for society if spectrum is used efficiently, i.e. if it is used to produce the maximum benefits for society. These benefits include both the private and broader social value associated with spectrum use.

2.19 Alongside our principal duty and our duty to secure optimal use of spectrum, we have a wide range of other duties (under the Communications Act 2003 and the Wireless Telegraphy Act 2006[6], as well as the requirements under the European Regulatory

[6] See in particular sections 3 and 4 of the Communications Act 2003 and section 3 of the Wireless Telegraphy Act 2006.

Framework Directives) that are relevant to, and have an impact on, our spectrum decisions. These include:

- Promoting competition;
- Securing the availability throughout the UK of a wide range of electronic communications services; and,
- Securing the availability, throughout the UK, of TV and radio services of high quality and wide appeal, and duties relating to fulfilling the purposes of public service broadcasting in the UK.

2.20 When taking decisions on spectrum matters we consider all relevant duties, alongside those directly related to our spectrum functions.

Ofcom's policy principles

2.21 Ofcom's overall spectrum management strategy[7] and our wider regulatory principles[8] guide our spectrum work in relation to the satellite and space science sectors. We have aimed in this document to translate those principles into a more specific set of policy principles to guide our work in the satellite and space science sectors.

2.22 As noted, we have a number of functions in this area, which are carried out in a wide range of different circumstances and which may be subject to particular legal requirements and considerations. However, where appropriate, the following principles may provide a useful framework for the fact and evidence-based approach that we take into consideration of particular issues.

2.23 Specifically, we:

- Use market mechanisms where possible and effective, but take regulatory action where necessary, recognising the particular international nature of the satellite and space science sectors;
- Look for opportunities for spectrum sharing, including managing the coexistence of different services and promoting technology improvements that minimise interference;
- Lead the debate on key international spectrum issues that have particular relevance to the interests of UK citizens and consumers, and support wider international initiatives, including:
  - improvements to international rules that both support efficient allocation of global space resources and are predictable enough to enable long term investments; and,
  - studies (for example on new sharing opportunities) which could enhance the value of spectrum use.

[7] Ofcom, Spectrum management strategy - Ofcom's approach to and priorities for spectrum management over the next ten years. http://stakeholders.ofcom.org.uk/consultations/spectrum-management-strategy/
[8] https://www.ofcom.org.uk/about-ofcom/what-is-ofcom

- Prioritise our efforts to focus on those activities where we can make the biggest improvement to UK citizen and consumer's benefits, whilst recognising that we have a wider role in representing the UK internationally;

- Engage with Government, as appropriate, to enable us to represent the interests of the UK in relevant international fora; and,

- Manage satellite filings in a thorough, fair and efficient manner consistent with international rules. To ensure we do this in a transparent and predictable way we follow a clear set of published procedures.[9]

UK space industry

2.24 In response to our March 2016 consultation some industry stakeholders said we should take account of UK industry interests, especially in the international regulatory environment to support the provision of their services overseas.

2.25 As noted above, Ofcom represents the UK in international fora that deal with spectrum. We can and do take account of wider UK public interests in our international representation work as we consider appropriate. These interests may include public safety, national security and government policies relating to economic growth. We may consider these interests even where satellites do not provide direct services to UK consumers and citizens.

2.26 We are aware that satellite systems and networks often require significant investment and investor risks in order to successfully launch satellites and deliver services. While we do not act as the representative of specific industries or companies, we create the conditions for investment in new technologies and services by promoting optimal use of spectrum in the international arena.

2.27 As a result we have clarified our principle on how we prioritise our efforts (see fourth bullet in paragraph 2.23 above) to recognise our wider role in representing the UK internationally.

Other relevant work

2.28 Our strategy is related to several other areas of Ofcom activity, including:

Broadband USO

2.29 Ofcom has been asked by the Department for Culture, Media and Sport (DCMS) to provide technical analysis and recommendations to support the design of a broadband universal service obligation (USO). We published a call for inputs in April 2016, seeking views from industry and consumers on the broadband USO design.[10]

2.30 Respondents from the satellite industry indicated that satellite broadband could be part of a solution. However, some respondents expressed concerns that latency and reliability issues may affect the ability of current satellite technologies to deliver a suitable service.

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[9] Procedures for the management of satellite filings https://www.ofcom.org.uk/consultations-and-statements/category-1/satellite-filings-15

[10] Designing the broadband universal service obligation - Call for inputs https://www.ofcom.org.uk/consultations-and-statements/category-1/broadband-uso-cfi

2.31 These views are taken into consideration in our advice to Government[11] which provides a range of options for the delivery of universal decent broadband. Ultimately it will be the Government's decision as to which of our proposed options best meets its objectives.

Mobile Data Strategy

2.32 In June we published an update to our long term strategy for addressing the increasing use of data by mobile devices.[12] The bands we are prioritising for that work include some which are used for satellite and/or are adjacent to bands with satellite use. These include:

- 3*.6-3.8 GHz:* National regulators across Europe and the mobile industry have identified the wider 3.4-3.8 GHz band as a potential first 5G band. This band can provide the large bandwidths necessary for new 5G services and is harmonised within Europe for electronic communications networks including mobile. We have consulted on policy options to extend mobile use in the band.[13]

- 5 *GHz band:* We have proposed to focus our short-term efforts on opening up 5725–5850 MHz for Wi-Fi, while considering other parts of the 5 GHz band in the medium and longer term.

- *26 GHz band:* The 24.25-27.5 GHz band ("26 GHz band"), has been identified by the RSPG and CEPT as one of the 'pioneer' bands for European next-generation (5G) wireless systems.[14] We support the identification of this band and will be publishing a consultation on pioneer spectrum bands for 5G (including the 26 GHz band) in Q2 2017. This band is considered further in section 3 where we discuss our earth observation priority.

- *1427-1518 MHz*: Part of this band, 1452-1492 MHz, is currently available in the UK for mobile services. We will be considering the options for whether and how to make the wider 1427-1518 MHz band available for mobile use, taking account of satellite and space science use in adjacent bands.

Fixed Wireless Spectrum Strategy

2.33 In July 2016 we published a call for inputs asking stakeholders for their initial views on a strategic review of spectrum used by fixed wireless services.[15] This call for

[11] Technical advice to UK Government on broadband universal service – December 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0028/95581/final-report.pdf

[12] http://stakeholders.ofcom.org.uk/binaries/consultations/mobile-data-strategy/statement/update-strategy-mobile-spectrum.pdf

[13] Improving consumer access to mobile services at 3.6 GHz to 3.8 GHz https://www.ofcom.org.uk/consultations-and-statements/category-1/future-use-at-3.6-3.8-ghz

[14] See *5G for Europe: An Action Plan*, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, September 2016, https://ec.europa.eu/digital-single-market/en/news/communication-5g-europe-action-plan-and-accompanying-staff-working-document; *Opinion on spectrum related aspects for next-generation wireless systems (5G)* http://rspg-spectrum.eu/wp-content/uploads/2013/05/RPSG16-032-Opinion_5G.pdf and *5G Manifesto for timely deployment of 5G in Europe,* July 2016, http://ec.europa.eu/newsroom/dae/document.cfm?action=display&doc_id=16579

[15] https://www.ofcom.org.uk/consultations-and-statements/category-1/call-for-inputs-fixed-wireless-spectrum-strategy

inputs is part of a phased review whereby Ofcom is aiming to develop a deeper understanding of current use, as well as how technologies, supply and demand are likely to develop. Responses will help inform Ofcom's strategy, its future spectrum policy decisions and the prioritisation of work related to fixed wireless services. It is linked to our work on space spectrum as many of the bands used by fixed wireless services are shared with satellite services. We expect to publish proposals for our strategy in spring 2017.

Sharing in 3.8-4.2 GHz

2.34 In April 2016 we published a call for inputs introducing the 3.8-4.2 GHz band as a candidate band for enhanced spectrum sharing for potential new innovative applications.[16] In light of the responses we received, we published an update in August 2016 setting out our belief that there is potential for further exploring enhanced sharing based on geographically defined authorisations (while continuing to allow current and future deployments of incumbent fixed links and fixed satellite services). We are continuing to engage with stakeholders who are interested in furthering the discussion in this area.

[16] http://stakeholders.ofcom.org.uk/consultations/opportunities-for-spectrum-sharing-innovation/

Section 3

Our strategy

Overview

3.1 Our strategy comprises **three priority areas** which will inform, as appropriate, our work on developing the framework for spectrum authorisation in the UK and on influencing international rules on spectrum:

- Enabling growth in **satellite broadband** communications provided via satellite to hard-to-reach locations, on land, ships and aircraft.
- Enabling growth in the quality and quantity of **earth observation** data collected by satellites.
- Recognising the **existing benefits** of satellite and space science whilst exploring opportunities for **new uses**.

3.2 We will also **monitor developments in other important areas** (including M2M, satellite positioning and safety related applications) to understand if and when further work in those areas may be appropriate.

3.3 In addition, we aim to **deliver our on-going activities (such as satellite filings and spectrum licensing) in a high quality and efficient way**, and will look for ways to further improve how we do this work.

Enabling growth in satellite broadband communications

3.4 The demand for broadband data services (in all locations and via all delivery technologies) continues to grow and we expect this trend to continue. However, terrestrial fixed and mobile networks do not currently reach all UK citizens, and so satellites may have a role in meeting this growing demand in some locations.

3.5 Consistent with Ofcom's overall goal of making communications work for everyone, we will, where appropriate, help to enable growth in satellite broadband communications to locations which are hard to reach by terrestrial networks. Specific benefits which we are looking to realise include:

- Better fixed broadband options for residential consumers and businesses in the hardest to reach locations in the UK, which terrestrial broadband technologies do not serve well at the moment; and
- Better broadband connectivity (e.g. Wi-Fi) for passengers on aircraft and on ships.

3.6 There may also be benefits in terms of better mobile broadband coverage, where satellites could have a role in providing backhaul for mobile base stations in the most remote locations.

3.7 A number of stakeholders responded that we should not limit the focus of this priority to satellite's role in serving the hardest to reach parts of the UK. They said that

satellite can compete against fixed line services across the UK, and may have a role in increasing competition.

3.8 Ofcom is committed to promoting competition in the provision of broadband connectivity. Our view is that for many parts of the UK this can best be achieved through the large-scale roll-out of new ultrafast fixed line broadband networks, including fibre direct to homes and businesses.[17]

3.9 We welcome any role that satellite broadband could play in increasing competition in the provision of fixed broadband services in areas which are unable to benefit from multiple new cable and fibre networks. However, we think the most important role for satellite broadband in the UK will be in providing connectivity to places which are very hard to reach using terrestrial networks. In this context, we are working with the Government to make decent, affordable broadband a universal right for every home and small business in the UK. Depending on the technical specification of the universal service, satellite broadband could potentially play a role in connecting the very hardest-to-reach premises.[18]

3.10 We will achieve our aims for satellite broadband by:

- Liberalising spectrum use to enable greater exploitation of new technologies (such as non-geostationary satellite constellations) where possible;
- Monitoring satellite broadband take-up and use of bands already available in the UK;
- Where necessary, considering action to ensure efficient use of bands already available in the UK; and,
- Considering making additional spectrum available in the future if and when this becomes appropriate.

3.11 In addition, some of our future actions on satellite broadband will depend on factors that are likely to become clearer over the next 12-18 months, including:

- Data on the level of, and trends in, satellite broadband take-up;
- Government decisions on the nature of a broadband USO which could affect the demand for satellite broadband; and
- The findings of our Fixed Wireless Spectrum Strategy, which will inform our thinking on the future of bands which are shared between fixed wireless links and satellite applications.

3.12 Therefore, we may publish a short further update on satellite broadband once these factors become clearer.

[17] See our Initial Conclusions of the Digital Communications Review here.

[18] See Technical advice to UK Government on broadband universal service – December 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0028/95581/final-report.pdf

Liberalise spectrum use to enable greater exploitation of new technologies

3.13 We will take action, as necessary and appropriate, to enable bands already available in the UK for satellite applications to be used for new technologies, such as non-geostationary orbit satellite (NGSO) systems, Earth Stations in Motion (ESIM)[19] and Complementary Ground Components (CGCs). This action relates to our international negotiation and licensing functions. We will take account of incumbent services when doing this.

3.14 Regulation enabling ESIM is particularly important for the provision of high capacity connectivity to aircraft (e.g. to support in-flight Wi-Fi and other services), ships and other mobile platforms. For example, if there were an international framework for use of 27.5-29.5 GHz by ESIM this could increase the bandwidth usable by ESIM by several multiples, depending on location, compared to today (where there is an international framework for 29.5-30 GHz). This additional bandwidth could be re-used across several orbital locations and hence in aggregate potentially enable very large capacity increases.

3.15 NGSO networks can offer lower latency services compared to geostationary orbit (GSO) satellite networks due to their lower orbits. Lower latency is important for some applications such as video calls. However, in comparison to GSO networks there is likely to be a lower limit to the number of NGSO networks, which could limit their contribution to boosting the capacity of satellite broadband services.

3.16 Given the international nature of satellite applications, each of these technologies may benefit from relevant agreements at both international (ITU) and regional (CEPT) levels, as well as needing relevant authorisations in the UK.

3.17 We will therefore prioritise our work to ensure that the UK licensing framework supports the use of these technologies where this is likely to benefit UK consumers. Where appropriate, we will also support international bodies undertaking relevant studies that could lead to future international agreements or recommendations. The nature of our support for such international work will vary, depending on the situation, from supporting the aims of the work in principle, to undertaking technical analysis ourselves and providing on-going representation at international meetings.

3.18 However, there may be some exceptions to this approach depending on the facts relevant to specific bands. For example, we have identified 3.6-3.8 GHz as a high priority band for future (terrestrial) mobile use. Therefore, facilitating the development of an international framework for new NGSO systems in this band[20] is a relatively low priority for us.

Monitor satellite broadband demand

3.19 We will monitor satellite broadband take-up to better understand current demand levels and to assess the likelihood of different future demand scenarios. In particular, we have started to collect data from satellite service providers on UK subscriber numbers and revenues. These will be published in our 2017 Communications Market Report. We will also consider how best to monitor the growth of inflight Wi-Fi services.

[19] Earth stations in motion include those mounted on an aircraft, ship, train or road vehicle. ESIM were previously described as Earth Station on Mobile Platforms (ESOMPs)

[20] Currently being studied under agenda item 9.1.3 for WRC-19

3.20 Getting a more accurate picture of take-up is particularly important because there were a range of responses to our consultation which indicated that future demand could be pushed in different directions. For example:

- In our demand scenarios we assumed a contention ratio[21] of 20:1, but SES responded that they would expect a ratio of 200:1 or higher. A 200:1 contention ratio would result in ten times less demand than our published scenario.

- The UK Space Agency responded that we may have underestimated future data rate requirements, which should be more than 10 Mbit/s. We had modelled a 20 Mbit/s scenario for 2025, but acknowledge that data rates higher than 10 Mbit/s could be in demand before then.

- We considered scenarios where 0.7% of total UK premises (200,751) are served by satellite broadband in 2020, rising to 1% (286,787) in 2025, but received input suggesting much lower and higher scenarios.

    - Actual VSAT[22] numbers and forecasts submitted by the Global VSAT Forum (sourced from Comsys) indicate much lower demand than our scenarios. They show that the number of UK VSAT sites in service (which includes but is not limited to consumer fixed broadband premises) will grow from around 65,000 today to 80,000 in 2020 (approximately 0.3% of premises) and falling in later years due to greater rollout of terrestrial services.

    - OneWeb argued that we need to consider the demand from 5% of UK premises (this corresponds to premises which may not be reached by the current Government aim to deliver superfast broadband to at least 95% of premises by 2017).

3.21 The diversity of these inputs – with some factors suggesting 10 times higher demand, whilst others 10 times lower demand - serve to illustrate the current uncertainty about future demand scenarios. Collecting data on actual subscriber numbers will help to resolve some of this uncertainty.

3.22 In addition, we note that the role of satellite in supporting the delivery of the broadband USO is still to be finalised, as it will depend on a number of policy decisions by Government. If satellite broadband were to play a part in delivering the broadband USO, then this might be consistent with a scenario where it is serving premises in the final (say) 1% of UK premises that are not able to receive download speeds of 10 Mbit/s. If, however, satellite broadband systems do not meet the technical specification requirements that are set for the USO, then much lower levels of take-up are more likely.

3.23 Collecting data on actual take-up and having a firmer view on the nature of the broadband USO should mean that demand levels become clearer over the next 12-18 months.

[21] Contention is the degree to which bandwidth is shared between different end users

[22] Very Small Aperture Terminal. A satellite earth station equipped with an antenna of relatively small size.

Efficient use of existing bands

3.24 We will take action, where necessary and appropriate, to enable efficient use of bands currently available in the UK for satellite applications. We have considered the following aspects:

- Access to spectrum in the Ka band 27.5-30 GHz uplink spectrum;
- Extensive fixed link use in the Ka band 17.7-19.7 GHz downlink spectrum;
- Efficient use of Ka band 17.3-17.7 GHz downlink spectrum;
- Efficient use of Ku band 14.25-14.50 GHz uplink spectrum;
- Efficient use of orbital resources and reforms to the international satellite filing process.

3.25 Of these, we think the most important area is the efficient use of Ka band spectrum as this is currently the most important band for supporting the growth of high capacity satellite broadband services. The above issues are primarily relevant to our licensing functions, except for the last one which is relevant to our international negotiation and satellite filing functions.

Access to spectrum in the Ka band 27.5-30 GHz uplink spectrum

3.26 In response to the consultation some stakeholders argued that spectrum in Ka band is not as usable as we had assumed in the UK, due to the presence of auctioned licences in part of the uplink band (27.5-30 29.5 GHz) and extensive use by fixed links in part of the downlink band (17.7-19.7 GHz, see below). This issue is relevant to our licensing functions.

3.27 Licences auctioned in 2007[23] on a technology neutral basis comprise 1.232 GHz of the spectrum available to the Fixed Satellite Service (FSS) across the full 27.5-30 GHz uplink band. Some stakeholders saw these auctioned licences as a barrier to getting access to this spectrum for satellite uplinks. OneWeb asked Ofcom to review the current situation in the auctioned blocks and allow coordinated use of the spectrum by Permanent Earth Stations (PES). ViaSat said there is potential for sharing between FSS terminals and Fixed Service (FS) links using a database of deployed FS systems.

3.28 However, the technical conditions of the auctioned licences allow for satellite use of the spectrum, and the licences are tradable. As such there should be no regulatory barrier in the UK to the spectrum being used for its highest value use.

3.29 Therefore, we encourage operators, both the licensees and those seeking access, to engage in discussions to find a commercial solution acceptable to both parties. This is consistent with our spectrum sharing framework, where we set out our expectation that stakeholders seeking access to spectrum take into account whether access is available through trading in the secondary market.

[23] 10 GHz, 28 GHz, 32 GHz and 40 GHz Award http://webarchive.nationalarchives.gov.uk/20160702162827/http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/awards-archive/completed-awards/1040award/

Extensive fixed link use in the Ka band 17.7-19.7 GHz downlink spectrum

3.30 In the downlink direction, uncoordinated earth stations in the 17.7-19.7 GHz portion of the band operate on a non-protection basis from fixed links. The band is widely used for fixed links in the UK (as well as in many other countries) with over 7,500 links mainly used by BT and Vodafone. Therefore, some stakeholders (Global VSAT Forum, Avanti, Inmarsat) pointed out that only 500 MHz of the Ka-band spectrum (i.e. the 19.7-20.2 GHz band) is available for earth stations which is unconstrained by fixed link use. They recommended that to make the band more useable for FSS earth stations there should be a freeze on new fixed link licences in parts of the band in rural or remote areas (Global VSAT Forum and Avanti), or protection of mobile receive earth stations in some spectrum in the range (Inmarsat). This issue is relevant to our licensing functions.

3.31 Existing studies ECC Report 241[24] and CoRaSat[25] suggest that, given the directionality of fixed links and the elevation of earth stations, sharing may be possible in a large proportion of the band. Further, ECC Report 241 sets out that public availability of fixed link assignment information can facilitate frequency sharing.

3.32 Ofcom already publishes this data as part of its Wireless Telegraphy Register Open Data[26]. Therefore, this data could be used to plan deployment of earth station receivers. Although this does not remove the risk of new fixed link assignments being made near to the earth station, it may be that this risk is low if the latter is primarily deployed to provide broadband in remote/rural areas. Alternatively, it is already possible to apply for a coordinated earth station licence (for a fee), which would ensure that the earth station is taken into account in planning future fixed links in the band.

3.33 Nonetheless, it may be that neither of these options is ideal to enable significant growth of satellite broadband use of these bands. However, before considering any additional action to facilitate sharing in this band, we would want to see evidence that existing mechanisms for sharing are insufficient, as well as having a clearer view on future demand for capacity (also see monitoring demand above).

Efficient use of Ka band 17.3-17.7 GHz downlink spectrum

3.34 We believe there may be scope for greater use of the spectrum band 17.3-17.7 GHz for downlink capacity (the band is allocated to FSS downlink in Region 1). The band is used by a small number of Broadcasting Satellite Service (BSS) feeder links (along with 17.7-18.4 GHz) and is closed to new fixed links (with just two remaining links in Jersey). As above, data on these links is published in the Wireless Telegraphy Register and is also released as Open Data on the Ofcom website.

