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

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)?:

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?:

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.:

The primary application that Facebook wishes to address in this review is broadband Internet access. With nearly 1.5 billion people worldwide using Facebook on a monthly basis, Facebook is committed to its mission of giving people the power to share and making the world more open and connected.

Facebook is advancing this mission at a time when the world is going through one of the greatest economic transitions in history, moving from economies based on physical resources to economies based on knowledge. Ideas and the ability to access, develop and share those ideas are increasingly becoming the drivers of innovation, growth, jobs and productivity. Unlike physical resources, knowledge is not a zero-sum resource-one person having it does not necessitate another being excluded from it. It is infinitely renewable and available to everyone. This is the power of the knowledge economy.

But it is a power that remains untapped in many parts of the world. Currently, 3.2 billion people worldwide use the Internet. This is an incredible achievement, but it also means that only 43.4% of the world's population is connected to the Internet. The unconnected are disproportionately located in developing countries-82.2% of the population in the developed world is online compared to just 35.3% in developing countries. Moreover, Internet adoption is slowing-the rate of growth declined for the fourth year in a row to just 6.9% in 2014. (For the statistics in this paragraph, see International Telecommunication Union, ICT Facts and Figures (May 2015), available at http://www.itu.int/en/ITU-D/Statistics/Pages/facts/default.aspx.)

To combat this crisis of unequal opportunity, Facebook has created Internet.org, a Facebook-led partnership made up of technology leaders, nonprofits, local communities, and experts. Internet.org is charged with the mission of bringing broadband Internet access to the 4.2 billion people in the world who are not yet connected to the Internet.
Internet.org's mission of broadband connectivity for unconnected and underserved communities worldwide relies on different types of broadband delivery systems: terrestrial, satellite and high altitude solar planes. In some cases, such as dense urban areas, terrestrial systems are efficient both for end users and for backhaul links. In remote, sparsely-populated

areas, where there are significant gaps in infrastructure, and the economic barriers to installing terrestrial infrastructure are considerably higher, satellite delivery is likely to be appropriate. And in medium-density suburban and rural areas, where broadband infrastructure must be deployed over a wide area to be cost-effective, broadband connectivity delivered from high altitude solar planes can provide an efficient component of the solution.

A UK-based Facebook design team is developing unmanned, solar-powered lightweight aircraft that will maintain fixed station keeping at altitudes above 18 km in the stratosphere to maintain coverage of a constant service area on the ground. Such nominally fixed aircraft, which could be considered HAPS, are one promising model for delivery of broadband from a high altitude station. Facebook primarily envisions the use of these aerial platforms to provide backhaul-type links from fiber point-of-presence to service aggregation points such as cell towers or WiFi access points, complementing terrestrial links between these aggregation points and the end user.

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.:

The primary purpose of this response is to address spectrum needs for high altitude solar planes. Although Facebook plans to use various other satellite applications for the Internet.org project, we have not yet identified significant policy barriers to these services. Facebook's satellite services are expected to use existing and planned frequency allocations and the services of other operators. However, Facebook expects its requirements for satellite spectrum to evolve over time as Internet.org advances.

As discussed in our response to Question 8, future deployment of HAPS will increase significantly, requiring additional spectrum. Facebook's HAPS platform will require approximately 2 GHz of radio spectrum to achieve the target throughput as described in our response to Question 5. For HAPS aircraft-to-aircraft and aircraft-to-ground communications, Facebook is exploring optical links in addition to RF/microwave.

The ITU fixed service HAPS identifications today include: 600 MHz in the Ka-band (27.9-28.2 GHz for HAPS to Earth, 31.0-31.3 GHz for Earth to HAPS); and 160 MHz in the 6 GHz range (6440-6520 MHz for HAPS to Earth, 6560-6640 MHz for Earth to HAPS). Some of these designations are heavily restricted geographically. The 6 GHz designation only applies to Australia, Burkina Faso, Cote d'Ivoire, Mali, and Nigeria. Likewise, the Ka-band

designation only extends to Bhutan, Cameroon, South Korea, Russia, India, Indonesia, Iran, Iraq, Japan, Kazakhstan, Malaysia, Maldives, Mongolia, Myanmar, Uzbekistan, Pakistan, the Philippines, Kyrgyzstan, North Korea, Sudan, Sri Lanka, Thailand, and Viet Nam. Strict technical restrictions and power limits have also constrained the implementation of HAPS. And yet another restriction is embedded in Radio Regulation 4.23, which provides that "transmissions to or from high altitude platform stations shall be limited to bands specifically identified in Article 5" (ITU Radio Regulations Article 4.23).

Facebook supports modifying the existing HAPS identifications in accordance with a proposal being considered by the Inter-American Telecommunication Commission ("CITEL") for Agenda Item 10 of the 2015 World Radiocommunication Conference ("WRC-15"), which in turn sets forth the agenda for the 2019 World Radiocommunication Conference ("WRC-19").

The CITEL proposal would study additional fixed service identifications for HAPS in the 10.95-11.2 GHz, 11.45-11.7 GHz, 21.4-22.0 GHz, and 24.25-28.35 GHz frequency bands. The proposal also calls for studying the potential for (i) sharing and compatibility between broadband applications delivered over HAPS in the included bands and existing services and (ii) revisions to the existing geographic, technical, and regulatory restrictions on the current HAPS bands. Finally, the proposal invites WRC-19 to consider other appropriate regulatory actions, based on the studies conducted.

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).:

The Facebook high altitude solar planes are being developed by a team that includes a development and testing facility in Bridgwater, Somerset, providing UK jobs. Facebook expects that the project will create many more UK jobs if it is successful.

Although the focus of Internet.org is on the developing world, Facebook believes that its high altitude solar planes could play a role in delivery of broadband Internet access to underserved areas of the UK. The UK government has faced some significant issues in finding providers to cost-effectively deliver the services required to meet its rural broadband targets (see UK Next Generation Network Infrastructure Deployment Plan (March 2015), available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/418567/UK_Next_Generation_Network_Infrastructure_Deployment_Plan_March_15.pdf). Facebook would welcome the opportunity to work with Broadband Delivery UK at the Department of Culture, Media and Sport, Ofcom and others to be part of the solution.

Furthermore, promotion of economic growth, education and health in developing countries are key policies of the UK Department for International Development ("DfID") (see https://www.gov.uk/government/policies?organisations%5B%5D=department-for-international-development). The broad availability of Internet access that is the goal of Internet.org is crucial to advancement of these policy goals. Facebook would welcome the opportunity to work with DfID and other UK government bodies on these issues.

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

Facebook believes that high altitude aerial platforms will be an increasingly important complement to the terrestrial and satellite services in the coming years. Facebook's planned aircraft will operate at an altitude of 18-27 km, compared to 160-2000 km for low earth orbit satellites, 19,000-24,000 km for medium earth orbit satellites, and 35,786 km for geostationary satellites. Lower altitude of the aerial platforms permits significantly higher-bandwidth services using the same radiated power levels and/or reduction of power levels and latency comparable to the terrestrial systems.

Increased use of new generation of the high altitude solar planes will require significantly greater bandwidth than has been designated for HAPS based on the technology that is largely outdated by now. Early HAPS services focused on narrowband technologies primarily supporting basic voice, text, and low-speed data, consistent with throughput rates for wireless connections in the 1990s of up to 200 Kbps. By contrast, the stations that Facebook is designing will be capable of achieving 10 Gbps and above, consistent with the throughput speeds available with 4G mobile technologies and planned for 5G technologies.

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).:

As explained in our response to Question 5, there is a massive gap in Internet access for over 55% of the world's population. Facebook believes that Internet.org will play a leading role in closing that gap.

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.:

As explained in our response to Question 5, there are serious challenges of availability and affordability of Internet, particularly in developing countries. Facebook's Internet.org project is meant to address these challenges.

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?:

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?:

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.:

As explained in our response to Question 6, Facebook supports a robust agenda item on HAPS for WRC-19, based on the CITEL proposal for Agenda Item 10 of WRC-15. Facebook would welcome the opportunity to work with the UK delegation in connection with WRC-15 and thereafter on development of this agenda item.

More generally, there is a need for international spectrum availability for a variety of broadband access technologies, and a flexible, pro-connectivity regulatory framework to support development of those technologies. Policy development in these areas is a key Ofcom priority, including in connection with its Annual Plan 2015/2016 published in March 2015 and its Strategic Review of Digital Communications published in July 2015. Facebook will continue to engage with Ofcom on these issues.

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.: