Securing long term benefits from scarce spectrum resources

A strategy for UHF bands IV and V

Consultation

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Section 1

Executive summary

In this consultation we are aiming to secure long term benefits from scarce spectrum resources in UHF spectrum bands IV and V

1.1 Spectrum is an essential building block in the communications sector, enabling the delivery of a wide range of services spanning television and radio through to mobile telephony, emergency services and outside broadcast event coverage.

1.2 Changing the use of spectrum from one service to another can take several years and in some cases more than a decade, especially where new international agreements are required and where there are existing users of the spectrum whose requirements need to be taken into account.

1.3 In contrast the pace of innovation and change in the communications sector is accelerating. In particular, there is an unprecedented growth in the demand for mobile broadband capacity.

1.4 This tension raises the need for a long term strategic approach which can help both:

- Matching the future supply of spectrum with demand for services capable of delivering significant benefits to citizens and consumers; and
- Retaining sufficient flexibility to respond to uncertain future service, market and international harmonisation developments.

1.5 The need for this approach is particularly relevant for UHF band IV and V spectrum (shown in figure 1) because:

- This spectrum is in scarce supply and is in demand by a wide range of services including: digital terrestrial television (DTT), mobile broadband, local TV, programme making and special events (PMSE), emergency services, and applications using white space devices (WSD);
- The use of high power DTT transmitters in this spectrum requires international agreements to co-ordinate any significant changes to its use.

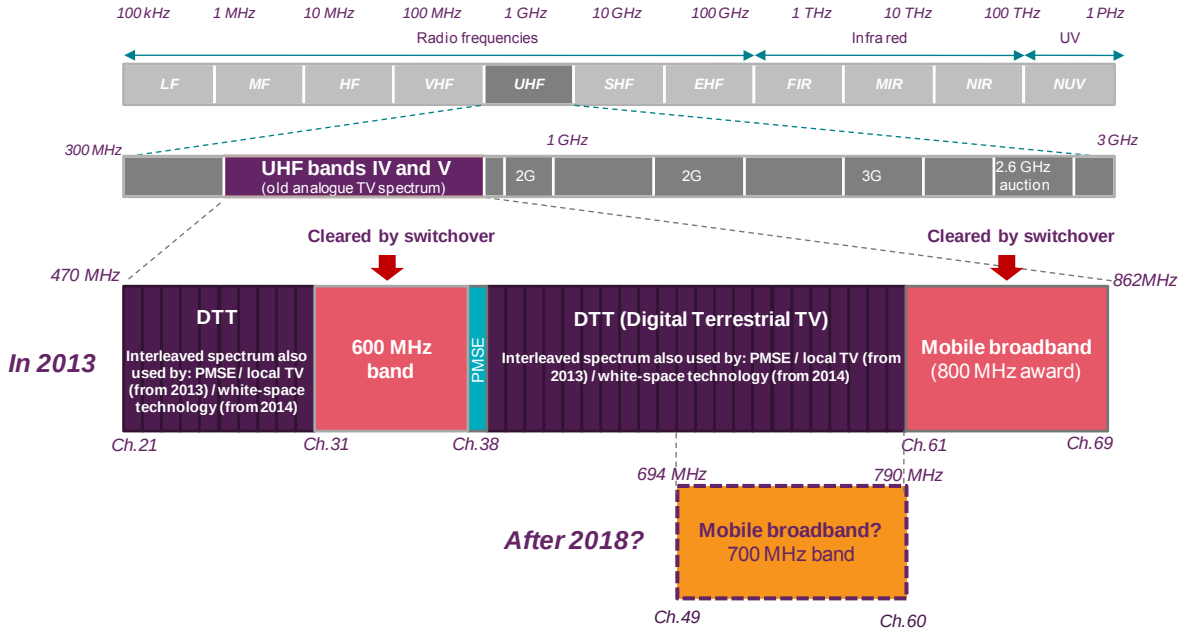
1.6 In this consultation we set out a proposed strategic approach for this spectrum capable of achieving positive outcomes over the long term. These are:

- Sustaining the delivery of DTT and other services which make shared use of its spectrum; and
- Enabling the future release of potentially valuable harmonised mobile broadband spectrum in the 700 MHz band to meet the growth in demand for mobile data capacity.

1.7 We consider that this strategic approach is a crucial step towards ensuring the best possible use for these important bands over the long term. However, it is important to recognise that decisions on the most appropriate processes and timescales for any

future change of use in the 700 MHz band need to be taken closer to the time of implementation and will need to be informed by more detailed work.

Figure 1 - UHF bands IV and V and the 700 MHz band



Demand for mobile broadband capacity is increasing rapidly

1.8 There is a rapid growth in the demand for mobile broadband capacity driven by the increasing use of video and data services on smart phones and tablet PCs. Under a mid-level growth scenario, mobile data capacity demand will experience an 80 fold increase between 2012 and 2030[1], and a 300 fold increase under a high-growth scenario.

1.9 Meeting this growth in demand could deliver significant benefits to citizens and consumers by:

- Enabling the future delivery of higher capacity mobile services, supporting further innovation in mobile applications;
- Ensuring that the UK's mobile infrastructure is capable of supporting future growth in the wider economy; and
- Enabling the future delivery of next generation video and data based emergency service applications.

Additional mobile broadband spectrum will be needed to meet this growth in demand

1.10 Mobile operators can use a range of different approaches to increase the capacity of their networks. These include:

[1] See Real Wireless report on techniques for increasing the capacity of wireless broadband network: http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf

- Using more high and low frequency spectrum. We estimate this could provide between a 7 and 13 times increase in mobile data capacity by 2030;

- Upgrading existing mobile networks to more efficient mobile broadband technologies, including LTE (Long Term Evolution). We estimate this could provide between a 3 and 10 times increase in mobile data capacity by 2030;

- Offloading mobile data onto fixed networks using Wi-Fi and Femtocells. We estimate that this could serve over half of the predicted increased demand for mobile data capacity; and

- Building more mobile sites. This tends to be a higher cost option for mobile operators and can be constrained by the need to secure planning consent for new sites.

1.11 To meet the expected increase in mobile capacity demand a combination of these approaches is likely to be needed.

1.12 The use of additional mobile broadband spectrum can play a special role in reducing the number of new mobile sites that need to be built, reducing network deployment costs and the need to secure planning consent for a large number of new sites.

1.13 In practice, only additional spectrum which has been internationally harmonised for mobile broadband is likely to be used because harmonisation increases economies of scale, widening the availability of handsets and reducing prices.

1.14 Additional harmonised spectrum is likely to be made available by:

- The planned 800 MHz and 2.6 GHz spectrum awards;

- The re-farming of existing 2G mobile bands to 3G and LTE;

- Government's plans to release 500 MHz of public spectrum, part of which could provide a significant amount of additional higher frequency harmonised spectrum including the 2.3 GHz and 3.4 to 3.6 GHz bands; and

- Other emerging higher frequency spectrum options include the 1.452 to 1.492 GHz and 3.6 to 3.8 GHz bands, which are subject to ongoing harmonisation work in Europe.

Additional lower frequency mobile broadband spectrum in the 700 MHz band could be particularly valuable

1.15 The availability of additional harmonised mobile broadband spectrum at lower frequencies is likely to be limited. Lower frequency spectrum can be particularly valuable for mobile broadband use because its good propagation characteristics mean that it can:

- Deliver important savings in the number of new mobile sites that will need to be built to meet the expected growth in demand for mobile data capacity; and

- Provide better quality of service in difficult to reach indoor and outdoor locations.

1.16 The 700 MHz band, which is currently used to deliver DTT and other services on an interleaved basis, represents the most attractive option for providing additional lower frequency spectrum. This is because there is now global momentum behind it being harmonised for mobile broadband:

- In the US, the 700 MHz band is being used for mobile broadband LTE services;
- In Asia, Australia and New Zealand are planning to use the 700 MHz band for LTE, whilst India as well as various other countries are exploring a similar approach;

1.17 In Europe, Africa and the Middle East a resolution was passed at the 2012 World Radio Conference (WRC 12) paving the way to a decision to enable the 700 MHz band to be used for mobile broadband after the next World Radio Conference in 2015. A key driver for this was a strong desire by several African countries to launch LTE services in the 700 MHz band.

1.18 Enabling the use of the 700 MHz band for mobile broadband in the UK would require a new international frequency co-ordination agreement. This could take several years to complete and will depend on the position adopted by other European countries. Our current view is that the earliest date this could be achieved is 2018, provided there is sufficient agreement in Europe.

The use of the 700 MHz band for mobile broadband could affect DTT and other services sharing the spectrum it uses

1.19 The DTT platform currently performs a very important public policy role in providing universal low cost access to Public Service Broadcasting (PSB) content, whilst also providing a wider consumer choice of channels, receiver equipment and platforms.

1.20 These roles are likely to remain relevant at the time when the 700 MHz band could be released for mobile broadband. This is because it is likely that the DTT platform will continue to be the platform of choice for many viewers, and switching to alternative platforms at this time would require DTT viewers who have no broadband subscription or satellite dish installation to incur additional costs.

1.21 Over a much longer (post 2030) timeframe the universal take-up of superfast broadband could enable IPTV services to provide a viable substitute for the DTT platform, enabling a potential future DTT switch-off scenario. We do not believe that this scenario is a viable option within the shorter timescales considered by this consultation.

We propose a strategic approach capable of achieving positive outcomes over the long term for mobile broadband, DTT and the services it shares spectrum with

1.22 In this consultation we set out a proposed strategic approach for UHF bands IV and V spectrum capable of achieving positive outcomes over the long term. These are:

- Being able to release the 700 MHz band, alongside other higher frequency mobile broadband spectrum, to help avert a capacity crunch on mobile broadband networks; and

- Retaining an amount of DTT spectrum that supports its role in providing important benefits, as well as supporting the other services sharing spectrum with DTT.

1.23 There are two main factors that could help achieving these outcomes:

- Future improvements in digital television compression and transmission technology; we expect these will be progressively implemented by the market, enabling increasing efficiencies in spectrum usage for DTT over the next decade;

- The potential use of the 600 MHz band released by digital switchover for DTT and the other services making shared use of its spectrum, if the 700 MHz band is released for mobile broadband. This could reduce risks that the DTT platform is unable to deliver the objectives set out below.

1.24 The amount of broadcast capacity required by the DTT platform to deliver benefits to citizens and consumers can be viewed from:

- *A public policy perspective:* the amount of broadcast capacity needed to deliver the PSB channels;

- *A platform sustainability perspective:* the amount of broadcast capacity required to enable the DTT platform to remain sufficiently attractive to viewers so that it can remain commercially sustainable as a platform and hence a means of providing access to the PSB channels;

- *A consumer choice perspective:* the amount of broadcast capacity required to sustain consumer choice in TV content, platforms and equipment.

1.25 If the DTT platform were re-planned without the 700 MHz band and no additional spectrum, it could, subject to future international agreements, deliver three multiplexes with 98.5% coverage, the same level of coverage that will be achieved by the current three PSB multiplexes post digital switchover (DSO). However, this would only provide half of the broadcast TV capacity available on the DTT platform today.

1.26 There is a significant risk that these three multiplexes would provide an insufficient amount of DTT broadcast capacity to meet all of the objectives set out above. This risk is increased if:

- There is a slow platform transition to more efficient broadcast standards;

- Viewer preferences shift from standard to high definition television consumption;

- IPTV does not provide a viable means of compensating for the reduced level of DTT broadcast capacity, for example because of insufficient broadband take-up or caps on broadband data usage.

1.27 To reduce this risk the 600 MHz band could be used to provide additional DTT capacity after the release of the 700 MHz band. Using this spectrum, the DTT platform would be able to continue to operate with six multiplexes and maintain PSB multiplex coverage.

1.28 Under these circumstances the 600 MHz band would be used as part of a frequency re-plan of the DTT platform after 700 MHz release. This would mean that we would

not award long term rights for the 600 MHz band that would limit our ability to change its use and/or re-plan the spectrum in the future.

1.29 A potential cost of this approach is that 600 MHz spectrum could not be used for alternative innovative applications in the longer term. However, across much of the world the 600 MHz band is harmonised for DTT use making this the most likely attractive use of this spectrum.

1.30 A potentially attractive innovative alternative use of the 600 MHz band is services based on White Space Devices (WSDs). WSDs are being developed to operate across the whole of the DTT band and would be able to operate in the 600 MHz band on an interleaved basis if it were used for DTT.

Achieving these positive outcomes will depend on the careful management of the wider impacts of the future change of use of the 700 MHz band

1.31 The implementation of any future change of use of the 700 MHz band is likely to have associated costs. These will need to be carefully considered as decisions are taken in future on the most appropriate timescales and processes for achieving such a change of use.

1.32 We believe that by preparing sufficiently early for any future change of use of the 700 MHz band will help reduce any associated costs and disruption this could cause for consumers and other stakeholders.

1.33 We believe that such preparatory action should include:

- Ensuring that a future frequency re-plan of the DTT platform remains compatible with roof top antennas by signalling the need for wideband antennas capable of operating across the whole of the DTT band;

- Ensuring that mobile broadband services operating in the 700 MHz band and DTT services can co-exist by an early signalling of the need for DTT receivers to be capable of functioning with 700 MHz mobile broadband services;

- Ensuring the continuing provision of PMSE, local TV and white space device based services. This could be achieved by the early signalling of the need for future equipment to be capable of operating in the interleaved spectrum of a re-planned DTT platform, and the need to achieve longer term spectrum efficiency savings, including the progressive digitisation of analogue services and the adoption of cognitive radio technology.

1.34 In addition to the above, using the 600 MHz band as part of a frequency re-plan for the DTT platform to enable a change of use of the 700 MHz band will make it easier for this re-plan to remain compatible with existing roof top antennas, and provide an increased amount of DTT spectrum to share with other services.

1.35 A combination of these steps should ensure that the wider impacts of a change of use of the 700 MHz band can be managed to maximise benefits for citizens and consumers over the long term, whilst minimising any associated costs and disruption.

The outcome of this consultation will establish a longer term strategic framework for decisions relating to the future uses of UHF band IV and V

1.36 Through this consultation Ofcom intends to establish:

- A long term view on the future demand for mobile broadband capacity and the frequency bands and techniques that could be used to meet this growth in demand;
- Whether our long term strategic approach to UHF band IV and V spectrum should be to enable the future harmonised release of the 700 MHz band for mobile broadband, whilst ensuring that the DTT platform and other services sharing the spectrum it uses can continue to provide important benefits to citizens and consumers;
- Whether we should enable use of the 600 MHz band as part of future re-plan of the DTT platform following the release of the 700 MHz band for harmonised mobile broadband use, and if so, how this spectrum should be released for shorter term use; and
- The UK's position in future international harmonisation and co-ordination activities for the 700 MHz band.

1.37 We invite all interested stakeholders to respond to this consultation by 7 June 2012.

Section 2

Purpose and scope of this consultation

2.1 Spectrum is a scarce resource that makes a substantial contribution to the UK economy and society. It is an essential building block in the communications sector, enabling the delivery of a wide range of services spanning television and radio through to mobile telephony, emergency services and outside broadcast event coverage. Through these and other services, spectrum provides substantial value to UK citizens and consumers.

2.2 It can take a number of years to enable spectrum change of use, especially where international agreements on the harmonisation and co-ordination of spectrum use are required and there is an established user of the spectrum whose needs must be considered. In contrast, the pace of service developments in the communications sector is accelerating; for example, whilst it took 14 years for multichannel television to achieve 50% household penetration, it is predicted that smartphones will reach 50% penetration within 6 years[2].

2.3 In recognition of the challenge of matching spectrum supply to these service demands, this consultation seeks to develop a better understanding of the future demand for scarce spectrum resources by different services and to identify the steps we should take now best secure the greatest value for citizens and consumers over the long term. However, developing such a long term approach is not without risks as this requires reaching a view on uncertain future service and market developments and their future impact on spectrum demand.

2.4 In this document we give particular emphasis to the spectrum challenge posed by the rapidly increasing demand for mobile broadband capacity. The need for additional spectrum to meet the anticipated increase in demand for wireless and mobile data has been widely recognised internationally, for example:

- The UK Government announced plans in 2010 to identify and release 500 MHz of publicly-held spectrum below 5 GHz, part of which will help with meeting the growing demand for mobile data[3].
- The adoption of the European Radio Spectrum Policy Programme (RSPP) in 2012 included the intention to make 1200 MHz of spectrum available for wireless broadband services, half of which will comprise new allocations.
- In the United States, the Federal Communications Commission's (FCC) National Broadband Plan set out in 2010 the intention to make 500 MHz of spectrum available for mobile services within 10 years.

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[2] Oliver and Ohlbaum, as referenced in Ofcom, Communications Market Report 2011, figure 1.23, http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr11/UK_CMR_2011_FINAL.pdf

[3] Following an announcement as part of the Spending Review 2010, the Government published an action plan in March 2011 (http://www.culture.gov.uk/publications/7994.aspx) and an update in December 2011 (http://www.culture.gov.uk/publications/8690.aspx)

2.5 Spectrum has a potentially important part to play in meeting the growth in demand for mobile data capacity alongside other capacity enhancing techniques including:

- the use of more efficient mobile technologies;
- reducing cell sizes by adding more mobile sites; and
- offloading mobile traffic onto fixed networks using Wi-Fi and Femtocells.

2.6 Much of the additional mobile broadband spectrum that is likely to become available to help meet this growth in demand will be at higher frequencies, above 2 GHz. This includes the spectrum likely to be released by the Government.

2.7 In contrast, there is likely to be a much greater scarcity in the supply of additional mobile broadband spectrum below 1 GHz. This spectrum is particularly attractive for mobile network applications due to its good propagation characteristics.

2.8 Only spectrum which has been internationally harmonised is likely to be used by mobile operators, because this harmonisation increases economies of scale for handsets and network equipment, reducing prices. The leading candidate for providing additional harmonised sub 1 GHz spectrum for mobile broadband applications is the 700 MHz band shown in Figure 2, which is currently used by the digital terrestrial television platform. This is because:

- In North and South America (ITU Region 2), the 700 MHz band has already been allocated to mobile broadband and is being used to deploy LTE based mobile services on a mass market scale in the United States; other countries in this region are also considering or moving towards use of this band for mobile broadband over the next few years;
- In the Asia Pacific region (ITU Region 3), the 700 MHz band has already been allocated to mobile broadband. Countries including Australia and New Zealand are likely to release this band in the short term enabling LTE deployments, whilst in others, like India[4], plans for release are currently at an early stage;

2.9 As for Europe, Africa and the Middle East (ITU Region 1), a resolution was recently passed at the recent 2012 World Radio Conference (WRC 12) indicating that, subject to the completion of relevant technical work, a decisions to allow the 700 MHz band to be used for mobile broadband services will be taken at the next World Radio Conference in 2015 (WRC 15).

2.10 These international developments raise questions for the future use of UHF band IV and V spectrum in the UK, of which the 700 MHz band forms part.

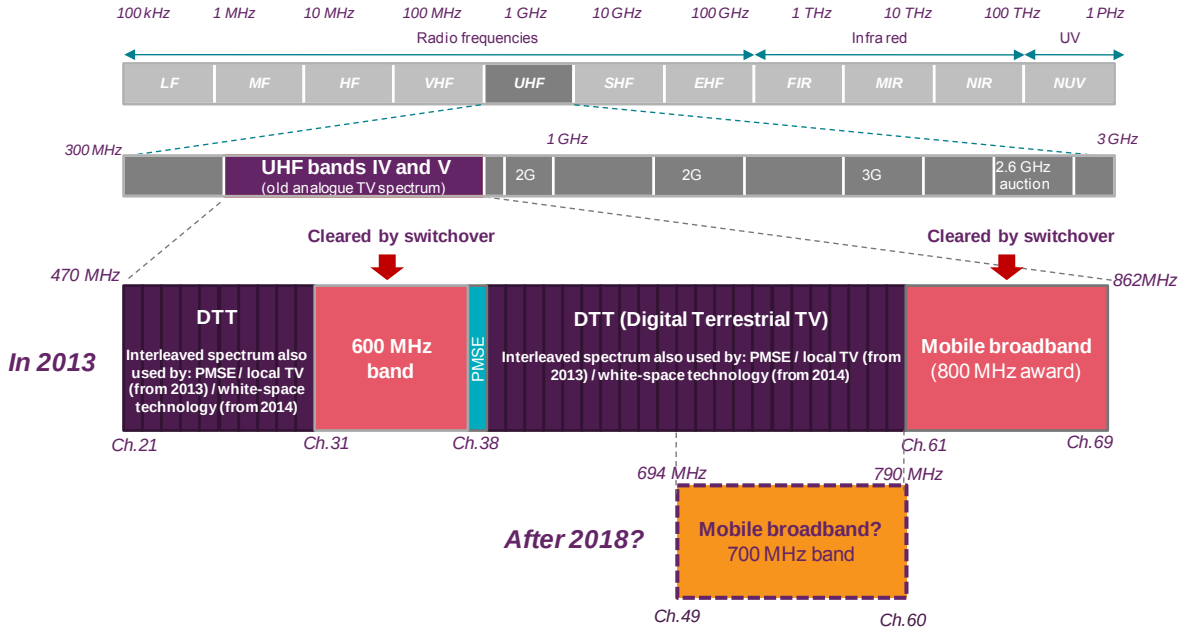
2.11 The propagation characteristics of this spectrum makes it attractive for the delivery of a variety of services, including:

[4] India is one of the countries in ITU Region 3 that explicitly identified spectrum in the 700MHz range for IMT applications during the 2007 World Radio Conference (see Radio Regulations footnote 5.313A). It has been recently reported that the Indian Government is considering a potential release of the 700MHz band for mobile broadband – see http://economictimes.indiatimes.com/news/news-by-industry/telecom/egom-decides-to-free-700-mhz-spectrum-for-4g-services/articleshow/12150669.cms

- Broadcast digital terrestrial television services (DTT);
- Programme Making and Special Events (PMSE) services which share DTT spectrum on a geographically interleaved basis[5];
- Local TV services, which are also planning to share DTT spectrum on a geographically interleaved basis; and
- Applications based on white space device technology (WSD).

2.12 Any future change of use of the 700 MHz band for mobile broadband could therefore impact on the delivery of all these services.

Figure 2 - UHF bands IV and V and the 700 MHz band



2.13 In general, we believe that it is best to minimise the level of intervention by the regulator in resolving competing demands for scarce spectrum resources. This is because we believe that the markets are generally better placed to efficiently allocate scarce resources.

2.14 However, we do not believe that market forces alone can determine the future use of the 700 MHz band which maximises benefits for citizens and consumers because:

- Markets may not always take into account external value such as that delivered by PSB content. Ofcom has a role here in establishing an appropriate balance of use that takes account of the public policy objectives like those related to the delivery of PSB content delivery and emergency services provision;

[5] The DTT platform uses different frequencies to broadcast the same services at different transmitter site locations. This approach results in what is known as a multiple frequency network (MFN) where there are a number of unused frequencies at each transmitter site. These unused frequencies are collectively known as interleaved spectrum and can be used at lower transmitter powers

- There is a need for the international coordination of the high power frequency assignments used by broadcast services and new assignments for mobile broadband services – where Ofcom has a clear role to play in representing UK interests;

- A potential change of use of 700 MHz band for mobile broadband use would require a complex frequency re-planning exercise of the UHF band IV and V spectrum requiring a significant degree of coordination between existing DTT, PMSE, local TV users and new mobile broadband and white space users. There is a high risk of co-ordination failure occurring between these different sets of stakeholders in completing this task and regulatory action is likely to be required to facilitate any future re-planning exercise; and

- Broadcast and mobile services are characterised by different technical requirements for spectrum usage, which makes it difficult to design a technology neutral award for these services.

2.15 For these reasons, Ofcom has a potentially important role to play in terms of both determining whether the future use of the 700 MHz band for mobile broadband is likely to secure greater benefits of citizens and consumers over the long term and in helping facilitate industry stakeholders to deliver these benefits.

2.16 In this document we also consider whether use of the 600 MHz band could play a part in securing future benefits from any change of use at 700 MHz. The 600 MHz band has historically been used for analogue terrestrial television broadcasting and will be available for new uses when DSO completes later in 2012. As noted by various stakeholders who responded to our April 2011 Call for Input[6], it is important to ensure that our approach to the use of spectrum at 600 MHz is consistent with a longer term view on securing the greatest benefit from the whole of UHF bands IV and V.

Our relevant duties

2.17 In performing this role Ofcom needs to balance the different competing demands for scarce UHF spectrum resources by different services in a way that is consistent with our primary duty, as set out in section 3(1) in the Communication Act 2003 of:

- Furthering the interests of citizens in relation to communications matters; and

- Furthering the interests of consumers in relevant markets, where appropriate by promoting competition.

2.18 In carrying out our functions pursuant to our primary duty, we are required to secure a range of other matters which are also particularly relevant to developing our long term spectrum strategy:

- Securing the optimal use of spectrum taking into account current and future demand[7];

[6] See paragraph 2.29 in this document and http://stakeholders.ofcom.org.uk/consultations/uhf-spectrum-bands/

[7] Section 3(2)(a) Communications Act 2003 and section 3(1) Wireless Telegraphy Act 2006

- Securing the wide-ranging availability of communications services and TV and radio services of high quality and wide appeal[8], and duties relating to fulfilling the purposes of public service broadcasting in the UK[9].

- Promoting competition, encouraging investment and innovation and encouraging the availability and use of high speed data transfer services throughout the United Kingdom[10].

2.19 In addition, general duties derived from the European regulatory framework are of relevance to our strategic spectrum approach. These include the objective of contributing to the development of the internal market by, among other things, removing obstacles to the provision of electronic communications networks and services at a European level and encouraging the interoperability of pan-European services[11].

