Strategic review of satellite and space science use of spectrum
June – August 2015

Inmarsat Response

Inmarsat is pleased to respond to Ofcom's call for input: "Strategic review of satellite and space science use of spectrum".

Question 1: Do you have any comments on our approach to this review?

We are pleased to see that the international context is identified as an important element for satellite services. However the international dimension should not be limited to "...how international developments could influence demand, supply and the available options for mitigating imbalances between demand and supply", as stated by Ofcom in para 2.5.

Because of the international dimension of satellite services, a national regulator must sometimes refrain from making decisions which damage the access to spectrum for satellite services. For example, the international regulations (the ITU Radio Regulations) often allow for both terrestrial and satellite applications to be deployed in the same band. Even if a national regulator considers that greater economic value can be achieved by a terrestrial service in their country, it is necessary to also consider the high social value created by satellite services in the international context. If this is not done, satellite spectrum would gradually be removed piecemeal, eventually removing the possibility for satellite services to be deployed.

A further consideration regarding the international dimension is that sharing situations that might be feasible in the UK may not be feasible in other countries. This might be because the use of certain satellite applications is greater in other countries, or because regulators in other countries do not have similar resources to Ofcom or the national legal framework to manage potential interference issues in the same way. Sharing arrangements that may initially be promoted on a national basis only, may eventually spread and lead to interference to satellite services abroad.

The need to ensure adequate access to spectrum for satellite services is also important considering that the UK Space Innovation and Growth Strategy 2014-2030, supported by the Government, has set ambitious targets for the growth of the satellite industry in the UK[1]. Growth of the UK satellite industry will require access to more spectrum, both in the UK and abroad.

Although not specifically mentioned in section 2 of the call for input, we understand that Ofcom is generally seeking new opportunities for spectrum sharing. We take this opportunity therefore to stress that:

[1] Space Innovation and Growth Strategy 2014-2030, available at: https://connect.innovateuk.org/web/space/space-igs-2014-30. The headline target is an increase in the share of the expected £400 billion global space-enabled market to 10% by 2030.

a) Most frequency bands used by satellite services are used by a large number of different systems and operators. This is particularly the case where bands are used by geostationary satellite systems, which allow the same frequencies to be reused by satellites serving the same area, spaced by a few degrees in longitude. Hence, bands which might be exclusively available for satellite services are shared among different satellite networks.
b) Satellite earth stations are often very sensitive to interference, as it is necessary to receive weak signals transmitted from space. This constrains the possibilities for frequency sharing with other services.
c) Some satellite systems have very large numbers of fixed terminals (for example TV receive only earth stations) and some satellite systems have mobile terminals, which can be operated from virtually any location. For such systems, there is very limited prospect for satellite services to share with other services or applications.
d) Satellite beams covers very large areas, sometimes the size of a continent or more, and therefore interference issues involving satellite services are not only national in nature.

Question 2: Do you have any comments on our broad overview of the satellite sector set out in this section? In particular, do you have comments on the completeness of the list of applications, their definitions and their use of the relevant ITU radiocommunications service(s)?

Inmarsat generally agrees with the list of services and satellite applications identified by Ofcom.

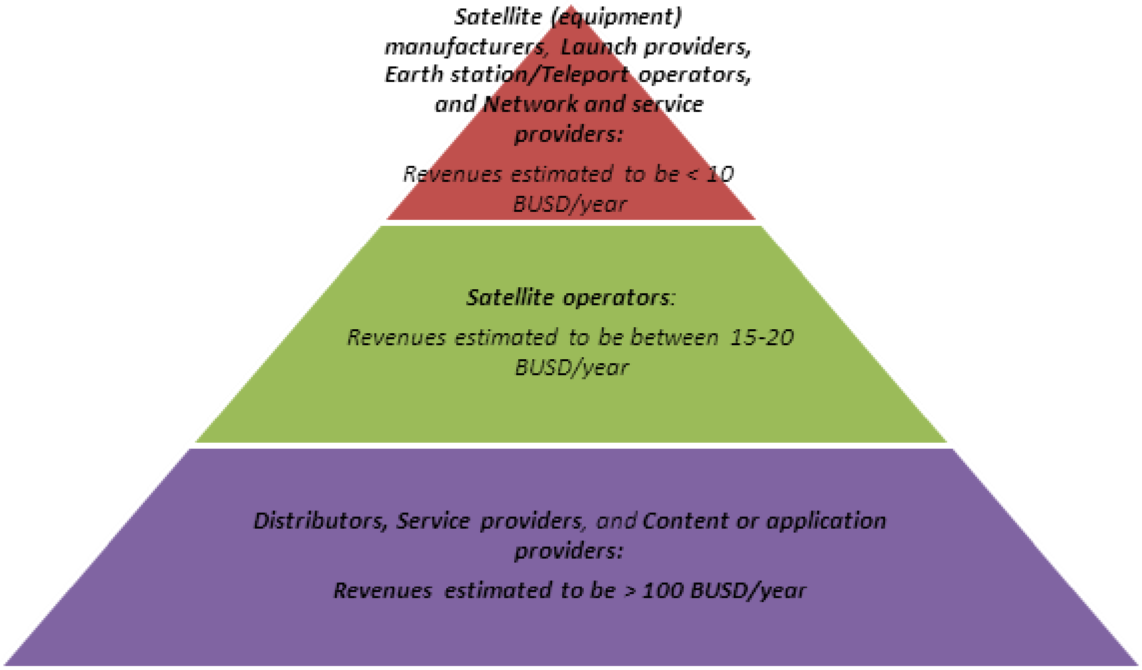
To ensure that no applications are overlooked, we also highlight the use of MSS systems which use a "complementary ground component" (CGC). Inmarsat is one of two satellite operators which are developing new MSS systems in the 2 GHz MSS bands in Europe that will use a complementary ground component. In the context of definition of services in the ITU Radio Regulations, the base stations of the complementary ground component and the user terminals when communicating with the base stations are part of the *mobile service*.