3.35 17.3-17.7 GHz is also used by the MOD for radiolocation (radar) on a secondary basis, which means it cannot claim protection or cause harmful interference to

[24] Enhanced access to spectrum for FSS uncoordinated earth stations in the 17.7-19.7 GHz band http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP241.PDF

[25] COgnitive RAdio for SATellite (CoRaSat) Communications is a European Commission project aimed at investigating, developing, and demonstrating cognitive radio techniques in satellite communication systems for spectrum sharing http://www.ict-corasat.eu/

[26] https://www.ofcom.org.uk/research-and-data/open-data/opendata provides information on all assignments that Ofcom has made publicly available. Certain assignments have been withheld from disclosure.

primary services, including FSS, in the band. This band is also identified in the Radio Regulations (under provision 5.516B) as a High-Density FSS band.

3.36 Therefore, while not entirely unconstrained, the small number of BSS feeder links is likely to impose less of a constraint on uncoordinated satellite earth stations than the fixed links in the 17.7-19.7 GHz band.

Efficient use of Ku band 14.25-14.50 GHz uplink spectrum

3.37 The other band which is currently available and could potentially be used more efficiently is the Ku band uplink at 14.25-14.5 GHz. This issue is relevant to our licensing functions.

3.38 In the UK, in order to avoid interference into the approximately 165 fixed links in the band, the frequencies can currently only be used for coordinated earth stations (such as Transport Earth Stations and Permanent Earth Stations), but not for uncoordinated deployments which are more suitable for satellite broadband user terminals. If uncoordinated earth stations were able to access this band it would increase the bandwidth available in Ku band for uplinks from uncoordinated user terminals, from 250 MHz to 500 MHz. This was supported OneWeb and Global VSAT Forum in response to our consultation.

3.39 The band is relatively lightly used by fixed links and is closed to new assignments, with the absolute number of links gradually declining over recent years. Stakeholders noted that the band is not used by the fixed service across the majority of Europe, and other countries allow the use of it by satellite systems on an uncoordinated basis. However, making the band available for uncoordinated terminals in the UK would either involve clearing the band of existing links or perhaps developing an authorisation regime that relied on terminals to protect fixed links based on knowledge of their location and frequency.

3.40 Our initial thinking is that both of these options would be relatively costly to implement - the former in direct costs in moving incumbent links and the latter in the time and effort to develop an appropriate authorisation regime that would appropriately protect incumbent users. It would also free up a relatively small amount of spectrum (250 MHz) in Ku band, where there is likely to be lower growth in satellite broadband systems compared to Ka band. Therefore, we do not have an immediate plan to consider if and how we could enable uncoordinated use in this band. However, we will keep this under review, particularly if more evidence about the potential benefits and costs of any change becomes available.

Efficient use of orbital resources and reforms to the international satellite filing process

3.41 We will, where suitable opportunities arise and in conjunction with other administrations, support reforms to the international satellite filing and coordination process that promote efficient use of spectrum. We will also oppose changes to the process that could make it less efficient. The efficient use of orbital resources is relevant to our international negotiation and satellite filing functions.

3.42 We believe a measured approach is appropriate as, following consultation with stakeholders, there does not currently appear to be a high risk of new satellite broadband services being completely prevented as a result of any inefficiencies in the current international process (e.g. due to proliferation of paper satellites). However, the extent of our concern will somewhat depend on the level of demand for

satellite broadband in the UK, and the consequent demand for orbital slots to meet that demand. For example, the challenges of securing two or three suitable orbital slots serving the UK and the rest of Europe will be much lower compared to a situation where 10-20 satellites and orbital slots are needed to serve demand in this area.

3.43 In the March 2016 consultation we identified the risk that 'paper satellites' (filings not related to genuine satellite projects) may lead to an inefficient use of spectrum and orbital resources and may negatively impact the provision of satellite broadband services to UK citizens and consumers. For example, we highlighted that for each potential orbital location visible from the UK there were an average of 12 satellite filings at the stage of coordinating their potential spectrum use with other satellite networks.

3.44 In general, stakeholders saw the current filing mechanism as an imperfect but relatively functioning system that allows some degree of risk management in relation to securing orbital slots. Based on further discussions with stakeholders, there also appears to be a partial secondary market for filings. This market may allow stakeholders to reach commercial agreements to access the necessary orbital resources.

3.45 However, there is scope for improvement. Following further analysis and discussion with stakeholders, we understand that the most important potential issue is that of 'virtual' satellites, which are frequency assignments (permanently) registered in the ITU Master International Frequency Register (MIFR), but which are not used by a real satellite. Related to this is a lack of readily available information for many filings, including the identification of the company or organisation who is behind each of them, that may make the secondary market more difficult to access. Therefore, we will generally be supportive of initiatives that help to tackle these problems.

3.46 A related issue is the efficient allocation of spectrum resources by non-geostationary systems. Compared to the geostationary orbit, there is likely to be a limited number of these systems (albeit each network will have a large number of satellites compared to a single GSO satellite) and the international regulatory rules relating to their use of spectrum are not as well developed. Consequently, there may be a higher risk of inefficient use - for example, if only one complete system is possible and that one network only deploys 1% of their network, which then prevents any use by others.

3.47 Another important element that affects the efficient use of spectrum and orbital resources by non-geostationary systems is their inter-system coordination. We believe that the number of systems that can share the same resources may increase if the companies and/or organisations behind them coordinate the use of their constellations with each other. Therefore, we will support actions that ensure that inter-system coordination is carried out appropriately.

3.48 Ofcom will continue to monitor, and where appropriate engage in related issues (for example on the rules on 'bringing into use' of NGSO networks being studied in preparation for WRC19), whilst taking account of the importance of regulatory predictability for investments in these new systems.

Consider making additional spectrum available in the future

3.49 We may consider making additional spectrum available (i.e. in bands not currently available for use in the UK) as demand becomes clearer. However, at present we

think these benefits are more distant and less significant compared to enabling greater use of Ka band. As discussed above, we have not yet seen evidence that demand is likely to grow significantly faster than in the scenarios we analysed in the consultation, but will keep this under review. We consider two specific issues below. One (licensing V band earth stations in existing allocations) relates to our licensing functions whilst the other (WRC19 agenda items relating to V band) relates to our international negotiation functions.

Licensing feeder links in existing V band allocations

3.50 The main band where we could potentially make more spectrum available in the UK in the future is in V band (specifically the FSS allocations currently in 37-43.5 GHz, 45.5-50.2 GHz and 50.4-51.4 GHz). At present we do not license satellite earth stations in these bands.

3.51 We received many responses to our consultation stating the future importance of these bands for feeder links and gateways, and that this should be included as an area of priority in our strategy. We acknowledge that enabling existing allocations in V band to be used for feeder links in the UK might further improve satellite broadband in future if there is strong demand for capacity. The additional bandwidth could help because some capacity in Ka band currently used for feeder links could be freed up for service links (providing capacity to end users) if feeder links were migrated to V band in the future.

3.52 We also note that bands 37-43.5 GHz, 45.5-50.2 GHz, and 50.4-52.6 GHz are being studied for WRC-19 Agenda Item 1.13 (considering bands for potential 5G mobile use). In general, we are supportive of efforts to study ways in which 5G deployment in V band could effectively share (probably on a geographic basis) the spectrum with satellite feeder links. Fortunately, the benefits from 5G deployment in these bands are more likely to arise from deployment in populated areas and transport routes, whereas the benefits from additional feeder links only require a small number of sites which do not need to be near these areas.

3.53 In the case of 40.5-43.5 GHz auctioned spectrum, access for use by feeder links would be a commercial decision for the licensees of those bands. In the 37-40.5 GHz, 45.5-50.2 GHz, and 50.4-51.4 GHz bands, authorisation of feeder links would be a decision for Ofcom, taking account of other users of the band, including fixed links and, potentially, 5G mobile systems. We would therefore not expect to consider the authorisation of feeder links until after WRC-19, once the status of these bands for 5G is clearer.

International agenda items related to V band satellite use

3.54 Two further potential actions in relation to V band satellite use are being discussed in preparation for WRC-19. However, at present we do not see a reason to prioritise work in these areas:

- WRC-19 Agenda Item 1.6 on facilitating non-geostationary satellite use of V band, could enable new NGSO networks to be deployed at higher frequencies. In line with our general principles, we support studies such as this that could enable use of new technologies and more efficient use of spectrum. This work might ultimately boost the capacity of broadband services provided by NGSO networks. Nonetheless, the benefits are relatively uncertain and distant at this stage, and the resulting capacity increase may be relatively small compared to enabling better use of the geostationary orbit (which can be reused many times e.g. up to

42 orbital slots visible from the UK). Therefore, whilst supporting this work in principle, at present it is a relatively low priority for our WRC-19 work.

- WRC-19 Agenda Item 9.1.9 is studying the possibility of an FSS allocation in 51.4-52.4 GHz (Earth-to-space). This could enable additional feeder link capacity for satellite broadband. However, our current thinking is that the benefits from this additional capacity are likely to be less certain and more distant than the benefits of feeder links in the bands currently available. Therefore, at present this is also a relatively low priority for our WRC-19 work.

Table 1: Summary actions for Satellite Broadband

Action	**Timing**
Liberalise spectrum use to enable greater exploitation of new technologies	
Actively support and contribute to ITU work considering extending ESIM access in Ka band to include the 17.7-19.7 GHz and 27.5-29.5 GHz bands at the international level at WRC-19	To complete by WRC-19
Implement updates to our earth station licence products to enable use with NGSO satellite networks	Statement published March 2016 Implementation planned for Q1 2017[27]
Follow and where appropriate be supportive of CEPT work on developing an appropriate regulatory framework for authorising NGSO satellite user terminals in Ku band	ECC Decision targeted for September 2017
Monitor demand	
Collection of UK satellite broadband subscriber data	Publication of findings in summer 2017 Communications Market Report
Efficient use of existing bands	
Monitor any regulatory barriers to access to spectrum in the Ka band (specifically 27.5-30 GHz, 17.3-17.7 GHz, 17.7-19.7 GHz)	On-going
Efficient use of Ku band 14.25-14.50 GHz uplink spectrum	No immediate action but keep under review
Efficient use of orbital resources – support initiatives tackling 'virtual' satellites, improved information availability and NGSO	WRC-19 and potentially beyond

[27] See https://www.ofcom.org.uk/__data/assets/pdf_file/0025/12994/ngso_statement.pdf. Implementation is currently expected in Q1 2017; however, stakeholders should contact Ofcom if they have a more urgent requirement for a licence.

bringing into use	
Additional spectrum	
Consider authorisation of V band feeder links	Potentially consider after WRC-19
Update on satellite broadband	
Publish short update on satellite broadband if necessary	No earlier than 2018

Enabling growth in earth observation

3.55 We will help to enable growth in the quality and quantity of information about the earth collected by satellites. UK citizens and consumers can benefit from the insights that more and higher quality earth observation data can bring through, for example improved weather forecasting, more efficient public services, new commercial applications and more informed policy making (for example in relation to climate change). Growth in this area is particularly driven by growing use of small and nano-satellites because of their lower cost and shorter development times.

3.56 There are three aspects of earth observation use of spectrum that we will work on:

- Long-term predictability of access to bands used for sensing, particularly passive sensing;
- Supporting the growing numbers of small and nano-satellites by facilitating access to suitable spectrum for Telecommand, Tracking and Control (TT&C);
- Enabling access to spectrum for downlinking data from earth observation satellites

3.57 In addition, we recognise that much of the innovation in this sector is anticipated to come from smaller and/or newer organisations which may be less familiar with the satellite regulatory environment than more established operators. We will therefore review the information we make available to stakeholders - online and where appropriate via other channels - to ensure this is as easy to access and understand as possible (also see the sub-section on our on-going activities below).

Long-term predictability of access to bands used for sensing

3.58 The key issue for earth observation applications that rely on spectrum for active or passive sensing is the predictability of spectrum access over long periods of time. This is especially important for passive sensing (for example radio astronomy or monitoring of soil moisture) which depends on access to bands which are determined by specific natural phenomena. We will:

- Continue to take appropriate care before deciding to introduce new services, either adjacent to (or for active bands, potentially co-channel with) bands used for sensing. This relates to our licensing functions. For example, we want to see sufficient study of coexistence between passive services at 23.6-24 GHz and potential 5G mobile services in the adjacent band. In response to the

consultation, stakeholders stressed that studies that enable passive bands to be protected are particularly important.

- Support international work to provide guidance, and improvements in filtering for satellites making observations in passive bands. The aim of this work is to reduce the risk of future services in adjacent bands causing interference into those satellites (or imposing unnecessary costs through constraints on the operation of those other services). This relates to our international negotiation functions.

Supporting the growing numbers of small satellites by facilitating access to suitable spectrum for TT&C

3.59 The growth in use of small satellites opens up scope for greater innovation due to lower costs and shorter development lead times. These satellites typically use omni-directional antennas and operate at frequencies below 1 GHz mainly due to designs which rely upon the use of low cost equipment. Although spectrum below 1 GHz is very intensively used, TT&C requires only a very narrow bandwidth (generally 100 kHz or less).

3.60 We will help enable growth in small satellites by:

- Supporting the work of WRC-19 to study the spectrum needs for small satellites with short duration missions. This relates to our international negotiation function. Specifically, we will participate in CEPT/ITU work on assessing the suitability of existing Space Operations allocations and studying potential sharing opportunities, including the identification of mitigation techniques to protect incumbent services;

- Looking for ways to simplify and streamline the process for stakeholders wishing to access spectrum (e.g. for use by nano-sat TT&C links) that is used by the public sector. This relates to our licensing functions.

Enabling access to spectrum for downlinking data from earth observation satellites

3.61 In order for consumers and citizens to benefit from the richer, higher resolution and more frequently updated earth observation data being generated, there needs to be spectrum available to enable this data to be downlinked from EO satellites. We will work to enable appropriate access to spectrum to enable these benefits.

3.62 In particular, the two specific bands that are important are:

- **8025-8400 MHz (X band):** Many EO missions use this band at present for downlinking their data.

- **25.5-27 GHz (Ka band international EESS allocation):** The international allocation in Ka band offers four times the bandwidth of X band. Ka band is likely to be used for future growth of data volumes from higher resolution instruments. The band is also used for inter-satellite links which are used in connection with EO data relay satellites.

3.63 Our view, based on the analysis we set out in the consultation document, is that these two bands will be sufficient for considerable future growth in EO data downlink requirements. All responses that commented on this point agreed with this finding. The Natural Environment Research Council and National Centre for Earth

Observation noted that developments in high data rate EO sensors might change this position in the future, and therefore we will monitor developments in this area.

8025-8400 MHz (X band)

3.64 This band is currently used in the UK by the MOD for military applications and by a small number of receive only earth stations that receive data from EO satellites. In addition, feasibility work looking at the potential for shared use by civil fixed links is at an advanced stage.

3.65 In order to provide greater certainty to users wishing to use this band for receive only earth stations, we intend to consult on the introduction of RSA for EESS earth stations in this band. A grant of RSA provides formal recognition of the use of frequencies for radio services that do not require a WT Act licence and ensures we have comprehensive information on these users. Granting RSA relates to our licensing functions as it enables us to take account of receive only earth stations when licensing other users.

25.5-27 GHz (Ka band international EESS allocation)

3.66 Our work on 25.5-27 GHz relates to both our licensing and international negotiation functions. We currently offer RSA in 25.5-26.5 GHz, for receive only data downlink sites[28] so that these earth stations can be taken into account when making new assignments for other services in the band. The frequency band 24.45–27.5 GHz is also used for inter-satellite links which are used to support communication between earth observation satellites and data relay satellites. In addition, the frequency band 26.5-27 GHz is currently administered by the MOD for military use, but the MOD has confirmed the band is extremely lightly used (if it is used at all).

3.67 The 24.25-27.5 GHz band (the "26 GHz band'), which overlaps with the international 25.5-27 GHz EESS allocation, has been recently identified by the RSPG and CEPT as one of the 'pioneer' bands for European next-generation (5G) wireless systems.[29] The Radio Spectrum Committee (RSC) has also recently agreed a Commission mandate to CEPT to develop harmonised technical conditions for spectrum use in this band in support of the introduction of 5G terrestrial wireless systems in the European Union. This particular band is intended, in future, to provide ultra-high capacity for innovative new services in Europe and has the potential for global harmonisation.

3.68 Ofcom fully supports Europe's identification of 26 GHz as a pioneer band for 5G. We will actively contribute to international coexistence studies aimed at identifying the appropriate technical conditions that will enable the continued use within the band by EESS earth stations and proportionate protection of the on-board receivers of data relay satellites.

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[28] Recognised Spectrum Access (RSA) for Receive Only Earth Stations: Statement on the making of regulations to introduce RSA in the frequency bands 7850 – 7900 MHz and 25.5 – 26.5 GHz (24 June 2015) https://www.ofcom.org.uk/__data/assets/pdf_file/0024/84192/statement_on_making_regulations_for_rsa_for_roes.pdf

[29] On 9 November 2016 the Radio Spectrum Policy Group (RSPG) launched a strategic roadmap for 5G in Europe with the publication of its 'Opinion on spectrum related aspects for next-generation wireless systems (5G)' http://rspg-spectrum.eu/wp-content/uploads/2013/05/RPSG16-032-Opinion_5G.pdf

3.69 We believe that coexistence between 5G and EESS downlinks can be managed if proportionate measures are taken, including locating EESS Earth stations away from urban areas. In addition, we expect that only a small number of earth stations may be needed in order to realise the benefits from that data. This is because once downlinked to Earth, the data can be distributed to users using terrestrial (e.g. fibre) networks.

3.70 We are prioritising early studies to understand the appropriate coexistence measures and will actively contribute to work in ECC PT1 and ITU (for WRC-19) on managing coexistence between 5G services and the satellite services that use this band, including data downlinks, and inter satellite links used for data relay satellites.

3.71 Given these developments, we strongly encourage stakeholders to discuss with us any plans they may be considering to use the Ka band for data downlinks, and to very carefully consider the siting of any future earth stations.

3.72 For example, earth stations in or near urban areas could end up receiving interference from future roll-out of 5G services. In cases where the impact on future 5G services could be significant, we will consider whether it would be appropriate to grant a new RSA in this band. In contrast earth stations sited sufficiently far away and/or screened from 5G deployments using 26 GHz, could allow 5G mobile services and earth observation data downlinks to coexist.

Table 2: Summary actions for Earth observation

Action	**Timing**
Access to bands for sensing	
Take appropriate care before deciding to introduce new services, especially adjacent to / co channel with bands using for sensing.	Relevant to our on-going work on a number of bands including 26 GHz.
Propose and contribute to international work on filtering to provide guidance, and improvements in filtering for satellites making observations in passive bands.	We plan to submit a proposal for this work to ITU Study Group 7 in April 2017.
Facilitating access to suitable spectrum for TT&C	
Simplify / streamline, where possible, process for accessing spectrum used by the public sector	2017 and on-going
Support, and where appropriate contribute to, work preparing for WRC-19 (Agenda Item 1.7) on the spectrum needs for small satellites with short duration missions.	To complete by WRC-19
Review / update UK earth station authorisation framework as necessary in light of WRC-19 outcome.	2020
Spectrum for downlinking EO data	
Consult on the introduction of RSA in the 8025-8400 MHz band.	Q3/4 2017

Publish consultation on pioneer spectrum bands for 5G (including the 26 GHz band)	Q2 2017

Existing benefits and new uses

3.73 We recognise the wide range of benefits that satellite and space science use of spectrum deliver. We also appreciate that regulatory predictability is important to enable operators to make investment decisions. Further, for some space science applications, there is no choice in the frequencies that can be used as these are determined by specific natural phenomena.

3.74 However, we also note that there are growing and competing demands on the spectrum currently used by these sectors from other services which can also deliver a range of benefits. This means that we also need to consider opportunities for sharing spectrum – both terrestrial services accessing bands currently used only for satellite services and vice versa – as well as opportunities for enabling new spectrum use alongside satellite and space science use.

3.75 In doing this we will carefully consider any changes to spectrum use, including:

- Taking care to understand the ability of different services to coexist (and where appropriate considering how to mitigate the risk of harmful interference). We undertake coexistence studies to establish the feasibility of and conditions for sharing and will continue to do so. This relates to our licensing and international negotiation functions, for example where we engage with the technical studies undertaken in the CEPT and ITU.

- Taking action, for example enforcement, to deal with interference problems should they arise in practice. This relates to our licensing functions. Although we cannot offer a guarantee of interference free spectrum, in cases where the source of unlicensed use or source of interference is within the UK we may provide advice and assistance, investigate specific sources of interference, or where appropriate use enforcement powers.

3.76 In addition to our work specifically associated with the introduction of new services, we also undertake or support work that proactively looks at facilitating sharing opportunities in general. This relates to our licensing functions and includes:

- Our framework for spectrum sharing[30], which we will apply to future spectrum authorisation decisions to assess spectrum sharing opportunities.

- Our support to the Government Central Management Unit's (CMU) Data Sharing Project. This work aims to ensure the best information is available on public sector spectrum use and demand. It will underpin the provision of better and more reliable data for the Public Sector Spectrum Release Programme (PSSRP).

- Updating the UK Frequency Allocation Table (FAT) and its associated annexes to provide more information about public sector use. For example, the current Radio Astronomy annex to the FAT is being replaced with an expanded Space Science document which could become the main source of information about Space Science spectrum use.

[30] https://www.ofcom.org.uk/consultations-and-statements/category-2/spectrum-sharing-framework

Table 3: Summary actions for existing benefits and sharing / new uses

Action	Timing
Carefully consider any changes affecting existing use and take appropriate action to deal with interference problems should they arise in practice	On-going
Proactive actions to investigate / facilitate future sharing opportunities: - Support to the Government's CMU data sharing project for public sector spectrum use - UK FAT update and publication of space science and meteorology spectrum allocations	 On-going January 2017 and periodic updates beyond that as necessary

Monitor other important areas

3.77 We will monitor growth in other applications to understand if and when further consideration of those areas may be needed.

3.78 These applications include:

- Higher resolution broadcast TV content;
- Satellite navigation and positioning;
- Machine-to-machine (M2M) communications and the 'Internet of things' (IoT);
- Safety-related communications.

3.79 We do not currently anticipate that these applications will need to be a focus of regulatory action in the short to medium term, but we will update our thinking as appropriate, for example if there are significant unanticipated developments in demand which could have an impact on our assumptions about future spectrum use. In response to our consultation, most stakeholders agreed that no specific actions were required in the short to medium term, but several highlighted areas which we should keep under review, including broadcasting, navigation and safety-related communications.

3.80 One area particularly highlighted by stakeholders, which we will monitor carefully, is innovation and growth in M2M and IoT applications. At present we think many of these applications are likely to have low data requirements and/or be a subset of the demand for satellite broadband (discussed above). We recognise, however, that it is hard to predict with accuracy the future development of this sector. In particular, it is possible that innovation and demand for new applications (for example provision of

software updates to autonomous cars) could potentially lead to new spectrum implications.[31]

Deliver our on-going activities in a high quality and efficient way

3.81 In addition to the priorities that we have identified for specific regulatory action, we aim to deliver our on-going activities in a high quality and efficient way. These activities cover earth station authorisation and recognition, management of satellite filings, provision of information on spectrum regulation and use, and international representation. Our work also includes simplifying commercial access to spectrum that is used by public sector users, so that stakeholders can use Ofcom as their main interface for access to this spectrum.

3.82 We will continue to look at ways to further improve our processes and information provision. We welcome feedback and suggestions from stakeholders that helps us to do this.

3.83 Our work on these activities will also take account of the broader trends identified by our strategy, including growth in NGSO satellite networks and nano-satellites.

Earth station licensing and recognition

3.84 We are responsible for the on-going licensing of spectrum access for satellite earth stations and provision of RSA for receive-only earth stations. We have an on-going programme of work to both update the licence products we offer and improve the efficiency of our processes for licensing earth stations and issuing RSAs.

3.85 For example, we are currently updating our earth station licence products to enable use with NGSO satellite networks. We have also introduced new software which improves the efficiency with which we administer applications and amendments to licences, and makes it easier for stakeholders to make online licence payments. We will continue to develop the software with a view to enabling e-licensing for certain licence products, making it possible for stakeholders to apply for and amend their licences online.

Managing satellite filings

3.86 We manage satellite 'filings' for companies or other organisations registered in the UK, the British Overseas Territories, the Channel Islands and the Isle of Man. Satellite filings are the process for obtaining internationally recognised orbital positions and spectrum frequency assignments for satellite networks. We introduced updated satellite filing procedures in March 2016.

3.87 Our satellite filing work will take account of important trends identified by our strategy, particularly:

- Growth in use of small and nano-satellites. We understand that a proportionate and efficient regulatory process can be particularly important for stakeholders wishing to launch small and nano-sats, because of their shorter development time and mission duration. We will continue to work with stakeholders to understand and where possible address their needs.

[31] Also see our 2015 report on Promoting investment and innovation in the Internet of Things https://www.ofcom.org.uk/__data/assets/pdf_file/0025/38275/iotstatement.pdf

- Growing interest in the deployment of large constellations of NGSO satellites. As discussed at 3.15 and 3.46, these introduce a number of opportunities and challenges for efficient spectrum use, which are particularly relevant where we are the administration responsible for filings for such systems.

3.88 Stakeholders should also be aware that the Digital Economy Bill 2016-2017[32] contains a clause that would enable Ofcom to recover the costs it incurs in managing satellite filings from stakeholders. If this receives royal assent, we plan to consult on an appropriate methodology for how we will recover these costs.

Provision of information on spectrum regulation and use

3.89 We will continue to work to improve the availability of information about spectrum regulation and use through a range of channels. This information may be relevant to any of our functions, but particularly our licensing function. As discussed above, we recognise this can be especially important for smaller and/or newer organisations (for example those developing nano-sats) who may be less familiar with the satellite regulatory environment than more established players.

3.90 One specific example of this is the interactive data on space spectrum that we published alongside our March 2016 consultation document.[33] We also released the data in open format, in line with our policy to make the data Ofcom collects and creates available to the public wherever possible.[34]

3.91 Taking account of stakeholder feedback, we will focus our efforts on maintaining two areas of the interactive data that we believe provide the most benefit to stakeholders, namely:

- Frequency allocations and/or licence products; and

- Details of licensed earth station use for known, permanently sited earth stations. We do not intend to update this data for transportable earth stations, which is difficult to extract and process into interactive format.

3.92 We currently publish information on spectrum allocations and licence products in our Interactive Spectrum Map[35] and will look to see how this can be further refined. We are also considering a new interactive data tool that may combine elements of the UK FAT, UK Plan for Frequency Authorisation (UK PFA) and Wireless Telegraphy Act Register (WTR). We will also continue to release information on most frequency assignments as Open Data. Currently this information is released quarterly but we may look to more frequent updates if there is a demand from stakeholders for this information. We do not intend to publish sensitive data such as Critical Infrastructure use and some military and government use.

3.93 We will keep the space spectrum interactive tool (published alongside our March 2016 consultation) as a snapshot. The data will not be updated but we have made some small improvements to aid understanding and usability of the data as a result of feedback from stakeholders. For example, we have made it clearer that that the

[32] https://services.parliament.uk/bills/2016-17/digitaleconomy.html

[33] https://www.ofcom.org.uk/consultations-and-statements/category-1/space-spectrum-strategy/interactive-data

[34] http://stakeholders.ofcom.org.uk/market-data-research/opendata/

[35] http://static.ofcom.org.uk/static/spectrum/map.html

interactive tool does not include sensitive data or specific information that we do not hold, such as the details of Direct-To-Home (DTH) satellite TV receivers, mobile satellite terminals and VSATs which do not require specific licensing or registration. We have also improved some of the labelling of elements in the interactive data.

3.94 The interactive tool also included ITU data on global satellite filings, their filing administration and status. We were able to provide this information because the ITU has recently made summary data on satellite networks available to the public.[36] We welcome this development and, rather than duplicate this information going forward, we refer stakeholders to the ITU data, which we understand will be updated on regular basis.

International representation

3.95 As noted in section 2, Ofcom represents the UK at international bodies relating to spectrum, and through this we support as appropriate the wider UK interest. This work is particularly important for the satellite and space science sectors and we have an on-going process to engage with stakeholders in preparation for relevant international meetings. The International Frequency Planning Group (IFPG) and its Working Groups are the main route for stakeholders to provide input into Ofcom's international spectrum work.

3.96 As for the other processes above, we aim to ensure this process works as smoothly and efficiently as possible.

[36] http://www.itu.int/ITU-R/go/space/network-information/en

Annex 1

Summary of consultation responses

A1.1 This annex provides a summary of comments received from stakeholders in response to our consultation, published on 1 March 2016, together with our responses to these comments and/or a reference to where our response is contained in the main sections of this document. A total of 24 responses were received to the consultation, of which one was confidential.

A1.2 Where stakeholders have made the same, or very similar, comments to multiple questions in their response we have included the comment only once under the question to which the comment has greatest relevance.

A1.3 Organisations that submitted non-confidential responses are listed below:

- Arqiva
- Avanti
- BBC
- Boeing UK
- BT
- Communications Consumer Panel and Advisory Committee on Older and Disabled People (CCP-ACOD)
- EchoStar
- EMEA Satellite Operators Association (ESOA)
- Global VSAT Forum (GVF)
- Inmarsat
- ManSat
- Met Office
- Mott MacDonald (Mr A Grey and Mr P F Lion Stoppato)
- Natural Environment Research Council and National Centre for Earth Observation (NERC-NCEO)
- O3B
- OneWeb
- SES
- techUK and UKspace (techUK-UKspace)
- Thuraya
- Transfinite
- UK Space Agency (UKSA)
- ViaSat

Comments on our principles

A1.4 In addition to answers to the questions we asked, we also received comments on the principles we set out for our work in the space sector.

Stakeholder comments	Ofcom response
Some stakeholders (CCP-ACOD, GVF) specifically supported the prioritisation of our work based on what will provide most benefit to citizens and consumers. Several industry stakeholders (TechUK-UKspace, Avanti, O3b, ESOA, ManSat) said that Ofcom should additionally take account of UK industry interests, especially in the international regulatory environment. They said this is particularly relevant to support their provision of services overseas, as these would not be covered by our focus on UK citizen & consumers. ESOA and ManSat responded that our UK focus was too restrictive, as companies based in the UK provide services outside the UK. O3B questioned how, given our focus on UK citizens and consumers, industry concerns are reflected.	We have further clarified our role in relation to our international representation work at paragraph 2.25.

Responses to questions

Question 1: How useful is the interactive data that we have provided on our website and why? How can the presentation and interactivity of the data be improved? How frequently would it be useful for us to update the information and why?

Stakeholder comments	Ofcom response
Stakeholders including Met Office, Mott MacDonald, NERC-NCEO, OneWeb, techUK-UKspace, Thuraya and UKSA said that the interactive data provided is useful. Arqiva responded that the interactive data could reduce the need for interaction with Ofcom on operational matters. Avanti and GVF particularly welcomed the interactive charts showing frequency allocations from the FAT and the details of available licence products. BT, Inmarsat and ViaSat responded that	Having taken into account the comments from stakeholders, we set out the data we will be collecting on an on-going basis in section 3 (see 3.91). We have also made some small changes to aid

the information would not be useful to them, although ViaSat noted that it may be useful to the public or other stakeholders who wish to acquire a better understanding of satellite industry spectrum use. ManSat said Ofcom should avoid duplicating information provided by the ITU.A number of stakeholders commented that keeping all the data up to date is difficult, and would be impractical and burdensome for Ofcom and stakeholders. O3B had concerns that the data may be inaccurate or misleading, as it does not account for use that does not require licensing or registration (e.g. DTH receivers, MSS and VSATs). Similar points were made by UKSA and the BBC. BT was concerned if the earth station location data set were to be used as a planning tool to enable sharing of satellite bands with terrestrial services. CCP-ACOD noted that Ofcom currently has no statistics on the number of satellite broadband subscribers. They strongly encourage Ofcom to look into providing this information.	understanding of the current interactive data (see 3.93). In addition, we have started to collect data from satellite service providers on UK subscriber numbers.

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?

Stakeholder comments	**Ofcom response**
In general, stakeholders agreed with the industry and technology trends identified in the consultation document (see paragraphs 6.3 to 6.10 in the consultation document). We also received comments on the following additional points: • Respondents said that there was increasing demand for C, Ku, and Q and V bands, in addition to the increasing use of Ka band that we identified in the consultation. Boeing, BT, EchoStar and OneWeb particularly highlighted a growing trend for Q/V bands for broadband	We believe that Ka band spectrum is at present the most important band for supporting the growth of high capacity satellite broadband services. We discuss calls for increased availability of part of the Ku band (14.25–14.5 GHz) in section 3, paragraphs 3.37 to 3.40. We also consider the possibility of making additional spectrum available in V band in the future, at paragraphs 3.50 to 3.53. Ofcom acknowledges that in Europe CGCs have only

gateway earth stations. • Avanti and GVF responded that convergence of satellite systems is a trend, and that BSS, FSS and MSS services are all converging in Ka and Ku bands. • Avanti noted that technologies to improve frequency re-use include multi-polar antenna discrimination using either linear or circular polarisation discrimination, to double the available capacity of a beam. • ViaSat believed it was premature to include CGC as a trend and considered that use of CGC could reduce spectrum efficiency.	been considered in the 2 GHz band, and therefore it is currently unclear whether this is part of a wider trend.

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?

Stakeholder comments	**Ofcom response**
Overall, stakeholders broadly agreed with our assessment of application specific trends for the satellite sector (see paragraphs 6.11 to 6.24 of the consultation document). <u>Broadcasting (DTH TV, contribution and distribution)</u> The BBC responded that the demand created by higher resolutions are likely to be met by technology, but that Ofcom should monitor this. They also responded that migration to higher throughput modulation and encoding can be difficult due to the need to simulcast and because of spectrum constraints on existing satellites in some parts of the world. Arqiva, CCP-ACOD and the BBC (in relation to their international services) responded that the end of SD/HD simulcast is difficult to foresee because of legacy	<u>Broadcasting</u> Our analysis in the consultation document showed that even with much higher growth of UHD than the main scenarios considered (for example growing to 100 UHD channels rather than 30), there would be sufficient capacity. Nonetheless we will be vigilant regarding the development of any innovations which might suggest even higher growth in demand. <u>Broadband connectivity</u> As set out in paragraphs 3.7 to 3.9, our view is that, for many parts of the UK, competition in provision of broadband connectivity can be best achieved through

consumer equipment, particularly in the global context. SES responded that UHD will grow to the levels of HD today and beyond in the long term (2025), and that Ofcom's estimate of 30 UHD channels by 2025 is too low. Demand for 8K video and virtual reality (requiring 360° high quality video) could also contribute to potential long term growth. <u>Broadband connectivity (fixed and mobile)</u> A number of stakeholders said there was increasing demand in general for applications like online video centric content (Boeing, EchoStar, ESOA, Mott McDonald) and Big Data applications (BT, techUK-UKspace). Several stakeholders, including ESOA, techUK-UKspace, and ViaSat, said that satellite's role in meeting this growing demand is not only for rural or hard to reach areas, and should be considered as a viable alternative or complement to terrestrial delivery, including hybrid satellite / 5G networks. ViaSat also responded that while connectivity on aircraft is important, so are other mobile applications like ships, buses and trains. UKSA responded that the Cisco estimate of 107 GB per capita by 2019 seems too low. <u>Positioning</u> NERC-NCEO said that the potential for combining navigation with EO, or communications with EO, might have spectrum implications that have not yet characterised. UKSA noted that satellite location and timing are increasingly becoming embedded into services. <u>Machine to machine (M2M)/Internet of things (IoT)</u> <u>Stakeholders said that this has been a high growth area over the last few years and</u>	roll-out of new ultrafast fixed broadband networks, including fibre direct to homes and businesses. We note that satellites might offer a complement to, or possibly hybrid with, terrestrial networks, including 5G mobile networks. We have considered the implications of comments on our modelling assumptions at paragraph 3.20. <u>Positioning</u> We note the trends highlighted by stakeholders. <u>M2M/IoT</u> We acknowledge the potential for considerable growth in M2M/IoT applications and will monitor this area carefully (see paragraph 3.80). <u>Other trends</u> We note the other trends highlighted by stakeholders.

could grow further. Thuraya stated that M2M/IoT will require more capacity, while Inmarsat stated that we need to monitor it. Avanti, ESOA and GVF all highlighted software updates for cars as a high growth area for which satellites can provide the most efficient delivery mechanism, particularly in the global context. <u>Other trends</u> We also received comments on the following additional trends: • Trends in hybrid satellite-terrestrial services, including Hybrid Broadcasting-Broadband already used in connected TVs (ESOA) • Increasing use of companion screens (tablets, smartphones) to consume secondary content (camera angles, advertising etc.) associated with a TV programme while that programme is being viewed on a TV (BT). • Satellite is the only reliable option for Public Protection and Disaster Relief (PPDR) (EchoStar).	

Question 4: Do you agree with the industry and technology trends we have identified for the space science sector? Are there other trends that could have implications for spectrum use?

Stakeholder comments	**Ofcom response**
Those that responded to this question generally agreed with the trends we identified (see 6.26 to 6.30 of the consultation document). We received comments on the following additional points: • NERC-NCEO and the UKSA responses highlighted the increasing use of bands above 100 GHz. • As sensors become more sensitive, they also become vulnerable to interference (UKSA). • Increased bandwidth requirements are not limited to earth observation, but are a general trend across all space science missions (UKSA). The number of commercial satellites is expected to grow significantly (UKSA). • The Met Office was of the view that advances in data transfer protocols should balance out the expected increase in number of missions (and associated increase in data volumes).	We note the additional comments provided by stakeholders. We are aware of the increased use of higher bands, and are following developments in the ITU.

Question 5: Do you agree with the application specific trends we have identified for the space science sector? Are there other trends that could have implications for spectrum use?

Stakeholder comments	**Ofcom response**
Those that responded generally agreed with the trends we identified (see 6.31 to 6.34 of the consultation document). We received comments on the following additional points: • The dependence of operational weather and climate services on satellite data is only likely to increase in the future (Met Office). • The trend towards higher accuracy means more sensitive instruments (NERC-NCEO) and also instruments in lower frequency bands, e.g. VHF / UHF / P-band, with increased penetration (NERC-NCEO, UKSA). • Active sensors are making more use of current allocations and gradual expansion into new spectrum identified at WRC-15 is expected (UKSA). • Sharing assumptions based on principles of spectrum use during satellite overpasses may become increasingly difficult to implement as EO systems move towards quasi-continuous coverage using constellations and overpasses become more frequent (UKSA). • UKSA is promoting use of satellite derived data to improve public sector services. • There is a trend towards greater direct and personal use of EO data (NERC-NCEO)	We note the additional comments provided by stakeholders and believe these further support the importance of prioritising work on EO in the future. We note that the potential challenge in sharing spectrum between large constellations of earth observations satellites has some similarities to the issue discussed in paragraphs 3.46 to 3.48 regarding NGSO satellite broadband constellations.

Question 6: Do you agree with the applications we have identified as having particular potential for growth in consumer and citizen benefits?

Stakeholder comments	**Ofcom response**
Stakeholders largely agreed with the areas that were identified in the consultation (paragraph 6.35 of the consultation). They also suggested other areas of benefit, including: • A number of stakeholders highlighted M2M/IoT as a growth area, with satellite important for ubiquitous coverage and availability for these services, for example connected cars (Avanti, EchoStar, ESOA, GVF, Inmarsat, ManSat, techUK-UKspace, Thuraya). • There are other services which provide high benefits but do not have same potential for growth, for example safety-related communications for ships, off-shore platforms and aircraft (ESOA). • Safety-related communication services for ships replying on mobile satellite have potential for growth in benefits. Supporting different operators to provide GMDSS could provide great benefits to consumers and citizens (for example smaller/lower cost equipment for ferries and yachts) (Thuraya). • PPDR will bring benefits to the consumer (EchoStar). • Innovation in UK spaceflight and launcher technology has significant potential to benefit the UK. There is potential growth in the benefits of space science, including hard benefits (scientific advances) and soft (inspiring scientists and engineers) (UKSA).	We note the additional benefits identified. We agree M2M/IoT could be an important growth area (also see response to Question 3 above). We note the potential for innovation in UK spaceflight and launcher technology and are ready to consider any spectrum related issues associated with this.

Question 7: Do you agree with the three priorities that we have proposed for our strategy? Are there other priorities that are as important, or more important, for citizens and consumers and why?

Stakeholder comments	**Ofcom response**
Stakeholders agreed with our priorities of enabling growth in satellite broadband in hard to reach locations, and enabling growth in the quality and quantity of earth observation data. In relation to satellite broadband, some stakeholders (Avanti, GVF, ViaSat and techUK-UKspace) suggested that satellite broadband should not be considered purely as a fall-back service for remote and rural connectivity, but a viable alternative in suburban areas, with a role in increasing competition. Regarding our priority of enabling continuation of the benefits that citizens and consumers currently enjoy whilst exploring opportunities for spectrum, stakeholders were concerned that we should ensure satellite systems are adequately protected, and noted that satellite can be particularly sensitive to interference because of its low signal strength and international nature. There were also concerns that we should not limit growth of satellite operators or the future development of satellite, including new and innovative satellite uses. Additional suggested priorities included: • Communications on the move, delivering services to vehicles (i.e. connected cars). The advent of electronic steerable flat plate antennas may be an enabler for satellite-based services to vehicles (Arqiva). • The role of satellite in contributing to the deployment of 5G networks (ESOA, ManSat). • CCP-ACOD encouraged further investigation of easing mobile data 'not spots' and recommends this issue feature prominently within the strategy. Solving the problems for citizens and consumers on the ground	We discuss the role of satellite broadband in paragraphs 3.7 to 3.9. Our priority relating to existing benefits and new uses is discussed in paragraphs 3.73 to 3.76. For the additional priorities suggested: • Communications on the move: We agree that flat panel antennas could enable innovations in satellite 'connected cars' and will keep the spectrum implications under review. • Role of satellite in 5G networks: We note that satellites might offer a complement to, or possibly hybrid with, terrestrial networks, including 5G mobile networks. • Mobile data 'not spots': Ofcom is continuing to work on a range of options to improve mobile coverage. We note that satellites might have a role in providing backhaul for mobile base stations in the most remote locations. In addition to the priorities identified by our strategy we will continue to deliver our on-going spectrum management activities include satellite filings and earth station licensing.

should take priority over those in the air. Some stakeholders said that having these priority areas should not result in resources being unavailable for other activities. This includes more day-to-day spectrum management activities (ESOA), or international meetings in the ITU and CEPT (Transfinite). Transfinite says it is important that Ofcom provide continuing support including monitoring and tracking activity at a wider range of meetings (e.g. working parties and study groups). UKSA responded that it would like to see the strategy enabling growth across the whole space sector, including growth in space science and exploration, navigation, space security, PPDR, IoT and non-broadband networks, spaceflight, and aviation.	

Question 8: Are there other areas where spectrum liberalisation could enable better satellite broadband services and what specific actions should we be considering?

Stakeholder comments	**Ofcom response**
Stakeholders generally supported of the approach we set out in the consultation (paragraphs 7.12-7.13) and provided a number of suggestions for additional actions we could take in specific bands: • Make 14.25-14.5 GHz available for FSS applications on an uncoordinated basis and on moving platforms, possibly by removing legacy fixed service links in the band (OneWeb, GVF). • Make 17.7–19.7 GHz more usable for additional licence exempt FSS applications. Avanti, GVF suggested this can be achieved by freezing new fixed service licences in parts of the band in rural/remote areas of the UK as a minimum, while also allowing the FSS to access it on a shared basis when large amounts of existing contiguous spectrum for coordinated Permanent Earth Stations (PES) are to be used for gateways. Inmarsat suggested that action could include protection of	The proposed actions in these bands are discussed in the main text: • for 14.25-14.5 GHz see paragraphs 3.37 to 3.40; • for 17.7-19.7 GHz see 3.30 to 3.33; • for 28 GHz (27.5-30 GHz) see 3.26 to 3.29; • For higher frequency bands (V band), specifically 37-43.5 GHz, 45.5-50.2 GHz and 50.4-51.4 GHz, see paragraphs 3.49 to 3.53. We are supportive of industry efforts to develop new

mobile receive earth stations in some spectrum in the range. • Revisit the arrangements in the 28 GHz band. Arqiva responded that 28 GHz has been licensed in a way which fragments the frequencies between UK licensees. This means that the only way to deliver the entire 28 GHz band satellite services in the UK is for a consolidation of frequencies, ideally through some form of transfer between operators. Misalignment of commercial incentives between spectrum licensees such that frequencies are used in a way which leads to a sub-optimal outcome. OneWeb made similar points in its response, and suggested that at 28 GHz Ofcom should have a policy of 'use it or lose it' and take away licences if spectrum is not being effectively utilised by licence holders, opening an already allocated FSS band to satellite. OneWeb also urges Ofcom to make this spectrum available on a coordinated basis for PESs, as in other bands (11 GHz, 14 GHz, and 18 GHz). ViaSat said there is potential for sharing between FSS terminals and Fixed Service (FS) links using a database of deployed FS systems. • EchoStar responded that Ka band is increasingly congested globally, and that planning for satellite access to additional spectrum, including in the 30/40 GHz bands and beyond, must be a high priority for Ofcom. We also received some additional non-band specific suggestions: • Support of industry efforts to advance discussions on new technical standards for electronically steered antennas. These standards could have implications for the adoption of new services such as connected cars (ESOA, GVF, Avanti); • Authorisation of Complementary Ground Components (CGCs) (Inmarsat, ManSat).	technologies such as electronically steered antennas and update the relevant technical standards. We have separately consulted on the authorisation of CGCs.

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?

Stakeholder comments	**Ofcom response**
There were mixed views on Ofcom's analysis of demand and supply of spectrum, and whether Ka and Ku bands will be sufficient to meet new FSS demands. Some respondents suggested changes to our demand assumptions. • SES did not think the contention ration we used is realistic. Rather than 20:1 or 50:1 they would expect a ratio of 200:1 for a 10 Mbps peak rate (and more than 400 for a 20 mbps peak rate). • UKSA responded that we should be challenging the sector to provide more than the 10 Mb/s implied in our analysis. • OneWeb responded that current UK broadband needs in rural and remote areas are larger than that able to be covered by current spectrum available to satellite. OneWeb said that our analysis in the consultation showed that, in 2025, no more than 1% of the needs could be addressable in the current satellite bands, where it is envisaged that more than 5% of UK premises will not have true broadband. The definition of "broadband" keeps changing as urban dwellings continue to get better and faster services with fibre getting closer to premises. • We received actual VSAT numbers and forecasts from GVF suggesting the number of sites will be 80,000 in 2020. Some respondents (OneWeb, GVF, Avanti, Inmarsat) argued that the spectrum in Ka band (17.7-20.2 GHz downlink and 27.5-30 GHz uplink) is not as usable as we had assumed in our modelling, as regulatory arrangements mean both bands cannot be used fully for FSS. This is due to the need to share with fixed links in the downlink and the fragmentation of the 27.5-30 GHz band by Ofcom's 28 GHz	Comments on the assumptions used in our demand scenario are discussed in paragraph 3.20. Access to Ka band (uplink and downlink) is discussed in paragraphs 3.26 to 3.33). We discuss the potential for facilitating satellite use of V band (specifically 37-43.5 GHz, 45.5-50.2 GHz and 50.4-51.4 GHz) in paragraphs 3.49 to 3.53, and 51.4-52.4 GHz at paragraph 3.54.

licensing arrangements. A number of stakeholders (EchoStar, ESOA, ManSat, OneWeb, SES) asked Ofcom to promote the Q and V bands for very high data rate services. Boeing strongly supported efforts to make 51.4-52.4 GHz available for FSS.	

Question 10: To what extent does the proliferation of filings for 'paper satellites' create costs or barriers that hinder the provision of satellite services to UK citizens and consumers?

Stakeholder comments	**Ofcom response**
Some stakeholders were supportive of the idea that paper satellites are a problem (ManSat, CCP-ACOD, Arqiva, BBC). Arqiva responded that the satellite filing process creates spectrum inefficiencies, as it incentivises the practice of countries reserving satellite spectrum capacity on the basis of 'option value' rather than genuine commercial need for spectrum to underpin actual services. The BBC said that the proliferation of 'paper satellites' has a negative impact on provision of services by satellite. Lack of certainty about filings, ownership and responsibility can make it difficult for users like the BBC to identify suitable satellites to use and also to resolve incidences of harmful interference However, a number of stakeholders responded that paper satellites can be a consequence of uncertainty in the ITU coordination process. Operators that genuinely intend to launch a satellite feel the need to make extra filings to manage risk (OneWeb, Mott MacDonald) or provide operators with flexibility to find the right orbital location to enable successful coordination with other operators (GVF, ViaSat, EchoStar). EchoStar therefore expressed concerns about Ofcom's proposed review of the efficient use of orbital resource and what actions it will take. ManSat said that the definition of 'paper filings' should not be associated with the need to carry out multiple filings in order to seek to access new markets. Some stakeholders (Avanti, GVF, OneWeb, TechUK-UKspace) responded that the real issue lies with 'virtual satellites', rather than 'paper satellites'. The former	As set out in section 3 (see 3.41 to 3.45), following further analysis and discussions with stakeholders we agree that the most important potential issue is that of 'virtual satellites' – frequency assignments registered in the ITU Master International Frequency Register (MIFR) but which are not used by a real satellite. We will, where suitable opportunities arise and in conjunction with other administrations, support reforms to the international satellite filing and coordination process that promote efficient use of spectrum. We continue to welcome feedback from stakeholders with regard to the practical application of our update Procedures for the Management of Satellite Filings.

consist of networks whose notified characteristics differ from those deployed in reality. Inmarsat responded that inefficiencies in the ITU processes, particularly those related to false notifications, reduce competition and increase costs for final users. There was a strong theme that improvements to the current rules must be agreed internationally (ESOA, Inmarsat, ManSat, Mott MacDonald, SES, techUK-UKspace). Inmarsat said that if Ofcom were to apply more stringent rules unilaterally, that would harm operators filing through the UK. A few respondents (ESOA, SES, GVF) expressed the view that some of the recent changes to Ofcom's Procedures for the Management of Satellite Filings may hinder the provision of satellite services to UK citizens and consumers by having a negative effect on investment in the UK satellite industry. However, Thuraya encouraged the modifications of Ofcom's procedures which require more details to be provided than the ITU.	

Question 11: Are there other actions we should be considering that could enable greater benefits from satellite broadband?

Stakeholder comments	**Ofcom response**
There was significant concern that IMT/5G services could take away key spectrum for satellite services. This included particular concern about the FCC's initiative on 5G mobile use of the 28 GHz band (Avanti, GVF, ESOA, ManSat, O3B). Stakeholders acknowledged that we are not supporting this band, but said it was important for us to engage internationally to support satellite use of the band. Other actions included: • The UKSA said that Ofcom could do more to make consumers aware of satellite broadband and encourage take up. EchoStar suggested changes to the voucher scheme, or replacing with a grant approach. • Thuraya said that we should explore the possibility of having a new allocation to MSS (especially for cases where small antenna size is	Ofcom supports the identification of the 24.25-27.5 GHz band as a pioneer band for 5G and we have made this view known internationally. We have recently provided advice to Government on options for a broadband USO. Satellite could potentially play a role in connecting the hardest to reach premises under certain scenarios, depending on the technical specification of the universal service. Decisions relating to the USO and the current satellite broadband voucher scheme are for Government. Our work on improving mobile services in the UK (on land) focuses on provision of services to terrestrial

required should be taken into consideration).	mobile terminals, i.e. those used by the vast major of consumers. Very few UK consumers have access to a satellite MSS terminal.

Question 12: Do you agree that existing bands are likely to provide sufficient capacity for considerable growth in earth observation data downlink 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 scenarios?

Stakeholder comments	**Ofcom response**
All those who responded to the question agreed that existing data downlink capacity in the X and Ka bands is sufficient to meet the growing demand for EO data downlink. UKSA noted the development of more powerful imaging instruments under development, for deployment from 2025, with bandwidth requirements of the order of 4 Gbit/s. NERC-NCEO said that Ofcom will need to monitor developments in high data rate EO sensors.	We remain of the view that existing allocations in X band and Ka band will be sufficient for considerable growth in EO data downlink requirements (also see paragraphs 3.61 to 3.63). We will monitor developments in high data rate EO sensors to understand what implications those could have for spectrum use.

Question 13: What other specific actions should we be considering to facilitate earth observation data downlink?

Stakeholder comments	**Ofcom response**
Stakeholders who responded to this question agreed with our proposed actions on national spectrum access and protection of EO data downlink facilities and highlighted the importance of these actions for enable growth in small satellite/EO applications. Concerns were also expressed about the potential identification of the 26 GHz band for 5G.	The future use of the 25.5-27 GHz band for EO applications and the identification of the 24.25-27.5 GHz ('26 GHz') band for 5G mobile services, is discussed in paragraphs 3.66 to 3.72.

Question 14: To what extent will access to suitable spectrum for TT&C enable greater use of small satellites and why? Do you agree with the specific actions we have identified and what else should we be considering?

Stakeholder comments	**Ofcom response**
Stakeholders who responded to this question supported our initiatives on spectrum needs for TT&C for small satellites (including work under WRC-19 agenda item 1.7). They also supported our engagement with public sector spectrum users to facilitate sharing of spectrum with earth observation users for TT&C links. Stakeholders also highlighted that our participation in the international fora (ITU-R Working Parties etc.) that are considering additional spectrum for TT&C applications is very important for achieving a successful WRC outcome.	Our work to support the growing numbers of small satellites by facilitating access to suitable spectrum for TT&C is discussed at 3.59 to 3.60.

Question 15: What other actions should we be considering to support long term predictability of access to sensing bands?

