Inmarsat response to Ofcom Call for Input on

"Future demand for mobile broadband spectrum and consideration of potential candidate bands"

29 April 2013

1. Introduction

Inmarsat is pleased to respond to Ofcom's call for input on "Future demand for mobile broadband spectrum and consideration of potential candidate bands" and WRC-15 agenda item 1.1. We request that Ofcom gives careful consideration to our comments.

2. Spectrum requirement forecasts

Ofcom discusses the spectrum requirement forecast in section 4 and asks several questions (Questions 1-7) to help in the assessment of the spectrum demand for terrestrial mobile broadband applications. It is likely that Ofcom will receive inputs from mobile equipment manufacturers and some terrestrial mobile operators suggesting very high growth in the demand for mobile data, leading to demand for additional spectrum for terrestrial mobile broadband. Some of the predictions for the growth in mobile data are shown in Figure A5.1 of the consultation document.

In most cases, any new frequency bands for terrestrial mobile broadband would come at the expense of the current users of the band. Hence, it is important that Ofcom reviews the demands for terrestrial mobile broadband critically. In so doing, Inmarsat proposes that at least the following aspects should be considered:

- *There is a practical limit to the amount of data that can be consumed by mobile devices.* It is not at all clear what applications will require significantly higher data consumption than those available today. Given the relatively small screen size of a mobile device, there is a limit on the amount of information that can be displayed and hence on the amount of data that can be consumed. Some of the assumptions in previous ITU-R studies, such as those in ITU-R Report M.2072 seem unrealistic. For example, that report considers some mobile users viewing mobile HDTV for a duration of up to 14 812.04 seconds per "session" at a rate of 20 Mbit/s. This equates to a consumption of 37 GByte in a period of just over 4 hours, well beyond any requirement of a mobile devices. (For comparison a high definition film available for download on iTunes has a file size of about 4 GByte). It is important that any spectrum demands include a credibility check on the assumptions of the data consumption per user.

- *WiFi offloading*. WiFi offloading is currently widely used to enhance the mobile broadband experience, particularly in the home, where most mobile broadband consumption takes place. Given the cheapness of WiFi infrastructure, and planned improvements in roaming to be provided by the WiFi "Passpoint" system[1], it seems likely that WiFi will be used more extensively in the future. While use of WiFi is sometimes criticised as being unable to support a guaranteed quality of service, its widespread use today suggests that that drawback is not significant in most cases. The relatively flat line shown in Figure A5.2 of the consultation document therefore probably underestimates the future use of WiFi off-loading.

- *Technology improvements*. Improvements in efficiency through new technologies planned for the next few years will increase the efficiency of use of the currently available mobile broadband spectrum. Studies such as the Real Wireless report for Ofcom[2] suggest approximately a five-fold increase in bit/s/Hz/cell between now and 2020. Other technical solutions such as the use of small cells within the currently available spectrum further increase the efficiency of use of the currently available spectrum. It is quite possible that these and other technology improvements could meet the future demand for mobile broadband data.

- *The benefits of terrestrial mobile, versus the economic impact of displaced services.* In considering the identification of new frequency bands for terrestrial wireless systems, the benefits of increased spectrum for terrestrial applications should be weighed against the costs of constraining or removing the existing users of the band. As more and more spectrum is made available for terrestrial mobile, the increase in the economic benefits becomes less. For example, the incremental benefit in going from 1000 MHz to 1100 MHz of available spectrum is very much less that going from 100 MHz to 200 MHz. However the impact on any victim service in the additional 100 MHz is the same. So there comes a point where, from a narrow economic perspective alone, it does not make sense to make more spectrum available for terrestrial mobile.

- *How much will consumers pay?* Whenever a new band is made available, a new infrastructure needs to be deployed, including compatible handsets and new base stations. The new base stations must be connected to the operator's backhaul network. This all adds to the costs, which must be passed on to the consumer. As there is around 100% mobile penetration in Europe, the costs must be borne by existing consumers. Meanwhile, the average revenues per user for terrestrial mobile operators are falling in Europe. There are therefore good reasons to doubt that users are prepared to pay higher charges for the availability of higher data rate services.

[1] http://www.wi-fi.org/discover-and-learn/wi-fi-certified-passpoint%E2%84%A2
[2] http://stakeholders.ofcom.org.uk/binaries/research/technology-research/2011/4g/4GCapacityGainsFinalReport.pdf

3. Frequency ranges under discussion

In Question 8, Ofcom asks for views on the bands listed in Table A6.1. Inmarsat offers the following views:

3.1 The bands 1427-1527 MHz, 1518-1559 MHz, 1626.5-1660.5 MHz, 1668-1675 MHz (L-band)

As summarised in Table A6.1, the band 1427-1527 MHz has been suggested as a potential band for terrestrial IMT, whereas the bands 1518-1559 MHz, 1626.5-1660.5 MHz, 1668-1675 MHz have been proposed not to be considered for terrestrial IMT. We note in particular that the band 1518-1527 MHz is proposed for terrestrial IMT by some parties and opposed by others.

Inmarsat requests that all of the bands 1518-1559 MHz, 1626.5-1660.5 MHz and 1668-1675 MHz are not further considered as candidates for terrestrial IMT for the reasons explained below.

The frequencies in the band 1525-1559 MHz and 1626.5-1660.5 MHz are used by Inmarsat and other GSO MSS operators. Globally, the frequencies are currently shared among Inmarsat, Thuraya (based in UAE), RSCC (Russia), ESA, Optus (Australia), Telecom Mexico, LightSquared (USA), Skyterra Canada, ACeS (Indonesia) and MLIT (Japan). These bands are authorised for MSS operations in the UK and are used globally and extensively for MSS operations, including safety related services for the maritime and aeronautical communities.

The bands 1518-1525 MHz and 1668-1675 MHz were allocated to the MSS at WRC-03. They will be brought into use with the launch of the Inmarsat “Alphasat” satellite during 2013. The total investment by Inmarsat and others in Alphasat and the associated use of extended L-band is around EUR 850m. Ofcom has recently authorised the use of the bands 1518-1525 MHz and 1670-1675 MHz for mobile earth stations.

These bands are identified as being available for the satellite component of IMT and some of the services offered by MSS operators form part of the “satellite component for IMT-2000”, as defined by Recommendation ITU-R M. 1850-1.

Regarding potential use of the MSS downlink frequencies (1518-1559 MHz), interference could be caused by terrestrial IMT transmitters to receiving mobile earth stations (MESs). Mobile earth stations receivers are required to be highly sensitive to allow them to receive the wanted signal transmitted by the geostationary satellite. MESs would therefore be vulnerable to interference from terrestrial IMT transmitters operating in the same band. ITU-R Report M.2039-2 contains example characteristics of IMT mobile stations and base stations. Using example characteristics taken from this Report, the required separation distance to protect a typical MES receiver is shown in Table 1 below.

IMT station type	**Mobile station**	**Base station**
IMT station e.i.r.p. (dBm)	24	43
emission bandwidth (kHz)	5000	5000
reference bandwidth (kHz)	200	200
IMT station e.i.r.p. in reference BW (dBW)	-20.0	-1.0
polarisation loss (dB)	3	3
MES receiver temp (K)	316	316
MES antenna gain (dBi)	2	2
MES noise in reference BW (dBW)	-150.6	-150.6
I/N criterion (dB)	-10	-10
maximum interference in ref BW (dBW)	-160.6	-160.6
minimum coupling loss (dB)	139.6	158.6
distance in free space (km)	150	1335

Table 1

It should be noted that the parameter values chosen for the IMT stations are examples. For the IMT station emission bandwidth, smaller values are included in Report M.2039 that would lead to higher interference and a larger separation distance.

The calculated required separation distances using free space loss are 150 km for an IMT mobile station and 1335 km for an IMT base station. In a real deployment situation free space loss would not apply when the IMT station and MES are beyond radio line-of-sight, and hence in reality, the required separation distances would be smaller in many cases. However these results demonstrate that any MES at least within line-of-sight of an IMT mobile station or base station, and some MESs beyond line-of-sight, could suffer harmful interference.

Interference could also be caused in the downlink bands by the MSS satellite emissions being received by the IMT mobile station and base station. MSS satellites use very large antennas – Inmarsat's I4 satellites use a 10 m diameter antenna, and other L-band operators have deployed larger antennas. This allows high gain spot beams to be used, which leads to a high power flux density (pfd) on the earth surface. This is necessary to provide sufficient signal power to small MSS user terminals, which include hand portable devices with small antennas. If MSS downlinks were required to protect MS receivers, this would lead to constraints on the downlink pfd, likely preventing service to MSS users. Table 2 below shows the interference from an example MSS downlink carrier to terrestrial IMT stations.

IMT station type	**Mobile station**	**Base station**
MSS eirp (dBW)	43	43
reference bandwidth (kHz)	200	200
pfd on earth surface (dBW/m2) (height 36,000 km)	-119.1	-119.1
IMT station thermal noise (for 5 MHz receiver BW) (dBm)	-98	-102
IMT station thermal noise in reference BW (dBm)	-112.0	-116.0
Antenna gain in direction of satellite (dBi)	0	17
I/N criterion (dB)	-6	-6
Maximum interference in reference BW (dBW)	-148.0	-152.0
Polarisation loss (dB)	3	3
Ae iso (dBm^2)	-25.1	-25.1
Interference received (dBW)	-147.2	-130.2
Interference excess (dB)	0.8	21.8

Table 2

Interference exceeds the criterion by 0.8 dB for the mobile station and by 21.8 dB for the base station. Hence, if the MSS downlink emissions needed to protect terrestrial IMT systems, it would constrain MSS operations such that some current services could no longer be provided. It is important to stress here that limiting the pfd in a particular beam affects the entire beam coverage area, and hence could constrain MSS not only in any particular country which might deploy terrestrial IMT systems, but also in the neighbouring seas and countries.

Regarding potential use of the MSS uplink frequencies (1626.5-1660.5 MHz and 1668-1675 MHz), interference could be caused by terrestrial IMT transmitters to MSS satellite receivers. This interference issue has been studied by the ITU in Recommendation M.1799 for the band 1668.4-1675 MHz. The Recommendation considers several different types of mobile systems, including "cellular or similar high-density mobile systems" for which the characteristics are based on terrestrial IMT systems. The Recommendation includes the following conclusion: "The study confirms Report ITU-R M.2041 (for bands around 2.5 GHz) that co-frequency sharing between MSS uplinks and mobile is not possible in the same geographic area. Furthermore, interference from such mobile service systems may cause harmful interference to any visible satellite operating in the same band. Hence if systems with characteristics similar to those assumed in § 3.3 [cellular or similar high-density mobile systems] were to be used, the impact on MSS could be significant – potentially preventing use of the band for MSS." Although this study is related to the band 1668.4-1675 MHz, the characteristics of MSS satellite systems are the same for all of the range 1626.5-1660.5 MHz and 1668-1675 MHz, and hence the conclusions are equally applicable to all these MSS uplink frequencies.

In summary, the bands 1518-1559 MHz, 1626.5-1660.5 MHz and 1668-1675 MHz are used by the MSS, or are about to the used by the MSS, and terrestrial IMT systems are not compatible with the MSS systems using these bands. These bands should not be considered as candidates for terrestrial IMT systems under WRC-15 agenda item 1.1 and Ofcom should oppose proposals to identify any part of these bands for terrestrial IMT.

3.2 The band 3400-4200 MHz (C-band)

This band is used by FSS downlinks. As is indicated in Table A6.1, all or parts of this band have been proposed as potential candidates for terrestrial IMT, while others have opposed the possible further identification of spectrum in this band for terrestrial IMT.

Parts of this band are used by Inmarsat as feeder links and telemetry links for our MSS satellite network.

Due to the limited power available on a satellite, ground terminals are designed to receive very low-power signals transmitted by a satellite located thousands of km away; the distance between the satellite and the receiving earth station is around 36,000 km–40,000 km. As a consequence, receiving hardware is usually very sensitive to any external interference. Once in orbit, satellites cannot be re-tuned to other frequency bands and are typically in operation for about 15-20 years.

Historically, the C-band FSS frequencies have been used for terrestrial radio-relay systems. Sharing with such systems is made feasible by the limited number of radio-relay stations required in most countries and the fact that radio-relay stations use highly directional antennas, which concentrate the power in a narrow beam. Furthermore, radio-relay systems are typically authorised at specific locations on a station-by-station basis, making coordination practicable. These factors facilitate the sharing of the band by the FSS and point-to-point radio relay systems.

In contrast, sharing with terrestrial broadband systems is much harder to achieve. Terrestrial networks normally make use of an extensive distribution of base stations within a given geographic area, transmitting high power simultaneously in every horizontal direction. The use of networks using carriers with the same centre frequency and wide bandwidths, as is the norm for terrestrial networks, means there is unlikely to be any possibility of being able to plan for an adequate frequency and geographical separation between IMT systems and FSS earth stations. ITU-R studies conducted in the run-up to WRC-07, such as those in ECC Report 100 and Report ITU-R M.2109 showed that distance separations of at least tens of kilometres, and in some specific cases more than 100 km, between a transmitting IMT station and a receiving FSS station would be required in order to avoid harmful interference to the FSS earth station. Those studies remain valid today.

The requirement to protect ubiquitously deployed FSS earth stations by maintaining large separation distances leads to large holes in any potential coverage by terrestrial IMT networks. In countries where FSS earth stations are extensively deployed, the combined exclusion areas may consist of virtually the entire country, making IMT operations impractical or impossible. Conversely, implementation of IMT stations would preclude the use of C-band receiving stations within a relatively large area around each IMT station, thus restricting further development/expansion of C band satellite services.

The band 3400-4200 MHz was heavily discussed during WRC-07, which led to the identification of the lower 200 MHz (3400-3600 MHz) for IMT in a number of countries, including the UK. The EC Decision 2008/411/EC ensures that the band 3400-3800 MHz is made available for “Broadband Wireless Access” (BWA) in the UK and the rest of the EU. This already gives the UK the regulatory authority to authorise terrestrial mobile systems in the band 3400-3800 MHz, subject to protection of FSS earth stations, and hence there is no requirement for any further action at WRC-15 in relation to the band 3400-3800 MHz.

Sharing is at least difficult in the lower half of the C-band downlink spectrum, i.e. the band 3400-3800 MHz, and in some countries is not possible. The upper half of the C-band downlink spectrum, i.e. the band 3800-4200 MHz, has many times more earth stations than the lower half. Consequently, sharing between mobile broadband systems and FSS earth stations in the upper half of C-band is even more difficult than the lower half. Hence sharing in the band 3800-4200 MHz is not practicable in the UK or in most other countries of the world.

No part of the band 3400-4200 MHz should be further considered for terrestrial IMT.

3.3 The band 5850-6425 MHz (C-band)

Parts of this band are used by Inmarsat for telecommand and feeder link carriers to our network of MSS satellites. These links ensure the proper functioning of the satellite and hence it is vital that such links do not suffer harmful interference.

The introduction of mobile broadband in the C-band FSS uplink frequencies could cause harmful interference to FSS satellites operating in this band. Furthermore, FSS earth station transmissions would result in high levels of interference into IMT stations, thus requiring large separation distances between FSS and IMT stations. Maintenance of such large separation distances would severely constrain the future development of FSS Earth stations by satellite operators. Moreover, such large separation distances, when considered in conjunction with the existing use of this band by the FSS, would also place significant restrictions on the deployment of any IMT or mobile broadband system – potentially making the deployment of such systems infeasible. We are not aware of any sharing studies into the possible use of this band for terrestrial IMT, but we are doubtful that sharing would be feasible.

3.4 18.1 – 18.6 GHz (Ka-band)

It is difficult to foresee how the frequencies in this band would be used for terrestrial IMT systems as the propagation conditions are significantly worse compared to the frequency bands below 6 GHz. We understand that there is very limited interest in this band for IMT, even among the terrestrial IMT community.

This part of the Ka-band downlink frequencies will be used by Inmarsat's new Ka-band system "Global Xpress", which is currently under construction. Many other satellite operators are also developing new Ka-band FSS systems. We are not aware of any sharing studies with respect to IMT systems operating in this band but we are doubtful that sharing would be feasible.

3.5 27 – 29.5 GHz (Ka-band)

It is difficult to foresee how the frequencies in this band would be used for terrestrial IMT systems as the propagation conditions are significantly worse compared to the frequency bands below 6 GHz. We understand that there is very limited interest in this band for IMT, even among the terrestrial IMT community.

This part of the Ka-band uplink frequencies will be used by Inmarsat's new Ka-band system "Global Xpress", which is currently under construction. Many other satellite operators are also developing new Ka-band FSS systems that will operate in this band.

Several sub-bands have already been identified for high density applications in the FSS for licence exempt earth stations. The remaining sub-band frequencies are available for licensed FSS earth stations in most countries. If this band were to be used for terrestrial IMT, sharing with respect to licensed and unlicensed earth stations would need to be addressed, as would potential interference to FSS satellite receivers. We are not aware of any sharing studies with respect to IMT systems operating in this band but we are doubtful that sharing would be feasible.

3.6 Other bands

Question 9 asks: "Are there any other bands that are not in Table A6.1 for which you think we should be considering their pros and cons for mobile broadband and for existing applications using this spectrum?". In addition to the bands mentioned above, we highlight that the band 6425-6725 MHz is allocated to FSS uplinks and is used by Inmarsat for the feeder links to our MSS network. Similar comments to those for the band 5850-6425 MHz apply also to the band 6425-6725 MHz. We are not aware of any sharing studies into the possible use of this band for terrestrial IMT, but we are doubtful that sharing would be feasible.

4. Conclusion

Some of the frequency bands which are used by Inmarsat to support users and services in the UK and throughout the world have been suggested as potential candidate bands for terrestrial IMT. In the case of the bands 1518-1559 MHz, 1626.5-1660.5 MHz, 1668-1675 MHz in particular, the use of all or parts of those bands for terrestrial IMT would pose a serious interference risk to our services. We request that Ofcom oppose identification of these bands for terrestrial IMT, to ensure the continued availability of our services.

Shared use by IMT systems of some of the C-band spectrum is already in place through the decisions of the WRC-07 and the EC. Due to the interference issues outlined above, no further identification of C-band spectrum for IMT should be done at WRC-15.

The Ka-band spectrum is essential for Inmarsat's and other satellite operator's future plans and we don't see any feasibility to identify spectrum for terrestrial IMT in this frequency range.