Unmanned Aerial Vehicles (UAVs) are mentioned in para 3.4 in the context of military and government users but it should be noted that there are also commercial users of UAVs.

Question 4: Do you have any comments on our representation of the value chain for the satellite sector? How do you think industry revenues are broken down between players at different positions in the chain?

The representation provided by Ofcom, is in line with Inmarsat's view of the satellite sector.

Evidently, depending on the amount of risk taken by the bearer (along the value chain), the return on investment is bound to be different. Given the breakdown of the satellite sector supply chain, the risk differs between the different nodes, as the market demand and supply play a different role. The revenues along the value chain therefore increase when going downstream (as presented in the figure below):



Most of the value is created at the service level; additionally the number of players is growing as we go down the value chain, which reflects the market willingness for more services. As an example, the limited launch service providers represent a risk for the satellite operators to gain access to space, and the limited number of manufacturers is limiting the reduction of satellite costs (which represents a downside for the satellite industry). On the other hand, there is an increasing trend of new service providers due to the low barriers to entry (which represents an upside for the satellite industry).

Question 5: What is the extent of your organisations' role(s) in the value chain? Which satellite applications (as summarised in Table 1 in section 3) does your organisation:

- use;
- provide: or
- help to deliver?

Please list all applications that apply and your role in each in your response.

Inmarsat is a satellite operator and service provider. We sell our services directly to users and via a network of other service providers and partners. Our role in providing the listed applications is indicated below.

Application	ITU radio communications service(s)	Inmarsat's role
End-user applications		
Direct-to-Home Broadcast TV	FSS, BSS	N/A
Broadband internet access	FSS	N/A
Machine-to-Machine (M2M)	MSS (including ISS)	Provide (key market player)

Commercial Mobility	MSS (including ISS), FSS8, MMSS, AMSS	Provide(market leader)
Corporate Networks	FSS (including ISS)	Partly Provide
Emergency distress alert	MMSS (limited to the operation of the GMDSS), AMS(R)S	Provide (market leader)
Navigation including location based	RNSS	Provide
Other applications		
Distribution	FSS, BSS	N/A
Contribution and OU TV	FSS, BSS	Partly Provide
Legacy telephony and carrier	FSS	Partly Provide
Telemetry, tracking and command	Space Operations, FSS	Provide (for Inmarsat satellites and for other operators)
Military and government	FSS, MSS, ISS, MMSS (including the operation of the GMDSS), AMSS, AMS(R)S, RNSS	Provide (key market player)

Question 6: For each of the satellite applications you use, provide or help deliver (as identified in Question 5), and taking into account your role in the value chain, where applicable please provide:

- the specific spectrum frequency ranges used for each application, distinguishing between the frequencies used for service provision, for the feeder / backhaul links and for TT&C ;
- the coverage area for services links; or, in the case of TT&C and feeder / backhaul links, the location of the gateway station(s);
- the estimated number of users (e.g. MSS terminals, DTH subscribers, FSS earth stations);
- an estimate of the average use by end user (for those applications for which the demand for spectrum is driven by end user traffic);
  and
- for applications for which the demand for spectrum is driven by other factors, please state what the factor is and the scale of the factor (e.g. for DTH TV the number of TV channels broadcast by format).

Please provide your response with respect to the UK, the rest of Europe, and other parts of the world where this may be relevant to UK use.

Frequency ranges

Inmarsat’s L-band networks operate in the following bands.

1518-1559 MHz (downlink) 1626.5-1660.5 MHz and 1668-1675 MHz (uplink)	Used by Inmarsat MESs (user terminals) in UK and globally
1573.42-1577.42 MHz and 1166.45-1186.45 MHz	Used to provide RNSS augmentation signals to GPS and Galileo receivers, in Europe and globally
3550-3700 MHz (downlink) and 6424-6575 MHz (uplink)	Used for feeder links for the MSS service links, and for the uplink for the RNSS augmentation signals. Specific earth stations around the world, none in UK.
6338-6342 MHz (uplink)	Satellite telecommand. Specific earth stations around the world, none in UK.
6420-6425 MHz (uplink)	Satellite telecommand. Specific earth stations around the world, none in UK.
3945.0-3955.0 MHz (downlink)	Telemetry. Specific earth stations around the world, none in UK.

Inmarsat S-band network "Europasat" (currently under development) will operate in the following bands.

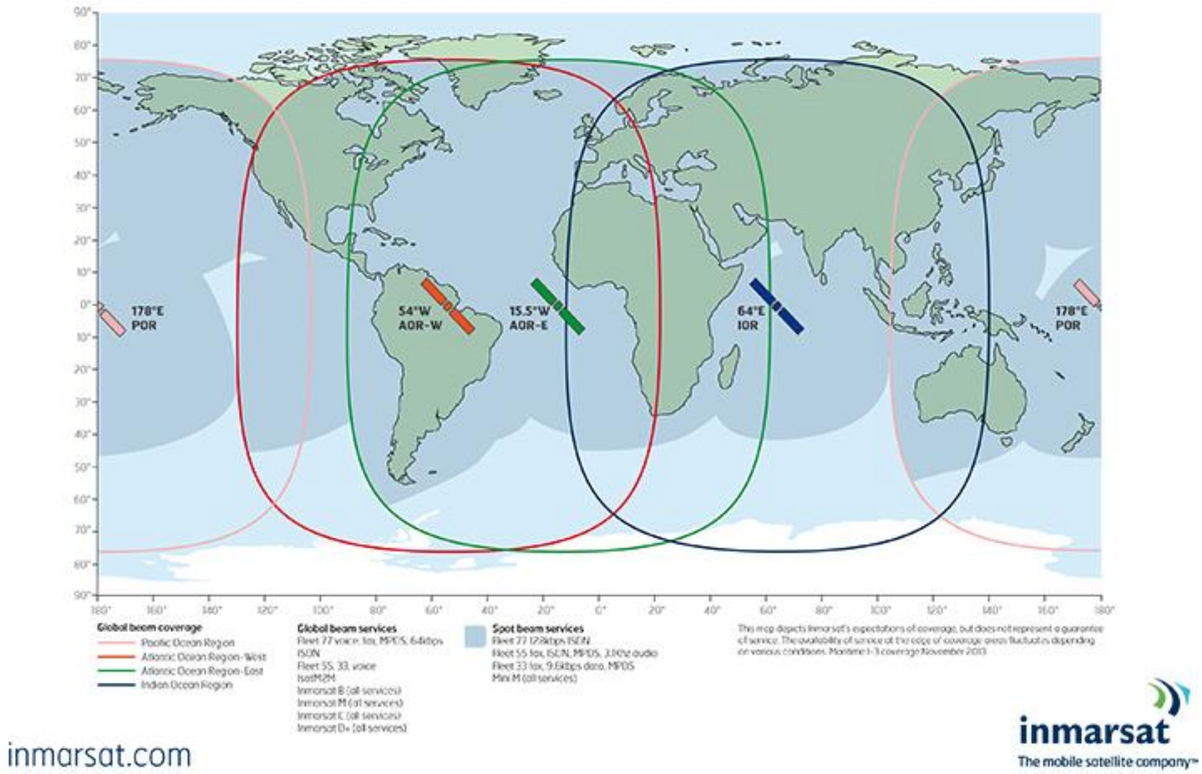
1980-1995 MHz (uplink) and 2170- 2185 MHz (downlink)	Used by MESs, and complementary ground component, in UK and elsewhere in Europe.
28.8-28.9 GHz (uplink) and 18.7-18.8 GHz (downlink)	Used for feeder links for the MSS service links,. Specific earth stations in Europe, none in UK.

Inmarsat Global Xpress network operates in the following bands.

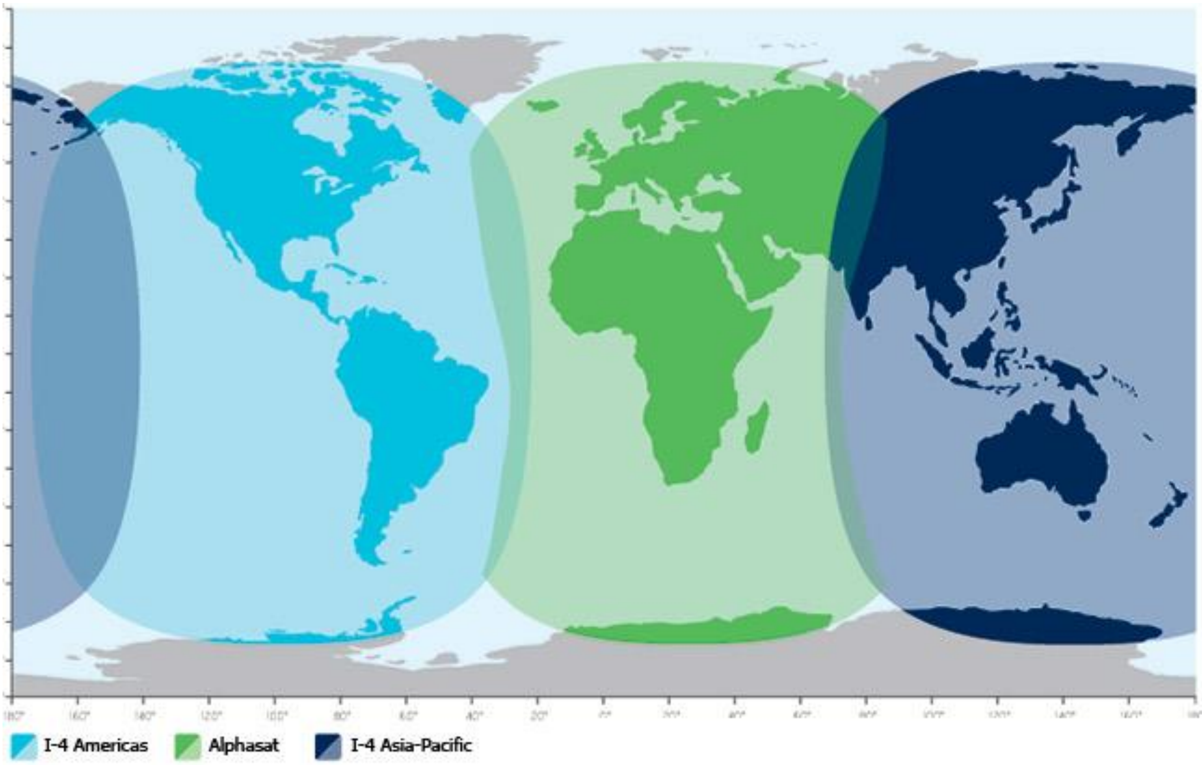
29-30 GHz (uplink) and 19.2-20.2 GHz (downlink)	Used by civil user terminals in UK and elsewhere in the world. In UK and some other countries, parts of the bands 29-29.5 GHz and 19.2-19.7 GHz are not available for UT operations.
30-31 GHz (uplink) and 20.2-21.2 GHz (downlink)	Used by government user terminals in UK and elsewhere in the world. Geographic location of terminals is flexible and subject the national agreements.
27.5-29.5 GHz (uplink) and 17.7-19.7 GHz (downlink)	Used for Global Xpress feeder links. Specific earth stations around the world, none in UK.
28.0045-28.0095 GHz and 29.5045-29.5095 GHz (uplink)	Signalling channels. Specific earth stations around the world, none in UK.
18.2045-18.2095 GHz and 19.7045-19.7095 GHz (downlink)	Signalling channels. Specific earth stations around the world, none in UK.
29.46755-29.49445 GHz (uplink)	Telecommand. Specific earth stations around the world, none in UK.
19.70041-19.70259 GHz (downlink)	Telemetry. Specific earth stations around the world, none in UK.
5926.05-5926.95 MHz and 6422.05-6422.95 MHz (uplink)	Telecommand. Specific earth stations around the world, none in UK.
4198.91-4199.09 MHz and 4199.41-4199.59 MHz (downlink)	Telemetry. Specific earth stations around the world, none in UK.

Coverage areas

The service coverage area of L-band services provided via Inmarsat-3 and Inmarsat-4/Alphasat satellites is shown below.



Inmarsat-3 satellite coverage



Alphasat and I-4 Coverage Map (March 2015)

Number of users and average use

Confidential Information on the number of users and average use is provided in Annex 2.

Question 7: For each of the satellite applications you provide, please could you indicate how UK consumers and citizens benefit from their use? Where possible please also provide an indication of the scale of the benefits (either qualitatively or quantitatively).

There is a very wide range of satellite applications that operate over the Inmarsat networks as indicated by the list of services in Annex 1. The actual applications for which the service is used is up to the end users and are sometimes not known to Inmarsat as Inmarsat's offering is either a data connection or a voice connection of different throughput and different performance objectives. However, we provide a broad indication of the applications below.

Land: Land terminals are used to provide communications to users virtually anywhere in the world. Our services are particularly valuable for users who sometimes require communications when outside the range of terrestrial networks (whether in the UK or abroad). Example users are TV journalists (transmitting live or pre-recorded news reports from remote areas), government users, and globally travelling businesspeople. An important application for Inmarsat terminals is the provision of emergency communications in disaster situations such as after an earthquake or hurricane. For example, Inmarsat services were used extensively in the aftermath of the recent earthquakes in Nepal. Land terminals are also used by users and business which use satellite communications as an emergency back-up, in case of failure or congestion in the terrestrial network. For such users, the number of minutes of use might be relatively low but is of very high value to the users – providing a reliable back-up in case of failure of emergency.

Inmarsat provides terminals specifically intended for M2M applications, which are used, for example, for vehicle tracking and for monitoring of pipelines and utilities.

Maritime: Inmarsat maritime terminals are the primary means to provide communications to ships, virtually anywhere in the world. The services range from low data rate store and forward communications (used, for example, for e-mail) to high bandwidth Internet based services. The services are also used for the operation of the ships and for "leisure communications" for the ship's crew and passengers. The ability for the ship's crew to keep in contact with family and friends while away from home are important for maintaining the happiness of the crew.

Inmarsat services are required for a large number of ships which fall under the IMO SOLAS regulations. Inmarsat is the major supplier of satellite communications which are part of the GMDSS.

Aeronautical: Around 80% of wide-body aircraft are equipped with Inmarsat terminals. They are used for air traffic control communications (AMS(R)S), for aircraft operations, and for communications for passengers (mobile phone and Internet connectivity).

For the maritime and aeronautical safety services, there is no alternative or very limited alternative to the satellite services provided by Inmarsat. The services have a very high social value, particularly when it comes of safety-of-life related communications, but the benefits are difficult to quantify in monetary terms. In the case of land, although our services are not part of a mandatory safety system, they are often used for safety related applications and applications of high social value such as news reporting.

Only a small proportion of UK citizens would be direct users of Inmarsat services, but UK citizens benefit indirectly from the use of Inmarsat services both within the UK and abroad. UK citizens benefit from the safety and security provided by Inmarsat to UK emergency services and by the safety and security provided to our national infrastructure. UK citizens also benefit from the use of Inmarsat services outside of the UK, which could be from safe travel on aircraft, by supporting maritime trade (which supports the UK economy), and by supporting news journalism from almost any location on earth.

Inmarsat is introducing a new satellite network: "Global Xpress" which operates in the Ka-band FSS bands. There are currently two satellites in orbit, a third is awaiting launch, and a forth is under construction. With the higher bandwidth available in Ka-band compared with L-band, Global Xpress provides much higher data rates, up to about 50 Mbit/s downlink to the terminal, and about 10 Mbit/s uplink from the terminal. As for the L-band system, there are terminals for land, maritime and aeronautical use. The maritime and aeronautical terminals will provide broadband Internet access for crew and passengers on ships and aircraft. Land terminals will provide mobile broadband service to virtually anywhere on earth. The main benefit to users will be from the provision of broadband Internet access from many locations not covered today.

Many governments, including the UK, have set objectives for the provision of broadband access to their citizens. Governments are investing in broadband Internet access in recognition of the benefits to citizens and to reduce the digital divide. The Inmarsat Global Xpress system will provide those benefits when UK citizens are travelling on trains, ships and aircraft, when in the UK and when travelling abroad.

Inmarsat has also committed a c.$450m investment towards introducing a new hybrid satellite (Europasat)/ CGC network in Europe (the “EU Aviation Network”), which will utilise S-band/2GHz spectrum - as awarded to Inmarsat in 2009 following a harmonised pan-EU selection process – to deliver the world’s fastest in-flight broadband connectivity service for UK passengers and other European citizens across the Member States. The hybrid, integrated nature of the service means that we will take full advantage of the benefits of ubiquitous coverage and robustness offered by satellites, complemented by the superior capacity inherent in the CGC network.

For passengers, the EU Aviation Network will mean in-flight access to the full range of internet services via their mobile devices – from checking email and reading safety instructions in their own language to live streaming TV. For airlines, the EU Aviation Network will deliver the competitive edge – delivering on passengers’ ever-increasing needs and expectations to be ‘always connected’. It will also increase crew efficiency by improving operational and administrative communications and the new service could also be mandated to track aircraft, deliver weather and other safety services.

Inmarsat concluded an MoU with British Airways last year for the early deployment of on-board connectivity systems, utilising the EU Aviation Network, on board of their narrow-body aircraft in Europe.

In terms of the investment benefits and wider economic impact of our planned in-flight connectivity service for the UK and Europe as a whole, we are pleased to share the following key figures, taken from an in-depth report produced by a leading UK-based firm of economists:

- The total economic impact of Inmarsat’s planned in-flight broadband service is estimated at £1,581m over 2014-2025.
- The roll out and maintenance work is expected to create over 500 high-skilled, high-tech jobs across Europe. We estimate the installation of approximately 12 towers in the UK, along the major flight paths.
- The consumer surplus that leisure passengers will enjoy from being connected in-flight (browsing social media, online shopping etc.) is estimated to total £722m over the 2014- 2025 period.
- The value that business passengers will enjoy while in the air (e.g. keeping up to date on important projects, email contact with colleagues etc.) is estimated to total £465m over 2014-25.
- The wider economic benefits such as technological advancement due to agglomeration in the space and telecom sectors; higher value employment opportunities and increased labour

force productivity; as well opportunities for improved environmental and airline safety standards are together expected to be valued in excess of £40m over 2014-25.

- Finally, the new service is expected to have a positive impact on taxation, with contributions from increases in income tax and national insurance, corporation tax and other taxes. This combined tax effect is expected to total around £379m over 2014-2025.

Question 8: From your perspective, what high level trends will affect the satellite sector in the coming years?

We expect that demand for our services will be strengthened by some or all of the following trends.

- Continuing need for natural/manmade disaster relief.
- Geopolitical changes (e.g. internet becoming a basic human need).
- The growing use of Social Media (the need for additional throughputs).
- Growth of emerging markets.
- Increased need for ubiquitous connectivity (including on the move).
- M2M/IoT (connected smart devices).
- Backup connectivity service requirements.

From the technology perspective, we see a significant increase in demand for satellite capacity for mobile communications. This will naturally increase the requirement for access to spectrum and more flexible satellites that will allow better re-use of the existing spectrum and satellite resources. Digitally processed payloads will increase in order to reach a level of flexibility that is closer to the current mobile narrowband satellite.

The request for higher throughput will also increase the requirements for spectrum for feeder links. We expect this to drive a development of Q/V band payloads.

In addition we see the following trends:

- Very low cost, very low data rate, possibly non-real time terminals for M2M services
- Need for better coverage of remote areas, particularly for safety related communications for ships and aircraft.
- Hybrid satellite / terrestrial networks

Question 9: For each of the satellite applications you use, provide or help deliver what do you see as the a) current demand trends; and b) underlying current and likely future drivers of demand for the satellite application(s) your organisation uses or provides?
Please include in your response for both a) and b) above:

- the scale and future impact of the trends/drivers on demand;
- any variations in the type and scale of trends/drivers by geography (i.e. in the UK, the rest of Europe, and other parts of the world where this may be relevant to UK use) and why;

- whether future demand is expected to be temporary or intermittent, and the reasons for this.

In your response, please provide any evidence which supports your position on the drivers of demand (e.g. forecasts, studies and statistics).

Demand trends and drivers for the satellite applications are summarised below.

Application	Key demand trends	The scale and future impact of the trends/drivers on demand	Variations in the type and scale of trends/drivers by geography	Future demand is expected to be temporary or intermittent
Machine-to-Machine (M2M)	• Automation. • Increasing use of unmanned machinery. • Surveillance and tracking needs.	• Significant (double digit) growth in the number of devices. • Revenue growth somewhat limited due to low ARPU	• Growth currently driven by established markets in US and Europe, trend slowly moving to emerging markets.	• Long term sustainable growth.
Commercial Mobility	• Need for ubiquitous connectivity (ships, airplanes, etc.) • Growing trend of BYOD. • Enhanced safety communications and regulatory requirements for ships and aircraft • Unmanned aircraft systems	• Mid-single digit growth.	• Growth driven on a global basis due to increase in trade and new technologies. • Global growth driven by new regulations (e.g. GMDSS and GADSS)	• Steady growth in the long term.
Corporate Networks	• Growth driven by emerging markets	• Mid-single digit growth.	• BRICS, Africa, LATAM and Asia-Pac.	• Somewhat limited by expansion of terrestrial networks (fibre, GSM, etc.)
Emergency distress alert	• Increasing regulation and awareness of satellite capability.	• Unpredictable due to the event driven nature of disasters.	• Globally	• Satellite connectivity will remain the most reliable and the only technology that is independent from the fragile ground infrastructure.
Navigation including location based	• Increase integration between navigation and communication application • Increasing use of high precision geo-localization data.	• Growing	• Global	• Long term sustainable demand.
Contribution and OU TV	• Increasing amount of news channel	• Unpredictable but structurally growing due to the event driven	• Growing regionally and internationally	• Sustainable growth

	coverage	nature of the industry.		
Legacy telephony and carrier	• Being replaced by VOIP	• Decreasing demand	• Global • Slower decline in emerging countries.	• Continuing decline

Question 10: Taking into account the drivers you have identified in your response to Question 9 above, what (if any) challenges is your organisation concerned about in meeting potential future demand? Please provide the information by application and band, along with any supporting evidence, if available.

