Securing long term benefits from scarce low frequency spectrum

UHF strategy statement

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Statement

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One page summary

Spectrum is a valuable resource. It enables the delivery of a wide range of wireless services spanning television and radio through to mobile telephony, emergency services and outside broadcast event coverage. Through the many services it delivers, spectrum provides significant value to UK citizens and consumers.

Lower frequency spectrum is favoured by many popular services, including TV and mobile telephony, because it can pass through walls and other obstructions more easily than higher frequency spectrum, improving service coverage.

As the amount of low frequency spectrum is limited, it is important that the best possible use is made of it. A key challenge associated with doing this is that changing spectrum use can take more than a decade to achieve, especially where there is a need for new international agreements over its future use. In contrast, demand for spectrum by new wireless services and devices is changing at an accelerating pace.

The mobile sector is experiencing unprecedented growth in demand for mobile data, driven by the popularity of smartphones and tablet PCs. By 2030, mobile data demand could be 80 times higher than today. Meeting this increase could deliver significant benefits to consumers, through new and improved mobile data services. It could also sustain wider growth in the economy by improving the capability of the UK's mobile infrastructure.

If more low frequency spectrum were available to meet the growth in demand for mobile data, it would make a significant technical contribution to future mobile networks, also by providing better services in difficult to reach indoor and outdoor locations.

Mobile spectrum needs to be used on an international basis to provide the economies of scale necessary to ensure the wide availability of devices at reasonable cost. The only low frequencies likely to meet this requirement are part of the spectrum currently used by digital terrestrial television (DTT), and also accessed by equipment for entertainment programmes and live events. This spectrum (known as the 700 MHz band) is already used in the US and Asia to provide mobile broadband services and is set to become globally allocated for mobile use after the next World Radio Conference in 2015.

The DTT platform performs very important roles in providing low cost universal access to the public service TV channels and in sustaining viewer choice. Using additional low frequency spectrum for mobile broadband services may leave the DTT platform with insufficient TV channel capacity to continue to fulfill the roles it performs today. This is a potentially significant risk for UK citizens and consumers, because other TV delivery platforms including satellite, cable and IPTV are unlikely to provide a suitable alternative to DTT when additional low frequency spectrum is needed for mobile broadband.

Given the challenges set out above, we have decided to aim to secure the dual long term strategic objectives of providing more low frequency spectrum for mobile broadband whilst also securing the ongoing delivery of benefits provided by DTT. To achieve this we will:

- Support the international process and seek to enable a harmonised release of additional low frequency spectrum for mobile broadband;
- Seek to ensure that the DTT platform can access alternative frequencies assuming that some its spectrum will be reallocated for mobile use. This approach will also support services sharing spectrum with DTT including wireless microphone links.

The need for new international agreements makes it likely that none of these changes will take place until 2018 at the earliest. We intend to prepare for these changes in advance, working with relevant stakeholders, to reduce the disruption and cost of implementation.

Section 1

Executive summary

1.1 Spectrum is an essential building block in the communications sector, supporting the delivery of a wide range of services ranging from TV through to mobile telephony and emergency services. Spectrum is also a limited resource and it is important to ensure that its use maximises benefits to citizens and consumers.

1.2 Spectrum scarcity is particularly relevant for frequencies in UHF bands IV and V (470 to 862 MHz), because its attractive propagation characteristics mean it is in demand by a wide range of services.

1.3 The use of this lower frequency spectrum needs to be coordinated at an international level to manage interference across borders, and reaching relevant agreements for changing its use can take several years. In contrast, the pace of change in the communications sector is accelerating.

1.4 In particular there is unprecedented growth in the demand for mobile data. As we noted in our recent Infrastructure Reporting update[1], between 2011 and 2012 the amount of data handled over UK mobile networks has more than doubled. In future, under a mid growth scenario, there could be an 80-fold growth in this demand by 2030, driven by the increasing take-up and use of smartphones, tablet PCs and machine-to-machine applications.

1.5 In future, there will be a potentially significant increase in the supply of additional harmonised spectrum, through the upcoming combined award at 800 MHz and 2.6 GHz, Government's plans to release 500 MHz of public spectrum, and other high frequency bands which could be released over the long term. Nevertheless, the availability of additional spectrum at lower frequencies would still be important.

1.6 The 700 MHz band is currently used for national digital terrestrial television (DTT) transmissions, and other services sharing spectrum with it, including programme making and special events (PMSE). In the near future, this spectrum will also be used for Local TV and new applications based on white-space technology. This band could, however, play an important role in meeting increasing demand for mobile data, alongside other techniques. This is because its use for mobile would:

- Help meet growth in mobile data requirements using a reduced number of new mobile sites;
- Provide a better quality of service in difficult to reach locations, in rural areas and inside buildings; and
- Enable economies of scale in mobile handsets and equipment deriving from its likely global use for mobile broadband services after 2015.

1.7 However, changing the use of the 700 MHz band raises the risk that the DTT platform would be unable to continue to fulfill its important role of providing near-

[1] http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/broadband-speeds/infrastructure-report-2012/

universal low cost access to public service broadcast services and of maintaining viewers' choice of platforms, services and equipment.

1.8 To address the challenges associated with balancing the future spectrum needs for mobile broadband, DTT and the services sharing spectrum with DTT, we set out in this statement a long term strategy that aims to secure the dual objectives of providing more low frequency spectrum for mobile broadband whilst also securing the ongoing delivery of benefits provided by DTT. To achieve this we will:

- Support the international process and seek to enable a harmonised release of the 700 MHz band for mobile broadband use;
- Seek to ensure that the DTT platform can access the 600MHz band assuming change of use at 700 MHz takes place. This approach will also help secure the ongoing delivery of other services sharing spectrum with DTT, such as wireless microphone links and new services based on white space technology.

1.9 In light of this long term strategy, in this document we also:

- outline areas of further work Ofcom will be conducting over the coming years to prepare for a successful implementation of our strategy that seeks to reduce associated costs and disruption; and
- set out our decision on how to enable use of the 600 MHz band in the interim period ahead of a potential future change of use of the 700 MHz band, to maximise value for citizens and consumers whilst supporting our longer term objectives.

1.10 These decisions are based on a careful consideration of stakeholder responses to our March 2012 consultation document: *Securing long term benefits from scarce spectrum resources: a strategy for UHF bands IV and V*[2].

There is likely to be a significant future growth in demand for mobile broadband capacity

1.11 A significant future challenge facing the communications sector is the rapid growth in demand for mobile broadband capacity driven by the increasing use of video and data services on smartphones and tablet PCs. As we noted in our recent Infrastructure Reporting update[3], between 2011 and 2012 the amount of data handled over UK mobile networks has more than doubled. In future, under a mid-level growth scenario, mobile data capacity demand will experience an 80 fold increase between 2012 and 2030[4], and a 300 fold increase under a high-growth scenario.

1.12 Meeting this future 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;

[2] http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/summary/spectrum-condoc.pdf
[3] http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/broadband-speeds/infrastructure-report-2012/
[4] 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

- Ensuring that the UK's mobile infrastructure is capable of supporting future growth in the wider economy;

- Enabling the future delivery of next generation video and data based emergency service applications.

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

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

- 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;

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

1.14 To meet a mid-level scenario for an 80 fold increase in mobile capacity demand by 2030 a combination of all these approaches is likely to be needed.

1.15 Some respondents to our consultation stated that they did not believe that additional spectrum would be needed stating that mobile operators could make a more effective use of their existing spectrum.

1.16 We note that increasing the efficiency of spectrum use through new technologies and the use of small cells will be very important. However, technical research commissioned by Ofcom has highlighted that additional mobile broadband spectrum would play a fundamental role in meeting growing capacity requirements even when existing mobile spectrum is used with more efficient technology and there is significantly increased amount of offloading to Wi-Fi and other small cells. Hence, we remain of the view that additional mobile spectrum will form an important part of meeting the anticipated growth in demand for mobile broadband capacity.

Only internationally harmonised spectrum is likely to be used for mobile broadband

1.17 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.

1.18 In the future, there will be a potentially significant increase in the supply of additional harmonised spectrum resulting from:

- The planned 800 MHz and 2.6 GHz spectrum awards;

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

- Government's plans to release 500 MHz of public spectrum, which could provide a significant amount of additional higher frequency harmonised spectrum including 40 MHz at 2.3 GHz and the 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.

1.19 Much of this increase is likely to be concentrated at higher frequencies above 1 GHz, with the exception of the upcoming award of the 800 MHz band released by the switchover from analogue to digital television.

1.20 Technical research commissioned by Ofcom has shown that the availability of additional low frequency spectrum beyond the 800 MHz award could be particularly relevant for mobile broadband use. This is because its good propagation characteristics mean that it can:

- Help meet growth in mobile data requirements using a reduced number of new mobile sites; our research has also highlighted that this effect is likely to be greater the earlier additional lower frequency spectrum becomes available; and

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

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

1.21 The 700 MHz band, which is currently used to deliver DTT and other services on a geographic interleaved basis, represents the most attractive option for providing additional lower frequency spectrum because there is now momentum behind it being allocated for mobile broadband use on a global scale:

- In the Americas: the 700 MHz band is already being used for mobile broadband LTE services in the United States; Canada, Mexico and other countries in the region are also progressing plans to make this band available for mobile broadband.

- In Asia: Japan has recently allocated the 700 MHz band for mobile broadband use. Australia and New Zealand and other countries in the region are also taking steps towards enabling use of this band for mobile broadband;

- 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 and Middle Eastern countries to launch LTE services in the 700 MHz band. The WRC 12 resolution has prompted a European debate on the future of the 700 MHz band and the European Commission has recently initiated a process which could lead to establishing harmonised technical conditions for wireless broadband use of the 700 MHz band in the European Union.

1.22 International harmonisation of the 700 MHz band provides important benefits, by:

- increases economies of scale for mobile handsets and devices, thus reducing prices;

- securing a wider choice of devices developed and sold in the global market to national customers; and

- making it easier to co-ordinate its use with neighbouring countries, improving spectrum efficiency.

1.23 Enabling the use of the 700 MHz band for mobile broadband in the UK would require a new international frequency co-ordination agreement. This is because signals at high power in UHF bands IV and V can create interference across borders, thus potentially severely affecting services provided in the UK and other countries unless relevant coordination rules are agreed. This could take several years to complete and will depend on the position adopted by other European countries on whether to enable change of use at 700 MHz. 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 700MHz band for mobile broadband would affect DTT and other services sharing the spectrum it uses

1.24 The frequency assignments in the 700 MHz band are currently licensed for use by multiplex operators running the DTT platform. Other services make use of frequencies unused by DTT in specific locations, on a so called geographic interleaved basis. These services include Programme Making and Special Events (PMSE), the Northern Ireland DTT multiplex (NI Mux), and, in the near future, Local TV services and innovative applications based on 'white-space' technology. Using the 700MHz band for mobile broadband could affect all of these services.

1.25 The DTT platform currently performs a very important public policy role in providing near-universal low cost access to Public Service Broadcasting (PSB) content, whilst also providing consumers with a wider choice of services, receiver equipment and platforms. These roles are likely to remain important when the 700 MHz band could be released for mobile.

1.26 A number of respondents to our consultation suggested that we may have underestimated the role broadband IPTV delivered services could play in providing a viable substitute to the DTT platform. We recognise that in the very long term (i.e. post 2030) there is a potential for the universal take-up of superfast broadband to enable IPTV services to provide a viable substitute for the linear broadcast TV service provided by the DTT platform, enabling a potential future DTT switch-off scenario. This scenario falls outside the timeframe for the UHF strategy we are setting out in this statement and does not therefore form part of our current strategy.

1.27 Nevertheless, we remain of the view that over the timescales of a future release of the 700 MHz band, potentially as early as 2018, there is a significant risk that IPTV would not be able to provide a sustainable alternative to the DTT platform. This is because of:

- The uncertainty that broadband connections with sufficient speed and data capacity limits needed to support linear broadcast IPTV services will be universally available to all households over this timeframe;

- The high likelihood that there will not have been a universal consumer take-up of high speed broadband connections and IPTV compatible receivers over this timeframe;

- The current absence of standalone IPTV services providing a range of linear TV services comparable to that available on the DTT platform. More recent IPTV service propositions such as YouView have been developed to provide an on-demand complement as opposed to a replacement for linear broadcast TV platforms.

A long term strategy for achieving positive outcomes for mobile broadband, DTT and the services it shares spectrum with

1.28 In our consultation we set out that by securing the dual objectives of:

- Enabling the 700 MHz band to be used for mobile broadband once it is internationally harmonised and co-ordinated to help avert a capacity crunch on mobile broadband networks, alongside other higher frequency mobile broadband spectrum and other mobile network capacity enhancing techniques;

- Ensuring that a sufficient amount of spectrum is available for use by the DTT platform when the 700 MHz band is used for mobile broadband so that it can continue to fulfil its current roles;

is most likely to deliver the greatest benefits to citizens and consumer in the longer term.

1.29 Consultation responses revealed a reasonable degree of consensus with our proposals:

- Respondents from the mobile and satellite broadcasting sectors took the view that our proposals were overly protective of DTT, but generally recognised its ongoing relevance in providing key benefits, especially in case of early release of the 700 MHz band.

- Stakeholders with an interest in DTT or the services sharing spectrum with it were sceptical of the need of 700 MHz release for mobile broadband. Some stated that they did not believe that the need to use the 700 MHz band to meet the growth in mobile data demand had been proven, given future market uncertainties. But most of these stakeholders did recognise the international momentum towards the likely future international harmonisation and co-ordination of the 700 MHz band for mobile broadband. In view of this they thought it would be important to take steps to ensure that DTT and the services it shares spectrum with can continue to provide benefits for citizens and consumers in the future.

1.30 In our consultation we identified two factors that could help ensure there is a sufficient amount of DTT broadcast capacity for the ongoing delivery of important benefits:

- Future improvements in digital television compression and transmission technology enabling the DTT spectrum to use spectrum more efficiently; we expect these will be progressively adopted by multiplex operators, enabling increasing efficiencies in spectrum usage by the DTT platform over the next decade;

- The potential use of the 600 MHz band released by digital switchover for DTT and the other services sharing spectrum with it, if the 700 MHz band is released for mobile broadband.

1.31 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

1.32 If the DTT platform were re-planned without the 700 MHz band and no alternative spectrum at 600MHz, it might be possible, subject to future international agreements, to accommodate 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). This could be consistent with the first of the three outcomes above. However, this approach would only provide half of the broadcast TV capacity available on the DTT platform today, creating a risk that the other two outcomes above could not be delivered.

1.33 Consumer research commissioned by Ofcom highlighted that the attribute of the DTT platform consumers' value most highly is access to a sufficiently large number of free-to-air TV channels. This suggests there would be a significant risk that just three multiplexes would not provide sufficient DTT broadcast capacity to meet all of the objectives set out above. The majority of respondents concurred with this view.

1.34 However, some respondents stated that the DTT platform could provide the same number of TV channels using a reduced number of multiplexes in the future by using more efficient broadcast standards. But there is a risk that this would not be the case if:

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

- Future viewer preferences shift from standard to high definition television or other high capacity services;

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

1.35 Given this, we consulted on our view that the 600 MHz band should remain available to provide alternative DTT spectrum after the release of the 700 MHz band. Using this spectrum as part of a wider spectrum replan, it is likely that the DTT platform would be able to continue to operate with six multiplexes and maintain PSB multiplex coverage. This significantly reduces the risk that the DTT platform would have an insufficient amount of future capacity and coverage to continue to deliver the benefits it provides today.

1.36 An important additional benefit associated with this approach is that it would make it easier to implement a frequency re-plan of the DTT platform after 700 MHz release that is compatible, as far as possible, with existing roof-top antennas. It will also aid the continuing provision of services sharing spectrum with DTT, by making alternative spectrum available to them in the 600 MHz band.

1.37 Most respondents concurred with our proposed approach that alternative spectrum at 600 MHz should be made available for DTT and other services in case of change of use of the 700 MHz band.

1.38 A consequence of this approach is that it would not allow the 600 MHz band to be used to deliver alternative services to DTT over the longer term. We note that no stakeholder favoured an option of awarding long term rights to use spectrum at 600 MHz given international developments around the 700 MHz band. The 600 MHz band is also only harmonised for broadcast use, making DTT and other services sharing spectrum with it the most likely uses of this spectrum.

1.39 Based on the above, we believe that a precautionary approach should be taken towards mitigating the risk that DTT will not being able to provide ongoing benefits if the 700 MHz band is released. We have therefore concluded that we should retain the ability to use the 600 MHz band as part of a future frequency re-plan of the DTT platform assuming the 700 MHz band is released.

1.40 Having considered and balanced all of our statutory duties and following careful consideration of all the responses received to our consultation and the evidence available to us, we have decided to adopt a long term strategy for UHF spectrum bands IV and V. This will aim to secure the dual objectives of providing more low frequency spectrum for mobile broadband whilst also securing the ongoing delivery of benefits provided by DTT. To achieve this we will:

- Support the international process and seek to enable a harmonised release of the 700 MHz band for mobile broadband use;

- Seek to ensure that the DTT platform can access the 600MHz band assuming change of use at 700 MHz takes place. This will also help secure the ongoing delivery of other services sharing spectrum with national DTT services, including Local TV, PMSE, and new services based on white space technology.

1.41 This strategy will guide and inform relevant Ofcom work over the coming years, ensuring that future policy decisions are consistent with a long term perspective on how to secure significant benefits from the use of UHF bands IV and V

1.42 We believe that establishing this approach now is a crucial step towards ensuring that the best possible use of scarce spectrum resources in UHF bands IV and V can be made over the longer term.

1.43 It is also important to recognise that we are not seeking to reach final decisions on the process and timescales of any future release of the 700 MHz band in this document. In practice, we believe that these decisions will have to be informed by further work. The optimal process (including detailed arrangements required to facilitate an actual change of use of the 700 MHz band) and timing of release will depend on future harmonisation and co-ordination developments, and market developments within the DTT, mobile and other service sectors in the UK – factors which remain uncertain at this stage. Ofcom will monitor (and, where appropriate,

engage with) these developments in order to inform our position on the process and timing.

Implementing our strategy

1.44 Any disruption and costs caused by a future change of use of the 700 MHz band are likely to be more easily managed by preparing for this change in advance. With this in mind we intend to support a number of preparatory actions in collaboration with relevant stakeholders.

1.45 These activities will include:

- Pressing forward on international engagement with a view to securing an outcome which best serves the interests of UK citizens and consumers in two important areas:
    - discussions on the future mobile broadband band plan to be used in the 700 MHz band; and
    - frequency coordination negotiations which underpin a future frequency re-plan of the DTT platform.
- Examining the key questions of how and when a future change of use of the 700 MHz band can be secured, which optimises the timing of release and which best serves the interests of UK citizens and consumers. We intend to publish further work in this area during 2013.
- Exploring opportunities for reducing and potentially avoiding the costs and disruption to citizens and consumers, such as those related to the need to modify or bring forward the replacement of equipment as a result of the change in use of the 700 MHz band. As part of this, we will explore approaches that could help accelerate the consumer adoption of receivers compatible with efficient technology standards, as these are likely to be used more extensively in future DTT transmissions.
- Working with multiplex operators to consider the implementation of technical and regulatory changes to safeguard the benefits of DTT services.
- Enabling the continued provision of existing and future planned PMSE, local TV, NI Mux and WSD based services by the early signalling of our decision, and therefore:
    - our commitment to working with these users to reduce and potentially avoid any costs and disruption, and to help manage the transition of existing and planned services;
    - the need for equipment to be capable of operating in the geographic interleaved spectrum of a re-planned DTT platform; and
    - the importance of achieving longer term spectrum efficiency savings, including the progressive digitisation of analogue services and the adoption of cognitive radio technology.
- Continuing to support Government activities related to future decisions around spectrum allocations for emergency services applications.

1.46 We believe that through a combination of these activities a change of use of the 700 MHz band can be implemented so that it maximises net benefits for citizens and consumers over the long term, whilst reducing associated costs and disruption.

The short term use of the 600 MHz band

1.47 Our long term strategy involves seeking to enable the harmonised release of the 700 MHz band for mobile broadband, whilst also seeking to preserve the availability of alternative spectrum in the 600 MHz band for the DTT platform and the other services sharing spectrum with it. As we discuss above, these changes may start to occur as early as 2018. Accordingly, we have decided that any short term use of the 600MHz band should be authorised[5] in a way which allows us to terminate its use in 2018[6].

1.48 We therefore need to have regard to the potentially short window of opportunity to use the currently cleared 600 MHz band before it is needed as part of a future DTT re-plan. Given the potential need to take back the spectrum, the value of using the 600 MHz band over a short time period is likely to modest.

1.49 Consultation responses converged on two options for the shorter term use of the 600 MHz band:

- Shared use by DTT, PMSE and White Space Devices (WSDs).
- Exclusive reservation as an innovation space for WSD applications.

1.50 We believe that both of these proposals are potentially attractive.

1.51 Under the first option one or two temporary multiplexes carrying additional services in DVB-T2 and MPEG-4 could be provided, with their geographic interleaved spectrum used by PMSE and WSDs. This approach is consistent with views expressed in responses from the TV sector, BT, respondents from the PMSE community and some of the stakeholders with an interest in WSDs other than Sky.

1.52 This approach could offer various potential benefits:

- In the short term, expanding the range of HD services available on the DTT platform would strengthen its ability to deliver consumer benefits, as it would expand the range of services available to households that already have a compatible receiver.
- Over time, the expanded range of services available could provide incentives for consumers to accelerate the take-up of DVB-T2 MPEG-4 compatible receivers. If this were the case, this could facilitate a faster migration of the DTT platform to these more efficient standards. This would in turn result in: greater spectrum efficiency being achieved earlier; greater flexibility in achieving multiplex coverage levels comparable to today through a future DTT replan; greater potential for the DTT platform to continue to remain attractive and sustainable as a means of delivering important citizen and consumer benefits over the long term.

[5] Spectrum use can be authorised by a WT Act licence or by licence exemption regulations.
[6] We refer to the period between now and 2018 as the “interim period” and the uses of the 600MHz band during this period as “interim uses”.

1.53 The second of the options emerging from consultation responses for the short term use of the 600 MHz band would result in the 600 MHz band being used exclusively for WSD use, to provide an innovation space for the emerging WSD market. This option was raised by Sky.

1.54 WSDs are being developed to operate across the whole of the TV frequency band. These services make use of spectrum left unused by DTT and PMSE services in specific locations, on the basis that they would not cause interference to these services.

1.55 We believe it is important to support future innovation based on emerging WSD technology, as this has the potential to make a more effective and efficient use of spectrum, and deliver benefits to citizens and consumers through new or improved services. To this end, Ofcom is progressing ongoing work in collaboration with industry to establish a regulatory framework and the technical conditions to enable these services.

1.56 As noted by Sky, reserving the 600 MHz band for WSDs could offer various potential benefits

- The innovation reserve at 600 MHz could provide a test bed for developing WSD applications and spectrum access protocols. This could lead to an earlier advancement of relevant testing activities, easing time constraints related to the definition of rules for accessing geographic interleaved spectrum in other parts of UHF bands IV and V.

- It could provide greater flexibility for the development of emerging WSD equipment, enabling an opportunity to operate devices at higher power levels and using wider channel widths through access to contiguous channel blocks, than in the case of access to geographic interleaved spectrum.

1.57 In assessing the relative merits of these two proposals we have taken account of the following considerations:

- *Potential benefits delivered from interim use of the 600 MHz band*: the first option could deliver incremental benefits associated to a wider range of DTT services to viewers with a compatible receiver, and, over time, a potentially faster transition of the DTT platform to more efficient transmission standards. The first option could also deliver benefits from the ongoing provision of PMSE in the 600 MHz band, and by avoiding the prospect of a 'double migration' for PMSE out this band if it was reserved for other uses in the short term, and back into it when 700 MHz release takes place. The second option could, in principle, provide greater flexibility for WSD innovation. However, preliminary technical analysis indicates this effect appears to be limited[7]. In addition, the extent to which such effect could result in incremental benefits to citizens and consumers is, at best, very uncertain.

- *Consistency with our longer term strategy for UHF bands IV and V*: in principle, both options could be consistent with our long term strategy insofar as we will be able to terminate interim uses to allow the 600 MHz band to be used as part of a future re-planned DTT platform. However, the first option differs from the second

[7] Our view is informed by technical simulations of TVWS availability, conducted using coexistence parameters and other assumptions that are still under discussion in relevant technical working groups, and that are unlikely to be finalised until several months into 2013.

in that it can positively support the delivery of our longer term strategy, by facilitating the delivery of DTT benefits over the long term through a potentially faster platform transition to more efficient standards.

- *Continuity of service on future change of use in UHF bands IV and V*: the first option could secure continuity of service as the expected transition towards a future UHF replan takes place. In particular, if there is sufficient platform transition DVB-T2 and MPEG-4 (which could be facilitated by the first option), it is likely that the additional services provided in the interim could be accommodated in the multiplexes delivered following the future replan, as the capacity of the platform increases with use of more efficient standards. In contrast, it is difficult to assess long-term continuity of provision of WSD applications relying exclusively on the second option, as it is unclear as to whether these could actually emerge.

- *Timing considerations*: delaying our decision on short term use of 600 MHz until we have greater clarity on technical coexistence parameters between WSDs and other potential uses of the 600 MHz band puts at risk the incremental value to consumers and citizens that could be provided through this spectrum over the interim period. The period of certainty over which spectrum at 600 MHz can be used on an interim basis could be as short as five years, from 2013 to 2018. Delaying our decision could cause a material reduction in this already short timeframe.

1.58 Taking these factors into account, and having regard to all our statutory duties, we have decided to proceed with an approach that will enable a shared short term use of the 600 MHz band for one or more DVB-T2 MPEG-4 DTT multiplexes, PMSE and white space devices.

1.59 To give effect to this decision, we will be publishing as soon as practicable a further document on how best to award 600 MHz spectrum, by licensing one or more DTT multiplexes using DVB-T2 and MPEG-4. We also intend to conduct further work on the precise arrangements for the coexistence of PMSE equipment and WSDs in the 600 MHz band.

Section 2

Introduction and structure of this document

2.1 Spectrum is a limited 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 are established users of the spectrum the needs of which must be considered. In contrast, some areas in the communications sector are changing at an accelerating pace.

2.3 In particular, there is unprecedented growth in the demand for mobile broadband capacity. 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.

2.4 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 by 2020, part of which will help with meeting the growing demand for mobile data[8].
- 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, approximately 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.

2.5 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.

[8] 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)

2.6 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.

2.7 In this context, it is highly significant that a resolution[9] passed recently at the 2012 World Radio Conference (WRC 12) indicated that, subject to the completion of relevant technical work, a decision to allow the 700MHz band to be used for mobile broadband services in ITU Region 1 (Europe, Middle East and Africa) will be taken at the next World Radio Conference in 2015 (WRC 15).

2.8 The WRC 12 resolution has prompted a European debate on the future of the 700 MHz band. The Radio Spectrum Policy Group initiated a series of activities to explore implications of this resolution on EU policy in June 2012[10]. More recently, the European Commission has initiated a process which could lead to establishing harmonised technical conditions for mobile broadband use of the 700MHz band in Europe.

2.9 The 700MHz band can already be used for mobile broadband in other ITU Regions:

- 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, like Canada and Mexico, are 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. Japan has recently concluded a 700 MHz band award. Countries including Australia and New Zealand are likely to release this band in the short term enabling LTE deployments, whilst in others plans for release are currently at an early stage;

2.10 The recent WRC 12 resolution therefore raised prospects for use of the 700MHz band for mobile broadband on a global scale, significantly increasing momentum in international fora.

2.11 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.

2.12 This spectrum is used together with other parts of UHF bands IV and V (see figure 1) for the delivery of terrestrial broadcast services including:

- nationally available digital terrestrial television services, referred to throughout this statement as ‘DTT’ or ‘the DTT platform’;

- local TV services, planning to launch in various locations across the UK in the near future, which will share DTT spectrum on a geographic interleaved basis[11][12]; and

[9] See ITU Resolution 232 [COM5/10] (WRC 12), available at http://www.itu.int/oth/R0A0600004B/en
[10] See http://rspg.groups.eu.int/_documents/activities/activ_pressreleases/rspg28_press_release_20120606.pdf
[11] 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

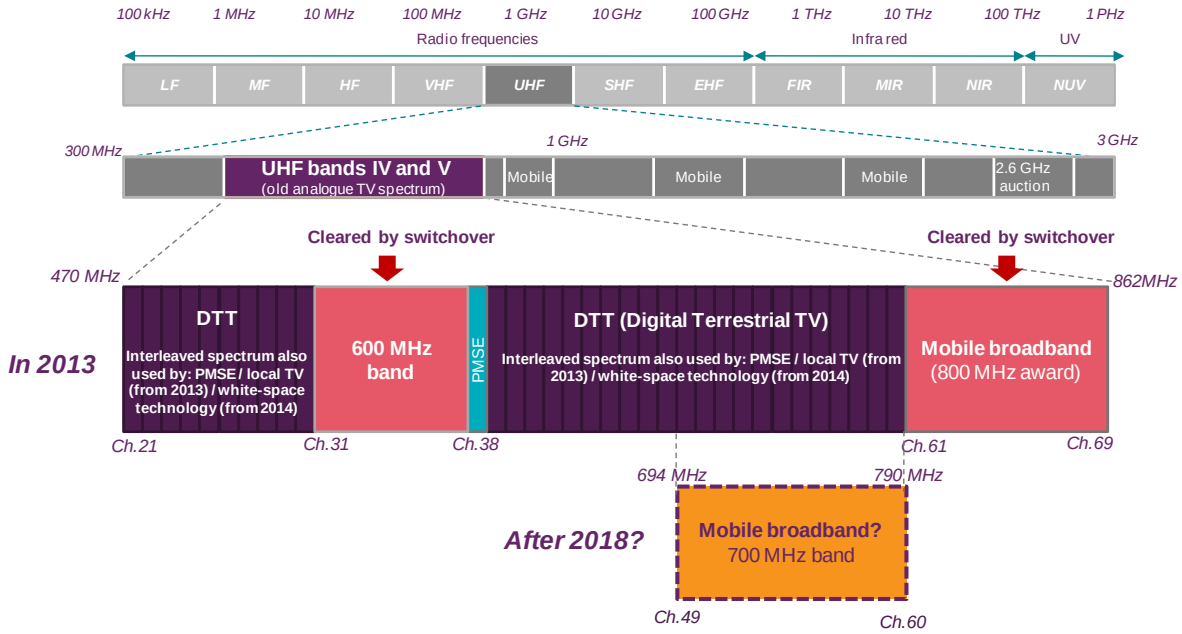
- a multiplex which provides Republic of Ireland television services in Northern Ireland (the 'NI Mux'). The NI Mux also shares DTT spectrum on a geographic interleaved basis.

2.13 Geographic interleaved spectrum is also shared by Programme Making and Special Events (PMSE) services.

2.14 Each of these types of users is authorised to use the spectrum on terms set out in their respective licences.

2.15 In addition, Ofcom is taking steps to enable the use of geographic interleaved spectrum on a licence-exempt basis by applications based on emerging white-space technology.

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



2.16 In this document Ofcom takes account of international and market trends to establish a long term strategy that seeks to maximise the delivery of benefits for UK citizens and consumers from the use of UHF bands IV and V.

2.17 As discussed further in the following sections, any potential reorganisation of UHF bands IV and V and the associated change of use at 700 MHz is unlikely to start before 2018. However, the long timescales associated with internationally coordinated changes to spectrum use require us to take a view on relevant issues with long lead times.

2.18 This involves risk, as it requires the regulator to exercise judgement on the best way to match the supply of scarce spectrum resources with competing demands by different valuable services over the long term, whilst maintaining sufficient flexibility to respond to uncertain future service, market and international developments.

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collectively known as interleaved spectrum and can be used at lower transmitter powers by other non-interfering users

[12] In Cardiff and Manchester two additional 8MHz channels of spectrum which could be used to transmit local broadcast multiplexes were licensed by Ofcom in 2008, although at present services are only being broadcast in Manchester.

2.19 In general, we believe that markets are better placed to efficiently allocate scarce resources. However, in the case of UHF bands IV and V there is a clear role for Ofcom in contributing to ensure the best possible outcomes for citizens and consumers. This is because:

- Recent developments are likely to lead to changes to international agreements on the harmonised use of relevant spectrum bands. In addition, high power frequency assignments used for broadcasting services and new assignments for mobile broadband services need to be coordinated on an international basis, due to risks of cross-border interference. Ofcom has a clear duty to represent the UK's interest during international discussions on harmonisation and coordination.

- Markets do not always take into account external value associated to public policy objectives, such as those related to PSB content and emergency services provision. Ofcom has a role in establishing an appropriate balance that takes account of these.

- Regulatory action is likely to be required to facilitate the practical implementation of a future re-planning exercise; in part, this is likely to be required to remove regulatory barriers that may prevent efficient market functioning; in part, regulatory action will be required to address the risk of coordination failure amongst the various stakeholder groups that will be involved in such exercise.

Our relevant duties

2.20 In defining a long term strategy for UHF bands IV and V Ofcom needs to balance the different competing demands for these scarce spectrum resources 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.

2.21 We have had regard to the full range of our statutory duties in preparing this statement. 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, including:

- Securing the optimal use of spectrum[13];

- Securing the wide-ranging availability of communications services and TV and radio services of high quality and wide appeal[14], and duties relating to fulfilling the purposes of public service broadcasting in the UK[15].

- Promoting competition, encouraging investment and innovation and encouraging the availability and use of high speed data transfer services throughout the United Kingdom[16].

[13] Section 3(2)(a) Communications Act 2003
[14] Section 3(2)(b) and (c) Communications Act 2003
[15] Section 3(4)(a) Communications Act 2003
[16] Section 3(4)(b), (d) and (e) Communications Act 2003

2.22 Ofcom is also required to have regard to the principles under which regulatory activities should be transparent, accountable, proportionate, consistent and targeted only at cases in which action is needed[17].

2.23 When carrying out functions related to the management of radio spectrum, section 3(1) of the Wireless Telegraphy Act 2006 imposes a number of further duties. Ofcom is required to have regard to:

- the extent to which the electromagnetic spectrum is available for use, or further use, for wireless telegraphy;
- the demand for use of the spectrum for wireless telegraphy; and
- the demand that is likely to arise in future for the use of spectrum for wireless telegraphy.

2.24 Section 3(2) of the Wireless Telegraphy Act provides that Ofcom must also have regard to the desirability of promoting the efficient management of radio spectrum, the economic and other benefits that may arise from the use of wireless telegraphy, the development of innovative services and competition in the provision of electronic communications services.

2.25 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[18].

2.26 In the context of a long term strategy for the spectrum considered in this document, these duties mean that Ofcom must have regard not only potential future uses and users, but also to existing users of the band. We have taken appropriate regard of the rights and interests of existing users of UHF bands IV and V in determining our long term strategy for this spectrum and will continue to do so in all future consultations and decisions on this subject.

Structure of this document

2.27 This statement:

- Identifies the key market and international developments that are likely to impact of the delivery of benefits provided by different services operating in UHF bands IV and V over the longer term;
- Sets out a strategic approach aimed at matching the supply of UHF spectrum in band IV and V to the demand by services capable of providing significant benefits to citizens and consumers. This involves supporting the international process and seeking to enable the harmonised release of the 700 MHz band for mobile broadband, whilst ensuring that the DTT platform has access to a sufficient amount of spectrum to continue to fulfill the important roles of providing near-universal low cost access to PSB content, and sustaining consumer choice of services, platforms and equipment. To achieve this will seek ensure that the 600

[17] Section 3(3)(a) Communications Act 2003
[18] Article 8 of the Framework Directive (Directive 2002/21 – as amended)

MHz band can be used as part of a re-plan of the DTT platform assuming release of the 700 MHz band takes place;

- Outlines areas of further work that Ofcom intends to conduct over the coming years to ensure that such approach can be implemented in a way that maximises the benefits of the expected release of the 700 MHz band for mobile broadband whilst reducing and potentially avoiding the costs and disruption for consumers other users of the spectrum.

2.28 The long term strategic approach to UHF spectrum bands IV and V set out in this statement follows careful consideration of the stakeholders responses received through the consultation process we initiated in March 2012 with the *Securing long term benefits from scarce spectrum resources: a strategy for UHF bands IV and V*[19] document.

2.29 In **section 3** we consider the likely growth in demand for mobile broadband data capacity and the consumer benefits of meeting this demand. We also consider the range of techniques mobile operators would need to adopt to meet this growth in demand. We conclude that the availability of additional harmonised spectrum for mobile broadband will be an important factor alongside other techniques. In particular we conclude that additional lower frequency spectrum in the 700 MHz band could play a very valuable role. This is because the 700 MHz band is set to become a global band for mobile broadband services and is hence likely to be supported by the worldwide mobile handset market. Its attractive propagation characteristics also mean that its timely use for mobile broadband applications could significantly reduce the number of additional mobile sites that would need to be built to meet the growth in demand for mobile broadband capacity as well as providing improved indoor coverage. However, we also note that a change of use of the 700 MHz from DTT to mobile broadband use would significantly reduce the amount of spectrum available for DTT and other services making use of its geographically interleaved spectrum.

2.30 In **section 4** we consider the role that the DTT platform currently plays in delivering important benefits to citizens and consumers today, including the provision of low cost near-universal access to the PSB channels and in sustaining viewers' choice of digital television services, platforms and consumer equipment. We conclude that these roles are likely to remain relevant when a change of use of the 700 MHz could feasibly take place and that other platforms, including IPTV, are unlikely to be able to fulfil these roles at this time. We also note that advances in transmission and compression technologies are likely to significantly increase the efficient use of spectrum by the DTT platform but that these efficiencies could be offset by an increased demand for high capacity HD services. This means that the use of these more efficient technologies may not increase the future number of TV channels that can be delivered in the DTT spectrum. Consumer research suggests that a reduction in the number of free-to-air channels available on the DTT platform could reduce its attractiveness to viewers. This would affect the DTT platform's ability to continue to provide benefits associated with delivering a range of services that sustains viewers' choice, potentially also affecting its commercial sustainability. We therefore conclude that, in order to reduce the risk that the DTT is unable to continue to perform in future the important roles it plays today, we should ensure that it has access over the long term a sufficient amount of spectrum.

2.31 In **section 5** we consider other sources of current and future potential demand for spectrum in UHF bands IV and V for services including PMSE, Local TV and the NI

[19] http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/summary/spectrum-condoc.pdf

Mux, as well as new applications based on emerging white-space technology and future emergency services applications. We highlight that a future change of use of the 700 MHz band would have important implications for the delivery of these services. In particular, any reduction in the amount of spectrum available to DTT would have knock-on effects for services that share use of the same spectrum. Use of the 700 MHz band for mobile broadband would however open opportunities to provide new kinds of emergency services applications on an internationally harmonised basis. We conclude that our long term strategy should take into account these implications, and in particular seek to preserve opportunities for the delivery of other services in the UHF spectrum, whilst also seeking to meet the future spectrum needs of the DTT platform and mobile broadband services.

2.32 In **section 6** we identify, based on the conclusions set out in previous sections, that that our long term strategy for UHF bands IV and V should aim to secure the dual objectives of:

- Enabling the availability of additional harmonised UHF spectrum available for mobile broadband use; and
- Securing the ongoing delivery of benefits provided by DTT.

2.33 To achieve this we conclude that we will:

- Support the international process and seek to enable a harmonised release of the 700 MHz band for mobile broadband use;
- Seek to ensure that the 600 MHz band can be used as part of frequency re-plan of the DTT platform assuming harmonised release of the 700 MHz band for mobile broadband takes place. This is because without the use of the 600 MHz band the capacity of the DTT platform could be materially reduced, creating a significant risk that it would be unable to deliver the PSB channels with near-universal coverage and provide a sufficient range and number of TV channels to sustain viewers' choice.

2.34 We also note that the harmonised use of the 700 MHz band for mobile broadband would raise the possibility of delivering new emergency services applications in this band, and that the use of the 600 MHz band for DTT would help reduce the impact of 700MHz clearance on the geographic interleaved users of the DTT spectrum including PMSE, WSDs, local TV and the NI Mux.

2.35 In section 6 we also set out the range of preparatory activities that Ofcom intends to conduct over the coming years to ensure that the benefits of securing these strategic objectives are maximised while reducing the potential costs and disruption for consumers and industry.

2.36 In **section 7** we discuss implications of our long term strategy on the interim use of cleared spectrum at 600 MHz. After giving consideration to different stakeholders' proposals for its interim use, we conclude that its shared use by DTT, PMSE, and WSD services is likely to deliver benefits to citizen and consumers and would support a smoother future change of use of the 700 MHz band. We set out next steps for enabling the interim use of the 600 MHz band by these services.

2.37 **Section 8** provides a summary of key conclusions and next steps

2.38 **Annex 1** provides a summary of the main points made in responses to our March 2012 consultation. Stakeholder views are raised and discussed throughout the document as relevant to the discussion it presents.

2.39 **Annex 2** discusses the technical analysis we conducted to inform our assessment of options for the short term interim use of the 600 MHz band. Relevant to this, we are also publishing two third party reports alongside our statement:

- a report by the BBC and Arqiva[20] presenting preliminary simulations of white-space availability under different scenarios of use of the 600 MHz band; and
- an independent audit report[21] that considered whether the BBC / Arqiva simulations are consistent with the approach defined by Ofcom and discussed with industry in technical working groups for TV white spaces.

2.40 We have considered the impacts of our proposals and decisions and set these out throughout both our consultation on this issue and in this statement. We note that due to the difficulty associated with assessing the long term costs and benefits associated with different spectrum uses, we have focused on identifying the main drivers of future spectrum requirements and providing a qualitative rather than quantitative assessment of these factors in these documents.

2.41 It is also important to recognise that we are not seeking to reach final decisions on the process and timescales of any future release of the 700 MHz band in this document. In practice, we believe that these decisions will have to be informed by further work. The optimal process (including detailed arrangements required to facilitate an actual change of use of the 700 MHz band) and timing of release will depend on future harmonisation and co-ordination developments, and market developments within the DTT, mobile and other service sectors in the UK – factors which remain uncertain at this stage. Ofcom will monitor (and, where appropriate, engage with) these developments in order to inform our position on the process and timing.

[20] http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/statement/BBC_Arqiva_preliminary.pdf
[21] http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/statement/Real_Wireless_audit.pdf

Section 3

Addressing the future mobile capacity crunch

3.1 In our consultation we set out, based on consensus between a range of different analysts' forecasts, how the increasing penetration and use of mobile data services is likely to create a significant increase in demand for mobile data capacity. We also set our preliminary view that meeting this growth in demand could provide significant benefits to citizens and consumers by enabling the delivery of a wider range of attractive mobile services and by ensuring that the UK's mobile infrastructure is able to support future innovation and growth in the wider economy.

3.2 The results of a technical study published alongside our consultation showed that a combination of different mobile network capacity enhancing approaches will be needed to meet a mid range projection for there to be an 80 fold increase in mobile data capacity by 2030. These approaches include: the use of additional high and low frequency spectrum, using improved efficiency mobile technologies, mobile data offloading onto fixed networks using Wi-Fi and Femtocells and deploying more macro and small cell sites.

3.3 This technical study also demonstrated the special role that additional mobile spectrum is able to play when used in combination with other capacity enhancing techniques in significantly reducing the additional number of mobile sites that would need to be built to meet the anticipated future increase in demand for mobile capacity.

3.4 In practice, only spectrum that has been internationally harmonised for mobile data use is likely to be of real value to mobile operators because of the greater economies of scale and lower prices this creates for handsets and base station equipment.

3.5 We identified that a potentially significant amount of higher frequency spectrum above 1 GHz might become available for harmonised mobile broadband use in the future, including spectrum at 2.3 and 3.4 GHz, which form part of the Government's ongoing public spectrum release programme. Whilst further work is needed to release and enable these and other high frequency bands to be used on a harmonised basis for mobile broadband, plans to achieve this are already ongoing.

3.6 In contrast, we identified that there is likely to be a much greater scarcity in the supply of additional harmonised spectrum below 1 GHz, which due to its attractive propagation characteristics is particularly attractive to mobile operators. Our technical study highlighted that the availability of additional sub 1 GHz spectrum beyond the currently planned award of the 800 MHz band, which is being released by digital switchover, could significantly reduce the number of new mobile sites that would need to be built to meet the future growth in demand for mobile capacity whilst also providing improved indoor coverage.

3.7 The most attractive candidate for providing additional spectrum below 1 GHz is the 700 MHz band[22], which has already been allocated in the US and Asia to deploy LTE

[22] The 700MHz band is currently used to deliver DTT and other important services on an interleaved basis. Issues raised by the prospect of a change of use at 700MHz in the UK are discussed in Sections 4, 5 and 6.

based mobile broadband services. In addition, at this year's 2012 World Radio Conference a clear direction of travel was set for enabling a co-primary allocation of the 700 MHz band for mobile broadband and broadcast uses across Europe and Africa at the next World Radio Conference in 2015/16. This would potentially enable mobile broadband use at 700MHz on a global basis.

3.8 In this section, we review, based on consultation responses, the benefits of enabling the 700 MHz band to be used in combination with other mobile capacity enhancing techniques, once it is internationally harmonised and co-ordinated, to help address an anticipated mobile capacity crunch. A detailed summary of the views expressed by stakeholders on this issue is provided in Annex 1.

The demand for mobile data is set to continue to grow significantly

3.9 Ofcom's recently published 2012 Infrastructure Reporting update[23] shows that total data traffic handled by UK mobile networks was 19.7m GBs. This represents an increase of over 110% over the same metric reported in 2011[24].

3.10 In the March 2012 consultation we described how the growing demand for mobile data is being driven by three key factors which are likely to continue in future:

- **The increasing penetration of data and video capable mobile devices**: the consumer take-up of smartphones and tablets is increasing rapidly. According to consumer research conducted by Ofcom in Q1 2011 27% of UK adults had a smartphone and 2% a tablet PC. By Q1 2012 this had grown to 39% of adults having a smartphone and 11% a tablet PC. In future, mobile data capabilities are also likely to be added to a wide range of other personal or industrial appliances, enabling so-called machine-to-machine (M2M) communications that take place automatically without the need for human input. These developments could compound further current trends towards growing mobile data requirements.

- **Increasing mobile data usage**: According to recent data collected by BillMonitor[25] the average monthly usage of data by smartphone users has more than doubled between July 2010 (at 71MB) and January 2012 (at 154MB). In our Infrastructure Report update we also highlight that monthly mobile data consumption considered on a per-household geographical basis was 680 MB in June 2012. Future improvements in the processing power and video capabilities of new mobile devices are likely to sustain further growth in data consumption.

- **Growth of video traffic**: the increasing penetration of video-capable mobile devices is making mobile video services a central part of future content distribution strategies. Information released by the BBC[26] illustrates how video content consumption on mobiles and tablets grew to unprecedented levels during the London 2012 Olympic Games. As video generally has greater capacity requirements than other forms of mobile traffic, its continuing growth is likely to become a key driver of future mobile data demand.

[23] http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/broadband-speeds/infrastructure-report-2012/
[24] http://stakeholders.ofcom.org.uk/binaries/research/telecoms-research/bbspeeds2011/infrastructure-report.pdf
[25] As reported by Ofcom in the Communications Market Report 2012, figure 5.10: http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr12/CMR_UK_2012.pdf
[26] http://www.bbc.co.uk/blogs/bbcinternet/2012/08/digital_olympics_reach_stream_stats.html

3.11 There are a range of different analysts' forecasts for how the demand for mobile data will evolve over the next 5 years. Cisco, in their recent 2012 forecast, predicted UK mobile data traffic will increase by a factor 12 between 2011 and 2016, with a corresponding compound annual growth rate of 65%[27]. Other analysts also predict a significant upwards trend in the demand for mobile data over the same period, albeit at generally less aggressive compound annual growth rates, with estimates ranging from 30 to 60% over 5 years[28]. We also note that predictions for mobile data growth rates over the last few years have tended to underestimate those achieved in practice.

3.12 There are relatively few predictions for the growth in demand for mobile data capacity over longer timescales. The technical study commissioned by Ofcom described three different scenarios for the longer term growth in demand for mobile broadband capacity between 2012 and 2030[29]:

- *A low growth scenario:* the demand for mobile data flattens off after 2015, with mobile data usage being dominated by low data applications such as instant messaging and mobile payments as opposed to rich web media and video. Under this scenario, total UK traffic volumes in 2030 reach 20 times their current level.

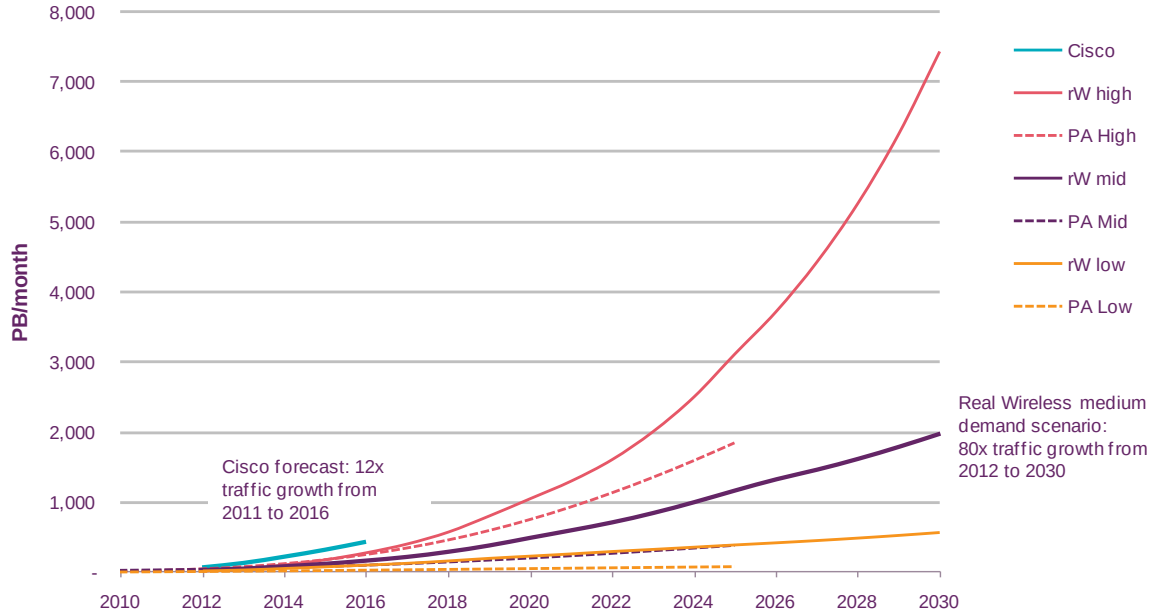
- *A medium growth scenario:* the demand for mobile data continues to increase at current annual growth rates until 2020. After 2020 growth rates slow as the full consumer penetration of data and video-capable devices is reached. Under this scenario, total UK traffic volumes in 2030 reach 80 times their current level.

- *A high growth scenario:* the demand for mobile data consumption continues to grow significantly up to and beyond 2020 driven by the widespread mobile consumption of HD and 3D video and immersive gaming. Under this scenario, total UK traffic volumes in 2030 reach 300 times their current level.

3.13 These three scenarios are illustrated below, alongside the most recent Cisco forecasts for mobile data growth to 2016 and longer term projections provided by PA Consulting in 2009 as part another Ofcom commissioned study[30]. The trajectory of the shorter term Cisco growth forecasts to 2030 is broadly aligned with the Real Wireless 'high growth' scenario described above. Whilst the mid case growth scenario provided by PA Consulting is broadly aligned with the mid growth Real Wireless scenario. Unlike the Cisco forecasts the PA forecasts do not take into account the higher than expected growth in mobile data usage over the past few years.

