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

Iridium supports Ofcom to take a long-term strategic approach to spectrum planning for space services. As operator of a global satellite network in operation for nearly 20 years, and with a new network about to launch imminently, we have a significant investment in radio spectrum at a global level. However, we have concerns about the commercially-sensitive nature of the information that Ofcom seeks in this consultation, and the resulting responses that Ofcom will receive as a result. Iridium believes that most commercial network operators will be unable to release information which could compromise its business planning and future investments, including market segmentation, projections and estimates of future demand. We therefore have reservations about how Ofcom will be able to assess and use the information that it receives.

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)?:

The list shown appears to be complete from the perspective of identifying ITU-defined "services". However, whilst these clearly have a role to play in determining the characteristics of some classes of service (for example, safety services such as AMS(R)S), in many cases these are becoming less relevant due to the convergence of several services. The demand for mobility and the development of small steerable antennas is blurring the definitions between fixed and mobile services, and the rapid explosion of multi-media data services is eclipsing broadcast and point-to-point definitions. Increased use of commercial networks for military and government communications clearly shows that the ITU service separation may not be helpful in this review. We would therefore urge Ofcom to consider (in most cases) applications and quality of service as being more critical drivers in identifying particular segments of the satellite market.

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?:

As a generic model, this representation is a reasonable approximation of the satellite industry as a whole.

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.:

In Iridium's case, we operate a global network including the earth stations, satellites and network management. We procure our satellites and launch vehicles on the open market, and

provide service to distributors and system integrators for onward sale to end-users. Our core product to the end-user is a mobile-satellite service (MSS), although we use FSS and ISS links for network backhaul. However, a proportion of our customer traffic is derived from applications that may also be defined as "fixed", such as remote sensing transmitters and transportable communications hubs. Our satellite services are delivered directly to the end-user, although the commercial relationship is generally managed through distributors and resellers.

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.:

Iridium's network is currently authorised to use the following frequency ranges by the US/FCC, and provides the following services:
- 1617.775-1626.5 MHz for MSS user links (8.725 MHz, including 0.95 MHz overlapping with another MSS operator). These service links operate globally, supporting 766,000 subscribers worldwide (as of June 2015) in a number of critical applications including safety-of-life services such as AMS(R)S.
- 19.4-19.6 GHz / 29.1-29.3 GHz for FSS feeder links (2 x 200 MHz). This band is used for links between the 17 operational and planned ground gateways and the satellite constellation. These gateways are distributed around the world, and further may be added to serve particular markets. At this time, there is no gateway in the UK or dependent territory (Norway is currently the closest gateway location to the UK).
- 23.18-23.38 GHz for ISS links (200 MHz). This band supports bi-directional inter-satellite links between each of the operational satellites and the in-orbit spares, routing traffic to and from the gateway links.

Iridium's use of spectrum is highly efficient. The user link band 1617.775-1626.5 MHz is reused extensively across the entire network, thanks to the cellular spot-beam structure of the user links (each of the 66 satellites has 48 spot beams). Furthermore, the band is used in a bidirectional manner, for both space-to-Earth and Earth-to-space links. The feeder and inter-satellite links provide a robust backhaul network with very high reliability and availability due to link diversity. This backhaul network is also used for network control, and for

gateway-to-gateway trunk communications.

Iridium's frequency spectrum was largely determined when the system was first designed in the 1990's. In respect of the user links (L-band), the system has been designed to operate over the 1616-1626.5 MHz range, although the system is currently restricted to operate above 1617.775 MHz under the FCC licence. In respect of the feeder and inter-satellite links, the spectrum requirement was largely driven by the backhaul requirements for the user links. However, Iridium is currently replacing the first-generation satellite fleet with a new constellation called Iridium NEXT, the first of which will be launched in December 2015. NEXT will continue to provide voice and low-rate data communications to handheld terminals anywhere on the globe, but will also expand the provision of higher-rate mobile data services for vehicular and transportable terminals, in response to user demand. As a result, NEXT will employ higher-order modulation schemes to enhance the capacity of the frequency bands that it currently utilises, increasing the spectral efficiency of the overall network.

Iridium is a global network, and its services are available in any location. Even within the UK and Europe, which is extensively covered by terrestrial mobile networks, demand is high for Iridium's service where users require 100% availability. More than 15% of Iridium's global traffic originates or is terminated within Europe, not counting a signficant volume of maritime traffic that originates from European vessels at sea.

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).:

Iridium's services benefit the UK in a number of ways. Directly, UK companies and the military use Iridium services for operational and emergency communications, including for land, sea and air transport, oil and resource exploration and remote monitoring. Indirectly, UK consumers and businesses buy goods and services from suppliers who rely upon the Iridium communications network for their operation and safety, including cruise ships and airlines.

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

Demand for data services has been a major driver for the satellite industry as a whole, including Iridium. Growth in data services has outstripped voice, and now represents a significant majority of overall traffic on the network. Iridium has designed NEXT with much greater emphasis on data services, in response to customer demand.

Mobility is another factor that is having a profound impact on the shape of satellite services. Iridium has served a user demand for global mobile connectivity since its inception, but there is also a growing demand also for multi-Mbps services to vehicular transport such as commercial aircraft, cruise liners and long-distance trains.

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).:

The information sought by Ofcom in this question is highly commercially sensitive. At a high-level, Iridium can point to the levels of investment in new satellite infrastructure and terminals, by itself and by many other players in the sector, as evidence of anticipated demand growth for satellite services of all types. By the nature of the sector, satellite operators cannot respond easily to transient demand as infrastructure deployment requires long lead times and even longer amortisation periods - a typical satellite network may take 6 - 8 years to build and deploy, and operate for up to 15 years. Ofcom should therefore understand the critical need for long-term spectrum planning to support such growth, and to defend existing frequency bands from other potentially incompatible services.

However, Iridium cannot provide a more detailed breakdown of its forecast for demand, and we doubt that any other satellite operator is in a position to do so either. In a highly competitive environment like that of the satellite communications market, market intelligence is extremely commercially sensitive and is a key tool for operators and manufacturers to manage the development of their business and plan future investment. Further, even if it were provided to them, it is unclear what Ofcom would do with such information.

Iridium remains willing to assist Ofcom to develop a picture of the satellite sector and of likely spectrum demand, but would urge Ofcom to review what information it actually needs and how it should gather such information.

Ofcom may consider instead a review of commercially-available studies of the satellite market. One example is the "Mobile Satellite Communications Markets Survey" which is published by Euroconsult (now in its fifth edition), which provides very useful market intelligence on services and revenues. Other reports are available for other segments of the satellite market.

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.:

From the perspective of the satellite industry, we believe that the most significant challenge in the near-term will be the defence of long-allocated satellite frequency bands against

proposals to introduce high-density terrestrial cellular mobile systems into them. The enormous investments made by satellite operators (including Iridium) in new infrastructure is under serious threat if the spectrum needed to support this infrastructure is not available and suitably protected. The demand for high-speed data services has meant that most satellite designs now rely upon advanced modulations schemes and sophisticated antenna designs in order to maximise capacity from existing spectrum allocations, but this makes them more sensitive to interference and complicates the process of coordination. Recent efforts to increase satellite spectrum allocations, for example under WRC-15 agenda item 1.6, have not been supported by Ofcom or by other regulators. Satellite operators must therefore maximise the use of the existing frequency bands, and this will inevitably require more difficult coordination discussions, and a higher degree of protection against potential new sharing 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?:

The main factor for mitigation of spectrum demand is traditionally spectrum re-use. As discussed earlier, most new designs now incorporate sophisticated antenna systems that use multiple spot-beams that re-use available spectrum in a cellular-like pattern. Higher-order modulations schemes are also employed to improve the spectral efficiency (bits-per-Hz) of the available bands. But whilst these techniques permit higher data throughputs within the current spectrum allocations, they also increase the required protection from harmful interference, complicate coordination and reduce the potential for sharing with other services.

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?:

Satellite operators already employ all available mitigation techniques to maximise the capacity of the existing frequency bands. Iridium does not believe that such techniques will reduce demand for satellite spectrum in the existing bands.

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.:

Iridium believes that Ofcom must actively discourage any consideration of existing satellite allocations for use by terrestrial cellular networks in the future, for the reasons described above. In this respect, Iridium fully supports Ofcom's stance within CPG to limit any consideration of new IMT spectrum to bands that are not currently allocated to satellite services. Iridium also urges Ofcom to support efforts to increase the available Ku-band

satellite allocations at WRC-15, and identify further bands in the future to ensure that the industry has capacity to maintain its growth in the longer term.

Question 3: Do you have any comments on our broad overview of the space science sector? In particular, do you have comments on the completeness of the list of applications, their definitions and their use of the relevant radiocommunications service(s)?:

Question 14: Do you have any comments on our representation of the value chain for the space science sector? How do you think industry revenues are broken down between players at different positions in the chain?:

Question 15: What is the extent of your organisations? role(s) in the value chain? Which space science applications (as summarised in Table 2 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.:

Question 16: For each of the space science applications you use, provide or help deliver (as identified in Question 15), and taking into account your role in the value chain, where applicable please provide:
- the specific spectrum frequencies used, distinguishing between the frequencies used for the science application, the frequencies use for downlinking data and, for TT&C
- whether the application is limited to use of specific frequencies and why (e.g. due to fundamental characteristics of the phenomena being measured and/or availability of technology designed for that frequency)
- whether the applications use continuous or intermittent measurements
- the typical resolution and associated measurement bandwidths, including an indication of any implication for spectrum requirements
- the geography this use extends over (e.g. land or sea, and regional or global)
- the location of the gateway station(s) for TT&C and downlinking data
- the estimated number of users.:

Question 17: For each of the space science 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).:

Question 18: From your perspective, what high level trends will affect the space science sector in the coming years?:

Question 19: For each of the space science application(s) your organisation uses or provides, what are the a) current trends, and b) likely future drivers of demand for spectrum?

Please include in your response:
- the scale of the demand drivers
- the reason for additional demand (e.g. higher resolution radar data rates/bandwidth required) and whether this increased demand is for data delivery or for the taking of measurements
- whether increased demand can only be met at specific frequencies and why
- any variations in demand drivers by geography (i.e. regional or global), and why, and
- 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).:

Question 20: Taking into account the drivers you have identified in your response to Question 19 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.:

Question 21: Are there any future developments, such as the radio astronomy SKA, that could reduce the demand for space science spectrum in the UK?:

Question 22: 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? To what extent do you believe that these mitigations apply only to certain applications?:

Question 23: 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?:

Question 24: Beyond the activities already initiated and planned for the space science 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.: