Mr. Justin Moore
Ofcom
Riverside House
2a Southwark Bridge Road
London. SE1 9HA
United Kingdom

27 February 2015

Subject: Reply to Ofcom Call for Input on Spectrum above 6 GHz for future mobile communications

Dear Mr. Moore,

SES Satellites (Gibraltar) Ltd
Suite 9A, Leanse Place,
50 Town Range
Gibraltar
Tel. +350 200 77025
Fax +350 200 78025
www.ses.com

Company Registration Number
57393

Hereby SES Satellites (Gibraltar) Ltd ("SES") submits for your consideration our input to Ofcom's Call for Input (CFI) on "Spectrum above 6 GHz for future mobile communications".

In summary SES believes it is of interest to all parties involved that Ofcom, together with the international community, ensures that any new spectrum to be identified for future mobile communications for IMT or 5G would take place in the frequency bands above 31 GHz, where these bands are not allocated to satellite services on a co-primary basis. This is due to the fact that (a) thosebands above 31 GHz are not yet widely used, (b) the bandwidth needs for future mobile communications require very wideband contiguous communications with very high capacity. Importantly, this approach would likely lead to a much more efficient ITU process, avoiding the difficult and time-consuming discussions that are for instance being observed in the current study cycle for Agenda Item 1.1 leading up to WRC-15.

Further reasons can be found in Annex 1, where SES has provided answers to the specific questions that were published in the CFI.

Finally, SES, as a part of the European Satellite Operators' Association (ESOA) also underwrites the input made by this association to this same CFI.

We remain at your disposal should you have any questions or wish to discuss our views further.

Patrick van Niftrik
Vice President, Spectrum Management & Development EMEA

Question 1: Are there practical ways of achieving the very high performance that use of wide channels above 6 GHz could offer, for example using carrier aggregation of lower frequency bands?

The entirely new user experience that 5G is expected to provide through the provision of very high data rates (up to 1 Gbps, or even more) will require very wide bandwidths while simultaneously ensuring a very high overall system capacity. This may require effective total bandwidths (per user or operator, as appropriate) of 1 GHz or more (for a total system bandwidth of several GHz). Carrier aggregation of several bands into such wide bands may theoretically be feasible, but may not be practical. Mobile equipment vendors have reported cost issues related to carrier aggregation for such high aggregate bandwidths. Furthermore, it may be difficult to find sufficient spectrum sub-bands below 6 GHz (or even 31 GHz, see also answers to other questions) to achieve such ambitious aggregate bandwidth.

Question 2: What recent or emerging advances in technology may provide effective solutions to the challenges in higher frequency bands? For example can increased propagation losses be mitigated by using the high gains available with massive MIMO?

For the ambitious bandwidth needs set out for 5G (cf. Q1), the higher frequencies offer more opportunities than challenges. The very high user data rates require very substantial system capacity (consider the amount of overall system capacity required to support millions of users with peak data rates of 1 Gbps or even more). A spectrum efficient deployment of such networks requires maximizing the frequency reuse factor, which increases with the carrier frequency as the user range decreases due to physics of signal propagation. Going to higher carrier frequencies is thus an advantage rather than a drawback.

It is expected that use of frequencies above 6 GHz will rely primarily on line-of-sight paths at ranges in the order of 100 – 200m or less. Research has indicated that massive MIMO can provide additional benefits, which can be exploited more effectively as the carrier frequency increases[1].

Question 3: Are there any fundamental/inherent frequency constraints of the 5G technologies currently being investigated with regard to:

> **a) minimum contiguous bandwidth per operator? Will the spectrum for multiple operators need to be contiguous (i.e. a single band) or could multiple operators be supported through multiple bands?**

Given that carrier aggregation does not appear to be a very attractive solution to support the very high data rates required to provide the true 5G experience [cf Q1], a wide contiguous bandwidth is required per user, and hence per operator (in case the spectrum is attributed on an operator-specific basis). It has been reported that the minimum contiguous user bandwidth should be up to as much as 1 GHz, possibly even more[2]. Several GHz of total bandwidth should thus be required to support multiple operators.

---

[1] S. Hur, et al., “Millimeter-wave Channel Modelling based on Measurements in Inbuilding and Campus Environments at 28 GHz", will be presented on COST IC1004 10th Meeting, May 2014; Y. Chang, et al., “A Novel Two-Slope mmWave Channel Model Using 3D Ray-Tracing Technique in Urban Environments”, submitted to IEEE PIMRC 2014; M. K. Samimi, et al., “Ultra-Wideband Statistical Channel Model for Non Line of Sight Millimeter- Wave Urban Channels,” submitted to IEEE Globecom 2014

[2] This intention was expressed in the reply of various stakeholders to the recent FCC ‘Spectrum Frontiers’ NOI (Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, Notice of Inquiry, FCC 14-154 (Oct. 17, 2014) (“Notice of Inquiry”)) : “It would be desirable to secure at least 500 MHz of bandwidth, and 1 GHz or more bandwidth” (source: Samsung page 11) // “Huawei believes, will require contiguous channel bandwidths in excess of 1-2 GHz available within each access network” (Source Huawei page 11) // “To accommodate very large channel bandwidths and to support carrier aggregation of spectrum bands, Motorola Mobility agrees with the suggestion in the Notice that new bands ideally should be 1 to 2 GHz wide” (Source Motorola page 9) // “Licensees will therefore be incentivized to obtain licenses with a large amount of bandwidth (between 500

Theoretically, multiple operators (if applicable) could be supported through multiple bands. However, depending on the different band attributions, the consequence may be very different deployment and operational conditions (e.g. interference, co-existence with other services, number of base stations, standardization, global harmonization, device support, etc) between operators. As a consequence, not all devices might support the bands of all operators. This could potentially result in very different commercial scenarios for different operators, which would not facilitate the rapid deployment of 5G in the United Kingdom, Europe and beyond.

In summary therefore, it would seem that a single, contiguous frequency band is preferred for a smooth and rapid introduction of 5G in the United Kingdom.

b) frequency range over which the technologies are expected to be able to operate, for example due to propagation, availability of electronic components, antenna designs and costs of deployment? For example, is 10-30 GHz better or worse than 30-50 GHz and why?

A single, globally harmonized band is to be preferred for the reasons as set out above. The ability to deploy 5G rapidly would be greatly improved by focusing on bands that are wide enough to accommodate the requirements, yet are least affected by potential sharing difficulties. For example, the frequency band between 10 and 30 GHz is widely used by a variety of services, of which the satellite service is a notable one.

For example, SES is using a substantial amount of satellite capacity in Ku-band (FSS and BSS in bands between 10.7 GHz and 12.75 GHz on the downlink) for video distribution in the United Kingdom. Even excluding services provided to cable head-ends, SES satellites reach more than 12 million United Kingdom households. Corresponding uplinks are made through many of our United Kingdom based customers in the band 12.75-13.25 GHz, 13.75-14.50 and 17.3-18.1 GHz.

SES also has significant investments made in development of Ka-band in the United Kingdom and Europe in order to address various customer service needs such as the provision of broadcast services, satellite news gathering (SNG), data services to businesses and government, DTH, as well as Internet and wireless backhaul.

Any operations of 5G networks in these bands below 31 GHz will lead to significant sharing issues with those incumbent services, and, if such sharing were possible at all (which is unlikely given the general inability of IMT to share with other services), would inevitably lead to higher implementation costs and a less efficient use of the overall spectrum.

As confirmed also in EU sponsored research (METIS), several bands above 31 GHz are promising candidates in this respect[3]. These bands would have the additional benefit of enabling the very high system capacity required to support the 5G applications (cf. Q2). Availability and cost of electronic components should not be an impeding factor in this respect. Indeed, the EU is sponsoring significant R&D in this context. By focusing on bands above 31 GHz, which could be available on a globally harmonized basis, United Kingdom and Europe-based companies could gain a competitive advantage.

Question 4: Will 5G systems in higher frequency bands be deployed, and hence need access to spectrum, on a nationwide basis or will they be limited to smaller coverage areas? And if so, what sort of geographic areas will be targeted?

MHz and 1 GHz)" (source T-Mobile Page 9) // "A number of the bands identified in the NOI have 500 MHz or greater channel Bandwidth" (Source Qualcomm page 17) // "The other approach consists in using much larger bandwidth (e.g., 2GHz) of contiguous spectrum to achieve maximum data throughputs of 10 Gbps" (source Nokia page 13)

[3] METIS_D5.3_v1, Section 2.5 (Document Number: ICT-317669-METIS/D5.3, dated 29-August-2014

As referred to above, 5G systems will require very high user data rates and very high system capacities. Only the specific frequency bands for wideband use will allow users to enjoy the unique 5G broadband experience wherever they are and whenever they want. Access to the wideband contiguous spectrum will therefore have to be made on a full-time, nationwide basis and with the minimum amount of local or global constraints from other services that need to be preserved. It is no different from other IMT networks (2G, 3G, 4G, etc) in this respect.

Question 5:

a) To what extent will 5G systems in higher frequency bands need dedicated spectrum on a geographical and/or time basis or can they share?

The considerations with respect to Question 4 are substantially similar as those for this question 5a. 5G systems will require very high user data rates and very high system capacities. Only the specific frequency bands for wideband use will allow users to enjoy the unique 5G broadband experience wherever they are and whenever they want. Access to the wideband contiguous spectrum will therefore have to be made on a full-time, nationwide basis and with the minimum amount of local or global constraints from other services that need to be preserved. It is no different from other IMT networks (2G, 3G, 4G, etc) in this respect.

b) If they can share, what other types of services are they likely to be most compatible with?

Currently, there are many R&D efforts ongoing towards development of the 5G eco-system. The 5G system requirements are very ambitious and cover a wide range of performance requirements (from 1 ms latency at extreme high datarates to high latency extremely reliable IoT applications). As a consequence, it is highly likely that technical and operational characteristics of the mobile devices will keep changing continuously (indoor/outdoor, microcells or not, power levels, device densities) in the coming period. These aspects will make sharing studies of such high density networks with incumbent services a real challenge. This was already experienced in the work of ITU-R Joint Task Group 4-5-6-7 (JTG-4567). Sharing studies in this group were very difficult in part due to the late arrival of the IMT characteristics to be used in the studies. Based on the current developments in 5G it seems unlikely that a better situation would exist w.r.t. studies in ITU study periods to come.

Therefore, it is at this stage very difficult to predict with what other types of services 5G would be compatible. However, based on the past experience with sharing studies between IMT and satellite services, it seems very likely that for the foreseen high density, ubiquitous deployment of 5G, sharing with satellite services is not an option.

A key aspect of the potential to share spectrum is the relative directivity of the antennas involved by the services sharing. Sharing between high-gain antennas like those used by satellite and point-to-point microwave has generally been shown to be feasible. However, once low-gain or uncontrolled-gain antennas are used, and multipath is used to boost channel capacity, interference cases multiply and sharing becomes problematic. An important aspect to the consideration of 5G at mm-wave bands is whether the actively formed beams will have significant sidelobe suppression in addition to their designed-for main beam directivity. This aspect remains to be determined by the terminal developers.

By targeting bands above 31 GHz, it is SES' view that many of the above foreseen difficulties in the sharing would be avoided.

c) What technical characteristics and mitigation techniques of 5G technologies could facilitate sharing and compatibility with existing services?

As already indicated in our answer to question 5b, sharing of high density and ubiquitous 5G services with other services such as satellite services is not feasible. Indeed, sharing of such a service with *any* incumbent service has proven to be very challenging, and most success in the past have been achieved were frequency bands (for IMT) were basically exclusively allocated to terrestrial mobile broadband. This also appears to be the mobile operators' preference.

Mitigation techniques have in past cases promised to be (on paper) solutions for co-existence with some incumbent services. However, practical implementation of some highly sophisticated mitigation techniques are often very challenging, or in the end not feasible. Therefore, mitigation techniques would first need to be proven to work, before they can be proposed in any sharing scenario. Also, mitigation techniques would add to additional cost in implementation. Therefore, at the outset, a rapid and smooth introduction of 5G in the United Kingdom and beyond would be best served by avoiding the need for implementation of such complex and rather theoretical mitigation techniques, focusing instead on identifying unencumbered wideband contiguous spectrum bands, and this seems most promising in bands above 31 GHz.

d) Could spectrum channels be technically shared between operators?

To the extent that there are no issues with other services, this question is primarily for technical experts in the terrestrial mobile broadband field.

Question 6:

a) Given the capacity and latency targets currently being discussed for 5G how do you anticipate backhaul will be provided to radio base stations? Are flexible solutions available where the spectrum can be shared between mobile access and wireless backhaul?

First of all, shared mobile access and wireless backhaul would need very careful studying. For example, over the years, certain satellite services and fixed point-to-point terrestrial services have shown to be able to share the same spectrum, whereas IMT / 5G benefits most from exclusive access to spectrum, as shown in sharing studies and also repeatedly mentioned by operators. If point-to-point services (sharing with other services on a case-by-case basis) would change their characteristics and would become quasi-mobile links (i.e. omni- or multidirectional), then the sharing scenarios change and a significant risk of incompatibility will emerge.

The demanding low latency requirements set out for 5G would require, especially for video, the content to be delivered very close to the end user. Satellite can play an important role here as traditional satellite networks can provide an efficient multicast distribution of popular content across the 5G network, thus relieving some of the backbone bandwidth requirements. Caching management enables also to reduce further the bandwidth requirement on the backhaul link and would improve the low latency experience. This is especially relevant as video-centric content, in particular in high-definition (HD) and ultra-high definition (UHD) formats, will represent a large majority of the most appealing content.

In addition, satellite – both geostationary and non-geostationary (which may provide lower latency and higher throughput) – can also play an important role for backhaul in less dense areas.

b) What, if any, spectrum will be required? What channel sizes will be needed? Will the bands used be similar to those currently used for wireless backhaul?

It is clear that the 5G eco system requires sufficient capacity for backhauling and any spectrum requirements would have to be carefully assessed, and the technical characteristics of the backhaul links need to be studied. This is especially the case if the backhauling is foreseen to be done by making use of point-to-multipoint or even omni-directional transmissions.

However, due to the high capacity that 5G is foreseen to provide, ground infrastructure – through fibre – would seem essential. Also, as already mentioned under question 6a, satellite – both geostationary and non-geostationary (which may provide lower latency and higher throughput) – can play an important role for backhaul in less dense areas as well.

Question 7: Should we expand the scope of bands being reviewed beyond the 6-100 GHz range?

The SES view is that, instead of inquiring about expanding the scope, our view is that the scope should be narrowed, and that a review of the bands should start above 31 GHz, for reasons explained in our replies to this CFI.

Keeping the scope as wide is it currently is, or even expanding it, would consume enormous resources from the international community in having to engage in a vast amount of sharing studies over the next several years, likely resulting in significant implementation delays for 5G. It would benefit all stakeholders to avoid the experience of the work done in JTG-4567 which was preparing for WRC-15 Agenda Item 1.1. The vast amount of incumbent uses below 31 GHz would lead to many contentious discussions, and a polarized debate. Instead, 5G should focus on the long term future and a timely deployment. It has the change to develop an eco-system almost from a clean sheet of paper by focusing on the bands above 31 GHz.

Question 8: Do you agree that it is likely to be necessary for bands to have an existing allocation to the mobile service? Does this need to be a primary allocation?

It seems logical to look at bands that have an existing allocation to the mobile service, and indeed this would facilitate the timely deployment of 5G. However, identification for IMT, or having the 5G ecosystem in mind, leads to a very specific interference environment, which is very different from what was common knowledge at the time when the original mobile allocations were made. Therefore careful study is required to make sure that this new use of spectrum can co-exist with existing allocations and uses.

SES notes however that the METIS study referred to under question 3b did also review frequency bands above 31 GHz for which there is no mobile allocation today.

Question 9: Do you agree with the criteria we have used for our initial filter of bands, and are there other criteria that could also be used?

The most important criterion in SES' view is that the filter of bands should also take into account the existing and planned services and uses in such bands and that these should not be negatively impacted by the introduction of such new services. Relevant sharing studies have already shown that sharing of high density and ubiquitous terrestrial mobile services (as anticipated for 5G) with incumbent services like satellite services is not feasible.

Many satellite system operators around the world currently operate / plan to operate global or regional satellite services using C, X, Ku and Ka-band frequencies. These satellite networks do and will provide valuable services in many regions around the world and are actually also enablers for terrestrial operators. For example, Arabsat, Avanti, EchoStar, Es'hailsat, Eutelsat, Gazprom Space Systems, Hispasat, Inmarsat, Intelsat, Nilesat, Nigcomsat, O3b, RSCC, SES, Telenor, Telesat, Thaicom, Turksat, Viasat, Yahsat, and the governments of Brazil, Australia, and France currently operate or plan to operate satellite systems within the C-band 6000-7075 MHz frequencies, Ku-band 12.75-13.25 / 13.75-14.50 / 17.30-18.10 / 10.70-12.75 GHz frequencies and Ka-band 24.65-25.25 / 17.3-17.8 / 21.4-22 GHz and 27.0 – 30.0 / 17.7 – 20.2 GHz frequencies.

Question 10: Of the spectrum bands/ranges mentioned in this section, are there any that should be prioritised for further investigation?

As a general principle it is SES' view that only frequency bands above 31 GHz should be considered for 5G. More in particular, our comments on the bands highlighted by Ofcom are the following:

<u>5925-8500 MHz</u>: The band 5925-6425 MHz is the uplink band for FSS "C-band". This band is heavily used by the satellite services, and in this band satellite services and terrestrial point-to-point links are sharing the spectrum efficiently already. The band 6425-6725 MHz is an important band in the "extended C-band" for uplink services as well and in any case only would only offer 300MHz at best. The band 6725-7025 MHz is part of the AP30B uplink band plan, and as such should remain reserved for such use. The band 7250-7750 MHz and 7900-8400 MHz are bands heavily used by the FSS for mainly governmental purposes. In summary, most of this range contains allocations to the FSS which are in use today and would not be compatible with terrestrial mobile broadband services. As such, wide contiguous bands in the order of magnitude as expressed by Ofcom would not be available for development of 5G in the band 5925 – 8500 MHz. *Therefore this band should not be prioritized*

<u>10.5-11.7 GHz (excl. 10.68-10.7 GHz)</u>: The band 10.7-11.7 GHz is intensely used in Europe for satellite services. In Ku-band in general, in the UK, more than 12 million TV households are served in this band by using small receive antennas. In Europe, 85 million TV homes receive their signal from satellites (up from 84 million in 2011). Over the last four years, satellite has increased its reach in Europe by 17 percent. All in all, SES' ASTRA sysem serves 143 million European TV households (including indirect cable and IPTV reach), 73 percent of all European satellite homes and 80 percent of all European satellite HD homes. Due to the ubiquitous deployment of these antennas, sharing with the any terrestrial mobile (or fixed) broadband services would cause immediate and harmful interference and sharing is therefore not feasible. *Therefore this band should not be prioritized*

<u>14.4-15.35 GHz</u>: The band 14.4-14.5 is allocated to FSS uplinks and is intensely used by many geostationary satellites for a variety of purposes. The band 14.5-14.8 GHz is allocated to FSS uplinks for feeder links in AP30A (BSS), and part of this band is also a harmonized NATO band. The availability capacity in this band would not be enough for true 5G, especially if multiple operators need a spectrum attribution. *Therefore this band should not be prioritized*

<u>17.8-19.7 GHz</u>: The band 17.8-18.1 GHz is allocated to FSS uplinks for feeder links in AP30A (BSS) as well as to FSS downlink. The band 18.3-19.3 GHz is identified for use by high-density applications in the fixed-satellite service in Region 2. These allocations and identifications are not compatible with terrestrial mobile broadband. The level of Ka-band satellite investment in this band is very substantial, as there are worldwide over 60 satellite systems launched or being procured. *Therefore this band should not be prioritized*

<u>21.2-23.6 GHz</u>: The band 21.4-22 GHz is allocated to BSS in ITU Region 1 and 3. BSS services are inherently not compatible with terrestrial mobile broadband. SES alone operates a number of satellite systems in this frequency bands over Europe, such as e.g. SES-5 and ASTRA-2E. *Therefore this band should not be prioritized*

<u>25.25-29.5 GHz</u>: The band 27.0 GHz to 29.5 GHz is allocated to FSS uplinks for Ka-band. The level of Ka-band satellite investment in this band is very substantial, as there are worldwide over 60 satellite systems launched or procured. Many of the operators who have procured satellites in this band have their ITU filings through the United Kingdom. Due to the congestion experienced in C-band and Ku-band, development of Ka-band is extremely important for the satellite sector in order to be able to serve the demand. It should be noted that Ka-band (HTS) systems are seen as an important enabler in the terrestrial mobile broad eco-system through the wireless backhaul that they can provide to areas with insufficient terrestrial backhaul infrastructure. *Therefore this band should not be prioritized*

Question 11: Are there any bands/ranges not mentioned in this section that should be prioritised for further investigation? If so, please provide details, including why they are of particular interest.

It is SES' view that only frequency bands above 31 GHz should be considered for 5G.

Question 12: Are there any particular bands/ranges that would not be suitable for use by future mobile services? If so, please provide details.

SES believes that it is in the interest of all stakeholders for Ofcom to consider only frequency bands above 31 GHz, and to avoid those bands for which there is a primary allocation to a satellite or space service.

Question 13: What additional information, beyond that given in Annex 5 would be useful to allow stakeholders to develop their own thinking around spectrum options?

No comment

Question 14: What are the most important criteria for prioritising bands going forward?

SES believes that it is important to ensure that existing and planned radio services already deployed or planned to be deployed under existing ITU radio allocations are (a) not subject to unacceptable interference from future 5G / IMT systems; (b) not subject to constraints in their future development by future 5G / IMT systems; (c) not subject to the threat of future displacement out of their current operating bands due to progressive encroachment / entry by 5G / IMT radio systems.

Further, it is should be of the highest interest to the terrestrial mobile broadband stakeholders to target bands with the greatest opportunity for global harmonisation at ITU level, and with an ability to deploy as soon as possible and with the minimum amount of disturbance of existing users and uses (which would also avoid the difficult debates as currently experienced in the context of WRC-15 Agenda Item 1.1).

The bands to be targeted should offer large contiguous allocation of spectrum for terrestrial 5G / IMT of several GHz in order to accommodate up to 1 GHz per user and multiple operators. Further, these bands should have the higher carrier frequency in order to be able to increase overall system capacity through efficient frequency reuse.