

Authorisation of terrestrial mobile networks complementary to 2 GHz Mobile Satellite Service (MSS)

Statement on the technical conditions and fees for 2 GHz MSS Complementary Ground Component (CGC) for aeronautical use

STATEMENT

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About this document

This document sets out the technical conditions and fees that will apply to the authorisation of terrestrial base stations (CGC base stations) that, in combination with a satellite, will provide broadband services to aircraft, following our earlier consultation in 2016 and our recent decision to authorise this use.

It also includes, for information, the technical conditions that will be included in any Notice of Variation of the Aircraft Radio Equipment licence needed to permit the installation and use of CGC-facing terminals on the aircraft that communicate with these CGC base stations.

This work follows plans by Inmarsat to use spectrum in the 2 GHz band to provide broadband services to passengers on aircraft. The company plans to do this through a combination of satellite and ground-based communication links to aircraft.

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1. Executive summary

- 1.1 This document sets out the technical conditions and fees for the authorisation under the Wireless Telegraphy Act 2006 of terrestrial base stations that, in combination with a satellite, will provide broadband services to aircraft.
- 1.2 The 2 GHz band was allocated for mobile satellite services (MSS) use across the EU in 2008. In 2009 Inmarsat and Solaris (now EchoStar) were awarded MSS spectrum access rights across the EU under an EU-led pan-European harmonised selection and award process.
- 1.3 Ofcom developed a licence for terrestrial base stations (known as the Complementary Ground Components, or CGCs) to be used as part of the MSS system in 2009. This is known as the Spectrum Access 2 GHz Licence. This licence is a UK wide licence, and is available to both operators.¹
- 1.4 More recently, Inmarsat said it will use its radio spectrum assignment to deliver broadband services to aircraft, through a system comprised of both a satellite component and a terrestrial component. As such, Inmarsat requested that Ofcom consider the authorisation regime for the CGC base stations that form part of their proposed system. (The on-aircraft equipment forming part of this system will be authorised separately by varying existing wireless telegraphy licences for each aircraft held by UK registered airlines that request a variation.)
- 1.5 Following this request, in 2016 we proposed a second CGC wireless telegraphy licence, the Network 2 GHz Licence (“network” refers to the network of terrestrial base stations). This licence was based on the existing Spectrum Access 2 GHz Licence (which continues to be available), with some differences reflecting the needs of the aeronautical service (see below at para 2.1 for a summary of these differences).
- 1.6 We published our proposal for the additional Network 2 GHz Licence (the second licence) on 22 February 2016, and opened a consultation which ran until 18 April 2016 to get stakeholders’ views on the proposed licence conditions.
- 1.7 On 10 October 2017 Ofcom decided to authorise the terrestrial base stations forming part of Inmarsat’s aeronautical service. This document sets out our conclusions on technical conditions and fees consequent on that decision.²

¹ The fee for this licence is prescribed in the Wireless Telegraphy (Licence Charges) Regulations 2011 (as amended), Schedule 2.

² The reasons for that decision, including the applicable legal framework and a detailed explanation of our current understanding of how Inmarsat’s service will operate, are set out in our 10 October 2017 *Authorisation under the Wireless Telegraphy Act 2006 of Inmarsat Ventures Limited’s ground-based stations forming part of its system for provision of mobile satellite services for aeronautical use*: https://www.ofcom.org.uk/_data/assets/pdf_file/0014/107015/Inmarsat-mobile-satellite-services.pdf

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- 1.8 In summary, we intend to proceed, with only minor amendment, with the proposals we presented in our consultation document for the technical conditions and fees for the Network 2 GHz Licence for aeronautical use. In particular, we intend to:
- i) include technical conditions in the licence that take into account compatibility studies undertaken by the European Conference of Postal and Telecommunications Administrations (CEPT)³ to safeguard adjacent users, both in-band and adjacent, from harmful interference;
 - ii) amend the technical conditions of the licence to include the maximum permissible transmitted power of the CGC-facing terminals to align with the terms of existing block licences, where the network controls the user terminal power;⁴ and
 - iii) base the fee for the Network 2 GHz Licence on the UK-wide fee applicable to the Spectrum Access 2 GHz Licence (£554k per 2 x 1 MHz per annum). However, for this Network 2 GHz Licence the fee will be based on a charge per individual base station, dependent on the population density at the location of the base station, which will range from £825 to £54,000 per 2 x 1 MHz per base station per annum. This methodology is currently used to determine fees for certain business radio licences under the Wireless Telegraphy (Licence Charges) Regulations 2011 (as amended).⁵
- 1.9 We intend to amend the Wireless Telegraphy (Licence Charges) Regulations 2011 to prescribe the fee for the Network 2 GHz Licence. However, in advance of such amendment, we have the power to charge the fees set out in this document.⁶
- 1.10 Additionally, as mentioned above, the Spectrum Access 2 GHz Licence (the first licence) continues to be available to both 2 GHz MSS operators (to enable the CGC to be used, for example, for the provision of terrestrial mobile services as part of the 2 GHz MSS system). We have decided to slightly amend the technical conditions of the Spectrum Access 2 GHz Licence, in order to ensure consistency with the Network 2 GHz Licence and other similar licences. Specifically, we will include the maximum permissible transmitted power of the user terminals to align with the terms of existing licences, where the network controls the user terminal power (to mirror the decision referred to in para (1.8ii) in respect of the Network 2 GHz Licence).
- 1.11 We also include, for information, the technical conditions that will be included in a Notice of Variation for the Aircraft Radio Licence that UK registered airlines will need to apply for in order to install the CGC-facing terminal on their aircraft.

³ <http://www.ecodocdb.dk/doks/relation.aspx?docid=2561>

⁴ This provides us with the necessary enforcement powers against the network operator in the event the network increases the user terminal power beyond that permitted

⁵ See in particular Schedules 5 and 6.

⁶ Regulation 6 of the Wireless Telegraphy (Licence Charges) Regulations 2011 (as amended). This regulation is made under section 12(2)(b) of the Wireless Telegraphy Act 2006.

2. Introduction

2.1 In 2016 we consulted on, among others, the technical conditions and fees for the Network 2 GHz Licence for aeronautical use. This licence was based on the existing Spectrum Access 2 GHz Licence (which continues to be available). The proposed differences between the Spectrum Access 2 GHz Licence and the Network 2 GHz Licence reflected the needs of the aeronautical service. Specifically, the differences were as follows:⁷

- i) whereas the format of the Spectrum Access 2 GHz licence was UK wide, the format of the Network 2 GHz licence would be site-specific, authorising transmissions at specific locations to be included in a schedule attached to the licence;
- ii) the technical conditions of the licence were different, to reflect the additional technical constraints needed to protect adjacent users from interference associated with aeronautical use; and
- iii) the structure of the licence fee was different, to reflect the site-specific nature of the licence.

2.2 We received comments from 12 stakeholders, including satellite operators, satellite manufacturers, providers of inflight connectivity services, fixed and mobile network operators, and the public sector.⁸ A full list of consultation respondents is included in Annex A1 and the non-confidential responses can be viewed on Ofcom's website.⁹

Legal framework for 2 GHz MSS and CGC

2.3 Ofcom has powers under the Wireless Telegraphy Act 2006 to determine technical conditions and fees in respect of wireless telegraphy licences. The relevant powers are the following:

- a) Under section 9 of the Wireless Telegraphy Act 2006, Ofcom may grant a wireless telegraphy licence subject to such terms, provisions and limitations as Ofcom think fit. Under section 9ZA any limitations must be necessary for certain specified purposes, including avoiding undue interference with wireless telegraphy and safeguarding the efficient management and use of the part of the electromagnetic spectrum available for wireless telegraphy).
- b) Section 12 of the Wireless Telegraphy Act 2006 provides for the charging of fees in respect of wireless telegraphy licences. The Wireless Telegraphy (Licence Charges)

⁷ See para 7.2 of the 2016 consultation.

⁸ To the extent that these responses raised concerns in relation to the issue of whether Inmarsat's proposed service is consistent with the EU and UK legislative framework, this question is addressed in our 10 October 2017 *Authorisation under the Wireless Telegraphy Act 2006 of Inmarsat Ventures Limited's ground-based stations forming part of its system for provision of mobile satellite services for aeronautical use*: <https://www.ofcom.org.uk/consultations-and-statements/category-2/2ghz-mobile-satellite-systems>

⁹ <https://www.ofcom.org.uk/consultations-and-statements/category-2/2ghz-mobile-satellite-systems>

Regulations 2011 are made under this section.¹⁰ Under section 12(2)(b) of the act and regulation 6 of the regulations, Ofcom may charge such sums as Ofcom may determine in the particular case where a sum is not prescribed by regulations.

Impact assessment and equality impact assessment

- 2.4 The analysis presented in this document, and our consultation process, represents an impact assessment, as defined in section 7 of the Communications Act 2003 (“the Act”).
- 2.5 In carrying out our functions, we are also under a general duty under the Equality Act 2010 to have due regard to the need to: (i) eliminate unlawful discrimination, harassment and victimisation; (ii) advance equality of opportunity between different groups; and (iii) foster good relations between different groups, in relation to the following protected characteristics: age; disability; gender re-assignment; pregnancy and maternity; race; religion or belief; sex and sexual orientation.
- 2.6 Such equality impact assessments (“EIAs”) also assist us in making sure that we are meeting our principal duty under section 3 of the Act.
- 2.7 We have therefore considered what (if any) impact this statement may have on equality. We do not, however, consider the impact of this statement to be to the detriment of any group within society. We have therefore not carried out separate EIAs in relation to race or gender equality, or equality schemes under the Northern Ireland and Disability Equality Schemes.

¹⁰ And under sections 13(2) and 233(7).

3. Format and technical conditions of the Network 2 GHz Licence

Site-specific format of the authorisation

- 3.1 In our 2016 consultation document, we outlined our proposals for the licensing of Inmarsat's CGC base stations part of the EAN system, in the form of a new Network 2 GHz Licence.
- 3.2 We explained that we felt it was appropriate to base this new licence on the terms and conditions of the existing Spectrum Access 2 GHz Licence for CGC base stations.
- 3.3 We proposed adapting certain aspects of the format of the Spectrum Access 2 GHz Licence to reflect the requirements of the proposed aeronautical service. In particular, we proposed adapting the format of the licence, from a UK-wide Spectrum Access Licence to a site-specific Network Licence in which transmissions are authorised at specific sites, listed in a schedule. We also proposed the retention of all the non-technical conditions of the Spectrum Access 2 GHz Licence as we judged that these conditions were suitable for inclusion in the Network 2 GHz Licence.
- 3.4 As we explained in our consultation we proposed a network licence approach because we believe there is merit in being able to provide incentives for the aeronautical CGC operator to locate its base stations outside areas of high population, given that:
 - a) Inmarsat is looking to install a relatively small number of CGC base stations (in the few tens in the UK);
 - b) there is significant flexibility in where these small number of sites can be located to provide the service and therefore there are opportunities for Inmarsat to make location decisions informed by price; and
 - c) our current experience indicates that the demand for many/most high value uses of spectrum is largely driven by population density.
- 3.5 We have a specific strategic objective to facilitate greater sharing of spectrum and anticipate that this will, in many cases, arise from geographic sharing. A major hurdle to geographic sharing is the locations of pre-existing transmission sites, even when these are small in number. Therefore, we wish to incentivise location of transmission sites outside of areas of potential future high value to other services, where this does not impose a significant cost on these transmission sites, such as in this case. By doing so we hope to encourage innovation in sharing techniques and technologies by maximising the gains that such innovation could release.

Technical conditions of the authorisations

3.6 In our consultation, we proposed a set of technical conditions for the Licence. These were initially proposed to us by Inmarsat, and we undertook a technical review of these with reference to the findings of ECC Report 233, a report carried out by the CEPT into interference and compatibility issues associated with CGC for aeronautical use.¹¹ We concluded that the proposed conditions were in line with the report’s findings and proposed that they be included in the Licence for the reasons set out in the detailed technical review provided in the consultation.

3.7 These technical licence conditions were as follows:

- a) a maximum permissible power of 62dBm / 5 MHz EIRP and 55dBm / MHz EIRP;
- b) the block edge mask shown in Table 1 below:

Table 1: Proposed block edge mask

Offset from relevant block edge	Maximum mean EIRP for out-of-block emissions
-10 to -1.5 MHz (lower block edge)	+3.5 dBm/MHz
-1.5 to -1 MHz (lower block edge)	-9.5 dBm/30 KHz
-1 to -0.2 MHz (lower block edge)	Linear from -9.5 dBm/30 KHz to +2.5 dBm/30 KHz
-0.2 MHz to -0 MHz (lower block edge)	+2.5 dBm/30 KHz
0 MHz to +0.2 MHz (upper block edge)	+2.5 dBm/30 KHz
+0.2 to +1 MHz (upper block edge)	Linear from +2.5 dBm/30 KHz to -9.5 dBm/30 KHz
+1 to +1.5 MHz (upper block edge)	-9.5 dBm/30 KHz
+1.5 MHz to +10 MHz (upper block edge)	+3.5 dBm/MHz

3.8 We also proposed that the technical conditions would reference the relevant ETSI standard in the UK Interface Requirements (IR).

Stakeholder comments

3.9 In relation to the format of the authorisation, our primary proposal was to adapt the format of the licence from a UK-wide Spectrum Access Licence to a site-specific Network Licence. We received no responses directly relevant to this proposal. Some stakeholders

¹¹ In 2005 the European Commission issued a mandate to the CEPT to study the harmonised technical conditions for the use of the 2 GHz bands for MSS. In 2006 the CEPT issued its report, CEPT Report 13. This report was referred to in Decision 2007/98/EC on the harmonised use of radio spectrum in the 2 GHz frequency bands for the implementation of systems providing mobile satellite services. However, CEPT Report 13 did not consider potential use of aeronautical CGC systems. The purpose of ECC Report 233 was to consider these issues (see page 8).

made comments in relation to other issues regarding our general approach to licencing the MSS operators. Having considered these comments, they have not led us to change our general approach. In particular, we do not consider that it is necessary to conclude ongoing enforcement action before authorising the CGCs of the MSS operators;¹² and note that both operators have notified us that their MSS satellites have been launched.