The development of more capable and flexible satellites will only partly support the expected demand. The available spectrum is and will be the bottle neck. This is applicable to broadband and narrowband satellites.

The goal for Ka band satellites is to replicate the flexibility and the frequency re-use reached in the L-band. There are three axes to flexibility: coverage, power per beam and spectrum allocation. All these will require in the next years a significant technology push.

We anticipate increasing demand in L-band, which will be accommodated by technology improvements to provide some increase in spectrum efficiency. Future efficiency benefits in L-band are expected to be more modest than they have been in the past and they would not reduce the L-band spectrum demand. There is a challenge to accommodate requirements in L-band, not just due to increasing demand from Inmarsat customers, but also from the continuing need to accommodate other L-band MSS operators.

Increasing use of the L-band spectrum will lead to an ongoing need for feeder link spectrum in C-band and likely demand for increased C-band feeder link spectrum. This is a concern to Inmarsat, particularly considering the push by Ofcom and some other administrations to open the C-band spectrum for terrestrial mobile broadband systems. Our C-band earth stations have occasionally suffered interference from terrestrial wireless access systems and there are indications that some of our earth stations will not have licences renewed in the long term. If the terrestrial mobile systems envisaged for C-band (3.4-3.8 GHz) are successful and widely deployed, it will become even more difficult to protect our earth stations from interference and to find locations for new earth stations.

The datarates provided by terrestrial broadband systems (whether wired or wireless) are expected to increase in the near future. This will drive a demand for higher data rates to be provided by mobile satellite systems as some users will expect or require similar broadband capabilities that they have at home or in the office in remote and mobile locations. Regarding Inmarsat's use of Ka-band, we envisage that future satellites will be more capable, supporting larger bandwidths for the service links that will be necessary to support higher user bandwidths.

We are concerned about the possibility to access more spectrum in the Ka-band for service links, considering for example that major tranches of the 28 GHz band have been designated for terrestrial use in Europe. Considering that there appears to be very little actual use of some of these bands for terrestrial systems, it might be necessary in the long term to re-purpose that spectrum for satellite use. Given the global nature of Inmarsat's services, there is a need for any new service link spectrum to be harmonised internationally, which introduces an additional challenge.

This growth in user expectations will also require more spectrum for feeder links. If more spectrum in the Ka-band can be given over to service links, it will be necessary to use a different band for the feeder links. To meet demand, we also anticipate use of higher frequency FSS bands in Q/V band (the range 37-51 GHz) for feeder links.

We are therefore concerned about the possible use of part of the Ka-band FSS spectrum and the Q/V bands for new broadband IMT systems ("5G"). Parts of these bands are currently being discussed for a possible agenda item for WRC-15 to find more spectrum for 5G mobile. We are pleased to see that the 28 GHz band is not supported by Ofcom, but we are concerned about possible impact on Q/V band IMT systems on satellite systems. Having these bands considered for possible allocation to IMT would undermine the regulatory certainty for satellite services.

Question 11: Do you have any comments on the list of potential mitigations we have identified? What likely impact would each of the mitigations have on spectrum demand? E.g. what order of magnitude increase in frequency re-use might be achieved? To what extent do you believe that these mitigations apply only to certain applications?

To address future demand for satellite services, Ofcom has highlighted in their consultation document (para 4.14):

1. Smaller beams to re-use frequency bands
2. New transmitter & receiver technologies
3. Increasing sharing efficiency
4. Change satellite network parameters to e.g. reduce orbital separation
5. Better coordination between satellite networks to avoid paper satellite
6. Make additional spectrum available in higher frequencies or "repurposing spectrum from other, lower value uses"

As explained above the spectrum availability is always the bottleneck. Inmarsat is already nearing the limits of what is physically possible in terms of L Band spectrum reuse. Since aggregate re-use is limited by minimum beam size which is in turn limited by reflector size, it will be very difficult to improve reuse by an order of magnitude. Most of the technologies which have enabled the improve frequency reuse for terrestrial communications (e.g. MIMO do not apply to line of sight satellite communications.

Technology developments in the satellite side for broadband applications will help sustain the demand with the available spectrum being the limit. The introduction of Q/V band technology would allow Ka-band feeder link spectrum to be freed up and mitigate the scarcity of spectrum but will have implications in terms of ground complexity.

Ofcom suggests that “Increasing sharing efficiency” could mitigate demand for spectrum. In principle, the potential shared use of certain frequency bands as a means to improve overall efficiency makes sense. However the feasibility of sharing depends very much on the technical and operational characteristics of the satellite service and the potential other uses of the same band. The C-band FSS bands have been shared with fixed point-to-point links for many years, and shared use is made possible by the fact that both the earth stations and fixed links are at fixed locations and both use narrow-beam antennas which limit the risk of interference to be caused. Furthermore, the deployment of earth stations and fixed link stations is at a small number of sites, which in most cases ensures sufficient separation distance between the stations to avoid interference. However other scenarios would not allow for sharing of frequency bands. This is particularly the case where one or both of the services involved use mobile terminals because when terminals are mobile, no minimum separation distance can be ensured. Furthermore, most mobile systems (satellite and terrestrial) are intended to provide wide area coverage, so users may communicate from any location. This makes sharing of the spectrum not practical in many cases. Bands which are used for satellite services which are mobile, or bands where earth stations are ubiquitously deployed, create a very challenging sharing environment where shared use is not likely to be feasible.

New sharing techniques such as “white space devices”, have been suggested as a way to facilitate sharing. While these techniques could work in some cases, in others in other cases it would not work from either a theoretical or practical perspective. Hence all potential cases of shared use of frequency bands should be evaluated case-by-case to assess the risk of interference.

Ofcom suggests that reducing orbital separation could mitigate demand for spectrum. The size of the orbital separation between two GSO networks is driven in particular by the size of the earth station antenna. A larger antenna could, in theory, allow for smaller orbital separation between satellites using the same frequencies. However the current drive is in general to use smaller earth station antennas, to keep the cost of terminals low and to allow for mobile terminals to be implemented. We therefore do not anticipate that this mitigation can be practically implemented.

Ofcom suggests that better coordination between satellite networks to avoid paper satellites could mitigate demand for spectrum. Inmarsat generally supports moves to improve the satellite coordination and filing procedures, to avoid abuse which could lead to access to orbital slots being unnecessarily blocked. As Ofcom implies, such abuses reduce the efficiency of use of the geostationary orbit and therefore reduce the efficiency of use of the satellite frequency bands. The main route to achieving improvements in the satellite filing procedures is through possible changes to the RR at World Radiocommunication Conferences such as WRC-15. Inmarsat has responded to Ofcom’s recent consultation on the UK filing procedures and has been working with Ofcom regarding proposals for changes to the Radio Regulations under WRC-15 agenda item 7. We support continuing to make improvements in this regard.

Ofcom suggests making additional spectrum available in higher frequencies or “repurposing spectrum from other, lower value uses”. There is a clear trend towards increasing use of higher frequency bands for satellite services. An example of this trend is the new Inmarsat Global Xpress system, providing satellite mobile communications in the Ka-band frequencies. The Ka-band FSS frequencies have seen very rapid uptake in the past few years, with many existing and new satellite operators bringing new Ka-band systems into operation. The two main drivers for the uptake of Ka-band are: 1) the wide bandwidths available to support broadband services; and 2) congestion in the lower frequency FSS bands, in particular in C-band and Ku-band. This trend is likely to continue in the near future with more use of the Q/V band FSS frequencies (between about 37 and 51 GHz). Inmarsat is expecting to include Q/V-band payloads of the order of 2x3 GHz on satellites currently under development. Likely bands of interest are 37.5-40.5 GHz and 47.2-50.2 GHz.

The rapid uptake of the Ka-band frequencies does not mean that lower frequency bands are no longer required for satellite applications. Different frequency bands have different technical characteristics, meaning that for any application, some bands are better suited than others. High availability requires the use of lower frequency bands due to more severe propagation impairments in the higher bands. Broadband data rates require the use of higher frequency bands due to the large spectrum bandwidths available. While there will be some migration of applications from lower to higher frequency bands, any extra capacity in the lower frequency bands is expected to be taken up with the growth of applications most suited to the lower frequency bands (e.g. low bandwidth safety applications).

Regarding the possible moving or removing of “lower value uses” of the spectrum, as discussed elsewhere, satellite applications generally have a high value considering their unique ability to provide ubiquitous coverage, often providing critical communications where there is no practical alternative. We do not see any scope for identifying low value uses of satellite systems and moving those uses to alternative frequency bands.

Question 12: What other mitigation opportunities do you foresee that we should consider? For what applications are these likely to be applicable and what scale of improvement are they likely to deliver?

Inmarsat expects increased data rates to come from improved S/N of the link. However, since the data rate is proportional to the logarithm of the S/N, this is nowhere near as effective as increasing the bandwidth of available spectrum. At L Band, Inmarsat is already using 64 QAM modulation yielding spectral efficiencies of around 5 bits/Hz.

Question 13: Beyond the activities already initiated and planned for the satellite sector (e.g. as part of WRC-15), do you think there is a need for additional regulatory action that may, for example, help your organisation to address the challenges it faces?
In your response, please indicate what type of action you consider may be needed and why, including any evidence to support your view.

Regarding the use of the Ka-band FSS frequencies for mobile satellite terminals, a number of regulatory changes have been introduced over the last few years, particularly within the CEPT and within the ITU. We anticipate that additional action would be required to allow for further parts of the Ka-band FSS bands to be used for satellite mobile systems. This includes a possible agenda item for WRC-19 on earth stations on mobile platforms in the bands 17.7-19.7 GHz and 27.5-29.5 GHz.

Furthermore, the proposed introduction of terrestrial mobile systems in the L-band frequencies (in particular, below 1518 MHz) would create a high risk of interference to Inmarsat user terminals. This will require the development and applications of technical limits on terrestrial mobile systems to ensure that MSS users do not receive harmful interference.

Regarding the use of the associated complementary ground component of Inmarsat's planned 2GHz MSS system, we look forward to finalising reasonable and proportionate licencing conditions in the UK, as in other EU Member States, including in respect to fees.

Annex 1
(Non-Confidential)

DESCRIPTION ON THE NATURE OF SERVICES PROVIDED BY INMARSAT IN L BAND

The full range of Inmarsat services are to be considered, as follows.

Inmarsat BGAN

BGAN is accessible via a range of small, lightweight satellite terminals, which provide performance options to suit different operational needs. The smallest terminals are designed to suit single users. The larger terminals offer a WLAN capability and are particularly suitable for small teams that need to establish a temporary office for an extended period. They are also suitable for users requiring higher bandwidth to enable applications such as live broadcasting. A single BGAN terminal provides simultaneous voice and broadband data up to 492kbps, enabling you to access the internet or send email, and talk on the phone at the same time.

BGAN Link is a broadband data service for users who have a requirement for high volumes of standard IP data in one location. It provides companies working in a remote area for sustained periods of time with a data connection speed of up to half a megabit, suitable for standard office-type applications such as email, internet and intranet access, and VPN access to corporate networks.

BGAN HDR: A portfolio of high data streaming rates for broadcasters, media organisations and governments looking to deliver superior video quality anywhere in the world. It supports a portfolio of four channel streaming rates including symmetric and asymmetric options. BGAN HDR also provides a minimum throughput of 580kbps with its full channel option, but users can expect to see an average speed of 600-700kbps, reaching as high as 800kbps. It is also possible to double the streaming rates by bonding two terminals together, enabling connection speeds over 1Mbps.

BGAN M2M is a reliable, global, two-way IP data rate service designed for long-term machine-to-machine management of fixed assets. It delivers a cost-effective and ubiquitous IP service, which connects monitoring and control applications in remote, unmanned locations.

INMARSAT-B
Provides phone, fax and data at up to 64kbit/s. IMO approved for GMDSS.

INMARSAT-C
Two-way messaging through briefcase-sized terminals, provides store-and-forward transmission and reception of messages. IMO approved for GMDSS.

ISAT M2M

IsatM2M is a two-way burst messaging service that enables a wide range of machine-to-machine applications for tracking and monitoring remote fixed or mobile assets on a global basis – whether on land, at sea or in the air. IsatM2M is available across the globe, apart from the extreme polar regions with speeds of 10.5 or 25.5 bytes in the send direction and 100 bytes in the receive direction and with latency typically between 30 to 60 seconds.

ISAT DataPro

A low data rate service ideal for remote management of fixed assets including tracking and telemetry, IsatData Pro operates in near real-time anywhere in the world. With burst-mode communication and a gateway for store-and-forward messaging, IsatData Pro also offers a convenient web-based portal for adjusting settings. It is possible to send 6,400 bytes and receive 10,000 bytes, with a latency of 15-60 seconds depending on message size.

INMARSAT MINI-M

Inmarsat's desktop-sized personal communicator includes phone, fax and 2.4kbit/s data in maritime environments.

INMARSAT AERO

AERO-C: Supports two-way 600bps store-and-forward data messaging, polling and integrated GPS position-reporting for non-safety-related purposes.

AERO-H/H+: Multi-channel phone, fax and data at up to 10.5kbps. ICAO approved for safety services.

AERO-I: Multi-channel phone, fax and data at up to 4.8kbps. ICAO approved for safety services.

Aero-L: Low-speed data for air traffic control and other operational communications, 600 to 1200 bps real-time data.

AERO-MINI-M: Satcoms for small business aircraft and general aviation, Single-channel voice, fax or 2400bps data. Applications include communications for local, national, regional and corporate aircraft operators.

Swift 64: ISDN data rates to aircraft operators and passengers, services include 64kbit/s ISDN and packet data.

SwiftBroadband HGA delivers the full capabilities of Inmarsat's top-of-the range communications service for general aviation. Up to four channels per aircraft deliver simultaneous voice and data communications, always-on data up to 432kbps per channel, guaranteed data rates up to 128kbps on demand, and full-channel streaming with SwiftBroadband X-Stream.

SwiftBroadband IGA delivers high-quality voice communications and a symmetric, always-on data connection of up to 332kbps per channel. It is also possible to make use of up to four channels per aircraft for concurrent voice and data links, with the ability to add four more VoIP connections with each. A range of guaranteed data rates can be also selected up to 128kbps.

SwiftBroadband 200 is a single channel system, offering high-quality voice, plus always-on data at up to 200kbps per channel and guaranteed rates of 8 and 16kpbs.Four additional voice channels can be accessed through the in-built VoIP functionality in the SB200 terminal. All voice services can be used in parallel to the packet switched data services

INMARSAT Fleet

Fleet 77 offers a unique new mobile ISDN and Mobile Packet Data service for the maritime community delivering global voice, fax and high-speed data communications at speeds up to 128kbps. IMO approved for GMDSS.

Fleet 55 is a smaller antenna version of the 77 and offers a unique new mobile ISDN and Mobile Packet Data service, delivering voice, fax and data services at speeds of up to 64 kbps.

Fleet 33 has the smallest antenna in the Fleet 77, 55 and 33 range and offers global voice as well as a choice of communication tools, including Integrated data that delivers a data stream at 9.6kbps (and up to seven times faster with compression); always online with the Mobile Packet Data Service (MPDS).

FleetBroadband

FB500 type terminal provides broadband data and voice, simultaneously, through a compact antenna on a global basis with Standard IP up to 432kbps and Streaming IP up to 256kbps. Also supports ISDN at 64kbps for legacy applications.

FB250 type terminal provides always on connection at up to 284kbps for applications such as email and internet access, real-time electronic charts and weather reporting. Guaranteed rates up to 128kbps are available on demand for live applications such as video conferencing and database synchronisation, as well as up to nine telephone lines with FleetBroadband Multi-voice.

FB150 type terminal offers standard IP up to 150kbps

GSPS

IsatPhone Pro is Inmarsat's own-designed and manufactured satellite phone, offering clear voice telephony, globally. It also comes with a variety of data capabilities, including SMS, short message emailing and GPS look-up-and-send, as well as supporting a data service of up to 20 kbps.

IsatPhone 2 is the latest addition to Inmarsat handheld satellite phone portfolio, offering a range of new features.

ISatPhone Link is a low-cost, fixed, global satellite phone service. It provides essential voice connectivity for those working or living in areas outside of cellular coverage. It can serve as a village phone for rural communities, a temporary fixed phone for welfare calling, provide remote site offices with voice connectivity or serve as back up to primary communications across a range of market sectors. IsatPhone Link comes with a range of data capabilities including SMS, short message emailing and GPS look-up-and-send, as well as supporting a data service of up to 20kbps

FleetPhone service is a fixed phone service ideal for use on smaller vessels where voice communications is the primary requirement or on vessels where additional voice lines are needed. It provides a low-cost, global satellite phone service option for those working or sailing outside of cellular coverage.

FleetOne service provides voice and IP data services at up to 100 kbps for leisure and fishing boats. It also supports Inmarsat "505" safety service.