Stakeholder comments	Ofcom response
The UKSA and Met Office emphasised long term predictability of spectrum access for planning EO missions and data continuity. UKSA supported the aim of reducing the risk of adjacent band interference and noted that some adjacent band sharing options particularly where high power systems are adjacent to passive sensors, are likely to be difficult and should be avoided if possible. NERC-NCEO made a similar point and suggested being more prescriptive of the power used by spectrally adjacent sources. Transfinite said that uncertainty and regulatory risk could be reduced if Ofcom were to recognise the low feasibility of creating rules permitting the introduction of Licence Exempt mobile devices in the 5350-5470 MHz band used by remote sensing applications.	Long term predictability of access to bands used for sensing is one of the three aspects of our earth observation priority; see 3.58. One of the specific actions we are taking to ensure long term predictability is supporting international work on filtering to provide guidance and improvements in filtering for satellites making observations in passive bands. We plan to submit a proposal to ITU study group 7 in April 2017. In May 2016 we consulted on proposals for increasing the amount of radio spectrum available for Wi-Fi in the 5 GHz band to deliver high speed wireless broadband for consumers.[37] In this consultation we asked for views from stakeholders on whether we should pursue a longer term objective of opening up spectrum if possible at 5350-5470 MHz.

Question 16: Are there other actions we should be considering that could enable greater benefits from earth observation?

Stakeholder comments	Ofcom response
NERC-NCEO said that we have identified good priority actions and that significant effort might be needed in the near term to support growth in constellations of small	We consult stakeholders about prospective 5G bands through IFPG working group 1, which will be undertaking

[37] https://www.ofcom.org.uk/__data/assets/pdf_file/0037/79777/improving-spectrum-access-consumers-5ghz.pdf

(and very small) satellites in non-GSO orbits. Met Office said that before access to candidate bands for 5G is finalised, there should be independent scientific assessment of the possible scientific value of any such bands before access to them is denied permanently. UKSA suggested that Ofcom put greater international resources towards supporting satellite and science sector spectrum use (Study Groups 4 and 7), in contrast to international work supporting the broadband agenda.	relevant studies. Ofcom represents all UK interests in ITU and CEPT. The priorities for our international work in the satellite and space science sectors are informed by this strategy.

Question 17: Are there any improvements we should consider in how we enable existing benefits to continue, whilst exploring sharing / new uses?

Stakeholder comments	**Ofcom response**
Several stakeholders (Avanti, EchoStar, ESOA, GVF, ManSat) said that in addition to enabling existing benefits to continue we should allow for future growth of satellite applications. Some stakeholder re-emphasised points on the importance of predictability of spectrum access for long term investments (Avanti, O3b), the importance of not impacting certain incumbent users and the importance of Ofcom action at the international level to ensure technical conditions for sharing avoid interference to incumbents. (ESOA, Inmarsat, ManSat). Specific improvements that were suggested for how we enable sharing included a new committee (including UKSA and research councils) to actively explore sharing opportunities (UKSA) and possibly more Ofcom resources for enforcement e.g. removing non-compliant equipment from the market (UKSA). Stakeholders highlighted the general difficulty or impossibility of sharing in bands where there are high density and/or mobile deployments of satellite or terrestrial	See paragraphs 3.73 to 3.76 where we set out that we will need to consider options for spectrum sharing and how we will do this. We note the general concerns highlighted by stakeholders regarding sharing in bands with high density of deployments, as well as the specific band concerns raised.

terminals (BBC, BT, SES) and noted specific cases where: • They had concerns about new uses - future mobile services in 28 GHz (Avanti, GVF) and in 1427-1518 MHz (Inmarsat). • There was potential for future sharing - between (FSS) permanent earth stations and potential future 5G services in V band (Boeing) and shared access to auctioned blocks at 28 GHz by Permanent Earth Stations (OneWeb) (also see Question 8).	

Question 18: Do you agree that the applications we identify do not need to be a particular focus for regulatory action in the short to medium term?

Stakeholder comments	**Ofcom response**
Many responses (including Avanti, BT, EchoStar, ESOA, Inmarsat, Met Office, Mott MacDonald, SES), agreed that no particular regulatory action was required in the short to medium term for the applications we identified. SES said that existing bands needed to be kept available to accommodate anticipate growth in UHD and broadband. Some noted that we should keep specific applications under review, in particular • High resolution broadcast content - in case demand or technology assumptions change (BBC). • M2M and IoT (CCP-ACOD, Inmarsat). GVF noted the WRC-19 agenda item on M2M. • Safety related communications (Inmarsat, GVF). UKSA additionally noted the recent designation of space as Critical National Infrastructure (CNI) and that on-going assessment of space sector resilience may	As set out in section 3 (see 3.77) we will monitor other space applications where there are expected to be growing benefits to citizens and consumers. We note the designation of space as CNI. We agree that it is important for us to be agile in responding to developments which may require us to re-prioritise our resources. At present, we have not identified GMDSS modernisation, to introduce additional providers, as a priority.

result in recommendations for regulatory action to protect spectrum related to space sector CNI. A small number of responses identified a generic need to have resources available to tackle unpredicted issues (Transfinite) or (unspecified) new initiatives by UK operators (ManSat). Thuraya suggested action may be needed on Global Maritime Distress and Safety System (GMDSS) modernisation to introduce additional providers.	

Annex 2

Glossary

5G	Fifth generation mobile phone standards and technology
BSS	Broadcasting Satellite Service. One-way transmission of high-power broadcast signals by GSO satellites directly to consumers, who receive the signals on locally installed antenna equipment (e.g. satellite dishes).
CEPT	European Conference of Postal and Telecommunications Administrations
CGC	Complementary Ground Component. A terrestrial network which forms as integral part of a MSS system and uses the same frequencies, in the same direction as the satellite and which does not increase the spectrum demands of the MSS system.
CMU	Central Management Unit for spectrum in UK Government Investments Limited
CNI	Critical National Infrastructure
DCMS	Department for Culture Media & Sport
DTH	Direct to Home. Involves the reception of television signals directly from satellites.
Earth station	A station located either on the earth's surface or within the major portion of the Earth's atmosphere and intended for radio communication with one or more satellites or space stations
ECC	Electronic Communications Committee
EESS	Earth Exploration Satellite Service. A satellite radiocommunication service which obtains information relating to the characteristics of the Earth and its natural phenomena from active or passive sensors on the satellite, and distributes this information to earth stations.
EO	Earth Observation
ESIM	Earth Station In Motion. A satellite earth station mounted on a mobile platform such as an aircraft, ship, train or road vehicle, intended for communication with one or more satellites
ESOMP	Earth Stations on Mobile Platform (see ESIM)
FCC	Federal Communications Commission (US)

Frequency band	A defined range of frequencies that may be allocated for a particular radio service, or shared between radio services
FSS	Fixed Satellite Service. Two-way communication links between earth stations, usually at fixed locations, and one or more satellites.
Galileo	Europe's satellite navigation system (similar to GPS) under civilian control
GHz	Gigahertz. A unit of frequency of one billion cycles per second.
GMDSS	Global Maritime Distress and Safety System. A particular system operating under the MMSS providing communication services to people in distress.
GPS	Global Positioning System. A space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.
GSO	Geostationary Satellite Orbit. The orbit of a satellite whose circular and direct orbit lies in the plane of the Earth's equator and which remains fixed relative to the Earth's surface.
HD	High Definition
IFPG	The International Frequency Planning Group (IFPG) manages the UK preparations for ITU World Radiocommunication Conferences (WRCs).
IMT	International Mobile Telecommunications. The ITU term that encompasses 3G, 4G and 5G wireless broadband systems.
IoT	Internet of things. Refers to the interconnection [wirelessly] of uniquely identifiable embedded computing-like devices within the existing Internet infrastructure.
ITU	International Telecommunications Union - part of the United Nations with a membership of 193 countries and over 700 private-sector entities and academic institutions. ITU is headquartered in Geneva, Switzerland.
ITU-R	International Telecommunications Union Radiocommunication Sector
Ka band	Spectrum frequencies commonly in the ranges around 30 GHz (Earth-to-space) and 18 GHz (space-to-Earth)
Ku band	Spectrum frequencies commonly in the ranges around 14 GHz (Earth-to-space) and 11 GHz (space-to-Earth)

M2M	Machine to Machine refers to technologies that allow both wireless and wired systems to communicate with other devices of the same type. M2M is a broad term as it does not pinpoint specific wireless or wired networking.
MetSat service	Meteorological Satellite Service. A type of earth exploration-satellite service for meteorological purposes.
MHz	Megahertz. A unit of frequency of one million cycles per second.
MIFR	ITU Master International Frequency Register
MMSS	Maritime Mobile Satellite Service. A particular type of MSS for which user terminals are located on board ships.
MOD	Ministry of Defence
MSS	Mobile Satellite Service. Two-way communication links between portable user terminals and one or more satellites.
non-GSO / NGSO	Non-geostationary satellite orbit
Ofcom	Independent regulator and competition authority for the UK communications industries
Orbital arc	An imaginary line tracing all positions along a given orbit
Orbital separation	The angular separation between two satellites on a given orbit
Orbital slots	The orbital position of satellites, typically on the geostationary satellite orbit
PES	Permanent Earth Station
PSSRP	Public sector spectrum release programme
Radio Spectrum	The portion of the electromagnetic spectrum below 3000 GHz used for radiocommunications
RAS	Radio Astronomy Service. The ground based reception of naturally occurring emissions in order to research astrophysics and cosmology. This service is typically used in the study of celestial bodies such as pulsars, the formation of new stars, the properties of interstellar gases and plasmas, solar activity and microwave background radiation, the study of invisible mass and energy, and the expansion of the Universe.
RNSS	Radionavigation Satellite Service. One-way transmission of signals from constellations of satellites towards the Earth. The coded and time-stamped signals are used to determine the position and velocity of receive-only terminals on the Earth and to synchronise other devices to a single time reference. GPS and Galileo operate

	under this service.
ROES	Receive-Only Earth Station. A satellite earth station which receives radio signals but does not transmit.
RR	Radio Regulations
RSA	Recognised Spectrum Access. RSA is a means for Ofcom to take into account, within national spectrum planning, the use of frequencies used for the reception of services that do not need to be licensed.
RSC	Radio Spectrum Committee
RSPG	Radio Spectrum Policy Group
SD	Standard Definition
TT&C	Telemetry, Telecommand and Control. Used in both satellite and space science communications where links are used to monitor data from a satellite on its health and functioning (telemetry); track the location of the satellite (tracking); and send commands from the ground to the satellite to satisfy operational mission requirements or to respond to emergency conditions (command).
UHD	Ultra High Definition
UKFAT	UK Frequency Allocation Table. Details spectrum allocations in the UK and identifies responsibilities for the management of frequency bands or services
UKPFA	UK Plan for Frequency Authorisation. Provides information on which frequencies are available for assignment by Ofcom, for what purposes the different frequencies have been allocated and whether these can be traded.
USO	Universal service obligation
VSAT	Very Small Aperture Terminal. A satellite earth station equipped with an antenna of relatively small size.
WRC	World Radiocommunication Conference. The WRC reviews and revises the Radio Regulations. They are held every three to four years. The last three conferences were held in 2003, 2007 and 2012. The next WRC will be held in Geneva in November 2015 and is referred to as WRC-15.
WT Act	Wireless Telegraphy Act 2006

WTR	Wireless Telegraphy Register. Ofcom’s online register which provides information about individual licences.