- 3.10 We received 7 responses to the technical conditions we proposed, of which 5 expressed agreement (Inmarsat, Deutsche Telekom, T-Systems Limited, BT & EE and a confidential respondent).
- 3.11 EchoStar argued that Ofcom should not conclude on the technical issues associated with this consultation until satellite co-ordination is successfully completed between Inmarsat and EchoStar under the ITU Radiocommunication Sector (ITU-R) co-ordination process. However, we do not consider that it is necessary for operators to complete the ITU-R satellite coordination process before we authorise the use of equipment in the band.¹³ We also note that co-ordination may have progressed since EchoStar made its submission as the two operators have now launched their satellites.
- 3.12 Only EchoStar raised specific issues related to the technical licence conditions proposed in the consultation document. These were about:
- a) Consistency between the proposed technical conditions and the assumptions contained in ECC Report 233;
 - b) Maximum permissible power level; and
 - c) Potential for harmful interference into EchoStar’s 2 GHz system.
- 3.13 EchoStar also commented on the technical details for both the CGC-facing terminals and the satellite-facing terminals. Although the CGC-facing terminals were not the subject of the consultation we address their comments in this section below. As regards the satellite-facing terminals, we addressed EchoStar’s comments in our “Decision to make Wireless Telegraphy Exemption Regulations 2016”.¹⁴
- 3.14 Ministry of Defence (MoD) raised a concern about how the protection of three of their sites that could be impacted by this use of 2 GHz would be ensured.

Consistency between the proposed technical conditions and the assumptions contained in ECC Report 233

- 3.15 EchoStar argued that some of the parameters proposed by Ofcom do not conform to the technical parameters assumed in ECC Report 233. EchoStar stated its belief that to mitigate

¹² This was raised by Panasonic, Viasat and Omnispace.

¹³ Also see paragraph 3.10 of the “Decision to make wireless telegraphy exemption regulations 2010 – User terminals” for our response on user terminals https://www.ofcom.org.uk/__data/assets/pdf_file/0032/93659/Statement-Wireless-Telegraphy-Exemption-Regulations-2016.pdf

¹⁴ <https://www.ofcom.org.uk/consultations-and-statements/category-3/wt-exemption-2016>

the risk of harmful interference to its CGC network the conditions in the licence should align directly and comprehensively with the assumptions made in ECC Report 233.

- 3.16 EchoStar specifically raised concerns about the following technical conditions and argued:
- a) the block edge emission mask specified on the proposed licence does not align to Table 28 in EN 302 574-1 V2.1.0.¹⁵ EchoStar noted that the EIRP appeared to be 15 dB higher than EN 302 574-1. It noted that the additional 15 dB appeared to be equivalent to Inmarsat's CGC base station antenna gain. EchoStar proposed that Ofcom revise the block edge emission mask so that it aligns with the requirements of ETSI EN 302 574-1, Section 6 table 28; and
 - b) if the CGC base station antenna has an up tilt of less than 10 degrees or the antenna's vertical radiation pattern was relaxed, this would result in a significant increase in interference on the ground in the adjacent band. EchoStar, therefore, felt that both a restriction of a minimum up tilt angle of 10 degrees and the antenna vertical radiation pattern specified in ECC Report 233 should be imposed as licence conditions of the Network 2 GHz Licence.

Ofcom's response

- 3.17 On the specific points EchoStar raised we note that:
- a) The block edge emission mask aligns with the ETSI EN 302 574-1 Harmonised standard and ECC Report 233. It is 15 dB higher on the licence because the licence is in EIRP whereas the EN 302 574-1 is defined in terms of transmitter output without antenna gain; and
 - b) Our policy is to provide as much flexibility to licensees as possible and so include as few constraints as are necessary to prevent harmful interference to others. We do not include minimum antenna up tilt angles or radiation patterns for other terrestrial base stations. Having considered the risk of harmful interference in this case, and given the likely usage, we see no reason to include these additional constraints.
- 3.18 We consider, therefore, that the parameters included in the technical licence conditions we proposed do align, to the extent necessary, with ECC Report 233. While ECC Report 233 formed an important input to our consideration of the typical usage scenario, we do not deem it necessary to translate all the technical assumptions into licence conditions.

Maximum permissible power level

- 3.19 EchoStar raised a number of issues about the proposed maximum permissible power level for the Network 2 GHz Licence, both in their response to the consultation and in subsequent communications. In particular they commented that:

¹⁵ EN 302 574-1 V2.1.2 (2016-09) has been published and cited in the Official Journal of the European Union since the submission was made. Table 28 remains unchanged.
http://www.etsi.org/deliver/etsi_en/302500_302599/30257401/02.01.02_60/en_30257401v020102p.pdf

- a) the EIRP specified in the Network 2 GHz Licence was 62 dBm / 5 MHz whereas ECC Report 233 used 62 dBm / 10 MHz. If the proposed EIRP is converted to a 10 MHz bandwidth this would be equivalent to 65 dBm / 10 MHz. This is 3 dB higher than the assumptions in ECC Report 233. EchoStar considered that this will increase the unwanted emissions into the adjacent band. EchoStar recommended that the power limit be set to align with ECC Report 233; and
- b) the maximum permitted power levels are higher, by 1 dB, in the Network 2 GHz Licence than the Spectrum Access 2 GHz Licence (62 dBm/5 MHz EIRP vs 61 dBm/5 MHz EIRP respectively). On the one hand, EchoStar submitted the power level in the Network 2 GHz Licence would also lead to higher out-of-band emissions; on the other hand, they requested that we raise the maximum permitted power level in the Spectrum Access 2 GHz Licence to that in the Network 2 GHz Licence for consistency.

Response

- 3.20 The maximum EIRP specified on the proposed Network 2 GHz Licence is 3 dB higher than that studied in the report because this allows for both polarisations to be operated. However, our judgement is that this will not materially affect the interference environment for EchoStar. In particular, the maximum EIRP in the Network 2 GHz licence will not affect the unwanted emissions as these are limited by the block edge emission mask which is defined in absolute and not relative terms.
- 3.21 On the issue of the discrepancy of the maximum permissible power level between the Spectrum Access 2 GHz and Network 2 GHz Licences, we note that in 2010 we varied the Spectrum Access 2 GHz Licence to allow a maximum permissible power level of 65dBm/5 MHz.¹⁶ EchoStar's observation that the Network 2 GHz Licence allows a higher power level is, therefore, incorrect.
- 3.22 We considered whether we should reflect this increase in the Network 2 GHz Licence, but as the compatibility study assumed the lower power level and as Inmarsat has not requested the higher power level we have decided that it would be disproportionate to undertake the technical studies that would be needed for us to satisfy ourselves that this would not cause harmful interference. In future, if requested, we would be open to considering a variation of the Network 2 GHz Licence to allow this higher power limit.
- 3.23 We have decided to remove the 55 dBm / 1 MHz limit in the Network 2 GHz Licence as this is unnecessary given the likely minimum bandwidth would be 5 MHz. Not specifying a power limit in a 1 MHz bandwidth is consistent with the adjacent public mobile network 2100 MHz paired licences;
- 3.24 We have also decided to include the terminal EIRP limits in both the Spectrum Access and Network 2 GHz Licences, as we currently do for terrestrial mobile licences, to reflect the fact that CGC terminal power levels, in practice, are controlled by the operator of the

¹⁶ <https://www.ofcom.org.uk/consultations-and-statements/category-2/3glicences>

network and not the terminal user. This is included in the technical schedule of the example Network and Spectrum Access 2 GHz Licences provided on our website.¹⁷ We explain the power limits that will apply to these terminals in paragraphs 3.34 and 3.35.

Potential harmful interference into EchoStar's system

3.25 EchoStar expressed concern, based on its own analysis, that Inmarsat's proposed use could cause harmful interference to EchoStar's planned network. It identified two specific interference scenarios:

- a) from Inmarsat's CGC base stations into EchoStar's MSS user terminals, and
- b) From Inmarsat's CGC use into EchoStar's CGC use.

3.26 It suggested that significant mitigation techniques or restrictions to Inmarsat's system's technical parameters and planned operations may be required. EchoStar suggested that a guard band be imposed and that this should come from Inmarsat's spectrum allocation. It noted that the size of this guard band would still need to be determined.

Ofcom's response

3.27 In relation to the first scenario - Inmarsat's CGC base stations causing interference into EchoStar's MSS terminals - our view is that the most relevant potential interference scenarios are MSS receiver blocking by CGC base stations and interference due to out of band emissions. We note that co-existence issues have been studied in ECC Report 233, and previously in ECC Report 197 and ERC Report 065. All of these reports concluded that compatibility could be achieved based on certain assumptions and mitigations. However, we note that the impact of MSS receiver blocking has not been studied in detail.

3.28 Having considered the various interference scenarios, we consider that potential interference will primarily be a result of the vulnerability of the MSS receivers to transmissions outside of the intended receiver bandwidth. The receiver blocking performance of the terminals dominates over unwanted emissions in the interference scenario.¹⁸ However, given that there will be a relatively small number of Inmarsat CGC base stations we believe that the likelihood and level of interference is unlikely to be sufficient to be deemed harmful interference. If in future, we find evidence that indicates that harmful interference is occurring we will review this decision in light of the circumstances and consider whether we should take any action.

3.29 We further note that MSS receivers may be equally susceptible to 3G base stations transmitting in the 2110-2170 MHz band as they are to CGC based stations transmitting within the 2170-2200 MHz band¹⁹. There is wide-scale deployment of cellular mobile systems in the paired 1920-1980 MHz (uplink) and 2110-2170 MHz (downlink) bands,

¹⁷ https://www.ofcom.org.uk/data/assets/pdf_file/0025/107467/Example-2-GHz-Licences.pdf

¹⁸ In-band blocking is specified at -70 dBm for the frequency range of 2160 – 2210 MHz in section 7.7.2, ETSI TS 101 376-5 V3.5.1. Out of band blocking is specified at -40 dBm below 2160 MHz or above 2210 MHz in Section 4.2.7, ETSI EN 302 574-3 V2.1.1

¹⁹ bis

which is directly adjacent to the 1980-2010 MHz and 2170-2200 MHz MSS band. These types of networks are comparable to a CGC network, both using mobile cellular technologies based on 3GPP standards. EchoStar MSS terminals will need, therefore, to consider the impact of 3G base stations in the adjacent band. There are many thousands of these 3G base stations already deployed today (i.e. many more than the number of CGC base stations that Inmarsat is expecting to deploy).

- 3.30 With respect to the possibility of interference from Inmarsat’s CGC use into EchoStar’s potential future CGC use, we note that this is a reciprocal risk, with Inmarsat’s CGC system similarly open to the possibility of interference from EchoStar’s use. We note that, whilst there is this risk of interference between two adjacent networks using 3GPP technologies, in practice mobile operators using 3GPP technologies in the adjacent band can, and do, co-exist adjacent to each other without guard bands, additional licence conditions or in general the need for active co-ordination.²⁰ Given that the technical licence conditions for both 2 GHz Licences are based on LTE, a 3GPP mobile technology, we consider that there will be a comparable co-existence scenario and, therefore, no need to add any additional constraints to Inmarsat’s use of the spectrum.
- 3.31 We also note that the most efficient use of the spectrum is likely be achieved by co-operation between the two operators at an operational level which we consider would be mutually beneficial to both parties. We therefore expect both EchoStar and Inmarsat will have an incentive to work closely together so that potential interference risks are mitigated and both networks can operate without undue constraint.

MoD concerns on the protection of its sites

- 3.32 MoD raised a concern about the protection of three of their transmission sites that could be impacted by this use of 2 GHz. In particular, they wished to ensure that coordination with these sites was a requirement of the authorisation.

Ofcom response

- 3.33 We have given further consideration to what would be the most appropriate way to ensure ongoing protection of the MoD sites. We have decided that a better way of achieving this is to issue a formal Notice of Coordination to the 2 GHz operators (rather than referencing these sites in the Licence) when we issue the Licence. The text of this Notice is provided in Annex A3.

CGC-facing antenna

- 3.34 EchoStar provided supplemental comments²¹ in October 2016 on Inmarsat’s submission²² to our “Notice of proposal to make Wireless Telegraphy Exemption Regulations 2016”

²⁰ETSI TR 136 942 V14.0.0 (2017-04) defines coexistence between E-UTRA networks and other E-UTRA or UTRA networks

²¹ https://www.ofcom.org.uk/data/assets/pdf_file/0024/93570/EchoStar-supplemental-comments.pdf

²² https://www.ofcom.org.uk/data/assets/pdf_file/0020/90524/Inmarsat.pdf

consultation.²³ EchoStar expressed concern about proposals made in Inmarsat's submission which suggested maximum permissible power limits and technical conditions to be included in a Notice of Variation (NoV) to an Aircraft Radio Licence in respect of the CGC-facing terminal. Inmarsat suggested limits of 40 dBm/5 MHz for altitudes above 1000m and 24 dBm/5MHz for altitudes below 1000m. EchoStar considered that these technical limits were not consistent with ECC Report 233, particularly the EIRP limit for the CGC-facing terminal being expressed in a 5 MHz bandwidth rather than the 10 MHz used in the studies.

Response

3.35 In relation to EchoStar's concerns, we plan to prescribe the maximum EIRP limit as 24 dBm below 1000 m and 40 dBm EIRP for 1000 m or above with no prescribed bandwidth. The TRP / EIRP limits on cellular mobile user equipment are not defined by reference to a bandwidth on our other licences (see IR 2092.24 For example). The TRP / EIRP limits remain the same regardless of the bandwidth that the terminal is transmitting on. We do not believe that this changes the conclusions of ECC Report 233. In addition, the maximum EIRP of 24 dBm for altitudes under 1000m has been chosen instead of 23 dBm (which was an assumption in ECC Report 233) because this is consistent with the level we specify for the adjacent 2100 MHz licences and is consistent with IR 2092. This is also no higher than a mobile handset operating in the adjacent bands.

Conclusion on the format and technical conditions of the authorisation

3.36 We have decided to proceed with the format of the licence proposed as set out above and in our consultation document.

3.37 Having carefully considered all the comments received from stakeholders on the technical licence conditions for the Network 2 GHz Licence, we intend to proceed broadly in line with the technical licence conditions as set-out in our consultation document and summarised above with the exception of the:

- i) removal of the 55 dBm / 1 MHz limit in the maximum permissible power level (see paragraph 3.23 above); and
- ii) inclusion of terminal EIRP limits in the technical schedule of the Licence (see paragraph 3.24 above).

3.38 Given the conclusions of ECC Report 233 and the likely usage scenarios we consider that the risk of harmful interference to adjacent systems is low. However, should harmful interference occur in the future Ofcom has the power to vary the technical conditions and is also open to revisiting the technical rules and the licence conditions where appropriate.

²³ <https://www.ofcom.org.uk/consultations-and-statements/category-3/wt-exemption-2016>

²⁴ https://www.ofcom.org.uk/_data/assets/pdf_file/0026/84671/IR_2092.pdf

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4. Spectrum fees for the authorisation

Level, structure and location factor of the licence fee

Level of fee

- 4.1 As we have explained, we proposed that the Spectrum Access 2 GHz Licence (the first licence) will remain available in addition to the Network 2 GHz Licence (the second licence) so that Inmarsat and EchoStar will have a choice as to which form of licence to apply for. We proposed that there should be a measure of consistency between these licences on the level of fee charged (at the UK-wide level).
- 4.2 Our 2009 statement set out a fee for the Spectrum Access 2 GHz Licence of £554k per 2 x 1 MHz per annum UK-wide.²⁵ We noted that this rate for a UK-wide licence recognised the possibility that this spectrum could be used to provide a public terrestrial mobile CGC network as part of the 2 GHz MSS system. However, we also noted a number of uncertainties that argued that the opportunity cost of the 2 GHz spectrum might be lower than that of public terrestrial mobile. This included the uncertainty over how the ecosystem for equipment might develop and the uncertainty of the spectrum becoming available for public terrestrial mobile throughout Europe. As we discussed in our 2009 statement, the implementation of the EU Decisions in respect of the permitted uses of spectrum for CGCs could vary by administration and, therefore, public mobile use of the CGC spectrum might not be permitted by all administrations in Europe.
- 4.3 We recognised in our 2009 statement that there might be cause to look at the UK-wide level of fee as and when more information became available. However, in our 2016 consultation document we indicated that we believe that the kinds of uncertainties described in our 2009 statement still apply. In particular, we indicated that we did not believe they had changed in a way that would give us firm grounds to review the nationwide fee rate for the Spectrum Access 2 GHz Licence set out in 2009.
- 4.4 In light of the above, we proposed to keep the £554k per 2 x 1 MHz per annum rate for UK-wide spectrum access as the starting point for the fees in the Network 2 GHz Licence.

Structure of fee

- 4.5 As we explained above, we proposed to adapt the UK-wide fee (Spectrum Access) into a site-based fee (Network). This would take the form of a fee for each individual CGC base station installed, where this site-based fee includes a location factor based on population density. We proposed this because, as discussed above, we wish to incentivise the 2 GHz MSS operators to locate their CGC base stations outside of highly populated areas.

²⁵ Under Schedule 2 of the Wireless Telegraphy (Licence Charges) Regulations 2011 (as amended), the per annum fee applicable to a "Satellite (Complementary Ground Components of a Mobile Satellite System)" licence for each 2 x 1 MHz national channel in the bands 1980-2010 MHz and 2170-2200 MHz is £554k.

- 4.6 The proposed Network 2 GHz Licence took the form of a single Licence with a Schedule attached that would provide the location details of the individual locations where the licensee is authorised to install and transmit CGC base stations in UK. We stated our expectation that, when the operator applied for the licence initially, it would provide details of all the locations at which it planned to install CGC base stations.
- 4.7 The main difference between the Spectrum Access 2 GHz Licence and the Network 2 GHz Licence would, therefore, be that the former is UK-wide and the latter is site specific.

Implementation of location factor in the fee

- 4.8 As proposed in our consultation, the location factor used to determine the fee for the Network 2 GHz Licence will be based on the existing model which Ofcom uses to charge fees for business radio licences (the “business radio model”). Pursuant to this model, the fees for certain business radio wireless telegraphy licences are determined under the Wireless Telegraphy (Licence Charges) Regulations 2011 (as amended)²⁶ by reference to “high”, “medium” and “low population areas”. These population areas are identified by reference to grid squares of the Ordnance Survey National Grid system.²⁷
- 4.9 We proposed that, using a similar methodology to that used in the business radio model, the existing UK-wide fee of £554k per 2 x 1 MHz is pro-rated against a set of individual geographical areas (defined by grid squares) within the UK. We proposed to do this in a way that reflects the fact that spectrum access is, in general, more valuable in areas with greater population density given that this is what typically drives high value uses.
- 4.10 We adopted what we judge to be a pragmatic and proportionate way of doing this, by using the existing methodology developed and implemented for our business radio fees. This approach employs a set of 50 km x 50 km grid squares that are each characterised, for business radio use, as high, medium or low demand based on the population density in each square.
- 4.11 The business radio methodology results in 247 grid squares that we referred to in our consultation as:
- a) One of high demand (which provides coverage of London), Category A;
 - b) 47 of medium demand, Category B; and
 - c) 199 of low demand, Category C.
- 4.12 For consistency with the Business Radio terminology for these categories, we intend to rename them as:

²⁶ Regulation 4 states that licence charges are set out in Schedule 2. Schedule 2 sets out licence charges for business radio (area defined) licences by reference to Schedule 6, which sets out charges by reference to high, medium and low population areas. These are defined in regulation 2 by reference to Schedule 5. Schedule 5 sets out grid square references for high, medium and low population areas, by reference to the Ordnance Survey National Grid system.

²⁷ “Grid square” is defined in regulation 2 as “a National Grid square of the 2nd series of Landranger maps published by the Ordnance Survey”.

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- a) One of high population (which provides coverage of London), Category A;
- b) 47 of medium population, Category B; and
- c) 199 of low population, Category C.

4.13 The ratio of fee level between these three tiers of fee was based on relative population density in the three different categories of grid square. Applying these ratios to the £554k per 2x 1 MHz UK-wide fee for 2 GHz MSS CGC resulted in the following proposals for fees per base stations per location category:

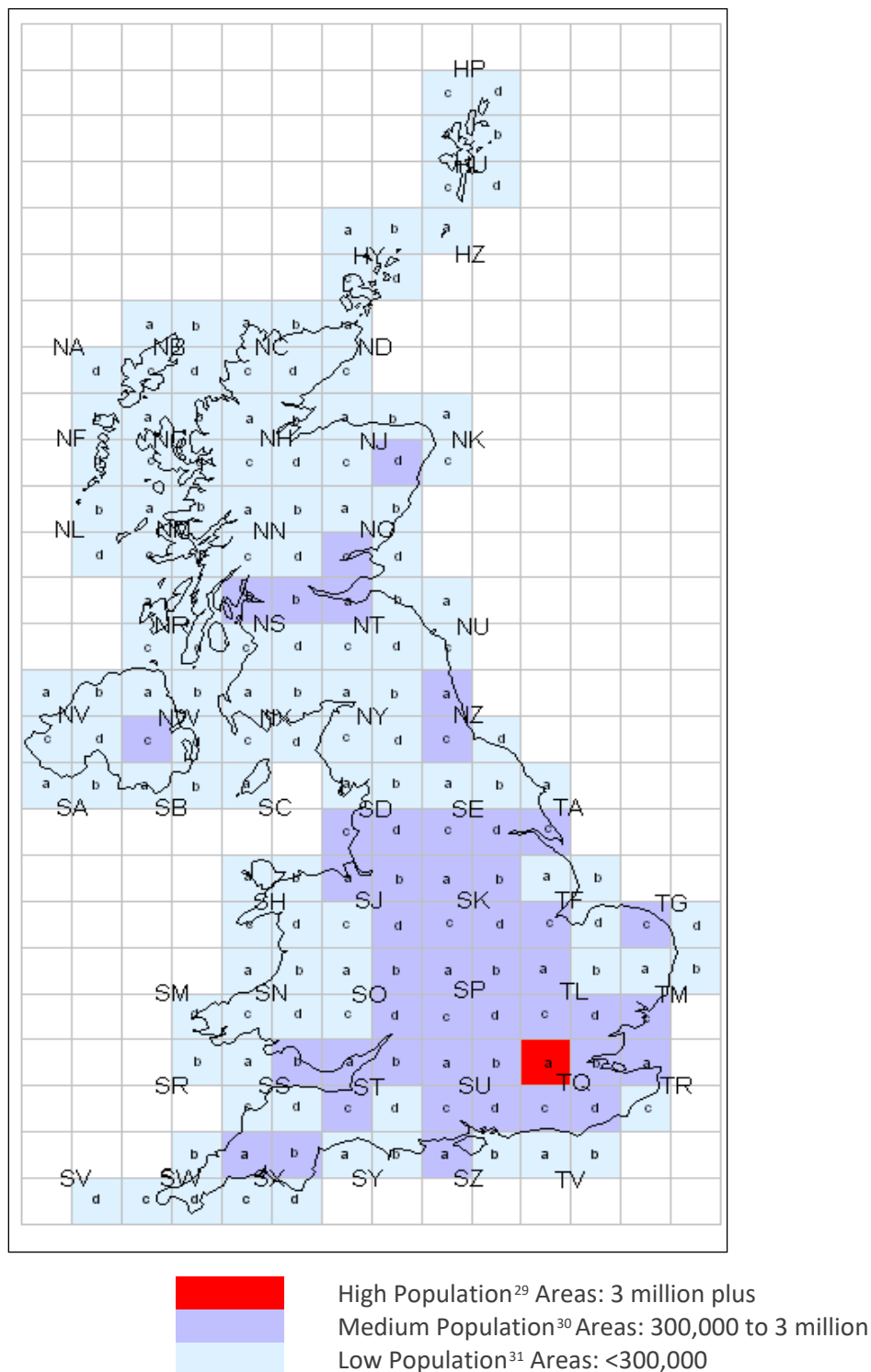
Table 2: Proposed fees per base station, based on location

Location category	Fee per base station per 2 x 1 MHz	Fee per base station per 2 x 15 MHz²⁸
A – High demand	£64,000	£960,000
B – Medium demand	£8,025	£120,375
C – Low demand	£825	£12,375

- 4.14 We noted in the consultation that if the CGC operator installed a CGC base station in each of the grid squares in the UK, the applicable fee would be the UK-wide fee as for the Spectrum Access 2 GHz Licence.
- 4.15 In our consultation, we also provided the map below identifying the specific geographic locations of these different location categories.

²⁸ Each operator has a maximum of 2 x 15 MHz that can be assigned to the CGC so this represents the maximum fee per site in each type of location.

Figure 1: Map of population density categories proposed to be used for the Network 2 GHz Licence fees



²⁹ Previously termed high demand

³⁰ Previously termed medium demand

³¹ Previously termed low demand

- 4.16 We considered that the use of the business radio model (rather than developing a new methodology) to implement the location factor was a pragmatic one proportionate to the need. We noted that we have consulted on this methodology before and therefore have comfort that it adequately reflects population density and, therefore, the relative demand from alternative services in these locations.
- 4.17 We also proposed in the consultation document that if a licensee installed more than one CGC base station in a single square then it would attract a fee for each CGC base station. This approach would discourage the operator from using this Network 2 GHz Licence to deploy multiple CGC base stations in urban areas, for example as part of a terrestrial mobile network as part of the 2 GHz MSS system. Indeed, we noted that if the operator were to install multiple CGC base stations in multiple squares, then the applicable fee could become greater than the UK-wide fee under the alternate Spectrum Access 2 GHz Licence for CGC use in this spectrum. However, we observed that the operator has a choice of which of the two CGC licences to apply for, based on its plans for using the spectrum. In the case where the operator wanted to install a large number of sites we suggested that it would be more appropriate for it to apply for the UK-wide Spectrum Access 2 GHz Licence.
- 4.18 We considered this approach to be a pragmatic means of implementing a location factor for a Network 2 GHz Licence. We believed that it would give incentives to the CGC operators to locate CGC base stations, where possible, outside of high population locations. It could, therefore, improve future sharing opportunities.
- 4.19 In our consultation, we asked stakeholders for comments on all aspects of the proposed fee.

Stakeholder comments

- 4.20 We received 9 responses to this question, of which 5 agreed with our proposal. Those in agreement were Inmarsat, Deutsche Telekom, T-Systems Limited and two confidential respondents.
- 4.21 EchoStar, Panasonic Avionics Corporation, ViaSat and a confidential respondent raised issues with the following aspects of our proposals:
- a) the level of the licence fee level;
 - b) the ability of operators to switch between the Network and Spectrum Access 2 GHz Licences; and
 - c) the technology and service neutrality of the Network 2 GHz Licence.

The level of the licence fee level

- 4.22 One confidential respondent argued that the proposed estimate of opportunity cost that the licence fee was set with reference to was too low a level, as it was based on outdated 2009 prices. i.e. the nationwide fee level set for the Spectrum Access 2 GHz Licence is now materially out of alignment with its likely opportunity cost. It suggested that the

opportunity cost on which the fee was based should now have risen to £1.63m per 2 x 1 MHz based on the Annual Licence Fee (ALF) for the 1800 MHz band as outlined in our September 2015 Decision on the fee to be charged for the mobile bands.³² ViaSat also argued that the fee should be based on the same level of opportunity cost as that paid for by terrestrial mobile operators.

4.23 EchoStar, on the other hand, argued that the fee that it would be required to pay, whether it applied for the Network 2 GHz Licence or the Spectrum Access 2 GHz Licence, would be excessive because:

- The award process and constraints imposed by the EU Decisions increased the costs to the 2 GHz MSS operators; and
- The level of AIP was set in 2009 at a time when spectrum auctions priced this resource at higher levels than it trades for today.

Ofcom's response

4.24 Under Schedule 2 of The Wireless Telegraphy (Licence Charges) Regulations 2011 (as amended) the sum payable for a "Satellite (Complementary Ground Components of a Mobile Satellite System" licence is £554k for each 2 x 1 MHz national channel in the bands 1980-2010 MHz and 2170-220 MHz, payable at 12 month intervals. This follows the conclusion reached in our 2009 statement in respect of the Spectrum Access 2 GHz Licence.

4.25 We noted in our 2009 statement that this rate for a UK-wide licence recognised the possibility that this spectrum could be used to provide a public terrestrial mobile CGC network as part of the 2 GHz MSS system. However, we also noted a number of uncertainties that argued that the opportunity cost of the 2 GHz spectrum might be lower than that of public terrestrial mobile. This included the uncertainty over how the ecosystem for equipment might develop and the uncertainty of the spectrum becoming available for public terrestrial mobile throughout Europe. As we discussed in our 2009 statement, the implementation of the EU Decisions in respect of the permitted uses of spectrum for CGCs could vary by administration and, therefore, public mobile use of the CGC spectrum might not be permitted by all administrations in Europe.

4.26 We recognised that there might be a case to look at the UK-wide level of fee as and when more information became available.

4.27 We reviewed this decision in our 2016 consultation document and stated that we believe that the kinds of uncertainties described in our 2009 statement still apply. In particular, they have not changed in a way that would give us firm grounds to review the fee rate for the Spectrum Access 2 GHz Licence set out in 2009.

³² https://www.ofcom.org.uk/data/assets/pdf_file/0022/83146/annual-licence-fees-900MHz-1800-further-consultation.pdf

- 4.28 In particular, we recognise that this band has now been included in the 3GPP standards (band 65). However, it is still uncertain whether, and when, equipment will be manufactured to include this band. If it is developed, it is also not clear how far its adoption would spread through the eco-system. As such, the band still cannot be considered to be equivalent to mainstream harmonised mobile bands (such as the 1800 MHz band).
- 4.29 Moreover, there are risks and constraints in this band that are materially different to the mainstream bands. There is still uncertainty surrounding authorisation of CGC in different EU member states. Additionally, we recognise that specific risks associated with the operation of MSS CGC, such as:
- the requirement to launch and operate an MSS satellite until 2027;
 - the obligations on the geographic coverage and data speeds of the satellite service;
 - the requirement to terminate the CGC after 18 months in the event of satellite failure;
 - the limited duration of the Licence³³ with no expectation of an extension.
- 4.30 The effect of these risks is to reduce the value of the licence compared to bands that do not have these restrictions.
- 4.31 Conversely, we have no evidence to indicate that the value of the use of this spectrum has fallen since our 2009 statement.
- 4.32 In line with our pricing principles, we would only look to review a fee level where the evidence suggests that a review would be justified, including evidence of a likely and sufficiently material misalignment between the current rates and the opportunity cost of the spectrum.
- 4.33 In this case, we continue to consider that there is insufficient evidence to review the fee level we concluded on in our 2009 statement. We, therefore, intend to proceed on the basis of the level of fee outlined in our consultation and our 2009 statement of £554k per 2 x 1 MHz per annum UK-wide.
- 4.34 On the issues raised by EchoStar, we acknowledge, as discussed above in paragraph 4.29 above, that there are risks and constraints in this band that are materially different to the mainstream mobile bands. For this reason, we will not be charging the significantly higher level of fee that applies to the licences for mainstream mobile bands. We also note that when looking to set the AIP fee applicable to the Spectrum Access 2 GHz Licence in 2009 we did not consider the prices paid for auctioned mobile licences, but rather considered the AIP fee rates applicable at the time for the relevant mobile licences.

³³ Term of licence is limited to 2027

The ability of operators to switch between the Network and Spectrum Access Licences

4.35 One confidential respondent argued that the 2 GHz MSS operators should not be able to switch from one licence to another; they should have to choose one type of licence and stick with it, arguing that MNOs were never offered this same flexibility.

Ofcom's response

4.36 Both licences will be available to the 2 GHz MSS operators from the outset, and we see no policy reason to prevent them from applying for either Licence at any time and subsequently surrendering the other if their needs change (although we think this is unlikely to happen in practice).

4.37 In designing licence conditions at the time that the existing mobile spectrum licences were awarded, it was not considered that a Network Licence, such as this, would be an attractive alternative to mobile operators. A site-based fee structure, such as that used in this Network Licence, would make fees for deployment of conventional mobile networks more complex and expensive (see paragraphs 4.17 above and 4.39 below).

The technology and service neutrality of the Network Licence

4.38 Panasonic raised a concern that Inmarsat appeared to be receiving preferential treatment regarding the fee structure, as the proposed Network 2 GHz Licence appears to only be available for aeronautical use. Panasonic asked Ofcom to clarify whether the Network 2 GHz Licence fee structure will be technology-neutral, and be available for terrestrial use of CGC base stations.

Ofcom's response

4.39 We can confirm that the licence (and its fee structure) is service neutral, and not restricted to aeronautical use. However, as discussed above, we would expect that, given the number of base stations required for a terrestrial mobile service (as part of a 2 GHz MSS system) the structure of the Network 2 GHz Licence fee would make such use under this Licence significantly more expensive than under the alternative Spectrum Access 2 GHz Licence.

Conclusion on the fee level and structure

4.40 We intend to proceed with the fee level and structure as set-out in our consultation document and above. We have, however, decided to change the terminology used to define the three categories of geography that relate to the fee to be consistent with that already in use in the business radio fees structure. This means that what we previously referred to as grid squares of high/medium and low demand, will now be referred to as grid squares of high/medium and low population.

5. Conclusions and next steps

- 5.1 Having taken into account the input that we received from respondents to our consultation, and additional information provided since the consultation closed, we have decided to proceed broadly in line with the approach set out in our consultation document, with only minor amendments as set out in sections 3 (with respect to technical conditions) and 4 (with respect to fees).
- 5.2 Both the Spectrum Access 2 GHz (the first licence) and the Network 2 GHz Licence (the second licence) will be available to both the 2 GHz operators. Any licence subsequently granted will be substantially in the form of the example licences provided on our website.³⁴ Apart from the changes explained in this statement, we have made non-substantive drafting changes to both licences. We note that both the example Spectrum Access Licence and the Network Licence available on our website cover the entire 2 GHz MSS band and so can be used by either operator. However, the 2 GHz MSS operators can only apply for the spectrum bands that they were given the rights to through the EU process.
- 5.3 Pursuant to regulation 6 of the Wireless Telegraphy (Licence Charges) Regulations 2011 (as amended), Ofcom currently already has the power to charge such sum as it may determine in the particular case. Accordingly, we will charge the fees set out in this statement for Network 2 GHz Licence. In due course we will make changes to the statutory instrument which sets out fees for wireless telegraphy licences, to make these fees explicit.³⁵ However, the absence of fees regulations in respect of the Network 2 GHz Licence does not prevent us from issuing the licence.
- 5.4 Our 2016 consultation only concerned the licensing arrangements for the CGC base stations of Inmarsat's planned service. We note that in November 2016 we also concluded a separate consultation on the licence exemption of 2 GHz MSS satellite terminals and made available information on the technical terms of a Notice of Variation (NoV) that we plan to issue to airlines to enable them to install and operate Inmarsat's satellite-facing terminal for the purpose of MSS services.³⁶ Similarly, in this document, we include (for information) in Annex A2 the technical conditions that will apply to the NoV that will be available for airlines to apply for in relation to the CGC-facing terminals located on the aircraft.

³⁴ https://www.ofcom.org.uk/_data/assets/pdf_file/0025/107467/Example-2-GHz-Licences.pdf

³⁵ The fees for the Spectrum Access 2 GHz Licence are already prescribed in the Wireless Telegraphy (Licence Charges) Regulations 2011 (as amended), Schedule 2.

³⁶ <https://www.ofcom.org.uk/consultations-and-statements/category-3/wt-exemption-2016>

A1. List of consultation respondents

- A1.1 The following stakeholders submitted responses to our consultation on the authorisation of Inmarsat's proposed CGC for aeronautical use:
- BT plc and EE Ltd
 - Deutsche Telekom AG
 - EchoStar Mobile Limited
 - Inmarsat
 - MoD
 - Omnispace UK Ltd
 - Panasonic Avionics Corporation
 - T-Systems Limited
 - ViaSat UK Ltd
- A1.2 We also received two fully confidential responses, and one further response from which the respondent's name has been removed.
- A1.3 Electronic copies of the non-confidential responses to this consultation can be found on Ofcom's website.

A2. Technical conditions for the Notice of Variation for CGC-facing terminals

A2.1 This Annex provides the technical conditions that will be included in the Notice of Variation that airlines can apply for to enable them to operate the CGC-facing terminal on the aircraft.

Technical limitations for CGC user terminals on-board aircraft in the 1980 to 2010 MHz band

Maximum Transmit Power / Power Density	40 dBm e.i.r.p for altitudes at 1000 meters or above 24 dBm e.i.r.p for altitudes below 1000 meters
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A3. Notice of required coordination for MOD sites related to 2 GHz licences

- A3.1 This Notice is notified to each 2 GHz licensee under their respective 2 GHz licences.
- A3.2 MOD has on-going use that could be impacted by the use of the 2 GHz band at three locations:
- a) Oakhanger (SU 776 357);
 - b) Colerne (ST 808 717);
 - c) Menwith Hill (SE 209 561).
- A3.3 This Notice requires 2 GHz licensees reach formal coordination agreement with MoD in respect of their use of the 2 GHz band. Parties to the coordination agreement must do so in good faith and with the intention of imposing the least constraint needed to meet the objectives of protection existing use. In the absence of an agreement, OFCOM may impose requirements on the 2 GHz licensees.
- A3.4 In this Notice: “2 GHz Band” means the following frequencies: 1980 – 2010 MHz and 2170 – 2200 MHz.

A4. Glossary

3GPP	The 3rd Generation Partnership Project – collaboration between groups of telecommunications associations, to make a globally applicable third-generation (3G) mobile phone system specification within the scope of the International Mobile Telecommunications-2000 project of the International Telecommunication Union (ITU).
Administration	Any governmental department or service responsible for discharging the obligations undertaken in the Constitution of the ITU, in the Convention of the ITU and in the Administrative Regulations.
AIP	Administered Incentive Pricing – a fee charged to users of the spectrum to encourage them to make economically efficient use of their spectrum.
Allocation	Use of a frequency band. Entry in the table of frequency allocations of a given frequency band for the purpose of its use by one or more terrestrial or space radio communications services or the radio astronomy service under specified conditions. This term is also applied to the frequency band concerned.
Assignment	Use of a radio frequency or radio frequency channel. Authorisation given by an administration for a radio station to use a radio frequency or radio frequency channel under specified conditions.
CEPT	European Conference of Postal and Telecommunications Administrations
COCOM	Communication Committee of the European Commission – its members are EU Member States and it assists the Commission in carrying out its executive powers at the top level. It provides a platform for an exchange of information on market developments and regulatory activities.
Concurrent	(Of spectrum trading) a transaction in which rights and obligations are transferred while continuing to be rights and obligations of the transferor.
Earth stations	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
EC	European Commission
ECC	Electronic Communications Committee

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EIRP	Equivalent Isotropically Radiated Power – the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna (absolute or isotropic gain).
ERC	European Radiocommunications Committee – a previous committee within CEPT, the responsibilities of which are now undertaken by the ECC.
Exemption	Exemption regulations made by Ofcom allow anyone to use specified radio equipment without the need to have a WT Act licence.
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
Geo-synchronous orbit	An orbit around the earth that is at a distance which results in it orbiting at the same speed and direction as the earth spins on its axis.
GHz	Gigahertz – a unit of frequency of one billion cycles per second.
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.
Harmonisation	The identification of common frequency bands throughout a region (e.g. Europe) for a particular application and, in some cases, technology.
Hz	Hertz – the basic unit of frequency, one hertz is equivalent to one cycle per second.
Interference	Unwanted disturbance caused in a radio receiver or other electrical circuit by electromagnetic radiation emitted from an external source.
ITU	International Telecommunication Union - the United Nations agency for information and communication technology responsible for developing and publishing the International Radio Regulations.
Ka band	Spectrum frequencies commonly in the ranges around 30 GHz (Earth-to-space) and 18 GHz (space-to-Earth).
L band	Spectrum frequencies commonly in the ranges around 1.5 GHz (space-to-Earth and Earth-to-space)
LTE	Long-Term Evolution – a standard for communication of high-speed data for mobile phones and data terminals. The term 4G is generally used to refer to mobile broadband services delivered using the next generation

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of mobile broadband technologies, including Long Term Evolution (LTE) and WiMAX

Market Mechanisms	Approach to managing spectrum where key decisions, e.g. on acquiring or disposing of spectrum and what service to provide are made by spectrum users rather than by the regulator.
MHz	Megahertz – a unit of frequency of one million cycles per second.
MNO	Mobile Network Operator – the UK’s four MNOs are EE, Vodafone, Three and O2.
Ofcom	Independent regulator and competition authority for the UK communications industries
Opportunity cost	The cost of a decision or choice in terms of the benefits which would have been received from the most valuable of the alternatives that was foregone
Outright	(Of spectrum trading) a transaction in which the transferred rights and obligations pass to the transferee and no longer appertain to the transferor.
Partial	(Of spectrum trading) a transaction in which some of the rights and obligations are transferred while others are not.
PMSE	Programme Making and Special Events – a class of radio application that supports a wide range of activities in entertainment, broadcasting, news gathering and community events.
Radio Regulations	International Radio Regulations made by the ITU, which have the status and force of a treaty, allocate frequencies globally to various applications and deal with cross-border interference.
Radio Spectrum	The portion of the electromagnetic spectrum below 3000 GHz used for radiocommunications.
RSC	Radio Spectrum Committee of the EC, made up of EU. administrations and which assists the EC in the adoption of technical implementing measures in support of Community policies.
Satellite	An object which is located in an orbit around a celestial body. In radiocommunications, a man-made electronic device which receives and transmits signals to and from earth stations on the earth’s surface.
S band	Spectrum frequencies commonly in the ranges around 2 GHz (space-to-Earth and Earth-to-space).

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Spectrum	The range of electromagnetic radio frequencies from LF frequencies to x-rays and gamma rays.
Spectrum liberalisation	Removal of restrictions from WT licences and RSA to allow holders greater flexibility to change how they use spectrum.
Spectrum trading	Ability of spectrum users to transfer rights and obligations under WT licences to another person in accordance with regulations made by Ofcom. Trades may be total, partial, outright or concurrent.
Total	(Of spectrum trading) a transaction in which all the rights and obligations are transferred to the transferee.
UKFAT	UK Frequency Allocation Table – details spectrum allocations in the UK and identifies responsibilities for the management of frequency bands or services
UKSSC	Cabinet Office committee that discusses matters relating to the use of the radio spectrum, including by government departments and other public sector bodies
WRC	World Radiocommunication Conference – reviews and revises the Radio Regulations. Held every three to four years. The last four conferences were held in 2003, 2007, 2012 and 2015. The latest WRC was held in Geneva in November 2015 and is referred to as WRC-15.
WT Act	The Wireless Telegraphy Act 2006, which sets out the statutory framework for management of the radio spectrum consolidating a number of older Acts dating back to 1949.
WT licence	Licence granted by Ofcom to authorise installation or use of radio equipment as required by section 8(1) of the WT Act.