2.20 We have had regard to the full range of our statutory duties in preparing this consultation.

Structure of this document

2.21 Based on an understanding of the market developments likely to impact on the future demand for scarce spectrum resources by mobile, DTT and other relevant services, this consultation is seeking to develop a long term strategic approach for enabling these demands to be met in a way that secures significant benefits for citizens and consumers.

2.22 **In Sections 3 to 5** we explore the key demand and technological trends that are likely to affect long term spectrum demands for mobile broadband, DTT, and other relevant services including emergency services, PMSE, Local TV and applications based on white-space device technology.

2.23 **In Section 6** based on the findings of previous sections, we set out our view on the objectives for DTT and mobile broadband that are most likely to secure significant benefits for citizens and consumers over the long term. These are: to enable the release of the 700 MHz band and other higher frequency bands for mobile broadband once it is internationally harmonised and coordinated, and to maintain a certain amount of spectrum for DTT use such that it can continue to deliver important benefits to citizens and consumers. We also consider the likelihood of being able to meet these objectives both with and without using the 600 MHz band released by digital switchover in a frequency re-plan of the DTT platform, after the release of the 700 MHz band for mobile broadband.

2.24 **In Section 7** we outline the potential wider impacts on consumer equipment and other services likely to be associated with any future release of the 700 MHz band for mobile broadband and how these impacts could be managed by preparing for these changes sufficiently early and using the 600 MHz band as part of a frequency re-plan of the DTT platform. These include: the potential impact of frequency re-plan of the DTT platform on existing consumer DTT antenna installations; the future co-

[8] Section 3(2)(b) and (c) Communications Act 2003
[9] Section 3(2)(a) Communications Act 2003
[10] Section 3(4)(b), (d) and (e) Communications Act 2003
[11] Article 8 of the Framework Directive (Directive 2002/21 – as amended)

existence of mobile services operating in the 700 MHz band with DTT services; the potential need for a new 700 MHz international band plan for mobile services; the need for some local TV services to change frequencies; the amount of interleaved DTT spectrum available for PMSE and services operating with white space devices.

2.25 **In Section 8** in light of the findings of previous sections, we outline why the approach discussed in sections 6 and 7 is likely to secure significant benefits for citizens and consumers from the use of UHF band IV and V spectrum over the long term. We also outline the principal next steps we plan to take after the conclusion of this consultation.

2.26 In summary, the main purpose of this consultation is to establish a strategic approach to secure benefits to citizens and consumers over the long term form the use of scarce spectrum resources in UHF bands IV and V. Such an approach should provide clarity to stakeholders on future policy direction, whilst being flexible enough to respond to future international and market developments. In particular, we are seeking to establish whether using the 700 MHz band in combination with other additional higher frequency spectrum bands for mobile broadband is likely to deliver benefits for citizens and consumers over the long term and whether the 600 MHz band released by digital switchover should be used as part of a frequency re-plan of the DTT platform if the 700 MHz band is released for mobile broadband.

2.27 The analysis presented in the whole of this document represents an impact assessment, as defined in section 7 of the 2003 Act. However, it should be noted that due to the difficulty associated with assessing the long term costs and benefits associated with different spectrum uses, at this stage we have focused on identifying the main drivers of future spectrum requirements and providing a high level qualitative assessment rather than detailed quantitative assessment of these factors in this consultation.

2.28 It is also important to recognise that through this consultation we are not seeking to reach final decisions on the process and timescales of any future release of the 700 MHz band. In practice, we believe that these decisions will have to be informed by further work, and can only be taken closer to the time of actual implementation. This will include monitoring and assessing future international harmonisation and co-ordination developments, and market developments within the DTT, mobile and other service sectors, as well as an assessment of the detailed arrangements required to facilitate an actual change of use of the 700 MHz band.

Linked documents

2.29 This consultation builds on the responses to an Ofcom's Call for Input issued in April 2011, which asked stakeholders for views and evidence on the long term demands of different services for spectrum in UHF bands IV and V[12]. Responses to the Call for Input have provided an important contribution to the work that led to this consultation and are summarised in Annex 5.

2.30 We have also published, alongside this consultation, a series of independent research reports that Ofcom has commissioned and used to inform and provide evidence to support our views in this consultation. They are:

[12] See http://stakeholders.ofcom.org.uk/consultations/uhf-spectrum-bands/

- A consumer research study by BDRC Continental on consumer preferences in relation to DTT and mobile broadband[13];
- A technical study by Real Wireless, examining the role of different capacity-enhancing techniques in meeting the future expected growth in mobile data demands over the period 2012-2030[14];
- A technical study by ZetaCast, examining the potential technical evolution of DTT over the period 2015-2030[15]; and
- A study by Arqiva Spectrum Planning, examining high-level options for re-planning DTT following a potential clearance of the 700 MHz band[16].

[13] See http://stakeholders.ofcom.org.uk/market-data-research/other/spectrum-research/UHF-strategy-research/
[14] See http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf
[15] See http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/zetacast.pdf
[16] See http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/arqiva.pdf

Section 3

Future mobile broadband spectrum requirements

3.1 In this section we consider the increasing demand for mobile broadband capacity and the role additional spectrum could play in meeting this demand, given the range of other methods mobile operators could use to increase the capacity of their networks, which include:

- The use of more efficient mobile delivery technologies such as LTE;
- The deployment of additional mobile sites; and
- Offloading mobile data onto fixed networks using Femtocells or Wi-Fi.

3.2 We also consider the special role additional sub 1 GHz UHF spectrum could play in reducing the number of additional mobile sites that would need to be built to cost effectively meet the future growth in demand for mobile broadband capacity.

Demand for mobile data is growing rapidly

3.3 The rapidly increasing growth in demand for mobile data sets a significant challenge for spectrum management and mobile networks deployment.

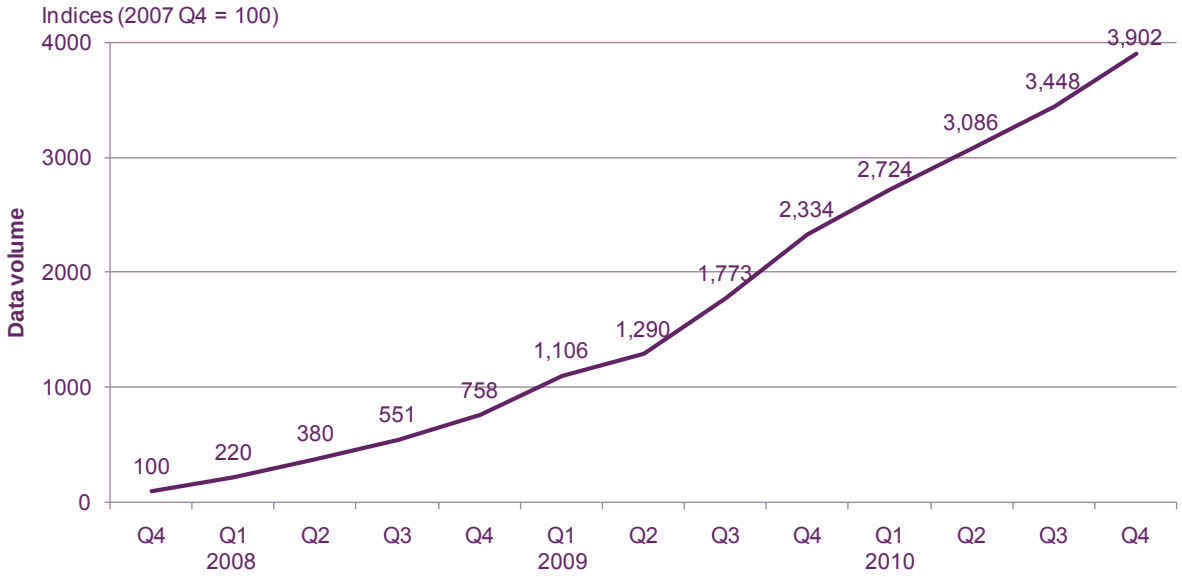
3.4 Whilst the rapid growth in demand for mobile data is a relatively recent phenomenon, it is set to continue, driven by a number of interrelated factors, including:

- **Increasing penetration of data and video capable mobile devices**: the consumer take-up of data and video capable devices, including smartphones and tablet PCs, is increasing rapidly making high capacity mobile data and video services accessible to an increasing number of mobile users.
- **Increasing usage of mobile data and video services**: as the capabilities of data and video enabled mobile devices increases, each user is more likely to consume more data. The anticipated improvements in processing power and video capabilities of future mobile devices are likely to sustain this increased growth in user data consumption.
- **Growth of video traffic**: video is set to become a more predominant form of mobile traffic over the coming years, as the increasing penetration of video capable mobile devices make mobile video services a greater part of content providers' future distribution strategies. Because video typically requires significantly more capacity than other types of mobile services it is likely to be a significant driver for the future growth in demand for mobile data capacity.

3.5 The volumes of data carried over mobile networks started to increase significantly in 2008, initially driven by the popularity of dongles and 3G enabled laptops, and was then driven by the surging penetration of smartphones. Figure 3 illustrates how

mobile data volumes were approximately four times greater at the end of 2010 than they were at the end of 2007. In 2010 alone, mobile data traffic grew by 67%.

Figure 3 – Estimated growth in mobile data volumes, relative to Q4 2007



Source: Ofcom Communications Market Report 2011

3.6 As described above, much of the growth in mobile data volumes is being driven by the increased penetration and use of mobile devices with increased video and data processing capabilities, including dongles, smartphones and tablet PCs. Ofcom's consumer survey data[17] indicates that smartphone ownership reached a penetration level of 27% of UK adults in Q1 2011, tablets a 2% penetration level, and mobile broadband services were accessed through a dongle or laptop by 17% of UK adults.

3.7 The penetration levels for these devices are likely to grow much further. For example, smartphones have continued to represent an increasing proportion of mobile device sales over the past few years, reaching 48% in Q1 2011[18]. In a recent online survey commissioned by Ofcom, 26% of respondents not currently using mobile internet said they are planning to acquire smartphone over the coming year and 16% said that they are planning to acquire a tablet PC to access the internet through a mobile network[19].

3.8 There are a wide range of different predictions by industry analysts for the future growth of mobile data consumption. Considering that such predictions should always be interpreted with a degree of approximation, it is worth noting that there is general consensus that there will be significant future growth. Forecasts by Cisco are updated on an annual basis and are widely cited in the industry. In their latest set of forecasts Cisco predict a twelve fold increase in UK mobile data traffic between 2011

[17] Ofcom technology tracker, Q1 2011, base: UK adults aged 16+

[18] See figure 5.20, Communications Market Report, 2011: http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr11/UK_CMR_2011_FINAL.pdf

[19] See BDRC Continental summary report on UHF Strategy Research for Ofcom: http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/UHF-strategy-research/research_report.pdf .

and 2016, with compound annual growth rates of 65%[20]. Whilst other analysts tend to predict lower annual growth rates[21], it is notable that over the past few years growth forecasts have generally been revised upwards as the actual amount of data consumption has outstripped expectations.

3.9 There are relatively few predictions for the likely growth in mobile data consumption over a longer time period. In 2009, as part of work commissioned by Ofcom, PA Consulting[22] developed a number of different scenarios for the future longer term growth in requirements of various services, including mobile data and video, to 2025. Figure 4 compares a relevant subset of these estimates with those provided more recently by Real Wireless[23], as part of a wider study commissioned by Ofcom into the different techniques mobile operators could use to meet the future growth in mobile data demand. The Real Wireless projections are higher than those of PA Consulting because they factor in the higher than expected growth in mobile data consumption over the past three years.

3.10 Given the difficulty associated with predicting the growth in mobile data capacity demand over a long time period, Real Wireless has developed, as part of a technical study we commissioned, three future scenarios spanning a very wide range of potential outcomes:

- **A "low" growth scenario**: this assumes a flattening out in the growth in mobile data usage after 2015, caused by a capacity crunch on mobile networks which pushes future mobile device and application developments towards supporting less-data intensive types of traffic (such as voice, SMS, mobile payments as opposed to fast internet access and video). In this scenario, total traffic volumes in 2030 are approximately 20 times greater than in 2012;

- **A "medium" growth scenario:** this assumes a growth in mobile traffic in line with current analysts' expectations until 2020, with media and internet centric mobile devices and applications becoming increasingly popular. Post 2020 the rate of growth slows with the saturation in the penetration of data and video capable mobile devices. In this scenario, total traffic volumes in 2030 are approximately 80 times greater than in 2012; and

- **A "high" growth scenario:** this assumes a rapid growth in mobile data consumption driven by the popularity of high resolution video accessed on handheld devices, including HD and 3D video and immersive gaming. In this scenario, growth rates comparable to the Cisco projections to 2016 are sustained

[20] Cisco Mobile Visual Networking Index 2012

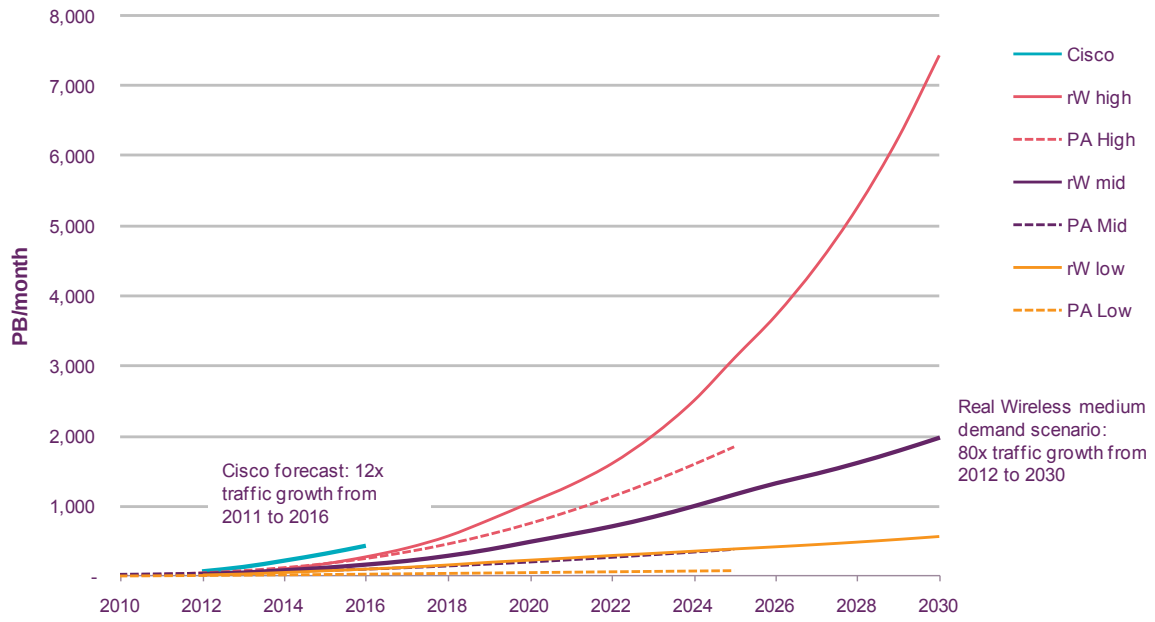
[21] A technical paper by the FCC published in October 2010 (http://transition.fcc.gov/Daily_Releases/Daily_Business/2010/db1021/DOC-302324A1.pdf) highlighted that Cisco forecasts for US data traffic were higher than those of other two analysts houses, Yankee Group and Coda. Analysys Mason 2011 forecasts predict a 38% in mobile data traffic in Western Europe. In December 2009 HSBC Global Research produced a 45% CAGR forecasts to 2015 for a typical mobile operator in a mature market, and then revised it to 50-60% CAGR in April 2010.

[22] PA Consulting, Predicting Areas of Spectrum Shortage, April 2009: http://stakeholders.ofcom.org.uk/binaries/research/technology-research/shortage.pdf

[23] See Real Wireless report on techniques for increasing the capacity of wireless broadband networks: http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf

through to 2030. In this scenario, total traffic volumes in 2030 are approximately 300 times greater than in 2012.

Figure 4 – Projected growth in UK mobile data demands



Source: Real Wireless for Ofcom 2012

There are likely to be ongoing commercial incentives for mobile operators to invest in their networks to meet the growth in demand for mobile data

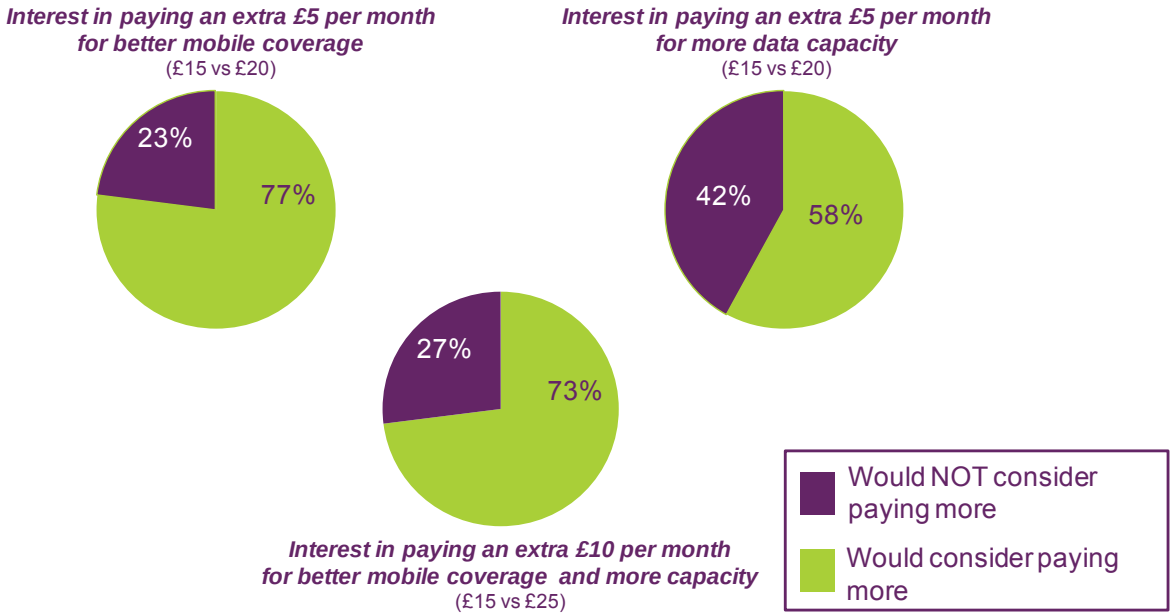
3.11 In practice, mobile data traffic can only grow to the extent to which it is matched by a corresponding supply of capacity on mobile networks. The medium and high growth rate scenarios for the future growth in mobile data traffic described above are based on an assumption that the physical capacity of mobile networks will continue to increase and not limit the growth in demand. This is unlikely to occur if mobile network operators do not have appropriate incentives to invest in increasing the data capacity of their networks. In particular, operators are only likely to invest in providing additional capacity if users value, and are willing to pay for, the resulting improvements in network capabilities.

3.12 We commissioned consumer research to investigate consumer preferences for different attributes of mobile broadband services[24]. This consumer research enabled a comparison to be made of consumer preferences for different mobile broadband packages offering different levels of coverage and capacity at different prices. The approach and findings of this research are set out in more detail in the BDRC Continental Report, which is being published alongside this consultation.

[24] See BDRC Continental summary report on UHF Strategy research: http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/UHF-strategy-research/research_report.pdf

3.13 As illustrated in figure 5, this consumer research identified that a significant proportion of existing mobile broadband customers would potentially be interested in paying £5 to £10 more per month for improved capacity and coverage mobile services, on top of a typical average mobile monthly bill of £15. This suggests that there are likely to be ongoing commercial incentives for mobile operators to continue to invest in improving the future capacity and coverage of their networks in order to deliver more valuable services to their customers.

Figure 5 – Proportion of consumers who would consider paying extra for improved mobile broadband capacity and coverage



Source: BDRC Continental for Ofcom, 2012

Meeting growth in mobile data demand could deliver significant benefits to citizens and consumers

3.14 The ability of mobile network capacity to expand to meet the future growth in demand for mobile data is likely to be important in delivering significant benefits to UK citizens and consumers. There are a number of important reasons for this:

3.14.1 **It could sustain or increase the already substantial economic value accrued by consumers through mobile services**: the market for mobile services in the UK is large with revenues of £15.1 billion in 2010. The great majority of UK adults (and many children) use these services, with 1.3 active mobile connections per head of population and one active 3G mobile connection for every two people. The average household spends £63 per month on telecoms, approximately half of which is spent on mobile services. Mobile services are also important to UK businesses which account for £6.6 billion of mobile revenues[25].

[25] All figures taken from Ofcom's 2011 Communications Market Report, Figure 5.1 and page 298.

3.14.2 In 2006, Europe Economics produced a report for Ofcom[26] which estimated the consumer surplus generated by mobile services. Consumer surplus is the value of a service to a consumer minus the price paid by the consumer for the service. Using a range of methods, Europe Economics estimated a total consumer surplus of £19.0 billion from the consumption of mobile services in the UK (both by private and business consumers). Adjusting for inflation would suggest a consumer surplus of £20.7 billion today. Further adjusting for the growth in mobile connections over the period implies a consumer surplus of more than £24.0 billion today[27][28]. The provision of additional or more attractive mobile services through the use of additional spectrum could in principle increase this consumer surplus.

3.14.3 Consumer value may also be enhanced to the extent that additional mobile capacity is supported by a good quality of service. Based on the magnitude of the consumer surplus suggested above, even moderate improvements in quality of service could have a significant impact in aggregate. For example, a 1% increase in consumer surplus would represent around £2 billion increase over 10 years, and £3.4 billion over 20 years, in present value terms. We recognise that improvements in quality of service would not necessarily be solely attributable to access to more spectrum – compared to other techniques to increase network capacity – or even particular spectrum bands. Nevertheless, as discussed further in this section, the use of additional spectrum below 1 GHz would enhance the consumer experience inside buildings and in hard-to reach areas, e.g. by enabling better data intensive applications, compared to use of higher frequency spectrum bands. Therefore even if only a proportion of any increase in consumer surplus is attributable to the use of additional spectrum this could still represent a significant value.

3.14.4 **It could deliver significant benefits from a citizen perspective** including improving high capacity broadband availability to remote areas and in enabling the delivery of next generation emergency services applications.

3.14.5 **It could enable further innovation in mobile services and applications**: meeting the future growth in demand for mobile data is likely enable further innovations, making an expanding range of new high value mobile services available to consumers, including: payments and transactions, navigation, video, location based services, and augmented reality based applications[29].

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[26] Economic impact of the use of radio spectrum in the UK. A report by Europe Economics, November 2006. http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/economic_impact.pdf

[27] If we compare this figure to industry revenues (£15.1 billion in 2010) we can see that consumer surplus is larger. This suggests that, for example, a customer who paid £15 for a mobile service would typically value that service at £39, so consuming the service creates a consumer surplus of £24 (i.e. £39 minus the £15 price of the service).

[28] Europe Economics' estimate is an average of results from four different methods.

[29] Augmented reality refers to the interaction with elements of the physical environment mediated by devices (including handheld devices) which enhance (or augment) such physical elements through the elaboration of contextual information, delivered over the internet or generated by the device itself. Augmented reality has a number of fields of current and potential applications, from advertising, to navigation, entertainment and education.

3.14.6 **It could meet business needs and hence growth in the wider economy**: increasing the capacity of mobile networks would help ensure the UK's mobile infrastructure is better able to support the future mobile data needs of businesses, enabling wider growth in the economy.

Question 1: Do you agree that meeting the future growth in demand for mobile broadband capacity will deliver significant benefits to citizens and consumers?

Using additional spectrum is one of a range of different approaches mobile operators can adopt to increase the capacity of their networks

3.15 Technical research commissioned by Ofcom[30] has identified that there are a range of different approaches mobile operators could adopt to increase the future capacity of their networks. These include:

- Using more spectrum;
- Using more efficient mobile technology;
- Using more mobile sites; and
- Using more Wi-Fi and Femtocell mobile data offloading.

3.16 This research has also identified that mobile operators will need to use a combination of all of these techniques to cost effectively meet the anticipated growth in demand for mobile broadband capacity. This means that additional mobile broadband spectrum will form an important part of addressing the increasing demand for mobile broadband capacity, but will be insufficient to meet this growth in demand alone.

Increasing mobile broadband network capacity using more spectrum

3.17 International harmonisation creates greater economies of scale for handset and base station equipment, reducing prices[31]. It also provides interoperability between different national and international mobile networks. Because of these reasons only additional spectrum which has been internationally harmonised is likely to be used by mobile operators.

3.18 There are two principal ways in which additional harmonised spectrum capacity could become available for mobile broadband services:

- **Spectrum re-farming:** here spectrum already assigned to mobile is used for an upgraded technology such as LTE to better support mobile broadband services.
- **New mobile spectrum assignments:** here new spectrum is made available for mobile broadband services, which was previously allocated for different uses,

[30] See Real Wireless report on techniques for increasing the capacity of wireless broadband networks: http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf

[31] For example, existing 2G and 3G mobile services operate only in the internationally harmonised mobile frequency bands at 900 MHz, 1.8 GHz and 2.1 GHz

such as defence purposes. This additional spectrum can be further separated into spectrum likely to become available for mobile broadband in the short to medium-term and spectrum likely to become available in the longer-term[32].

3.19 Figure 6 illustrates the different spectrum bands that are or could become harmonised for mobile broadband use. These are set out in more detail table 1. A more detailed, band-by-band discussion in presented in the following sub-sections.

Figure 6 - Overview of bands potentially suitable for mobile broadband (downlink and uplink)

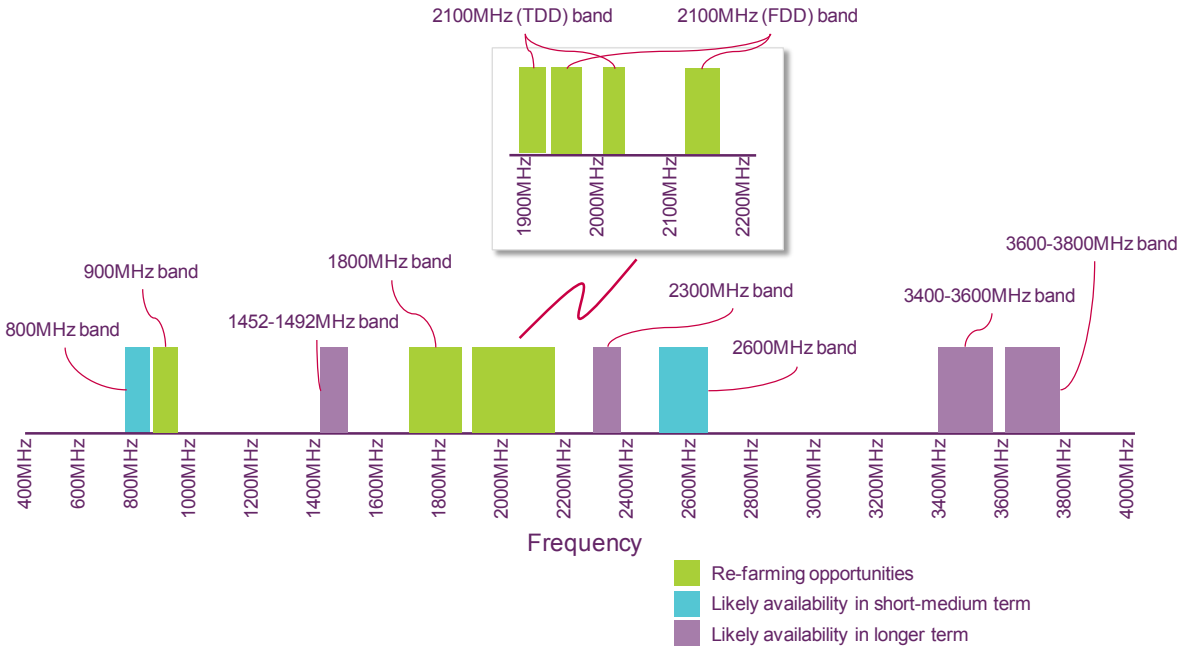


Table 1: Summary of bands potentially suitable for mobile broadband (continues on next page)

Frequency band	Bandwidth (taking guard and duplex bands into account, if appropriate)	Availability for mobile broadband	Regions where harmonised for mobile broadband use
800MHz	30MHz (downlink)	Following forthcoming spectrum award	EMEA, Asia-Pacific
900MHz	35MHz (downlink)	Progressive re-farming to mobile broadband	EMEA, Asia-Pacific
1800MHz	72MHz (downlink)	Progressive re-farming to mobile broadband	EMEA

[32] In the following band-by-band discussion, the bandwidths mentioned are net of duplex and guard bands. The discussion of timing of use of these bands reflects assumptions taken in our technical work.

Frequency band	Bandwidth (taking guard and duplex bands into account, if appropriate)	Availability for mobile broadband	Regions where harmonised for mobile broadband use
2100MHz (FDD)	60MHz (downlink)	Currently available	EMEA, Asia-Pacific
2100MHz (TDD)	35MHz	Currently available for TDD services	Europe for 3G TDD services, currently considering other uses
2600MHz	70MHz (downlink) 45MHz (unpaired)	Following forthcoming spectrum award	EMEA
2300MHz	70MHz (unpaired)	40MHz following MoD spectrum release in 2015/16.	Global
3400 – 3600MHz	20MHz (downlink, UK Broadband) 70MHz (downlink, MoD)	Following potential spectrum award in 2015/16	EMEA, parts of Asia-Pacific and the Americas
1452 – 1492MHz	40MHz (unpaired)	Not currently	Ongoing work to identify potential uses, including mobile broadband in Europe
3600 – 3800MHz	82MHz (unpaired, UK Broadband) 60MHz (unpaired, satellite earth stations)	UK Broadband allocation currently available	No, but subject to ongoing work within Europe

Spectrum below 1 GHz has particularly attractive propagation characteristics, but is in scarce supply

3.20 Lower frequency spectrum below 1 GHz in UHF bands IV and V combines good outdoor and indoor propagation characteristics with an ability to operate with antennas that can be integrated into mobile devices and handsets. This makes this spectrum particularly attractive to mobile operators for use at larger sized macro sites, as well as sites offering more localised coverage.

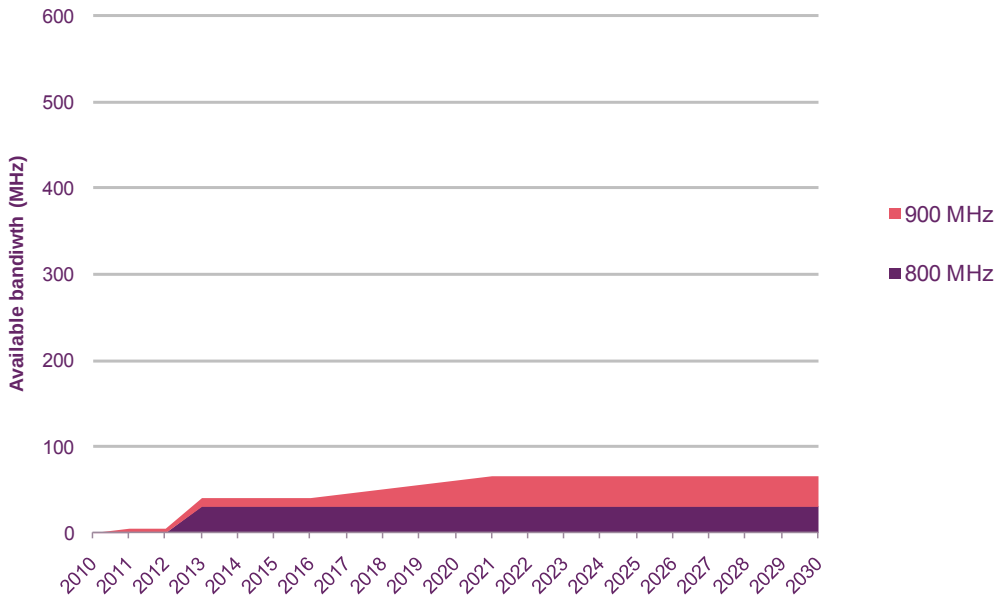
3.21 There is a low likelihood that there will be a significant increase in the amount of additional harmonised spectrum available below 1 GHz for mobile broadband use before 2030. The only current likely increases in the amount of this spectrum will be provided by (see figure 7):

- **900 MHz band re-farming.** This band is currently used to provide 2G mobile services and 3G services are beginning to be deployed alongside. This band is

already harmonised for mobile broadband use in the EMEA area and Asia-Pacific. All of the 35 MHz of downlink 900 MHz spectrum could be progressively re-farmed to use advanced 3G or LTE technologies, providing more mobile broadband spectrum over the next decade.

- **800 MHz band release.** The 800 MHz band released by DSO is currently the only additional spectrum harmonised for mobile broadband use. This band is harmonised for mobile broadband use in the EMEA area and could provide 30 MHz of additional mobile broadband spectrum. This would represent a substantial increase in the amount of sub 1 GHz spectrum available for mobile broadband use in the UK, but is significantly lower than the anticipated increase in higher frequency spectrum shown in figure 8, and would account for approximately only 5% of the likely *total* future increase in harmonised mobile broadband spectrum over the period 2012 to 2030 under mid-case assumptions.

Figure 7 - The potential increase in additional harmonised mobile broadband spectrum below 1 GHz from 2012 to 2030 (downlink only)



Source: Real Wireless report on techniques to increase capacity in mobile networks

3.22 The auctions of 800 MHz spectrum that have already taken place in other European countries provide some indication of the value to producers (i.e. mobile operators) of sub 1 GHz spectrum relative to higher frequency spectrum. The prices that have been paid for 800MHz spectrum are significantly higher than the prices paid for spectrum above 1GHz. For instance, the outcomes of auctions of 800 MHz spectrum for mobile use in Sweden, Spain and Germany indicate prices for this spectrum in the range of $0.6/MHz/pop to $0.9/MHz/pop[33]. In Spain, the equivalent price paid for 2.6 GHz spectrum was $0.04/MHz/pop[34].

[33] Sweden - $0.58; Spain - $0.66; and Germany - $0.9. Note: figures based on US dollar exchange rates at time of auctions. Source: New Street Research: July 2011

[34] Source – ibid.

3.23 Clearly the amount paid at auction can be influenced by a range of factors (e.g. the degree of competition for the spectrum, the way in which the auctions are structured, whether the auction is designed to maximise revenue, etc.) but the results of these auctions do suggest that mobile operators value the sub 1 GHz spectrum more highly and that is likely to be due - at least in part - to its technical advantages.

There is likely to be a significant amount of additional harmonised mobile spectrum becoming available above 1 GHz

3.24 There is a high likelihood that a significant amount of additional harmonised mobile spectrum will become available at higher frequencies above 1 GHz by 2030. A characteristic of this higher frequency spectrum, and in particular spectrum above 2 GHz, is that it suffers more propagation attenuation than lower frequency spectrum below 1 GHz. This makes higher frequency spectrum better suited for use at sites with relatively localised coverage.

3.25 The potential sources of additional higher frequency mobile broadband spectrum are set out below.

Spectrum re-farming opportunities above 1 GHz

3.26 **1800 MHz band.** This band is currently licensed for 2G and 3G mobile services, and is used in the UK to deliver 2G services. However, a European decision also requires Member States to have designated and made this band available for mobile broadband services by 31 December 2011. Consequently, since that date licensees have been able to apply for a licence variation authorising them to operate mobile broadband services in this band. Such an application has been received from Everything Everywhere and Ofcom is currently consulting on varying its 1800 MHz licences to allow them to deploy LTE services[35]. Should the licence variation be granted, a phased adoption of LTE in the 1800 MHz band over the next decade is likely, enabling the full 72 MHz of downlink bandwidth available in this band to be used by mobile broadband services.

3.27 **2100 MHz (FDD) band.** This band is currently used by 3G mobile services but can also be used to provide advanced 3G and next generation mobile broadband services. It is likely that there will be a phased adoption of advanced 3G services in this band over the next decade and to LTE in the longer term. This band provides 60 MHz of downlink bandwidth.

3.28 **2100 MHz TDD bands (1900 – 1920 MHz and 2010 – 2025 MHz).** The bands are currently available in Europe for TDD-based 3G systems, but these have not been commercially deployed. In recognition of this, the European Commission is in the processes of considering alternative uses of these bands. These bands could provide up to 35 MHz of additional spectrum for mobile broadband services.

Additional spectrum, likely to become available in the short to medium-term

3.29 **2600 MHz band.** This spectrum is already harmonised for mobile broadband use and is planned to be cleared of incumbent services (including PMSE) and awarded in the short term. This band will provide an additional 70 MHz of downlink spectrum for mobile broadband services.

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[35] See http://stakeholders.ofcom.org.uk/consultations/variation-1800mhz-lte-wimax/

Additional spectrum, which could become available for mobile broadband in the longer-term

3.30 **2300 MHz band (2310 – 2390 MHz).** This band is currently held by the Ministry of Defence (MoD) and forms part of the Government's plan to release 500 MHz of public sector spectrum. This band has been identified by the ITU as a global band for mobile broadband and equipment is already available and in use in the Asia-Pacific region. The MoD plans to release 40 MHz in this band in 2015. In our technical work we have also modelled the effect of more spectrum being made available in the longer term, i.e. up to 70 MHz of unpaired spectrum used for downlink from 2020.

3.31 **3400 – 3600 MHz band.** This is a paired band including 20MHz of downlink bandwidth currently allocated to UK Broadband and 70 MHz of downlink bandwidth held by the MoD. The band is currently shared with PMSE users. This band is harmonised for mobile broadband use and forms part of the Government's plans to release 500 MHz of public sector spectrum. This band could make up to 70 MHz of additional downlink spectrum available for mobile broadband use.

3.32 **1452 – 1492 MHz band.** This band was originally identified for broadcasting services (e.g. T-DAB and S-DAB[36]) across Europe but has not been widely used to deliver these services. In 2008, this spectrum was awarded to Qualcomm in the UK. Work is currently underway within CEPT to explore future options for the use of this band, one of the potential applications being considered is a supplementary downlink for mobile broadband, where this band becomes paired with the uplink in other mobile frequency bands. This approach could provide up to 40 MHz of additional downlink spectrum for mobile broadband use.

3.33 **3600 – 3800 MHz band.** This is an unpaired band which includes 82 MHz of bandwidth currently allocated to and used by UK Broadband, and 60 MHz of bandwidth currently used for satellite earth stations and, therefore, unavailable for mobile broadband services. This satellite band is not currently harmonised for mobile broadband use, but is subject to ongoing harmonisation work within Europe. If the numerous satellite earth stations making use of this spectrum across the UK were allocated alternative spectrum this would provide up to 60 MHz of additional spectrum for mobile broadband use.

3.34 Figure 8 illustrates a mid-case scenario for the expected availability of higher frequency bands for mobile broadband between 2012 and 2030. A more detailed description of the assumptions made as part of the technical study we commissioned is provided in section A4 of the annex to the Real Wireless report[37].

3.35 Through the Real Wireless study, we estimate that taken together spectrum re-farming and additional low and high frequency spectrum bands could provide between a seven and thirteen times increase in the total amount of spectrum available for mobile broadband use by 2030, with a mid range estimate of a nine times increase shown in figure 8.

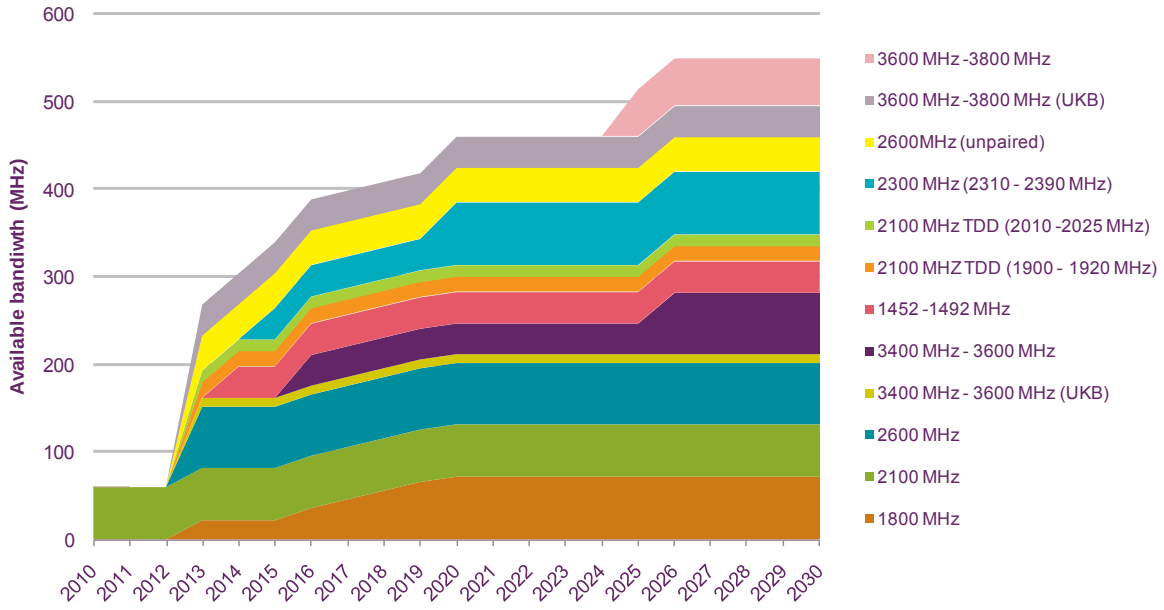
3.36 We anticipate that mobile device and network technologies will evolve to support operation across multiple frequency bands, although not all bands would necessarily be supported by all devices. Furthermore, devices and networks are likely to be

[36] S-DAB – Satellite - Digital Audio Broadcasting

[37] See http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf

capable in the future of simultaneously aggregating together connections, or carriers, across multiple bands, to make best use of spectrum resources and support higher data rates.

Figure 8 - Potential increase in harmonised mobile broadband spectrum above 1 GHz from 2012 to 2030 (downlink only)



Source: Real Wireless report on techniques to increase capacity in mobile networks

Increasing mobile network capacity by using more efficient mobile technology

3.37 This approach involves upgrading existing 2G and 3G networks to more efficient technologies, including LTE-Advanced and its future evolutions. This technology upgrade enables each mobile site to provide more data capacity using the same amount of spectrum. The features of LTE that enable this increase to be achieved include:

- Multiple Input Multiple Output (MIMO) antenna technology which enables different antenna combinations to be used to improve the quality of the wireless connections between mobile base stations and handsets;
- Improved efficiency modulation and coding technologies that increase the amount of capacity that can be supported in each mobile channel;
- The joint processing of mobile signals from different mobile sites to better distribute capacity demand between sites and reduce interference between them; and
- The aggregation in future mobile handsets of capacity provided by different frequency bands.

3.38 In the work we commissioned, Real Wireless estimate these technology developments will provide between a three and ten times increase in mobile capacity for macro cells with three sector antennas by 2030[38].

Increasing mobile broadband capacity by deploying more mobile sites

3.39 The additional capital and operational costs associated with providing and operating more mobile sites tends to make this a more expensive option for mobile operators than using more spectrum and more efficient technologies at existing sites. However, where these measures alone cannot meet the growth in demand for mobile capacity it will become necessary to deploy additional sites. By splitting the coverage of existing sites into smaller cells the number of mobile users sharing the capacity provided by each mobile transmitter is reduced, creating an effective increase in mobile capacity available to each user. However, there are practical limits on how closely cells can be packed together without causing interference with one another and in securing planning permission for new sites.

Offloading indoor mobile traffic onto fixed networks using Wi-Fi or femtocell approaches

3.40 Over half of mobile data traffic could potentially be offloaded onto fixed networks by 2030 using WiFi and Femtocells[39]. However, there are uncertainties over the ability of these approaches to keep up with the future growth in demand for mobile data, including the ability to ensure offload devices can be targeted and used in the most effective locations, and whether sufficient provisioning of sufficient backhaul capacity can be provided to these devices.

In summary, we consider that a combination of all these approaches will be required to meet the expected growth in mobile data demand

3.41 We do not consider that any of the approaches described above is capable in its own right of physically or economically meeting a mid-growth scenario for a 80 times increase in the demand for mobile data capacity by 2030, and will need to be used in combination to meet this level of demand. This means that, whilst more mobile spectrum alone is unlikely to meet the future demand for mobile data capacity, it will form an essential part of a range of different techniques that will need to be used to meet this demand.

Additional spectrum below 1 GHz could play an important role in meeting the future growth in demand for mobile capacity and coverage

3.42 Technical research conducted by Real Wireless for Ofcom[40] has modelled the most cost-efficient technical approaches for increasing mobile network capacity to meet the projected growth in data demands in urban, suburban and rural study areas. This

[38] See Real Wireless report on techniques to increase capacity in mobile networks: http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf
[39] Ibid
[40] Ibid

involved modelling different combinations of additional high frequency and sub 1 GHz spectrum, upgrading existing sites to more efficient mobile technologies, and adding more small and larger sized mobile sites.

3.43 For simplicity this modelling work has assumed an idealised situation, where in each study area, there is a single UK-wide mobile network which can access the total available amount of high and low frequency spectrum[41]. These simulations indicate that in order to minimise costs mobile operators are most likely to start by making optimum use of their existing sites by: re-farming their existing mobile spectrum at these sites to more efficient LTE technology, using greater levels of antenna sectorisation at these sites and using additional 800 MHz and 2.6 GHz mobile broadband spectrum.

3.44 The modelling indicates that despite using this combination of capacity enhancing techniques at existing sites mobile operators would still need to provide a significant number of additional large macro and small sized mobile sites to meet the future growth in demand for mobile data capacity. The increase in the number of new sites can be reduced if additional mobile broadband spectrum becomes available at the time when other capacity enhancing techniques at existing sites have been exhausted. However, even if all the additional higher frequency and lower frequency spectrum bands shown in figures 6 and 7 and table 1 were to become available before 2030, mobile operators would still need to build 41% more sites in the rural study area, 73% more in the suburban study area and 30% more in the urban study area[42]. The majority of these new sites would be small cell sites as opposed to existing macro sites. By way of reference there are a total of approximately 30,000 existing macro mobile sites in the UK today.

3.45 These simulations were repeated assuming the availability of the 700 MHz band (described in more detail below) for mobile broadband use, which could provide an additional 90 MHz of sub 1 GHz spectrum, in addition to the 800 MHz and 900 MHz bands shown in figure 7.

3.46 These simulations show that the availability of additional spectrum at 700 MHz could materially reduce the number of new mobile sites that mobile operators would need to build[43] in order to create sufficient network capacity, and that its benefit become greater if it is available at the time when other capacity enhancing techniques at existing mobile sites have been exhausted.

3.47 The potential reduction in new sites build ranges from 21% in the rural study area to 57% in the suburban study area, to 28% in the urban study areas[44]. These results are summarised in table 2 below.

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[41] In practice, there is more than one mobile network present in the vast majority of UK areas, with varying degrees of infrastructure sharing and varying spectrum assets across different mobile networks operators. We would expect the utility of additional sub 1 GHz spectrum to vary between different mobile operators based of their current spectrum assets.

[42] These statistics consider both small and macro sites. For a breakdown, see table 2

[43] As discussed in footnote 41, the extent to which additional sub 1 GHz spectrum would effectively enable individual operators to increase capacity in their networks more efficiently is likely to be materially influenced by the pre-existing spectrum and infrastructure assets

[44] See footnote 42.

Table 2 – Simulated idealised future mobile network build requirements with and without additional sub 1 GHz spectrum from the 700 MHz band

		Baseline	No access to the 700MHz band		700MHz band available from 2020		Savings in increment of new site numbers due to 700MHz band
		Mobile network sites in 2012	Mobile network sites in 2030	*% increase in mobile network sites from 2012 to 2030*	Mobile network sites in 2030	*% increase in mobile network sites from 2012 to 2030*	
Rural study area	Macro sites	157	202	*29%*	192	*22%*	*22%*
	Small sites	7	29	*314%*	25	*257%*	*18%*
	Total	164	231	*41%*	217	*32%*	*21%*
Suburban study area	Macro sites	227	247	*9%*	236	*4%*	*55%*
	Small sites	10	162	*1520%*	75	*650%*	*57%*
	Total	237	409	*73%*	311	*31%*	*57%*
Urban study area	Macro sites	95	111	*17%*	106	*12%*	*31%*
	Small sites	360	481	*34%*	447	*24%*	*28%*
	Total	455	592	*30%*	553	*22%*	*28%*

Source: Real Wireless report on techniques to increase capacity in mobile networks

3.48 The reductions in new site build achieved using additional sub 1 GHz spectrum would provide advantages both in terms of reducing future network deployment costs and in reducing the challenge of securing planning permission for large numbers of new mobile sites.

3.49 Further, additional sub 1 GHz could potentially sustain a better quality of service in difficult to reach indoor and outdoor locations. This potential benefit has not been taken in account in the current modelling work. The potential role of additional sub 1 GHz spectrum in reducing the need to target heaviest usage areas with a large numbers of Femtocells and Wi-Fi base stations has also not been explicitly modelled.

3.50 There is a high degree of uncertainty associated with this modelling work in terms of what the actual level of future demand for mobile data capacity will be and its geographical distribution, the level of capacity increases that will be provided by technology improvements, the future amount of mobile capacity offloading onto fixed networks using Wi-Fi and Femtocells, the amount additional harmonised spectrum and when it will become available, the level of future site sharing between mobile operators and the extent to which different mobile operators will respond similarly or differently to meet the increasing demand for data capacity. To test the resilience of the role additional sub 1 GHz spectrum could play in meeting the future growth in mobile data capacity it was tested for a range of different scenarios using different assumptions for these parameters[45].

3.51 This analysis confirmed that additional sub 1 GHz spectrum could play a significant role in meeting the future growth in demand for mobile broadband under nearly all plausible future scenarios. It could also generate an economic benefit to the extent that a reduction in the number of sites translates into reduced network costs. Its

[45] See sections 4.4 to 4.9 and Annex A7 and A8 in Real Wireless report: http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf

contribution was also found to be greater if it becomes available before other capacity enhancing techniques are exhausted at existing sites[46].

3.52 The timing of when other capacity enhancing techniques are likely to become exhausted is subject to a significant level of uncertainty. However, this analysis suggests that having the option to use additional sub 1 GHz spectrum for mobile broadband as soon as is practical is likely to be important in maximising its value.

There is growing momentum behind the worldwide use of the 700 MHz band for mobile broadband applications

3.53 The most attractive option for providing additional harmonised mobile broadband spectrum below 1 GHz is the 700 MHz band, which occupies the frequency range 694 to 790 MHz and is currently used to deliver Digital Terrestrial Television (DTT) services (see figure 2). This is because:

- In North and South America (ITU Region 2): the 700 MHz band has already been allocated to mobile broadband and is being used to deploy LTE based mobile services on a mass market scale in the United States; other countries in the region are also considering or moving towards use of this band for mobile broadband over the next few years;

- In the Asia Pacific region (ITU Region 3): the 700 MHz band has already been allocated to mobile broadband. Countries including Australia and New Zealand are likely to release this band in the short term enabling LTE deployments, whilst in others, like India, plans for release are currently at an early stage;

3.54 In Europe, Africa and the Middle East (ITU Region 1) a resolution was passed at the 2012 World Radio Conference (WRC 12) indicating that, subject to the completion of relevant technical work, a decision to enable the 700 MHz band to be used for mobile broadband will be taken at the next World Radio Conference in 2015. A key driver for this was a strong desire by several African countries to launch LTE services in the 700 MHz band.