[27] Cisco Mobile Visual Networking Index 2012
[28] Analysys Mason 2011 forecasts predict a CAGR of 38% in mobile data traffic in Western Europe to 2015. A more recent iteration of this forecast revised the CAGR between 2012 and 2017 at 29%. 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.
[29] See Real Wireless report on techniques to increase capacity in mobile networks: http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf
[30] PA Consulting, Predicting Areas of Spectrum Shortage, April 2009: http://stakeholders.ofcom.org.uk/binaries/research/technology-research/shortage.pdf

Figure 2 - Projected growth in UK mobile data traffic



Source: Real Wireless for Ofcom 2012

3.14 Some respondents to our consultation highlighted the inherent difficulties associated with making accurate long range forecasts for the growth in demand for mobile data capacity but agreed that this demand is set to continue to grow significantly in the future. In particular, the Multiplex Operators expressed doubts on whether these forecasts take into account the potential for mobile device penetration saturation, and inherent limits to the capacity requirements of individual users.

3.15 Our continuing view is that whilst there is a high degree of uncertainty associated with accurately predicting mobile capacity demand over the long term, the Real Wireless medium growth scenario, which is in alignment with a balance of current analysts' forecasts, represents a reasonable assumption for the most likely level of future growth in demand for mobile data capacity[31], and the low and high growth scenarios represent reasonable lower and upper bounds for future growths in demand.

[31] In particular, we note that the Real Wireless projections take into account trends towards penetration saturation of individual devices, but also trends towards multiple device ownership by a single individual. We also note that, as discussed in Annex 1 to the Real Wireless report, under mid-growth assumptions the model outputs suggest that, by 2030, laptops will generate an average traffic of almost 25 GB/month, with tablets at 8 GB/month and smartphones at 1.3 GB/month. We consider these to be reasonable levels for projections over a 20 year time period of consumption growth. In addition, as we discuss further in this section, the model treats a significant proportion of this data as being offloaded via fixed networks, as opposed to handled by mobile networks. See Real Wireless report on techniques to increase capacity in mobile networks: http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf and in particular pages 119 and 127 of the annex available at http://www.ofcom.org.uk/static/uhf/real-wireless-annex1.pdf

Meeting the expected growth in mobile data demand will provide significant benefits to citizens and consumers

3.16 Nearly all consultation respondents supported the position set out in our consultation that ensuring mobile networks can continue to evolve to meet the growing demand for mobile data capacity is likely to deliver significant future benefits to UK consumers and citizens in the future. These reasons for this include:

- **The economic value accrued by consumers through mobile services**: the UK mobile market is large, with revenues of £15.1bn reported in 2011. These services are used by a vast majority of the UK population and the average UK household spends over £32 per month on mobile services.[32] In 2006, Europe Economics produced a report for Ofcom[33] 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[34][35]. The provision of additional or more attractive mobile services through the use of additional spectrum could in principle increase this consumer surplus.

  Consumer value may also be enhanced to the extent that additional mobile capacity is supported by a good quality of service. Consumer research we commissioned for our consultation document[36] 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. 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 significant value. 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.

[32] Figures taken from Ofcom's 2012 Communications Market Report, figures 5. 5.52
[33] 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
[34] 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).
[35] Europe Economics' estimate is an average of results from four different methods.
[36] See BDRC Continental summary report on UHF Strategy research: http://stakeholders.ofcom.org.uk/binaries/research/spectrum-research/UHF-strategy-research/research_report.pdf

- **Benefits deriving from sustained 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[37].

- **Citizens benefits**: enhancing mobile networks capabilities to meet growing data requirements could improve high capacity broadband availability to remote areas and in enabling the delivery of next generation emergency services applications.

- **Meeting business needs and sustain 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.

Different approaches will need to be used in combination to meet the likely future growth in demand for mobile data capacity

3.17 A technical study commissioned by Ofcom from Real Wireless and published alongside our consultation considered the contribution different approaches can make in increasing the future data capacity of mobile networks including: the use of additional high and low frequency spectrum, the offloading of a significant amount of wireless data onto fixed networks using Wi-FI and Femtocells in buildings and high usage areas, the deployment of more macro and small cell sites and the use of improved efficiency mobile technologies. This study highlighted that if mobile operators are to most cost effectively meet all but the low growth mobile data demand scenario described above, they will need to use a combination of all of these techniques.

3.18 We review in more detail below the assumptions underpinning this conclusion, taking into account consultation responses.

Improved mobile technology

3.19 Improved efficiency mobile technologies such as LTE-Advanced and its future evolutions will enable each mobile site to provide more data capacity using the same amount of spectrum. The future data capacity enhancing features of LTE compared with today's 2G and 3G networks are likely to 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;

[37] 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.

- 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.

3.20 Taken together these technology improvements are likely to provide between a three and ten times increase in mobile capacity for macro cells based on the use of three sector antennas by 2030[38]. Stakeholders offered no alternative views on the levels of capacity improvement that might be provided by future improvements in mobile technology efficiency.

Mobile traffic offloading

3.21 Our technical study assumed that under a medium mobile data demand scenario, approximately half the increased demand for mobile data would be offloaded onto fixed networks via WiFi or Femtocells[39].

3.22 Several stakeholders suggested that Wi-Fi offloading could play an even greater role, given that the majority of mobile data is consumed indoors or in nomadic situations, such as cafes and railway stations where Wi-Fi connectivity is available. This, they said could help further reduce the need for more mobile network capacity, potentially offsetting the need for additional mobile spectrum. In practice there are a number of factors which could constrain a greater level of Wi-Fi offloading in the future:

- **Wi-Fi capacity constraints:** The ability of Wi-Fi networks to support the offloading a significant amount of the growth in demand for mobile data is currently uncertain and will be dependent on: future technical improvements in Wi-Fi efficiency, the availability of additional Wi-Fi spectrum, the growth in demand for Wi-Fi capacity by other high capacity services, including for example the wireless distribution of SD and HD IPTV services throughout the home;

- **Backhaul capacity constraints:** Backhaul connections to some Wi-Fi access points, in particular Wi-Fi hot spots where the backhaul connection is provided using a wireless link or lower speed DSL connection, may be insufficient to support a significant increase in Wi-Fi data;

- **Wi-Fi availability:** The universal rollout of Wi-Fi connectivity into all buildings and high use locations is likely to be constrained by physical propagation and economic considerations.

3.23 These potential constraints raise doubts as to whether more than half of a fast growing amount of mobile data traffic can be practically offloaded onto Wi-Fi. Hence, we continue to believe that an assumption that half of the future growth in demand for mobile data will be offloaded onto Wi-Fi remains reasonable for the purposes of our current analysis.

[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] In the Real Wireless report, the proportion of offloaded indoor data is assumed to vary over time and by location. For example, in suburban and urban study areas, the study assumes that 42% of indoor data gets offloaded in 2012, growing to 50% in 2030. The study also includes sensitivity analysis, with alternative assumptions made for 'low' and 'high' offload scenarios. See http://www.ofcom.org.uk/static/uhf/real-wireless-report.pdf for further details.

Deploying additional sites

3.24 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.

3.25 However, there are practical limits on how densely cells can be packed together without causing interference with one another and in securing planning permission for new sites. This issue was highlighted in particular by respondents from the mobile sector.

Using additional mobile spectrum

3.26 Many stakeholder responses highlighted the importance of the need for additional mobile spectrum to be used in conjunction with other mobile broadband capacity enhancing techniques.

3.27 Stakeholder responses also stressed the need for additional mobile spectrum to be internationally harmonised to provide greater economies of scale and lower prices for handset and base station equipment[40]. International harmonisation also makes it easier to manage interference between different national and international services.

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

- **Spectrum re-farming:** here spectrum already assigned for mobile applications is upgraded to efficient mobile data delivery technologies such as LTE.

- **New mobile spectrum assignments:** here new spectrum is made available for mobile broadband services, which was previously allocated for different uses, 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[41].

3.29 Figure 3 illustrates the different spectrum bands that are or could become harmonised for mobile broadband use. These are set out in more detail table 1.

[40] 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

[41] 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.

Figure 3 - Overview of bands potentially suitable for mobile broadband (downlink and uplink)

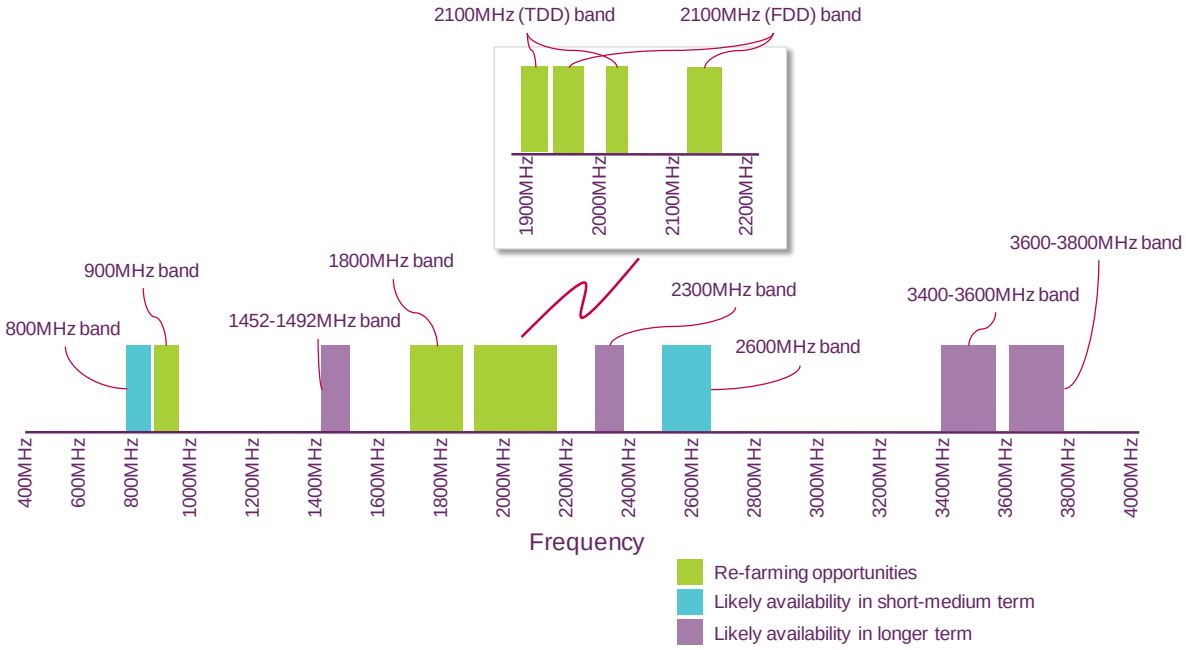


Table 1: Summary of bands potentially suitable for mobile broadband (continues on next page)

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
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 2013/14.	Asia-Pacific. Harmonisation activities also underway for Europe
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)	Awarded in 2008, no service as yet	Ongoing work to identify potential uses, such as supplemental downlink[42] for mobile broadband
3600 – 3800MHz	82MHz (unpaired, UK Broadband) 60MHz (unpaired, satellite earth stations)	UK Broadband allocation currently available	No, but subject to ongoing work within Europe

Additional spectrum will need to be used in combination with other techniques to ensure increasing demands are met

3.30 As discussed in our consultation document a combination of the capacity enhancing techniques described above is likely to be needed most cost effectively meet a medium level prediction for the growth in demand for mobile capacity. This means that, whilst additional mobile spectrum alone is unlikely to be able to meet the future demand for mobile data capacity, it will form an essential part of a range of different techniques that will be to be used together to meet this level of demand.

3.31 Most respondents agreed with this view, which is also consistent with an international recognition that more mobile spectrum will be needed alongside other mobile capacity enhancing techniques to match future demand, for example:

- The UK Government announced plans in 2010 to identify and release 500 MHz of publicly-held spectrum below 5 GHz, in part to help with meeting the growing demand for mobile data[43].
- The European Radio Spectrum Policy Programme (RSPP) includes an 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.

[42] Supplemental downlink is a mobile broadband technology which, by means of base station transmitters in the network, uses unpaired spectrum in the downlink direction to provide a supplemental downlink capacity.
[43] 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)

3.32 In contrast, consultation responses from Programme Making and Special Events (PMSE) stakeholders highlighted that they were unconvinced that mobile services will need additional spectrum in the future. Some of these stakeholders stated that mobile operators should make more efficient use of existing mobile spectrum allocations to meet the growth in demand.

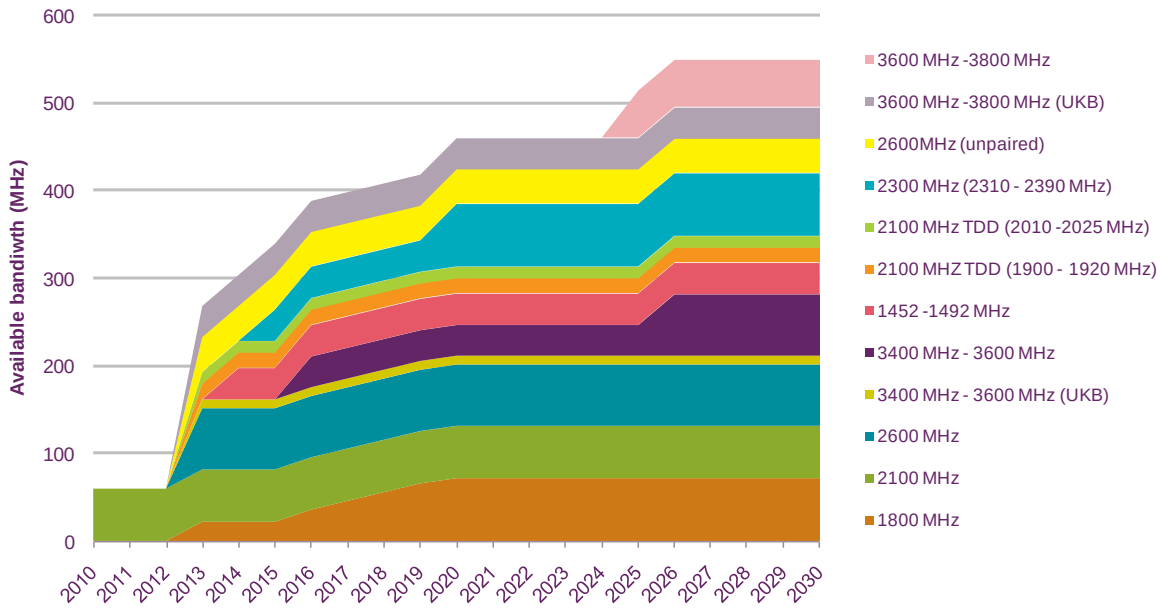
3.33 However, this view is inconsistent with the technical research commissioned by Ofcom which illustrated how the early availability of additional mobile broadband spectrum used in conjunction with more efficient mobile technology and offloading mobile data onto fixed networks can play a special role 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.

3.34 In conclusion, we remain of the view that additional mobile spectrum will form an important part of meeting the anticipated growth in demand for mobile broadband capacity.

Low frequency spectrum can play a special role in meeting the growth in demand for mobile data

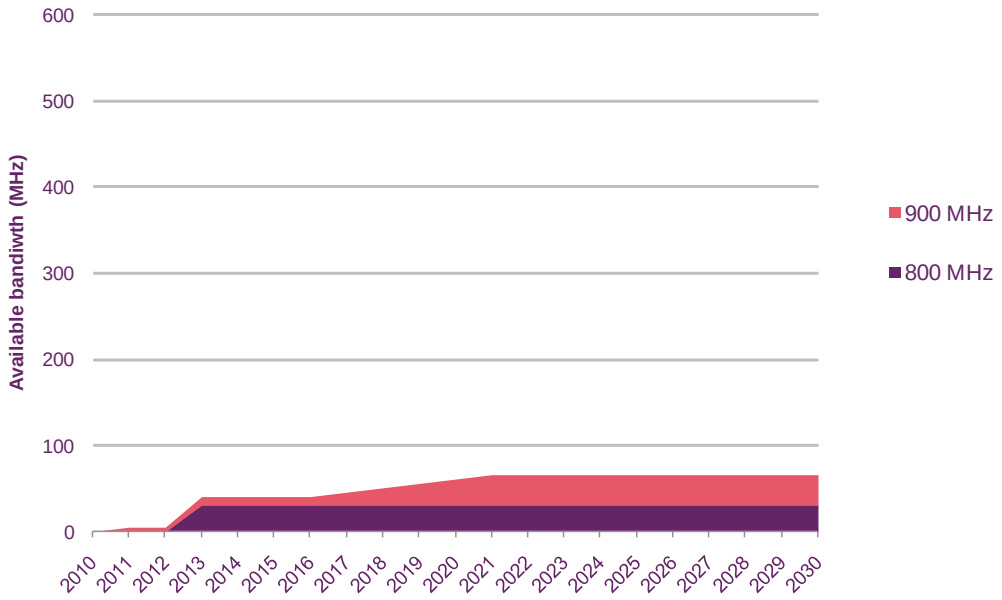
3.35 As illustrated in the figure below, the availability of additional spectrum for mobile broadband is likely to be concentrated at frequencies above 1 GHz, whereas additional harmonised mobile broadband spectrum below 1 GHz is likely to be limited to the currently planned award of the 800 MHz band and the future reframing of 2G spectrum in the 900 MHz mobile band to efficient mobile data delivery technologies.

Figure 4 - 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

Figure 5 - 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

3.36 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.
- Provide better quality of service in difficult to reach indoor and outdoor locations.

3.37 Mobile operators agreed that availability of additional 700 MHz will form a critical part of meeting a future mobile capacity crunch. Whilst some respondents from other industry sectors were unconvinced that more low frequency spectrum would be needed to meet the increased demand for mobile data capacity given the opportunities provided by Wi-Fi offloading and the ability to use additional high frequency spectrum in locations with high data consumption (such as urban areas).

3.38 Technical simulations conducted by Real Wireless for Ofcom[44] have illustrated that based on the assumptions set out above for: the range of future demand for mobile data capacity, the level of Wi-Fi offloading and an idealised situation where a single UK-wide mobile network could access all of the additional frequency spectrum described above[45] using improved efficiency mobile technology as it becomes available; that additional spectrum in the 700 MHz band in 2020 would reduce the number of new mobile sites that would need to be built in a typical rural study area by

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

[45] 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.
For further details please see pages 28-31 of the UHF consultation document http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/summary/spectrum-condoc.pdf

21%, by 57% in a typical suburban area and by 28% in a typical urban area to meet the growth in demand for mobile capacity.

3.39 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 of 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 that additional sub 1 GHz spectrum could play in meeting the future growth in mobile data capacity this was tested for a range of different scenarios using different assumptions for these parameters[46].

3.40 This sensitivity analysis revealed the additional 700 MHz spectrum would significantly reduce the number of additional mobile sites that would need to be built in the future under nearly all plausible scenarios. This study also highlighted the role additional sub 1 GHz spectrum can play is greater the earlier it becomes available as it can be deployed before other capacity enhancing techniques are exhausted at existing sites and new additional sites need to be built.

3.41 In conclusion, we remain of the view that the future availability of additional sub 1 GHz spectrum could play a significant role in meeting the future growth in demand for mobile data capacity and that this role will become greater the earlier it becomes available[47].

The 700 MHz band represents the only likely candidate to increase the supply of harmonised low frequency spectrum

3.42 In our view the 700 MHz band, which is currently used to deliver DTT and other services on an geographic interleaved basis, represents the most attractive option for providing additional lower frequency spectrum. This is because there is now international momentum behind it being globally allocated to mobile broadband:

- In the Americas: the 700 MHz band is already being used for mobile broadband LTE services in the United States; Canada, Mexico and other countries in the region are also progressing plans to make this band available for mobile broadband.

- In Asia: Japan has recently allocated the 700 MHz band for mobile broadband use. Australia and New Zealand and other countries in the region are also taking steps towards enabling use of this band for mobile broadband;

- 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 and Middle Eastern countries to launch LTE services in the 700 MHz band. The WRC 12 resolution has prompted a European debate on the future of the 700 MHz band and the European Commission has recently initiated a process which could lead

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

to establishing harmonised technical conditions for wireless broadband use of the 700 MHz band in the European Union.

3.43 Should the current international momentum continue, our current view is that the conditions enabling a harmonised and coordinated release of the 700MHz band could feasibly be in place within the next decade.

3.44 The harmonised and coordinated use of the 700 MHz band for mobile broadband in Europe and other parts of the world would significantly increase its value to UK consumers beyond the benefits associated with its favourable propagation characteristics discussed above. This increase in value is likely to arise from

- **Economies of scale in the development and production of equipment driving down prices**. As more countries around the world use the 700 MHz band for mobile broadband, manufacturers could achieve greater economies of scale for the development and production of new mobile network and handset equipment, increasing the range of equipment available and reducing prices[48]. 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.

- **Widening choice for UK consumers of devices developed and sold in the global market.** 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.

- **More efficient use of spectrum**. If, following WRC 12 and WRC 15 decisions, all ITU Region 1 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. This would result in a more spectrally efficient new frequency co-ordination plan and spectrum efficiency gains in the UK and across the rest of ITU region 1.

3.45 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.

3.46 Respondents from the mobile sector underlined the importance of a harmonised approach to spectrum release. In particular, one respondent stated that while the

[48] 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.
[49] See http://stakeholders.ofcom.org.uk/binaries/consultations/800mhz/statement/clearing.pdf

envisaged increases in the gross volume of spectrum available mobile broadband are encouraging, the mass market for mobile devices, which will drive most of the future increase in mobile traffic, will most likely only support a limited set of frequency bands. The increasing use of the 700 MHz band for mobile broadband on a global basis, including its early adoption in the US market, is likely to make it one of the 'core' bands supported in future handsets, increasing its value relative to other frequency bands which are available on only a regional or national basis.

Conclusions

3.47 After considering stakeholders responses, we remain of the view that mobile data requirements are likely to grow significantly in future and that meeting this growth in demand could deliver significant benefits to citizens and consumers.

3.48 Mobile operators face a significant challenge in meeting even a medium level scenario for the future growth in consumer demand for mobile data. In order to achieve this, operators will most likely need to use a combination of: more high and low frequency mobile spectrum, more Wi-Fi offloading, better mobile technology and building a significant number of new mobile sites to achieve this.

3.49 Additional sub 1 GHz spectrum could play a particularly important role, because it attractive propagation characteristics mean that it can deliver important savings in the number of additional mobile sites that would need to be built, and in providing better quality of service in difficult to reach indoor and outdoor locations

3.50 The likely harmonisation of the 700 MHz band for mobile broadband use provides the most attractive option from a mobile operator perspective for providing additional sub 1 GHz spectrum. Given the prospects for the harmonisation and adoption of the 700 MHz band on a global scale for mobile broadband, the benefits associated with using this band for mobile broadband in the UK are likely to be significant and greater than the benefits simply associated with its attractive propagation characteristics. This is because international harmonisation delivers important benefits through economies of scale and efficiency in the use of spectrum.

3.51 However, the 700 MHz band is currently used to deliver DTT and other important services on an geographic interleaved spectrum basis. The issues raised by the prospect of a change of use of the 700 MHz band from broadcast to mobile use in the UK are considered in the following sections.

Section 4

Preserving PSB universality and viewers' choice

4.1 In the previous section we set out our view that additional harmonised mobile broadband spectrum will be needed to use in combination with other capacity enhancing techniques to cost effectively meet the anticipated increase in the demand for mobile data capacity. We also set out how additional harmonised sub 1 GHz frequency spectrum has an especially important role to play in meeting this demand by reducing the number of additional mobile sites that would need to be built and in providing improved indoor coverage. Finally, we considered that there is likely to be a much greater scarcity in the supply of spectrum below 1 GHz than at higher frequencies, and that the 700 MHz band represents the only realistic opportunity for providing a significant increase in the supply of this spectrum over the next decade beyond the planned award of the 800 MHz band.

4.2 The DTT platform currently uses the 700 MHz band in combination with other spectrum in UHF frequency bands IV and V to provide six digital multiplexes; three with coverage substantially matching analogue TV coverage at approximately 98.5% and three with approximately 90% coverage. Each of these multiplexes typically provides a combination of TV and radio channels, and data services.

4.3 A change in use of the 700 MHz band from broadcast to mobile broadband applications could impact on the number of services that the DTT platform is able to provide and as a consequence the benefits its provides to citizens and consumers. In this section we consider in the light of consultation responses:

- The importance of the role currently played by the DTT platform, including its provision of low cost near-universal access to PSB content and the widening of viewer choice of TV platforms, services and equipment;
- The importance of the DTT platform being able to continue to fulfil these roles over a timeframe when the 700 MHz band could be feasibly made available for mobile broadband on an internationally harmonised basis;
- The amount of broadcast capacity that is likely to be required by the DTT platform, in order to continue to provide benefits to citizens and consumers, if change of use at 700 MHz were to take place

Today DTT delivers important benefits and these are likely to remain relevant in future

4.4 In our March 2012 consultation document we considered the roles currently played by the DTT platform in the wider TV delivery landscape. We also considered the importance of the DTT platform being able to continue to fulfil these roles over the timeframe when a release of the 700 MHz band for mobile broadband use might feasibly occur, taking into account ongoing changes in viewers' consumption of TV services and the developments in alternative delivery platforms such as IPTV. Based on a consideration of these factors we set out our initial views that:

- The DTT platform currently performs an important role in providing viewers with near-universal low-cost access to PSB content, and in enabling a wider consumer choice of channels, receiver equipment and TV platforms;

- Alternative delivery platforms, including satellite, cable and IPTV are unlikely to provide a viable substitute to the DTT platform in performing these roles over a timeframe when the 700 MHz could be released for mobile broadband on an internationally harmonised basis. In particular we set out a view that IPTV is more likely to continue to act as a complement as opposed to a substitute for DTT over this timeframe;

- The attribute of the DTT platform that viewers currently value most is the availability of a wide choice of free-to-air TV channels;

- Whilst the amount of DTT platform capacity is set to increase through a greater use of more efficient transmission and compression standards including: DVB-T2, MPEG-4 and HEVC these increases might be offset by a increased consumer demand for high capacity HD services as opposed to lower capacity SD services.

4.5 Taking these different factors together, we then set out our preliminary assessment that:

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

- In order to reduce the risk that the DTT platform will be unable to fulfil these important roles, steps should be taken to ensure that the DTT platform is able continue to operate with broadly the same number of multiplexes and coverage as today after a release of the 700 MHz band for mobile broadband.

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

4.7 This remainder of this section reviews this preliminary assessment in the light of stakeholder responses, a summary of which is provided in Annex 1.

The role currently played by DTT is likely to remain important by the time a change of use of the 700 MHz band could take place

4.8 The first broadcast TV services commenced on the DTT platform in 1998 when it was operated as a pay TV platform, called On Digital (and then later ITV Digital). In 2002, following the collapse of this business, a consortium of broadcasters and infrastructure providers launched a new free-to-air TV proposition called Freeview. The wide range of free-to-air services available on this platform coupled with an ability to receive them on low cost receivers and integrated TV sets has proved

popular with consumers, and the DTT platform is now the UK's most widely used television platform, attracting 43% of all TV viewing in 2011[50].

4.9 In addition to providing a popular free-to-air consumer proposition, the DTT platform also currently plays a number of important roles in the UK's TV platform market:

- **It fulfils an important public policy role** – the DTT platform currently represents the default platform for providing UK viewers with low-cost, near-universal access to PSB services. This derives from:
  - A Government decision that post digital switchover, DTT coverage for PSB channels should substantially match that of the existing analogue terrestrial channels.
  - The historical role played by the terrestrial television platform in providing access to free-to-air broadcast TV services, which has led to there being a large installed base of compatible roof top aerials and the availability of low cost receivers. This has had the effect of making the DTT platform a lower cost means of accessing digital TV services for the majority of households than other digital TV platforms.
- **It widens consumer platform choice** – the DTT platform provides access to a wide range of popular digital TV channels and radio stations, widening the choice of digital TV platforms alongside other platforms including satellite, cable and IPTV.
- **It provides significant economic value** – access to DTT services is valued by a significant number of consumers. Europe Economics estimated that in 2006 the consumer value of terrestrial television (analogue and digital) was £8.9 billion, which allowing for inflation is equivalent to approximately £10.6 billion in 2011. This figure excludes the additional value provided by the greater take-up of digital DTT services since 2006.

4.10 The extent to which these roles currently played by the DTT platform will continue to remain relevant in future is dependent on its ability to respond to any significant changes in how viewers consume TV and wider service developments on alternative digital TV platforms. These developments include:

- **A shift from linear to on-demand viewing and internet-enabled features**: a significant viewer shift away from the consumption of linear broadcast television services to on-demand services could undermine the future popularity for the linear broadcast services provided on the DTT platform. In practice, the proportion of time-shifted TV viewing has remained relatively stable over the last few years[51], driven by the popularity of DVRs, whilst non-linear consumption through VoD on IPTV or cable still represents only a small proportion of total viewing. In addition, many of the more recent IPTV enabled consumer propositions, including the DTT related YouView IPTV service, are being developed to complement the linear broadcast TV services offer rather than to compete directly with it.

[50] See Ofcom's Communications Market Report 2012, Figure 2.5, Page 120 http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr12/CMR_UK_2012.pdf
[51] See Ofcom's Communications Market Report 2012, Figure 2.61, Page 171 http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr12/CMR_UK_2012.pdf

- **Potential change in viewers' preferences towards HD**: the DTT platform has relatively limited capacity compared with satellite and cable platforms which could affect its future attractiveness to viewers' if their preferences shift significantly away from SD to high capacity HD services, and these were only offered in sufficient quantity on other competing platforms. However, four free-to-air HD channels are already available on the DTT platform and a future platform transition from first generation DVB-T MPEG-2 transmission and compression technology to more efficient next generation technologies (such as DVBT-2 and MPEG-4 or HEVC) has the potential to enable the delivery of an increased number of free-to-air HD channels in the future.

4.11 The majority of stakeholder responses to our consultation did not challenge our assessment that the DTT platform currently plays an important role in delivering benefits to citizens and consumers and that it is likely to remain a popular with viewers over a timeframe when harmonised release the 700 MHz band for mobile broadband could become feasible. However, Everything Everywhere highlighted trends towards growing consumer demand for non-linear content as a key challenge to DTT's future role.

4.12 As discussed above, our view remains that based on the evidence available today, non-linear viewing is unlikely to replace linear viewing over the next 10 years. Whilst non-linear viewing could grow in future, it is unlikely that DTT's attractiveness could be severely impacted by this, as emerging propositions aimed at satisfying growing requirements for flexible audiovisual consumption tend to be positioned as complements to the basic linear viewing DTT offering.

Alternative platforms are unlikely to fulfil the role played by DTT when a potential change of use of the 700 MHz band occurs

4.13 We also considered in our consultation whether, in the eventuality that there is a change of use of the 700 MHz band that affects the DTT platform's role in delivering benefits citizens and consumers, whether alternative platforms might provide a viable substitute to the DTT platform in delivering these benefits.

4.14 We identified that other television platforms are likely to be limited in their ability to provide a viable substitute for the DTT platform's role over a timeframe when 700 MHz release might occur, in particular with respect to providing near-universal low cost access to PSB channels. The reasons for this included:

- The coverage provided by satellite television platforms may not match that of the DTT services in all locations due to the need for a line-of-sight path to the satellite, meaning that a small but significant number of households may be unable to switch from DTT to satellite;

- The PSB channels are also available on the UK's cable television platform but these services are only accessible by approximately 50% of UK households, and as part of a subscription rather than free-to-view package. We do not anticipate that there will be a significant expansion in cable network coverage over the next decade to match the level of coverage achieved by the PSB services delivered on the DTT platform;

- Whilst the PSB channels are available on a free-to-air basis on satellite television platforms, households needing to switch from DTT to satellite that have no installed satellite receiver equipment would need to bear the costs of installing a

satellite dish and acquiring a satellite receiver, which is likely to be of the order of several hundred pounds;

- There is unlikely to be a universal household take up of broadband connectivity with the speed and performance needed to support IPTV by the time the 700 MHz band could be potentially released. Hence, households without a suitable broadband connection would need to bear the costs of acquiring one in order switch from DTT to IPTV reception.

4.15 Whilst most stakeholders agreed with this assessment, some stakeholders expressed a view that we had underestimated the potential for IPTV to provide a viable alternative to DTT when the 700 MHz band might be released. As a result, they considered that we had given too much weight to the need to maintain the DTT platform's future role in providing near-universal low cost access to PSB content. In contrast the Communications Consumer Panel cautioned against relying on broadband IPTV services to provide reliable universal access to television services. It pointed out that UK broadband adoption rates are not universal, with approximately 25% of homes not connected, and that the speed and reliability of these broadband connections are currently limited across some parts of the country.

4.16 In light of these consultation responses we have reconsidered the role linear IPTV services could play in providing a viable substitute for the DTT platform in the future. For the reasons set out below, we remain of the view that whilst IPTV services could potentially constitute a viable substitute for DTT over the very long term (post 2030), this is unlikely to be feasible over the shorter timeframe when the 700 MHz band could be released for mobile broadband.

4.17 This is because there is a risk that broadband connections with sufficient speed and data capacity caps will not be universally available to all households over this timeframe, meaning that the option to switch from DTT to IPTV reception might not be possible for some households. Government has set out plans to ensure that all UK homes have access to a broadband connection of at least 2 Mbps by 2015, which will be sufficient deliver a single TV stream and a modest amount of internet traffic to computers and other online devices in the home. However, these connections would not be able to support IPTV delivery to multiple TV sets and/or simultaneous high internet usage on other devices. This means that some households with a standard broadband connection would need to upgrade a higher speed connection and bear the associated costs in order to access a level of IPTV service quality comparable to that of DTT. Doing this may not even be an option for some households, as sufficiently fast broadband connections may not be available on a universal basis by the time change of use at 700 MHz could take place.

4.18 A complete transition from DTT to IPTV would also probably cause other additional costs for some viewers:

- It is unclear whether there will be universal household penetration of broadband connectivity, meaning that some households would need to incur cost of acquiring a broadband connection to switch from DTT to IPTV reception. The take-up of broadband connection services is was 76% of households in Q1 2012, with take-up growth declining[52]. This makes it is unlikely that there will be a natural universal take-up of broadband connectivity by the time when 700 MHz release could occur arising purely from consumer demand. Hence, there is a risk that a significant number of households would need to incur the costs of a

[52] Ofcom Communications Market Report, figure 5.55

acquiring a broadband connection in order to continue to access the PSB services currently available on the DTT platform.

- IPTV receivers are not yet built as standard in TV sets and many viewers switching from DTT to IPTV would need to incur the cost of acquiring an IPTV receiver. For households with several TV sets currently relying on access to DTT services, several IPTV receivers would potentially need to be purchased alongside a means of distributing these signals around the home.

4.19 In addition, there are currently no standalone IPTV services providing a range of linear TV services comparable to that available on the DTT platform. More recent IPTV service propositions such as YouView are being developed to provide an on-demand complement as opposed to a replacement for linear broadcast TV platforms.

4.20 Hence, we have concluded in line with the preliminary position that we set our March 2012 consultation that it is unlikely that alternative TV delivery platforms could replicate the DTT platforms role in providing low cost near-universal access to PSB content over the timeframe we are considering for the release of the 700 MHz band. This means that it is important to consider whether a future release of the 700 MHz band would create risks to the delivery of benefits to citizens and consumers provided by the DTT platform.

Securing DTT benefits over the long term could require a similar number of multiplexes as today

4.21 In our March 2012 consultation we set out the factors that are likely to impact on the amount of broadcast capacity and hence spectrum the DTT platform may require in the future so that it can continue to provide the benefits it currently provides to citizens and consumers. These included:

- **The number of broadcast TV channels.** Consumer research published alongside our consultation indentified that the television service characteristic most valued by DTT viewers was access to a sufficiently large number of free-to-air TV channels[53]. This suggested that maintaining a similar number of free-to-air channels as are available today is likely to be important in ensuring its ongoing sustainability and attractiveness to viewers and hence its wider roles in providing low cost near-universal access to PSB channels, and in sustaining consumer choice of TV content, platforms and consumer equipment.

- **Technological developments enabling spectrum to be used more efficiently**. Improved digital transmission and compression efficiency technologies, including DVB-T2 and MPEG-4 and HEVC could enable more TV

[53] For our March 2012 consultation we commissioned consumer research to improve our understanding of the features and characteristics that consumers most wanted from the DTT platform, to better understand the question of what size it would have to be to satisfy consumer demand. This research included conjoint analysis, designed to reveal consumers preferences for different hypothetical TV packages offering different platform services and features. It highlighted that the feature most valued by DTT viewers was access to a significant number of free to air channels, as opposed to other digital TV platform features such as: access to paid-for premium content, catch-up TV, recording functionality and advanced EPG functionality. Further details are available in pages 53-54 of our consultation document (http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/summary/spectrum-condoc.pdf) and in the BDRC continental report published alongside it (http://stakeholders.ofcom.org.uk/market-data-research/other/spectrum-research/UHF-strategy-research/).

channels to be delivered in the future using the same amount of broadcast spectrum. However, these technologies are not compatible with first generation DVB-T and MPEG-2 receivers, limiting the opportunity for the DTT platform to make a complete transition to use these technologies until there is a sufficient penetration of compatible receivers. According to recent industry forecasts, DVB-T2 MPEG-4 receiver take-up will reach circa 80% of primary sets in households relying on DTT for their primary TV feed at the end of 2018[54], when the 700 MHz could potentially start to be released for mobile broadband. This lack of universal take-up of DVB-T2 and MPEG-4 compatible receivers could require the continuing operation of at least one legacy DVB-T MPEG-2 multiplex in order to provide ongoing access to the PSB channels to those households with only first generation receivers. This would have the effect of deferring some the DTT platform spectrum efficiency gains than can be achieved through the use of DVB-T2 and MPEG-4.

Single Frequency Networks (SFNs) as opposed to Multiple Frequency Networks (MFNs) could in principle be used to improve the spectrum efficiency of DTT services. This approach enables the same frequencies to be re-used at adjacent transmitter sites, providing greater spectrum efficiency. However, the application of this approach has limitations in coastal areas where the SFN transmission frequency needs to be co-ordinated with other countries. In addition, unlike an MFN approach, SFNs are not able to support the delivery of regional programmes and advertising.

- **A potential shift from SD to HD as the preferred broadcast television format**. There is the potential for HD as opposed to SD to become the preferred television format for viewers, If this preference became a key competitive driver for TV platforms, it would imply an increase in the amount of broadcast capacity needed to deliver each TV channel even if the next generation of more efficient DVB-T2 and MPEG-4 transmission and compression technologies are used. Looking further ahead, new more 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. Hence, spectral efficiency gains achieved by the use of more efficient technologies might be offset in the future by changing viewers' preferences for high capacity broadcast TV formats.

4.22 Taking these factors together we set out our preliminary view that in order to ensure that a similar number of programmes can be provided at the time when 700 MHz release could occur, the DTT platform is likely to require a number of multiplexes and levels of coverage similar to today.

4.23 Respondents expressed a range of different views on the number of DTT multiplexes and coverage that will be required after a future release of the 700 MHz band. The Multiplex operators, other respondents from the TV sector, BT, PMSE respondents and consumer groups supported our preliminary view that there should be a sufficient amount of spectrum available to the DTT platform for it to be able to continue to provide the same number of multiplexes and coverage as today. Several respondents from the television industry also stated that additional spectrum should be made available to the DTT platform in the shorter term to enable the delivery of additional services operating with DVB-T2 and MPEG-4 in order to facilitate a faster platform transition to these more efficient standards. They also argued that a longer term transition to more efficient platform standards should not be used as a basis for

[54] 3 Reasons Ltd – autumn 2012 multichannel TV model

reducing the amount of spectrum available for use by the DTT platform in the longer term, as the efficiency gains achieved by their use would be cancelled out in the future by a need to provide more increased capacity HD services.

4.24 Other respondents, including stakeholders from the mobile sector, Samsung and BSkyB, said that the use of more efficient compression and transmission technology would mean that the platform DTT could use a reduced amount of spectrum to provide the same number of TV channels in the future.

4.25 Given the uncertainties over the future demand for high capacity HD services and other high capacity TV format and the speed of full platform transition to more efficient technologies, and the likely continuing importance of the role played by the DTT platform; we continue to favour a precautionary approach of ensuring that, should a change of use at 700 MHz take place, the DTT platform has available to it a sufficient amount of spectrum to deliver near-universal access to PSB channels and sustains viewers' choice through a similar number of multiplexes with similar coverage levels as today.

Conclusions

4.26 We maintain our view that the DTT currently performs a very important role in providing near-universal low-cost access to PSB content, whilst also enabling a wider consumer choice of channels, receiver equipment and TV platforms.

4.27 After consideration of stakeholders' responses, we also remain of the view that alternative delivery platforms are unlikely to provide a viable substitute to the DTT platform in performing these roles over the next decade, when the release of the 700 MHz band might feasibly occur. In particular we consider that IPTV platforms are more likely to act as a complement, as opposed to a substitute to broadcast TV platforms over these timescales. However, we continue to believe that over much longer timescales, IPTV developments supported by the universal availability and take-up of superfast broadband may enable IPTV platforms to provide a viable substitute to the DTT platform leading to an eventual DTT switch-off scenario post 2030. This potential scenario falls outside the timeframe and hence scope of the current UHF strategy we are seeking to establish.

4.28 Hence, we believe that securing the ongoing delivery of the benefits currently provided by the DTT platform to citizens and consumers will be an important objective if any change of use of the 700MHz band from broadcast to mobile broadband use, enabled by international harmonisation and co-ordination developments, takes place.

4.29 Consumer research commissioned by Ofcom has highlighted the importance of there being a sufficiently large number of free-to-air channels available on the DTT platform to maintain its attractiveness to viewers. Whilst trends towards greater use of efficient transmission and compression standards (e.g. DVB-T2 and MPEG-4, or HEVC) could in the future enable the platform to deliver the same service as today by using less spectrum the wider adoption of HD services may offset this.

4.30 Taking these factors into account we consider that, on balance, in order to reduce the risk that a future change of use at 700MHz could prevent the delivery of the important benefits delivered by the DTT platform, we should seek to ensure that the DTT platform has available to it an amount of spectrum that enables it to continue to deliver near-universal PSB coverage and an overall number and coverage of DTT multiplexes similar to today.

Section 5

Delivering other services through UHF bands 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 today, or plan to share in future, the spectrum used by DTT on a geographically interleaved[55] spectrum basis. These include programme making and special events (PMSE) services, local TV and the NI Mux and applications based on emerging white space device (WSD) technology.

5.3 For the spectrum used by DTT today service co-existence rules have been established whereby PMSE must not cause interference to DTT services, and work is progressing to define appropriate parameters to ensure WSDs do not cause undue interference to both DTT and PMSE services.

5.4 Other services rely on a more dedicated use of the UHF spectrum, including PMSE services in channel 38. Potential future Public Protection and Disaster Relief (PPDR) services could potentially operate either on a dedicated spectrum or on a prioritised shared spectrum basis with future mobile broadband services.

5.5 In our consultation we discussed the main factors that could affect future spectrum requirements of these services. We also highlighted that a future change of use of the 700 MHz band could have important implications for the delivery of these services and that our strategic approach for UHF bands IV and V should take these into account. In particular, we should seek to preserve opportunities for the delivery of other services in the UHF spectrum, whilst also seeking to meet the future spectrum needs of the DTT platform and mobile broadband services.

5.6 In this section we revisit these points in light of consultation responses.

Future spectrum requirements for other services

Programme Making and Special Events (PMSE)

5.7 Some PMSE applications make use of the geographic interleaved spectrum to support a number of different applications including: wireless microphones, in-ear-monitors (IEMs), talkback and audio links. These services support a wide range of activities ranging from programme making, theatres productions, live concerts and events, sports event coverage and smaller scale local applications in churches and schools. Licensing of the spectrum for PMSE is carried out on our behalf by JFMG. In Band IV/V. JFMG coordinates spectrum use in order to avoid interference to DTT and between PMSE users.

[55] 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.

5.8 Currently there are PMSE assignments across the whole of UHF band IV and V. However, the pattern and availability of the geographic interleaved spectrum is changing because of digital switchover (DSO) and the clearance of the 800 MHz band. As part of these changes PMSE use of the 800 MHz band (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 as a dedicated channel for PMSE use, providing a replacement for channel 69 after 800 MHz clearance.

5.9 In future, there is likely to be continuing demand for access to geographic interleaved spectrum by PMSE services. This view was supported by PMSE respondents. Shure predicted that use of PMSE equipment will increase in future.

5.10 The British Entertainments Industry Radio Group (BEIRG), Shure and Brian Copsey also highlighted the benefits associated with meeting PMSE spectrum requirements. These respondents put forward estimates of the contribution to the UK economy made by the creative industries, to which PMSE services contribute. We acknowledge that PMSE use of spectrum contributes to delivering important benefits, but it is difficult to assess the proportion of the overall value delivered by the creative industries which can be exclusively attributable to PMSE. We must therefore treat with caution the estimates of economic value put forward by PMSE respondents.

5.11 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.

5.12 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 geographic interleaved spectrum[56]. 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.

Local TV

5.13 Local TV stations are being licensed by Ofcom and are expected to launch in 2013, making use of the spectrum used by existing DTT services on a geographic interleaved basis. A local TV multiplex operator will be assigned a single 8 MHz channel in each of a number of locations across the UK. This channel may occupy a different frequency in different locations within the band of frequencies used by DTT. Each of these channels will support a digital TV multiplex which are likely to be broadcast using a variant of the transmission technology used by the existing national DTT multiplexes. As only one local TV operator will be licensed for a given

[56] 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. In his response, Brian Copsey challenged these findings, but did not provide evidence in support of his views.

area, the amount of geographic interleaved spectrum assigned for local TV at any location will be 8 MHz[57].

5.14 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 TV services without needing to change their antenna.

The NI Mux

5.15 A new multiplex carrying the Republic of Ireland television services TG4 and RTÉ One and RTÉ Two has recently launched in Northern Ireland. The NI mux makes use of the spectrum used by existing DTT services on a geographic interleaved basis, broadcasting from three separate transmitter sites in Northern Ireland.

White Space Devices

5.16 White space devices (WSDs), is a term used to describe an emerging category of devices that will operate in the geographic interleaved DTT 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 parts of UHF bands IV and V currently used for DTT. We are working towards putting in place necessary regulations to allow WSDs to operate on a non-protected, licence exempt basis. These WSDs must also not cause undue interference to other, licensed spectrum users, including DTT and PMSE services.

5.17 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. 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.

5.18 The technologies enabling use of TV white spaces are under development. No white space devices are currently available on the market, but their future potential has been widely recognised for such applications as public wi-fi hotspots; rural broadband; home propagation of digital signals; smart metering; machine-to-machine communications; and health applications.

5.19 Our current work on WSDs is focused on enabling licence exempt access to UHF white spaces to promote and encourage innovation and experimentation[58]. However, our fundamental approach is sufficiently flexible to support other spectrum bands and alternative licensing approaches, should this subsequently become appropriate. 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.

[57] In Cardiff and Manchester two additional 8MHz channels of spectrum which could be used to transmit local broadcast multiplexes were licensed by Ofcom in 2008, although at present services are only being broadcast in Manchester.

[58] We note as well that a key element of WSDs is that they are being developed to tune to the whole of UHF bands IV and V, as opposed to their operation being specific to a smaller set of frequencies.

5.20 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.

5.21 Respondents from the WSD sector highlighted the opportunities associated with applications that could in future be delivered through white-space technologies and encouraged Ofcom to proceed as quickly as possible with putting in place the necessary regulations to enable the operation of WSDs in UHF bands IV and V.

Emergency services applications at UHF frequencies

5.22 In the UK, the PPDR (Public Protection and Disaster Relief) service used by the police, fire and ambulance services is currently provided by Airwave Services Ltd and is 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.

5.23 The current TETRA network across mainland UK (E,W,S) is operated by Airwave Solutions Ltd. The service operates in two bands between 380 – 395MHz and 410 - 422MHz and, therefore, is not currently a user of UHF band IV and V spectrum. Approximately 2x5 MHz is licensed under the public safety harmonised initiative that designated the band in 380-395 for emergency services and public safety within Europe (CEPT members) to provide the core service. In the UK, an additional bandwidth of 2x2MHz in the 410-422MHz band is made available in certain locations to provide extra capacity. Operating at these frequencies affords the TETRA 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 emergency services. These enable direct handset to handset communications (or Direct Mode Operations, DMO) that do not involve the network and operator to cater for specialist working and temporary communications in the event of reduced coverage. 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.

5.24 In 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. 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.

5.25 In the US, plans for next generation PPDR networks are more mature than in the UK. Spectrum has been identified in the 700 MHz band[59] 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, potentially leading to economies of scale on equipment and a market to develop even more applications for devices.

[59] A 2x5 MHz pair at 763-768 MHz and 793-798 MHz for broadband use plus a 2x6 MHz pair at 769-775 MHz and 799-805 MHz for narrowband use.

5.26 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.

5.27 There are a number of ways in which, in principle, PPDR services can be deployed. For example, the current approach used by emergency services across Europe involves using a common technology (for cross border operations and interoperability) and 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.

5.28 Respondents from the PPDR sector highlighted that a future release of the 700 MHz band for mobile broadband provides opportunities for the delivery of high speed data applications for emergency services based on harmonised technology solutions. Motorola Solutions and the TETRA and Critical Communications Association (TCCA) indicated that the particular requirements of the PPDR community, in particular with reference to resilience, may be best met through dedicated networks using reserved spectrum. The same stakeholders highlighted activity at European level conducted as part of the CEPT FM49 working group, to which Ofcom is participating representing UK interests.

5.29 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. In particular, we note that ongoing activities are being conducted as part of the Emergency Services Mobile Communications Programme coordinated by Government departments.

Other innovative applications

5.30 In our consultation we asked stakeholders whether other innovative uses of UHF bands IV and V should be considered in our work. Consultation responses by the Telecommunications Association of the UK Water Industry (TWAUI) and the TCCA highlighted that a release of spectrum at 700MHz use could raise opportunities for delivering telemetry applications for the energy sector based on mobile broadband transmissions standards. The TCCA also raised the possibility of pooling spectrum resources for emergency services and energy metering.

The potential consequences of a future change of use of the 700 MHz band on the delivery of these services

5.31 The prospect of an internationally harmonised release of the 700 MHz band for mobile broadband use has potentially important implications for the future delivery of the other services discussed above in the UHF spectrum:

- It could create opportunities for the provision of next generation multimedia based PPDR services using internationally harmonised mobile broadband solutions in the 700 MHz band;

- It could change the amount and location of the geographic interleaved spectrum for the future delivery of services currently sharing spectrum or planning to share spectrum with DTT on a geographic interleaved basis, including PMSE, Local TV, the NI Mux and white-space device applications.

5.32 PMSE respondents were opposed to a future release of the 700 MHz band, because they believe this would hinder the PMSE community's ability to continue to provide benefits to the creative and entertainment industries, because of the impact of:

- a reduction of the total amount of spectrum available to them to a level potentially below PMSE future requirements;
- additional costs due to the need of substituting some equipment when UHF geographic interleaved spectrum allocations to PMSE change. This is because typical PMSE equipment can only operate in specific subsets of the available interleaved frequencies;

5.33 We did not receive responses to our consultation by stakeholders from the Local TV community, or from the operators of the NI Mux. However, the Multiplex Operators noted that in absence of alterative spectrum provided to DTT, the release of the 700 MHz band may create barriers to finding suitable frequencies for the future delivery of Local TV services.

