1. Introduction

This joint submission represents the views of the UK DTT multiplex operators, namely the BBC, ITV, Channel 4, Arqiva and SDN. Therefore, a key goal in this submission is to prevent any action which could ultimately lead to the removal of 470-694 MHz for broadcasting use.

We welcome the opportunity to respond to Ofcom's Call for Input, *Future demand for mobile broadband spectrum and consideration of potential bands.* Ofcom is to be commended for seeking views from stakeholders in this transparent way, so as to inform the UK position on World Radiocommunications Conference 2015 (WRC-15), Agenda Item 1.1. This is a matter of great concern for all spectrum users, and we are keen to engage constructively with Ofcom and DCMS to ensure that the goal of a viable long-term DTT platform – as set out in Ofcom's November 2012 UHF Strategy statement – is realised.

Underpinning this submission is the cultural, social and economic value that the DTT platform provides to UK citizens and consumers. Ofcom's UHF strategy acknowledges this and clearly sets out an ambition that free-to-air television should be retained on the UHF platform for the long term:

> *The DTT platform will need to be able to continue to fulfil its current important roles in providing near-universal low cost access to PSB content and in widening consumer choice at the time when the 700 MHz band could be released for mobile broadband.*[1]

Ofcom also accepts that IPTV will not be in a position to deliver universal free-to-air content for the foreseeable future. Therefore, the UK position is effectively that DTT must be in place until 2030:

> *We also highlighted that over a much longer time period, post 2030, the universal rollout and take-up of super fast broadband could enable IPTV services to provide a viable substitute for the DTT platform, enabling an eventual potential switch-off scenario for the DTT platform. But that this scenario falls outside the timeframe we are considering for our current UHF spectrum strategy.*[2]

UK terrestrial broadcasting recognises that the conclusion from WRC-15 on this Agenda Item could be of critical importance to the future of a number of radio services. Not only the future of mobile broadband services, but also that of broadcasting and most other users of spectrum between 400 MHz and 6 GHz.

Clearly, the scope of this Call for Input is to inform the UK position only on this critical Agenda Item. Alongside future constructive discussions with Ofcom and the wider UK delegation for WRC-15, we look forward to a robust exchange of ideas and views with other ITU, CEPT and EU stakeholders.

This submission is set out as follows:

In Section 2, **Executive Summary**, we set out our high level observations

[1] Ofcom, *Securing long term benefits from scarce low frequency spectrum: UHF strategy statement*, November 2012, Paragraph 4.5
[2] Ibid Paragraph 4.6

In Section 3, **Overview**, we give a general commentary on the issue of finding spectrum to meet future mobile data demand

In Section 4, **Response to questions**, we give our views on those issues that Ofcom sought representations on in its Call for Input.

2. Executive summary

The debate on where to find spectrum to meet the ever-growing demand for mobile data has dominated spectrum policy discussions in the UK and internationally for a number of years now. During that time significant quantities of spectrum have been released into the market for IMT, primarily through the 3G and 4G spectrum awards. But we are told that this is not enough.

This submission to Ofcom seeks to introduce some realism into the debate at a time when improbable forecasts of future mobile data demand are increasingly being called into question. In particular, we suggest the following:

- There is growing evidence that mobile data demand forecasts are significantly overstated;
- The mode of consumption is largely static and facilitated by traffic offload. Indeed, one of the key challenges should be to secure additional higher frequency spectrum to meet the growing demand for off-loading and small cells;
- The benefits of deploying new services in new allocations are entirely unclear and if pursued, particularly sub 1GHz, is likely to result in regulatory failure;
- Discussions on the "wider UHF band" make no logical sense unless there is some evidence that future mobile data demand will require IMT access to the spectrum between 470-694 MHz. No such evidence has been presented;
- Further analysis and validation must be undertaken before any policy decisions could be taken to incur cost and consumer disruption by clearing high value uses out of sub 1-GHz spectrum; and
- Special consideration should be given to the programme making and special events (PMSE) sector which relies entirely on sharing UHF spectrum with broadcasting.

In our answer to question 8 in this submission, we show that the spectrum band 470-694 MHz is almost uniquely unsuitable for IMT allocation on the basis of its technical characteristics, lack of actual or potential prospect of mobile equipment and standards development in the frequencies and scale of disruption that could ensue from undermining the status of the band as a broadcasting allocation.

Accordingly, we also set out in this document the numerous compelling reasons why Ofcom should argue on behalf of the UK against studies being pursued to determine the suitability of 470-694 MHz as a future IMT allocation.

3. Overview

This Call for Input focusses on two distinct but clearly related issues, namely:

- The future spectrum requirements for mobile broadband; and
- The set of potential frequency ranges that WRC-15 could consider.

We welcome the focus that Ofcom has given to both questions. However, we are concerned that Ofcom has somewhat prejudged the outcome of these enquiries both within this Call for Input and elsewhere[3]. For example, paragraph 4.2 of this Call for Input states:

> *There had been a number of studies published, including studies commissioned by Ofcom, which suggested that growth for wireless broadband traffic is set to rise rapidly in the future*

Whilst mobile data demand has clearly increased significantly over the past few years, it is far from clear that the rate of this rise in the future will be as rapid as some of these studies have indicated. In an environment of increasing uncertainty, we question Ofcom's subsequent assertion in paragraph 4.3 that "it is anticipated" that additional spectrum will have to be made available for mobile broadband. There is evidence to suggest that there are credible alternative means of meeting any significant increases in mobile data demand aside from further allocations of spectrum. What data growth there is will be met, in no small part, by offload to Wi-Fi and small cells. Even where spectrum is needed, sub- 1 GHz spectrum is not optimal to meet capacity needs.

However we do recognise that it is appropriate to consider which spectrum bands may be most appropriate to meet that demand, should additional spectrum be needed.

We believe that the inclusion of the 470-694 MHz band for consideration for mobile broadband, even as a co-primary allocation with DTT, would be detrimental to the DTT platform. It would cast doubts around DTT's use of this band at a time when the broadcast industry faces significant uncertainty, disruption and investment risk around the potential clearance of 700MHz band.

Moreover, further consideration of the 470-694 MHz band for mobile broadband would directly conflict with Ofcom's stated position on the desirability of a long-term viable DTT platform. The following provide compelling reasons for Ofcom to put forward a strong argument at WRC-15 *against* the allocation of co-primary status for the 470-694 MHz band:

- The technical limitations of this band for mobile broadband;
- The lack of evidence to support the assumption that future mobile data demand will require IMT access to the spectrum in this band; and
- The lack of an existing ecosystem and infrastructure for mobile broadband devices in this band.

[3] http://www.mobilenewscwp.co.uk/tag/steve-unger/

A reality check on the forecast growth in demand for mobile data

We are encouraged that Ofcom has requested views on the **nature** and **magnitude** of the likely increase in mobile data demand at a time when industry demand forecasts are increasingly being made on the basis of real world measurements.

The wider debate over the past decade on identifying increased spectrum for mobile broadband applications has rested on two assumptions:

1) There will be an "explosion" in demand for mobile data, driven primarily (though not exclusively) by demand for video; and

2) This increase in demand will inevitably require increased spectrum allocations for International Mobile Telecommunications (IMT).

However, there is growing evidence that mobile data demand forecasts are significantly overstated and more uncertain than initially thought. Furthermore, we are seeing that the vast majority of data consumption by mobile devices is static and can be readily facilitated by Wi-Fi traffic offload. Even if more spectrum *is* required, the primary issue is about capacity. Hence, higher frequency bands, rather than sub 1 GHz bands, are best suited to meet that need.

Over the last decade, a number of mobile data demand forecasts have been published which support the first premise and, accordingly, spectrum has been identified (such as the 800 MHz and 2.6 GHz bands) to facilitate new 4G services. The general acceptance of these assumptions has led to additional measures being taken to allocate spectrum for IMT. For example, the 2012 Radio Spectrum Policy Programme has set a target for EU Member States to find at least 1200 MHz of spectrum to support increased demand for "wireless data traffic". In addition and closer to home, the UK government has set itself a target of releasing 500 MHz of sub-5GHz spectrum to the market – much of which is suitable for IMT[4] services.

However, evidence is emerging that questions the extent to which these assumptions should be accepted. As outlined below, the demand forecasts for mobile data have been significantly overplayed and there is evidence that increases in demand can be met through means other than through additional spectrum. This increasing uncertainty means that the extent to which far-reaching decisions on spectrum allocations can be made in the short term is questionable. The benefits of deploying IMT services in new allocations are entirely unclear and, yet, if pursued are likely to cause real and significant detriment to existing spectrum applications. This is because there are significant costs and consumer disruption in moving high value existing services which have millions of daily users. Regulatory failure would therefore result were it to subsequently prove impossible to realise the uncertain forecast benefits of IMT use of released spectrum.

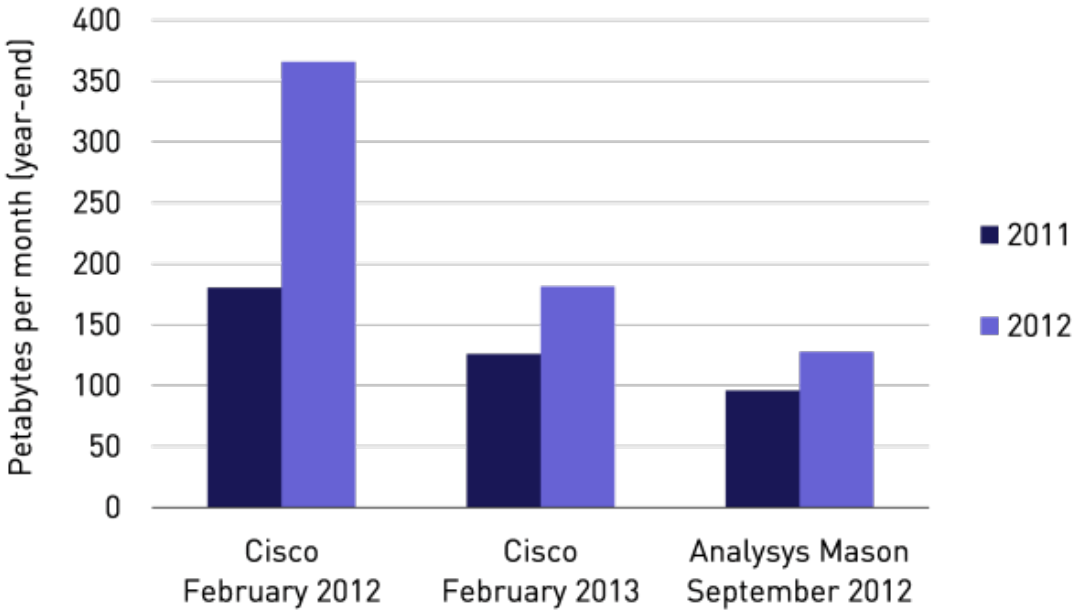
In particular, we would like to highlight a recent Cisco report, whose previous assessments have typically been used by policy makers to support the case for more IMT spectrum. It shows an overestimate of future data volume of mobile radio in Western Europe, effectively halving a forecast for less than one year in the future (forecast of February 2012 for December 2012). These revised

[4] The 2.3 GHz and 3.4 GHz bands, for example, are both subject to EU Decisions mandating deployment of mobile services

forecasts have been subject to further challenge by Analysys Mason[5], who claims that they are *still* significantly overstating the likely future demand for mobile data:

Figure 1: Sample variance in mobile data demand forecasts (Western Europe)

Source Analysis Mason - *http://www.analysysmason.com/About-Us/News/Insight/Cisco-mobile-data-forecasts-Feb2013/*



The historic unreliability of these forecasts suggests very high levels of uncertainty of mobile data demand forecasts, particularly given the reliance on these Cisco forecasts in the past as evidence for the "exponential" growth of the mobile use of the internet by increasingly data-hungry users. We note that Ofcom itself based its own assessment of significant increases in demand for data, in part, on the same 2012 Cisco report that has now been revised[6].

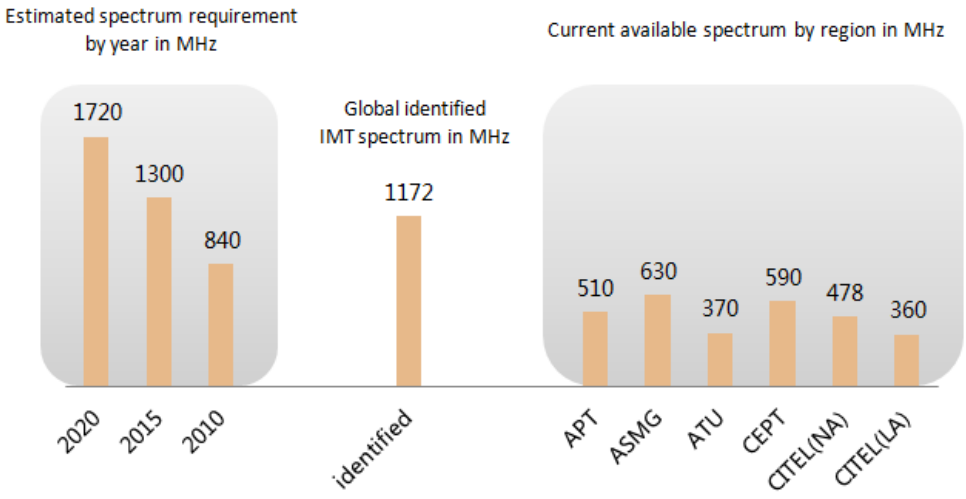
In terms of the second assumption that an increase in mobile data demand would inevitably result in the need to find additional spectrum allocations for IMT, there is some real world evidence that this may not necessarily be the case. At the very least, the urgent need for additional spectrum allocations may well be overstated when other more efficient measures for meeting increased mobile data demand are taken into account. This is particularly the case with the role of data off-loading, which Ofcom has acknowledged in this Call for Input as being part of a solution to meeting increased mobile data demand and which was a key reason for Cisco's reduction in its own mobile data forecast. We address this more fully in our answer to question 3 below.

Furthermore, we draw Ofcom's attention to the following figure which suggests that mobile operators are already successfully meeting demands for data based on a combination of existing spectrum holdings and other approaches:

[5] http://www.analysysmason.com/About-Us/News/Insight/Cisco-mobile-data-forecasts-Feb2013/
[6] *Securing long term benefits from scarce spectrum resources: A strategy for UHF bands IV and V,* Paragraph 3.8 http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/summary/spectrum-condoc.pdf

Figure 2 : Regional spectrum availability compared to forecasted requirements

Source *ITU-R M.2078*



This graph sets out a 2010 ITU estimate that by 2013, 1172 MHz of spectrum would be needed globally to meet forecasted demand for mobile data. However, in all regions, the spectrum available for IMT is shown to be less than this forecast requirement. Indeed, in some regions, less than half of this amount is available. And yet here we are, in 2013, and mobile networks in combination with Wi-Fi networks continue to carry all data traffic requested. Extensions to spectrum already identified, but not available, will allow significant increase in the capacity for data carriage. Taken together with reduced estimates of data growth, now should be the time to ask whether future estimates of spectrum requirements to meet demand remain valid.

Moreover, we note that much of the spectrum designated for IMT is still being utilised by legacy systems to deliver 2G voice and text services. Advances can be made by mobile operators in meeting demand for data by optimising their networks to reflect the evolving demands of consumers.

The example of Hutchinson 3G (H3G) in the UK further suggests that the topology of the network infrastructure is central to efficiently meeting high levels of data demand as opposed to the quantity of available spectrum. Before the 800 MHz/2.6 GHz awards in January 2013, H3G held 2 x 15 MHz of paired spectrum at 2.1 GHz. This accounted for only 9% of the paired spectrum holdings of the four MNOs[7]. Yet it carried 46% of the total UK data traffic[8]. This is, in part, because it has built its network specifically to carry mobile data and has designed it to do this in the most efficient way utilising the latest technology.

Finally, as we set out in more detail below, the role of small cell off-loading (especially the growing prevalence of Wi-Fi) appears to have been substantially underplayed by previous forecasts. The

[7] By comparison, Vodafone were licensed 2 x 37.8 MHz; O2 licensed 2 x 33 MHz, Orange 2 x40 MHz, and T-Mobile 2 x 40 MHz.
[8] http://www.three.co.uk/About_Three/Wholesale?intid=topnav

result of this is that much of the future increases in data demand will very likely be met by a means which will not call for more and more spectrum allocations and particularly not sub 1 GHz.

Considering additional spectrum frequency ranges for mobile broadband

The Call for Input helpfully sets out in Annex 6 the summary of frequency ranges under discussion under WRC-15 Agenda Item 1.1. The first band in that table is 470-694 MHz in which we clearly have an interest as this is the only spectrum that can be used to deliver free-to-air terrestrial TV content in the long term.

Ofcom signalled in its 2012 UHF Strategy Statement that, subject to the progress of international negotiations and spectrum re-planning work, it was minded to clear the 700 MHz band of broadcasting use, thus enabling the deployment of mobile services in that spectrum. As outlined below, we remain concerned about the implications of this policy decision and will work closely with Ofcom on the cost benefit analysis it is undertaking.

The only other band in which terrestrial TV transmission is harmonised, Band III (174-230 MHz), is not available for TV broadcasting in the UK as it is allocated to digital sound broadcasting (occupying around 37% of the band) and private mobile radio services (occupying the other 63%). As a result, a loss of the 700 MHz band for DTT would have a profound impact on its ability to deliver high quality free-to-air content. It would remove 12 of the 39 radio usable frequency channels currently harmonised for use by terrestrial TV broadcasting, representing just under one-third of the total.

Accordingly, it is imperative that the work of the Joint Planning Project (JPP) establishes the viability of Ofcom's assumption regarding existing coverage levels and number of multiplexes before any final decisions is taken regarding release of the 700 MHz spectrum. We will continue to work with Ofcom and the JPP to inform the decision-making process as quickly as possible, while remaining consistent with minimising uncertainty and risk.

As part of their UHF Strategy statement, Ofcom has outlined plans that if it were to clear the 700 MHz band, it would work to ensure that the DTT platform can access alternative frequencies via the 600 MHz band. We are grateful for Ofcom's commitment to the DTT platform in the longer term. It is clear that a minimum amount of spectrum needs to be retained by the DTT platform in the UK if we are to meet Ofcom's ambition of sustaining existing coverage levels. It is also necessary to sustain the number of multiplexes required to support continuing innovation, enhancing a service offering that sustains the competitive benefits of a DTT platform. We therefore consider it to be wholly inconsistent for Ofcom, in light of their stated position on DTT, to support further studies and discussions of the future of the 470-694 MHz as part of the preparatory work for WRC-15.

Indeed, if a final decision is made to clear broadcasting from 700 MHz, some very significant infrastructure investment decisions will be faced. Any rational decision of this nature will require some degree of certainty for whoever is responsible for committing the necessary resources. We believe that this degree of certainty would clearly be incompatible with any signal to industry that 470-694 MHz is being enabled for future mobile services.

The same decisions will be faced by the programme-making and special events (PMSE) sector that provide much of the high quality content for broadcasting as well as cultural, sporting and

community events. It similarly relies on the availability of UHF spectrum in significant quantities and also has no other credible alternative mode of delivery. No solution to the long recognised PMSE problem has ever been successfully arrived at.

We set out our views in more detail in our answer to question 8 below.

4. Responses to questions

Question 1: How much do you expect UK mobile data demand to change in the period 2015-2030? Please provide evidence for the trend and, where possible, please indicate how demand might vary across the device categories listed in paragraph 4.7

In order to ensure an informed debate on these issues, we suggest that Ofcom provides greater clarity on how it defines "mobile". At present, the term appears to be defined as consumption of content and data on mobile devices. However, we believe that this definition is unsatisfactory as measures of traffic show a pivotal and growing role for Wi-Fi offloading. Such offloading more properly belongs in the realm of fixed mobile broadband – an approach consistent with a Radio Spectrum Policy Group definition as set out in 2009[9]. We would suggest that genuine mobile use should be defined as where one mobile cell hands over to another as a result of a user's nomadic use. One of the effects of this definition would be to more correctly frame this debate as one where fixed networks (including Wi-Fi) are increasingly rising to the challenge of meeting significant increases in consumer data demand.

Definitions aside, there have been a number of studies which have assessed the likely increase in future mobile data demand. All of them have, in some way, qualified their analyses by pointing to the uncertainty inherent in such forecasts. There are a significant number of variables in these forecasts and the final estimate is sensitive to slight variations in a number of those variables. Many of these factors are reflected in Ofcom's Call for Input such as the previously understated role of off-loading, the impact of more efficient technologies, the potential for cell-splitting and the differing patterns of demand in different service environments.

We are concerned that these forecasts should not merely be based on conceptual and abstract calculations which take no account of real world developments. This is particularly important, given that there is growing evidence that some of the improbably high demand forecasts that have hitherto shaped the debate on spectrum allocations are not being borne out by reality.

As stated above, Cisco admitted in February 2013 that it had overestimated the volume of mobile data in Western Europe by nearly 80% in a forecast less than twelve months ahead (forecast of February 2012 for December 2012.) Cisco explained that it had not fully taken into account:

- the pricing policies of the mobile network operators, especially the abolition of "all-you-can-eat" tariffs;
- a slowdown in the sales of mobile connected laptops; and
- the extent of off-loading mobile data traffic via fixed networks.

This revised forecast was then itself judged to still be a significant overestimate of likely future data demand by Analysys Mason.[10]

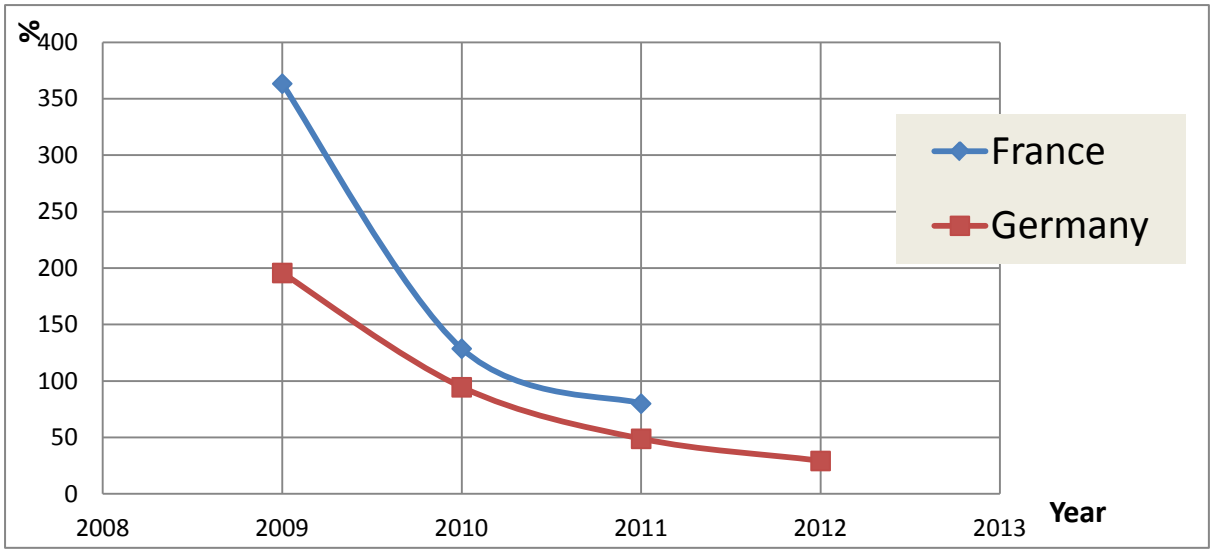
[9] RSPG09-284, Position Paper on Wireless Broadband
[10] http://www.analysysmason.com/About-Us/News/Insight/Cisco-mobile-data-forecasts-Feb2013/

Analysys Mason has evaluated data provided to it by European regulators and concluded that *relative* growth has been decreasing year on year. It says that a linear and not an exponential growth in data demand is to be expected in the coming years – and that will be driven by increased demand by those users without a strong affinity to technology (known as "late adopters"). It predicts that the data volume in Western Europe will grow by the factor of 3.6 in the period 2012–2017 which compares to Cisco's prediction of 7.6. According to the forecast by Analysys Mason, the total data volume in 2017 will be less than a third of the volume predicted by Cisco (taking into account a lower initial value and the lower predicted growth rate).

These more modest forecasts are broadly consistent with an assessment made by the Institut für Rundfunktechnik based on actual – not forecast - growth rates in demand for mobile data in France and Germany. These clearly indicate a significant trend of a slowdown in the rate of growth of data demand:

Figure 2 : Slowdown in growth of mobile data demand in France and Germany

Source *The Institut für Rundfunktechnik*[11]



The perceived wisdom on the purported growth in mobile data is that the availability of faster bit rates through, for example, LTE services will lead to significantly more data demand (especially video streaming) from users. However, the concept of increased availability of bit-rates actually *promoting* significantly increased demand for data is, intuitively, of limited value. We need to reflect on the growing evidence that where there is increased demand for video streams, this is aligned with consumer preferences for static viewing (primarily, home and office) and will continue to be met through some form of off-loading. The notion that this established behaviour will substantively change in response to data being available on a more mobile basis seems a specious one to us. We do accept that there will likely be *some* increase, particularly in areas of poor network capacity now where video quality will be limited. However, it is far from certain that this will lead to "explosive" growths in overall data demand in the future.

[11] Institut für Rundfunktechnik, *Growth of the mobile data volumes in France and Germany 2009 - 2012*

Of greater importance to policy makers should be the risk that excess spectrum capacity for mobile operators could lead to huge, inexpensive data plans for mobile broadband not by any intrinsic demand or consumer benefit, but simply by the need to get some kind of return on investment.

We are also concerned that the economic realities of pricing and tariffs appear to be missing from previous mobile data forecasts. Unconstrained access to spectrum could, of course, conceivably lead to "explosions" in demand by users who have no incentive to restrain how much data they are using. We note that Ofcom has not made specific provision in this Call for Input to take pricing impacts into account even though we consider it to be a crucial factor in assessing future data demand for the following reasons:

- Users' willingness or ability to pay for mobile services will be limited;
- The expansion of the networks is only possible to the extent that the customers are willing to pay for it; and
- Even where there is a strong competition between them, the network providers will price their services to end users in such a way that they can achieve a reasonable profit.

Typically, future mobile traffic forecasts span a wide range – from around 5-fold growth out to 2030 to more than 100-fold. Over the period to 2030, allowing for population growth (around 10%) and an increase to 100% data contract penetration per capita (from over 50% today), the number of people paying for mobile data in the UK would approximately double. Any increase in traffic beyond 2-fold must therefore imply higher expenditure on data per individual or correspondingly lower prices per GB of data. The plausibility of either or both of these outcomes should be explored as a sanity check on assumed mobile data growth.

Clearly, providing detailed forecasts of mobile data demand between 2015 and 2030 is beyond the scope of UK DTT multiplex operators. However, we urge Ofcom to reflect on the risks associated with making profound policy decisions *now* (such as those being discussed under WRC Agenda item 1.1) in an environment of such uncertainty and where the extent of future data demand is very much unclear.

Question 2: What evidence do you think is relevant to assessing the extent of consumer benefits associated with meeting the increase in demand for mobile data?

As set out elsewhere in this response, there will likely be great difficulty in assessing the consumer benefits associated with meeting the increase in demand for mobile data as a result of:

- The high levels of uncertainty of what that increase in demand will be;
- The lack of information on consumers' willingness to pay for that data (especially as recent developments suggest that there is some price sensitivity in the demand for 4G services); and
- An absence of a clear view on how any significant increase in demand should best be met.

The extent of any benefit associated with meeting the increase in demand for mobile data can only be assessed when compared with the full costs of the action taken to meet that demand. Our overriding concern is that it is far too early to be able to quantify any benefits that could accrue from allocating further spectrum to IMT. This is before the likely significant costs and consumer disruption of clearing high value existing users (such as DTT) from that spectrum are taken into account.

Again, we would caution Ofcom against supporting any policy position which could lead to an underutilisation of spectrum and has the effect of incentivising mobile network operators in the future to offer inexpensive data plans and not fully exploit the spectrum assets that they already own.

Question 3: What proportion of mobile data do you expect to be carried over a) Wi-Fi and similar systems in licence-exempt spectrum? How do you expect this to change over the period 2015-2030 and how do you expect total demand for Wi-Fi and similar systems in licence-exempt spectrum to change over the same period? How might this vary by location, environment?

Ofcom's March 2012 consultation, *Securing long term benefits from scarce spectrum resources - A strategy for UHF bands IV and V*, helpfully set out the four credible identified ways of meeting any significant increase in mobile data demand. These were:

- Using more spectrum;
- Upgrading existing mobile networks to more efficient mobile broadband technologies, including LTE (Long Term Evolution);
- Offloading mobile data onto fixed networks using Wi-Fi and Femtocells; and
- Building more mobile sites.

At the time, Ofcom suggested that a mixture of all four approaches would probably be required, notably including the need for additional spectrum. However, we believe that the central role of offloading to Wi-Fi and other small cell approaches may have been underplayed by Ofcom. We have set out above the revised Cisco and Analysys Mason mobile data demand forecasts - driven, in part, by the increased role of Wi-Fi offloading in meeting data demand.

We also note a separate piece of work being undertaken by Analysys Mason in support of the RSPP inventory process. In a document presented to commercial stakeholders in February 2013, it set out revealing new data that 80% of T-Mobile traffic could be "easily off-loaded to Wi-Fi". This startling admission contrasts with Ofcom's more tentative suggestion in its 2012 UHF Consultation that offloading "could serve over half of the predicted increased demand for mobile data capacity".

Again, references to real world measurements can give a more realistic view of these factors. For example:

- According to internal research, BBC iPlayer statistics show that amongst iOS users (which represented approximately 85% of all requests from mobile devices in an average week in February 2013), 92% of plays were requested via Wi-Fi compared to just 8% via 3G;

- According to 3 Reasons LLP, in the second half of 2012 c97.5% of video on demand[12] was delivered via Wi-Fi to tablets, and over c80% to smartphones. (We further note that this is in an environment where viewers watching i-Player on tablets has now surpassed those watching on smartphones[13]) ;

- Ofcom's own 2012 Communications Market report[14] states that 65% of tablets in the UK are only Wi-Fi enabled. Of those which are Wi-Fi *and* 3G enabled there will inevitably be some devices that download data through Wi-Fi exclusively or as its primary means; and

- Similarly, according to one US industry assessment in 2011[15], fully 90% of tablets do *not* actually connect to the internet via cellular networks and rely solely on Wi-Fi for data downloading.

These figures are consistent with the view given by the European Commission's communication, *Promoting the shared use of radio spectrum resources in the internal market,* in September 2012. In that document, the following was stated:

> *More than half of all smartphone traffic appears to be routed over Wi-Fi networks,* ***and this nomadic traffic is growing 4-6 times faster than mobile traffic*** *[our emphasis]*

In other words, while the Commission was broadly in line with Ofcom's assessment of the extent of current Wi-Fi offloading at about 50% of total data, it went much further in its assessment of the rapid growth and importance of this means of data delivery over the coming years. We also note that the above real-world signals of the future importance of Wi-Fi appear to far exceed the view of the Real Wireless report of 2012[16] which directly informed Ofcom's decision to support the clearance of the 700 MHz band. That report suggested a more modest range of between 45-60% of data being off-loaded through Wi-Fi by as late as 2030.

The current draft RSPG Opinion on *Strategic Challenges facing Europe in addressing the Growing Spectrum Demand for Wireless Broadband* goes further and sets out the essential desirability of promoting off-loading, stating:

[12] This measurement tracks long form, lawful content and excludes adult content and simulcasting.
[13] http://www.guardian.co.uk/media/2013/apr/19/bbc-iplayer-tablet-smartphone
[14] Ofcom, 2012 communications market report http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr12/UK_1.pdf
[15] http://www.chetansharma.com/US_Wireless_Market_Q4_2011_Update_Mar_2012_Chetan_Sharma_Consulting.pdf
[16] Real Wireless, *Techniques for increasing the capacity of wireless broadband networks: UK, 2012-2030*, April 2012 http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf

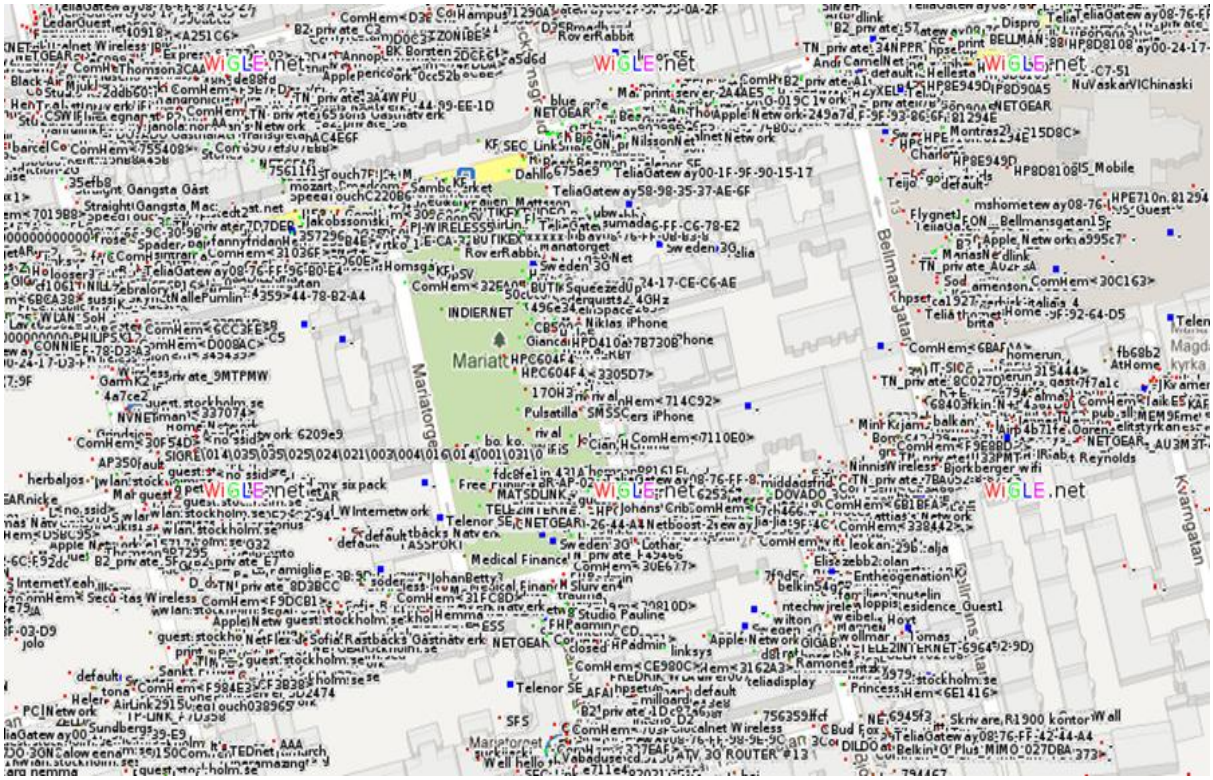
> *Wireless connections over short distances are more spectrally efficient as it allows for greater re-use of spectrum. Short distances are also preferred because of the power limitations of the user equipment.*

Furthermore small cells provide local capacity to meet demand as well as increasing macro cell capacity. A Small Cell Forum study indicated that with ten small cells per macrocell placed in high traffic locations the median (typical) throughput across all users is increased by 523% and that across macrocell users by 246%.[17]

These developments are in response to consumer preference and are aligned with stated EU policy on spectrum efficiency. Indeed, industry is continuing to respond to this consumer preference by developing a Wi-Fi eco-system that meets the European Commission's goal for the most efficient use of spectrum. This can be shown by the image below representing a plot of existing Wi-Fi Networks in a small part of Stockholm. The strikingly dense network of Wi-Fi devices strongly suggests that solutions are already being put in place in some countries to meet any future significant demand for data.

Figure 3 : Registered Wi-Fi networks in a part of Stockholm

Source www.wigle.ne



[17] SCF "W-CDMA Open Access Small Cells", May 2012, page 38, http://www.smallcellforum.org/resources-white-papers

More widely, AT&T will have deployed 40,000 small cells in the US by 2015.[18] Wi-Fi is also becoming a standard element of small cell equipment and may provide greater capacity in future with 802.11ac and potentially additional 5 GHz spectrum.[19]

Question 4: What factors will act to change the spectral efficiency of mobile technologies in the future? What spectral efficiency values are appropriate for consideration in our study for the period 2015-2030?

We set out below those factors that may drive spectral efficiencies over the time period although, as we have set out in some depth elsewhere in this submission, forecasting developments in this arena is fraught with uncertainty.

We note that much of these developments would focus on the further development and enhancement of small cell frequency re-use, including some requirement for regulatory intervention to ensure that consumer demand is not frustrated by lack of higher frequency spectrum. We would also expect to see some increased role for spectrum sharing. Other factors include:

- The coding and modulation employed in LTE is approaching theoretical limits for spectral efficiency so no great improvements can be expected from these. LTE does support higher order MIMO modes that have yet to be practically implemented, these will theoretically allow up to 10 fold capacity increases. In practical communication channels, these capacity increases are not achievable but increases of at least 3 fold on current LTE rates can be expected;

- The anticipated arrival of effective Femto-cell technologies in the 2.6GHz band allowing fibre to the kerb super-fast broadband circuits to provide further efficient offload from the mobile network (with appropriate design, the issues of network association and security that result in under-utilisation of WiFi networks could lead to more efficient and seamless offload of mobile traffic to new 2.6GHz femtocells and picocells);

- An increase in the density of cell sites and perhaps the development of newer more efficient or flexible technologies to replace current generation Wi-Fi for off-load (such as Mi-Fi);

- Work on natural expansion bands for Wi-Fi (e.g. 2.3 -2.4 GHz) , which is being considered in CEPT for mobile backhaul but should perhaps be considered as Wi-Fi expansion bands given their close proximity to the existing Wi-Fi band;

- Underutilised spectrum in the 2.6 GHz band (2500-2690 MHz) could also be shared for secondary Wi-Fi using emerging geolocation techniques which could identify whitespaces in this spectrum band;

[18] http://www.attinnovationspace.com/innovation/story/a7787182
http://www.att.com/gen/press-room?pid=23506&cdvn=news&newsarticleid=35661&mapcode=corporate%7Cconsumer
[19] http://www.plumconsulting.co.uk/pdfs/Plum_Jan2013_Future_proofing_Wi-Fi.pdf

- An adoption and deployment of Multimedia Broadcast Multicast Service (eMBMS) to support the efficient delivery of broadcast video to mobile devices;
- Further development of 3GPP standards, especially the completion of the development of 4G and then onwards to 5G; and
- The potential use of 1452-1492 MHz for supplemental IMT downlink capacity.

We also believe that Ofcom should consider the issue of device constraints in this context. Smartphones account for a significant share of mobile traffic growth. Their design also involves constraints and trade-offs in terms of the efficiency of the radio interface, particularly as support for additional frequency bands is added. In short, the more bands a smartphone is designed to support, the less efficiently it uses this spectrum.

A band requires one or more duplex filters and each duplex involves a loss of around 1 dB or 10% in terms of capacity. For a shared RF stage this loss applies not only for the additional band, but also existing bands. As the amount of spectrum available for mobile grows there may therefore be diminishing returns since as the quantity of spectrum available grows the loss associated with supporting another band becomes more significant (10% of a larger base is a larger loss in overall capacity).

These constraints may be particularly significant for the 700 MHz band which cannot be made available in the near term and would represent a relatively small increment (perhaps 2x30 MHz on a base of over 500 MHz). Furthermore, at lower frequencies a single duplex can only cover a small frequency range, and more than one may be required (particularly if requirements for roaming are considered).

Question 5: What service bit rates are appropriate for consideration in our study period 2015-2030? What evidence do you have of changing needs for service bit rates?

Portable devices are clearly likely to be able to take some advantage of higher bit-rates over this period as LTE networks begin to offer higher capacity. Indeed, there is no reason to assume that the maximum downstream bitrates offered by LTE networks won't increase considerably as those offered by UMTS have done.

However, the more relevant question is whether availability of greater mobile capacity will significantly change consumer behaviour away from the current tendency to consume high quantities of data (particularly video) from fixed locations such as home or the office. There will likely be some increase in genuine demand for mobile data but it is very unclear how significant this will be as static data consumption will likely remain the norm and continue to be met by off-loading. Again, if there are capacity issues that need to be addressed by spectrum they are likely to be localised and best met through higher frequency bands.

Other applications (web browsing, audio streaming etc) are already well supported by existing networks. The data demanded for these applications, therefore, is likely to depend on device penetration rather than demand per user.

Question 6: What proportion of traffic do you consider should be assumed to be carried on each cell types for the period 2015-2030? How will this vary with service environment ie between home, office, public areas, rural, suburban and urban? What evidence do you have of the factors affecting the uptake of small cells in licensed spectrum in the future?

Consistent with the details given in this submission, Ofcom should seek to facilitate, where necessary, the off-loading of traffic to small cell networks in response to consumer demand and in line with principles of efficient spectrum use. This may require action from Ofcom to enable sharing of small cell and Wi-Fi networks by mobile operators - enabling mobile users to more readily access data to meet any growing demand. We have set out in response to Question 3 above the extent to which small cells and Wi-Fi offload already plays a significant role in delivering data to mobile devices we see no reason why their importance should diminish over time.

Question 7: Given the current mix of services on cellular networks what is the ratio of downlink to uplink capacity currently dimensioned for and how would you expect this to change over time by 2015, 2020, 2025 and 2030? How do you expect the ratio of downlink to uplink demand to vary for the service categories given in Table A5.4 of Annex 5, and what factors might affect this? How does this ratio of downlink to uplink capacity change (if at all) with network technology and offload to licence-exempt systems?

We have no comment on this question.

Question 8: What are your views about the pros and cons of the frequency range in Table A6.1 for mobile broadband and for existing applications using this spectrum? Do you have views on other bands that are not in table A6.1?

Ofcom does not set out an analytical framework under which it would determine the suitability for taking forward studies on these bands. We would expect different stakeholders to seek some form of protection for those specific bands which are of interest to them.

However, we consider that a sensible objective framework for assessing suitability for IMT designations could be based on the factors below:

- Is the spectrum technically suitable for deployment of IMT?
- Is there an existing equipment or infrastructure that would facilitate deployment of IMT services?
- Is there a prospect that equipment or infrastructure that would facilitate deployment of IMT services will be available in a reasonable and relevant period of time?
- Is there likely to be alternative spectrum to facilitate displaced legacy users?

- Could displaced legacy users credibly use non-spectrum based platforms?
- Can legacy users of spectrum be displaced without significant consumer disruption and cost?
- Would making this band available for IMT conflict with existing UK spectrum policy?

Our principal concern with regards to the bands set out in Table A6.1 is the inclusion of 470-694 MHz as being suitable for further compatibility studies. We set out below how this spectrum scores against the suggested framework:

Table 1 : *Assessment of the suitability of 470-694 MHz for IMT*

Criteria	Score	Comment
Technically suitable for deployment of IMT?		Requires larger antennas that cannot be readily integrated into smart phones and will likely result in very poor efficiency. Lower frequency propagation characteristics deliver poor frequency reuse and spectrum efficiency in urban areas
Existing IMT equipment or infrastructure?		None globally.
Prospect of future IMT equipment or infrastructure?		No plans we are aware of to develop 470-694 for mobile services.
Alternative spectrum available for legacy use (broadcasting/PMSE)?		No other harmonised broadcasting spectrum of sufficient quantity and quality to facilitate legacy use.
Alternative platform available for legacy use (broadcasting/PMSE)?		Because of requirement for government intervention and/or technical unsuitability it would be almost implausible to change platforms.
Ability to avoid significant consumer disruption and cost?		c20m homes in the UK would face some form of disruption potentially requiring the replacement of more than 40m devices and Broadcast network re-engineering and will be subject to significant government intervention.
Conflicts with existing UK spectrum policy?		Appears to be inconsistent with the UK aim for a viable DTT platform until 2030

On the basis of this suggested approach, the spectrum at 470-694 MHz is likely to be almost uniquely unsuitable for IMT allocation at this time. On many levels, it presents obstacles that would suggest that it should be discarded as a candidate band for IMT for the foreseeable future.

That being said, we are concerned that Ofcom may still see no essential risk with this band being allocated on a co-primary basis to broadcasting and mobile services. In contrast, we consider that any change to the radio regulations to enable mobile services in this band would ultimately create uncertainty for the DTT platform, disincentivising investment in it (including in a platform-wide transition to DVB-T2/AVC), and would conflict with Ofcom's broader long-term goal for the DTT platform.

We support Ofcom's position on sustaining the DTT platform over the long term. However, we do not believe that the approach it adopted for 470-862 MHz in 2007 (namely, supporting a co-primary allocation) would be appropriate to the status of 470-694 MHz in 2015. Indeed, in light of the more recent experience of conferring co-primary status on the 700 MHz band, we consider it would be wholly inconsistent for the UK to support further studies and discussions of the future of the 470-694 MHz as part of the preparatory work for WRC-15.

In theory, a co-primary allocation does not, in itself, commit a Member State to deploy a service that is included in either one of the enabled allocations. Therefore, the new Region 1 status of the 700 MHz band in the Radio Regulations after WRC-2015 should not *automatically* lead to mobile services being deployed in that spectrum in the UK and/or EU. However, broadcasters' experience over the past two years strongly suggests that any move to repeat the 700 MHz process with 470-694 MHz may well be fatal to the DTT platform in the UK. It is clear that enabling mobile use of spectrum signals a clear direction of travel for both industry players and regulatory decision makers which significantly increases the likelihood of a total displacement of terrestrial broadcast services due to a lack of investment /innovation caused by the signals.

Indeed, in its April 2013 Call for Input, *Future use of the 700 MHz band,* Ofcom said the following:

> *The allocation for mobile use, on a co-primary basis with broadcasting, does not guarantee the band will be used for this service* ***but it is a significant enabler*** [our emphasis]

Ofcom appears to be tacitly accepting here that a co-primary allocation would be more than a mere administrative tool to improve flexibility in future spectrum use.

To further illustrate this point, in the European Commission mandate to the RSPG on the ongoing work identifying additional spectrum for wireless broadband, there is a reference to 700 MHz being "earmarked"[20] for mobile use. This clearly goes beyond the actual purpose of conferring co-primary allocation status and, indeed, exceeds the more neutral positioning of the Radio Spectrum Policy Programme which made no mention of the 700 MHz band.

The potential clearance of the 700 MHz band means that UK broadcasting will be faced with some very big challenges in the short term. More widely, far-reaching investment decisions would need to

[20] *Request for an Opinion on Strategic Challenges facing Europe in addressing the Growing Spectrum Demand for Wireless Broadband*, April 2012 https://circabc.europa.eu/sd/d/ebdbf8a7-d781-4c38-a3d3-2c3f9f4245c4/RSPG12-415%20Request%20for%20Opinion_Spectrum%20for%20Broadband%20Final.pdf

be taken to ensure that DTT infrastructure adapts to a truncated set of available UHF frequencies. Ofcom is currently undertaking an analysis of what the extent of these costs might be with an expected conclusion towards the end of 2013.

In that environment, it is inconceivable that the UK could support any current process (including taking part in compatibility studies) which could ultimately lead, or be perceived to lead, to a co-primary allocation of 470-694 MHz and a repeat of the 700 MHz experience. It is equally unclear how any large-scale investment decisions could be made to migrate services out of the 700 MHz band if, ultimately, there was such uncertainty over DTT's long term access to the remaining spectrum in the 470–694 MHz band.

Furthermore, it is unclear to us *why* any sustained proposal to extend the Radio Regulations allocation of 470-694 MHz to include mobile services should be made unless there was some specific desire to use that spectrum for that purpose. Bearing in mind that the UK is committed to ensuring the long term viability of the DTT platform, it is unclear what purpose would be served by prolonging detailed discussions whereby potential mobile services could be enabled in 470-694 MHz. The UK has explicitly ruled out that option in the long term.

On a technical level there are some significant challenges in using 470-694 MHz for mobile use which should call into question this band's suitability for IMT use. Low frequency spectrum requires larger antennas that cannot be readily integrated into smart phones and are likely to deliver very poor efficiency at these frequencies. Low frequency spectrum would also quickly become congested in urban areas due to its lower roll-off with distance and capacity requirements could only be met by very large numbers of cells operating at very low powers. In contrast, low cost femtocells integrated into ADSL modems and cable modems using higher frequency spectrum would be a substantially more efficient means of providing relatively uncontended access.

Also, man-made noise becomes significant at lower frequencies such as 470MHz and is likely to be produced by the device receiving the mobile data. By comparison, spectrum at 1800MHz and above has negligible noise levels. The precise difference in noise levels is not known but this would need to be investigated before proceeding with lower frequency mobile network plans.

Finally, Ofcom must consider the very important issue of programme making and special events (PMSE) when assessing its approach to 470-694 MHz. Users of wireless microphones and in-ear monitors belong to a sector that, according to Ofcom, significantly contribute to the social and cultural well-being of the UK. PMSE provides the content that underpins cultural and sporting events, theatres, broadcasting and community events (such as church and schools).

However, wireless microphones and in-ear monitors need access to spectrum in sufficient quantity and quality that can only be provided by the spectrum used by broadcasting (on an interleaved basis). Indeed, it is unclear whether the particularly high spectrum demands of UK professional PMSE users will effectively be met in the event that the 700 MHz is cleared of broadcasting use. To Ofcom's (and, indeed, the European Commission's) credit, there has long been an acceptance that the reduction in UHF spectrum availability for broadcasting will cause a significant challenge for PMSE. However, no long-term solutions have ever been forthcoming for this sector.

We therefore urge Ofcom to ensure that no approaches are taken to the 470-694 MHz band which could lead to the further undermining of this crucial sector. After the recent disruption brought about by DSO, PMSE users may be faced with additional significant investment decisions as the result of a 700 MHz clearance. We would argue that, as with broadcasting, a period of certainty is now essential for PMSE users to allow them to make those decisions, ensuring a viable and sustainable future.

Question 9: 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?

We note the absence of a number of bands from this table that, whilst allocated for mobile use and liberalised to enable deployment of 3G and 4G services, continue to deliver legacy 2G voice and text services. This is the case with the 900 MHz and (most of) the 1800 MHz bands. Not only do we consider that these should be included in the table but we would further suggest that these bands should be the priority for any assessment for spectrum which should be made available for the future delivery of mobile data.

Similarly, unpaired TDD spectrum at 1900-1920 MHz and 2010-2025 MHz are currently unused and have been fallow in most countries since the 3G awards of the early 2000s. The lack of deployment of services in these frequencies has led the European Commission to initiate a programme of work that will likely lead to intervention to force deployment of services.

Question 10: What are your views on bands which should be a priority for mobile broadband?

As set out above, the premises that underpin the notion that further spectrum actually *needs* to be found for mobile broadband need rigorous analysis and validation before they can be relied upon to support policy decisions. With existing allocations in the 800 MHz band, 900 MHz band, 1800 MHz band, 2.1 GHz band, 2.6 GHz band and 3.4 GHz band (some of which are not being utilised to support mobile broadband services); with spectrum further identified in the 700 MHz band, 1.4 GHz band, 2.3 GHz band and 3.6 GHz band; with spectrum allocated for Wi-Fi in the 2.4 GHz band and 5 GHz band, and in an environment where the purported explosion in mobile data demand (as distinct from increased data being offloaded) is most uncertain – we very much question whether this exercise is actually necessary at this stage.

We reiterate our view expressed in our answer to question 8 that, in light of Ofcom's stated position on the desirability of a long-term viable DTT platform, it would be wholly inappropriate for the UK to support further studies in the 470-694 MHz band. Any future investment decisions in this spectrum would be seriously compromised by any signals that this band was being investigated for future mobile allocations.

Ofcom may wish to consider that higher frequencies will become relatively more attractive for capacity purposes over time since larger bandwidths may be available at higher frequencies and a single duplex can cover a wider frequency range. We would therefore suggest that any work on

securing additional spectrum for IMT should be focussed on those higher frequencies as opposed to less suitable spectrum, especially sub-1 GHz.