3.55 Whilst the WRC 12 decision creates a realistic prospect for an eventual release of the 700 MHz band for mobile services in Europe, any such decision is likely to be some years off pending the results of further studies and other technical work. This will need to include amendment to the existing Geneva 06 agreement which underpinned digital switchover in Europe, Middle East and Africa.

3.56 Our current view is that the need for an amendment to the Geneva 06 agreement and subsequent bi-lateral frequency co-ordination agreements between neighbouring countries, makes it unlikely that any clearance of the 700 MHz band to enable a harmonised and coordinated release for mobile broadband use could start before 2018. This date is subject to a high degree of uncertainty because it is dependent on the position adopted by other ITU-R region 1 countries on the future release of the 700 MHz band for mobile broadband. Many European countries, including the UK, currently use of the 700 MHz band for DTT broadcasting.

3.57 However, the decision taken at WRC 12 to agree a future co-primary allocation of the 700 MHz for broadcast and mobile broadband services is highly significant because it

[46] See section 5 of Real Wireless report: http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf

now creates international momentum behind the long term global use of the 700 MHz band for mobile broadband.

The global use of the 700 MHz band for mobile broadband is likely to enhance the value that this band can provide in the UK

3.58 Given the resolution passed at WRC 12 regarding the 700 MHz band, we believe there is now a realistic prospect of a globally harmonised use of the 700 MHz band for mobile broadband in future. As described above a number of countries around the world, including the US, India and Japan are actively deploying or considering deploying LTE services in this band.

3.59 The global use of the 700 MHz band is likely to increase its value beyond the benefits associated with reducing the number of new mobile sites required to meet the future growth in demand for mobile broadband capacity and in improving the quality of service coverage provided in difficult to reach indoor and outdoor locations. This additional increase in value is likely to arise from:

- **Economies of scale in the development and production of equipment**. As more countries around the world use the 700 MHz band for mobile broadband, manufacturers could achieve greater economies of scale for the research and development and manufacture of new mobile network and handset equipment, increasing the range of equipment available and reducing prices[47]. Using the 700 MHz band for mobile broadband in the UK could therefore lead to greater benefits if the band is widely adopted internationally, so that economies of scale are realised. Given the prospects for a growing number of frequency bands becoming available for mobile broadband described above, manufacturers could potentially focus on developing new devices for frequency bands that are adopted on the widest scale. If this were the case, then UK consumers could benefit from a wider choice of devices through the global adoption of the 700 MHz band for mobile broadband[48].

- **More efficient use of spectrum**. If following WRC 12 and WRC 15 decisions some ITU Region 1 countries decide to use the 700 MHz band to deliver mobile broadband services there will be a need for a new international frequency co-ordination agreement for the use of this band to prevent interference between mobile broadband and DTT services operating in different countries. If all countries, including the UK, decide to use the 700 MHz band for mobile broadband this will make it easier to manage interference between services operating in neighboring countries, resulting in a more spectrally efficient frequency co-ordination plan and spectrum efficiency gains in the UK and across the rest of ITU region 1.

[47] In practice the presence of different band plans for the 700 MHz band across different regions of the world could pose some limits to the ability of equipment manufacturers to realise economies of scale on a global scale. For example, as discussed in section 7, the bandplans recently defined by the APT Wireless Forum (AWF) in ITU Region 2 (Asia-Pacific) differ from those adopted in the United States. However, we would expect that manufacturers seeking to address the global market will seek to produce equipment that has some flexibility to utilise different bandplans in this frequency range.
[48] For example, the latest version of the Apple iPad tablet supports the 700 MHz band adopted in the United States but not the 800 MHz and 2.6 GHz LTE bands.

3.60 The benefit of aligning spectrum use in the UK with other neighbouring countries was recently illustrated by the clearance of the 800 MHz band released by digital switchover. Here an economic analysis found that the additional value achievable from aligning the clearance of all of the frequencies in this band on a harmonised European basis was £2bn to £3bn[49].This additional value arose from equipment manufacturers being able to achieve greater economies of scale, reducing prices, and in enabling a more spectrally efficient co-ordinated use of the 800 MHz spectrum in the UK and in other European countries.

In summary, additional harmonised mobile broadband spectrum has the potential to realise significant benefits and the 700 MHz band could play an important role

3.61 In this section we have set out why we consider that the demand for mobile data is likely to grow significantly over the next decade and beyond. This will require a corresponding increase in mobile network capacity, and our view is that achieving this increase in capacity is likely to deliver significant benefits to UK citizens and consumers. Additional harmonised spectrum will play an essential role in providing this additional capacity, and we consider that additional sub 1 GHz spectrum could play an important role.

3.62 Ofcom has a duty to further the interest of citizens and consumers and to secure the optimal use of spectrum. Ofcom has a potentially important role to play in helping ensure that scarce spectrum resources are made available to services that can deliver the largest benefits to citizens and consumers. Indeed, enabling the release of additional spectrum to help meet the growth in demand for mobile services, has been one of Ofcom's key priorities over the past few years, and this was confirmed in our Annual Plan for 2012/13. The upcoming award of 800 MHz and 2.6 GHz spectrum will represent key milestones in making more spectrum available for mobile broadband, but additional spectrum will be required if the demand for mobile data continues to grow in line with analysts' predictions.

Question 2: Do you agree that additional harmonised mobile broadband spectrum will play an important role in meeting the future growth in demand for mobile broadband capacity? What are your views on the overall quantity of harmonised spectrum that will be required to meet future demand? How does this compare with the expected increase in spectrum for mobile use discussed in this section?

3.63 Given the technical advantages of sub 1 GHz spectrum in helping to meet the growth in demand for mobile data and in providing better quality of service in hard to reach areas, and the increasing momentum behind the global use of the 700 MHz band for mobile broadband, we consider it is likely that this band could play a special role in delivering future benefits to UK citizens and consumers in future.

3.64 We also consider that, to maximise its benefits and reduce the number of new mobile sites built in the future, the 700 MHz band would need to be available for release before other capacity enhancing techniques (other than building more mobile sites) have been exhausted.

[49] See http://stakeholders.ofcom.org.uk/binaries/consultations/800mhz/statement/clearing.pdf

Question 3: Do you agree that additional harmonised spectrum provided by the 700 MHz band could play an important role in meeting the future growth in mobile broadband capacity?

Question 4: Do you agree that the value of the role played by the 700 MHz band in meeting the future growth in mobile broadband capacity would be greater if it becomes available before other capacity enhancing techniques have been exhausted at existing mobile sites?

Question 5: What timing of 700 MHz release would maximise the benefits associated with its use for mobile broadband?

Section 4

Future DTT spectrum requirements

4.1 The prospect of a future release of the 700 MHz band has important implications for the services that are currently delivered through access to this spectrum. This includes DTT and other services sharing the spectrum it uses. Our long term strategic approach for securing benefits from scarce spectrum resources in UHF bands IV and V needs to consider these competing demands.

4.2 In this section we consider the future role the DTT platform is likely to play given changes in viewer consumption and new platform developments, including IPTV. This is to examine whether, absent major changes in the amount of DTT spectrum, DTT would continue to deliver important benefits to citizens and consumers over the long term

4.3 We also consider the impact that improved DTT compression and transmission technologies, and a potential longer term transition from standard definition to high definition broadcasting, could have on the future demands for spectrum by the DTT platform.

The DTT platform is a successful consumer proposition

4.4 Since its launch, the DTT platform has become one of the most popular TV delivery platforms in the UK. The foundation stones for this success were laid in the 1990s with the launch of the first Pay TV services on DTT. The initial DTT transmission infrastructure roll-out and the limited but material installed base of receivers were important conditions for the following successful evolution of the platform.

4.5 The launch of Freeview on the DTT platform in 2002 resulted in a significant take-up of DTT receivers, and a strong demand for DTT capacity from broadcasters. The key factors contributing to this success have been the simplicity and appeal of a multichannel free-to-view proposition, the marketing support provided by Freeview, and the emergence of a large horizontal market for DTT receivers, with economies of scale sustaining equipment innovation and lowering prices, and encouraging greater adoption.

4.6 Freeview also plays an important role in making the Public Service Broadcasting (PSB) channels universally available on a free-to-air basis after digital switchover. This role is recognised by Government who have set a general target that DTT coverage for the PSB channels should substantially match analogue coverage post digital switchover.

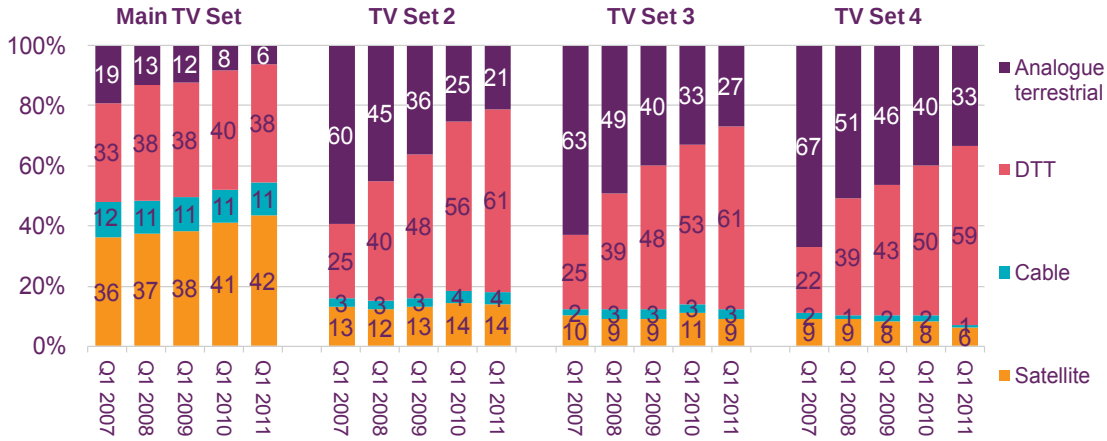
4.7 More recently new features have been added to the Freeview proposition enabling it to maintain its attractiveness to viewers given similar service developments on other platforms. These include:

- Set-top-boxes with integrated Digital Video Recorders (DVR), marketed under the Freeview+ brand;
- The launch of HD services, marketed as Freeview HD;

- The provision of complementary IPTV-based services, adding video on-demand (VoD) content and other internet-enabled features to the basic Freeview linear proposition. These include IPTV services provided by BT Vision, Talk Talk TV and soon-to-be launched YouView, backed by an industry consortium including the PSBs, Arqiva, BT and Talk Talk.

4.8 Figures published by Ofcom[50] show that the DTT platform had a 38% share of main TV sets in UK households by January 2011 (compared to 42% for satellite). This figure rises to 61% for second TV sets (compared to only 14% for satellite). The proportion of second sets using DTT has grown in relation to satellite as DSO has progressed.

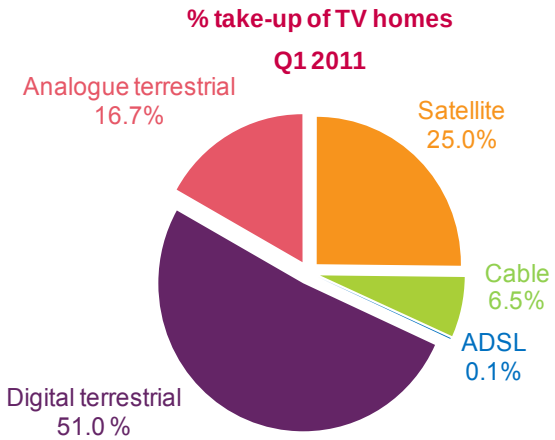
Figure 9 – Platform share for TV sets 1-4 in UK homes



Source: GfK NOP consumer research

4.9 The same study showed that in Q1 2011 74% of UK homes (19m homes) used DTT on at least one TV, with 51% of all UK TV sets being used primarily for DTT reception. The next most popular TV platform, pay satellite, was used in 36% of UK homes (9m homes) and on 25% of all UK TV sets.

Figure 10 – Market share of platforms across all TV sets Q1 2011



Source: GfK research; Note: Total TV sets = 60 million

[50] Ofcom Digital Television Update, 2011 Q1 http://stakeholders.ofcom.org.uk/market-data-research/tv-research/dtv/dtv-q1-2011/

4.10 The DTT platform is currently used and valued by a significant number of viewers and as a consequence provides significant economic value. Europe Economics estimated that in 2006 the consumer value of terrestrial television overall (analogue and digital) was £8.9 billion, which would be equivalent to approximately £10.6 billion in 2011 allowing for inflation. This figure excludes any additional value provided by the greater take-up of digital DTT services since 2006.

4.11 The universal availability of free-to-view services provided by DTT is also seen as important by viewers.

- Ofcom's PSB review, conducted in 2008, found that "over three quarters of people agree that 'it is important that TV is available to everyone'"[51].
- Consumer research by Freeview in 2011[52] also suggested that 83% of consumers agreed with the statement that "it is important there continues to be access to digital TV without a monthly subscription as an alternative to pay TV in the UK".

4.12 In conclusion, the current DTT platform as a whole is a popular consumer platform delivering substantial value to UK citizens and consumers. In the two sub-sections below we consider how its long term role is likely evolve with changes in wider audio-visual delivery market and consumer media consumption.

DTT plays a key public policy role which is likely to be needed beyond the next decade

4.13 As set out above, the services delivered by the DTT platform currently provide significant benefits to UK citizens and consumers. In particular, from a public policy perspective the DTT platform plays an important role in supporting the wider ecosystem of PSB content creation and delivery. This has been recognised by a Government decision to reserve some DTT platform capacity for the delivery of PSB channels. In particular, the DTT platform fulfils a core public policy role in providing universal low cost access to PSB channels. We believe it is unlikely, for the reasons set out below, that alternative TV delivery platforms could provide an adequate substitute for DTT in terms of fulfilling this public policy role within the foreseeable future.

4.14 The role of the DTT platform in continuing to provide a universal low cost means of accessing the PSB channels over the next 10-15 years is dependent on whether wider future satellite, cable and IPTV platform developments could enable these alternative digital television platforms to provide a viable substitute for DTT both in terms of providing universal coverage and low cost access to digital television content.

4.15 The large installed base of terrestrial television roof top antennas and the integration of terrestrial receivers into television sets have enabled terrestrial television to become the default low cost means of accessing the PSB channels. This role was reflected in the Government decision that post digital switchover DTT coverage for the PSB channels should substantially match the coverage of the analogue terrestrial

[51] See http://stakeholders.ofcom.org.uk/binaries/consultations/psb2_1/annexes/annex6.pdf
[52] Source: Freeview research, as in 4G Omnibus – ICM Research Ltd, October 2011

PSB channels. This requirement ensured that DTT households continued to have access to PSB channels after digital switchover.

4.16 Whilst the PSB channels are also available on a free-to-air basis on satellite on a near universal basis, households switching from DTT to satellite, who have only a terrestrial aerial and a standard DTT enabled TV set, would need to bear the cost of installing a satellite dish and acquiring a satellite receiver.

4.17 The PSB channels are also available on the cable platform but these services are only available to approximately 50% of UK households and are only accessible as part of a subscription package. We do not anticipate a significant expansion in cable network coverage over the next decade that would enable a matching of the level of coverage provided by the DTT platform.

4.18 Future IPTV developments could also be relevant to whether DTT's role in providing universal low cost access to PSB services is likely to remain relevant over the long term.

4.19 To date, IPTV has had a limited impact on the TV delivery market and IPTV based services have been primarily positioned as a complement to multichannel linear TV services broadcast on more traditional terrestrial, cable and satellite platforms, as opposed to providing a complete substitute for these platforms. Part of this is due to the current technical limitations of the existing broadband infrastructure, which currently makes IPTV better suited to:

- Delivering on-demand services as opposed to one-to-many broadcast services;
- Delivering a limited number of hours of TV content due to the high costs associated with delivering high capacity video services on broadband networks. In practice, many broadband subscription packages impose a monthly download cap which has the effect of limiting the number of hours of video that can be watched;
- Providing services in SD as opposed to HD due to the higher broadband speeds needed to deliver HD services.

4.20 However, it is likely that all these limitations will be addressed in the future. For example, the greater provisioning of broadband backhaul capacity and the wider adoption of multicast technology on broadband networks could enable a more cost effective delivery of broadcast content. There is also a high likelihood that higher speed super fast broadband connections based on either fibre-to-the-cabinet or fibre-to-the-premises technology will be rolled out on a universal basis in the future[53], enabling the simultaneous delivery of multiple HD streams to each household.

4.21 In addition, if viewer preferences were to progressively shift from linear broadcast TV to on-demand TV consumption, IPTV would become better adapted to meeting viewer expectations and may become more popular.

4.22 However, despite the technology improvements described above, we consider that over the next 10 to15 years the lack of universal consumer take-up of broadband will

[53] The UK Government has already committed to £530m funding to extend the rollout of superfast broadband in rural areas.

prevent IPTV from providing a complete substitute for DTT's role in providing low cost universal access to PSB services. Today, only 74% of UK households have a broadband connection. DTT viewers who do not have a broadband connection would need to bear the cost of acquiring one in order to access IPTV services. All DTT households would also need to install IPTV compatible receivers to access TV services.

4.23 Hence, whilst IPTV could potentially provide an alternative to DTT in providing universal access to PSB content we believe that it is unlikely that there will be sufficient consumer take-up of super fast broadband and IPTV receivers for IPTV to provide a complete substitute for the DTT platform at least over the next decade.

4.24 We recognise that barriers to the take-up of broadband and IPTV could fall away over much longer timeframes (e.g. post 2030). This could open possibilities of more radical changes in the delivery of PSB services, thus leading to a potential rationale for a DTT switch-off in the very long term. However, given the very speculative nature of any analysis of developments over such a long timeframe, we do not consider it appropriate to examine these possibilities further in this consultation.

Question 6: Do you agree that DTT will continue to play an important role in providing universal low cost access to PSB content over at least the next decade?

The DTT platform is also likely to remain attractive to viewers over the next decade

4.25 The DTT platform delivers wider benefits to citizens and consumers than simply providing access to the PSB channels: it also provides viewers with access to a wider choice of broadcast channels and platforms, which in turn facilitates more competition in the delivery of digital television. In addition, the DTT platform supports a significant horizontal consumer electronics retail market for DTT receivers, with an estimated 65 million compatible receivers[54] sold up to 2011. This receiver market enables a wider choice of TV receivers and reduces prices for consumers.

4.26 The ability of the DTT platform to continue to perform this role, absent significant changes in spectrum availability, will depend on broader sectoral developments

4.27 One behavioural shift that could affect the future attractiveness of the DTT platform is a shift in viewing behaviour towards on-demand consumption. Based on current viewer behaviour, there appears to be a low probability of this happening in the short term.

4.28 Results reported in Ofcom's 2011 Communications Market Report[55] showed that linear television remains popular with viewers and that the average linear TV viewing time per day increased from 3.75 hours per viewer per day in 2009 to 4.04 hours per viewer per day in 2010. In 2010, in those households with a DVR, 86% of the time spent watching television was still spent watching live broadcasts rather than recorded programmes. This ratio has held fairly constant since 2007 even though

[54] See submission by Freeview in response to our call for input: http://stakeholders.ofcom.org.uk/consultations/uhf-spectrum-bands/?showResponses=true

[55] See http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr11/

DVR equipment has become more prevalent over the same time period. Video on Demand (VoD) consumption on the TV using IPTV and cable is likely to currently represents only a small proportion of total viewing.

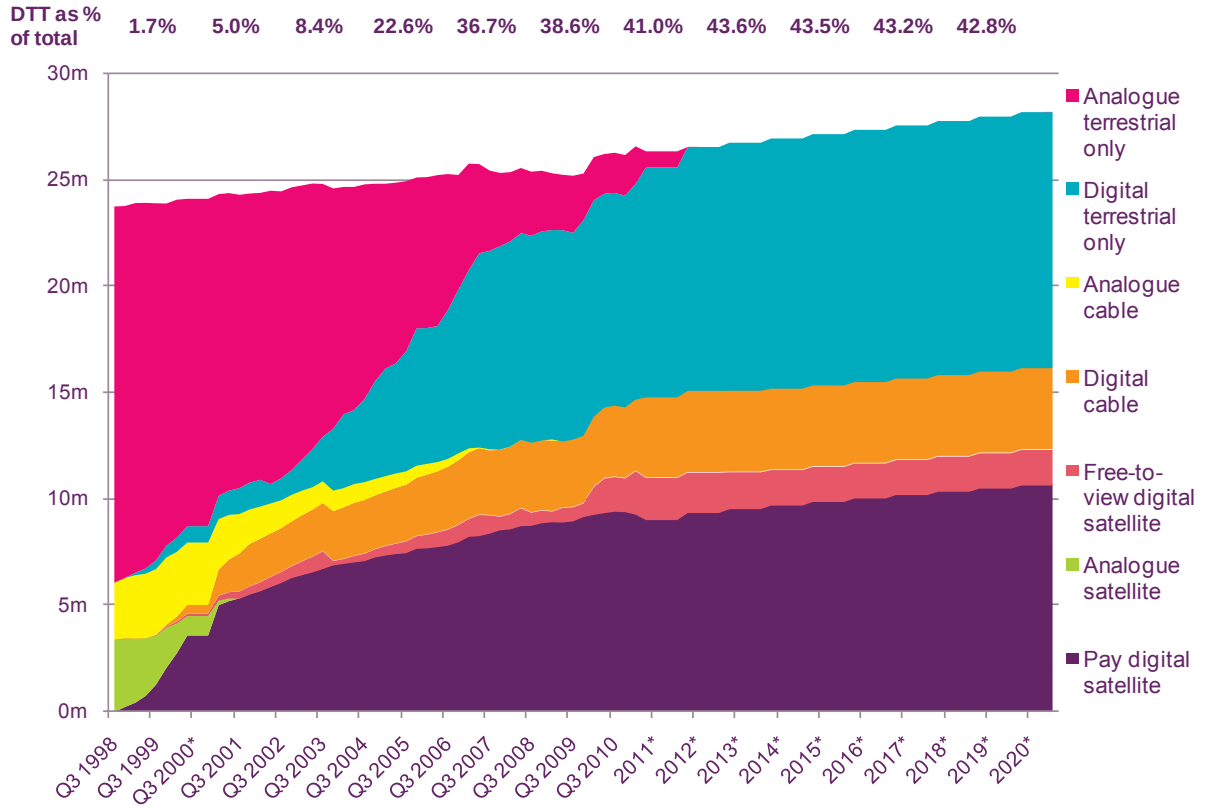
4.29 Over the long term, however, it is possible that shifts in viewer behaviour towards non-linear and other internet enabled features could become more prevalent. As noted above, in such circumstances IPTV platforms may be better suited to exploiting shifts in viewing behaviour. The complementarity and integration with IP-enabled features could therefore become important for the ongoing attractiveness of DTT.

4.30 Propositions such as YouView, an IPTV based VoD service to complement DTT broadcast linear channels due to launch later in 2012, could help meet future DTT viewers demand for on-demand consumption and contribute towards maintaining the attractiveness of the DTT platform.

4.31 A change in future viewer preferences from SD to HD could also impact on the future attractiveness of the DTT platform. This is because HD services require significantly more broadcast capacity than SD services. Capacity is much scarcer on the DTT platform than on alternative high capacity satellite and cable platforms. However, some HD services are already available on the DTT platform and improved transmission and compression efficiency, including DVB-T2, MPEG 4 and future third generation High Efficiency Video Coding (HEVC) compression are likely to enable a significant number of HD channels to be added in the future. However, this outcome will be dependent on the future amount of spectrum available for use by the DTT platform.

4.32 We note that, given the likely resilience of the DTT platform to changes in viewer behaviour and new service developments, analysts predict that, absent major changes in the amount of available spectrum, the DTT platform will continue to hold a significant share of primary TV sets for at least the next decade (see figure 11).

Figure 11 – Historic and projected multichannel take-up in UK households (primary TV sets) – 1998 - 2020



Source: Ofcom data (Q3 1998-Q4 2010); 3 Reasons LTD Autumn 2011 multichannel model (projections 2011-2020)

Question 7: Do you agree that, absent major changes in available spectrum, DTT would continue to remain attractive to viewers and deliver important benefits to citizens and consumers over at least the next decade?

Improved video compression and transmission standards can provide greater DTT spectrum efficiency

4.33 The DTT platform currently broadcasts on six multiplexes. Each multiplex uses different channel frequencies in different parts of the country, depending on international agreements and the need to avoid interference between transmitters. The resulting transmission plan for each multiplex results in what is known as a multi-frequency network (MFN).

4.34 Three of these six existing multiplexes are classified as PSB multiplexes[56], which will provide coverage to 98.5% of UK households after digital switchover, substantially matching the coverage level previously provided by analogue terrestrial television. Two of the PSB multiplexes currently deliver standard definition (SD) services and the third delivers high definition (HD) services. The other three multiplexes are

[56] Two of these are operated by the BBC, with control of the third divided between ITV and Channel 4 under the operating name D3/4.

defined as commercial multiplexes[57], which will provide coverage to approximately 91% of the UK households after digital switchover. All of these commercial multiplexes currently deliver SD services.

4.35 There are various developments which could change the amount of spectrum required to broadcast TV channels on the DTT platform in the future:

- Improved digital transmission and compression efficiency technologies, including DVB-T2 and H264/AVC, could enable more TV channels to be delivered using the same amount of spectrum;
- There could be greater use of Single Frequency Networks (SFNs) as opposed to Multi-Frequency Networks (MFNs). SFNs enable the same frequencies to be re-used at adjacent transmitter sites, thus providing greater spectrum efficiency;
- On the other hand, HD could become the preferred viewer television format. This would require a greater amount of broadcast capacity to be used to deliver each TV channel. Looking further ahead, new immersive broadcast display formats including 3DTV and ultra high definition television could further increase the amount of broadcast capacity required to deliver each TV channel.

4.36 A study by ZetaCast on the technical evolution of DTT[58] commissioned by Ofcom investigated the likely improvements in digital compression and transmission efficiency to 2030. This study has identified anticipated improvements to the platform that will be brought by successive first, second and third generation DTT multiplex technologies:

4.37 **First generation multiplex technology:** The DTT platform currently operates with five first generation DVB-T multiplexes. Two of these are PSB multiplexes and have a capacity of 24.1 Mbit/s, whilst the remaining three commercial multiplexes use slightly less robust DVB-T transmission parameters and provide a capacity of 27.1 Mbit/s. On each DVB-T multiplex approximately 1.5 Mbit/s is required to deliver services other than the broadcast TV channels including EPG and interactive data. The remaining 22.6 Mbit/s or 25.6 Mbit/s is available to deliver broadcast TV and radio channels. No further improvements in DVB-T transmission efficiency are expected.

4.38 The broadcast TV channels services delivered on first generation DVB-T multiplexes operate using first generation MPEG 2 video and audio compression. This first generation compression technology is now relatively mature and no further major improvements in MPEG-2 encoder efficiency are likely to occur. This means that over the next decade we can reasonably assume that each first generation PSB multiplex will carry around nine SD broadcast TV channels and each first generation commercial multiplex will carry around ten SD broadcast TV channels.

4.39 **Second generation multiplex technology:** The DTT platform currently operates with one second generation DVB-T2 multiplex which provides an increased multiplex capacity of 40.1 Mbit/s. This second generation multiplex delivers HD channels encoded using H.264/AVC compression. Assuming again that 1.5 Mbit/s is required

[57] Two of these are operated by Arqiva with the remaining multiplex under the control of SDN, which is owned by ITV.

[58] http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/zetacast.pdf

to deliver services other than broadcast TV channels there is 38.7 Mbit/s available to deliver HD channels.

4.40 H.264/AVC encoders are still continuing to improve, but at a slower rate than was the case in the first few years after the initial services were launched. Given these future improvements it is likely that the number of HD services that can be delivered on each second generation multiplex will progressively increase from four to six over the next few years.

4.41 **Third generation multiplex technology:** At present there are no third generation multiplexes operating on the DTT platform. Third generation multiplexes will probably continue to operate with DVB-T2 transmission technology. This is because significant further improvements in multiplex transmission efficiency are only likely be achieved by using MIMO technology. However, this would not represent a practical solution as it would require all DTT viewers to change their roof top antennas.

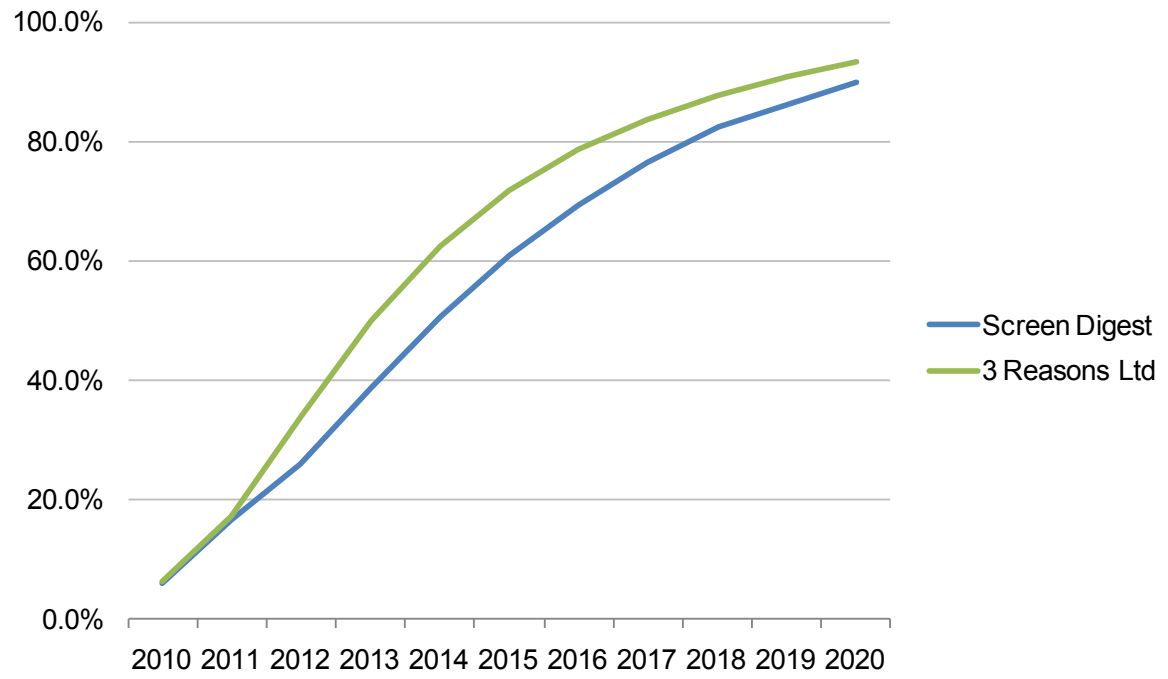
4.42 However, these third generation multiplexes could operate with improved efficiency HEVC video compression. The first HEVC encoders are expected to become available in 2014 and to rapidly improve in compression efficiency in the first few years before reaching a plateau by about 2030. If third generation multiplexes were used on the DTT platform they would enable the delivery of five HD channels in the full 1080p resolution format in 2015, 8 in 2020 before reaching a plateau of 10 HD channels in 2030.

Second and third generation multiplex technology is not compatible with first generation consumer receivers

4.43 Whilst second and third generation multiplexes are able to deliver significant improvements in overall multiplex efficiency, they are not compatible with first generation DTT receivers, which only support DVB-T transmission and MPEG 2 encoding.

4.44 Today analysts estimate that approximately 80% of DTT receivers used for primary TV sets only support first generation DVB-T MPEG 2 multiplexes, but this is estimated to fall to 10 to 20% of receivers by 2020 (see figure 12).

Figure 12 - Projected penetration of DVB-T2 H.264/AVC compatible equipment on DTT primary sets



Sources: 3 Reasons Ltd – autumn 2011 multichannel model; Screen Digest, December 2011 forecasts.

4.45 The future growth in take up of second generation receivers is expected to be driven by the greater consumer adoption of means to access improved functionalities, including HD DTT services, which are broadcast on second generation multiplexes.

4.46 It is also likely that the adoption of second generation receivers will be initially greater on large screen primary TV sets than on second and third TV sets. Part of the reason for this will be that the benefits of HD will be more visibly apparent to viewers on larger sets. In part, even when HD is not the key factor driving the decision to buy a new TV set, it will be because manufacturers tend to include the latest technology in the various components of higher end products, to position them as future-proof.

4.47 Until there is universal adoption of second generation receivers there is likely to be an ongoing need to duplicate the broadcasts of some TV channels on the DTT platform using both SD (DVB-T MPEG 2) and HD (DVB-T2 H.264/AVC)[59]. This approach provides:

- Continuing access to TV channels in SD on first generation receivers;
- Access to TV channels in HD on second generation receivers, providing also an ongoing incentive for other DTT users to upgrade from first to second generation receivers.

4.48 The need for continued simulcasting of certain channels in SD reduces some of the spectrum efficiency gains that can be achieved from using second generation multiplexes until there is a greater adoption of second generation receivers. Despite

[59] The simultaneous dual broadcasting of channels in both SD and HD is known as simulcasting.

this, at this stage we do not favour the option of regulatory intervention to manage a migration to second generation technology on the DTT platform because of the switching costs and disruption this would cause for DTT users with first generation receivers.

4.49 Instead we believe a better outcome is likely to be achieved through a market-led transition to second generation technology on the DTT platform, driven by the wider availability of HD and/or SD services delivered using second generation technology which would encourage the greater consumer adoption of second generation receivers.

4.50 We consider that there is likely to be a much lower level of adoption of third generation receivers over the next decade. These third generation receivers are not currently available in the market and are likely to be used to launch new picture formats on the DTT platform such as: 1080p, 3DTV or ultra-high definition television in order to provide an incentive for manufacturers to build third generation technology into their receivers and for consumers to buy these receivers. There is currently an uncertain level of demand for these new picture formats, which creates uncertainty over when the launch of third generation multiplexes, and the technology take-up that could be associated with it, may actually take place.

4.51 In conclusion, whilst second and third generation DTT multiplex technology will provide significant improvements in DTT capacity, some of these capacity gains will offset by the need to simulcast services using different DTT technologies to provide ongoing access to legacy first generation receivers and a potential longer term transition from SD to HD. Further improvements in spectrum efficiency could also be provided by the wider use of SFN as opposed to MFN networks.

Question 8: What are your views on the future technical evolution of the DTT platform? Are there other relevant factors affecting future DTT spectrum requirements that we should consider as we develop an approach to secure benefits from UHF band IV and V over the long term?

In summary, we believe it is appropriate to consider how to safeguard benefits delivered by the DTT platform

4.52 The current DTT platform is a successful consumer proposition and current evidence suggests that it delivers important benefits to viewers, not just in terms of making the PSB channels available on a universal basis at low cost but also in terms of supporting wider consumer choice.

4.53 Improved video compression and transmission standards will provide greater DTT spectrum efficiency but the speed of adoption of these new standards is uncertain. It is therefore uncertain what amount of spectrum will be required over the next 10-15 years for DTT to support a range of services similar to today's.

4.54 Against that background, we believe that it is appropriate to consider what measures we can take to safeguard benefits to viewers delivered by DTT over the longer term. This will be discussed in more detail in Section 6.

Question 9: Do you agree that a longer term approach to secure benefits from UHF band IV and V should consider how to safeguard benefits delivered by the DTT platform?

Section 5

Other uses of UHF band IV and V

5.1 There are a number of other important services that are either making use or could benefit from making use of UHF band IV and V spectrum in the future.

5.2 A number of these services share the spectrum used by DTT on a geographically interleaved[60] spectrum basis. These include most programme making and special events (PMSE) services, local TV and white space devices. Whilst others rely on dedicated use of the UHF spectrum including some PMSE services and potential future Public Protection and Disaster Relief (PPDR) services.

5.3 In this section we discuss the main factors that could affect future requirements of these services that we should consider as we develop an approach to secure long term benefits from UHF band IV and V.

Programme Making and Special Events (PMSE)

5.4 PMSE makes use of the interleaved spectrum to support a number of different applications: wireless microphones, in-ear-monitors (IEMs), talkback and audio links. These services support a wide range of activities from programme making, theatres, concerts, sports event coverage and smaller scale users including churches and schools. Access to the spectrum is licensed on our behalf by the Joint Frequency Management Group (JFMG), an independent company that manages and coordinates spectrum use in order to avoid interference to DTT and between other PMSE users.

5.5 Currently there are PMSE assignments across the whole of UHF band IV and V, but as the pattern and availability of the interleaved spectrum changes with DSO and the clearance of the 800MHz band, PMSE use in the frequency range 790 to 862 MHz will cease on 31 December 2012. As part of the 800 MHz clearance process channel 38 (606 to 614 MHz) has been allocated to PMSE exclusively as a replacement to channel 69 which will be cleared of PMSE use at the end of this year. Indoor use of channel 38 is also available UK wide, but its outdoor use is restricted in some areas until DSO is complete.

5.6 There will be a continuing demand for access to geographically interleaved spectrum for PMSE. PMSE representatives have expressed a view that the ever increasing size and complexity of programme productions will lead to increasing demand for channels[61].

[60] Geographically interleaved spectrum describes the set of frequencies that will be used to carry digital terrestrial television (DTT) following digital switch over at the end of 2012. Interleaved spectrum is so called because it can be used at a local level on a shared – or interleaved – basis with DTT.
[61] Response from the British Entertainment Industry Radio Group (BEIRG) to our call for input on Developing a Framework for the Long Term Future of UHF Spectrum Bands IV and V, http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-spectrum-band/responses/beirg.pdf

5.7 A large proportion of PMSE devices that make use of spectrum at UHF band IV and V are wireless microphones and in-ear monitors (IEMs). Currently, the majority of these devices use analogue transmission schemes, although some digital devices are now becoming available which could bring spectrum efficiency gains.

5.8 Whilst digitisation would not necessarily allow more PMSE channels to be supported within a single 8 MHz TV channel, it can provide spectrum efficiency gains for multichannel systems that span two or more adjacent 8 MHz TV channels, as digital transmissions are less susceptible to adjacent channel interference than analogue. This could potentially enable more PMSE devices to be supported in the same amount of geographically interleaved spectrum[62]. However, this would require PMSE users to invest in new digital systems and there are also concerns that the latency associated with digital processing would be too great to support live event applications.

Question 10: Are there other material factors affecting the future requirements of PMSE that we should consider as we develop an approach to secure long term benefits from UHF band IV and V?

Local TV

5.9 Local TV will make use of the spectrum used by existing DTT services on geographically interleaved basis. A local TV multiplex operator will be assigned a single 8 MHz channel in each of several locations across the UK across the entire band of frequencies used by DTT, within which they will deploy a multiplex likely to be based on the DVB-T standard. As only one local TV operator will be licensed for a given area, the amount of interleaved spectrum assigned for local TV at any location will be 8 MHz.

5.10 The exact frequency allocated to a particular local TV operator will be determined principally by the requirement not to cause interference to the existing UK-wide DTT multiplexes. The frequency will also be selected to be in-group with existing rooftop antennas, wherever possible, to maximise the likelihood that households will be able to receive the local services.

Question 11: Are there other material factors affecting the future requirements of Local TV that we should consider as we develop an approach to secure long term benefits from UHF band IV and V?

[62] A study undertaken on behalf of Ofcom suggested that in certain environments up to 15 wireless microphones could operate in a single 8MHz channel, irrespective of whether they are analogue or digital. However, the study observed that digital microphones were less likely to suffer from the interference effects of so-called *intermodulation products*, caused when devices operate in close proximity to each other. http://stakeholders.ofcom.org.uk/binaries/research/technology-research/sewm/finalreport.pdf

White Space Devices and other innovative applications

5.11 White space devices (WSDs) is a term given to an emerging category of devices that operate in interleaved spectrum, also known as white spaces. In September 2011 we published a statement setting out the outcome of our consultation on implementing a geolocation-based approach to enable white space access on a licence-exempt basis in the UHF TV band. Work is also progressing to put in place necessary regulations to licence-exempt white space devices. We are working towards putting in place necessary regulations to allow WSDs to operate on a non-protected, licence exempt basis, providing that WSDs do not cause interference to other, licensed spectrum users, such as DTT services and PMSE equipment.

5.12 The frequencies that can be used by a WSD at a particular location will depend on the incumbent licensed services to be protected. Our proposed approach to assign frequencies to WSDs and manage interference is based on a geolocation database.

5.13 A WSD will request access to spectrum from the geolocation database based on information on its location. The database then responds with an appropriate transmit frequency and power level that have been calculated not to cause interference to neighbouring DTT services and PMSE equipment.

5.14 Potential white space applications include local and metropolitan area networking and machine-to-machine communications. The attractive propagation characteristics of UHF band IV and V white space spectrum enables these applications to achieve better quality of service outdoor and in-building coverage, than higher frequency spectrum.

5.15 Our current work on WSDs is focused on enabling licence exempt access to UHF white spaces. However, our fundamental approach is sufficiently flexible to support other spectrum bands and alternative licensing approaches, should this subsequently become appropriate.

5.16 For example, following the proposed switchover of national and large scale local FM broadcast radio services to DAB in band III, there may be a possibility to exploit white spaces remaining in VHF band II. We are currently undertaking a study to determine whether this is viable.

5.17 As WSDs are deployed and its technology becomes more mature, it is likely that devices will able to use spectrum even more efficiently. WSDs are also likely to become more sophisticated and aware of their environment – the so-called *cognitive radio* concept – allowing them to co-ordinate their transmissions and reduce interference between devices.

Question 12: Are there other material factors affecting the future requirements of WSD applications that we should consider as we develop an approach to secure long term benefits from UHF band IV and V?

5.18 There may be other innovative ways in which UHF bands IV and V can be used to deliver services. As with WSDs, these approaches would need to ensure that interference is not caused to incumbent services. Such approaches may currently be at an early stage of development but may yield benefits in the long term.

Question 13: Aside from WSDs, are there other innovative ways in which to use UHF bands IV and V to deliver services and, therefore, material benefits to users

Emergency services applications at UHF frequencies

5.19 In the UK, the PPDR (Public Protection and Disaster Relief) service used by the police, fire and ambulance services is currently provided by Airwave and based on the ETSI TETRA (TErrestrial Trunked RAdio) standard. Airwave provides robust and secure voice and narrowband data messaging services. The system provides support for radio functionality services tailored for the emergency services, such as group calling, nationwide roaming and direct mobile to mobile calls without network infrastructure support.

5.20 The Airwave service operates in a number of bands between 380 and 470MHz and, therefore, is not currently a user of UHF band IV and V spectrum. Approximately 14MHz is assigned to Airwave to support its service, although additional bandwidth is made available in certain locations to provide extra capacity. Operating at these frequencies affords the Airwave system good range characteristics, including providing coverage inside buildings and underground. A number of individual narrow band assignments within this frequency range are used directly by the Police and Fire and Rescue services that do not involve Airwave.

5.21 Airwave has a service licence which expires in 2020. However, contracts with individual police services will begin to expire from 2016; this fragmentation reflects regionalised rollout of the Airwave service in its early days.

5.22 Steps are being taken, both in the UK and in other countries, to identify application and spectrum requirements for PPDR systems in the future. There is likely to be a requirement for the support of multimedia and broadband data, neither of which can be supported on the current network.

5.23 One service that cannot be deployed on current networks is high speed mobile broadband. For example, it may be desirable for fire fighters to be able to download detailed plans of buildings in order to navigate through them safely in darkness or smoke. Alternatively, high speed broadband would enable the upload of high quality video or photos of scenes of crime or injuries to incident co-ordination centres.

5.24 In the US, plans for next generation PPDR networks are more mature than in the UK. Spectrum has been identified in the 700MHz band and networks are being planned and deployed based on LTE. This approach has the major advantage that future PPDR networks will be based on the same technology as is used for commercial networks, leading to an obvious economy of scale on equipment.

5.25 The timetable associated with licensing the current Airwave service, the steps to identify future requirements and international moves towards deploying PPDR networks in UHF band IV and V spectrum mean that there is a likelihood that future decisions on emergency services' requirements could be relevant for our future approach to managing 700 MHz spectrum.

5.26 There are a number of ways in which, in principle, PPDR services can be deployed. For example, the current approach used by Airwave involves using dedicated spectrum that is only used for this purpose. An alternative might be for PPDR services to be deployed using spectrum or network infrastructure that is shared with non-PPDR users. Decisions on whether and how emergency services will require

use of spectrum in UHF band IV or V (or any other band), and how that would be secured, will be a matter for Government. We are noting this potential demand to ensure that stakeholders are able to consider this in their responses, and so that we and Government have the best information currently available about potential future demand.

Question 14: Are there other material factors affecting the future requirements of emergency services applications that we should be aware of as we develop an approach to secure long-term benefits from UHF band IV and V?

Section 6

Securing long term benefits for citizens and consumers

6.1 In section 3 we identified that a significant amount of additional harmonised spectrum is likely to be required, in addition to using more efficient mobile technology and more mobile sites, to meet the anticipated growth in mobile data capacity demand. We also identified that there is likely to be a much greater scarcity of supply of additional harmonised sub 1 GHz than higher frequency spectrum. Sub 1 GHz spectrum has the desirable attributes of being able to reduce the number of additional mobile sites that will need to be provided in the future to meet the growth in demand for mobile broadband capacity, and improve the quality of service provided in difficult to reach indoor and outdoor locations.

6.2 We also identified that the 700 MHz band, which is currently used to deliver DTT services and other services using interleaved spectrum, is likely to be the most suitable band for providing additional harmonised sub 1 GHz spectrum for mobile broadband because:

- In North and South America (ITU Region 2) the 700 MHz band has already been allocated to mobile broadband and is being used to deploy LTE based mobile services on a mass market scale in the United States;

- In the Asia Pacific region (ITU Region 3) the 700 MHz band has already been allocated to mobile broadband. Countries including Australia and New Zealand are likely to release this band in the short term enabling LTE deployments, whilst in others, like India, plans for release are currently at an earlier stage;

6.3 In Europe, Africa and the Middle East (ITU Region 1), a resolution was recently passed at the recent 2012 World Radio Conference (WRC 12) that signals an allocation to mobile broadband services following the next World Radio Conference in 2015 (WRC 15). This will bring Europe, Middle East and Africa into line with the rest of the world, creating global momentum behind the use of this band for mobile broadband;

6.4 In addition, part of 700 MHz band has been reserved in the US for the delivery of future generation of LTE based emergency service applications, creating the potential opportunity for greater economies of scale and reduced prices for future emergency services equipment in this band.

6.5 The benefits provided by additional mobile broadband spectrum at 700 MHz are likely to be greater if it becomes available before other capacity enhancing techniques at existing mobile sites have been exhausted and significant numbers of new mobile sites need to be built. Whilst the WRC 12 decision is likely to pave the way for eventual release of the 700 MHz band for mobile services in Europe, the need for an amendment to the Geneva 06 frequency plan and subsequent negotiations with neighbouring states over the implementation of this plan mean that any clearance of the 700MHz band for mobile broadband use is unlikely to start before 2018. There is currently a high degree of uncertainty over this date, which is dependent on the positions other countries in ITU region 1 take over the future use of the 700 MHz band for mobile broadband.

6.6 We also identified in section 4 that the DTT platform as a whole, which currently uses the 700 MHz band and other UHF spectrum, is likely to continue to provide important benefits to citizens and consumers at least over the next decade both in terms of providing universal low access to PSB content and in supporting a wider consumer choice of channels, receiver equipment and platforms.

6.7 There are several high level options in terms of the approach that Ofcom could take towards the potential future harmonisation and release of the 700 MHz band for mobile broadband:

- **Option 1:** Do not release the 700 MHz band for mobile broadband. This would be the least disruptive option for the DTT platform and other users of UHF band IV and V spectrum. However, this option would not allow the potentially significant benefits identified in section 3 of being able to use the 700 MHz band to meet the growth in demand for mobile broadband capacity in a cost-effective way and provide improved quality of service in difficult to reach locations.

- **Option 2:** Release the 700 MHz band once it is harmonised and co-ordinated for mobile broadband in Europe, with no further spectrum for DTT to ensure the benefits it provides are safeguarded. As discussed further in the rest of this section, this would create a risk that the DTT platform will be unable to perform its important public policy role of providing low cost universal access to the PSB channels over a time period where alternative platforms could be unable to substitute for this (as discussed in section 4). This option would also create a risk that the consumer choice of content, digital TV platforms and equipment could be reduced.

- **Option 3:** Release the 700 MHz band once it is harmonised and co-ordinated for mobile broadband in Europe, whilst also ensuring the DTT platform has spectrum to continue to perform both its public policy role in providing low cost universal access to PSB content and its role in sustaining consumer choice in platforms, content and equipment

6.8 Given the above, we believe option 3 represents the approach that is most likely to secure greater benefits for citizens from UHF bands IV and V spectrum over the long term.

Question 15: Do you agree that the approach that is most likely to secure significant benefits from UHF band IV and V over the long term is one that enables the release of the 700 MHz band for mobile broadband whilst also ensuring the role of the DTT platform is safeguarded?

Ensuring that DTT continues to deliver benefits to citizens and consumers

6.9 In section 4 we identified that second and third generation DTT transmission and video compression technologies can provide a significant improvement in DTT spectrum efficiency enabling the delivery of more TV channels using the same amount of spectrum or a similar number of channels to be delivered using higher definition formats.

6.10 We also identified that Single Frequency Networks (SFNs) as opposed to MFNs, which enable the same frequencies to be re-used at adjacent transmitter sites, can provide further potential improvements in spectrum efficiency.

6.11 The required number of broadcast DTT TV channels, and hence amount of DTT broadcast spectrum required in the future can be viewed from a number of different perspectives:

- *From a public policy perspective:* the amount of multiplex capacity and associated spectrum required to deliver the PSB channels with universal coverage;
- *From a platform sustainability perspective:* the amount of multiplex capacity and associated spectrum required to deliver a sufficient number of additional free-to-air and/or Pay TV channels to the PSB channels, to enable the DTT platform to remain an attractive proposition to viewers so that it can remain commercially sustainable as a platform and hence a viable means of providing universal access to the PSB channels.
- *From a consumer perspective*: the amount of multiplex capacity and associated spectrum required to enable and sustain choice for a range of TV channels for consumers who have invested in DTT reception equipment; we also note that a sufficiently attractive DTT platform could help maintain incentives for the ongoing development of TV and receivers equipment by manufacturers, and in supporting wider platform and service choice for consumers.

Releasing 700 MHz for mobile broadband without using any further spectrum for DTT raises risks in relation to the benefits delivered by DTT

6.12 We now explore whether the number of broadcast TV channels and service coverage that could be provided using the DTT spectrum remaining after clearing the 700 MHz band for mobile broadband[63] would be sufficient to deliver the desired outcomes set out above for citizens and consumers.

6.13 We commissioned consumer research to improve our understanding of the features and characteristics that consumers most want from the DTT platform. This research included conjoint analysis, designed to reveal consumers preferences for different hypothetical TV packages offering different platform services and features. This highlighted that the feature most valued by DTT viewers was access to a significant number of free to air channels[64].

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[63] In this subsection we refer to options for re-planning DTT making use of spectrum in UHF channels 21 to 30 and 39 to 48 inclusive (see figure 2), excluding the 600MHz band at channels 31 to 37

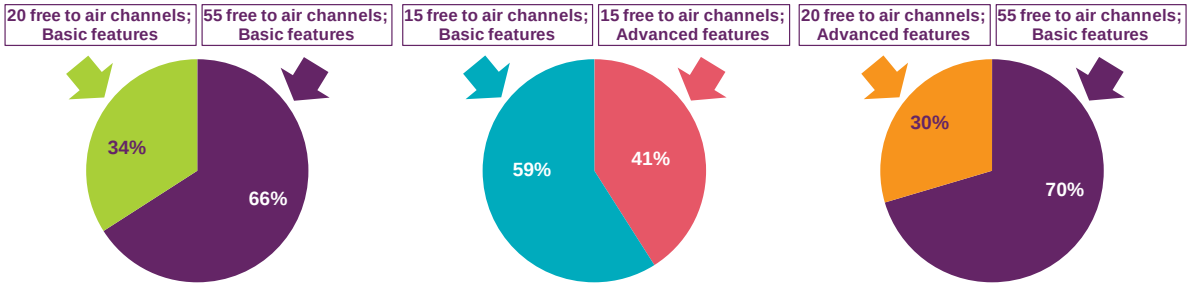
[64] Our consumer research included also a series of direct questions, aimed at obtaining stated preferences for TV functionalities, as opposed to revealed preferences (gathered through the conjoint exercise). The results of the survey exercise presented some differences from the conjoint ones. As illustrated in figure 8 of the BDRC Continental report, they showed a greater, positive preference for additional functionality such as DVR recording facilities and VOD services as well as additional SD channels, especially when we considering consumers' second and third choice features (See figure 9). It is not unusual for there to be a difference between consumers' stated preferences and their revealed preferences in a research exercise. In this case, differences between stated and revealed preferences could reflect the nature of the questions posed. In the stated preferences exercises respondents were able to make choices based on their attraction to it on its own merits; in the conjoint, revealed preferences exercise, respondents had to consider combinations of features, making either/or choices of different service packages, also considering the price premiums associated with some of these features. See

6.14 In the figure below, we replicate illustrative results from a model developed as part of this consumer research, which show respondents' preferences for different hypothetical TV packages. These results illustrate the importance of having access to a sufficiently large number of free-to-air channels in influencing respondents' preferences and a general reluctance to pay to receive TV services. In particular:

- 66% of DTT respondents would prefer a TV offering of 50 SD and 5HD free-to-air channels, as opposed to a TV offering of 10 SD and 10 HD free-to-air channels. This means that respondents currently value more highly access to a wider choice of SD channels than access to HD channels;
- 59% of respondents would prefer a TV offering with a smaller number of TV channels and less advanced TV platform features, such VoD, rather than having to pay to upgrade them. This trend was more pronounced amongst respondents who used Freeview on their primary TV set, with just 38% opting for a more advanced package with paid-for options, whilst 48% of respondents with Pay TV on their primary set made the same choice.
- 70 % of respondents would prefer a TV offering with 55 free-to-air channels and basic TV platform features, as opposed to an offering with 20 free-to-air channels and advanced features[65].

6.15 These results are illustrated in figure 13.

Figure 13 – Conjoint results illustrating importance to DTT viewers of number of free-to-air channels compared to other features



Features	20 channels, Basic features	55 channels, Basic features
SD channels	10 SD	50 SD
HD channels	10 HD	5 HD
PVR	Free box	Free box
Catch-up	7 days catch-up	7 days catch-up
EPG	Basic EPG	Basic guide

Features	15 channels, Basic features	15 channels, Advanced features
SD channels	10 SD	10 SD
HD channels	5 HD	5 HD
PVR	Free box	Option to buy special box for £50
Catch-up	7 days catch-up	30 days catch-up
EPG	Basic EPG	Interactive guide

Features	20 channels, Advanced features	55 channels, Basic features
SD channels	10 SD	50 SD
HD channels	10 HD	5 HD
PVR	Option to buy special box for £50	Free box
Catch-up	30 days catch-up	7 days catch-up
EPG	Interactive guide	Basic EPG

Source: BDRC Continental for Ofcom

6.16 If the use of 700 MHz band were changed to mobile broadband, a new DTT frequency plan would be required using the remaining spectrum. An independent

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http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/UHF-strategy-research/research_report.pdf for further detail.

[65] The results were influenced by the addition of an option to buy a special £50 PVR. Without this feature, the share of respondents choosing the 20 channel package rose from 30% to 38%.

spectrum re-planning study commissioned by Ofcom[66] suggests that the remaining DTT spectrum could potentially support 3 multiplexes with 98.5% coverage (the same coverage level that the current three PSB multiplexes will provide after switchover), independent of whether the 600 MHz band is used for DTT or not.

6.17 This high level planning work assumes the use of a combination of regional MFNs and some regional SFNs to provide a more spectrally efficient outcome. This approach would allow the continuing provision of regional programming on the DTT platform.

6.18 There are two further factors to consider in establishing whether the 600 MHz band should be used for DTT as part of a future re-plan of the DTT platform:

6.18.1 **The ability to practically secure PSB coverage:** In practice, the ability to secure PSB coverage for 3 multiplexes will be dependent on future amendments to the Geneva 06 agreement and the outcome of bi-lateral frequency planning negotiations with neighbouring countries. We believe that an outcome that seeks to maintain only 3 multiplexes with PSB coverage without using the 600 MHz band is, on balance, likely to be secured through international negotiation. However, if in addition to the 3 PSB multiplexes, there was also an objective to ensure the continuing provision of 3 commercial multiplexes without using the 600 MHz band, there would be a significant risk that PSB coverage will be reduced. This is because:

- There would be insufficient DTT spectrum available to provide the number of high power channel frequencies needed at each DTT transmitter site to support 6 multiplexes;
- Under this planning scenario the UK would not have access to a sufficient number of high power DTT transmitter frequency assignments (because it could not use those in the 600 MHz band) to exchange with other countries assignments in bi-lateral frequency co-ordination negotiations, to secure a better planning outcome for the DTT platform after 700 MHz clearance.

We would not consider this to be an acceptable outcome as it would be inconsistent with the public policy objective of ensuring that DTT platform provides coverage for the PSB channels post switchover, which substantially matches the coverage of the analogue terrestrial PSB channels.

6.18.2 **The ability to secure commercial multiplex coverage**: Re-planning the DTT platform without 600 and 700 MHz spectrum could, in principle, provide 3 PSB multiplexes and 3 further commercial DTT multiplexes. As set out above, under this scenario there would be a significant risk that PSB coverage will be reduced. The coverage of the three commercial multiplexes would also be significantly reduced from today's coverage level

[66] See report by Arqiva Spectrum Planning, commissioned by Ofcom to provide independent technical advice on high-level options for re-planning DTT following a potential future clearance of the 700MHz band: http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/arqiva.pdf

of 91% to 58%. This would mean a significant proportion of viewers would lose access to the full range of channels offered by the DTT platform

Recreating 3 PSB multiplexes with universal coverage without access to the 600MHz band

6.19 We now consider the DTT frequency re-planning outcome that provides only 3 multiplexes with PSB coverage. As set out above this outcome is likely to be achievable without using the 600 MHz band in a frequency re-plan of the DTT platform.

6.20 The number of broadcast TV channels that could be delivered in this reduced number of multiplexes is dependent on the digital transmission and compression technologies used and whether these channels are broadcast in SD or HD.

- The adoption of second and third generation digital transmission and compression technologies is potentially beneficial here in terms of enabling an increased number of TV channels to be delivered on each multiplex;

- The migration from SD to HD broadcasting is potentially detrimental here as a greater amount of broadcast capacity is required to deliver each TV channel.

6.21 As shown in figure 12 in section 4 there is unlikely to be a universal DTT user adoption of second generation receivers by the time the 700 MHz band could be cleared for mobile broadband. This means there is likely to be an ongoing need to broadcast some TV channels on the DTT platform using both first generation DVB-T MPEG 2, and second generation DVB-T2 H.264/AVC standards. This approach is known as simulcasting and requires additional DTT broadcast capacity to broadcast the same TV channel twice using different technical standards so that it is receivable on both first and second generation consumer receivers.

6.22 Using this simulcasting approach:

- A single first generation DVB-T MPEG 2 multiplex could, following a reshuffling of PSB services between different multiplexes, provide continuing access to the PSB channels on first generation receivers. This would ensure that an estimated 10 to 20% of DTT households do not lose access to the PSB channels without being forced to buy a new receiver, and that a likely greater proportion of UK households are able to continue to receive these services on secondary TV sets;

- A second generation DVB-T2 H.264/AVC multiplex, currently used to deliver some of the main PSB channels in HD could continue to provide:

    - Ongoing access to HD services to DTT viewers who have invested in a HD compatible second generation receivers;

    - An ongoing incentive for manufactures to provide, and consumers to purchase second generation HD DTT receivers, which will enable a longer term DTT platform transition to more efficient second generation DVB-T2 MPEG 4 standards.

6.23 This would leave one additional multiplex in addition to the first and second generation multiplexes described above to deliver other TV channels in addition to the PSB ones. The number of additional TV channels that could be delivered on this

multiplex is dependent on whether it operates with first, second or third generation technologies and whether it is used to deliver SD or HD services. Different scenarios are set out below:

- Scenario A: There is slow take-up of second and third generation receivers and a low demand for HD services. Here the additional multiplex could be used to deliver 9 SD channels using first generation multiplex technology;

- Scenario B: There is a fast platform transition to second generation technology and low HD demand. Here the additional multiplex could be used to provide up to 30 SD channels using second generation multiplex technology;

- Scenario C: There is a fast platform transition to second generation technology and high HD demand. Here the additional multiplex could be used to provide 6 HD channels using second generation multiplex technology and in the longer term 10 full HD channels using a third generation multiplex. However, it is highly unlikely that the consumer penetration of third generation receivers would be sufficient by the time the 700 MHz band could be released for mobile broadband to enable this third multiplex to operate with third generation technology.

6.24 There are currently approximately 45 free to air TV and 5 Pay TV channels simultaneously broadcast on the DTT platform in peak hours. Only scenario B would enable the total number broadcast TV channels delivered on the DTT platform to approach the number available today after clearing the 700 MHz band, but even under this scenario the total number of TV channels would be reduced by approximately 8.

6.25 Hence there is a risk that if there is a slow platform transition to second generation receivers and/or there is a strong consumer demand for HD services then this will result in a reduction in the number of services available, because there would be insufficient DTT platform capacity.

6.26 The risk of a long term shift from SD to HD broadcasting over the next decade is potentially significant and could result in a failure to satisfy the majority of DTT viewer preferences for access to large number of free to air services, identified by the consumer research described above.

6.27 The consequences of there not being a sufficient amount of DTT capacity to meet future viewer preferences are potentially significant because:

- For viewers choosing to keep DTT as their TV platform, there would be a reduction in the range of services that viewers currently receive, and thus a reduction in the benefits that they derive.

- Manufactures may stop investing in providing DTT receiver products if there is a reduced demand for DTT services, reducing consumer choice and increasing prices for consumers;

- The role of the DTT platform in continuing to support inter-platform competition could be undermined, reducing consumer choice of digital TV platforms.

6.28 Whilst IPTV developments could potentially provide a means for compensating for the reduced level of DTT broadcast capacity, 25% of DTT households do not have a broadband connection and would have to incur the cost of acquiring a broadband

connection to access IPTV services. The consumer research set out above suggests that DTT viewers tend to have low propensity to pay for access to TV services and to invest in additional equipment[67]. However, IPTV could potentially provide an attractive means of:

- Complementing the broadcast free-to-air DTT platform offer with video-on-demand services on new broadband enabled TV sets and set top boxes;
- Delivering Pay TV services to broadband customers, where the necessary IPTV reception equipment is typically provided by the service provider.

Recreating 3 PSB multiplexes and 3 COM multiplexes with reduced coverage without access to the 600MHz band

6.29 We now consider the alternative frequency re-planning outcome for the DTT platform after changing the use of the 700 MHz band that provides in addition to the 3 PSB multiplexes, 3 commercial DTT multiplexes with reduced coverage.

6.30 As noted in the spectrum planning report published alongside this consultation[68], it is not clear whether this is a realistic outcome of the re-negotiation process of international rights to high power assignments.

6.31 Nevertheless, if it was possible to coordinate such an outcome, this would significantly mitigate the risk that the DTT platform will have insufficient capacity available in the future to meet viewer preferences.

6.32 However, under this scenario the coverage of the three commercial multiplexes would fall from 91% to 58%. This could mean a significant proportion of viewers would lose access to the full range of channels offered by the DTT platform.

6.33 In addition, there is a significant risk that PSB multiplex coverage would need to be reduced in order to provide these additional 3 commercial multiplexes.

These scenarios raise risks for the benefits delivered by DTT

6.34 In conclusion, the different DTT frequency re-planning scenarios associated with clearing the 700 MHz band for mobile broadband without using the 600 MHz spectrum in a re-plan if the DTT platform will mean either:

- There is a risk that there will be a reduction in the number and range of services that viewers currently have access to via the DTT platform, in particular, if there is

[67] Pages 12 to 18 of the BDRC continental report discuss findings of the conjoint exercise conducted as part of the consumer research study we commissioned. The model illustrating simulations that incorporate the results of this exercise is available at this link: http://www.ofcom.org.uk/static/uhf/simulator.zip . Conjoint results indicate that all options associated to price premiums tended to have a negative influence on the preferences of Freeview respondents (i.e. respondents who indicated having Freeview on their main TV set). Such negative impact on the preferences for paid-for features was less marked for pay TV respondents (i.e. respondents who indicated having pay TV on their main TV set).

[68] See report by Arqiva Spectrum Planning, commissioned by Ofcom to provide independent technical advice on high-level options for re-planning DTT following a potential future clearance of the 700MHz band: http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/arqiva.pdf

slow consumer take-up of second generation receivers or there is a strong consumer demand for HD;

- There is a risk that, following international negotiations, the DTT platform is no longer able to provide universal access to the PSB channels at the level of coverage that substantially matches the coverage of analogue terrestrial PSB channels.

- There is a high likelihood that the coverage of any additional commercial multiplexes would be significantly reduced.

Question 16: Do you believe there is a material risk that the DTT platform will have insufficient spectrum to continue to deliver important benefits (including providing universal low cost access to PSB content) if the 600MHz band is not used for DTT after clearance of the 700 MHz band?

Releasing 700 MHz for mobile broadband using additional spectrum for DTT

6.35 In light of the risks identified above to the benefits delivered by DTT following a future change of use at 700 MHz band, we have considered whether, and if so how, additional spectrum might be used for DTT to mitigate these risks.

6.36 This spectrum would need to fall within the frequency range that is tuneable by existing DTT receivers. The only spectrum band capable of meeting this requirement is the 600 MHz band being released by digital switchover.

6.37 Technical planning work commissioned by Ofcom has found that by re-planning the DTT spectrum remaining after clearing the 700 MHz band with the 600 MHz band, 6 DTT multiplexes could be delivered, 3 with 98.5% coverage and 3 with coverage broadly similar to that currently provided by commercial multiplexes. To achieve this outcome there would need to be a complete re-plan of the DTT platform transmitter frequencies using both regional SFN and MFN networks, and the commercial multiplexes may need to operate with a most robust transmission mode using DVB-T2[69].

6.38 Again, the number of additional TV channels that could be delivered on these 6 multiplexes is dependent on whether they operate with first, second or third generation technologies and whether they are used to deliver SD or HD services. Different scenarios are set out below:

- Scenario A: There is slow take-up of second and third generation receivers and a low demand for HD services. Here these multiplexes could be used to deliver 45 SD channels using first generation multiplex technology and 6 HD channels using second generation multiplex technology;

[69] The independent planning study by Arqiva Spectrum Planning for Ofcom found that if the commercial multiplexes were to operate with a DVB-T2 transmission mode, their coverage levels post re-plan could be very similar to today's. If instead they continued to operate in DVB-T, coverage post re-plan could be at around 88% of what is currently achieved. We note that a more comprehensive re-planning, taking into account further options to optimise spectrum usage, might result in higher levels of coverage.

- Scenario B: There is a fast platform transition to second generation technology and low HD demand. Here five of the DTT multiplexes could be used to deliver up to 100 SD channels and 6 HD channels using second generation multiplex technology. The remaining DTT multiplex could be used to deliver 10 SD PSB channels to legacy first generation receivers;

- Scenario C: There is a fast platform transition to second generation technology and high HD demand. Here five of the DTT multiplexes could be used to provide 30 HD channels using second generation multiplex technology and in the longer term 50 full HD channels using third generation multiplex technology. The remaining DTT multiplex could be used to deliver 10 SD PSB channels to legacy first generation receivers.

6.39 Scenario A would deliver the same number of broadcast TV channels as today. Scenario B would result in there being a significant increase in the number of broadcast TV channels, whilst scenario C would result in a short term reduction and then a potential longer term increase in the number of TV channels.

6.40 In conclusion, we consider that re-planning the DTT platform using the 600 MHz band would enable the DTT platform to continue to support viewers' choice for a range of channels similar to today's, but could also support more SD and HD channels depending on the level of demand and the development of technology.

6.41 This is likely to significantly reduce risks to the role the DTT platform performs in delivering important benefits, including the provision of universal low cost access to the PSB channels and in supporting to wider consumer choice in the TV delivery market.

Question 17: Do you believe that using the 600 MHz band for DTT after clearing the 700 MHz band would reduce the risk that DTT platform is not able to continue to provide important citizen and consumer benefits?

The implications of using 600 MHz for DTT in long term

6.42 Before the recent WRC 12 planning conference agreed a co-primary allocation to mobile and broadcasting in the 700 MHz band, to come into effect after the next WRC conference in 2015, thereby raising the prospect of using 700 MHz spectrum for mobile broadband within the current decade, Ofcom had intended to hold an award for the neighbouring 600 MHz band. In line with conclusions reached in the Digital Dividend Review (DDR)[70], we had a presumption towards a market led award through an auction of the available spectrum.

6.43 In September 2011 we published an update on the award[71] setting out the prospect of an auction before the end of 2012, and expected to publish a consultation document on our detailed proposals in Q1. We had anticipated awarding indefinite licences with relatively long minimum terms (i.e. more than 10 years). This would provide investors with an opportunity to achieve a return over time taking into account any initial capital expenditure.

[70] http://www.ofcom.org.uk/consult/condocs/ddr/statement/statement.pdf
[71] http://stakeholders.ofcom.org.uk/binaries/spectrum/spectrum-awards/awards-in-preparation/2011/600mhz/600-rd-update.pdf

6.44 The developments at WRC 12, coupled with our assessment of how to best maximise benefits for citizens and consumers from the UHF spectrum set out in this consultation, mean we have reconsidered our approach to the 600 MHz award. In particular, the possibility that DTT might start to be cleared from the 700 MHz band as early as 2018 means the use of the 600 MHz spectrum must be considered more carefully.

6.45 We have identified above the option of using the 600 MHz band to maintain the capacity of the DTT platform as part of a frequency re-plan if the 700 MHz band is cleared for use by mobile broadband. This could significantly reduce the risks to the benefits to citizens and consumers provided by the DTT platform. However, such an approach would mean the 600 MHz spectrum could not be used for other uses beyond that point.

6.46 In February 2010 we published a consultation on the likely uses of the band once DSO clearance was complete[72]. There was agreement among most respondents that the spectrum was particularly suited to the provision of additional DTT multiplexes[73].This is consistent with its primary allocation for broadcasting services across Europe and the wide availability of DTT equipment that can receive services in this frequency range. We also believed it might be plausible for the 600 MHz band to be used instead to sustain new or enhanced WiFi-like services using technology derived from white-space devices, but based on spectrum access on a licenced basis.

6.47 As a result, and in line with band's most likely use, we anticipated auctioning the spectrum in lots suitable for DTT, but without restriction on alternative uses so long as they did not interfere with DTT in the same or neighbouring bands.

6.48 We have considered the potential cost of losing the long-term opportunity to provide a significant increase in DTT platform broadcast capacity to that provided today by the DTT platform, in the event that the 700 MHz band is cleared for mobile broadband and the 600 MHz spectrum is used instead to maintain existing levels of DTT capacity and coverage. We have also considered the cost of losing the opportunity to use the spectrum for services based on licensed use of the 600 MHz band through adapted white-space device technology.

- **Potential loss in value from being unable to significantly increase current levels of DTT broadcast capacity on a long term basis:** In respect of the unrealised consumer value from not using the 600 MHz band for additional DTT services, the loss is the value that might have been delivered from the provision of up to three new multiplexes in addition to the existing 6 DTT multiplexes. Each additional new multiplex could provide today capacity for 4 or 5 additional HD channels or 30 SD channels using second generation multiplex technology, in principle expanding the present set of DTT channels from around 45 SD to a maximum of 135 SD channels, or some other combinations of SD and HD channels. Provision of a significant number of channels, even where consumer willingness to pay for each channel was very low, could in principle generate reasonable consumer value over the population of DTT viewers over a 10 or 20

[72] http://stakeholders.ofcom.org.uk/consultations/600mhz_geographic
[73] http://stakeholders.ofcom.org.uk/binaries/consultations/600mhz_geographic/statement/summary-of-responses.pdf

year horizon. However, at the same time there is considerable uncertainty over the actual commercial value of additional channels and other associated variables, such as the impact on new channels on the DTT advertising market, a possible stagnation of TV advertising and future prices that broadcasters would need to pay to multiplex operators to access DTT platform capacity. These uncertainties, coupled with the potential impact of longer term IPTV developments on the digital TV broadcast market, raise questions in relation to the commercial viability of a significant expansion of DTT channels. This makes it difficult to predict the opportunity cost of not using 600 MHz spectrum for additional DTT services.

- **Potential loss in value from being unable to use the 600 MHz band for new service innovations on a long term basis:** The lost opportunity for long-term deployment new service innovations such as those based on licensed use of the 600 MHz band through adapted white-space device technology is also very difficult to assess because these are evolving technologies. Whilst we recognise the future potential for such technologies, there are significant uncertainties at present about the future timing and availability of mass market devices, and the applications for which they might be used. As a result, any business projections are likely to be somewhat speculative at this stage. The actual value of such deployments would depend on the level of take-up by consumers; the capital expenditure involved for investors; and the time-scale for mass-market availability. It is also uncertain to what extent licensed WSDs in the 600 MHz band could bring additional benefits compared to their licence exempt use in interleaved spectrum. In particular, licence exempt use would be possible in the 600 MHz band if it were used for DTT services following the release of 700 MHz spectrum.

6.49 These lost opportunities must be set against the benefits to society and the economy of clearing 700 MHz for mobile broadband and maintaining the role of DTT, which as set out above and in sections 3 and 4 could be significant.

6.50 An alternative approach would be to award 600 MHz licences that gave a sufficiently long period of certainty to licensees (eg to 2026 or later) to allow new services to be deployed in the band, whilst enabling the spectrum to be taken back after 2026 to facilitate 700 MHz release. However, we have already identified that there is a prospect of 700 MHz clearance starting as early as 2018 and that the value of 700 MHz is greater if it is available before other capacity enhancing techniques become exhausted at existing mobile sites[74]. This means that such an approach would be likely to significantly delay the availability of 700 MHz spectrum and reduce the benefits it could bring.

6.51 Therefore, on balance, our current view is that the value secured through meeting our key objectives of making the 700 MHz spectrum available for mobile broadband and ensuring a continuing role for DTT in providing important benefits is likely to outweigh the potential loss of opportunity from proceeding with the 600 MHz award as originally planned.

Question 18: Do you agree that the future benefits for citizens and consumers of enabling the release of the 700 MHz band whilst maintaining the role of DTT are likely to outweigh the

[74] The timing of this is uncertain but analysis by Real Wireless suggests that in plausible scenarios this could take place well in advance of 2026.

loss in benefits of the 600 MHz band not being able to be used for other services in the long term?

Short term uses for the 600 MHz spectrum that could deliver value in the interim

6.52 If the 600 MHz band were required to be used for DTT in the long term, our current thinking is that it would be preferable to enable some shorter term use of the spectrum rather than leaving it unused for a number of years until 700 MHz clearance begins. This view is dependent on there being demand for use of the spectrum under those conditions, and that the terms for short term use are clearly understood so that 600 MHz spectrum can be used for DTT when required.

6.53 Potential options for short term use are set out below. We would welcome the views of stakeholders on these and any other possible uses:

a) Access for PMSE and/or licence exempt WSDs on a similar basis as their access to existing interleaved spectrum. Access could continue beyond 700 MHz clearance but would then be constrained by DTT services operating in the 600 MHz band after 700 MHz clearance.

b) Use of the spectrum as an innovation reserve e.g. by issuing short term test & development licences. Such a reserve could be operated alongside the PMSE and WSD uses identified above. It would be available until 700 MHz clearance and could be offered under licence on a 'first-come-first-served' basis.

c) Award of short-term DTT licences without coverage obligations. This might allow an operator to set up new services transmitting only to selected major population centres. Unused spectrum could still be made available for uses outlined in a) and b). DTT operators might find it feasible to provide some additional services if they believe a case can be found for very short term DTT investments, for example simulcasting some popular channels in HD in limited geographic areas to encourage the speedier adoption of more efficient transmission technologies. We would welcome views and evidence from stakeholders on whether early availability of 600 MHz spectrum in this way would help in the transition to second generation technologies on the DTT platform.

d) Use-neutral UK-wide licences awarded via auction as originally planned – but with a short initial term such as 2017/18. In addition to short term DTT use this would also in principle enable licenced WSD use. However, in practice it is far from clear, given the early stage of their development, whether there would be a viable case for deploying such services over a short period.

e) Long-term licences but with conditions obliging the licence holder to accommodate DTT assignments displaced from the 700 MHz band. The licence holder would be free to use the spectrum for any purpose ahead of

700 MHz clearance and would retain 'overlay rights'[75] to any remaining unused spectrum thereafter - although they would need to take account of interference issues.

6.54 We believe that options for anything other than short-term use are likely to be extremely limited taking into account the recent WRC 12 decision and our proposed strategic aims set out above. Additionally, short-term use under options d) and e) are likely to present additional practical difficulties. For example, there is a possibility of consumer disruption if services are established successfully in the band only to be cut-off when the spectrum needs to be reclaimed for DTT displaced from the 700 MHz band.

6.55 Further, the option of issuing encumbered longer term licences – option e) above - might be an unattractive proposition. This is because of the additional complexity such an approach would introduce without bringing significant benefits that could not be realised in other ways. For example similar benefits might be realised via a short term licence with an award of future rights once it becomes clear if any spectrum will be available after current DTT multiplexes are accommodated within 600MHz.

6.56 Accordingly, options a) to c) might represent the most realistic approaches to short-term use of the 600 MHz band.

6.57 In any event, it is clear that changed circumstances mean it would be unwise at this stage for us to proceed with an award of the 600 MHz band, as originally envisaged. For this reason, we have decided to postpone concluding on how to release the 600 MHz band until the conclusion of this consultation.

6.58 Use of the 600 MHz band for PMSE was due to cease at the end of 2012 because of the planned auction of the spectrum. In the absence of a 2012 award this is no longer necessary and we have decided that PMSE use can continue until the spectrum is released for an alternative use. Consequently, access to the band (550 – 606 MHz) will continue until at least 1st April 2013 and might carry on beyond that time subject to Ofcom's conclusions about the approach to releasing this band. JFMG will continue to issue 12-month licences but with a condition allowing for revocation with a minimum of six months notice.

Question 19: Have we identified correctly the possible short-term uses of the 600 MHz spectrum? Are there other short-term uses we should consider?

Question 20: Which option(s) for releasing 600 MHz in the short term would maximise its value whilst supporting our proposed longer term objectives?

[75] In practice, overlay rights are likely to be useable only for PMSE, licensed WSDs or for compatible DTT services.

Section 7

The wider impacts of changing the use of the 700 MHz band

7.1 In section 6 we set out our view that, on the basis of present evidence, significant benefits are likely to provided to citizens and consumers over the long term by securing dual objectives of:

a) Being able to release the 700 MHz band once it is harmonised and co-ordinated for mobile broadband in ITU Region 1;

b) Ensuring that the DTT platform can continue to provide important benefits, including its public policy role in providing low cost universal access to the PSB channels, if the 700 MHz is released for mobile broadband.

7.2 In this section we set out our view that by establishing a long term strategic approach for a future change of use of the 700 MHz band now we can better prepare for and manage its impact on DTT users and the provision of other important services in this band.

7.3 The range of relevant preparatory actions would include:

- Ensuring that a future frequency re-plan of the DTT platform remains compatible with roof top aerials by signalling the need to use wideband aerials capable of receiving signals from across the whole of the DTT band;

- Ensuring that potential interference between mobile broadband services operating in the 700 MHz band and DTT is understood as fully and as early as possible. Any interference issues should then be managed where feasible through an appropriate design of a new 700 MHz band plan and the early signalling of the benefits of new DTT receivers being capable of co-existing with mobile broadband services in the 700 MHz band, reducing the need for more direct forms of intervention;

- Ensuring the continuing provision of PMSE services by early signalling the need for future equipment to be capable of operating in the interleaved spectrum of a re-planned DTT platform, and the need for more efficient uses to be made of this spectrum in the future, which, for example, could be achieved through a progressive digitisation of PMSE services and cognitive radio developments.

- Ensuring the continuing provision of suitable local TV broadcast frequencies needed to deliver these services as part of a future re-plan of the DTT platform;

- Ensuring an ongoing opportunity for applications based White Space Devices to continue to be able to operate in the interleaved spectrum of a re-planned DTT platform, by updating the geolocation database used by these services.

7.4 These are discussed in more detail below.

DTT re-plan and consumer aerials

7.5 A change of use of the 700 MHz band for mobile broadband would require a frequency re-plan of the existing DTT platform. One aspect of this re-plan is that it could create a need for some DTT households to use a wideband aerial.

7.6 We anticipate that the number of households that could require a wideband aerial could be significantly reduced if the 600 MHz band is used a part of the DTT re-plan, as this increases the number of high power assignments that could be chosen at each transmitter site to be compatible with existing roof top aerials. Using this approach we estimate that around 0.3% households could require a wideband aerial to receive the PSB channels and 30% of households to receive the PSB and commercial multiplex channels after a re-plan of the DTT platform.

7.7 These predictions are only indicative and are dependent on the actual outcomes of a new frequency co-ordination agreement for UHF band IV and V spectrum, enabling the release of the 700 MHz band for mobile broadband, and the results of bi-lateral co-ordination agreements reached with neighbouring counties.

7.8 In practice, only 40% of UK households are using DTT as their main means of receiving TV, reducing the number of households that may need to use a wideband aerial to continue to receive the PSB services on their main TV set to 0.12% and all six multiplexes to 12%.

7.9 It should also be noted that many of the households that would potentially need a wideband aerial have already installed one for digital switchover. Previous research[76] has shown that approximately 26% of rooftop aerials have been upgraded to wideband aerials. This further reduces the number of households that would need to install a new wideband aerial to approximately 0.1% (25,000 households) to receive the PSB services and all six multiplexes to 9% (2.5m households).

7.10 One of benefits of developing a forwards looking strategy for the future release of the 700 MHz band is that advice can be provided to consumers and equipment installers to install a wideband antenna when replacing or installing new DTT antennas over the coming decade, which would further reduce the number of new wideband aerials that would need to be installed following a future frequency re-plan of the DTT platform.

Co-existence of DTT and 700 MHz mobile services

7.11 The different planning criteria and locations of DTT and mobile sites means that additional steps are needed to prevent interference occurring between these services. For example, to ensure the co-existence of mobile services in the 800 MHz band cleared by DSO with DTT services, filters will be required to be used with DTT receivers in some locations to reduce interference from mobile services and maintain reliable DTT reception.

7.12 A similar approach may be required if mobile services operate in the 700 MHz band in the future, using filters adapted to this band. However, it is too soon to say what these filtering requirements might be and whether they would be required until decisions have been reached over the 700 MHz band plan to be used for mobile

[76] http://stakeholders.ofcom.org.uk/binaries/research/tv-research/aerials_research.pdf

broadband services in ITU Region 1 and the size of any guard band has been determined between the 700 MHz band and retained DTT spectrum.

7.13 One of the benefits of developing a forwards looking strategy for the future release of the 700 MHz band is that these considerations can be built into international negotiations over the future 700 MHz band plan to be adopted for mobile broadband services. It also enables an early signalling to be provided to DTT equipment manufacturers to recommend the design of future products such that these would be capable of co-existing with future mobile broadband services operating in the 700 MHz band.

700 MHz frequency range for mobile broadband services

7.14 The 700 MHz band occupies the frequency range 694 to 790MHz. This band is adjacent to the 800MHz band, which has been allocated for mobile broadband use and occupies the frequency range 790 to 862MHz.

7.15 In February 2012, the International Telecommunication Union's (ITU's) World Radiocommunication Conference (WRC) decided that the 700 MHz band would be allocated on a co-primary basis for broadcast and mobile broadband use. This new allocation will be effective following the next WRC in 2015 on completion of relevant technical studies, before becoming applicable to ITU Region 1, which includes Europe, Africa and parts of the Middle East.

7.16 Other parts of the world use a slightly different range of frequencies for their 700 MHz band. For example, the United States' 700 MHz band occupies the frequency range 698 to 806 MHz. This band in its entirety would not be compatible for use in the UK as it overlaps with the 800 MHz band. Work under the auspices of the ITU will seek to address the harmonisation of bands between different ITU regions ahead of the next WRC in 2015 to facilitate the realisation of economies of scale in mobile handsets and equipment.

Local TV services

7.17 Local TV services will operate in the spectrum used by DTT services on a geographically interleaved basis, with each local TV area served by a single multiplex occupying an 8 MHz channel.

7.18 Ofcom recently published a draft Note for Applicants on Coverage of Local Television[77] which details the proposed minimum coverage requirements and transmission arrangements for local TV services. Many of the proposed local TV transmitter sites would need to move to a new frequency following a future frequency re-plan of the DTT platform.

7.19 The ability to find a new transmitter frequency for these services is dependent on the choice of interleaved spectrum that will be available at particular locations after a frequency re-plan, which is not straightforward to estimate as it is subject to international negotiations and agreements.

[77] http://stakeholders.ofcom.org.uk/binaries/consultations/localtv/annexes/Note_on_Local_TV_coverage.pdf

7.20 However, it is possible to form a high level, intuitive view on the maximum amount of interleaved spectrum available, irrespective of location. This is purely for illustrative purposes and is unable represent the complexities inherent in predicting available spectrum at particular locations in the future.

7.21 The maximum amount of interleaved spectrum theoretically available at all locations at completion of DSO is 256 MHz[78]. At any given location we assume that six channels (48MHz) will be occupied by national DTT services, one channel for each multiplex. Therefore, the maximum amount of interleaved spectrum theoretically available at a particular location at completion of DSO is estimated to be 208 MHz.

7.22 If the 700MHz band is cleared for mobile broadband use, this band's 96 MHz of bandwidth will no longer be available as part of the interleaved spectrum. Therefore, in this case the maximum amount of interleaved spectrum available will fall from 208 MHz to 112 MHz.

7.23 Change of use in the 700MHz band and the subsequent reduction in the amount of interleaved spectrum could be compensated for in part by the inclusion of the 600 MHz band into the pool of frequencies used for interleaved spectrum. The 600 MHz band occupies the frequency range 550 to 606 MHz, a total of 56 MHz. If the 700 MHz band was cleared and the 600 MHz band made available for interleaved access, the maximum amount of interleaved spectrum available will increase from 112 MHz to 168 MHz.

7.24 This equates to an approximate loss in capacity of 46% if the 700 MHz band is cleared and no additional interleaved spectrum is made available. However, if the 700MHz band is cleared and the 600 MHz is made available for interleaved access, the loss in capacity is reduced to approximately 19%.

7.25 Future spectrum demand for local TV is expected to remain static at a single 8 MHz channel per licensed area. However, the reduced amount of interleaved spectrum resulting from clearing the 700 MHz is unlikely prevent a suitable alternative frequencies being found for local TV services, in particular if the interleaved spectrum in the 600 MHz band can be used for these services.

PMSE

7.26 PMSE devices, such as wireless microphones and in-ear monitors, also use interleaved spectrum. As set out above, it is possible to form a high level, intuitive view on the maximum amount of interleaved spectrum likely to be available to PMSE devices in the future. Any reduction in the amount of interleaved spectrum and changes to the specific bands available to PMSE have the potential to impact upon service delivery and it is important to identify and resolve issues at the earliest opportunity. Factors that have the potential to mitigate changes in available spectrum include making additional bandwidth available, such as the 600 MHz band, the introduction of more efficient technologies and the early signalling to the market that changes to equipment may be required.

7.27 It is expected that PMSE will continue to have access to the remaining interleaved spectrum. If the 700 MHz band is cleared and the 600 MHz band is made available for interleaved access then PMSE would have access to 216 MHz of spectrum as

[78]This is comprised of: 80MHz between 470 and 550MHz; 176MHz between 614 and 790MHz.

compared with 256 MHz as identified in our statement on future access to interleaved spectrum for programme making and special events published on 16 May 2011[79]. This does not include channel 38 which is exclusively allocated to PMSE and does not form part of the interleaved spectrum.

7.28 Spectrum availability for PMSE is dependent on the requirement to protect DTT and the interference from DTT services. This is specific to any given location including whether the use is indoors or outdoors. As laid out in our May 2011 statement all interleaved spectrum would be available indoors with various levels of 'quality' depending on incoming DTT interference. Outdoor use would be restricted by the need to protect DTT.

7.29 In the future, there may be possibilities to enable the existing levels of PMSE use to continue by taking advantage of more efficient technologies, such as digital microphones, or the more efficient allocation of frequencies. We welcome further engagement with the PMSE community and manufacturers of PMSE devices on these approaches and would, in particular, like to understand more about ongoing research to improve the efficiency of PMSE equipment.

7.30 Clearing the 700 MHz band for mobile broadband use will also have an impact on the range of frequencies available for interleaved access. In order to keep complexity and costs down, PMSE equipment often has a limited tuneable range, i.e. equipment can operate on only a subset of the available interleaved frequencies. The tuneable range of equipment varies between device type and manufacturer and can range from approximately 40 MHz to 180 MHz. Equipment operating in the 700 MHz band and with a small tuneable range will be unable to be used in the event that this band is cleared. Equipment is currently available with a tuneable range covering the 600 MHz band.

7.31 One of benefits of developing a forwards looking strategy for the future release of the 700 MHz band is that it enables an early signalling to European PMSE equipment manufacturers and operators to ensure that any new equipment is compatible with this change.

White spaces

7.32 White space devices (WSDs), like PMSE equipment, will operate in the DTT spectrum on a geographically interleaved basis. As with PMSE equipment above, it is possible to provide a high level illustration of the maximum, theoretical amount of spectrum likely to be available to WSDs in the future if the 700 MHz band is cleared for mobile broadband use.

7.33 The amount of interleaved spectrum available to WSDs will be approximately the same as previously calculated for PMSE devices, i.e. 104MHz if the 700MHz band is cleared for use for mobile broadband, 160 MHz if, in addition, the 600MHz band is available for interleaved use. In practice, the actual amount is likely to be available will be less and is highly dependent on the parameters adopted to protect incumbent services and the wanted transmit power of the WSD.

7.34 On the basis of this simple illustration, it can be seen that clearing the 700MHz band for mobile broadband use will lead to a reduction in the amount of interleaved

[79] http://stakeholders.ofcom.org.uk/consultations/bandmanager09/statement/

spectrum available to WSDs. This reduction can be offset in part by adding the 600 MHz band to the pool of frequencies used for interleaved spectrum.

7.35 The effect of any reduction in available interleaved spectrum on WSDs is currently unclear. WSD technology is still maturing and, aside from trials, no equipment has yet been deployed in the UK and it is therefore not possible to make an accurate assessment of any future market.

7.36 However, early WSD devices and prototypes appear capable of operating over a wide range of frequencies, from 470 to 790 MHz. Therefore, if the 700MHz band were cleared for mobile broadband use, WSDs would have a sufficiently wide tuneable range to operate at lower frequencies, should they be available. In addition, the proposed geolocation database approach to authorising WSDs is sufficiently flexible to easily remove frequency ranges that are no longer to be used.

Conclusions

7.37 We believe that a combination of the preparatory actions set out above and the use of the 600MHz band for DTT, which is likely to make it easier to ensure a frequency re-plan of the DTT platform is compatible with existing roof-top aerials and supports the delivery of services relying on DTT interleaved spectrum, will ensure that the wider impacts of clearing the 700 MHz band can be properly addressed.

7.38 In particular we observe that signalling sufficiently early the intention to clear the 700 MHz band for mobile broadband can help relevant stakeholders to better prepare and take advance steps to accommodate this change.

Question 21: Do you agree that the wider impacts of a future change of use of the 700MHz band could be managed to prevent them having a detrimental impact on consumers and the services operating in this band?

Section 8

Proposed approach for securing future benefits and next steps

Key findings from previous sections

8.1 In this consultation document we have set out the likely future demands for scarce spectrum resource by services likely to deliver significant benefits to citizens and consumers and the steps that we could take now to help ensure that these services have access to the spectrum they will need to deliver these benefits.

8.2 In section 3 we identified that a significant increase in additional harmonised spectrum is likely to be required to avert a future capacity crunch on mobile networks, and that the utility of this spectrum will be greater if it is available before other capacity enhancing techniques become exhausted at existing mobile sites, including 2G re-farming to 3G and LTE. This is because the timely availability of additional spectrum can significantly reduce the need to deploy additional mobile sites to meet the growth in mobile broadband capacity.

8.3 We also identified in section 3 that there is likely to be a much greater scarcity of supply of additional harmonised spectrum below 1 GHz to meet the growth in demand for mobile broadband capacity than harmonised spectrum above 2 GHz. Spectrum below 1 GHz is particularly attractive for use in future mobile network deployments because of its ability to deliver important savings in the number of additional mobile sites required to support the growth in mobile broadband capacity, and to provide better quality of service in difficult to reach locations.

8.4 The 700 MHz band is the leading candidate for providing additional harmonised spectrum below 1 GHz. This is because this band is already being used to deploy LTE services in the US ad Asia, and decisions recently taken at WRC 12 mean that this band could most likely be used for mobile broadband in ITU region 1, which includes Europe, after the next WRC conference in 2015.

8.5 Additional harmonised spectrum for mobile broadband at higher frequencies will also be very important to meet the expected increase in capacity requirements. This will include bands identified as part of the Government's plans to release 500 MHz of publicly-held spectrum.

8.6 However, in this consultation we have given particular focus to the issues associated with a potential change of use of the 700 MHz band for mobile broadband. This is because there are a complex set of co-ordination issues that would need to be addressed sufficiently in advance to enable the 700 MHz band to be used for mobile broadband, given that this spectrum is currently used to deliver DTT services and a range of other services in its interleaved spectrum.

8.7 In section 4 we identified that the DTT platform will probably continue to be the best placed platform to fulfil the public policy role of making the PSB channels available on universal low cost basis to viewers at the time when the 700 MHz band could be released for mobile broadband. We also discussed that, absent major changes in available spectrum, DTT would probably continue to deliver wider benefits by supporting consumer choice. At the same time, we recognised that over a much

longer time period a universal household adoption of super fast broadband could enable IPTV to provide a viable substitute to DTT for delivering PSB content.

8.8 In section 5 we discussed that other important services are likely to have ongoing requirements of UHF spectrum bands IV and V on an interleaved basis. This includes PMSE, Local TV and applications based on white-space device technology. We also discussed that there may be a future opportunity to deliver innovative emergency services applications through the use of mobile broadband spectrum at 700 MHz on a internationally harmonised basis.

8.9 In section 6 we set out our proposed approach for securing significant long term benefits for citizens and consumers from scarce spectrum resources in UHF bands IV and V. This includes seeking to enable the release of the 700 MHz band for mobile broadband once it is internationally harmonised and co-ordinated, whilst also ensuring that the DTT platform remains able to continue to provide important benefits, including providing universal low cost access to PSB content. This approach also keeps open a potential future option to use some of the 700 MHz band to deliver multimedia based emergency services applications. The case for this would in part depend on whether the 700 MHz band were to become a preferred international band for delivering these services.

8.10 In section 6 we also considered whether these outcomes could be achieved both with and without the 600 MHz band (becoming available through digital switchover) being used as part of a DTT platform frequency re-plan if the 700 MHz band is released for mobile broadband. This identified that the risk to the role of the DTT platform in providing important benefits could be potentially significantly reduced if the 600 MHz band were used for DTT. We would welcome in particular stakeholder views and evidence on the size of the DTT platform needed in the future in order to continue to be able to provide benefits to citizens and consumers, to inform our approach towards the longer term use of the 600 MHz band.

8.11 In section 6 we then considered the potential loss in consumer benefits associated with not being able to use the 600 MHz band for other applications in the future other than maintaining DTT capacity after the release of the 700 MHz band. The alternative 600 MHz services considered included providing additional DTT multiplexes to the existing 6 DTT multiplexes and licensed applications using white space equipment. We found that, on balance, there are a number of important uncertainties regarding the future value of using the 600MHz spectrum to provide either more DTT multiplexes or licensed applications using white space equipment. We would welcome stakeholder views and evidence on alternative long term uses of the 600 MHz band and the likely value of these services.

8.12 We then set out our preliminary view that benefits associated with securing the use of the 700 MHz band for mobile broadband on an internationally harmonised basis and reducing the risk that the DTT platform will be unable to continue to fulfil its role in future were likely to be greater than proceeding with the 600 MHz award as we had previously planned. This could have enabled alternative uses to be made of this spectrum on a long term basis. If we were to proceed with an approach that ensured that the 600 MHz spectrum can be used as part of a re-plan of the DTT platform after 700 MHz clearance, the implication of this is that we would not seek award long term rights for the 600 MHz band, but would seek to enable shorter term uses of this spectrum. We would welcome stakeholder views on approaches that would enable value to be realised from shorter term uses of the 600 MHz band if we were to proceed with this approach.

8.13 In this section 7 we set out our view that by establishing a long term strategic approach for a future change of use at 700 MHz band sufficiently early we can better prepare for and manage this change, so to minimise disruption to consumers and to the provision of other important services in this band.

8.14 The range of relevant preparatory actions would include:

- Ensuring that a future frequency re-plan of the DTT platform remains compatible with roof top aerials also by signalling the need for wideband aerials capable of receiving signals from across the whole of the DTT band;

- Ensuring that potential interference between mobile broadband services operating in the 700 MHz band and DTT is managed through an appropriate design of a new 700 MHz band plan and the early signalling of the benefits of new DTT receivers being capable of co-existing with mobile broadband services in the 700 MHz band;

- Ensuring the continuing provision of PMSE, local TV and white-space-device based services, by the early signalling the need for future equipment to be capable of operating in the interleaved spectrum of a re-planned DTT platform, and the need for more efficient uses to be made of this spectrum in the future. This, for example, could be achieved through a progressive digitisation of PMSE services and cognitive radio developments.

8.15 We also noted that the long term use of the 600MHz band for DTT is likely to be instrumental to a frequency re-plan of the DTT platform that remains as far as possible compatible with existing roof-top aerials, and supports the delivery of services relying on DTT interleaved spectrum.

Next steps

8.16 The main purpose of this consultation is to establish a strategic approach to secure benefits to citizens and consumers over the long term from the use of scarce spectrum resources in UHF bands IV and V. Such an approach should provide clarity to stakeholders on future policy direction, whilst being flexible enough to respond to future international and market developments.

8.17 Our preferred strategic approach is to seek to enable the release of the 700 MHz band for mobile broadband once it is internationally harmonised and co-ordinated, whilst ensuring, also through the potential long term use of the 600MHz band, that DTT can continue to provide important citizen and consumer benefits.

Question 22: Do you agree that the approach set out in this consultation is likely to secure significant benefits for citizens and consumers over the long term?

8.18 We are not seeking in this consultation to reach final decisions on the process and timescales of any future release of the 700 MHz band. In practice, we believe that these decisions will have to be informed by further work, and should be taken closer to the time of actual implementation, so to take into account the effective evolution of market developments and the international context on spectrum harmonisation and coordination.

8.19 The outcomes of this consultation will inform a number of important areas of further work, including:

- **Use of 600MHz spectrum**: we will determine next steps on the release of the 600MHz band in light of responses to this consultation, as well as previous relevant consultations. If possible, we will make a statement on how to release this spectrum for short term use in a way that is consistent with the longer term approach determined through this consultation. Alternatively, we will consult again on a more detailed set of options for the release of this band, whilst still seeking to ensure consistency with our strategic approach.

- **International engagement**: we will continue to represent UK's interest in international fora, including participating in further work under the auspices of the ITU on the harmonisation of the 700MHz band, and in longer term work on the international coordination of high power broadcast assignments that is likely to follow a resolution at WRC 2015.

- **Preparing for a future DTT re-plan**: we will work to define an approach for facilitating any required industry led re-plan of the DTT spectrum which minimises costs and disruption for relevant stakeholders. Particular consideration will have to be given to minimising disruption for consumers and any new coexistence issues that may be associated with any such re-plan.

- **Licensing arrangements**: the potential future changes to the use of spectrum we have outlined in this condoc will have important implications to spectrum and service licenses. Further work will be required this area, to understand how best to ensure that licensing arrangements enable the achievement of optimal outcomes for citizens and consumers.

- **Managing impact on uses of interleaved spectrum**: we will have to work further with stakeholders to understand how best to facilitate the current and future potential uses of DTT interleaved spectrum.

Question 23: Have we correctly identified the main areas of future work that could follow this consultation process subject to its outcome?

Annex 1

Responding to this consultation

How to respond

A1.1 Ofcom invites written views and comments on the issues raised in this document, to be made **by 5pm on 7 June 2012**.

A1.2 Ofcom strongly prefers to receive responses using the online web form at http://stakeholders.ofcom.org.uk/consultations/uhf-strategy/howtorespond/ , as this helps us to process the responses quickly and efficiently. We would also be grateful if you could assist us by completing a response cover sheet (see Annex 3), to indicate whether or not there are confidentiality issues. This response coversheet is incorporated into the online web form questionnaire.

A1.3 For larger consultation responses - particularly those with supporting charts, tables or other data - please email UHFframework@ofcom.org.uk attaching your response in Microsoft Word format, together with a consultation response coversheet.

A1.4 Responses may alternatively be posted or faxed to the address below, marked with the title of the consultation.

Marco Marini
Strategy, Chief Economist and Technology Group
Riverside House
2A Southwark Bridge Road
London SE1 9HA

Fax: 020 7981 3706

A1.5 Note that we do not need a hard copy in addition to an electronic version. Ofcom will acknowledge receipt of responses if they are submitted using the online web form but not otherwise.

A1.6 It would be helpful if your response could include direct answers to the questions asked in this document, which are listed together at Annex 4. It would also help if you can explain why you hold your views and how Ofcom's proposals would impact on you.

Confidentiality

A1.7 We believe it is important for everyone interested in an issue to see the views expressed by consultation respondents. We will therefore usually publish all responses on our website, www.ofcom.org.uk, ideally on receipt. If you think your response should be kept confidential, can you please specify what part or whether all of your response should be kept confidential, and specify why. Please also place such parts in a separate annex.

A1.8 If someone asks us to keep part or all of a response confidential, we will treat this request seriously and will try to respect this. But sometimes we will need to publish all responses, including those that are marked as confidential, in order to meet legal obligations.

A1.9 Please also note that copyright and all other intellectual property in responses will be assumed to be licensed to Ofcom to use. Ofcom's approach on intellectual property rights is explained further on its website at http://www.ofcom.org.uk/about/accoun/disclaimer/

Next steps

A1.10 Following the end of the consultation period, Ofcom intends to publish a statement in Autumn 2012.

A1.11 Please note that you can register to receive free mail Updates alerting you to the publications of relevant Ofcom documents. For more details please see: http://www.ofcom.org.uk/static/subscribe/select_list.htm

Ofcom's consultation processes

A1.12 Ofcom seeks to ensure that responding to a consultation is easy as possible. For more information please see our consultation principles in Annex 2.

A1.13 If you have any comments or suggestions on how Ofcom conducts its consultations, please call our consultation helpdesk on 020 7981 3003 or e-mail us at consult@ofcom.org.uk . We would particularly welcome thoughts on how Ofcom could more effectively seek the views of those groups or individuals, such as small businesses or particular types of residential consumers, who are less likely to give their opinions through a formal consultation.

A1.14 If you would like to discuss these issues or Ofcom's consultation processes more generally you can alternatively contact Graham Howell, Secretary to the Corporation, who is Ofcom's consultation champion:

Graham Howell
Ofcom
Riverside House
2a Southwark Bridge Road
London SE1 9HA

Tel: 020 7981 3601

Email Graham.Howell@ofcom.org.uk

Annex 2

Ofcom's consultation principles

A2.1 Ofcom has published the following seven principles that it will follow for each public written consultation:

Before the consultation

A2.2 Where possible, we will hold informal talks with people and organisations before announcing a big consultation to find out whether we are thinking in the right direction. If we do not have enough time to do this, we will hold an open meeting to explain our proposals shortly after announcing the consultation.

During the consultation

A2.3 We will be clear about who we are consulting, why, on what questions and for how long.

A2.4 We will make the consultation document as short and simple as possible with a summary of no more than two pages. We will try to make it as easy as possible to give us a written response. If the consultation is complicated, we may provide a shortened Plain English Guide for smaller organisations or individuals who would otherwise not be able to spare the time to share their views.

A2.5 We will consult for up to 10 weeks depending on the potential impact of our proposals.

A2.6 A person within Ofcom will be in charge of making sure we follow our own guidelines and reach out to the largest number of people and organisations interested in the outcome of our decisions. Ofcom's 'Consultation Champion' will also be the main person to contact with views on the way we run our consultations.

A2.7 If we are not able to follow one of these principles, we will explain why.

After the consultation

A2.8 We think it is important for everyone interested in an issue to see the views of others during a consultation. We would usually publish all the responses we have received on our website. In our statement, we will give reasons for our decisions and will give an account of how the views of those concerned helped shape those decisions.

Annex 3

Consultation response cover sheet

A3.1 In the interests of transparency and good regulatory practice, we will publish all consultation responses in full on our website, www.ofcom.org.uk.

A3.2 We have produced a coversheet for responses (see below) and would be very grateful if you could send one with your response (this is incorporated into the online web form if you respond in this way). This will speed up our processing of responses, and help to maintain confidentiality where appropriate.

A3.3 The quality of consultation can be enhanced by publishing responses before the consultation period closes. In particular, this can help those individuals and organisations with limited resources or familiarity with the issues to respond in a more informed way. Therefore Ofcom would encourage respondents to complete their coversheet in a way that allows Ofcom to publish their responses upon receipt, rather than waiting until the consultation period has ended.

A3.4 We strongly prefer to receive responses via the online web form which incorporates the coversheet. If you are responding via email, post or fax you can download an electronic copy of this coversheet in Word or RTF format from the 'Consultations' section of our website at www.ofcom.org.uk/consult/.

A3.5 Please put any parts of your response you consider should be kept confidential in a separate annex to your response and include your reasons why this part of your response should not be published. This can include information such as your personal background and experience. If you want your name, address, other contact details, or job title to remain confidential, please provide them in your cover sheet only, so that we don't have to edit your response.

Cover sheet for response to an Ofcom consultation

BASIC DETAILS

Consultation title:

To (Ofcom contact):

Name of respondent:

Representing (self or organisation/s):

Address (if not received by email):

CONFIDENTIALITY

Please tick below what part of your response you consider is confidential, giving your reasons why

Nothing ☐

Whole response ☐

Part of the response ☐

Name/contact details/job title ☐

Organisation ☐

If there is no separate annex, which parts?

If you want part of your response, your name or your organisation not to be published, can Ofcom still publish a reference to the contents of your response (including, for any confidential parts, a general summary that does not disclose the specific information or enable you to be identified)?

DECLARATION

I confirm that the correspondence supplied with this cover sheet is a formal consultation response that Ofcom can publish. However, in supplying this response, I understand that Ofcom may need to publish all responses, including those which are marked as confidential, in order to meet legal obligations. If I have sent my response by email, Ofcom can disregard any standard e-mail text about not disclosing email contents and attachments.

Ofcom seeks to publish responses on receipt. If your response is non-confidential (in whole or in part), and you would prefer us to publish your response only once the consultation has ended, please tick here. ☐

Name

Signed (if hard copy)

Annex 4

Consultation questions

Future mobile broadband spectrum requirements

Question 1: Do you agree that meeting the future growth in demand for mobile broadband capacity will deliver significant benefits to citizens and consumers?

Question 2: Do you agree that additional harmonised mobile broadband spectrum will play an important role in meeting the future growth in demand for mobile broadband capacity? What are your views on the overall quantity of harmonised spectrum that will be required to meet future demand? How does this compare with the expected increase in spectrum for mobile use discussed in this section?

Question 3: Do you agree that additional harmonised spectrum provided by the 700 MHz band could play an important role in meeting the future growth in mobile broadband capacity?

Question 4: Do you agree that the value of the role played by the 700 MHz band in meeting the future growth in mobile broadband capacity would be greater if it becomes available before other capacity enhancing techniques have been exhausted at existing mobile sites?

Question 5: What timing of 700MHz release would maximise the benefits associated with its use for mobile broadband?

Future DTT spectrum requirements

Question 6: Do you agree that DTT will continue to play an important role in providing universal low cost access to PSB content over at least the next decade?

Question 7: Do you agree that, absent major changes in available spectrum, DTT would continue to remain attractive to viewers and deliver important benefits to citizens and consumers over at least the next decade?

Question 8: What are your views on the future technical evolution of the DTT platform? Are there other relevant factors affecting future DTT spectrum requirements that we should consider as we develop an approach to secure benefits from UHF band IV and V over the long term?

Question 9: Do you agree that a longer term approach to secure benefits from UHF band IV and V should consider how to safeguard benefits delivered by the DTT platform?

Other uses of UHF bands IV and V

Question 10: Are there other material factors affecting the future requirements of PMSE that we should consider as we develop an approach to secure long term benefits from UHF band IV and V?

Question 11: Are there other material factors affecting the future requirements of Local TV that we should consider as we develop an approach to secure long term benefits from UHF band IV and V?

Question 12: Are there other material factors affecting the future requirements of WSD applications that we should consider as we develop an approach to secure long term benefits from UHF band IV and V?

Question 13: Aside from WSDs, are there other innovative ways in which to use UHF bands IV and V to deliver services and, therefore, material benefits to users

Question 14: Are there other material factors affecting the future requirements of emergency services applications that we should be aware of as we develop an approach to secure long term benefits from UHF band IV and V?

Securing long term benefits for citizens and consumers

Question 15: Do you agree that the approach that is most likely to secure significant benefits from UHF band IV and V over the long term is one that enables the release of the 700 MHz band for mobile broadband whilst also ensuring the role of the DTT platform is safeguarded?

Question 16: Do you believe there is a material risk that the DTT platform will have insufficient spectrum to continue to deliver important benefits (including providing universal low cost access to PSB content) if the 600MHz band is not used for DTT when the after clearance of the 700 MHz band?

Question 17: Do you believe that using the 600 MHz band for DTT after clearing the 700 MHz band would reduce the risk that the DTT platform will not be able to continue to provide important citizen and consumer benefits?

Question 18: Do you agree that the future benefits for citizens and consumers of enabling the release of the 700 MHz band whilst maintaining the role of DTT are likely to outweigh the loss in benefits of the 600 MHz band not being able to be used for other services in the long term?

Question 19: Have we identified correctly the possible short-term uses of the 600 MHz spectrum? Are there other short-term uses we should consider?

Question 20: Which option(s) for releasing 600 MHz in the short term would maximise its value whilst supporting our proposed longer term objectives?

The wider impacts of changing the use of the 700MHz band

Question 21: Do you agree that the wider impacts of a future change of use of the 700MHz band could be managed to prevent them having a detrimental impact on consumers and the services operating in this band?

Proposed approach for securing future benefits and next steps

Question 22: Do you agree that the approach set out in this consultation is likely to secure significant benefits for citizens and consumers over the long term?

Question 23: Have we correctly identified the main areas of future work that could follow this consultation process subject to its outcome?

Annex 5

Summary of responses to the April 2011 Call for Input

A5.1 On 20 April 2011 we published a call for input inviting stakeholders to submit their views on the long term future of UHF spectrum bands IV and V. We received 32 responses from a variety of stakeholders, including:

- Broadcasters and DTT multiplex license holders – including a joint submission from the BBC, ITV, Channel 4, Channel 5, S4/C, Arqiva and SDN (referred to as "the joint PSB / MUX operators' submission" in the remainder of this summary), a submission from Freeview and a separate individual submission from Arqiva.
- Mobile operators - Everything Everywhere (EE) and Vodafone
- BT
- Sky
- Technology companies – Motorola Solutions, Ericsson.
- Representatives of the PMSE community – including BEIRG, JFMG and various PMSE users
- Representatives of the PPDR (Public Protection and Disaster Relief) community – including BAPCO (British Association of Policing Communities), Tetra Association
- Consumer associations – Consumer Focus Scotland, Dorset Broadcast Action Group
- Cable industry stakeholders – Virgin Media, Cable Europe
- Other industry associations – Intellect, Confederation of Aerial industries
- Various interested individuals

A5.2 Most stakeholders welcomed Ofcom's initiative to undertake work aimed at providing a strategic view over the long term future of UHF spectrum, and the opportunity to contribute early to our thinking.

A5.3 Here below we summarise views expressed in relation to the key themes we have identified.

Future relevance of DTT

A5.4 The joint PSB / MUX operators' submission, Arqiva, Freeview and BT highlighted DTT is currently the most popular broadcasting platform in the UK, and it will continue to remain highly relevant to UK viewers over the long term, providing near universal FTA access to linear TV and PSB content in particular. This underlines DTT's contribution to public policy objectives and TV platform competition.

A5.5 BT and Arqiva also argued that the breadth and variety of services available through DTT is an important factor in determining its relevance and popularity, and that additional spectrum (at 600MHz) will be important to sustain DTT's evolution and competition across TV platforms.

A5.6 Vodafone, EE and Sky took a different view. They argued that DTT faces fundamental challenges in the long term as consumer preferences evolve towards HD, 3D, and non-linear video. Although a substantial proportion of consumers will continue to use DTT, especially for second sets, demand for advanced TV services will shift towards other platforms. This, associated with increasing efficiency resulting from upgrades to DVB-T2 and MPEG-4, will enable the opportunity for a reallocation of UHF spectrum to other services. Sky also stressed it supports moves to incentivise DTT services to use spectrum as efficiently as possible over time, potentially through AIP mechanisms and trading.

Alternative primary uses of UHF spectrum

A5.7 Vodafone, EE and Ericsson stressed that the expected strong growth in mobile data volumes will result in a general increase in demand for bandwidth for mobile services. Spectrum below 1GHz raise will be particularly important to increase coverage, especially in-building, given most data is consumed indoors. These stakeholders also highlighted the importance of international harmonisation to enable economies of scale. EE raised the issue that differences in sub 1 GHz spectrum allocation amongst the 4 MNOs could inhibit competition. EE also suggested that no further UHF spectrum should be devoted to DTT and once existing DTT licenses come up for review, Ofcom should consider whether the spectrum can be used for mobile broadband.

A5.8 BT and Sky instead argued that mobile operators will not require spectrum in addition to the bands already expected to be released for mobile use over the next few years (800MHz, 2.6GHz and bands likely to be released by Government). BT stressed that an increasing use of smaller cell sizes and Wi-Fi offloading will help meeting increasing demands for indoor mobile data.

A5.9 Sky underlined that Wi-Fi will require more spectrum in the near future. It signalled an immediate interest in a primary allocation in the 600MHz band to provide enhanced Wi-Fi services, although it also stressed the importance of TV white-spaces for the same end.

A5.10 Respondents representing the PPDR community highlighted the US decision to reserve spectrum in the 700 MHz band for emergency services applications. An internationally harmonised reservation of UHF spectrum for PDDR use modelled on the US decision would enable industry and Government to benefit from improved economies of scale. The implementation of solutions based on LTE networks would meet the increasing demand across the public safety community for richer applications and faster emergency responses, which would result in enhanced citizen benefits. Motorola also stressed that it would not be appropriate for new PPDR applications to be delivered through public mobile networks, as this would not meet specific reliability and QoS requirements.

A5.11 The Joint Radio Company noted that any future re-planning of UHF spectrum in future could also provide an opportunity to meet requirements of the utilities sectors, and underlined these would deliver citizen benefits given the link with Government objectives in relation to critical national infrastructure.

Secondary and tertiary uses of UHF spectrum

A5.12 The PMSE community raised significant concerns that changes to UHF allocations may hinder their ability to access interleaved spectrum. BEIRG, in a submission supported also by other members of the PMSE community, highlighted that any further reduction in DTT interleaved spectrum following the release of the 800MHz band would seriously affect PMSE users. BEIRG argued that in the event that the 700 MHZ band is earmarked for auction PMSE must be granted access to the 600 MHZ band. PMSE users also contended that their current use of spectrum is being challenged by cognitive devices, and that a future migration to other spectrum bands following a re-plan would not be practical due to the limited availability of equipment operating outside UHF spectrum.

A5.13 BT and Sky encouraged Ofcom to enable white-space devices (WSD) usage in UHF interleaved spectrum. BT highlighted that the continued presence of DTT in UHF spectrum is necessary to the development of WSD applications. Sky underlined that TV white spaces will be particularly relevant for the provision of Wi-Fi services.

Views on the 600MHz band

A5.14 The joint PSB / MUX operators' submission argued that Ofcom should delay the 600MHz spectrum awards until we have reached a clearer view on the longer term framework for the use of UHF spectrum, so to ensure that any release of UHF spectrum (beyond the 800 MHz band) is carried out in a strategically consistent manner.

A5.15 EE and Vodafone expressed a very similar position. They encouraged Ofcom to put the award of the 600MHz band on hold while a longer term strategy on UHF spectrum bands IV and V is being developed. Vodafone stressed that spectrum at 600MHz could be extremely valuable in facilitating the clearance of spectrum for a second digital dividend.

A5.16 Similarly, BEIRG argued that until the fact of UHF bands IV and V have been decided, there should not be further moves towards the release of 600MHz spectrum. BEIRG's view is that in the event that the 700MHZ band is earmarked for auction, the PMSE sector must be granted access to the 600MHZ band.

A5.17 Arqiva, in its individual submission, highlighted that spectrum at 600MHz would provide the additional capacity needed to overcome constraints to DTT innovation. Arqiva underlined it strongly believes that the 600MHz band should therefore be reserved for broadcast use. BT expressed a similar position and stressed that 600MHz spectrum should be released at the earliest opportunity to help satisfy demand for HD on DTT. BT contended that the present exercise examining the long term use of UHF spectrum should not disrupt the 600 award timeline.

A5.18 Sky stressed Ofcom should not do anything to risk a delay in the release of 600MHz spectrum. Sky also re-iterated its support to a market-led approach to allocating this spectrum and encouraged Ofcom to limit itself to reasonable and non-intrusive licence conditions.

Comments on timescales associated with possible future changes in use of UHF spectrum

A5.19 Arqiva noted that international discussions around potential for further harmonisation of alternative uses of UHF spectrum may begin at WRC 2015/16, and that the inclusion of an agenda item on this matter is currently under consideration. Arqiva estimated the timing associated with an internationally coordinated UHF re-plan, which it suggested may not be initiated until 2022/3.

A5.20 JFMG highlighted that our August 2010 statement on future spectrum access for PMSE recognised the need to provide 10 year security of tenure to PMSE users. BEIRG also indicated that any future re-balancing should allow for industry to produce compatible equipment and should not be considered until the replacement equipment purchased by PMSE users moving from channel 38 has reached the end of its lifespan.

A5.21 TETRA Association noted the in the UK there is a need to find a PPDR spectrum solution in good time before the expiry of the Airwave service contracts

Consumer issues

A5.22 The joint PSB / MUX operators' submission raised concerns about the significant costs to consumers of upgrading equipment and aerials in the event of a re-plan and the need for public communication and support for vulnerable groups, as was conducted for DSO. The same stakeholders suggested that any costs to consumers should be borne by the spectrum users that would benefit from re-balancing. Similarly, Freeview also noted that consumers have already made significant investments in DTT equipment, and expect continuity of service as a result. Vodafone suggested Ofcom should investigate how the TV aerial industry can be encouraged (or required) to install only wideband antennas throughout the UK, so as to minimise the number of domestic TV reception antennas that will need to be replaced following adjustments to the use of UHF spectrum.

A5.23 Ericsson conversely argued that whilst some DTT antennas would need replacing, a combination of LTE and MIMO networks providing mobile broadband and enhanced broadcast capacity would mean that replacement indoor antennas could be fitted inexpensively.

A5.24 Some stakeholders also raised concerns about coverage and availability, both of DTT and mobile broadband services. The Dorset Broadcast Action Group raised concerns that there is currently a shortfall in coverage of DTT, with uneven availability of channels in some areas (exacerbated by introduction of HD on one multiplex) which could be resolved by allocating additional spectrum to DTT.

A5.25 Consumer Focus Scotland highlighted issues related to poor mobile coverage and lack of access to fixed broadband in rural areas. They felt that any future framework developed for spectrum allocation must have a focus on how it can be used to bridge the digital divide, and should have reference to consumer demand.

Technical issues

A5.26 Another issue raised by some stakeholders was the extent to which there should be a guard band between DTT and other services. The Confederation of Aerial Industries contended that any further release of spectrum should provide for a

greater guard band than 1MHz applied on 800MHz clearance. Intellect also contended that interference/guard band issues between 800MHz and DTT Channel 60 should be addressed and resolved.

A5.27 In contrast, Sky argued that having a guard band for DTT in 600MHz may be unnecessary and disproportionate and highlighted its concerns that Ofcom may be overstating the risks from interference to DTT.

A5.28 Both Virgin Media and Cable Europe highlighted concerns about interference to cable CPE services from new services, such as mobile, operating in the UHF bands. Interference issues similar to those highlighted in laboratory tests for 800MHz band could be extremely serious due to large amount of households serviced by cable networks.

Annex 6

Glossary of abbreviations

3G Third generation of mobile telecommunication systems. Provides high-speed data transmission and supports multimedia applications alongside conventional voice services.

AVC Advanced Video Coding

DAB Digital Audio Broadcasting. A UK radio service based on the set of internationally-accepted standards for terrestrial digital radio broadcasts.

DDR Digital Dividend Review. Ofcom's programme of work to deal with the spectrum that is to become available for use following digital switchover from analogue TV. This spectrum is known as the digital dividend.

Dongle A device, attached to a PC's USB port, which adds hardware capabilities.

DSO Digital switchover. The process of switching over from analogue television or radio broadcasting systems to digital. Television DSO is due for completion in 2012.

DTT Digital Terrestrial Television. The television technology based on DVB international standards that carries the Freeview service.

DVB Digital Video Broadcasting. A set of internationally-accepted open standards for digital broadcasting, including standards for distribution by satellite, cable, radio and hand-held devices.

DVB-T2 The latest digital terrestrial transmission technology developed by DVB. The technology is being used for HDTV on DTT in the UK.

DVR Digital Video Recorder (also known as 'PVR'). A digital TV set-top box with a hard disk drive which allows the user to record, pause and rewind live TV.

EPG Electronic Programme Guide. A programme schedule, typically broadcast alongside digital television or radio services, to provide access to and information on the content and scheduling of current and future programmes.

Femtocell A miniature, low cost and low power 2G/3G mobile base station for indoor residential use. Typically uses the consumer's broadband connection to connect to the network operator's infrastructure.

Fibre-to-the-cabinet Telecoms access network consisting of optical fibre extending from the access node to the street cabinet usually located close to the subscriber premises. The connection from cabinet to customer is often a copper pair but could use another technology, such as wireless.

FM Frequency Modulation. Type of modulation produced by varying the frequency of a radio carrier in response to the signal to be transmitted. Used by radio broadcasters in VHF band II.

Free-to-air Broadcast content that people can watch or listen to without having to pay a subscription.

GHz Gigahertz.

H264/AVC A video compression standard which is part of most MPEG4 implementations. Approximately twice as efficient the earlier MPEG2 standard. (See MPEG entry below.)

HD High Definition. A technology that provides viewers with better quality, high-resolution pictures.

HEVC High Efficiency Video Coding. An new, more efficient, video compression standard whic h is currently under development.

IP Internet Protocol. The packet data protocol used for routing and carrying messages across data networks including the internet.

IPTV Internet Protocol Television. Television and/or video signals that are delivered to subscribers or viewers using IP. Typically used in the context of streamed linear and on-demand content delivered via home broadband connections.

IMT International Mobile Telecommunications. Refers to a series of requirements for mobile technologies defined by the ITU. Includes technologies branded as 3G (meeting IMT-2000 requirements) and 4G (meeting IMT-Advanced requirements)

ITU International Telecoms Union. The United Nations agency for information and communication technologies. Its role covers radiocommunications, standardization and development. Its membership includes 191 Member States and more than 700 Sector Members and Associates.

LTE Long Term Evolution. Part of the development of 4G mobile telecommunication systems that builds on technologies used for 2G and 3G networks. LTE does not meet the ITU requirements for 4G services.

LTE-Advanced A further development of the 4G LTE mobile system which does meet the ITU requirements for a 4G service.

Mbit/s Mega (million) bits per second. A measure of the speed of transfer of digital information.

MFN Multi-frequency network. A transmission network using different frequencies to cover different areas

MHz Megahertz. A unit of frequency comprising one million cycles per second.

MIMO Multiple-Input and Multiple-Output. The use of multiple antennas in the transmitter and receiver to improve communication performance

Mobile Broadband Various types of wireless high-speed internet access through a portable modem, telephone or other device.

MPEG Moving Picture Experts Group. A set of international standards for compression and transmission of digital audio-visual content. Most UK standard definition digital television services use MPEG2. MPEG4 offers greater efficiency and is used for new services including IPTV and HD TV.

Multichannel television The provision or receipt of television services other than the main five channels (BBC One and Two, ITV1, Channel 4/S4C, Channel Five). 'Multichannel homes' comprise all those with DTT, satellite, cable, or IPTV.

Multiplex A transmission consisting of multiple streams of information conveyed at the same time in the form of a single, complex signal. The separate streams are then recovered individually at the receiving end.

Non-linear Content that is delivered 'on demand' as opposed to linear, broadcast content.

'Over-the-top' video Audio-visual content delivered on the 'open' internet rather than over a managed IPTV architecture.

Pay TV Also known as 'subscription television'. Television broadcasts that the viewer pays to receive. UK Pay TV providers include BSkyB, Virgin Media, BT Vision, Top Up TV and Talk Talk TV.

PMSE Programme-Making and Special Events. A class of radio applicatiosn that support a wide range of activities in entertainment, broadcasting, news gathering and community events.

PPDR Public Protection and Disaster Relief. Includes emergency services such as the fire brigade and police.

PSB Public service broadcasting, or broadcaster. The Communications Act defines the PSBs as the BBC, ITV1 (including GMTV1), Channel 4, Channel Five and S4C.

PVR See DVR

QoS Quality of Service

SD Standard definition. The lower, and currently most common, of the resolutions used for television broadcasting.

SFN Single Frequency Network. A transmission network where all transmitters operate on the same frequency.

Smartphone A mobile phone that offers more advanced computing ability and connectivity than a contemporary basic 'feature phone'.

Streaming content Audio or video files sent in compressed form over a communications network such as the internet and consumed by the user as they arrive.

TETRA TErrestrial Trunked Radio. A system to providing communications services, commonly to the emergency services.

UHF Ultra-High Frequency. The frequency range from 300 MHz to 1 GHz.

VHF Very High Frequency. The frequency range from 30 MHz to 300 MHz.

VoD Video on Demand. A service that enables viewers to watch programmes or films whenever they choose to, not restricted by a linear schedule

WRC World Radiocommunication Conference. The WRC reviews and revises the Radio Regulations, They are held every two to three years.

WSD White Space Devices. Devices which make use of spectrum that is nominally allocated to other services but which is unused in their locality.