5.34 WSD respondents were of the view that, if the 700 MHz band is not used by DTT in the future, Ofcom should ensure that availability of white-spaces does not become excessively constrained. Sky and Neul said that Ofcom should give more relevance to the potential benefits that might be delivered through licence-exempt access to white-spaces when considering the appropriate balance of use amongst competing use of UHF spectrum over the long term.

5.35 We note that change of use of the 700 MHz band to mobile broadband use would reduce the amount of geographic interleaved spectrum available for the services relying on it. However, this reduction could be mitigated through achieving the objective (set out at the end of section 4) of seeking to ensure that DTT has an amount of spectrum available to it that enables it to continue to deliver the benefits it currently provides.

5.36 In the following section we consider these issues further as part our decisions on the long term strategic approach to UHF bands IV and V for securing longer term benefits for citizens and consumers.

Section 6

A long term strategy for the future of UHF bands IV and V

6.1 The objective of our consultation was to establish a long term strategic framework for UHF spectrum bands IV and V to enable a better match between the future supply of spectrum to services likely to deliver significant benefits to citizens and consumers. In our consultation we proposed that this framework should be based on pursuing the dual objectives of:

- *Objective 1:* Ensuring the availability of additional low frequency UHF spectrum for mobile broadband, by enabling the release of the 700 MHz band, once it is internationally harmonised;
- *Objective 2:* Ensuring the DTT platform has access to a sufficient amount of spectrum to enable it to continue to deliver of the benefits it currently provides to citizens and consumers when the 700 MHz band is released. This is also likely to support services sharing spectrum with DTT on a geographic interleaved basis.

6.2 Meeting the first of these objectives would help meet the anticipated significant increase in demand for mobile data capacity alongside the use of: additional higher frequency mobile spectrum, offloading of mobile traffic onto fixed networks using Wi-Fi, using more efficient mobile technology and building more sites. Additional low frequency spectrum at 700 MHz can play a valuable role in meeting the future demand for mobile data capacity by:

- Significantly reducing the number of new mobile sites that would need to be built, reducing costs and the need for planning permission for large numbers of new sites;
- Providing better quality of service in difficult to reach indoor and outdoor locations.

6.3 The use of the 700 MHz band in the US and Asia for mobile broadband and its likely global harmonisation for mobile broadband services at the next World Radio Conference in 2015 means it is likely to be supported in the future global mass market of mobile handsets. This increases the value of the 700 MHz band for mobile operators, because it reduces costs and extends choice of consumer devices and base station equipment.

6.4 Meeting this first objective, would also open possibilities for future emergency services applications, based on mobile broadband technology, to be provided in the 700 MHz band.

6.5 Meeting the second of these objectives would enable the DTT platform to continue to perform its important public policy role in providing near-universal low cost access to PSB content and in supporting a wider consumer choice of services, platforms and equipment. Attaining this second objective will also help mitigate the reduction in geographic interleaved DTT spectrum available for use by PMSE, Local TV and the

NI Mux and emerging applications based on TVWS technology associated with change of use at 700 MHz.

6.6 The main challenge associated with achieving these dual objectives is that the 700 MHz band is currently used to deliver DTT and other important services in its geographic interleaved spectrum, and that the 700 MHz band represents a significant proportion of the spectrum used by these services today. This means that a future change of use of this band for mobile broadband would create a risk that there would be an insufficient amount of spectrum available for DTT services and the services operating in its geographic interleaved spectrum to enable all of these services to continue to deliver the important benefits they currently provide to citizens and consumers. This represents a potentially significant risk for citizens and consumers, also because other delivery platforms are unlikely to provide a viable substitute to the DTT platform, when a harmonised release of the 700 MHz band for mobile broadband might become feasible.

6.7 To reduce this risk, we proposed in our consultation that the 600 MHz band should be used as part of a frequency re-plan of the DTT platform should the 700 MHz band be used for mobile broadband. We also set out our view that this approach would help reduce the impact of a future clearance of the 700 MHz band for mobile broadband on the services using (or expected to use) geographic interleaved spectrum including: Local TV, the NI Mux, PMSE and applications based on TVWS technology.

6.8 In this section we reconsider, in light of consultation responses, the merits of establishing a strategic approach based on enabling the harmonised release of the 700 MHz band for mobile broadband and the ongoing delivery of benefits provided by DTT, by ensuring that the 600 MHz band can be used as part of a future frequency re-plan of the DTT platform after 700 MHz release.

Our approach to the future likely harmonisation of the 700 MHz band for mobile broadband

6.9 As we concluded in section 3, ensuring that the growing consumer demand for mobile data capacity can be met over the long term is likely to deliver significant benefits to UK citizens and consumers.

6.10 The availability of additional internationally harmonised spectrum for mobile broadband has an important role to play in meeting this increased demand for mobile capacity and securing these benefits, alongside the use of other capacity enhancing techniques. This has been recognised internationally: in the US the FCC is taking action to achieve its objective of making 500 Mhz of spectrum available for mobile services by 2020, whilst in Europe the adoption of the 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 UK, Ofcom is currently working with Government to help implement plans for the release of 500 MHz of public spectrum to increase the supply of spectrum above 1 GHz by 2020.

6.11 In section 3 we concluded that additional low frequency spectrum in the 700 MHz band could play a special role in meeting the increased demand for mobile broadband capacity, alongside additional higher frequency spectrum, offloading mobile data using Wi-Fi onto fixed networks, using more efficient technology and building more mobile sites. The timely availability of the 700 MHz band for mobile

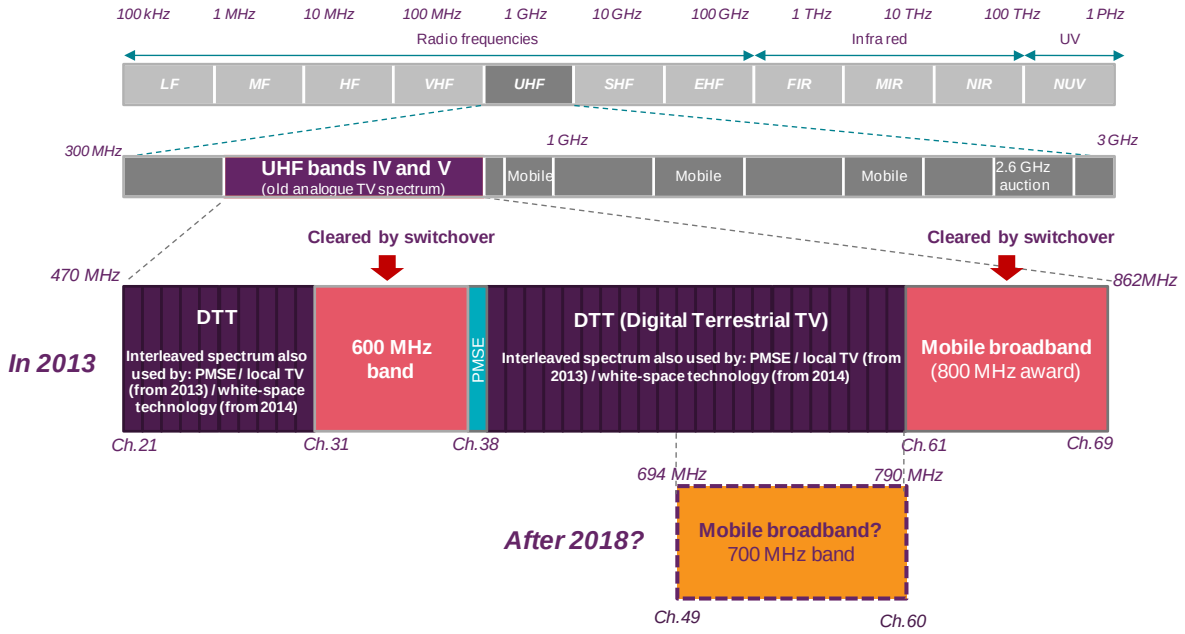
broadband could significantly reduce the number of mobile sites that would need to be built and would also provide improved coverage in difficult to reach indoor and outdoor locations.

6.12 As discussed previously, there is now significant international momentum behind the harmonisation of the 700 MHz band for mobile broadband use on a global scale. This band can already be used for mobile applications in the Americas and Asia-Pacific. In the United States spectrum in this range is being used by LTE services, and other countries in these two regions are also now moving towards enabling mobile broadband deployments in this band. In February of this year, the World Radio Conference passed a resolution that signalled that mobile broadband use of this band will also become possible in Europe, Middle East and Africa from 2015. This has prompted a European debate on the future of the 700 MHz band, with the Radio Spectrum Policy Group initiating activities in June of this year, and more recently the European Commission issuing a working draft mandate for the technical conditions of future use of the 700 MHz band for mobile broadband in Europe.

6.13 In view of these developments it is becoming increasingly likely that by the end of this decade many countries including those in Europe will be using or be planning to use the 700 MHz band for mobile broadband. Under such circumstances, a decision for a harmonised and coordinated release of the 700 MHz band in the UK for mobile broadband could provide important benefits that go beyond the pure technical role that additional low frequency spectrum can play in meeting future demand. These additional benefits include gaining access to global economies of scale for mobile devices and equipment in this band, and the ability to more easily co-ordinate the use of this spectrum with neighbouring countries to avoid interference, leading to a more efficient use of the 700 MHz band.

6.14 However, as shown in the figure below, the future use of the 700 MHz band for mobile broadband would significantly reduce the amount of spectrum available for use by the DTT platform and the other services delivered in geographic interleaved spectrum. There is therefore a risk that the significant additional benefits that could be achieved by a release of the 700 MHz band for mobile broadband use could not be achieved without losing the important benefits provided by these services.

Figure 6 - UHF bands IV and V



6.15 In our consultation, we considered three high level options on the approach Ofcom could take towards the likely future harmonisation of the 700 MHz band:

- *Option 1:* Maintain the current use of the 700 MHz band and do not enable its release for mobile broadband;
- *Option 2:* Enable the release the 700 MHz band once it is harmonised and coordinated for mobile broadband in Europe but do not make any alternative spectrum available for DTT and its geographic interleaved services to ensure that the benefits they provide can be safeguarded;
- *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 access to a sufficient amount of spectrum. This would enable the DTT platform continue to perform both its public policy role in providing low cost near-universal access to PSB content and its role in sustaining consumer choice in platforms, content and equipment. It would also help to enable continued provision of existing and planned geographic interleaved services.

6.16 In the consultation we set out our preliminary view that Option 3 was the approach most likely to secure greater benefits for citizens and consumers from the use of UHF bands IV and V in future.

6.17 Only PMSE stakeholders and the Confederation of Aerial Industries stated a clear preference for option 1 alone. These stakeholders focused on the negative impacts a change of use of the 700 MHz could have on the existing users of this band. Respondents from the PMSE community took the view that any reduction in the spectrum available for PMSE use would impact on their ability to deliver benefits in the live entertainment and content production industries. The Confederation of Aerial Industries were opposed the release of the 700 MHz band on the grounds that it could impact on current DTT coverage levels.

6.18 No respondents favoured option 2.

6.19 The majority of respondents agreed with our preliminary view that option 3 is more likely to provide longer term benefits for citizens and consumers, albeit with conditions.

6.20 The Multiplex Operators, [✂] and BT did not believe that the case for the need to use additional low frequency spectrum at 700 MHz to meet the future growth in demand for mobile data had been proven. However, they acknowledged the increasing international momentum behind the future harmonisation of the 700 MHz band for mobile broadband creates a risk that this band will eventually be released for mobile broadband. In light of this, they supported our view that steps should be taken to preserve the benefits provided by the DTT platform if the 700 MHz band is released. The Multiplex Operators characterised Option 3 as a 'second best' solution, preferring Option 1 but recognising that this may not be achievable due to international trends.

6.21 Respondents from the mobile sector highlighted that a change of use of the 700 MHz to mobile broadband would deliver significant benefits to citizens and consumers. They were also generally of the view that the benefits provided by the DTT platform, and in particular its role in relation to providing near-universal access to PSB services, will remain relevant by the time change of use at 700 MHz could take place. However, Telefónica said that the dynamics of the audio-visual sector could imply that an allocation of alternative spectrum to DTT would only be justified up to 2020 and that Ofcom should undertake a wider review of DTT spectrum allocations after then at some point in the future.

6.22 Everything Everywhere encouraged Ofcom to put in place mechanisms to incentivise a more efficient use of spectrum by DTT. This view was also shared by Sky, who suggested that Ofcom should examine further the value of making more sub 1 GHz spectrum licence-exempt as an alternative to it being used for DTT. The Cambridge White Space Consortium also thought that additional sub 1 GHz spectrum should be licence exempt but they did not suggest that this should be achieved by a reduction in the amount of spectrum used by DTT.

6.23 After a consideration of stakeholder responses, we remain of the view that Option 3 is more likely than Options 1 and 2 to deliver greater benefits for citizen and consumers over the long term. This is because it would enable both the delivery of significant benefits arising from the internationally harmonised and coordinated use of the 700MHz band for mobile broadband discussed in section 3, and the ongoing preservation of benefits delivered by DTT that are likely to remain relevant when the 700 MHz band is used for mobile broadband, as discussed in section 4. It would also help mitigate the reduction in geographic interleaved spectrum for PMSE and local TV users that would occur from an implementation of Option 2. We also note that Option 3 would be consistent with maintaining an opportunity to deliver applications based on white-space technology through the use of interleaved spectrum on a licence-exempt basis. Finally, unlike Option 1 it would create a future opportunity for next generation multimedia based emergency services applications to be provided in the 700 MHz band.

6.24 We believe that Option 1 is unlikely to deliver the greatest benefits to citizens and consumers, as it would prevent benefits being secured from the use of the 700 MHz band for mobile broadband. As discussed in section 3, this would mean that growing mobile data demand could not be cost effectively met under a range of different plausible scenarios for the future growth in mobile data demand. This raises the risk

that either the future growth in demand for mobile data will not be fully met or that it will be met at higher cost increasing prices for consumers. It would also mean that improved indoor coverage that could be provided by additional low frequency spectrum could not be realised. Option 1 would also mean that UK consumers are unable to exploit the handset economies of scale achievable from the globally harmonised use of the 700 MHz band for mobile broadband. It could also make the efficient frequency coordination of this spectrum across Europe more difficult to achieve if other countries decided instead to proceed with change of use of the 700 MHz band for mobile broadband.

6.25 We also believe that Option 2 is unlikely to deliver the greatest benefits. Whilst it would enable benefits to be secured from the mobile broadband use of the 700 MHz band, it would create a risk to the continuing delivery of DTT benefits as set out in more detail below. This option would also cause a significant reduction in the amount of geographic interleaved spectrum available for other uses, including PMSE, Local TV and the NI Mux, and applications based on white-space technology.

Without access to the 600 MHz band the DTT platform is unlikely to provide the benefits it delivers today after 700 MHz release

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

- *A public policy perspective:* the amount of multiplex capacity and associated spectrum required to deliver the PSB channels with near-universal coverage;
- *A platform sustainability perspective:* the amount of multiplex capacity and associated spectrum required to deliver a sufficient range of additional channels, 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 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.

6.27 In our consultation we set out that 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.

6.28 As discussed in section 4, a material reduction in TV capacity creates a risk that overall attractiveness of the DTT platform would reduce making it a less viable platform for providing near-universal low cost access to PSB content and in extending consumer choice of services, platforms and equipment.

6.29 Using suitable alternative spectrum for the DTT platform following a release of the 700 MHz band for mobile broadband could significantly reduce the risks outlined above. This alternative 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 cleared through the digital switchover process.

6.30 The preliminary planning work published alongside our consultation document[60] 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 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. In addition, some multiplexes may need to operate with a more robust DVB-T2 transmission mode if they were to maintain existing coverage levels.

6.31 The majority of respondents supported our view that the 600 MHz band would need to be used as part of a frequency re-plan of the DTT platform if the 700 MHz band were used for mobile broadband. The Multiplex operators and other respondents from the TV sector considered the reservation of the 600 MHz band for DTT to be an essential pre-condition for any future use of the 700 MHz band for mobile broadband. Respondents from the PMSE and WSD sectors were also generally supportive of the view that 600 MHz spectrum will be required for DTT use in the longer term.

6.32 MNOs agreed that spectrum at 600 MHz would probably be required in case of change of use at 700 MHz. However, Telefónica took the view that that longer term technology and market developments could mean that DTT may not require spectrum at 600 MHz if a change of use of the 700 MHz band were to take place after 2020.

6.33 Sky expressed the view that using more advanced transmission and compression technologies would allow a reduction of DTT spectrum requirements, and it did not agree that the evidence pointed to the need toallocate the entire 600 MHz band to DTT in the long terms. Sky also considered that the balance between current and potential competing uses of spectrum at 600 MHz should be considered further.

6.34 In section 4 we highlighted the benefits that more efficient DTT transmission technologies can play in increasing the capacity of the DTT platform using the same amount of spectrum. We also set out the risk that these spectrum efficiency gains could be cancelled out by an increased future viewer demand for high capacity HD, 3D and UHDTV services, were these to become key competitive drivers for TV platforms.

6.35 [✂].

6.36 Whilst we consider that a progressive transition of the DTT platform to more efficient technologies would be highly desirable from the perspective of increasing the overall capacity of the DTT platform and being able to sustain a delivery of more high capacity HD and 3D services we do not believe that a full platform transition to these technologies will be essential before a release of the 700 MHz band could occur. Indeed we note that there are various factors which will determine the importance of more efficient technologies in facilitating the release of the 700 MHz band in the future, including:

- The timing of the release of the 700 MHz band and hence consumer take-up of receivers that are compatible with more efficient transmission standards;

[60] See http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/arqiva.pdf

- The outcomes of a future international re-negotiation of the high power frequency assignments needed for a re-plan of the DTT platform after a release of the 700 MHz band, which may determine that several multiplexes would need to operate using a more robust transmission mode if they were to replicate current multiplex coverage levels;

- The future demand for high capacity services and hence the additional capacity provided by more efficient transmission standards;

- The uncertain role emerging technology improvements including HEVC (High Efficiency Video Coding) might play in the future.

6.37 According to current industry predictions it is unlikely that there will have been a universal take-up of DVB-T2 MPEG-4 compatible receivers by the time that an early change of use at 700 MHz could take place. Recent industry forecasts indicate that by the end of 2018 the uptake of DVB-T2 MPEG-4 receivers is likely to reach approximately 80% of primary sets relying on DTT and 69% of secondary sets[61] in households relying on DTT as, respectively, their primary or secondary feed. As discussed in section 4, this raises the prospect that one or more DTT multiplexes may need to continue to operate using legacy DVB-T technology to ensure ongoing access to PSB channels for households with DVB-T only receivers.

6.38 Further in this document we set out steps we propose to take in future to help facilitate a faster consumer uptake of TV receivers compatible with more efficient technologies to help improve the spectrum efficiency of the DTT platform.

6.39 On balance, we consider it appropriate that the DTT platform should retain access to an amount of spectrum that enables the ongoing delivery of the important benefits it provides to citizens and consumers should a change of use at 700 MHz takes place. We also consider that the spectrum efficiency benefits provided by more efficient DTT transmission technology could be offset by an increased viewer demand for high capacity HD services, and that to minimise the risk that the DTT platform would have an insufficient amount of capacity steps should be taken to ensure it would be able to continue to operate with the same number of multiplexes as today for the foreseeable future.

6.40 If the 600 MHz band were unable to be used as part of a future DTT re-plan after 700 MHz release, there would be a material reduction in DTT platform capacity putting at risk its ability to continue to provide a viable means of providing near-universal low cost access to PSB content and in creating a wider consumer choice of services, platforms and equipment. We do not consider this would be an acceptable risk given the associated potential significant loss of benefits for citizens and consumers, and as a consequence we have concluded that we should ensure that the 600 MHz band can be used as part of a future re-plan of the DTT platform assuming release for mobile broadband of the 700 MHz band for mobile broadband takes place

6.41 This approach makes it feasible for the DTT platform to have access to an amount of spectrum to enable it to continue to provide important benefits through the ongoing delivery of the PSB channels substantially matching analogue coverage and the support of a range of other services sustaining choice to DTT viewers.

6.42 Additional benefits of this approach would be that it will be easier to implement a DTT re-plan that remains as far as possible compatible with existing roof-top antennas. It

[61] 3 Reasons Ltd – autumn 2012 multichannel TV model

will also help ensure that PMSE and other services sharing spectrum with DTT can continue to be delivered.

6.43 A consequence of this approach would be that we could not proceed with our previous plans to award long term rights for the 600 MHz band, as this would limit the ability to re-plan this spectrum for DTT in the future. There could be a potential cost associated to this as it would preclude possibilities for using 600 MHz spectrum to deliver alternative applications over the long term.

6.44 However, no stakeholder has expressed a preference in an option to award long term rights to use the 600 MHz band in light of international developments around the 700 MHz band. In addition, across much of the world the 600 MHz band is harmonised for broadcast use, making DTT the most likely attractive use of this spectrum.

6.45 In light of these factors, we believe it is appropriate to take a precautionary approach to securing the long term delivery of DTT and other services currently using the 700 MHz band. We have therefore concluded that we should retain the ability to use the 600 MHz band as part of a future frequency re-plan of the DTT platform assuming future change of use of 700 MHz band takes place.

A long term strategy for UHF bands IV and V

6.46 For the reasons set out above, with this statement Ofcom establishes two strategic objectives to secure significant benefits from the use of limited spectrum resources in UHF bands IV and V:

- enabling the release of additional low frequency spectrum for mobile broadband use, to help meet the rapidly increasing demand for mobile data capacity.
- securing the ongoing delivery of benefits provided by DTT

6.47 To achieve this we will:

- Support the international process and conduct preparatory work to enable the harmonised release of the 700 MHz band;
- Seek to ensure that the 600 MHz band can be used for DTT and other service sharing spectrum with it on a geographic interleaved basis assuming harmonised release of the 700 MHz band for mobile broadband takes place. This will help ensure that a future replan of the DTT platform associated with change of use at 700 MHz secures the ongoing delivery of benefits associated with near-universal low cost access to PSB services and to the provision of a range of other DTT services that sustains viewers' choice in digital TV. This approach will also help the ongoing delivery of other services sharing spectrum with national DTT, including Local TV, the NI Mux, PMSE, and new services based on white space technology, by mitigating the reduction of spectrum available to them caused by change of use at 700 MHz.

6.48 This strategy will guide and inform relevant Ofcom work over the coming years, ensuring that future policy decisions are consistent with a long term perspective on how to secure significant benefits from the use of UHF bands IV and V.

6.49 Whilst the majority of respondents to our consultation were in broad support for this longer term strategic approach, BT and the Multiplex operators indicated that the case for a future change of use of the 700 MHz band from DTT to mobile broadband

use had yet not yet been demonstrated, as Ofcom has not conducted a full cost benefit analysis.

6.50 Our conclusions on our strategic approach are drawn from our analysis of the likely future demand for UHF spectrum by different services, a qualitative assessment of the benefits these could provide, and careful consideration of stakeholders' responses.

6.51 We consider that this approach is likely to deliver the greatest benefits for citizens and consumer over the long term. We therefore intend to proceed with preparatory activities for the implementation of a future re-organisation of UHF bands IV and V, enabling mobile broadband use of the 700 MHz band and use of the 600 MHz band for a re-planned DTT platform and other services using geographic interleaved spectrum, in the expectation that this will be in the best interest of UK citizens and consumers. In particular, we believe that our strategic approach should only be re-considered if significant unforeseen developments challenge the assumptions of our analysis as set out in this statement.

6.52 Decisions on the most appropriate processes and timescales for any future change of use in the 700 MHz band will be influenced by factors that remain uncertain at this stage. These include the position of other European countries and the way in which the future international processes for the harmonisation and coordination of this spectrum progress. We therefore consider that such decisions will need to be taken closer to the time of implementation and will need to be informed by more detailed work.

Implementing long term changes to UHF bands IV and V

6.53 Several stakeholder responses highlighted that re-planning the DTT platform to enable a release of the 700 MHz band, whilst preserving the ongoing delivery of DTT benefits and helping support the delivery of other services in UHF bands IV and V, is likely to be a complex and costly task.

6.54 We believe that one of the important benefits of establishing a long term strategic approach for the UHF spectrum bands IV and V now is that it enables preparatory actions to be taken sufficiently early to reduce and potentially avoid the costs and disruption associated with any future change of use of the 700 MHz band.

6.55 We intend to begin work on a number of preparatory activities, as set out below, following the publication of this statement.

International engagement

6.56 We will press forward on international engagement with a view to securing an outcome which best serves the interests of UK citizens and consumers in two important areas:

- discussions on the future mobile broadband band plan to be used in the 700 MHz band; and
- frequency coordination negotiations which underpin a future frequency re-plan of the DTT platform.

Timing and approach to future change of use

6.57 The costs to DTT multiplex licencees, other geographic interleaved spectrum users, and households caused by a DTT re-plan may vary depending on the timing of implementation. Similarly, we may defer the benefits from releasing additional mobile broadband capacity in the 700 MHz band if change of use was delayed.

6.58 Following publication of this statement, we will start work to examine the key questions of how and when a future change of use of the 700 MHz band can be secured which appropriately balances these requirements, optimising the timing of release and which best serves the interests of UK citizens and consumers.

Other implementation issues

Addressing consumer equipment issues

6.59 Re-planning the DTT platform would also have implications for DTT consumer equipment. We will explore opportunities for reducing and potentially avoiding the costs and disruption to citizens and consumers, for example the need to modify or bring forward the replacement of equipment as a result of the change in use of the 700 MHz band.

6.60 For the majority of households, it is likely that a future replan would only require a re-tune of their existing DTT receiver. For some households, a future re-plan could imply the need to use a different aerial. Our planned approach to ensure that the 600 MHz band can be used for a future DTT re-plan improves the prospects for achieving the widest possible compatibility of DTT services with existing roof-top aerials, by providing greater flexibility over how a frequency re-plan of the DTT platform is implemented.

6.61 In our consultation we indicated that between 0.1 and 0.3% of households may need to use a different aerial to continue to access PSB services, whilst a larger proportion (between 9 and 30%) may require a different aerial to access services from all of the commercial multiplexes. These figures are only indicative, because the actual number of households who will need to use a wideband aerial to continue to receive DTT services will depend on a number of factors including:

- The outcomes of a future international coordination of high power frequency broadcast assignments with our neighbouring countries;

- The number of households which will have already installed a wideband aerial: many households have already fitted wideband antennas as part of the digital television switchover process. We intend to explore opportunities for working with antenna installers and retailers to promote antenna replacements that will be compatible with a potential replan of the 700 MHz band.

6.62 We also intend to support any longer term market-led transition of the DTT platform to more efficient broadcast standards, which may be beneficial in enabling a smooth release of the 700 MHz band. This could include encouraging DTT stakeholders to identify approaches that could help accelerate the consumer adoption of compatible receivers. Such approaches might include the use of new receiver kitemarks to help consumers identify receivers that are compatible with these standards.

6.63 Furthermore we will explore options for working with industry stakeholders to promote the development of new receivers that are capable of providing improved

interference protection from future mobile services operating in the 700 MHz band. For example, there could be potential benefits from improving receiver AGC behaviour and developing selectable band edge filters which reflect any new band edge at 700 MHz.

Working with Multiplex operators to implement a new frequency plan

6.64 Any re-plan of DTT frequencies brought about by a change in use of the 700 MHz band would require a number of technical and regulatory changes, for example network transmitter changes and consequential licensing amendments.

6.65 We will be working closely with multiplex operators over the coming years to consider the implementation issues associated with our decisions.

Reducing the knock-on effects of a change of use of the 700 MHz band on users of geographic interleaved spectrum

6.66 Any re-plan of DTT frequencies brought about by a change of use of the 700 MHs band would also have a knock-on effect on the geographic interleaved users that share this spectrum with DTT.

6.67 The long term strategy for the future use of UHF bands IV and V established by this statement provides early signalling to PMSE, local TV and the NI Mux, and WSDs of the need for equipment to be capable of operating in the geographic interleaved spectrum of a re-planned DTT platform from 2018, and which future equipment purchasing decisions should be cognisant of. It also provides early clarity over the amount of geographic interleaved spectrum users are likely to have access to in the future and hence the need where appropriate to achieve longer term spectrum efficiency savings, including the progressive digitisation of analogue services and the adoption of cognitive radio technology.

6.68 We are committed to working with these users to reduce and potentially avoid any costs and disruption, and to help manage the transition of existing and planned services to enable their continued provision.

6.69 As noted above using the 600 MHz band for DTT after the release of the 700 MHz band would provide alternative spectrum for users of geographic interleaved spectrum to support continued provision of existing services.

6.70 We understand that WSDs are being developed to tune to the whole of UHF bands IV and V and hence could easily adapt to a change in the range of frequencies they have access to. These changes would be supported by updating the geographical WSD database which is used by WSDs to identify the frequencies that can be used in any given location.

6.71 Some local TV services may need to move to different frequencies after a re-plan of the DTT platform. Given their localised nature, we do not anticipate that these changes would significantly impact on the coverage of these services, though this is subject to fulfilling our international coordination agreements.

6.72 Responses to our consultation from PMSE stakeholders highlighted their concerns that:

- A DTT re-plan to release the 700 MHz band would reduce the total amount of geographic interleaved spectrum available to be used by PMSE applications.

- Much of the PMSE equipment currently used is only capable of tuning specific parts of the UHF band and may not be useable after a re-plan of the DTT platform.

6.73 These concerns were underlined in the BEIRG response to our consultation, supported by a significant number of PMSE users.

6.74 We believe that by signalling now the likely frequencies and amount of geographic interleaved spectrum that is likely to be available at least five years in advance of any eventual change provides the industry with an opportunity to take appropriate action to ensure that future PMSE equipment is compatible with these changes and that that equipment should seek to operate at an appropriate level of efficiency within the available spectrum.

6.75 We plan to engage with the PMSE community to conduct further work to assess current and future PMSE spectrum requirements and gauge how the entirety of their spectrum allocations can be best used to enable the continued provision of these services.

Prospects for delivering emergency services applications at 700MHz

6.76 We note that a future release of the 700 MHz band for mobile broadband use would open up a potential opportunity for future generations of video and data based emergency services applications to be delivered in this band.

6.77 We note that future requirements of the public protection and disaster relief (PPDR) community are currently being examined as part of the cross-departmental Emergency Services Mobile Communications Programme (ESMCP).

6.78 Consistent with our duties, we will continue to support Government activities related to future decisions around spectrum allocations for emergency services applications.

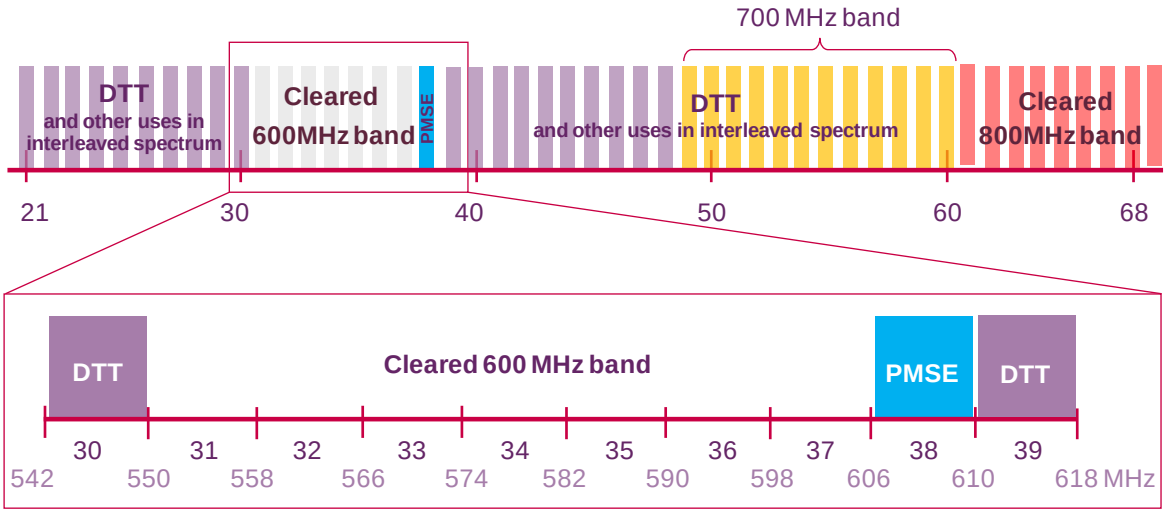
Section 7

Enabling the short term interim use of the 600 MHz band

7.1 In the previous section we set out our decision to pursue the dual long term objectives of releasing additional harmonised low frequency spectrum for mobile broadband whilst securing the ongoing delivery of benefits provided by the DTT platform. To achieve this, we explained that we would seek to ensure that alternative spectrum in the 600 MHz band (550-606 MHz) could be made available for use by the DTT platform assuming harmonised release of the 700 MHz band occurs. The use of this alternative spectrum would help reduce the risk that the DTT platform is unable to deliver low cost near-universal availability of PSB channels and a sufficient range of other TV channels in the future to sustain viewers' choice.

7.2 This approach means that the 600 MHz band could be made available for use by a number of candidate services in the short term. However, in the event of the release of the 700 MHz band for mobile broadband, these services would need to be cleared to make way for use by DTT (and other services sharing spectrum with DTT) as part of a re-planned DTT platform that encompasses the 600MHz band.

Figure 7 - The 600 MHz spectrum band



7.3 Our current estimate is that a harmonised change of use of the 700 MHz band might start to take place as early as 2018. Accordingly, we have decided that any short term use of the 600 MHz band should be authorised[62] in a way which allows us to terminate its use in 2018[63]. Moreover, these interim uses should be planned in the expectation that their authorisation will cease in 2018 (even if the authorisation could be extended in the event that the 700 MHz band were not released for mobile use in 2018).These arrangements will leave only a short period of time over which the 600 MHz band could be used by other services before it is needed for a re-planned DTT

[62] Spectrum use can be authorised by a WT Act licence or by licence exemption regulations.
[63] We refer to the period between now and 2018 as the "interim period" and the uses of the 600MHz band during this period as "interim uses".

platform. This is likely to pose challenges to the development of commercial services, such as those based on DTT or WSD applications. Respondents to our consultation highlighted this difficulty.

7.4 In our consultation we asked for stakeholder views on the potential short term interim uses of the 600 MHz band that could maximise its value whilst also supporting our longer term policy objectives. Stakeholder views converged on two main options for the shorter term use of the 600 MHz band:

- Option 1: shared use by DTT, PMSE and WSDs.
- Option 2: reservation for exclusive use by WSDs.

7.5 We believe that both of these proposals are potentially attractive. Below we discuss them in greater detail. In assessing their relative merits we have considered two important aspects of these proposals:

- the benefits that could be brought to citizens and consumers; and
- their compatibility with our long term policy objectives of supporting a harmonised future change of use of the 700 MHz band for mobile broadband, and ensuring the ongoing delivery of benefits provided by DTT.

Option 1: shared interim use of the 600 MHz band by DTT, PMSE and WSDs

7.6 Under this option, the 600 MHz band would be used to provide a combination of DTT, PMSE and WSD services on the same shared spectrum basis used in other parts of the DTT spectrum. To enable this, we would allow PMSE services to continue to access the 600 MHz band; update the geolocation WSD database to include 600 MHz frequencies as soon as it comes into operation; and explore opportunities for the provision of additional DTT multiplexes in the shorter term.

7.7 This approach was consistent with views expressed by various respondents, including Multiplex Operators, PMSE stakeholders, and some of the stakeholders with an interest in WSDs, including BT and the Cambridge White Space consortium.

7.8 Freeview, the Multiplex Operators and [✂] said that the provision of additional multiplexes in the 600 MHz band on an interim basis could help with a future clearance of TV services from the 700 MHz band. In particular, these stakeholders suggested that the provision of additional popular HD channels could help accelerate the consumer take-up of DVB-T2 and MPEG-4 compatible receivers enabling a faster platform transition to these more efficient standards. The Multiplex Operators and [✂] suggested that the use of these technologies would be important in helping maintain DTT coverage after a clearance of the 700 MHz band. [✂].

7.9 A specific proposal for the provision of additional interim multiplexes in the 600 MHz band has been submitted by the BBC, Channel 4 and Arqiva[64]. Here the additional multiplexes would make use of DTT transmission equipment being decommissioned after the digital switchover process. This approach would extend the range of HD DTT services available to viewers who have already purchased an HD compatible

[64] http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/responses/BBC_Channel_4_Arqiva.pdf

DTT receiver, and may encourage others to do so. PMSE and WSD use would be accommodated within the geographic interleaved spectrum of these services.

7.10 These stakeholders argue that the shorter term commercial case for providing these additional multiplexes is relatively weak due to the limited additional advertising revenues HD simulcasts are likely to attract. However, their ability to provide a faster platform transition to DVB-T2 and MPEG-4 could provide long term strategic benefits for the Multiplex Operators in terms of increasing its broadcast capacity and potentially also avoiding churn by DTT viewers desiring access to wider HD offering over the interim period. The multiplex operators also argue that a faster transition to DVB-T2 and MPEG-4 would also enable public benefits associated with securing an earlier release of the 700 MHz band.

7.11 Most of the WSD stakeholders who responded to the consultation explicitly favoured an option that would enable WSD use of the 600 MHz band by updating the geolocation WSD database to include relevant frequency assignments in the 600 MHz band. This approach would automatically allow a co-existence between WSDs and licensed services, including additional DTT services, when these come into operation. All the respondents who expressed a view on WSD use expressed a preference for accessing the 600 MHz band on a licence-exempt basis, although some also highlighted the potential benefits of a light-licensed approach.

7.12 PMSE stakeholders also supported a shared use of the 600 MHz band with DTT[65]. PMSE users are currently allowed to use the 600 MHz band on 6 month's notice, pending a decision on how the spectrum is to be used after this date. PMSE users stated that they are opposed to any reduction in the total amount of PMSE spectrum currently available to them, claiming that this would compromise their ability to support large scale sports and live music events in the future.

7.13 The option of shared DTT, PMSE and WSD use could also be compatible with the use of Channel 36 (590 – 598 MHz) in a limited number of UK rural locations for a propagation study. Through our involvement in ITU Study Group 6, we are aware of emerging discussions on the merits of undertaking, for a period of around 2 years, a study of UHF propagation in Channel 36 throughout Europe. Such a study could provide valuable information for the efficient planning of future DTT networks. Any DTT deployment in the 600 MHz band based on one or two MFNs would not make use of Channel 36, given the existing international frequency co-ordination limitations associated with this channel. It is also likely that such a study could coexist with usage of the same channel by WSDs and PMSE.

Option 2: exclusive use of the 600 MHz band for WSDs

7.14 Under this option the 600 MHz band would be used in the short term to provide an innovation space for emerging WSD technologies. This proposal was only raised by Sky. Under this approach the 600 MHz band would be reserved exclusively for WSD use on a licence-exempt basis.

7.15 We believe it is important to support future innovation based on emerging WSD technology, as this has the potential to make a more effective and efficient use of spectrum, and deliver benefits to citizens and consumers through new or improved

[65] In its response BEIRG favoured an option of short term use of the 600 MHz band on a geographically interleaved basis, although they suggested WSDs should not be allowed access to the same spectrum due to the potential for interference. BEIRG also suggested reserving part of the 600 MHz (channels 35 to 38) band for PMSE to mitigate interference from WSDs.

services. To this end, Ofcom is taking a leading role amongst regulators in Europe and progressing ongoing work in collaboration with industry to establish a regulatory framework and the technical conditions to enable these services. Discussions on these are being conducted as part of the Ofcom-chaired TV white-space Technical Working Group (TWG).

7.16 The WSD technologies needed to enable the use of TV white spaces are under development and there is scope for them to be used to drive innovation and experimentation. However, at this stage there is still considerable uncertainty about the commercial potential of services based on WSDs. No white space devices are currently available on the UK market and we have not seen any specific business plans for their use. Nevertheless, their future potential has been widely recognised for applications such as: public Wi-Fi hotspots; rural broadband; in-home wireless distribution of digital signals; smart metering; machine-to-machine communications; and health applications.

7.17 As discussed in our September 2011 white space statement[66], WSDs will make use of unused DTT transmitter frequencies in different geographical locations, known as 'white spaces'. Frequencies available to WSDs and their transmitter power level are set by a requirement that they should not cause interference to licensed DTT and PMSE services. This information is held in a geolocation database, used to control WSD access to the spectrum. Work to put in place the necessary regulations to permit the operation of WSDs is currently in progress.

7.18 As noted by Sky in an addendum to its UHF strategy consultation response, reserving the 600 MHz band for WSDs could offer various potential benefits:

- The provision of innovation reserve at 600 MHz could provide a test bed for developing WSD applications and spectrum access protocols. This could lead to an earlier advancement of relevant testing activities, easing time constraints related to the definition of rules for accessing geographic interleaved spectrum in other parts of UHF bands IV and V, through the operation of geolocation databases.

- It could provide greater flexibility for the development of emerging WSD equipment, enabling an opportunity to operate devices at higher power levels and using wider channel widths. Wider channels would be supported through greater access to contiguous UHF channel frequencies, compared to a case where WSDs share spectrum with other licensed services such as DTT and PMSE.

Assessing the merits of these two options

7.19 Where more than one potential use for spectrum exist, Ofcom's general preference is to determine spectrum use through a competitive award process. However, we do recognise that such an approach may not be appropriate in all circumstances. In this case, there a two key reasons why a competitive bidding process would not be appropriate to determine a choice between the two stakeholder options described above:

- it is difficult for licence exempt uses (such as WSDs) to be represented properly in a competitive bidding process due to coordination and free-rider challenges; the dispersed PMSE users base could also face coordination challenges in bidding for spectrum; and

[66] http://stakeholders.ofcom.org.uk/consultations/geolocation/statement/

- the public value component associated with potential uses may not be easily reflected in a market-based award. For instance, we note that components of public value could be relevant to DTT use of the 600 MHz band, such as contributing to maintain the DTT platform as a sustainable means of providing near universal low cost access to PSB services.

7.20 For these reasons, we consider it appropriate in this case to determine a way forward for the short term use of the 600 MHz band by assessing the relative merits of these two options.

7.21 Having regard to our statutory duties, we believe the following considerations are relevant to this assessment:

- the potential benefits for citizens and consumers associated with different interim use options;

- the consistency of the interim use of the 600 MHz band with our strategy for longer term use of UHF bands IV and V; and

- the continuity of service provision on future change of use of UHF bands IV and V.

7.22 The nature of the options is such that this assessment is subject to a number of significant uncertainties. Further technical work could reduce some of the uncertainty related to the opportunities that could be associated with different proposals, but a significant level of uncertainty would still persist over the benefits these could actually deliver to citizens and consumers. Any further technical work is likely to delay a decision being reached on the interim use of the 600 MHz band by a minimum of several months. We consider the implications of such a delay below, after addressing each of the three considerations referred to above.

Potential benefits for citizens and consumers from interim use

7.23 The difference between the options is that, in principle:

- Option 1 could deliver benefits through the use of the 600MHz band for additional DTT and PMSE services (as compared with option 2); and

- Option 2 could deliver benefits as a result of increased spectrum access for WSDs (over and above the spectrum available for WSDs under option 1).

7.24 There are two sources of potential benefit associated with DTT use of the 600MHz band during the interim period:

- *From additional services during the interim period itself:* expanding the range of services, including in HD, available on the DTT platform would strengthen its ability to deliver consumer benefits, as it would expand the range of services available to households that have a compatible DVB-T2 MPEG-4 receiver, or that buy one.

- *From faster migration to more efficient DTT standards*: the expanded range of services available, broadcast using DVB-T2 and MPEG-4, could provide additional incentives for consumers to purchase DVB-T2 MPEG-4 compatible receivers during the interim period. This could facilitate a faster penetration of these more efficient receivers into the consumer base. This faster penetration

could enable the DTT platform itself (i.e. the MUX transmitters) to be migrated to these more efficient standards at an earlier date. This would, in turn, result in greater DTT spectrum efficiency and, hence, more DTT services being broadcast from a given amount of spectrum allocated to DTT.

7.25 Turning to interim use for PMSE services, these users currently have access to the 600 MHz band on 6 months' rolling notice, pending a final decision on enabling use of the 600 MHz band. Ongoing access to the 600 MHz band would allow PMSE users to continue to deliver the benefits they already provide through access to this spectrum. There is also a potential benefit to the PMSE community in mitigating the costs of migration between spectrum bands. Typically, PMSE equipment has been developed to operate in only specific parts of the available geographic interleaved frequencies. If PMSE users have to migrate out of the 600 MHz band during the interim period (as they would have to under Option 2) then they may need to purchase new equipment that operates in other parts of the interleaved UHF band (the 700 MHz band, or below the 600 MHz band). As and when DTT platform moves out of the 700 MHz band and re-incorporates the 600 MHz band, PMSE users will then require 600 MHz equipment again. Such a double migration could result in costs for PSME users arising from the need to purchase replacement equipment. Continued access to the 600 MHz band under Option 1 would mitigate this cost.

7.26 We also note that under Option 1, WSDs could still operate in the 600 MHz band, even if it were not reserved exclusively for WSD use, on a shared basis with DTT and PMSE services, through the operation of a geolocation database to manage interference. This, together with other white-space spectrum available in the rest of UHF bands IV and V, would still provide scope to innovate and experiment with WSDs in many areas[67].

7.27 Benefits from Option 2 would relate to the extent to which a reservation of spectrum at 600 MHz for WSDs allows a faster development of relevant WSD technologies and, off the back of that, consumer propositions.

7.28 To explore Sky's suggestion that reserving the 600 MHz band for WSDs would lead to greater flexibility to use this spectrum at higher power and using more contiguous blocks of channels, we commissioned technical simulations of the TVWS spectrum availability under scenarios of exclusive and shared use of the 600 MHz band. The methodology, assumptions and results of these simulations are discussed in Annex 2.

7.29 These technical assessments are based on a range of assumptions related to DTT and WSD coexistence that are provisional at this stage. Furthermore, they have not taken into account the requirements for PMSE and WSD coexistence because the relevant work to define the necessary coexistence parameters is still ongoing[68]. The

[67] We note that, based on the technical analysis discussed below and in Annex 2, the overall aggregate capacity available to WSDs across UHF bands IV and V may not increase under Option 2 if evaluated against an alternative scenario in which the 600 MHz band remains completely fallow. A likely reason for this is that additional DTT services in the 600 MHz band would create additional protection requirements, causing incremental constraints to the availability of spectrum for WSDs in some areas. However, we do not consider a scenario in which the 600 MHz band remains completely fallow as a realistic counterfactual. In practice, a more appropriate counterfactual might be a scenario in which the 600 MHz band is allocated in block to DTT or other services requiring protection from WSDs, and no interleaved spectrum made available for WSDs. In these circumstances, we would expect the availability of spectrum for WSDs to be lower than in Option 2.

[68] These parameters are unlikely to be defined until several months into 2013, following the completion of relevant industry discussions.

inclusion of PMSE and WSD coexistence requirements is likely to reduce the overall amount of WSD spectrum available. For these reasons, the results of these assessments should be treated with a degree of caution although they do provide some insight into the potential implications of the different options for WSD spectrum access.

7.30 Under the preliminary assumptions used in this study, the simulations showed that the amount of WSDs spectrum for higher power and contiguous spectrum use may increase under some circumstances if the 600 MHz band is used exclusively for these services. However:

- The results showed a strong sensitivity to the type of WSD technology used and to the potential for future improvements in WSD transmission technology. Under most scenarios, the increment in the technical opportunity that might be provided by an exclusive reservation of the 600 MHz band for WSD use is less relevant than what might be achieved through ongoing improvements in WSD transmission technology. That is, similar or greater increments in WSD opportunities could be achieved through using technical improvements rather than additional spectrum.

- There are general limitations on WSD use related to the need to protect DTT receivers from interference operating on frequencies outside the 600 MHz band. These requirements are likely to constrain the opportunity of operating WSDs at high powers even if the 600 MHz band is reserved exclusively for WSDs. In particular, the results illustrate that DTT protection requirements are likely to inhibit the ability to use WSDs at high power levels (such as those that might be required for wide-area wireless data networks) on a mass market scale, regardless of whether the 600 MHz is reserved for their use.

7.31 Notwithstanding the residual uncertainty on final WSD coexistence parameters to be adopted, as discussed above, these results suggest that the incremental effect that an exclusive reservation of the 600 MHz band could have on the ability to innovate through greater technical flexibility, when compared to an alternative option of shared use, appears to be limited.

7.32 Whether any such incremental ability to innovate would translate into practical consumer benefits is also very uncertain at this stage, as they are likely to be dependent on the type of WSD application being considered. We note that Sky in its submission focused on the potential for the 600 MHz band to act as a test bed to develop WSD applications, and did not provide details on specific commercial propositions that could be sustained through exclusive access to the 600 MHz band. However, if there were WSD services that could only be developed relying on exclusive access to the 600MHz band (i.e. they are specific to Option 2), then, at best, it would be several years before they could be developed and deployed. This would leave little time for such WSD services to deliver consumer benefits during the interim period. Moreover, if such WSD services were dependent on having exclusive access to UHF spectrum then there would be challenges around service continuity once WSDs lost exclusive access to the 600MHz band, as we discuss further below.

7.33 Sky also suggested that a reservation of the 600 MHz band could ease time constraints for the operation of WSDs associated with defining rules for the operation of geo-location databases governing WSD spectrum access to other parts of UHF bands IV and V. As highlighted by the technical simulations presented in Annex 2, WSDs operating in the 600 MHz band could, under certain circumstances, still interfere with DTT receivers operating in other bands above and below 600 MHz.

This suggests that the definition of detailed rules to ensure WSDs do not cause undue interference to licensed services operating in other parts of UHF bands IV and V would still be required even in case of an exclusive reservation of the 600 MHz band for WSD use.

7.34 Overall, whilst we accept that, in principle, Option 2 could support greater flexibility in WSD innovation and experimentation, under current evidence this effect appears to be limited. In addition, the incremental benefits that could derive from this are, at best, very uncertain. In contrast, the benefits of Option 1, albeit potentially limited by the short timeframe of interim use, could derive from a range of different services, hence there may be a greater probability of benefits being achieved in practice.

Consistency with our strategy for longer term use of UHF bands IV and V

7.35 Interim use of the 600 MHz band needs to be consistent with our strategy for UHF bands IV and V and, in particular, with the prospect of the 600 MHz band being incorporated into a re-plan of the DTT platform.

7.36 In principle, both options would be consistent with this requirement as we will be able to terminate the authorisation of any interim use from 2018. However, there is a material difference in that Option 1 could positively support benefits delivered by DTT after the interim period, over the longer term, through a potentially faster platform transition to more efficient standards.

7.37 As discussed in section 6, we do not believe that a full platform transition to DVB-T2 and MPEG-4 would be required as a pre-condition for a future release of the 700 MHz band. Therefore, we do not agree with the Multiplex Operators' suggestion that interim use of the 600 MHz band for DTT could release public benefits associated with an earlier release of the 700 MHz band.

7.38 However, we consider that a potentially faster DTT platform transition to more efficient standards could be relevant:

- from a *platform sustainability* perspective, as it would contribute to the DTT platform having a sufficient amount of capacity to remain attractive to viewers, supporting its continuing public policy role in providing near-universal low cost access to PSB content;
- from a *consumer choice* perspective, as it would support DTT's ability to provide a wider range of services, potentially including the ongoing delivery of the additional services introduced over the shorter term; and
- from a *service coverage* perspective, as the use of more efficient standards could provide greater frequency re-planning flexibility in achieving multiplex coverage levels comparable to today after the release of the 700 MHz band.

Continuity of service on future change of use in UHF bands IV and V

7.39 The interim uses of the 600MHz band will need to cease as and when their authorisation is withdrawn. There is a potential difference between the options as regards continuity of service at the point that this happens.

7.40 Option 1 could provide a continuity of service provision for DTT, PMSE and WSD services if and when a change of use of the 700 MHz band occurs. In particular, if there is sufficient platform transition to more efficient DVB-T2 and MPEG-4

transmission standards (which itself might be facilitated by option 1), it is likely that the additional services provided in the interim could be re-accommodated in the multiplexes delivered following the future replan, as the capacity of the platform increases with use of more efficient standards. Meanwhile, we would expect PMSE and WSD services to continue to share spectrum with a re-planned DTT platform, albeit that the aggregate amount of spectrum access for these services is likely to be greater during the interim period than after the implementation of a re-planned DTT platform.

7.41 As noted above, it is unclear whether exclusive reservation for WSD use under Option 2 could lead to the development and deployment of commercial WSD services that would not have been developed and deployed under Option 1. However, if any such commercial propositions were to emerge, there could be a risk that they may need to be discontinued or their performance reduced when they lost the exclusive spectrum access they rely on, as and when the 600 MHz band was incorporated into a re-planned DTT platform. In such a scenario, consumers may not take account of the potentially limited life of these services when making purchase decisions related to them, and therefore might lose out if and when these services are discontinued.

Timing considerations

7.42 As discussed above, our consideration of whether an exclusive reservation of the 600 MHz band could provide incremental opportunities for WSD innovation is informed by technical analysis based upon preliminary parameters for the coexistence of WSDs with other services that are still under discussion in relevant industry technical working groups, and that are unlikely to be finalised until several months into 2013.

7.43 We have carefully considered whether we should delay a decision on use of the 600 MHz band until uncertainties related to these technical parameters are resolved

7.44 We consider that the analysis we have conducted so far is sufficient to conclude that the additional opportunities for WSD innovation that would result from an exclusive reservation of the 600 MHz band for WSDs appear to be limited. There are significant uncertainties over the benefits for citizens and consumers that might result from these additional opportunities. Even if we delayed a decision until WSD coexistence parameters are finalised in 2013, and more analysis were to be carried out, these significant uncertainties would still most probably persist.

7.45 The period of certainty over which spectrum at 600 MHz can be used on an interim basis could be as short as five years, from 2013 to 2018. Delaying a decision on short term use of the 600 MHz band until we have greater clarity on WSD coexistence parameters risks contracting this period to 2014 to 2018. This would result in a material reduction in this already short timeframe.

7.46 Given:

- that such a delay would at least postpone and hence reduce the benefits that consumers could get from interim use of the 600 MHz band (e.g. through additional DTT channels).

- the risk that such a delay could result in all consumer benefits from interim DTT use being lost if the timeframe for operating those multiplexes became too short to be viable;

- that the level of uncertainty in this assessment is likely to remain high even though additional analysis would reduce some aspects of this uncertainty, i.e. those related to technical coexistence parameters; and

- that there would still be scope for WSD innovation and experimentation through a shared approach to 600 MHz spectrum (and other UHF spectrum), albeit on a geographic interleaved basis;

we consider it appropriate to exercise our discretion in light of our duties to efficient management of the spectrum and proceed without further delay in deciding how the 600 MHz band should be used in the short term, and taking steps to enable this.

Conclusions and next steps

7.47 In light of the considerations above, we have decided to proceed with an approach that will enable a shared short term use of the 600 MHz band for:

- additional interim DTT multiplexes using DVB-T2 and MPEG-4;

- PMSE services; and

- applications based on white space device technology.

7.48 To give effect to this decision, we will be publishing a further document as soon as practicable on the process for awarding a licence for one or more DTT multiplexes using DVB-T2 and MPEG-4 standards in the 600 MHz band for the duration of the interim period.

7.49 A combination of PMSE and WSD services will be authorised to access spectrum in the 600 MHz band in the interleaved spectrum left open by DTT and in all locations until such time as DTT services are launched. PMSE users already have access to this band on the basis of a 6 months rolling notice period. WSD users will gain access to the 600 MHz band through its addition to geo-location databases that control WSD access to UHF spectrum as and when these become operational.

7.50 We intend to conduct further work on the precise arrangements for the coexistence of PMSE and WSD services in the 600 MHz band. In particular, we will consider whether these services should coexist on the same basis as currently planned for the rest of UHF bands IV and V, or whether particular arrangements should be made for the 600 MHz band. We expect to be in a position to provide further clarity on these arrangements as relevant work on technical protection parameters progresses into 2013. We will replace the 6 month rolling notice period that currently applies to PMSE access rights to the 600 MHz band with longer term access arrangements as soon as this work is complete.

7.51 We will also consider the viability of conducting a cross-European UHF propagation study using Channel 36 once more details emerge.

Section 8

Conclusions and next steps

8.1 With this statement Ofcom establishes two strategic objectives to secure significant benefits from the use of limited spectrum resources in UHF bands IV and V:

- enabling the release of additional low frequency spectrum for mobile broadband use, to help meet the rapidly increasing demand for mobile data capacity; and
- securing the ongoing delivery of benefits provided by DTT

8.2 To achieve this we will:

- Support the international process and conduct preparatory work to enable the harmonised release of the 700 MHz band; and
- Seek to ensure that the 600 MHz band can be used for DTT and other service sharing spectrum with it on a geographic interleaved basis assuming harmonised release of the 700 MHz band for mobile broadband. This will help ensure that a future replan of the DTT platform associated with change of use at 700 MHz secures the ongoing delivery of benefits associated with near-universal low cost access to PSB services and to the provision of a range of other DTT services that sustains viewers' choice in digital TV. This approach will also help the ongoing delivery of other services sharing spectrum with national DTT, including Local TV, the NI Mux, PMSE, and new services based on white space technology, by mitigating the reduction of spectrum available to them caused by change of use at 700 MHz.

8.3 This long term strategy will guide and informs relevant Ofcom work over the coming years, ensuring that future policy decisions are consistent with a long term perspective on how to secure significant benefits from the use of UHF bands IV and V.

8.4 Following publication of this Statement, Ofcom will initiate preparatory activities aimed at securing the delivery of these long term objectives in a way that reduces and potentially avoids costs and disruption for consumers, as well as current and future spectrum users. These activities will include:

- Pressing forward on international engagement with a view to securing an outcome which best serves the interests of UK citizens and consumers in two important areas:
  - discussions on the future mobile broadband band plan to be used in the 700 MHz band; and
  - frequency coordination negotiations which underpin a future frequency re-plan of the DTT platform.
- Examining the key questions of how and when a future change of use of the 700 MHz band can be secured which optimising the timing of release and which best

serves the interests of UK citizens and consumers. We intend to publish further work in this area during 2013.

- Exploring opportunities for reducing and potentially avoiding the costs and disruption to citizens and consumers, such as those related to the need to modify or bring forward the replacement of equipment as a result of the change in use of the 700 MHz band. As part of this, we will explore approaches that could help accelerate the consumer adoption of receivers compatible with efficient technology standards, as these are likely to be used more extensively in future DTT transmissions.

- Working with multiplex operators to consider the implementation of technical and regulatory changes to safeguard the benefits of DTT services.

- Enabling the continued provision of existing and future planned PMSE, local TV, NI Mux and WSD based services by the early signalling of our decision, and therefore:

    - our commitment to working with these users to reduce and potentially avoid any costs and disruption, and to help manage the transition of existing and planned services;

    - the need for equipment to be capable of operating in the geographic interleaved spectrum of a re-planned DTT platform, and which future equipment purchasing decisions should be cognisant of; and

    - the importance of achieving longer term spectrum efficiency savings, including the progressive digitisation of analogue services and the adoption of cognitive radio technology.

- Continuing to support Government activities related to future decisions around spectrum allocations for emergency services applications.

8.5 Having established our long term approach to UHF bands IV and V we also intend to enable use of the 600 MHz band on a short term interim basis by a combination of DTT, PMSE and WSD services.

8.6 To give effect to this decision, we will be publishing as soon as practicable a further document on how best to award 600 MHz spectrum, by licensing one or more DTT multiplexes using DVB-T2 and MPEG-4. We also intend to conduct further work on the precise arrangements for the coexistence of PMSE equipment and WSDs in the 600 MHz band.

Annex 1

Summary of main points made in responses to the March 2012 consultation

A1.1 Ofcom opened a consultation process to consider the future of the UHF band in March 2012, with the publication of the document 'Securing long term benefits from scarce spectrum resources - A strategy for UHF bands IV and V'. The consultation closed in June 2012. Over that period we received 40 full responses to our consultation document, and 57 letters in support of one response, by BEIRG.

A1.2 There were 23 consultation questions in our original document. In this Annex we have summarised the answers to these questions by theme. We have also grouped them by respondent type, for example summarising together all of the mobile network operators, and grouping together respondents with interests in programme making and special events ("PMSE") uses.

A1.3 The full groupings are:

- TV – Channel 5, Confederation of Aerial Industries, Digital Television Group (DTG), Freeview. The BBC, ITV, Channel 4, Arqiva and SDN submitted a joint response in their capacity as DTT multiplex operators.
- Mobile – Everything Everywhere, Ericsson, Hutchison 3G (H3G), Nokia Siemens Networks, O2, RIM, Vodafone.
- White Space Devices ("WSD") – Bglobal plc, BT, Cambridge White Spaces Consortium, Huawei, Kenyon Consulting, NEUL, Weightless.
- Programme Making and Special Events ("PMSE") – BEIRG, Christopher Hall, Copsey Communications Consultants, Shure, Truelight Sound and Vision. We also received over 50 letters from members of the PMSE community supporting BEIRG's submission.
- Public Protection and Disaster Relief ("PPDR") – Motorola Solutions, National Police Improvement Agency (NPIA), TETRA and Critical Communications Association (TCCA).
- Other industry stakeholders – BSkyB, Intellect, Samsung, Telecom Association of the UK Water Industry (TAUWI).
- Consumer groups, individuals and other respondents – Communications Consumer Panel, David Hall Systems, [✂], Scottish Government, Voice of the Listener and Viewer.

A1.4 We have grouped the stakeholders according to the interests and positions advocated by their responses. As a result, some organisations are grouped with others outside their usual focus; for example based on their respective submissions, BT is summarised alongside WSD respondents, while BSkyB is not grouped with other TV companies.

Views on the need for additional spectrum to meet increasing mobile data capacity requirements (consultation questions 1 and 2)

A1.5 Most TV broadcaster respondents accepted that the demand for mobile data will grow, but they questioned whether mobile network operators ("MNOs") will need more spectrum to meet that demand. Some respondents highlighted the mobile technology improvements that have increased spectrum efficiency, negating the need for an increased spectrum allocation. For example, the BBC, ITV, Channel 4, Arqiva and SDN ("the Multiplex Operators") recognised the importance of mobile spectrum but highlighted the role unlicensed spectrum and Wi-Fi offload can play in meeting the growth in demand for mobile broadband capacity. However, TV stakeholders generally recognised that international harmonisation developments are likely to result in an increase in spectrum made available for mobile broadband.

A1.6 The MNO respondents agreed with the Real Wireless study commissioned by Ofcom, which shows the benefits the 700 MHz band could bring in reducing the number of additional mobile sites that need to be built to meet the growth in demand for mobile broadband capacity. They favour 700 MHz spectrum release as part of a number of techniques required to meet increasing demand, and highlighted the practical challenges and cost implications of building additional mobile sites. Vodafone also underlined the European Commission's Radio Spectrum Policy Group's ("the RSPG") policy objective of indentifying at least 1200 MHz of additional mobile spectrum by 2015.

A1.7 White space devices ("WSD") stakeholders acknowledged trends towards growing mobile data requirements and international trends towards additional spectrum made available for mobile broadband on a harmonised basis. However, they noted that licence exempt spectrum could play an important part in meeting growing wireless data requirements.

A1.8 Public protection and disaster relief ("PPDR") stakeholders identified the benefits that additional harmonised mobile broadband spectrum could bring to citizens and consumers including the delivery of emergency services applications.

A1.9 Programme maker and special events ("PMSE") stakeholders were instead unconvinced that mobile services will need additional spectrum. Some stated that MNOs should make more efficient use of their existing holdings. They also stressed that the costs of clearance on other services (especially PMSE) should be considered as part of the decision whether or not to release the 700 MHz band for mobile use.

A1.10 Respondents from other areas of the communications sector, including BSkyB acknowledged that the demand for mobile data and spectrum is likely to continue to grow rapidly in future. However some of these respondents also stressed a need to ensure that other uses of the UHF spectrum are not neglected, including its licence-exempt uses its use by and machine-to-machine communications and wireless telemetry applications.

A1.11 Respondents representing consumer interests noted that a potential benefit of releasing the 700 MHz band for harmonised mobile use, is that this approach could reduce future mobile network and handset costs, reducing the cost of accessing mobile services for consumers.

The role of the 700MHz band for mobile broadband (consultation questions 3 to 5)

A1.12 The Multiplex Operators' response recognised the growing international momentum behind a future harmonisation of the 700 MHz band for mobile broadband use and the subsequent pressure this is likely to create for the future clearance of the 700 MHz band of DTT services in the UK. However they emphasised their belief that there should be a full CBA before a decision on the future clearance of the 700MHz band is taken. They also asserted that there are alternatives to using more low frequency spectrum to meet the growth in demand for mobile broadband capacity including: Wi-Fi offloading and using alternative, high frequency spectrum bands, which mean that it is not yet certain that the use of the 700 MHz band for mobile broadband will be necessary.

A1.13 The Confederation of Aerial Industries opposed prospects for future change of use at 700MHz, on the grounds that it will affect DTT coverage.

A1.14 The MNOs generally supported an early release of the 700 MHz band for mobile broadband use. They asserted that releasing spectrum takes a long time and that the risk of a mobile capacity crunch is impending. Hutchison 3G ("H3G") encouraged release of the 700 MHz band for mobile use by 2018 whilst Vodafone, asserted that its release will be necessary sooner than suggested by Ofcom's Real Wireless report. Telefónica expressed the view that the optimal timing for 700 MHz release will be dependent on the international timetable for its harmonisation.

A1.15 WSD respondents highlighted the alternative methods that could be used to meet the increasing demand for mobile data capacity, including the use of Wi-Fi offloading and femtocells. BT's response stated that Ofcom had not demonstrated the future economic case for 700 MHz clearance. It suggested that a decision on the need for its future clearance should be taken after the impact of earlier mobile broadband spectrum awards becomes apparent. BT stated its belief that 2018 is too soon to implement 700 MHz clearance, and that if it is to go ahead, it should happen in 2022 or later.

A1.16 PMSE respondents generally disagreed that mobile services need more spectrum, given the other methods available to MNOs to meet demand. Consumer group respondents also expressed this opinion, pointing to alternative technologies that could be used including cognitive radio. These respondents believed that the potential costs of 700 MHz reallocation, including social costs, to other spectrum users (especially PMSE users) would be greater than the benefits that would be realised by mobile. To make its point BEIRG – an industry group for PMSE users – highlighted the findings of a study by DCMS (the Department for Culture Media and Sport) into the economic benefits of the creative sector to the wider UK economy. BEIRG stated that around 80% of PMSE equipment sold operates in the 700 MHz band and would need to be replaced were clearance to happen. It also raised a concern that new mobile services could cause interference to existing PMSE users.

A1.17 PPDR respondents highlighted the potential benefits of the internationally harmonised use of the 700 MHz band for mobile broadband. They acknowledged the possible benefits of allocating more spectrum for mobile broadband in general, and suggested reserving some of this for PPDR use.

A1.18 Respondents from other areas of the communications sector generally thought that it was important for the UK to harmonise its use of spectrum with other countries.

They also believed that the 700 MHz band will be important for mobile broadband services because of its attractive propagation characteristics. They expressed their view that there will be a need for higher frequency spectrum too, a view shared with consumer group respondents.

A1.19 BSkyB also supported an early release of the 700 MHz band.

The future relevance and role of DTT (consultation questions 6 to 9)

A1.20 Respondents from the TV industry held the view that DTT is and will continue to play a crucially important role in providing services to primary and secondary sets. Some respondents also stated that the presence of the DTT platform also provides greater inter-platform competition. As a result, they believed that it would be important for the DTT platform to maintain at least its current scale of service offer and capabilities and, ideally, is able to develop these further in the future. The Multiplex Operators and [✂] believed that no alternative platforms could act a credible substitute to the DTT platform over the timeframe being consider for the release of the 700 MHz band. [✂]. Freeview cited the DTT frequency re-planning study by Arqiva, published alongside our consultation document, in their response. They highlighted that in their view this report has shown that DTT platform must be able to use the 600 MHz band to maintain current coverage levels if DTT services are cleared from the 700 MHz band in the future.

A1.21 The MNOs recognised that DTT is an important broadcast platform today, and thought it will remain so until 2020. However, they expressed the view that over time market developments towards HD and non-linear video will cause DTT's relevance to decrease. Therefore, in the longer term, provisions should be made to ensure DTT uses less spectrum. Vodafone suggested a need to identify strategies for viewers being migrated to other TV platforms.

A1.22 Most respondents – including WSD, PMSE and respondents from consumer groups and other parts of the communications sector – believed that DTT is and will continue to be important to the UK TV market and to consumers. BT mentioned DTT's role in fostering competition while PPDR respondents stated that the DTT platform can play an important role as part of the response to emergency situations. Meanwhile consumer groups stated that consumers value the free-to-air services available on the platform. PMSE respondents also believed that DTT is and will remain very important. BEIRG stressed the importance both the importance of the DTT platform and in allowing it to sustain itself and grow in the future.

A1.23 Whilst, BSkyB recognised DTT's importance today, it believed that its future relevance may diminish in the future due to market developments. BSkyB expressed the view that Ofcom has underestimated the potential for the alternative delivery of broadcast TV services using IPTV. They also said that appropriate incentive mechanisms (other than Administrative Incentivised Pricing, AIP) should be put in place to encourage adoption of more efficient broadcast TV technologies that use less spectrum. Huawei recommended that rather than maintaining the spectrum used by DTT, Ofcom (and industry) should consider using alternative means of delivery including ADSL (for IPTV) and satellite.

Views on other uses of UHF spectrum (consultation questions 10 to 14)

A1.24 TV industry respondents were of the view that WSD should be able to use the geographically interleaved spectrum associated with the DTT platform. The Multiplex Operators were also of the view that PMSE and local TV services should be able to use this interleaved spectrum too. Freeview stated its opinion that local TV services and other possible uses of the spectrum are less important than UK-wide DTT services. [Arqiva claimed that if DTT were granted early use of the 600 MHz band it would provide more white spaces for use by White Space Devices.] The Confederation of Aerial Industries noted that WSD can cause interference to wireless devices e.g. wireless CCTV camera systems, and that the likelihood of interference being caused to communal aerial systems was very high.

A1.25 Vodafone stated its opinion that the opportunity cost of UHF spectrum for uses other than mobile or DTT is increasing (i.e. that mobile and DTT are more valuable uses of this spectrum than alternative services). Vodafone suggested that PMSE could be moved to alternative spectrum, possibly to the 2010-2090 MHz band.

A1.26 WSD respondents highlighted that there are many possible WSD uses for the UHF band, with benefits associated with them. These included machine-to-machine services, health applications and rural broadband services. Some suggested that Ofcom could reserve some spectrum specifically for WSD. BT supported plans that allow for more widespread use of WSD but noted that with several different "communities of interest" in using WSD (rural broadband, machine to machine communication and emergency service usage), it is important that the overall amount of spectrum available is not restricted too much.

A1.27 PMSE respondents said that they believe Ofcom is underestimating the value and importance of PMSE to the UK. They stated their view that they are already constrained by spectrum congestion. In addition they asserted that WSD cause too much interference with PMSE devices. BEIRG suggested that only PMSE and DTT should use the 600 and 700 MHz bands and that PMSE should also have access to some exclusive spectrum. BEIRG, a representative body for PMSE users, also called on Ofcom to find a long-term home for PMSE, thereby granting it stability and protection.

A1.28 [✂].

A1.29 Respondents from other areas of the communications sector raised a variety of different suggestions for other uses of the UHF band. Intellect, a trade body, suggested that Ofcom should also consider PPDR uses, as discussed at CEPT (the European Conference of Postal and Telecommunications Administrations). Samsung expressed its view that WSD should be considered as secondary to demands for mobile services. BSkyB stated its support for Wi-Fi and licence-exempt services in this band while the Telecoms Association of Water Industry said that change of use at 700 MHz provides an opportunity for reserving part of this spectrum for use by the utility sector (for machine-to-machine services such as wireless meters and telemetry systems). The Communications Consumer Panel was pleased to see the mention of potential multimedia emergency service uses in the consultation document.

Views on future spectrum requirements for DTT and whether use of the 600MHz band will be required (consultation questions 15 to 17)

A1.30 All respondents from the TV industry stated their belief that access to the 600 MHz band would be absolutely necessary for DTT if 700 MHz clearance were to take place, to at least maintain the platform's current offering. [✂]. The Multiplex Operators also asserted what they considered their legal rights over continued use of DTT spectrum, thanks to their licence agreements. As a result they stated that they would only be willing to cooperate with a 700 MHz band clearance programme if they would be in the same position as they would have been absent the change, i.e. with the same number of channels, equal coverage levels to now, and at no cost to themselves. [✂]. Freeview claimed in its response that DTT will need more spectrum in future, to expand its services in order to meet consumer expectations and innovations as well as to continue its existing services. Channel Five stated that there is no business case to expand the number of channels on DTT. [✂].

A1.31 The MNO respondents supported the use of the 600MHz band for DTT given the prospect of an early release of the 700 MHz band. However, O2 said that after 2020 the efficiency of DTT spectrum allocations should be reconsidered and that opportunities should be taken to ensure that DTT uses less spectrum.

A1.32 Of the WSD respondents, Huawei and Weightless downplayed the need to move DTT to the 600 MHz band following its clearance from the 700 MHz band. Huawei stated its belief that TV should instead make use alternative means of distribution, e.g. IPTV using next generation access broadband connections. It emphasised its view that access to content is more important than the means of delivery. In contrast, BT said that DTT would need a minimum of six multiplexes, and that it saw the opportunity for additional temporary HD multiplexes to be provided or to use single frequency broadcast networks to increase capacity.

A1.33 PMSE and consumer group respondents were united in asserting that DTT should move to the 600 MHz band if it is cleared from the 700 MHz band. Shure felt that this move would mitigate the impact of clearance for DTT but not PMSE. PPDR respondents also supported migrating DTT to the 600 MHz band but noted, like respondents from other areas of the communications sector, that improving DTT technology will lead to greater spectral efficiency. Intellect, a trade body, emphasised the importance of maintaining the current number of DTT multiplexes as a minimum.

A1.34 However, BSkyB stated that our proposals were overprotective of DTT because there is no demand or business case for more SD or HD channels on DTT. It suggested that instead Ofcom could create an incentive structure to encourage DTT and other spectrum uses to work alongside each other in the 600 MHz band.

Views on short-term use of the 600MHz band (consultation questions 18 to 20)

A1.35 Most TV industry respondents thought that the 600 MHz band should be used for DTT to accelerate a transition to HD, DVB-T2 Multiplexes. The Multiplex operators proposed a low cost deployment with limited geographical coverage, to enhance Freeview's HD offering in the interim, before a wider transition to T2 of existing multiplexes takes place. [✂]. [✂], Freeview and the Multiplex operators noted the commercial obstacles to this proposal. They reasoned that the benefits of this move would mostly be to the facilitation of future 700 MHz band release, which in turn

would accrue to future 700MHz users. TV industry respondents that saw DTT migration to the 600 MHz band as a precondition for clearance of the 700 MHz band, were also of the view that any interim uses of the 600 MHz band should not impede this later migration. They also stated the view that WSD should only use interleaved spectrum.

A1.36 Vodafone expressed the view that the value to be gained from interim uses of the 600 MHz is likely to be small and that Ofcom should concentrate on plans longer term.

A1.37 Various other respondents argued in favour of interim uses that favoured their own area of specialisation. WSD respondents stated that Ofcom should allow WSD interim use of the 600 MHz band on an unlicensed basis. Some respondents made more specific suggestions and proposals: Cambridge Consortium and BT suggested that WSD could operate alongside DTT, in interleaved spectrum, relying on a geolocation database to avoid interference issues. BT also asked that we consider allowing temporary DTT multiplexes in the 600 MHz band to provide HD content and encourage migration to DVB-T2. BSkyB responded that the best option in their opinion would be to give WSD access to a contiguous block of spectrum, to help kick-start the WSD market. Weightless suggested that a "light licensing" approach could have benefits, for example for smart payments or machine-to-machine services.

A1.38 Conversely, Truelight Sound, Light and Vision, a PMSE respondent, suggested retaining the 600 MHz band for DTT with PMSE able to operate in the interleaved spectrum. It and other PMSE respondents felt that there should be no WSD in this spectrum because of interference problems.

A1.39 [✂].

A1.40 The respondents from other areas of the communications sector who addressed this question said that the 600 MHz band should be made available to WSD on an interim basis. However Intellect stressed that that this interim usage should not compromise its use for licensed DTT services. Samsung suggested using the 600 MHz band to facilitate DTT migration out of the 700 MHz band. BSkyB said that it would not support an auction for short-term use of the band and instead it emphasised what it saw as the importance of unlicensed spectrum use, for example as an innovation reserve.

Wider impacts of changing the use of the 700MHz band and areas of future work (consultation questions 21 to 23)

A1.41 The Multiplex Operators underlined that a future UHF transition is likely to be a complicated and costly task. They took the view that any future replan should take place with no undue costs for consumers or existing spectrum licencees, the legal rights of which should be respected. In particular, they highlighted that future aerial changes should be funded for all households using DTT, including those relying on it only for their secondary TV feed. [✂]. Freeview underlined that any change of use at 700 MHz should be accompanied by appropriate moves to protect television consumers from losing access to free-to-air television content, as well as safeguarding their expectations for an evolving and improving level of service. Channel 5 believed Ofcom should consider in detail the potential implications for consumers of transitions to new DTT technology standards, and that all

broadcasters involved in DTT, and not just the Multiplex Operators, should be consulted as part of future plans for a UHF transition.

A1.42 Most respondents from the mobile sector were of the view that a future release of the 700 MHz band can be achieved with minimal disruption and associated costs through appropriate preparatory actions, and agreed with Ofcom's proposed next steps. Everything Everywhere took the view that Ofcom should not delay taking a definitive decision on the future release of the 700 MHz band, without waiting for further international developments (e.g. WRC 2015).

A1.43 Respondents from the PMSE sector were sceptical that any future replan of UHF bands IV and V could be implemented with limited disruption to PMSE services. BEIRG took the view that further work on the coexistence between PMSE and WSDs should be conducted and called on Ofcom to investigate the possibility of a long-term home for PMSE.

A1.44 The Consumer Panel drew attention to potential future sources of consumer disruption, including aerial changes and new coexistence issues, and highlighted the need of implementing early a clear communications strategy.

Annex 2

Simulations of TVWS availability under different 600 MHz scenarios

A2.1 In an addendum to its consultation response, Sky suggested that a dedicated exclusive use of the 600 MHz band for WSDs could help encourage the development of this fledgling industry by providing manufacturers and service providers with greater flexibility over how WSD technology can be implemented. In particular, they suggested that such an approach might enable WSDs to operate at higher power levels and with wider channels using contiguous spectrum blocks, compared to a case where they share spectrum with other licensed services such as DTT.

A2.2 In light of this proposal, we commissioned a technical study of the total amount of UHF spectrum available to WSDs under different scenarios for the short term use of the 600 MHz band. These simulations were made for both single 8 MHz WSD channels, and contiguous blocks of channels.

A2.3 The technical simulations were made using a modelling tool developed by the BBC[69], with input DTT network parameters provided by Arqiva. We commissioned an independent technical audit of this modelling approach[70]. This found that the methods and assumptions described in the implementation specification of the BBC model are largely consistent with those defined by Ofcom for their TV White Spaces Study in all by two minor areas that we do not expect to have a material effect on the results.

A2.4 The results from these simulations should only be considered as indicative. This is because:

- The technical parameters needed to ensure that WSDs do not interfere with DTT services are still under development. Varying these parameters will affect the predictions of White Space availability. We expect work on these parameters to continue into 2013.
- The level of interference protection that needs to be provided to DTT services is dependent on the choice of WSD technology. The current simulations have been made for a range of different WSD technology approaches.
- The modelling tool only takes account of the need to protect DTT and not PMSE equipment from WSD interference. The need to protect PMSE services could

[69] The BBC model is the only tool currently available to model white space availability at a range of WSD powers and channel widths. This modelling tool uses essentially the same methodology and the reference geometry currently being used in the TV white spaces working group chaired by Ofcom. The methodology underlying the modelling tool has also undergone peer review in this working group. The modelling tool is still under development and further details are provided in the BBC report published alongside this statement at http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/statement/BBC_Arqiva_preliminary.pdf

[70] See http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/statement/Real_Wireless_audit.pdf

have a material impact on availability of white space spectrum in areas where there is intensive PMSE use. The technical parameters for protection of PMSE equipment are still under discussion in relevant industry working groups chaired by Ofcom, as part of wider white-space regulatory development activities.

Effects of 600 MHz use on single channel availability of white-space spectrum

A2.5 The technical simulations we commissioned were made for three scenarios for the shorter term use of the 600 MHz band:

- *Scenario 1:* The 600 MHz band remains unused and is not included on the list of available WSD frequencies.
- *Scenario 2:* The 600 MHz band is reserved exclusively for WSDs.
- *Scenario 3:* The 600 MHz band is shared by both DTT and WSDs.

A2.6 To test the sensitivity of TVWS spectrum availability to WSD technology choice, the results for these scenarios are shown for three different potential WSD technologies:

a) WiMAX use based on the current technical parameters for protection assumptions as used in the TV white spaces working groups chaired by Ofcom. This gives a likely lower case estimate of TVWS spectrum availability as this technology has greater DTT protection requirements.

b) WiFi use based on current technical parameter protection assumptions. This gives a likely mid-case estimate of TVWS availability as this technology has lower DTT protection requirements.

c) A 'improved WiFi case' scenario based on optimistic technical parameter assumptions for the protection that needs to be provided to DTT receivers operating more than nine 8 MHz channels away from WSDs. This gives a likely upper case estimate of TVWS spectrum availability taking into account potential future technical WSD improvements.

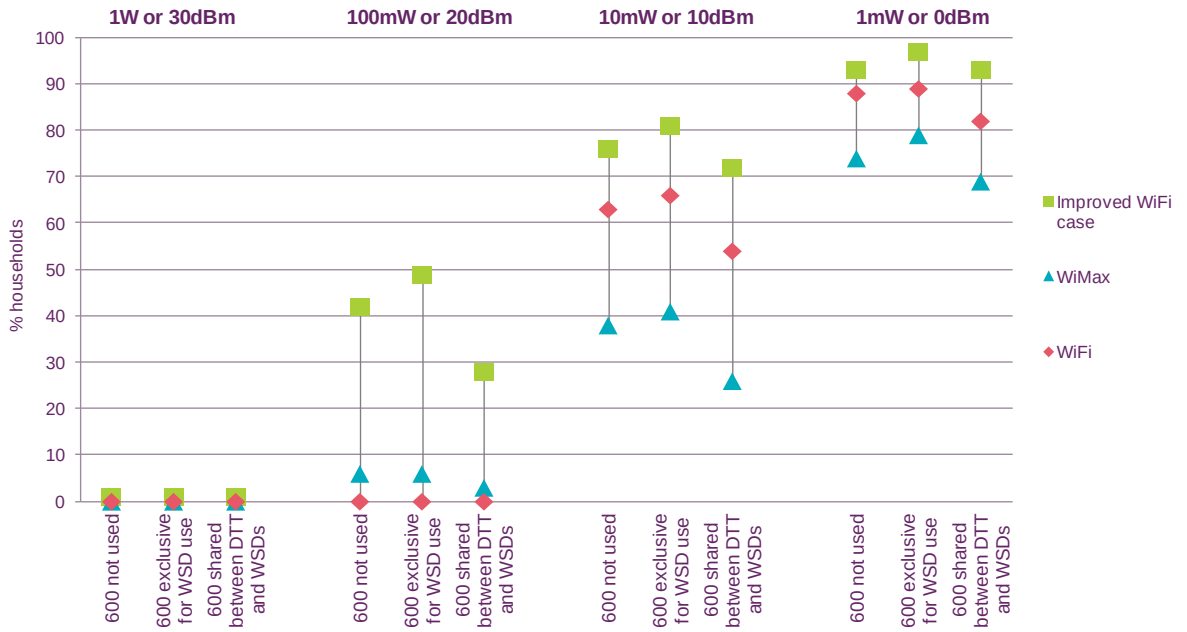
A2.7 The simulation results show the amount of WSD spectrum available for devices operating at the following power levels: 1 watt or 30 dBm, 100 mW or 20 dBm, 10 mW or 10 dBm, 1 mW or 0dBm.

A2.8 Operation at different power levels may be more suited to different kinds of applications. Higher power levels may be more suited to applications aimed at delivering data services with wide area coverage (or over longer distances) and larger data capacity requirements. Lower power levels could instead be more suited for applications with lower data capacity requirements and/or transmissions over shorter distances, e.g. in-home smart metering applications or machine-to-machine communications. By way of reference, Wi-Fi operates at approximately 17 dBm at 2.4 GHz, but the favourable propagation characteristics of lower frequency spectrum imply that similar coverage levels could be achieved with power levels at 10 dBm or below for devices operating in UHF bands IV and V.

A2.9 In figure 8 we have plotted the simulation results for: different WSD technologies, different WSD power levels and different scenarios for the use of the 600 MHz spectrum. These results show the proportion of households with access to at least 48 MHz of TVWS spectrum distributed in single 8 MHz channel blocks.

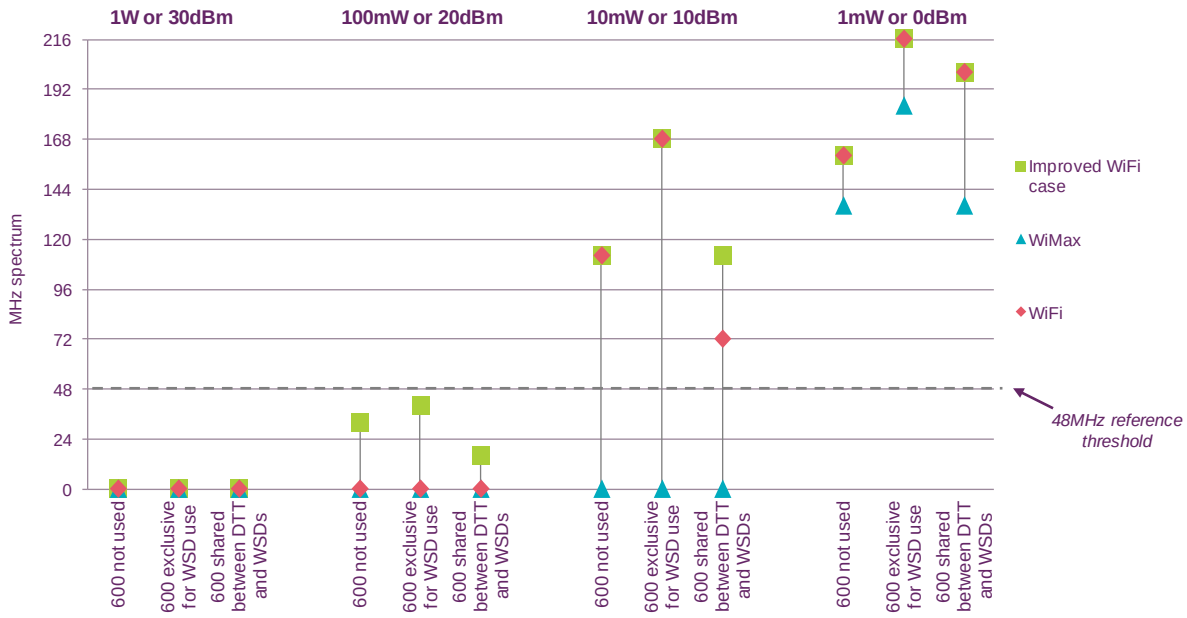
A2.10 In figure 9 we have plotted the total amount of TVWS spectrum that could be provided to 50% of households. In this graph, we show by way of reference when the total TVWS spectrum reaches an availability threshold of 48 MHz. Similarly, in figure 10 we illustrate results for the availability of TVWS spectrum in locations covering 70% of households.

Figure 8 – Proportion of households with at least 48 MHz TVWS available – single 8 MHz channel blocks



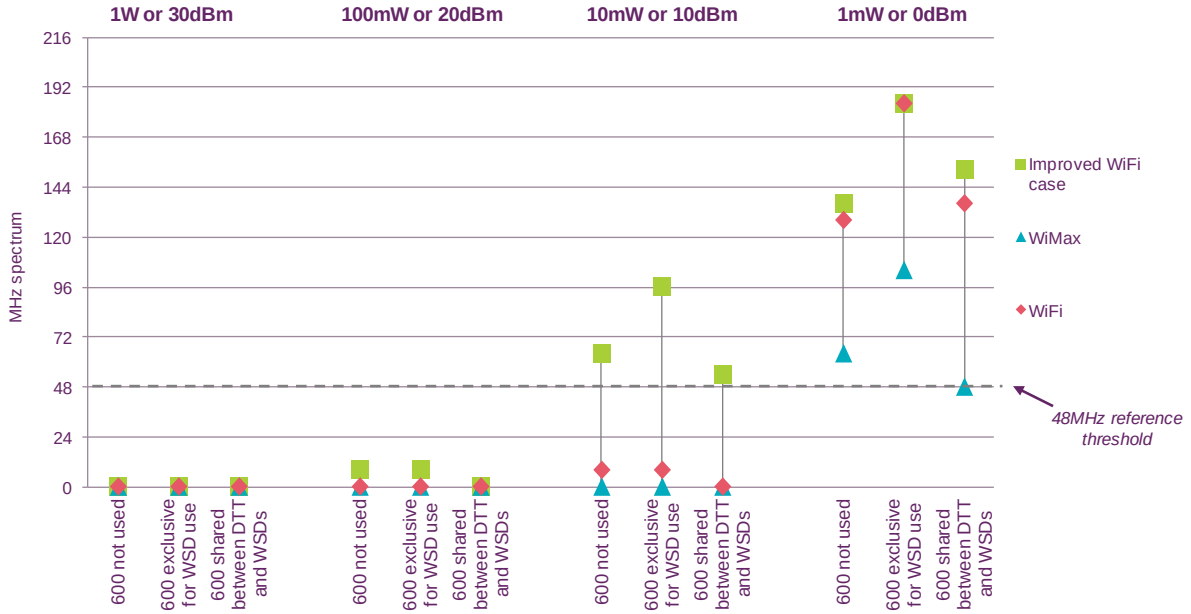
Source: Ofcom illustration of BBC / Arqiva preliminary modelling results

Figure 9 – Amount of TVWS available in 50% of households – single 8 MHz channels



Source: Ofcom illustration of BBC / Arqiva preliminary modelling results

Figure 10 – Amount of TVWS available in 70% of households – single 8 MHz channels



Source: Ofcom illustration of BBC / Arqiva modelling results

A2.11 These results indicate that:

- There is a strong correlation between the amount of white spectrum available and WSD technology used. WSD technical improvements aimed at providing better coexistence between WSDs and DTT receivers are likely to have a strong positive impact on the amount of white-space spectrum available. This impact could be more significant than that which could be achieved by an exclusive reservation of the 600 MHz band for WSD use. We note that in many of the combinations of variables examined, the sensitivity to technology choices appears greater than the increment in TVWS spectrum derived from a reservation of the 600 MHz band. These technical improvements could theoretically be achieved by changes to the WSD transmission technology, or changes to the design of the DTT receivers to reduce their susceptibility to interference (or both). We note that opportunities for technical improvements may be greater for WSD transmissions, as these technologies are still under development. In contrast there is a large volume of DTT receiver equipment already in use.

- The opportunity of operating devices at high power levels is constrained regardless of whether the 600 MHz band is reserved for WSDs. In all three of the figures above, the availability of TVWS spectrum for devices operating at 1 watt or 30 dBm is negligible. In addition, as shown in figures 9 and 10, reserving the 600 MHz band for exclusive use by WSDs would provide only a limited increase in the opportunity to operate WSDs at 100mW or 20 dBm in a material proportion of UK locations. The likely reason for these constrains is that the need to protect existing DTT services outside the 600 MHz band from WSD interference is an important limiting factor on the ability of WSDs to operate at higher powers.

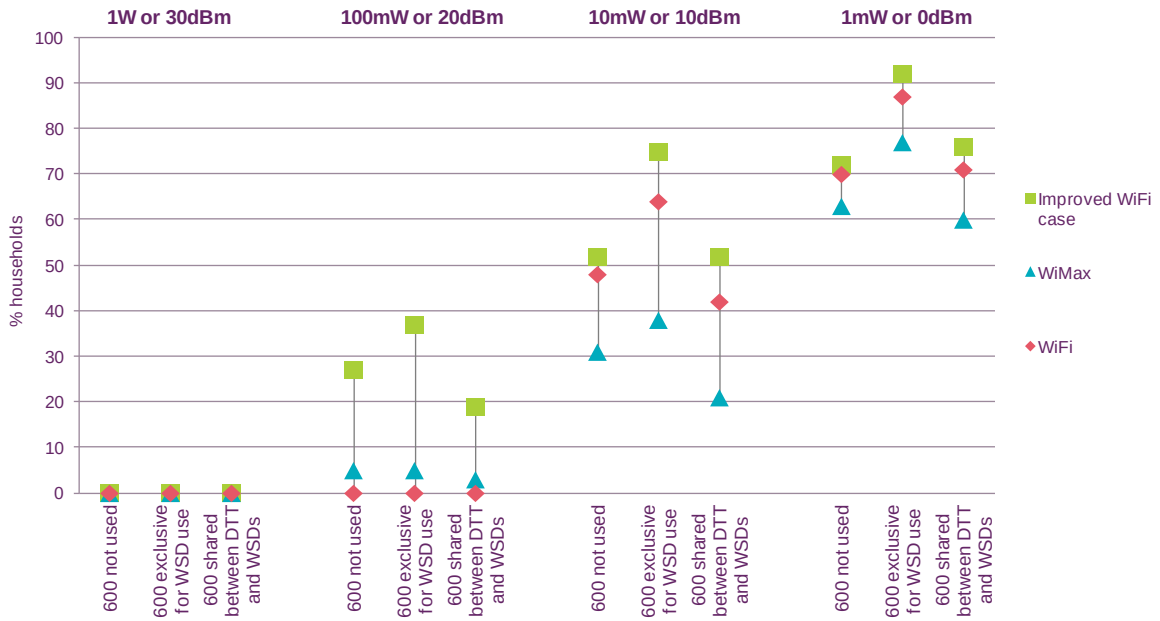
- The operation of DTT services in the 600 MHz band could cause a limited reduction in TVWS availability if compared against a case in which the 600 MHz band remains completely fallow. A likely reason for this is that additional DTT services in the 600 MHz band would create additional protection requirements,

causing incremental constraints to TVWS availability in some areas. However, we do not consider a scenario in which the 600 MHz band remains completely fallow as a realistic counterfactual. In practice, a more appropriate counterfactual might be a scenario in which the 600 MHz band is allocated in block to DTT or other services requiring protection from WSDs, and no interleaved spectrum made available for WSDs. In these circumstances, we would expect TVWS availability to be lower than in the shared DTT / WSDs scenario.

Effects of 600 MHz use on the availability of contiguous blocks of white-space spectrum

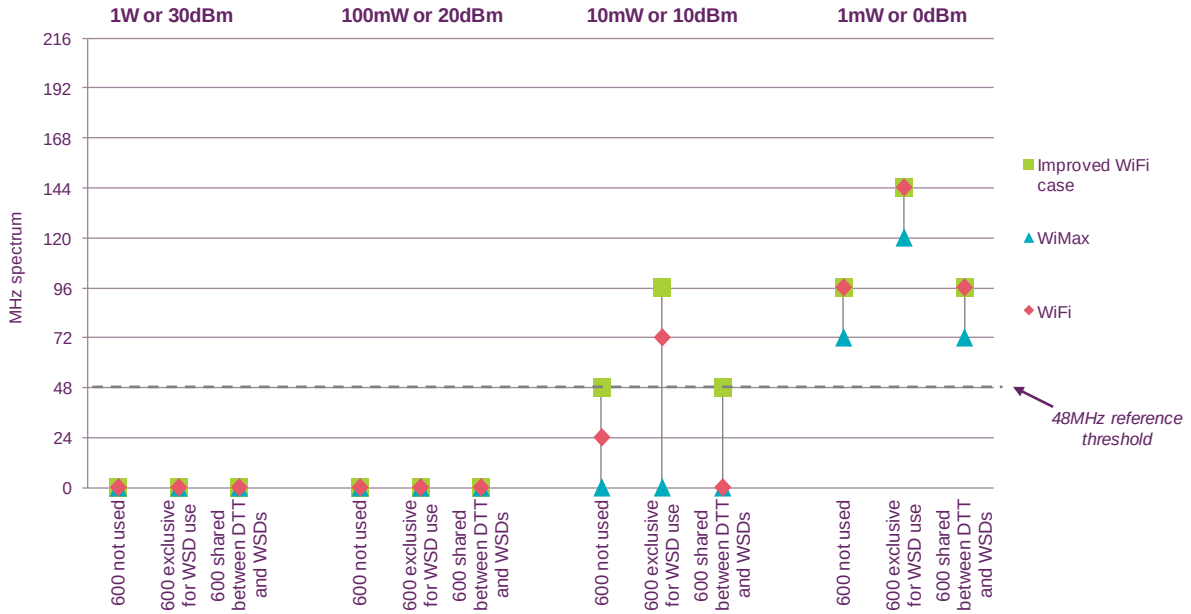
A2.12 Figures 11, 12 and 13 show the simulation results for contiguous WSD frequency channel availability for the same scenarios for 600 MHz use and the same WSD technology assumptions used above. This analysis is based on aggregate WSD block sizes of 24 MHz (i.e. three 8 MHz channels), and increments in TVWS availability are considered only in whole multiples of 24 MHz – i.e. considering only full blocks o three 8 MHz channels.

Figure 11 - Proportion of households with at least 48MHz TVWS available in contiguous blocks of three 8 MHz channels



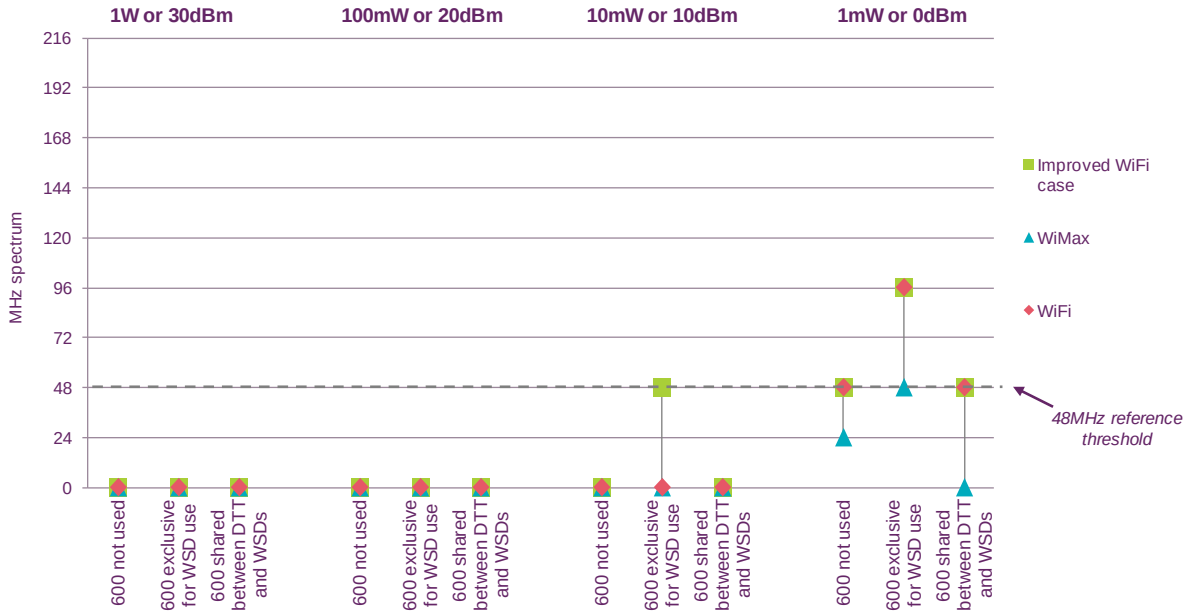
Source: Ofcom illustration of BBC / Arqiva preliminary modelling results

Figure 12 - Amount of TVWS available in 50% of households – contiguous blocks of three 8 MHz channels



Source: Ofcom illustration of BBC / Arqiva preliminary modelling results

Figure 13 - Amount of TVWS available in 70% of households – contiguous blocks of three 8 MHz channels



Source: Ofcom illustration of BBC / Arqiva preliminary modelling results

A2.13 These results indicate that the effect that a reservation of the 600 MHz band could have on the availability of white-space spectrum in contiguous blocks tends to be a little less susceptible to the choice of WSD technology than for single channel WSD availability.

A2.14 However, the opportunities of operating high-power WSD devices using contiguous blocks of spectrum in a significant number of locations remains highly constrained

regardless of how the 600MHz band is used (figures 13 and 14). The ability to use of three contiguous 8 MHz channels would, in theory, enable the operation of devices using channel widths that are comparable to those used in LTE transmissions (20MHz). To fully exploit the opportunity or providing wide-area LTE-like services using contiguous spectrum blocks, WSDs would need to operate at higher power than those operating with narrower channel widths. However, these simulations suggest opportunity for this could be severely constrained regardless of whether the 600 MHz is exclusively reserved for WSDs.

Expected changes to coexistence parameters between WSDs and other services could materially affect TVWS availability across all scenarios

A2.15 The technical parameters governing coexistence between WSDs and DTT, and WSDs and PMSE are the subject of ongoing discussions as part of TVWS industry working groups. Changes in such parameters could materially affect white space spectrum availability across UHF band IV and V. For example, a relaxation of DTT protection parameters is likely to lead to an increase of white-space availability in all scenarios, but it is unclear as to whether the differential between 600 MHz exclusivity and other scenarios would expand or reduce. The introduction of protection requirements for PMSE would also have a material impact on white-space availability, most probably reducing it under all scenarios in specific locations of intensive PMSE use (e.g. central London).

A2.16 We expect that technical protection parameters will not be finalised until several months into 2013, after the completion of relevant technical working group discussions.

Annex 3

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 has 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 completed 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.

Geographic interleaved spectrum The unused frequencies within an MFN which can be used at lower transmitter powers by other non-interfering users including PMSE and local TV. (See MFN entry below).

GHz Gigahertz.

H264/AVC A video compression standard which is part of most MPEG-4 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, such as that used by the DTT platform.

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. MPEG-4 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.

Mux See multiplex.

NI Mux A multiplex which provides Republic of Ireland television services in Northern Ireland, and which shares DTT spectrum on a geographic interleaved basis.

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 applications 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.

TVWS TV white spaces. Refers to spectrum available for use by white-space devices (WSDs)

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