



# Decision to make the 700 MHz band available for mobile data - statement

Statement

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# About this document

This document sets out our decision to make spectrum in the 700 MHz band available for mobile data use. It follows the consultation document which we published in May 2014. We present our assessment of the costs and benefits of this decision and explain why, having taken consultation responses into account, we expect the benefits will substantially outweigh the costs.

Enabling the 700 MHz band to be used for mobile data will allow mobile networks to provide better performance at a lower cost, which will bring considerable benefits to citizens and consumers.

However, there will also be costs of enabling the change: digital terrestrial television (DTT) and wireless communication for theatrical, musical and sporting events ('PMSE' services) currently use the 700 MHz band as well as other frequencies. DTT provides UK viewers with high quality free to view television and PMSE underpins many important cultural and social activities. The change will involve moving parts of these services from the 700 MHz band to other frequencies.

We intend to ensure that the change occurs in a way that safeguards the important benefits that DTT and PMSE services deliver to citizens and consumers. The document explains how it will be possible to make the 700 MHz band available for mobile data use without compromising the benefits provided by DTT or PMSE, and without causing significant disruption to viewers. Viewers will not need to take any action as a result of this change until around 2019. For the vast majority of TV viewers the only impact of this decision will be that they need to retune their televisions.

Our objective is to make the band available for mobile by the start of 2022 and sooner if possible. Given the substantial amount of effort that will be required to give effect to this decision, we will begin implementation work immediately. There will be a number of strands to our work on implementation, involving significant engagement with DTT providers, PMSE stakeholders, Government and representatives of TV viewers. We are also discussing the question of public funding with Government.

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## Section 1

# Executive Summary

## **We have decided to make the 700 MHz band available for mobile data use**

- 1.1 Consumers use mobile data services for a range of business and leisure activities, from working remotely to watching films and using social media on tablets or smartphones. Consumer demand for mobile data is growing rapidly. We expect it to continue doing so for the foreseeable future. Mobile network operators (MNOs) will be able to meet some of this increase in demand by deploying more base stations and using more efficient technology on their networks. However, if they are to meet the increase in demand efficiently they will also need access to more spectrum.
- 1.2 Consumers value mobile data highly.<sup>1</sup> Therefore planning for mobile data spectrum requirements is a major focus of work for Ofcom. As part of our work in this area, we have conducted a cost benefit analysis (CBA) assessing the case for making a valuable portion of spectrum known as the 700 MHz band available for mobile data use.
- 1.3 In May 2014 we published a consultation document setting out our provisional CBA and proposing to make the 700 MHz band available for mobile data. Having considered responses to the consultation document, we have updated our analysis and decided to go ahead with this proposal. This statement explains why we have taken this decision and sets out our objective to enable change of use as soon as possible.
- 1.4 The UK is not alone in proposing this change. Many other countries around the world already use or plan to use the 700 MHz band for mobile data. We expect the majority of European states to make the band available for this purpose over the coming years.

## **We can deliver this change in a manner which safeguards DTT and PMSE**

- 1.5 The 700 MHz band is currently used to deliver Digital Terrestrial Television (DTT) services, and is a substantial portion of the spectrum used for that purpose. In addition, many wireless microphones used at events such as concerts and theatre performances ('audio PMSE' devices) also transmit in the 700 MHz band. Making the band available for mobile data will mean that DTT and audio PMSE services can no longer use this spectrum.
- 1.6 DTT plays an important role in providing low cost near-universal access to public service TV channels and in sustaining viewer choice. As we explained in our recent discussion document, *The Future of Free to View TV*,<sup>2</sup> we believe DTT is likely to retain this central role over the next decade, with a full switch to alternative

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<sup>1</sup> Consumer research, commissioned for our UHF strategy consultation, showed that 73% of consumers would be willing to pay £10 a month more for improved mobile coverage and more data capacity.

<sup>2</sup> <http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/discussion/ftv.pdf>

technologies such as Internet Protocol Television ('IPTV') not appearing likely in the UK until at least 2030.

- 1.7 We intend to ensure that reducing the spectrum available to DTT does not materially affect coverage or channel line-up and that we avoid any significant disruption to viewers. Our analysis indicates that we will be able to accomplish this.
- 1.8 The concerts and performances which rely on audio PMSE devices make an important contribution to the creative economy and cultural life of the UK. Just as we wish to safeguard DTT, so we will aim to ensure that PMSE users have access to the spectrum they need to continue staging these events without materially compromising production values. We are confident that we will be able to achieve this objective.

### **We estimate the change will deliver benefits to the UK of at least £900m-1.3bn**

- 1.9 The analytical framework we have used for considering the case for change of use of the 700 MHz band is to assess whether the benefits of the change would exceed the sum of: (1) the costs of making the change; and (2) the opportunity cost of existing users losing access to the band.
- 1.10 The 700 MHz band is especially valuable for the delivery of mobile data services for two reasons:
  - 1.10.1 First, signals transmitted at these frequencies reach further and pass through walls and other obstructions more easily than signals transmitted at higher frequencies. This makes it particularly well suited to improving the quality of coverage in rural areas;
  - 1.10.2 Second, many countries across the world already use or plan to use the band for mobile data. This creates scope for economies of scale in the manufacture of equipment (e.g. mobile handsets) designed to operate at these frequencies.
- 1.11 Access to the 700 MHz band will enable MNOs to meet increases in demand for mobile data at a lower cost than would otherwise have been the case. It will also enable them to improve mobile data speeds indoors and in rural areas more cheaply than they otherwise would have. We expect competition in the market to result in a significant proportion of these benefits being passed on to consumers through lower prices and better quality mobile data services.<sup>3</sup>
- 1.12 We estimate the value of these benefits to be between £900m - 1.3bn. Our analysis indicates that the benefits will be greater the sooner change happens, as earlier access to spectrum will enable MNOs to meet consumer demand more efficiently.
- 1.13 In addition, there are a number of further benefits that we cannot quantify reliably. For example, if combined with a coverage obligation (e.g. an obligation targeting specific geographical locations such as A roads and/or train lines), release of the 700 MHz band could enable improvements in mobile coverage beyond today's levels. We have already imposed a stretching coverage obligation in one of the 800 MHz licences, but 700 MHz release would give us an important opportunity to go even further. The 700 MHz band could also play a role in the delivery of the next

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<sup>3</sup> To the extent that the value of the spectrum to MNOs is not captured by auction revenues.

generation of emergency services communications and potentially support the development of new services and technologies for consumers.

## **We estimate that the economic cost of change will be between £550m - 660m**

- 1.14 Set against these benefits, change of use of the 700 MHz band will have a number of costs:
  - 1.14.1 It will entail an extensive programme of modifications to DTT transmission infrastructure.
  - 1.14.2 For the vast majority of viewers the only impact will be that they need to retune their televisions. However, a small proportion (ca. 100,000 DTT households) will need to replace their aerials and in a very small number of cases viewers might need to fit a filter to their televisions to prevent mobile phone signals from interfering with TV reception.
  - 1.14.3 Many audio PMSE users will need to replace equipment to operate in different frequencies. Some may also need to alter some of their working practices and recruit or train more RF engineers as a result of the change.
- 1.15 The change will also have an opportunity cost reflecting the value of the spectrum lost for existing users. We have sought to capture this in our analysis and it accounts for around 17% of the total costs.
- 1.16 In our consultation document, we estimated that the economic costs of the change would amount to between £470m - 580m. We have adjusted this estimate in the light of evidence provided in responses to our consultation document. We now estimate the total economic costs of the change at between £550m - 660m. The increase is due to a number of revisions to our estimates. The most important of these – accounting for around three-quarters of the £80m increase – was made because of evidence from stakeholders that some affected DTT equipment has a much longer asset life than we originally estimated, and so would not have been replaced for many years absent a change of use of the 700 MHz band.
- 1.17 The full cash costs of the change (excluding opportunity costs and the value of time to retune TVs) amount to £430m-520m (2014 real terms).
- 1.18 In the light of our cost benefit analysis, we consider that change of use of the 700 MHz band is in the best interests of UK citizens and consumers and we have therefore decided to go ahead with the change. We will give effect to this decision in due course by varying the multiplex operators' licences and issuing notice for PMSE users to clear the band.

## **The benefits will be greater with early change of use**

- 1.19 We expect that the net benefits will be greater the sooner the change happens. Our objective is therefore to make the band available for mobile data as soon as practicably possible. There are a number of factors which could influence the timing of change, including the speed with which it is possible to modify DTT transmission infrastructure and the speed of progress with international frequency planning negotiations. At this stage there is still too much uncertainty about some of these factors for us to commit to a specific implementation timetable. However, we believe

that from a technical perspective it should be possible to release the 700 MHz band across the UK by the beginning of 2022, and potentially sooner.

- 1.20 If the programme were to complete in early 2022 we would expect that some viewers would need to start retuning TVs and replacing aerials in 2018 or 2019 and that some PMSE users to need to start replacing equipment that operates in the 700 MHz band at some point from 2019.

## **We will now commence detailed implementation work**

- 1.21 We will now move on to develop a detailed plan for implementing the changes.
- 1.22 Because radio waves travel across borders, many aspects of spectrum use require international agreement. We will therefore need to conclude a range of international spectrum planning agreements in order to make the 700 MHz band available for mobile data. Over the coming years we will devote a significant amount of energy to engaging in international frequency planning discussions and securing these agreements.
- 1.23 In parallel, we will work closely with broadcast stakeholders to prepare for and implement the modifications to DTT transmission infrastructure that are part of this programme.
- 1.24 Over the coming months and years we will also work with Government, industry and consumer groups to put in place appropriate measures to support viewers during the transition process.
- 1.25 In the meantime, there are a number of pre-emptive steps industry can take now to reduce future disruption to TV viewers. Industry bodies such as the Confederation of Aerial Industries (CAI) and the Digital Television Group (DTG) already advise aerial installers to sell customers aerials that will still be capable of receiving TV signals following the spectrum re-plan.
- 1.26 We are liaising with a number of industry bodies to ensure that:
  - 1.26.1 new TVs coming onto the market are as resilient as possible to interference from mobile phone signals;
  - 1.26.2 new TVs are designed in such a way as to make retuning simple for viewers; and
  - 1.26.3 mobile phone manufacturers design devices so as to minimise the risk of causing interference to TV reception.
- 1.27 Last year we initiated a strategic review of PMSE's long term spectrum requirements. This review will continue to be a priority for us and we expect to confirm in the summer of 2015 what spectrum audio PMSE devices will be able to use following change of use of the 700 MHz band.
- 1.28 In due course, we expect to design and hold an auction for the 700 MHz band. We currently consider it likely that we will hold this auction up to 2 years before the spectrum starts to become available. Holding the auction some time in advance of spectrum becoming available will give MNOs early certainty as to their future spectrum holdings. This will enable them to plan network investment more efficiently.

## Funding the costs of change

- 1.29 This document sets out the rationale for our spectrum management decision. In our May consultation document we recognised that change of use would impose costs on industry and consumers and set out an initial discussion of the way in which those costs might be funded. The responses to our consultation document from broadcasting and audio PMSE stakeholders argued that they should be compensated for any costs imposed on them by the change and that consumers should be protected.
- 1.30 In the analysis set out here we do not take a view on the way in which the costs of change are funded. In particular, any decisions on public funding are a matter for the Government. In this context, the Government has previously made clear its commitment to investment in spectrum clearance to support the availability of additional 4G spectrum<sup>4</sup> and as a consequence, we have funding in place to support implementation work to the end of 2015/16. We are discussing longer term funding arrangements with Government.

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<sup>4</sup> HMT, *Investing in Britain's Future*, 27 June 2013, <https://www.gov.uk/government/publications/investing-in-britains-future>, paragraphs 7.13-7.15.

**Table 1: Estimated costs and benefits of making the 700 MHz band available for mobile data<sup>5</sup> in 2014 NPV**

	Benefits of change		Costs of change	
Elements that we have quantified	Improvement in the performance that mobile users would experience particularly in rural areas and deep indoors	£390m-480m	DTT infrastructure modifications (including programme management costs, local TV replanning)	£420m-470m <i>(estimate in consultation: £350m-400m)</i>
			Consumer information scheme	£25m
	Reduction in costs of meeting increased demand for mobile data capacity from having to build and to operate fewer network sites	£480m-770m	Consumer aerial replacements	£3m-6m
			Cost of consumer time retuning TVs	£7m-10m
			Coexistence costs	£0-20m
			PMSE equipment replacement (including decommissioning costs)	£13m - 21m <i>(estimate in consultation: £6m - 18m)</i>
			DTT loss of value net of operating cost savings	£80m-100m
Reductions in consumer prices: a significant proportion of these network cost savings would likely be passed on to consumers		PMSE upskilling costs	£10m-13m	
<b>Total:</b> £900m-1.3bn of quantified benefits		<b>Total:</b> £550m-660m with potential for reduction as better information becomes available <b><i>(Estimate in consultation: £470m - 580m)</i></b>		
Elements that cannot be reliably quantified	Broader economic and social benefits from potential improvements in coverage if a 700 MHz award included a coverage obligation		WSD opportunity cost: current uncertainty over the deployment and take-up of WSDs does not support quantification and the change would be unlikely to have a material negative impact on white space availability overall	
	Use of centre gap: additional benefits would materialise, with several candidate uses but likely value uncertain			
	Access to new services: magnitude of benefits unclear. Could be very large, but could be zero			

<sup>5</sup> Costs ranging above £50m are rounded to the nearest £10m; costs do not sum to the total costs shown due to rounding.

	Increases in capacity for delivery of emergency services communications: magnitude of benefits unclear.	
	<b>Effect of unquantified benefits:</b> potential for significant upside over and above the quantified benefits	<b>Effect of unquantified costs:</b> not material to total costs

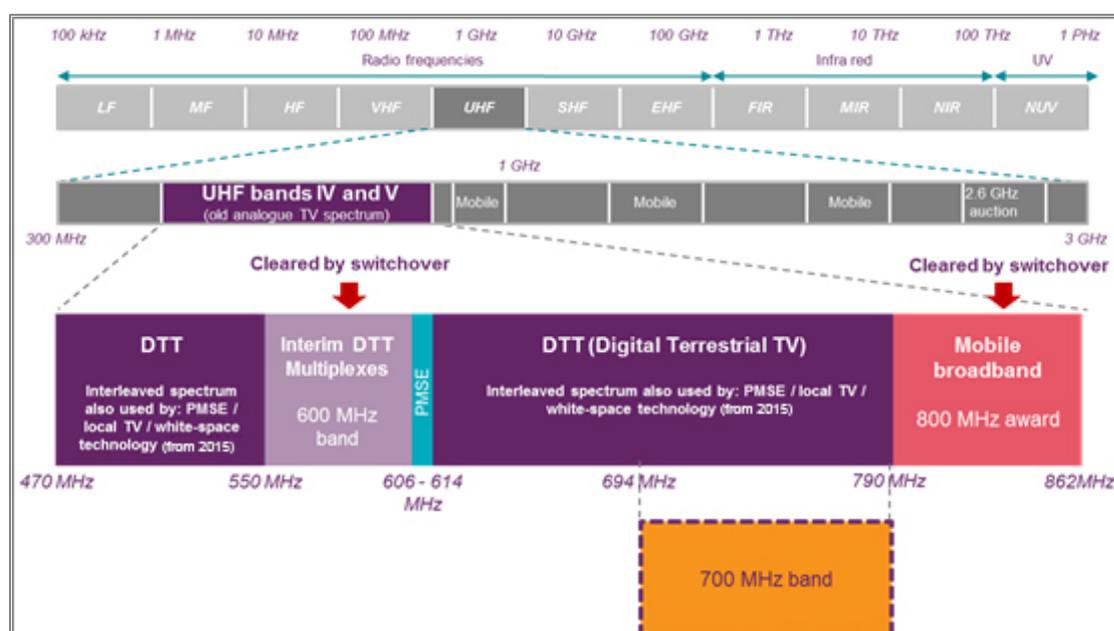
## Section 2

# Introduction

## This statement sets out our decision to make the 700 MHz band available for mobile broadband

- 2.1 As figure 1 shows, DTT and audio PMSE services currently use spectrum with frequencies between 470 MHz - 790 MHz. From 2015 onwards we expect white space devices (WSDs) will also be permitted to do so.<sup>6</sup> We have conducted a Cost Benefit Analysis (CBA) assessing the case for changing how part of this spectrum is used and re-allocating the frequencies between 694 MHz - 790 MHz (the '700 MHz band') for mobile data. In May 2014 we published a consultation document which set out our provisional CBA. In the light of this provisional CBA, the consultation document proposed to change use of the 700 MHz band as soon as possible.

Figure 1: Spectrum allocation before and after the change



- 2.2 The consultation closed on 29 August 2014. We received 57 responses. Most respondents, including the majority of broadcasters, broadly accepted the case for change. The mobile sector, in particular, was strongly supportive. However, a number of respondents, most notably PMSE stakeholders, opposed our proposal.
- 2.3 A number of respondents disagreed with aspects of our CBA. Some respondents noted that there is significant uncertainty about future levels of demand for mobile data, and by extension about the scale of the benefits of the change. Broadcasting and PMSE stakeholders, in particular, argued that our analysis may have overstated the benefits of making the 700 MHz band available for mobile. Conversely, some mobile network operators (MNOs) argued that our analysis had understated the benefits of change.

<sup>6</sup> WSDs are innovative new devices which are able to identify and make use of previously unused gaps in frequency bands.

- 2.4 Stakeholders had a range of views on the costs of change. Broadcasting and PMSE stakeholders expressed the view that our consultation document may have understated the impact the change would have on them. Conversely, some MNOs suggested that we had overstated some aspects of the costs of change. We discuss the responses we received in more detail in the course of this document and in annex 1.
- 2.5 This statement sets out the conclusions on the costs and benefits of change of use of the 700 MHz band that we have reached after analysing these responses. It explains that we have decided to change use of the 700 MHz band as soon as possible. The document is structured as follows:
- 2.5.1 The remainder of this section describes the analytical framework we have used to consider the case for change of use of the 700 MHz band, and discusses the context in which we have considered the case for change;
  - 2.5.2 Section 3 sets out the legal framework;
  - 2.5.3 Section 4 outlines our assessment of the benefits of the change;
  - 2.5.4 Section 5 outlines our assessment of the impact the change would have on the DTT platform;
  - 2.5.5 Section 6 outlines our assessment of the impact the change would have on viewers;
  - 2.5.6 Section 7 outlines our assessment of the impact the change would have on PMSE;
  - 2.5.7 Section 8 sets out our decision on the future of the 700 MHz band and gives a brief overview of our plan for implementing this decision;
  - 2.5.8 Annex 1 summarises the consultation responses we received;
  - 2.5.9 Annex 2 summarises the costs of change and the changes we have made since the consultation document.

## Our analytical approach

- 2.6 Spectrum is a scarce resource. Consistent with our statutory duties, we wish to ensure that, in so far as possible, it is allocated in a manner that maximises citizens' and consumers' welfare.
- 2.7 The way we have approached the question of whether to change use of the 700 MHz band is therefore to consider whether the change would best serve the interests of citizens and consumers. To do so we have assessed whether the benefits of the change would exceed the sum of (1) the costs of change; and (2) the additional benefits which DTT, PMSE and WSDs could have delivered had they retained access to the band. For this analysis, we have:
- 2.7.1 **Sought to quantify the benefits over a 20 year period starting at the beginning of 2022.** We chose 2022 because we consider that from a technical perspective it should be possible to complete the change by this

date. However, there is a range of other factors which could influence the timing of change.<sup>7</sup>

- 2.7.2 **Taken into account the cost of bringing equipment replacement forward as opposed to the cash cost of the change.** The majority of the costs relate to the replacement of equipment that we assume would otherwise have been replaced at the end of its useful life (e.g. PMSE equipment and DTT transmission infrastructure). The cost of bringing equipment replacement forward, rather than the full cost of the equipment is therefore the economic cost that we have adopted for this CBA.
- 2.8 Given the timeframes we are considering, there is inevitably some uncertainty about the costs and benefits of change. In the face of this uncertainty, we have, in general, taken a cautious approach and tended to err on the side of making pessimistic assumptions about the size of the costs and benefits of change. There is therefore a reasonable probability that the costs might end up being lower than we estimate in this document and/or the benefits being higher.
- 2.9 We aim to implement the change in a manner which is compatible with the following objectives:
- 2.9.1 **Safeguarding the ongoing delivery of the benefits DTT provides.** DTT plays an important role in providing low cost near-universal access to public service TV channels and in sustaining viewer choice. We believe DTT is likely to retain this central role over the next decade, with a full switch to alternative technologies such as IPTV not appearing likely for the UK until at least 2030.<sup>8</sup> Safeguarding the ongoing delivery of the benefits DTT provides is therefore a priority for us. In section 5, we discuss in more detail what we will need to do to achieve this objective.
- 2.9.2 **Safeguarding the ongoing delivery of the benefits PMSE provides.** The concerts and performances which rely on audio PMSE devices make an important contribution to the creative economy and cultural life of the UK. Just as we wish to safeguard the benefits DTT provides, so we wish to ensure that the PMSE community is in a position to continue delivering the important benefits it provides today.
- 2.10 When assessing the costs of change, we have taken into account the costs of the measures that we will need to take in order to meet these objectives.

## Context and background

### Our analysis of the case for change of use of the 700 MHz band is part of our broader programme of work on mobile data

- 2.11 The widespread uptake of smartphones and tablets has led to dramatic growth in demand for mobile data services. For example, between March 2011 and June 2013 mobile data traffic increased by 221%. Forecasts of future levels of demand for mobile data vary. However, there is a broad consensus that demand will continue to

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<sup>7</sup> We have discounted all costs and benefits back to 2014 using the Spackman approach. We explain this method in *Discounting for CBAs involving private investment, but public benefit*, July 2012 <http://stakeholders.ofcom.org.uk/consultations/discounting-for-cbas/statement>

<sup>8</sup> We provide a fuller exposition of our views on the role DTT plays in *The Future of Free to View TV*, May 2014, <http://stakeholders.ofcom.org.uk/consultations/700MHz/ftv/>

grow rapidly for the foreseeable future. We have used Analysys Mason's forecast that by 2030 levels of mobile data traffic before WiFi off-load could be more than 45x greater than today as the basis for the analysis in this document.<sup>9</sup>

- 2.12 MNOs will be able to meet some of this increase in demand by deploying more base stations and using more efficient technology on their networks. However, if they are to meet the increase in demand efficiently they will also need access to more spectrum.
- 2.13 Our work on the 700 MHz band is a key part of our broader programme of work in this area. However, there are a number of other strands to our response to the challenges posed by the growth in demand for mobile data. These include:
  - 2.13.1 Awarding the 2.3 GHz and 3.4 GHz bands for mobile data use;<sup>10</sup>
  - 2.13.2 Exploring longer term opportunities to make further spectrum bands available for mobile data use, either on an exclusive or a shared basis.<sup>11</sup>

### **There is an important international dimension to the debate about the future of the 700 MHz band**

- 2.14 When thinking about whether a change of use of the 700 MHz band would serve the interests of UK citizens and consumers, we have been mindful of the broader international context. There are a number of strands to this.
- 2.15 First, part of the reason the band is potentially attractive as a source of mobile spectrum is that a wide range of countries across the globe have either committed to use it for mobile broadband or are in the process of doing so. For example, countries across Latin America and the Asia Pacific region have decided to make the 700 MHz band available for mobile data as have a number of European countries including France, Germany, Sweden and Finland. More countries in Europe are likely to follow suit. Earlier this year, the European Commission set up an advisory group involving senior broadcasting and mobile industry figures to report on a long term strategy for 470 MHz - 790 MHz in the EU. In September 2014 the chairman of this group, Pascal Lamy, produced a report recommending that all EU member states make the 700 MHz band available for mobile data use by no later than 2022.<sup>12</sup> The report also recommended that the 470 MHz -694 MHz band continue to be reserved for terrestrial broadcasting and PMSE until 2030, with an opportunity to review this recommendation in 2025. These international developments are important because mobile spectrum needs to be used internationally to provide the economies of scale required to ensure a wide availability of devices at reasonable cost.

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<sup>9</sup> These forecasts are different to those used in our ongoing work on setting mobile call termination rates for 2015/16-17/18 (<http://stakeholders.ofcom.org.uk/consultations/mobile-call-termination-14/>). This is because they take account of expected technological developments and new mobile spectrum supply over the modelling period. The "anchor pricing" approach we use for setting MCT rates models a current network based on the technology of the day with no further technological changes in the future and no changes in spectrum supply over the modelling period.

<sup>10</sup> For more information see <http://stakeholders.ofcom.org.uk/spectrum/public-sector-spectrum-release/>

<sup>11</sup> For more information see <http://stakeholders.ofcom.org.uk/consultations/mobile-data-strategy/>

<sup>12</sup> Lamy, Pascal, August 2014, *Results of the work of the High Level Group on the future use of the UHF band*, <http://ec.europa.eu/digital-agenda/en/news/report-results-work-high-level-group-future-use-uhf-band>

2.16 Second, we will need a number of international agreements to be in place before we can make the 700 MHz band available for mobile broadband. These include the following:

2.16.1 **The International Telecommunications Union (ITU)<sup>13</sup> will need to amend the radio regulations to confirm a co-primary allocation for mobile and broadcasting in the 700 MHz band in ITU region 1 (Europe, the Middle East and Africa):** The radio regulations are the rules which govern international use of spectrum and satellite orbits. The ITU reviews the regulations at World Radiocommunication Conferences (WRCs) which take place every three to four years. The latest WRC in 2012 (WRC-12) resulted in a decision to agree a co-primary allocation for mobile and broadcasting in the 700 MHz band in ITU region 1, subject to a number of studies on technical and regulatory conditions. Without this co-primary allocation, there would be significant international constraints on using the 700 MHz band for mobile services. The decision is expected to be implemented in the radio regulations at WRC-15, which will take place in November 2015. Ofcom takes the lead for the UK in WRC negotiations under direction from the Government. We are therefore actively engaged in UK, European and international preparations for WRC-15.

2.16.2 **Agreement of a DTT frequency plan:** We will need to agree a revised DTT frequency plan with neighbouring states in order to manage the impact of interference between services in different countries. We discuss this in more detail in section 5.

2.16.3 **Agreement of a mobile band plan:** The European Conference of Postal and Telecommunication Administrations (CEPT)<sup>14</sup> will need to agree a mobile band plan, stipulating how frequencies within the 700 MHz band can be used for mobile in European countries. CEPT has considered the options and has decided to move forward with a 2x30 MHz arrangement. As figure 2 demonstrates, this leaves a 25 MHz centre gap between the mobile uplink and the mobile downlink.<sup>15</sup> CEPT members are still considering options for use of the centre gap. We discuss potential uses of the centre gap in section 4.

**Figure 2: Future configuration of the 700 MHz band**



<sup>13</sup> The ITU is the United Nations' specialised agency for information and communication technologies. Among other things, it is responsible for the allocation of radio spectrum and satellite orbits.

<sup>14</sup> CEPT is the European regional organisation for postal and telecommunications issues. Membership is made up of the postal and telecommunications administrations of 48 European countries.

<sup>15</sup> The uplink is the portion of the spectrum mobile devices use to communicate with base stations. The downlink is the portion of the spectrum base stations use to communicate with mobile devices. The centre gap (sometimes referred to as the 'duplex gap' is the spectrum between the uplink and the downlink).

## **White space devices**

- 2.17 In our Consultation, we considered the potential impact change of use of the 700 MHz band would have on the deployment of white space devices (WSDs) in the UHF bands. We found that the impact would vary from region to region but that overall the change was unlikely to reduce availability of spectrum for WSDs. On this basis, we did not consider that there would be a material cost associated with changes in WSD spectrum availability.
- 2.18 We continue to progress our policy of allowing WSDs to access UHF spectrum. We plan to publish a statement on implementing TV White Spaces (TVWS) in 2015. Our further work on TVWS and consideration of the responses to our consultation document gives us no reason to change our assessment of the impact change of use of the 700 MHz band will have on WSDs. As a result, we do not consider this topic in any more detail in this document.

## **Decisions about funding the change are a matter for Government**

- 2.19 Broadcasting and PMSE stakeholders (including BEIRG, Digital UK, and Arqiva) argued strongly in their responses to our consultation that neither existing users of the 700 MHz band nor consumers should bear any of the costs of the change. Rather, they argued that either Government or the MNOs should pay for the change.
- 2.20 This document does not address the question of funding. It is for Government to decide whether to make public funding available to support this programme. We are discussing this question with Government at the moment, having regard to consultation responses and to our duties to citizens and consumers.

## Section 3

# Legal framework

- 3.1 In making the decisions set out in this statement, Ofcom acts within a framework defined by both EU and UK law. In the context of considering the future use of the 700 MHz band, Ofcom has specific duties and powers related to the management of radio spectrum.
- 3.2 More particularly, Ofcom has a number of general and specific statutory duties derived from the European regulatory framework, the Communications Act 2003, and the Wireless Telegraphy Act 2006. These Acts recognise that, on occasion, Ofcom will need to exercise its discretion in terms of the weight given to different considerations when taking decisions. Ofcom must also have regard to the rights and obligations of the UK as a matter of the UK's international obligations – for instance, in relation to spectrum arrangements with our international neighbours. In this regard Ofcom has been directed by the Government to represent UK interests in negotiations within the main spectrum-related institutions, including the International Telecommunications Union (ITU), the European Conference of Postal and Telecommunications Administrations (CEPT), and spectrum committees, of the European Union.
- 3.3 Article 8 of the Framework Directive (Directive 2002/21 – as amended) sets out the objectives that national regulatory authorities must take all steps to achieve. These include:
  - 3.3.1 the promotion of competition in the provision of electronic communications networks and services by, among other things, encouraging efficient investment in infrastructure and promoting innovation, and encouraging efficient use of radio frequencies; and
  - 3.3.2 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, encouraging the interoperability of pan-European services and ensuring that, in similar circumstances, there is no discrimination in the treatment of undertakings providing electronic communication networks and services.
- 3.4 Section 3(1) of the Communications Act 2003 sets out Ofcom's general duties, including its principal duty:
  - 3.4.1 to further the interests of citizens in relation to communications matters; and
  - 3.4.2 to further the interests of consumers in relevant markets, where appropriate by promoting competition.
- 3.5 Pursuant to this general duty, section 3(2) of the Communications Act provides that Ofcom is required in carrying out its functions to secure, among other things:
  - 3.5.1 the optimal use for wireless telegraphy of the electro-magnetic spectrum;
  - 3.5.2 the availability throughout the United Kingdom of a wide range of electronic communications services;

- 3.5.3 the availability throughout the United Kingdom of a wide range of television and radio services which (taken as a whole) are both of high quality and calculated to appeal to a variety of tastes and interests; and
- 3.5.4 the maintenance of sufficient plurality of providers of different television and radio services.
- 3.6 Section 3(3) of the Communications Act 2003 provides that, in performing its duties, Ofcom must have regard in all cases to the principles of transparency, accountability, proportionality and consistency, as well as ensuring that actions are targeted only at cases where they are needed.
- 3.7 Section 3(4) of the Communications Act 2003 requires that Ofcom has regard, in performing its duties to a range of factors, as appear to be relevant in the circumstances, including the desirability of:
  - 3.7.1 promoting the fulfilment of the purposes of public service television broadcasting in the United Kingdom;
  - 3.7.2 promoting competition in relevant markets;
  - 3.7.3 encouraging investment and innovation in relevant markets; and
  - 3.7.4 encouraging the availability and use of high speed data transfer services throughout the United Kingdom.
- 3.8 Section 3(4) also requires Ofcom to have regard to the different needs and interests of all persons who may wish to use the electro-magnetic spectrum for wireless telegraphy.
- 3.9 Section 4 of the Communications Act requires Ofcom to act in accordance with the six Community requirements. These requirements give effect to the requirements of Article 8 of the Framework Directive.
- 3.10 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:
  - 3.10.1 the extent to which the electromagnetic spectrum is available for use, or further use, for wireless telegraphy;
  - 3.10.2 the demand for use of the spectrum for wireless telegraphy; and
  - 3.10.3 the demand that is likely to arise in future for the use of spectrum for wireless telegraphy.
- 3.11 Section 3(2) of the Wireless Telegraphy Act 2006 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.
- 3.12 Taking into account each of the above duties, we consider that our principal duty to further the interests of citizens and consumers, where appropriate by promoting competition, is of particular importance in considering the future use of the 700 MHz

band. Moreover, we consider that our duties relating to the following are particularly relevant in this context:

- 3.12.1 securing the optimal use of spectrum taking into account current and future demand;
- 3.12.2 the desirability of encouraging investment and innovation in relevant markets;
- 3.12.3 the desirability of encouraging the availability and use of high speed data transfer services throughout the United Kingdom;
- 3.12.4 the need to have regard to the different needs and interests of all persons who may wish to make use of spectrum; and
- 3.12.5 the availability throughout the United Kingdom of a wide range of television and radio services and the maintenance of sufficient plurality of providers of different television services.

## Impact assessment

- 3.13 Impact assessments provide a valuable way of assessing different options for regulation and showing why the preferred option was chosen. They form part of best practice policy-making. This is reflected in section 7 of the Communications Act 2003, which means that generally we have to carry out impact assessments where our proposals would be likely to have a significant effect on businesses or the general public, or when there is a major change in Ofcom's activities. However, as a matter of policy Ofcom is committed to carrying out impact assessments in relation to the great majority of our policy decisions. For further information about our approach to impact assessments, see the guidelines, "Better policy-making: Ofcom's approach to impact assessment", which are on our website.
- 3.14 We set out our impact assessment in our May 2014 consultation document. In this document we take into account relevant responses and set out our conclusions on the impact of the change.

## Equality Impact Assessment

- 3.15 We have conducted an Equality Impact Assessment to understand if change of use of the 700 MHz band will disproportionately affect any particular group of consumers or raise specific issues for groups that are protected under equality laws.
- 3.16 Ofcom data<sup>16</sup> show that the DTT audience is likely to include a comparatively higher share of viewers from older age groups. Change of use of the 700 MHz band will mean that a small number of households need to change their rooftop aerials or to add a filter to their television equipment to address interference (see Section 6 of this document). The practical steps involved in some of these changes are likely to raise challenges for disabled people.

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<sup>16</sup> *Communications Market Report 2014*, August 2014: [http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr14/2014\\_UK\\_CMV.pdf](http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr14/2014_UK_CMV.pdf) and *Public Service Broadcasting Annual Report 2013*, August 2013: <http://stakeholders.ofcom.org.uk/broadcasting/reviews-investigations/public-service-broadcasting/annrep/psb13/>

- 3.17 Older and disabled people are protected groups under equality law and the Communications Act 2003 also requires Ofcom to consider these groups specifically. As we explained in our May 2014 consultation document, due to their greater use of the DTT platform and potential challenges from dealing with TV equipment modifications, e.g. relating to mobility issues, these two groups could experience a greater impact from the change. A number of respondents to the consultation document, including Digital Outreach and Digital UK, echoed this point.
- 3.18 As we explain in section 6, we will work with Government, broadcasters and consumer groups to ensure that viewers receive appropriate information about and support with the changes we discuss in this document. When doing this we will give particular consideration to the needs of older and disabled viewers.

## Section 4

# Benefits of using the 700 MHz band for mobile

- 4.1 In this section we describe our analysis of the benefits of changing use of the 700 MHz band. We have specifically quantified the benefits of improved network performance and network cost savings (which we expect to lead to lower prices or better services for consumers) and estimate them to be between £900m -1.3bn. However, there are some other benefits which we have not been able to quantify. Therefore the quantified estimate may understate the total benefit of change of use of the band, potentially significantly. The benefits of change are likely to be greater the sooner that change occurs.

## Using the 700 MHz band for mobile data will deliver a number of benefits

- 4.2 We have identified a number of benefits of changing use of the 700 MHz band. These include:
- 4.2.1 **Mobile network cost savings from deploying fewer base stations.** Analysys Mason estimates the potential savings are between £480m - 770m, based on a 20 year analysis from 2022.
  - 4.2.2 **Improvements in mobile performance in hard to serve locations.** Analysys Mason estimates the reduced cost of delivering performance improvements to be between £390m -480m.
  - 4.2.3 **Potential for lower consumer prices.** Millions of consumers could benefit from lower mobile tariffs than would otherwise be offered, because we expect a significant proportion of the network cost savings to be passed through to consumers.
  - 4.2.4 **Extending data coverage.** The possibility of extending data coverage beyond the current footprint, possibly through the use of a coverage obligation, could deliver significant additional social and economic benefits.
  - 4.2.5 **Potential for new services or technology to be deployed in the band.** The 700 MHz band will be the only sub-1GHz band with harmonised use across such a large international footprint. This could support development of new services or technologies that would not otherwise be available to UK consumers.
  - 4.2.6 **Benefits of using the centre gap.** Up to 25 MHz of spectrum in the centre gap could be available for other uses such as supplemental downlink (SDL) or PMSE.
  - 4.2.7 **Facilitating emergency services communications.** The 700 MHz band may provide additional capacity for the next generation of emergency services communications.

- 4.3 The remainder of this section presents our analysis of the scale of each of these benefits. We have sought to quantify the first two benefits listed above. We have not identified a robust means of quantifying the other benefits. Instead we present a qualitative assessment of these benefits.

### **MNOs will be able to meet increases in demand for mobile data more efficiently with the 700 MHz band**

- 4.4 Using the 700 MHz band for mobile data will allow MNOs to meet a given level of data traffic with fewer base stations than they would otherwise have needed. This means they will be able to meet increases in demand for mobile data more easily and cheaply as a result of the change. We expect competition in the market will make them pass a significant proportion of this cost saving onto consumers by charging lower prices than would otherwise have prevailed.
- 4.5 In order to assess the scale of the benefit, we commissioned Analysys Mason to estimate:
- 4.5.1 how many fewer sites would be needed to meet projected increases in demand if the 700 MHz band were available for mobile data; and
  - 4.5.2 how large the network cost savings resulting from this reduction in site build would be.
- 4.6 Table 2 below sets out the key assumptions that drive Analysys Mason's estimate of network cost savings. Analysys Mason's report gives a detailed explanation of the methodology it adopted.<sup>17</sup>

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<sup>17</sup> Analysys Mason, *Assessment of the benefits of a change of use of the 700 MHz band to mobile*, 27 October 2013.

[http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/annexes/benefits\\_700MHz.pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/annexes/benefits_700MHz.pdf)

**Table 2: Assumptions in Analysys Mason Model**

Key parameter	Explanation
Traffic forecast	Level of traffic before offload to Wi-Fi networks. Higher traffic drives larger network cost savings as more sites need to be deployed to meet additional traffic. For modelling purposes the level of traffic is assumed to be the same both with and without access to the 700 MHz band. The base case assumption is an increase in traffic by 2030 to 45 times the level in 2014. This is based on traffic projections by Analysys Mason and Real Wireless.
Offloading assumption	Proportion of traffic that is offloaded onto Wi-Fi networks. Higher offload assumptions reduce the network cost savings, as less network build would be needed to meet forecast traffic levels without 700 MHz spectrum. In the base case offloading grows from 60% in 2014 to 77% in 2030.
Traffic distribution across sites	Traffic is not distributed evenly across sites. A small proportion of sites deliver a large proportion of busy hour traffic. The steeper the distribution, i.e. the more traffic is concentrated in a small number of sites, the larger the network cost saving as it is more likely a given site will hit the capacity limit.
Traffic served by sub-1 GHz spectrum only	The model assumes that a proportion of traffic can only be served using sub 1GHz spectrum. This varies between 18% and 22%. The higher the percentage the higher the network cost savings. <sup>18</sup>
Starting number of sites	This assumption determines the number of sites at the end of 2017. A larger number of starting sites means fewer sites need to be built later without access to 700 MHz spectrum, and reduces the network cost saving.
Proportion of shared new build sites	This is the proportion of new sites where costs are shared with another operator. If a higher proportion of sites are shared the cost of deploying new sites falls and therefore the network cost savings are lower.
Unit cost of sites	This is the cost of building a new site. The higher the build costs the greater the network cost savings.
Proportion of new sites that are six sector	The majority of sites today are three sector sites. If more sites are capable of being upgraded to six sectors there is less need to deploy additional sites and therefore the network cost savings fall.
Spectral efficiency forecast	Spectral efficiency determines how much capacity can be delivered with a given amount of spectrum. If spectral efficiency is higher there is less need to deploy sites and therefore network cost savings from 700 MHz fall.
Future spectrum availability	Availability of other spectrum bands potentially reduces the benefits of using the 700 MHz band. In the benefit range considered below 700 MHz is the only new sub-1 GHz band made available. However, Analysys Mason assumed that a number of bands above 1 GHz, including the 2.3 GHz band, the 3.5 GHz band and the 1452 MHz -1492 MHz band are available for mobile data use.

4.7 Taking these assumptions into account, Analysys Mason estimates that change of use of the 700 MHz band will deliver mobile network cost savings of £480m -770m. This is a “central range” estimate. The upper and lower limits of the range are based on alternative assumptions as to the value of key parameters. Analysys Mason has also generated a “wide range” estimate of the network cost savings from £190m - 930m. However values outside the central range appear less likely and values

<sup>18</sup> This is a stylised modelling approach that attempts to capture the importance of sub 1 GHz spectrum to a generic operator. The rationale behind the range is explained in the Analysys Mason report. We recognise that this stylised approach is a less accurate representation of some specific operators, e.g. there are operators offering mobile broadband services today using little or no sub 1 GHz spectrum. However we consider it reasonable to adopt a model suitable for a generic operator rather than developing separate models to reflect the individual circumstances of specific operators.

towards the extremes of the wider range are particularly unlikely. For example, for network costs to be at the bottom of the wide range would require one set of factors (including mobile traffic growth, peakiness of traffic distribution, and cost of network build) to be at the bottom of their plausible range of values, and would simultaneously require other factors (including spectral efficiency and starting number of sites) to be at the top of their plausible range of values.

- 4.8 As we discuss in detail in Annex 1, a number of respondents to our consultation document questioned the method and assumptions underpinning our estimate. In particular, BEIRG:
- 4.8.1 questioned our mobile data traffic forecasts. It argued that Analysys Mason may have overestimated future levels of data traffic (and by extension the scale of the network cost savings), because it had not factored consumers' willingness to pay for additional data into its analysis, and asked: "will consumers actually be prepared to pay for so much data?" BEIRG asked that we undertake a "clearly independent" analysis of projected mobile data demand.
  - 4.8.2 said it believes that, if MNO's are permitted and encouraged to use their existing spectrum holdings more efficiently, capacity would be sufficient to meet current and future demand. BEIRG suggested we undertake an "independent review" of the efficiency with which MNOs utilise the spectrum to which they currently have access.
  - 4.8.3 said that traffic and spectrum projections do not clearly identify the use of WiFi bands to carry that traffic.
- 4.9 On the other hand, Vodafone argued that the approach Analysys Mason had taken was likely to understate the scale of the benefits. Vodafone noted that Analysys Mason's approach assumes that absent change of use of the 700 MHz band, MNOs would fulfil forecast demand for mobile data by rolling out additional mast sites. However, Vodafone disagreed with this assumption on the grounds that:
- 4.9.1 It believes that 'economic externalities mean the benefits of serving demand do not flow to the network operators but instead to third parties in the mobile ecosystem', and that in some instances it will not be physically possible to roll out sufficient masts to meet demand.
  - 4.9.2 Hence without the 700 MHz band there may not be a business case to build new sites, or it may be impossible to do so, even if consumers value the provision of extra capacity more than the cost of site build. As a result, the benefits of 700 MHz release include fulfilling some demand for mobile data capacity that would otherwise not have been met, meaning that the benefits are higher than estimated by Analysys Mason.
- 4.10 We begin by considering BEIRG's arguments.
- 4.11 Given the long lead times for implementing change of use, we have to make a decision on the case for change many years before the 700 MHz band becomes available for mobile use. This necessarily entails significant uncertainty about how markets will develop over the relevant time period. The basis for Analysys Mason's estimates of future mobile data demand is set out in its report.. While in principle a more detailed model could explicitly estimate consumers' willingness to pay, we

consider that such an elaboration of the demand model would increase its complexity without necessarily increasing confidence in the resulting forecasts.

- 4.12 Analysys Mason estimated that the cost of additional infrastructure to meet this increased demand is around £1bn over a 20 year period. While significant in itself, this figure should be considered in relation to annual mobile industry revenues of around £16bn per annum (and £1bn present value over 20 years represents around 0.5% of £16bn per annum).<sup>19</sup> Even if, absent a 700 MHz change of use, these infrastructure costs were to be passed on in full to consumers over this period in higher consumer bills, we consider it unlikely that such an increase would have a large impact on the growing demand for mobile data.<sup>20</sup>
- 4.13 As regards BEIRG's second point above, we note that in another context MNOs have argued that they have a strong incentive to make efficient use of their existing spectrum to avoid increasing the amount of new spectrum they will need to acquire in expensive auctions. We consider there is some merit in this argument and are not persuaded that BEIRG has provided evidence to the contrary.<sup>21</sup>
- 4.14 On BEIRG's third point, we agree that there is significant uncertainty about the future role of Wi-Fi offload. We have tried to address this by considering a range of traffic forecasts and we continue to believe that our estimates are reasonable. We have assumed very significant offload, including some to femtocells, that grows to 77% by 2030 in the mid case.
- 4.15 Vodafone's arguments tend to go in the opposite direction to those of BEIRG – i.e. suggesting that our estimates of the benefits of 700 MHz change of use may be understated. We agree that, as Vodafone points out, there may be areas (e.g. national parks) in which it would not be possible to roll out sufficient base stations to meet demand if the 700 MHz band were not released. This would lead the model to understate the benefits of change of use of the 700 MHz band. However, we do not have evidence that the number of such areas is large.
- 4.16 Respondents made a number of other comments on our estimate of network cost savings. However, none of them provided additional evidence that would support changes either to the approach or the assumptions that we adopted. Therefore we do not believe there is a firm basis on which to revise the results set out in our consultation document. Annex 1 summarises all of these responses and explains how we have taken them into account in our analysis.

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<sup>19</sup> We also note that previous work suggests that the value of consumer benefits from mobile services significantly exceeds annual industry revenues. Consumer surplus from mobile services has been roughly estimated at £24bn per annum. See Second consultation on assessment of future mobile competition and proposals for the award of 800 MHz and 2.6 GHz spectrum and related issues', ofcom 2012, at paragraph 2.68 in Annex 6. <http://stakeholders.ofcom.org.uk/consultations/award-800mhz-2.6ghz>

We recognise, however, that this analysis relates to the generality of mobile services and is not focussed on consumer benefits from mobile data services.

<sup>20</sup> In this context, we note that in June 2014 Plum Consulting published a study forecasting that even if individual expenditure on data is constant to 2030, data traffic in Europe would increase 148 fold between 2013 and 2030. Plum, June 2014, [http://www.plumconsulting.co.uk/pdfs/Plum\\_Insight\\_June\\_2014\\_Do\\_you\\_need\\_a\\_mobile\\_data\\_forecast\\_to\\_estimate\\_spectrum\\_demand.pdf](http://www.plumconsulting.co.uk/pdfs/Plum_Insight_June_2014_Do_you_need_a_mobile_data_forecast_to_estimate_spectrum_demand.pdf)

<sup>21</sup> Ofcom, *Annual licence fees for 900 MHz and 1800 MHz spectrum*, Further consultation, August 2014 (paragraph A5.12) [http://stakeholders.ofcom.org.uk/binaries/consultations/annual-licence-fees-900-MHz-1800-MHz/annexes/Annexes\\_1-7.pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/annual-licence-fees-900-MHz-1800-MHz/annexes/Annexes_1-7.pdf)

- 4.17 We consider that network cost savings will be greater the earlier the change happens. The Analysys Mason model estimates that change of use in 2020 rather than the beginning of 2022 would increase the network cost saving benefits by between £10m – 50m in the central range as it would result in a reduction in the number of sites being built to meet increasing demand where the network cannot otherwise support it and a longer period over which benefits accrue. Conversely, a later change of use of 700 MHz band would reduce the benefits with more sites likely to be built in the meantime (or lower consumer benefits from reduced performance) and benefits over a reduced period of time.

### **Release of the 700 MHz band will enable MNOs to improve mobile data speeds in hard to reach locations**

- 4.18 In addition to increasing network capacity, use of the 700 MHz band will make it easier for MNOs to improve network performance at the edge of existing coverage i.e. deep indoors and in rural areas. Improvements in performance would increase the mobile data speeds that end users receive. This could allow users to consume new services, e.g. HD video on the move, or improve the overall user experience, e.g. by reducing mobile download times.
- 4.19 Analysys Mason’s analysis using the Ofcom coverage model indicates that a network with 700 MHz carriers deployed on all sites could deliver average speeds up to 20% faster for some users (compared to a network of the same size without 700 MHz) and that speed improvements could be greater at the cell edge.
- 4.20 Analysys Mason estimated that in order to replicate this performance improvement without access to the 700 MHz band a ‘generic MNO’ with 25 per cent market share would need to build a further 870-980 sites (over and above the sites needed to increase capacity). On this basis, Analysys Mason estimates that change of use of the 700 MHz band could reduce the costs of improving network performance by between £390m -480m (central range).
- 4.21 There is a risk that this estimate overstates the benefit that will flow from performance improvements. This is because consumers may not value the improvements in performance up to the cost of additional sites. However, it could alternatively understate the benefits if consumers valued the improvement significantly more than the cost of additional sites but operators were unable to monetise this value and, therefore, would not have an incentive to provide the higher performance in the without-700 MHz scenario.
- 4.22 It is difficult to assess how much consumers value improved mobile services. However evidence from consumer research and take-up of LTE services shows some consumers place a substantial value on improved performance. For example, consumer research, commissioned for our UHF strategy consultation, showed that 73% of consumers would be willing to pay £10 a month more for improved mobile coverage and more data capacity. Overall, we therefore believe the Analysis Mason estimate, of between £390m – 480m, provides a good indication of the performance benefit although we recognise the risk of overstatement or understatement.
- 4.23 The estimate above is based on change of use of the band at the beginning of 2022. If change of use happens in 2020 we estimate the performance benefits would increase by between £10m -20m (central range).

## **Change of use of the 700 MHz band could facilitate increases in coverage**

- 4.24 In addition to the performance benefits discussed above, change of use of the 700 MHz band could facilitate increases in coverage.
- 4.25 The 700 MHz band has similar propagation characteristics to the 800 MHz and 900 MHz bands, which are currently used by mobile services. Therefore, we would not expect market forces alone to cause MNOs with access to the 700 MHz band to increase coverage beyond the footprint provided by 800 MHz rollout. However, release of the 700 MHz band could be combined with other incentives or obligations to extend mobile coverage to more remote areas including, for example, roads and railway lines.
- 4.26 Increases in coverage could facilitate the development of new types of mobile applications, for example machine-to-machine technology. They could also promote benefits associated with social inclusion of citizens. It is these sorts of benefit that would support a coverage obligation – on the assumption that the benefits exceeded the cost of such an obligation. In our consultation document, we argued that the net benefits could potentially be very significant. However, we did not identify a basis for quantifying them robustly.
- 4.27 No consultation respondents disagreed with our assessment of the potential benefits of increasing mobile coverage. The Consumer Communications Panel and the Advisory Committee for Older and Disabled People expressed the view that we should impose a near universal coverage obligation on 700 MHz licences.

## **Change of use of the 700 MHz band could facilitate the development of new services and technologies**

- 4.28 The 700 MHz band will be unique as a sub 1GHz spectrum band harmonised across most regions of the world (with the exception of a few countries including the US). We would expect this to mean that the band would be supported by the majority of new mobile handsets worldwide. This may have implications on how new services, which could have significant value for consumers and citizens, could be deployed using the 700 MHz band. As a result of global harmonisation there could be new services exclusive to the 700 MHz band, increasing the consumer benefits for all countries which adopt the band for mobile use.
- 4.29 At this stage, we are unaware of any specific innovation that could be uniquely suited to a globally harmonised 700 MHz band. This is not surprising given the timeframes involved and the unpredictability of future technological change. But new services, potentially exclusive to the 700 MHz band, could develop between now and a change of use of the 700 MHz band. Alternatively, the 700 MHz band could support earlier development of certain services than would be possible in other bands.
- 4.30 It is difficult to estimate the size of this potential benefit since these possible future services are, as yet, unknown. The potential benefits range from the hundreds of millions if highly-valued services are launched exclusively in this band and taken-up by millions of users, or zero if new services can be accessed without the 700 MHz band. Given the uncertainty over these benefits, we have not placed much weight on them in our assessment, but note them as potential upsides.

## **There would be additional benefits from using the centre gap**

- 4.31 As outlined in section 2, we expect the 700 MHz band to include 2x30 MHz of paired mobile spectrum and a 25 MHz centre gap. The benefits discussed above relate exclusively to the use of the 2x30 MHz.
- 4.32 However, we would also expect the centre gap to be used. Examples of services that could use the centre gap include PMSE and supplemental downlink (SDL).<sup>22</sup> Use of the centre gap will deliver additional benefits over and above the benefits which flow from use of the paired spectrum.
- 4.33 We have not identified a way to quantify these benefits in a sufficiently robust manner. This is because:
- 4.33.1 We have not yet decided what services we will allow to use the centre gap; and
  - 4.33.2 Some of the services that could use the centre gap, for example SDL, have not yet been deployed in other bands. This makes it hard to assess the benefits associated with them.
- 4.34 We set this position out in our consultation document. No responses provided any evidence which sheds more light on the scale of the benefits of using the centre gap. However, as we explain in annex 1, a number of respondents expressed views as to what the best use of the centre gap would be. For example, Three argued that it should be used for SDL. By contrast, a confidential respondent argued that it should be made available for PMSE use and the Dynamic Spectrum Alliance argued that it should be available for use by WSDs. Decisions as to future use of the centre gap are not a matter for this document. Our initial view is that SDL is likely to be the highest value use for the centre gap. However, we recognise, depending on the outcome of our review of PMSE spectrum requirements, there may be a case for making the centre gap available for wireless microphones to use.

## **Change of use of the 700 MHz band could provide additional capacity for emergency services communications**

- 4.35 Government is currently in the process of procuring the next generation of emergency services communications technology (commonly referred to as Public Protection and Disaster Relief (PPDR) communications). It is procuring capacity for PPDR communications from commercial providers.
- 4.36 There are a number of spectrum bands these providers could use. However, if the 700 MHz band were available for mobile use it would provide a significant increment to the amount of low frequency spectrum available for the emergency services to use. This could potentially deliver benefits. We recognised this benefit qualitatively in our consultation.
- 4.37 In its consultation response, Motorola encouraged us to quantify the benefits of using part of the 700 MHz band for PPDR. However, such use is still highly uncertain and therefore we continue to include this as part of the unquantified benefits of change of use.

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<sup>22</sup> SDL allows MNOs to provide additional downlink only capacity.

## Section 5

# Implications for the DTT platform and resulting costs

- 5.1 Having discussed the benefits associated with change of use of the 700 MHz band, we now move on to consider the costs that will arise as a result of the change. This section sets out our assessment of the implications changing use of the band will have for the DTT platform.
- 5.2 It explains that:
  - 5.2.1 The change means we will need to re-plan the frequencies currently used by the DTT platform;
  - 5.2.2 We believe it is possible to implement the re-plan in a manner without materially affecting DTT coverage or channel line-up and we do not believe wider adoption of DVB-T2 is necessary to accomplish this objective;
  - 5.2.3 DTT transmission infrastructure will need to be modified in order to implement the change. We believe that including modifications related to national and local TV and programme management, this will cost between £420m -470m in real 2014 NPV; and
  - 5.2.4 We estimate that the reduction in value from the loss of access to the band for existing DTT services is between £80m -100m.

## Change of use of the 700 MHz band will require revisions to the DTT frequency plan

- 5.3 A network of over 1,100 transmitters delivers DTT services across the UK. This transmission network is a “multi-frequency network” (MFN) in which the frequencies used to deliver DTT services vary from transmitter to transmitter. However, all DTT transmissions use frequencies that fall between 470 MHz --790 MHz.
- 5.4 A consequence of the network being an MFN is that at any given location some broadcast spectrum is not used by national DTT services. We refer to this as geographically interleaved spectrum.
- 5.5 Ensuring that all DTT services can satisfy their coverage objectives without causing interference to each other involves careful planning of the frequencies each transmitter uses. Moreover, as radio waves travel across borders, the main details of DTT frequency plans have to be agreed internationally in order to manage interference.
- 5.6 Change of use of the 700 MHz band will mean that DTT services will no longer be able to use the spectrum between 694 MHz - 790 MHz. In order for the change to take place, we will therefore need to develop, and internationally co-ordinate, a revised frequency plan which delivers DTT services in the remaining broadcast spectrum.

## **We believe we can implement the change in a manner that safeguards the benefits DTT provides**

- 5.7 Currently, the DTT platform consists of the following multiplexes<sup>23</sup>:
- 5.7.1 Three PSB multiplexes – BBC and D3&4 provide these multiplexes. They broadcast from all of the transmitters in the DTT network and are available to around 98.5% of households.
  - 5.7.2 Three commercial multiplexes – these are licensed to Arqiva and SDN. They broadcast from the largest 80 transmitters achieving coverage of around 90% of households.
  - 5.7.3 Geographical Interleaved (GI) spectrum multiplexes – two portions of spectrum that can be used to provide a DTT multiplex in Manchester and Cardiff. The service in Cardiff has not been launched.
  - 5.7.4 Northern Ireland multiplex – one multiplex that broadcasts RTÉ and TG4 from three transmitters and covers approximately 78% of households in Northern Ireland.
  - 5.7.5 Local television multiplex - Comux holds the licence to broadcast the local TV multiplex which has launched recently and has set out plans to broadcast from 40-60 transmitter sites and achieve coverage of up to 50% of households. The award of this licence specifically referred to the possibility of change of use of the 700 MHz band. Since Comux won its licence, Ofcom has been awarding licences for local TV services in various locations to be carried on this multiplex and this process is continuing.
  - 5.7.6 Interim multiplexes - Ofcom awarded the 600 MHz spectrum band (550 MHz – 606 MHz) to Arqiva on an interim basis by granting a single licence for the establishment of temporary DTT multiplexes using DVB-T2/MPEG4 technology. The basis on which we made it available was to support short term use and the terms of the award set out specifically that we would revoke the licence to enable change of use of 700 MHz if we made a decision in favour of such a change. At the present time, only one of these multiplexes has launched.
- 5.8 Most of these multiplexes use a transmission technology called DVB-T and a compression standard called MPEG 2. However, one of the PSB multiplexes and the interim multiplex use a more advanced transmission technology called DVB-T2 and a more advanced compression standard called MPEG 4. DVB-T2 and MPEG 4 increase the amount of information multiplexes can carry, thereby enabling the delivery of more TV services or of HD services. Use of DVB-T2 can also enhance the coverage DTT services can achieve.
- 5.9 As set out in section 2, we are committed to safeguarding the ongoing delivery of the benefits DTT provides. In order to achieve this objective, we aim to develop a revised DTT frequency plan which allows for the continued delivery of:
- 5.9.1 Near-universal coverage for PSB services;

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<sup>23</sup> A multiplex is a single signal which contains, when decoded, multiple discrete streams of digital information (i.e. multiple TV or radio services).

- 5.9.2 Six national multiplexes with coverage broadly matching today;
  - 5.9.3 A similar quantity of local TV services to those that the platform is capable of delivering today (including the Manchester and Cardiff GI services); and
  - 5.9.4 The services carried on the Northern Ireland multiplex.
- 5.10 We will also seek to ensure that the PSB multiplexes retain the ability to broadcast programming specifically for the UK Nations and English regions. We will not, however, seek to ensure the continued delivery of the interim multiplex.
- 5.11 In the light of the frequency planning studies we have conducted to date,<sup>24</sup> we are confident of being able to meet these objectives without changing the mix of transmission and compression technologies currently used on the national multiplexes.
- 5.12 Not all consultation respondents agreed with this assessment. For example, Digital UK and Arqiva argued that there is a material risk of coverage losses occurring. They stated that our CBA should factor in the cost of taking actions to remedy potential coverage losses (for example building new transmitters). Arqiva stressed that we should not discount the possibility that more multiplexes might need to adopt DVB-T2 in order to meet our coverage targets. In the light of these comments, we have reviewed the findings of our frequency planning studies. We discuss the findings of this review in section 6 as part of our discussion of the impact change of use of the 700 MHz band will have on DTT viewers.

## Change of use of the 700 MHz band is likely to result in DTT infrastructure modification costs of £420m - 470m

### **We commissioned Arqiva to estimate the cost of DTT infrastructure modifications**

- 5.13 Many of the main components of the DTT transmission infrastructure are designed to operate over a set of specific frequencies and have limited versatility to change frequency. The necessary revisions to the frequency plan will therefore mean that broadcasters need to replace or modify a substantial proportion of the DTT network. We commissioned transmission company Arqiva to provide an estimate of the costs of these infrastructure modifications.
- 5.14 The two main factors that determine the cost of the infrastructure changes are:
- 5.14.1 **The number of DTT transmission antennas that need to be changed.** This is dependent upon the outcome of the international frequency planning and co-ordination process, which is unlikely to conclude before the end of 2015.
  - 5.14.2 **Decisions about network resilience during the infrastructure modification process.** As demonstrated in figure 3, Larger DTT transmitters typically have main and reserve antennas. In the unlikely event that the main antennas fail, the reserve provides a back-up. One approach to the infrastructure modifications would be to switch DTT services to the reserve antennas while the main antennas are being changed and then switch back to the main antennas while the reserves are changed. This

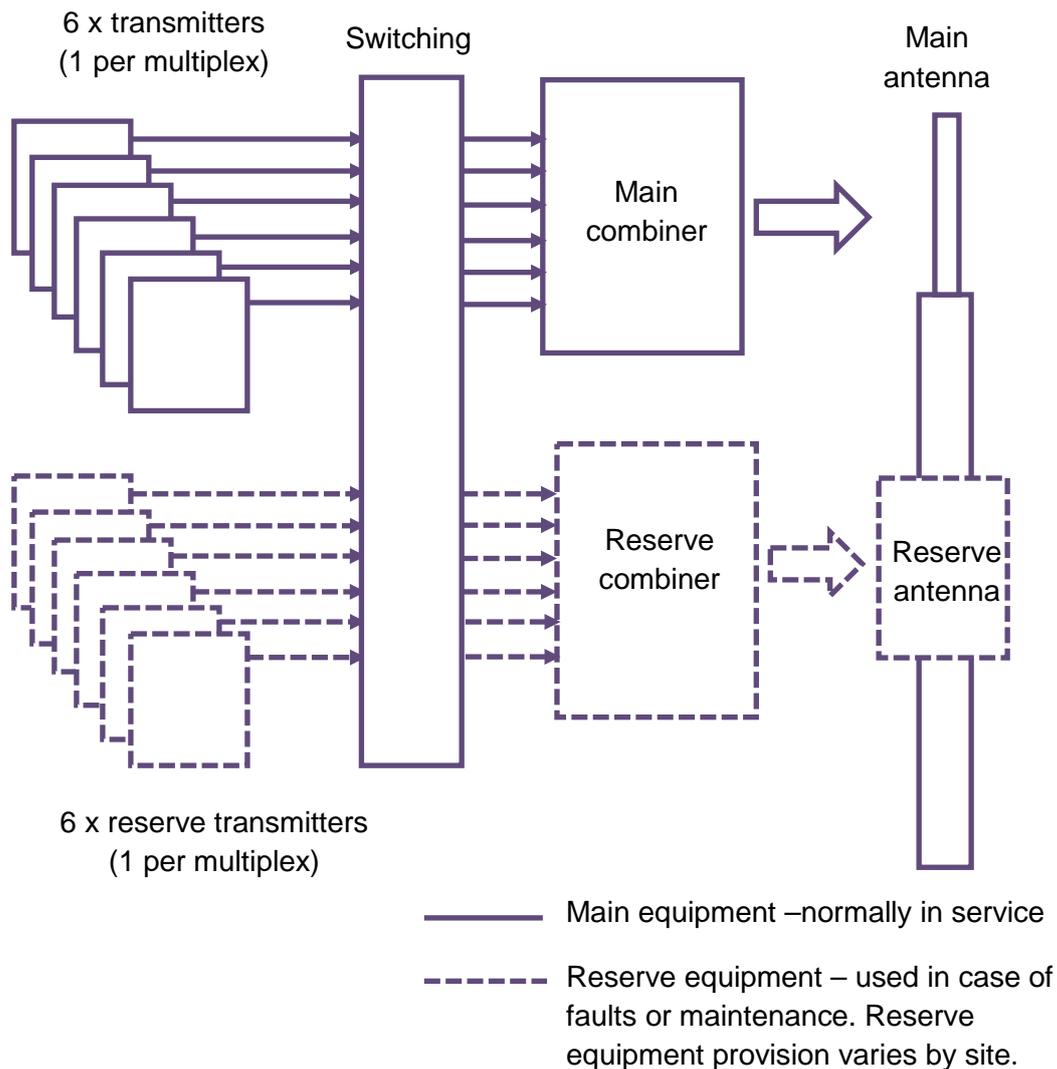
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<sup>24</sup> These frequency planning studies are summarised in annex 8 of our consultation document.

would ensure continuity of service, but would mean the network was temporarily less resilient during infrastructure modification process. An alternative approach would be to install a second, temporary, mast with duplicate main and reserve antennas at sites where modifications are required. This would be more expensive and time consuming, but would maintain resilience during the transition process.

5.15 In the following pages we discuss how Arqiva took account of these two factors in its cost estimate.

**Figure 3: Block diagram of a DTT transmitter**



**Arqiva estimated the cost of two different frequency plans**

5.16 International frequency planning negotiations are at an early stage. Therefore we do not at this time have certainty over the final frequency plan. In order to reflect this, we asked Arqiva to provide estimates of costs for two different planning scenarios:

- 5.16.1 Firstly, a ‘minimal change’ scenario in which services in the 700 MHz band are moved lower in the DTT band (mostly to the range 534 MHz – 606 MHz that is predominantly occupied by the interim multiplex). This is our preferred frequency plan. It would minimise the number of frequency changes required and would therefore minimise the costs of the re-plan; and
- 5.16.2 Secondly, a ‘commercial multiplex single frequency network scenario’. This would involve reconfiguring the network so the commercial multiplexes were carried on a single frequency network (SFN).<sup>25</sup> The PSB multiplexes would continue to be carried on an MFN. It would entail a more extensive series of modifications to the network and would therefore cost more.<sup>26</sup>

### Arqiva estimated the cost of two different approaches to network resilience

5.17 The approach multiplex operators take to network resilience will vary from transmitter to transmitter. At some transmitters temporary masts are likely to be required. At others, they will not. Final decisions about how many temporary masts are needed will not be taken until implementation work starts. Arqiva provided us with cost estimates for two different approaches to network resilience:

- 5.17.1 **The high scope or ‘standard SLA solution’:** This estimate is based upon minimising the reduction in resilience of each transmitter. This will ensure minimal impact on the contractual service level agreements (SLAs) between Arqiva and the multiplex operators. This option envisages that temporary masts and antenna systems would be deployed at all main transmitters where any antenna works are required (this might be up to 21 in total based on current frequency planning studies).
- 5.17.2 **The ‘reduced scope’ solution:** This is based on avoiding the use of temporary masts wherever possible. The approach would require the multiplex operators to slightly reduce the resilience of the network while the engineering works are carried out. Arqiva advises that use of temporary masts is likely to be unavoidable at around 7-8 transmitters due to constraints upon how the changes could be implemented (e.g. due to availability of space on existing masts or establishing safe methods of work).

5.18 Table 3, below, summarises the cost estimates Arqiva provided. Arqiva’s report *700 MHz High Level Estimate – Single hop & PSBMFN/COM SFN Plans* gives a fuller explanation of the infrastructure modification process and the costs and timescales associated with it.<sup>27</sup>

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<sup>25</sup> An SFN is a network where all transmitters operate on the same frequency.

<sup>26</sup> We describe these two options in more detail in annex 8 of our consultation document.

<sup>27</sup> Arqiva, May 2014, *700 MHz High Level Estimate – Single hop & PSBMFN/COM SFN Plans*, [http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/annexes/40\\_700\\_MHz\\_High\\_Level\\_Estimate.PDF](http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/annexes/40_700_MHz_High_Level_Estimate.PDF)

**Table 3: Arqiva estimate of national DTT network infrastructure cost in undiscounted 2014 prices<sup>28</sup>**

Total (£m)	Single Hop frequency plan	COM SFN frequency plan
High scope	410	470
Reduced scope	310	360

### **We believe the reduced scope estimate is most appropriate**

- 5.19 In our consultation document, we stated that we felt the reduced scope estimate was likely to provide a more accurate reflection of the costs of the infrastructure modifications. We used the reduced scope-minimal change scenario as the basis for the lower bound of our estimate of DTT infrastructure modification costs, and the reduced scope-COM SFN scenario as the upper bound.
- 5.20 Some respondents to the consultation document disagreed with this approach. Digital UK and Arqiva argued that it was not appropriate to expect multiplex operators to accept any loss of resilience during the transition process. Therefore, they suggested we should use the high scope figures as the basis for our CBA.
- 5.21 We recognise that there is some uncertainty about the scope of the DTT infrastructure modifications. However, we believe it is highly unlikely that 21 temporary masts will be required. On balance, we think that the most probable outcome is that 7-10 temporary masts will be needed. There are a number of reasons for this:
- 5.21.1 First, we have discussed the topic of temporary masts with a number of DTT infrastructure experts (both Ofcom’s in-house experts and an independent expert). Having reviewed the list of sites that might be affected by the DTT re-plan, their engineering judgement is that 7-10 temporary masts would be the most likely outcome.
- 5.21.2 Second, our estimate of the number of temporary masts that are likely to be required is consistent with the approach to network resilience taken during the DSO and 800 MHz clearance programmes. DSO involved major re-engineering work at all of the UK’s transmitters. At the larger transmitters, Arqiva replaced or modified the main antennas. In many cases, they installed new reserve antennas. Throughout the programme, they built five new masts and only three temporary masts. During 800 MHz clearance, one main and three reserve antennas at main transmitters with significant coverage were found not to meet specification at the new operating frequencies. Temporary masts were not needed in any of these cases. The digital switchover and 800 MHz clearance programmes are not perfect comparisons to the process that might be employed for making a change of use of the 700 MHz band. However, many of the activities are comparable and our experience with the two programmes suggests that in many cases it is possible to change or modify antennas without using a temporary mast.

<sup>28</sup> These numbers reflect the 700MHz High Level Estimate, released alongside the consultation document, with a correction for rounding errors in the original, and inflation to June 2014. These numbers include the full costs of equipment replacement (rather than the cost of bringing replacement forward), and without any discounting having been applied.

- 5.21.3 Third, we understand that at most transmitters it is likely to be possible to replace existing main antennas with antennas that are capable of functioning at any frequency in the broadcast spectrum ('wideband antennas'). We also believe it will be possible to build reserve antennas which are capable of operating across the vast majority of the frequencies DTT currently uses. This means that at most sites it should be possible to install antennas which can work on both current and future frequencies. This should simplify the antenna replacement process and reduce the period when services are subject to reduced resilience. This may reduce the need for temporary masts.
- 5.22 We also think that the COM SFN frequency plan is pessimistic. In our view, it is much more likely that the frequency plan will be closer to the minimal change plan than the COM SFN plan.
- 5.23 The figures Arqiva provided imply that a combination of (1) a frequency plan which is roughly halfway between the minimal change plan and the COM SFN plan; and (2) an approach to resilience which involved the use of 10 temporary masts or fewer would result in full costs of around £350m – 360m in 2014 prices - and importantly no more than £360m. In our view, it is highly unlikely that the outcome will be any worse than this, we believe that the estimate of the full costs of DTT infrastructure modifications which we used in our consultation document remain appropriate.
- 5.24 We recognise that there is a risk that the costs could be greater, either because the frequency plan ends up being considerably worse than we expect, or because we end up needing more temporary masts than we expect. We think this risk is relatively small. We understand that the cost estimate Arqiva provided includes around £40m of contingency. It is possible that a proportion of this contingency could, in principle, be used to pay for additional temporary masts or antenna changes. This further reduces the probability of costs exceeding the range we have quoted.
- 5.25 In addition to the costs of modifying the national DTT network which we have discussed above, Arqiva estimated that the full cost of managing the infrastructure modification process would be approximately £20m in 2014 prices and the cost of modifying the local TV network would be approximately £20m (also in 2014 prices). Since the consultation, we have also included an allowance for the potential costs to Ofcom or Government from managing the programme, which we estimate at £10m in 2014 prices.
- 5.26 This means that in total we think the full cost of modifying DTT infrastructure, including local TV changes and programme management is likely to be between £360m -410m in 2014 prices. This estimate is before discounting, and does not include any allowance for possible financing costs.'

### **We have modified our cost estimate to reflect changes in our assumptions about DTT asset life**

- 5.27 These estimates relate to the full cost of modifying DTT infrastructure (expressed in 2014 prices). However, as explained in section 2, it is the discounted<sup>29</sup> cost of bringing equipment replacement forward that is the relevant economic cost measure for our CBA.

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<sup>29</sup> As explained in the consultation, we have used the Spackman discounting method, which also includes some financing costs.

- 5.28 We have therefore discounted the costs, using the Spackman method which also adds financing costs, to give an estimate of £430m -490m. Further adjusting to account for only the cost of bringing forward equipment replacement, rather than full costs, reduces the estimate. We estimate that the discounted cost of bringing forward DTT infrastructure modifications, including programme management and local TV modifications, is between £420m – 470m in 2014 NPV.
- 5.29 This estimate is higher than the one presented in our consultation document. The principal reason for this is that we have changed our assumption about the asset life of DTT equipment. In our consultation document, we estimated an asset life of 25 years. On this basis, we calculated the cost of bringing DTT infrastructure modification forward, including local TV changes and programme management, to be between £350m - £400m in 2014 NPV.
- 5.30 In its response, Digital UK argued that much of the DTT infrastructure that would need replacing has ‘an asset life of much longer than 25 years - commonly of 50 years’.<sup>30</sup> It also made a number of other comments on our approach to calculating equipment replacement costs. We discuss these in detail in annex 1.
- 5.31 In the light of Digital UK’s comment, we have reviewed evidence from the Office of the Adjudicator on the asset life of each major component of the network.<sup>31</sup> Multiplex operators will need to replace many different components of the DTT network due to the re-plan. Some of these components have longer asset lives than others. Based on this evidence we have calculated an average infrastructure asset life. We have weighted this average to reflect the proportion each component accounts for in the total infrastructure modification cost. We calculate the weighted average asset life to be 43 years, and have modified our calculations to reflect this.
- 5.32 Table 4, below summarises the steps we have just described.

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<sup>30</sup> [http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/responses/Digital\\_UK\\_Limited.pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/responses/Digital_UK_Limited.pdf)

<sup>31</sup> The Office of the Adjudicator has responsibilities including dispute resolution between Arqiva and the broadcasters See <http://adjudicator-bts.org.uk/>

**Table 4 Summary of steps to estimate DTT infrastructure modification costs.**

Steps in estimating the cost of DTT infrastructure changes	Estimate	
Arqiva provided a range of estimates of the full costs of infrastructure related to national DTT	£310-£470m	Full cost of infrastructure changes for national DTT, 2014 prices
We considered that these were overly cautious estimates, and that a narrower range is realistic	£310-£360m	Full cost of infrastructure changes for national DTT, 2014 prices
We added £50m to cover the cost of local TV re-planning, and programme management costs	£360-£410m	Full costs of carrying out DTT infrastructure changes, 2014 prices
To reach a present value estimate of costs, we added potential financing costs and discounted to reflect that the costs occur in future years (the Spackman method of discounting)	£430-£490m	Full costs of carrying out DTT infrastructure changes, PV, 2014 prices
We consider that the correct estimate of economic costs includes only the cost of bringing equipment replacement forwards.	£420-£470m	Costs of carrying out DTT infrastructure changes, including only the costs of bringing forward equipment replacement, PV, 2014 prices

## **Initial estimates suggest that we could complete the programme of change by the beginning of 2022**

- 5.33 Arqiva has also provided indicative plans which set out the timing of the programme of infrastructure modifications that will be required. It suggests that DTT transmitters could begin to move to new frequencies from 2019 onwards, and that from an engineering perspective the programme of DTT frequency changes could be complete by the end of 2021. This implies that the 700 MHz band could potentially be fully available for mobile data use by the beginning of 2022.
- 5.34 In our consultation document, we explained that this estimate appeared broadly reasonable. However, we noted that experience from previous broadcast infrastructure modification programmes suggested that we may find ways to condense the timeline, potentially by up to two years, once we commence detailed planning. Everything Everywhere echoed this point in its consultation response. Conversely, both Digital UK and Arqiva expressed scepticism about the feasibility of expediting the infrastructure modification process. They did, however, agree that end 2021 appeared to be a feasible end date.
- 5.35 Having considered these comments, we remain of the view that making the 700 MHz band available for mobile data by the beginning of 2022 appears feasible and that there may be opportunities to condense timelines as the planning process progresses. However, we recognise that timelines for this project are not solely determined by the time it takes to modify DTT infrastructure but are also affected by other factors such as the speed of progress in international frequency planning negotiations. At this stage we are therefore not committing to a specific date for project completion.

- 5.36 We expect that the changes to the frequencies DTT uses will take place on a staggered region-by-region basis (as was the case for DSO). In addition to assessing whether it is possible to accelerate completion of the programme, we will explore whether there is scope to make the band available for mobile data early in regions which change frequencies early in the programme.

## **We estimate the foregone value from a reduction in the amount of spectrum available to DTT to be £80 million to £100 million**

### **The opportunity cost of change of use of the 700 MHz band depends on future demand for DTT**

- 5.37 In addition to calculating the costs of modifying equipment, we have considered the opportunity cost of change of use of the 700 MHz band.<sup>32</sup>
- 5.38 We expect that, if we did not make it available for mobile data, the highest value alternative use of the 700 MHz band would be for DTT, with PMSE and WSDs operating in interleaved spectrum. On this basis, the opportunity cost of the change is equivalent to the value that DTT, PMSE and WSDs could have delivered had we decided not to proceed, over and above that which they will be able to provide without access to the 700 MHz band.
- 5.39 We have considered WSDs in section 2 – we do not expect there to be a significant change in the availability of white space spectrum, and hence we do not believe there is an opportunity cost of white space use as a result of the change. In the following pages, we consider the additional value DTT could have delivered if it had retained access to the 700 MHz band. We discuss PMSE in section 7.
- 5.40 Absent change of use of the 700 MHz band, DTT could have delivered up to 8 national multiplexes instead of 6. The additional value it could have delivered had it retained access to the 700 MHz band is dependent on the value associated with being able to deliver these additional multiplexes. This in turn depends on future demand for DTT services.
- 5.41 The extent of future demand for DTT services is inherently uncertain. For the purposes of this analysis, we have considered three possible scenarios:
- 5.41.1 Scenario 1: Low demand for DTT – Future demand for DTT is at or below the capacity provided by the current six national multiplexes i.e. approximately 8 HD channels and 60 SD channels. In this case there is not sufficient demand to support the two interim multiplexes beyond 2022 and these multiplexes would close with or without change of use of the 700 MHz band.
- 5.41.2 Scenario 2: Medium to high demand for DTT – Future demand for DTT is for more than 8 HD channels and 60 SD channels (i.e. sufficient to justify continuation of the two interim multiplexes beyond 2022), ranging up to demand for as many channels as can be provided by 6 multiplexes upgraded to DVB-T2 while retaining or increasing the current number of SD channels.

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<sup>32</sup> The opportunity cost is the value of the best alternative forgone in a situation in which a choice needs to be made between multiple mutually exclusive alternatives.

5.41.3 Scenario 3: Very high demand for DTT – Future demand for DTT exceeds the number of channels that can be provided by 6 multiplexes upgraded to DVB-T2. Within this scenario following change of use of the 700 MHz band the DTT platform with 6 multiplexes would be unlikely to be able to provide enough capacity even with an upgrade to DVB-T2.

5.42 Our approach to estimating the DTT opportunity cost is to focus on scenario 2. We have taken this approach as we consider scenarios 1 and 2 are more likely than scenario 3 and by focussing on scenario 2 rather than scenario 1 we have been cautious and allowed for higher potential opportunity costs.

**We believe the cost of DVB-T2 migration is a useful proxy for the opportunity cost of change of use of the 700 MHz band**

5.43 Scenario 2 implies that if it did not lose access to the 700 MHz band, the DTT platform would have operated 3 DVB-T2 multiplexes and 5 DVB-T multiplexes. As table 5 demonstrates, without the 700 MHz band licensees would need to migrate some or all of the 5 national DVB-T multiplexes to DVB-T2 in order to meet the levels of demand implied by scenario 2.

**Table 5: Options for upgrading the DTT platform**

	(a) 6 muxes - no further DVB-T2 upgrade	(b) 6 muxes - Partial DVB-T2 upgrade	(c) 6 muxes - Full DVB-T2 upgrade	(d) 8 muxes - no further DVB-T2 upgrade
DVB-T multiplexes	5	2	0	5
DVB-T2 multiplexes	1	4	6	3
<b>Total capacity (Mbps)</b>	169	208	240	249
<b>Number of channels</b>				
SD channels	56	70	116	72
HD channels	8	20	20	20

5.44 We therefore believe that the cost of DVB-T2 migration serves as a useful proxy for the value the DTT platform will forgo as a result of change of use of the 700 MHz band. We would, however, stress that we do not believe DVB-T2 migration is necessary in order to deliver change of use of the 700 MHz band in a manner consistent with our objectives.

5.45 There is a question as to whether it would be more appropriate to use full or partial DVB-T2 migration as the basis for our opportunity cost calculation. As set out in table 5, a partial DVB-T2 migration (with two multiplexes continuing to use DVB-T) may be sufficient to meet the demand in scenario 2 and provides largely the same capacity as eight multiplexes without further upgrade. However, the costs of a partial upgrade are highly uncertain as they depend on:

5.45.1 how many consumers would upgrade (or bring forward upgrading of) equipment in response to a DVB-T2 upgrade; and

5.45.2 the lost welfare to consumers who chose not to upgrade equipment (these consumers would receive fewer TV channels following a DVB-T2 transition).

- 5.46 It is likely that by 2022 a proportion of viewers will not have replaced their TV equipment with DVB-T2-compatible equipment, and we have assumed this to be the case in estimating the cost of a full DVB-T2 upgrade. With a full DVB-T2 upgrade, these viewers will face the choice of paying to replace their equipment or losing access to DTT.
- 5.47 With a partial upgrade, in which two PSB multiplexes were still available on DVB-T, these viewers would have a choice between replacing equipment, or continuing to access the main PSB channels (losing access only to the COM multiplexes). The latter option would be attractive to viewers who have little interest in the channels carried on the COM multiplexes. However, the number of viewers who will be in this category in 2022 is highly uncertain.
- 5.48 As a result, while we consider that there is scope for a partial upgrade to reduce the viewer costs relative to a full upgrade (by giving viewers an alternative to replacing equipment) we have no basis for estimating how much viewer costs would in fact be reduced.
- 5.49 We have therefore focused on the costs of a full upgrade, recognizing that it is likely to overstate the impact on viewers to some degree.

**We estimate the opportunity cost of DTT no longer being able to use the 700 MHz band to be between £80m -100m**

- 5.50 As we explained in detail in the consultation document, we estimate the total upgrade cost in 2014 NPV terms of a full DVB-T2 transition would be between £340m – 370m. However, we estimate that running 6 multiplexes instead of 8 would result in an operating cost saving of between £250m -290m. Therefore the net cost of a DVB-T2 migration would be between £80m - £100m. By extension, we estimate the forgone value to the DTT platform resulting from change of use of the 700 MHz band to be £80m - £100m.
- 5.51 In its response, Digital UK argued that our approach failed ‘to capture the full loss of value, as the calculation does not consider the lost value to consumers from change of use – i.e. the loss of services on the [interim multiplexes]’. We recognize that the interim multiplex will need to be discontinued following change of use of the 700 MHz band. However, we believe that following the re-plan multiplexing efficiency improvements will mean that it is possible to accommodate the majority of the services it currently carries within the remaining national multiplexes, without the need for DVB-T2 migration. We consider that the cost of migration is a useful proxy for the (upper bound of) opportunity cost of any services that are lost as result of change of use. This is because we would expect that if these services were valued more highly than the cost of upgrade, the upgrade would take place and no services would be lost. We discuss Digital UK’s argument and other points respondents made about our approach to quantifying opportunity cost in more detail in annex 1.

## Section 6

# Impact on DTT viewers and resulting costs

- 6.1 This section considers the impact change of use of the 700 MHz band will have on DTT viewers. It notes that:
- 6.1.1 For the vast majority of viewers the proposed replan will only involve a simple retuning of their TVs or set-top boxes at the time of frequency changes. For up to 0.5% of households using DTT, it will also involve replacing their rooftop aerial. In addition, a small proportion of DTT viewers might be affected by interference from mobile handsets and base stations in the 700 MHz band. Our technical analysis to date indicates that the vast majority of cases could be solved by installing a DTT receiver filter.
  - 6.1.2 We will need to ensure that an information campaign is put in place to help viewers carry out retunes, aerial replacements and potentially receiver filter installations.

## Change of use of the 700 MHz band will mean some viewers will need to retune their televisions

- 6.2 As outlined in Section 5, change of use of the 700 MHz band will involve changes to the DTT frequency plan. Televisions and DTT set top boxes (STBs) are tuned to pick up signals transmitted on specific frequencies. Viewers in areas where the frequencies DTT uses change will therefore need to retune their televisions.
- 6.3 We anticipate consumer retunes will take place on a staggered region-by-region basis.<sup>33</sup> If the programme were to finish at the beginning of 2022, we would expect the first viewer retunes to take place in 2019 and the last retunes to take place at the beginning of 2022.
- 6.4 Based on early frequency planning studies, we estimate that 14m-20m households will need to retune. However, the precise number will depend upon the details of the revised DTT frequency plan. The timing of change of use of the band will not have a material bearing on the number of retunes.
- 6.5 Most viewers have already had experience of retuning. Not only did all DTT viewers need to undertake two retunes as part of DSO, but a proportion of viewers also needed to retune as part of the recent 800 MHz clearance programme. Moreover, Digital UK advises viewers who contact them via the call centre or use their website that they should retune their televisions from time to time in order to ensure that they retain access to all channels in the event of changes in the line-up on DTT multiplexes.
- 6.6 The available evidence indicates that a very large majority of viewers feel confident retuning their televisions when they are provided with appropriate communications and support. Research conducted by Digital UK from a retune in March 2013 in the Mendip and Winter Hill transmission areas found that 81% of people thought retuning

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<sup>33</sup> This is because, as we explain above, we expect DTT frequency changes will be regionally phased.

was a straightforward process and 79% said they would feel confident about retuning equipment in the future. Moreover, statistics from Digital UK's consumer helpline suggest that on the day of switchover, only around 1% of households had queries about retuning. In its response to our consultation document, Digital UK stated that 'with appropriate communications and support we agree that retuning is now a manageable process for most'.<sup>34</sup>

- 6.7 All this considered, we do not believe that retuning will cause significant detriment or inconvenience to viewers, provided the appropriate consumer support arrangements are in place. Nonetheless, we recognise that, as Digital UK's consultation response notes, a minority of viewers will find the retuning process challenging. As we explain in section 8, ensuring these viewers receive adequate support will be a priority for us.
- 6.8 Notwithstanding our view that retunes are unlikely to cause significant detriment to viewers, for the purposes of our CBA we have sought to ascribe a cost to the time spent conducting a retune. In our consultation document, we estimated that an average retune takes 5 minutes. Using an estimate of the value of consumer leisure time of £7.76 an hour in 2022,<sup>35</sup> we calculated the total cost of consumer time lost from retuning to be between £7m – 10m.
- 6.9 Digital UK disagreed with this estimate. It argued that an automatic retune typically takes 6 minutes and a manual retune 13 minutes. On this basis it suggested we use 8 minutes as a benchmark for the amount of time spent retuning. It also argued that we should adjust our estimate to reflect time spent retuning second sets. It therefore stated that £20m -30m would be a more appropriate estimate of the cost of time spent retuning.
- 6.10 We have already included in our estimate a cost for each household that has to retune at least one set (even if it is their secondary set). We recognise that some households will need to retune more than one set. Therefore our consultation document may understate the number of retunes required. However, there are a number of factors which offset this:
- 6.10.1 First, Digital UK's consumer helpline advises viewers that an automatic retune typically takes 3-5 minutes and a manual retune around 5 minutes.<sup>36</sup> We therefore believe that we may in fact have slightly overstated the average amount of time taken to do a retune.
- 6.10.2 Second, in reality, we believe most viewers will be able to carry out other activities while their televisions are retuning.
- 6.10.3 Third, Digital UK's consumer helpline advises that best practice is for viewers to retune every 'couple of months' in any case. It could therefore be argued that for a large proportion of viewers the 700 MHz retune will not constitute an additional retune but will simply replace a regular retune they would have undertaken anyway.
- 6.11 As a consequence, we do not believe there is a case for amending our estimate of the cost of time spent retuning.

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<sup>34</sup> [http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/responses/Digital\\_UK\\_Limited.pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/responses/Digital_UK_Limited.pdf)

<sup>35</sup> This approach is based on a previous estimate of the cost of consumer time from the Department of Transport and used previously by Ofcom.

<sup>36</sup> We would expect the majority of retunes to be automatic.

## A small proportion of viewers will need to replace their aerials

- 6.12 A small proportion of viewers will need to replace their aerials as a result of the re-plan.
- 6.13 Most aerials sold today are “wideband” aerials. This means that they are able to receive signals transmitted at any of the frequencies in the spectrum currently used by DTT. However, many older aerials (as well as a small proportion of those aerials sold today) are only capable of receiving signals transmitted on a subset of the frequencies DTT uses. Such aerials are called grouped aerials.
- 6.14 Because of the changes in frequencies associated with the re-plan, a small proportion of grouped aerials will no longer be able to receive TV signals following the change. By contrast, we do not expect any wideband aerials will need to be replaced due to the re-plan.
- 6.15 We estimate that in total between 105,000 and 110,000 households will need to replace their aerials. In order to generate this estimate, we assessed how many aerials will go out of group according to the frequency planning studies we have conducted and adjusted the figure to reflect the following factors:
- 6.15.1 **The number of wideband aerials expected to be used when frequency changes happen.** For the purposes of this analysis, we estimate that frequency changes will happen between 2019 and end 2021. We have therefore assumed that on average aerial replacements occur in 2020. At this point we forecast wideband aerial penetration will be 75-90%.<sup>37</sup>
- 6.15.2 **Households that continue to use set top or portable aerials.** Set top aerial users would continue to receive the DTT signal following a change of use of 700 MHz, as they are all wideband. We estimate that around 2% of DTT households use DTT on their main set and 8% use a set top aerial on another set. We note that the DTT network is not planned and designed for TV reception by way of set top aerials.
- 6.15.3 **A proportion of households do not use the DTT platform and will, therefore, not be affected by change of use.** Approximately 25% of households rely solely on an alternative platform.<sup>38</sup>
- 6.16 On average, it costs around £150 to replace an aerial. We therefore estimate that the full cost consumers incur replacing aerials will be £15-17m in undiscounted 2014 prices. Assuming aerials have an average asset life of 25 years, this means that the discounted cost of bringing aerial replacement forward is between £3m - 6m in 2014 NPV.
- 6.17 In our consultation document we had originally estimated that 80,000-90,000 households would need to replace their aerials and that the discounted cost of bringing aerial replacement forward would be £2m – 4m in 2014 NPV. However, we have since identified an error in our modelling – we had effectively assumed that all aerial changes were only required in 2022. As noted above, in reality, retunes will

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<sup>37</sup> Ofcom, May 2014, *Consumer aerial survey: Implementing Ofcom's UHF Strategy*.  
<http://stakeholders.ofcom.org.uk/consultations/700MHz/>

<sup>38</sup> Ofcom, April 2013, *Digital Television Update: Chart Pack for Q4 2012*, Figure 1:  
<http://stakeholders.ofcom.org.uk/binaries/research/tv-research/tv-data/dig-tv-updates/2012Q4.pdf>

happen on a phased basis over a number of years and a more appropriate assumption is an average change date of 2020.

- 6.18 If change of use of the 700 MHz band happened earlier, this would mean aerial replacements would start sooner and aerial replacement costs would be higher. If the change completed in early 2020 and aerial changes took place in 2018 on average, we estimate this would result in costs of £5m – 8m in 2014 NPV.
- 6.19 Because the number of households that will need new aerials is small, the total value of time lost to households upgrading aerial equipment (to select an installer, to procure their services and to engage with them as necessary) is likely to be low. We estimate this cost at less than £500,000, and possibly less than £50,000, depending on the average amount of time it takes a household to arrange an aerial replacement.

### **We do not expect a material number of households will lose DTT reception due to the change**

- 6.20 Digital UK argued that, in addition to the households that need to replace their aerials, up to 300,000 households could lose DTT reception due to the re-plan. It expressed the view that:
  - 6.20.1 Some of these households would be able to restore reception by re-pointing their aerials at other DTT transmitters; but
  - 6.20.2 Some would not be able to restore reception and would be at risk of losing access to DTT.
- 6.21 In the light of this comment we have reviewed the results of our frequency planning studies. As set out in section 5, the model we use for frequency planning predicts that we will be able to meet our coverage objectives. However, it also predicts that in theory around 300,000 households might experience a change in reception. These households can be divided into two categories:
  - 6.21.1 Households for whom localised coverage changes mean that the best signal might in future come from a different transmitter to the one that currently provides the best signals to that area. These account for the vast majority of the ca. 300,000 households under consideration. They are the households that Digital UK has suggested might need to repoint their aerial.
  - 6.21.2 Households whose signals might drop below the level above which we consider that area as served by DTT. These are a small minority of the households under consideration. They are the households that Digital UK has indicated might be at risk of losing access to DTT.
- 6.22 In practice we do not believe that a material number of these households will either lose access to DTT or need to repoint their aerial. Aerial installations tend to have more margin against failure than the planning model assumes in areas where DTT signals are weak. This means that the model tends to overstate the extent to which changes in the network affect them. If we take this effect into account, it is reasonable to infer that the number of households that lose coverage or need to repoint aerials will in reality be minimal.
- 6.23 The conclusions set out above are consistent with our experience of other TV network re-plans. Before DSO, the planning model predicted that just less than 250,000 households would lose access to DTT due to coverage changes. Similarly,

the planning model predicted that 800 MHz clearance would result in 20,000 households losing access to the PSB multiplexes and around 60,000 households losing access to the commercial multiplexes. Nonetheless, the available evidence suggests that these predicted losses did not occur in practice.<sup>39</sup>

## **A small proportion of DTT viewers might experience interference from mobile services**

- 6.24 There is a risk that mobile signals in the 700 MHz band could cause interference to DTT viewing in a small number of households. Affected viewers would experience temporary loss, or reduction in quality (pixellation), of their picture.
- 6.25 This is a related but different issue to the interference a small minority of DTT viewers experienced as a result of LTE deployment in the 800 MHz band. In that case, emissions from mobile base stations are the key source of interference. Base station interference may occur again in the case of the 700 MHz band. However, in the case of 700 MHz, because the frequency band will be configured differently, mobile devices are likely to be the predominant source of interference. Although mobile devices will of course often be much closer to DTT aerials than mobile base stations, they transmit at vastly lower power levels and (for the most part) at much lower heights than DTT aerials. These two factors significantly reduce the risk of interference.
- 6.26 We have conducted some preliminary technical analysis to investigate the issue in this case. We expect that the vast majority of households will not experience any interference at all due to change of use of the 700 MHz band. Any interference that mobile devices do cause is likely to be of a transitory nature. This is because mobile devices both move around and transmit intermittently at varying powers. Some households that appear to face a risk of interference based on theoretical calculations may never experience interference, or experience it very infrequently (e.g. for a few seconds a year or less).
- 6.27 On the basis of our preliminary analysis to date, however, we believe that the number of households that experience noticeable interference from handsets is likely to be low. Similarly, we expect that interference from 700 MHz base stations to DTT receivers will be no greater than the interference caused by 800 MHz band (as explained above, to date this has been minimal in scale). We discussed these issues in more detail in annex 10 of our consultation document.
- 6.28 Our analysis indicates that if any interference did occur, the vast majority of problems could be solved by installing a DTT receiver filter. In the remaining cases, other measures such as improving DTT installations or replacing equipment might be required.
- 6.29 For our CBA, we have assumed the cost of mitigating interference to be between zero and £20 million. We set this position out in our consultation document. No consultation respondents provided additional evidence that support changes to our

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<sup>39</sup> If coverage losses on this scale had occurred we would have expected to see large numbers of complaints from viewers. We did not end up doing so.

estimate. Indeed Digital UK noted that the 'allowance for mitigating interference of up to £20 million appears reasonable'.<sup>40</sup>

- 6.30 A number of consultation responses emphasised that more work is needed to assess the scale of the interference issue. We have sufficient confidence in the cost estimate above to be able to make a decision on future use of the 700 MHz band. However, as we move forward with implementation, we will carry out further work to refine our understanding of the nature and the scale of this issue. Annex 1 provides a comprehensive summary of the points consultation respondents made about coexistence and explains in more detail how we have taken them into account in our analysis.
- 6.31 In addition to refining our understanding of interference issues, we are taking a number of pre-emptive steps to try to reduce them.
- 6.31.1 First, we are engaging with manufacturers with a view to ensuring that they make TV receivers more resilient to interference from mobile signals in adjacent spectrum bands; and
- 6.31.2 Second, we are encouraging international standards bodies to tighten restrictions on out of band emissions from mobile handsets.
- 6.32 We have already secured agreement in 3GPP Release 12 that handset out of band emissions will not exceed -42 dBm in circumstances where MNOs operate channels no more than 10 MHz in width. We intend to work towards reducing the OOB emission limits for wider channel bandwidths, where possible and appropriate, in a future release of the 3GPP standard. Currently, international standards allow handset out of band emissions to be up to -25 dBm in circumstances where MNOs deploy channels that are wider than 10 MHz. We believe there is scope for standards bodies to tighten these further. However, if they do not do so and there were evidence that the looser out of band emissions restrictions could materially increase the number of households affected by interference, we would consider whether we needed to take further steps to address the problem. Such steps might include prohibiting the use of channels wider than 10 MHz in the 700 MHz band.

## **We will ensure that viewers receive appropriate information and support with the changes**

- 6.33 In view of the above analysis, we do not believe that change of use of the 700 MHz band will cause significant detriment to DTT viewers.
- 6.34 Nonetheless, as we explained in our consultation document, it is essential that viewers receive appropriate information about and support with the changes discussed in this document. A large number of consultation respondents, including the Voice of the Listener and Viewer, the Consumer Communications Panel, the Advisory Committee on Disability, and Digital UK echoed this point. They stressed the importance of a thorough consumer information and support campaign and underlined the need to pay particular attention to the needs of vulnerable viewers. We discuss their responses in detail in annex 1.

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<sup>40</sup> Digital UK, August 2014, *The future use of the 700 MHz band: Consultation response from Digital UK*, [http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/responses/Digital\\_UK\\_Limited.pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/responses/Digital_UK_Limited.pdf)

- 6.35 Over the coming months and years we will work with Government, industry stakeholders, and consumer groups to put consumer information and support measures in place. A key focus of our work in this area will be addressing the needs of vulnerable viewers.
- 6.36 As we explained in the consultation document, based on experience from DSO and 800 MHz clearance, we estimate that a consumer information scheme would likely cost in the region of £30m. For the purposes of our CBA, we have modified this number by spreading the cost out over the five years preceding change of use of the band and discounting it at the rate of social time preference (3.5% per annum). This gives a 2014 net present value of £25m if change of use of the band takes place in 2022. This does not include the cost of addressing coexistence issues, which we have discussed separately above.
- 6.37 Digital UK argued that in addition to the consumer information scheme discussed above there should be a separate ‘aerial support programme’ which provides:
- 6.37.1 Financial assistance to anyone needing a new aerial (for any TV set) as a result of change of use of the 700 MHz band; and
- 6.37.2 An additional level of end-to-end practical support for vulnerable groups.
- 6.38 Digital UK stated that we should take the costs of such a programme into account in our CBA. Moreover, it argued that this programme should reimburse viewers for the full costs of replacing their aerials and that therefore the CBA should consider the full cost rather than the cost of bringing aerial replacement forward.
- 6.39 As discussed in section 2, any decisions about public funding of this or other aspects of the programme are a matter for Government. However, irrespective of what decisions Government takes about support with aerial replacement, we do not consider that it would be appropriate to adjust our CBA to reflect Digital UK’s comment on this matter.
- 6.40 Our existing estimates already include the cost of aerial replacement, and these costs are the same regardless of whether they are met by consumers or through a grant scheme. We believe that, if an aerial support programme were deemed necessary, it could in principle be administered by the same body that manages the broader consumer information and support programme. We do not think this would increase the costs of the consumer support scheme above the level identified in the consultation document.
- 6.41 As we have explained, the CBA attempts to assess the economic costs and benefits of change of use of the 700 MHz band. It does *not* seek to establish the budget for implementing the change. We believe that the cost of bringing equipment replacement forward is the relevant measure of economic cost for the purposes of this analysis. Our use of the cost of bringing equipment replacement forward in this CBA has no bearing on decisions Government takes on what proportion (if any) of aerial replacement costs that might be funded.

## Section 7

# Implications for PMSE and resulting costs

- 7.1 Change of use of the 700 MHz band will have two main impacts on PMSE users. First, it will mean a significant number of PMSE users need to replace their equipment as it will no longer be usable without the 700 MHz band. Second, it will significantly reduce the supply of interleaved spectrum in the broadcast bands which PMSE users can access.
- 7.2 This section considers both of these impacts. It explains that:
- 7.2.1 We estimate change of use of the 700 MHz band will result in PMSE equipment replacement costs of between £13m – 21m in 2014 NPV and staff training and recruitment costs of £10m – 13m in 2014 NPV;
- 7.2.2 It may also result in some R&D costs and equipment decommissioning costs. We have not been able to quantify these costs, but we do not expect them to be sufficiently large to have a material impact on the overall balance of this CBA; and
- 7.2.3 We believe we will be able to ensure that PMSE users have access to sufficient spectrum to continue delivering the benefits they provide today once they lose access to the 700 MHz band.

## **Change of use of the 700 MHz band will result in PMSE equipment replacement costs of between £13m – 21m**

- 7.3 Audio PMSE devices such as wireless microphones, in ear monitors, and talkback/intercom systems use interleaved spectrum between 470 MHz - 790 MHz. This is the main source of spectrum for these types of device.
- 7.4 Following the change, PMSE users will no longer be able to access spectrum made available to future mobile data as part of the 700 MHz award. This will mean that they need to replace:
- 7.4.1 all PMSE equipment which operates exclusively in the 700 MHz band;
- 7.4.2 a proportion of equipment that has a tuning range which extends both above and below 694 MHz (i.e. which lies within and immediately below the 700 MHz band). This is because change of use of the 700 MHz band will reduce such equipment's usable tuning range. In some instances this reduction may be sufficiently material that it renders the equipment unfit for its intended purpose; and
- 7.4.3 a proportion of equipment that operates in the 470 MHz -694 MHz tuning range and is used in a fixed location. This is because revisions to the DTT frequency plan will mean that the interleaved spectrum which is available in some locations will change.
- 7.5 In order to assess the scale of the associated costs, we conducted a survey which asked a selection of large hiring companies, theatres and other owners of PMSE equipment to provide information on: the tuning range of their equipment; the

approximate value of their equipment; when they purchased it; and when they intended to replace it.<sup>41</sup>

- 7.6 On the basis of these survey results, we estimate that the costs of replacing PMSE equipment will be between £13m -21m in 2014 NPV if change of use of the 700 MHz band happens at the start of 2022. If the change happens in 2020, we estimate the costs will be between £15m – 26m in 2014 NPV.
- 7.7 These figures differ slightly from the estimate in our consultation document where we estimated that:
- 7.7.1 If change of use of the 700 MHz band took place at the start of 2022, the cost of replacing PMSE equipment would be between £6m - £18m in 2014 NPV; and
- 7.7.2 If change of use of the 700 MHz band took place in 2020, the cost of replacing PMSE equipment would be between £11m - £23m in 2014 NPV.
- 7.8 This estimate was predicated on the assumption that no equipment replaced between now and 2022 would be affected by the change. We made this assumption on the basis that we expected that once we had made a decision about the future of the 700 MHz band stakeholders who were replacing equipment would avoid buying items which used this band.
- 7.9 A number of consultation respondents questioned this assumption. For example, BEIRG argued that:
- 7.9.1 ‘Until alternative bands are designated...PMSE users will need to continue buying equipment which operates in the 700 MHz band, on the same basis that they do now, in order to have access to enough channels for large productions’; and
- 7.9.2 ‘any equipment purchased over the next eight years will be bought without a clear understanding of the configuration of spectrum post the clearance of the 700 MHz band. Hence, it is entirely possible that this equipment will become redundant’.<sup>42</sup>
- 7.10 We expect that from now on PMSE users will make efforts to avoid buying equipment which subsequently needs to be replaced early because of the re-plan. As we explain below, we are exploring options for PMSE users to use other spectrum bands once they lose access to the 700 MHz band. Once equipment which operates in these bands is available, we would expect stakeholders to cease buying equipment that operates in the 700 MHz band.
- 7.11 Nonetheless, we accept that before this there may be instances where constraints on the availability of interleaved spectrum below 694 MHz mean that PMSE users need to continue buying equipment in the 700 MHz band as part of their normal replacement cycle. We also recognise that it will be a number of years before the post clearance configuration of interleaved spectrum below 694 MHz will be known. This is because it will take a number of years for us to finalise the DTT frequency

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<sup>41</sup> We presented the results of this survey in annex 12 of our consultation document.

<sup>42</sup> BEIRG, August 2014, *Future use of the 700 MHz band: Cost benefit analysis of changing its use to mobile services - Response*, p.11, [http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/responses/British\\_Entertainment\\_Industry\\_Radio\\_Group\\_\(BEIRG\).pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/responses/British_Entertainment_Industry_Radio_Group_(BEIRG).pdf)

plan. We recognise that until they know what interleaved spectrum will be available where, PMSE users will not be able to guarantee that equipment they are buying will be fit for purpose following the re-plan.

- 7.12 For the purposes of our analysis, we now assume that for equipment that is purchased between now and the change of use, the same proportion will need replacing at that time, as is the case for existing equipment. Our new cost estimate reflects this change in assumptions. We believe this approach is likely to overestimate the cost somewhat as we think that even before other bands become available PMSE users will in many cases be able to avoid buying equipment that only operates in bands they will no longer be able to use following change of use.
- 7.13 Our analysis suggests that in order to address the challenges posed by change of use of the 700 MHz band, PMSE users will have to upgrade a proportion of their equipment rather than just undertaking a like-for-like replacement. When producing the above estimate, we made the following adjustments to reflect this:
- 7.13.1 We included a 20% to 40% mark-up on all equipment. This reflects the potential need to purchase equipment that is more frequency agile and covers a wider tuning range. This mark-up represents the average cost. Some equipment will not require upgrading while other equipment will cost more to upgrade.
- 7.13.2 We included a 25% to 50% mark-up on talk-back equipment. This reflects the potential need to replace this equipment with equipment that operates in a different frequency band. This is separate to the mark-up on equipment to cover a wider tuning range.
- 7.14 BEIRG has argued that these figures understate the size of the mark-up on new equipment. We asked BEIRG for further information about its reasons for believing this. However, it did not provide any evidence that would support us changing our assumptions about the size of the mark-up.

## **Change of use of the 700 MHz band may result in R&D costs and decommissioning costs**

- 7.15 The second change to our estimate of PMSE equipment costs relates to decommissioning costs. BEIRG argued that change of use of the 700 MHz band will result in decommissioning costs for some users. For example, the change may mean stripping equipment out of entertainment venues.
- 7.16 Our consultation document did not factor in the costs of decommissioning equipment. In the light of BEIRG's comment we have therefore sought to come up with an estimate of the potential magnitude of this cost. We believe that experience with the clearance of PMSE from the 800 MHz band provides a useful benchmark for making this estimate.
- 7.17 In its consultation response, BEIRG noted that during the 800 MHz clearance process one company committed 501 working days to decommissioning equipment. This included complex planning to arrange for the removal and replacement of equipment that was installed in venues on a long term basis. BEIRG argued that this cost would not have been incurred in the normal course of equipment replacement, which is a simpler process. Given the expertise needed to perform this task, we would expect the average day rate for the work to have been in the region of £250. This implies that the total decommissioning costs for the company in question were

about £125,000, or around 5 per cent of the replacement cost of the equipment the company decommissioned.

- 7.18 We consider that for other businesses, less of whose equipment is installed at venues, costs would be lower. We also consider that some decommissioning costs would be incurred at the time of equipment replacement, and so should not be counted as an additional cost resulting from clearance. However, an upper bound estimate of costs can be calculated by assuming that across the industry, decommissioning costs are around 5 per cent of equipment replacement (but not upgrade) costs. This would suggest that the decommissioning associated with 700 MHz clearance could cost £0.3m -0.5m in 2014 NPV across the industry. We believe that this is likely to be an overestimate.
- 7.19 In addition, BEIRG stated that there may be some R&D costs associated with developing equipment that functions in other spectrum bands. We recognise manufacturers may incur R&D costs and that they may ultimately pass the costs on by charging higher prices for equipment. However, this is already reflected in the mark-up we discuss above.

## **We aim to ensure PMSE users have access to sufficient spectrum following the change**

- 7.20 Change of use of the 700 MHz band will cause a material reduction in the amount of spectrum available for PMSE in the broadcast bands. As we explained in our consultation document, if left unmitigated, this reduction in spectrum availability could force producers of some large events (such as sporting events, concerts and plays) to significantly compromise production values. This would have a detrimental effect on audiences.
- 7.21 As explained in section 2, ensuring this does not happen is a priority for us. We are currently conducting a strategic review of the PMSE sector's future spectrum requirements (the 'PMSE Review'). One of the objectives of this review is to ensure audio PMSE devices have access to sufficient spectrum to continue delivering the benefits they provide following change of use of the 700 MHz band.
- 7.22 As part of the PMSE Review, we are currently looking to identify new spectrum sharing opportunities for audio PMSE users. We have identified two candidate bands that we believe have good potential for sharing with low power PMSE audio applications. These are:
- 7.22.1 **960 MHz - 1164 MHz:** this band is internationally allocated to the Aeronautical Service for a range of applications such as distance measuring equipment (DME) and secondary surveillance radar. The initial studies we have undertaken suggest that there is a good probability that PMSE will be able to share the band with these services. The channelling arrangements and locations of these aeronautical systems could provide a large amount of spectrum that could be accessed by low power PMSE applications on a geographically interleaved basis, particularly indoors.
- 7.22.2 **1525 MHz -1559 MHz:** this band is predominantly used for the Mobile Satellite Service. Our analysis suggests some risk of interference into MSS Earth receive stations. However, we believe there is likely to be scope for sharing in this band. We will discuss our findings with MSS stakeholders and carry out practical coexistence tests to further explore the potential for PMSE use of this band.

- 7.23 Undertaking further work on these bands is now the key focus of the PMSE Review. In particular, we need to carry out more detailed practical tests in order to confirm the feasibility of sharing options. However, based on the initial studies we have undertaken on these bands, we are currently confident that we will be able to ensure PMSE users have sufficient spectrum to continue delivering the benefits they currently provide following change of use of the 700 MHz band.
- 7.24 We are also exploring how far access to the 700 MHz centre gap and guard band could contribute to offsetting the loss of the rest of the 700 MHz band. We believe they could be used by PMSE applications that do not require such high quality of service e.g. production communications. Given this assumption, use of the centre gap and guard band for production communications could be an effective mitigation in many but not all of the cases we previously studied. From a spectrum management perspective we would prefer to see PMSE in one of the other bands, as we believe the centre gap could have significant value for SDL. However, until the conclusion of the PMSE Review we are keeping the option of using it for PMSE open.<sup>43</sup>
- 7.25 BEIRG argues that we should delay our decision on the future of the 700 MHz band until we have confirmed the feasibility of the sharing options discussed above. It gives two reasons for this:
- 7.25.1 First, BEIRG is concerned that there is a risk that the options in question will not prove technically feasible. It is concerned that if this were to prove to be the case, PMSE users would not have sufficient spectrum to continue delivering the important cultural benefits they do today. BEIRG does not believe it would be appropriate for us to take a final decision on the future of the 700 MHz band while this risk exists;
- 7.25.2 Second, BEIRG believes that if we take a decision on the future of the band in advance of identifying new spectrum options for PMSE, there is a risk that equipment which operates in this spectrum will not be ready for use before the change happens. BEIRG argues this would mean there is a period during which the PMSE sector had to operate with significantly constrained spectrum supply.
- 7.26 We have considered these points carefully. However, we do not believe that it would be in the best interests of citizens and consumers for us to delay our decision:
- 7.26.1 Based on the analysis we have undertaken to date, we believe the risk of not ensuring adequate spectrum is available for PMSE is low. Conversely, as we explain in section 8, the cost of delaying change of use of the band would be high. Because implementation work needs to begin now in order to achieve our objective of releasing the band as early as possible, this means that the costs of delaying our decision would also be high.
- 7.26.2 We anticipate that we will conclude the PMSE Review in 2015. We believe that this should allow sufficient time for manufacturers to develop and bring

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<sup>43</sup> In the consultation document we also outlined a number of other frequency bands between 1427 MHz and 1518 MHz which we would study. However, the bands have been identified for future mobile use and are unlikely to meet our objective of providing a long term solution for audio PMSE applications. Therefore at this time we are not planning to conduct further detailed analysis into whether they would provide sharing opportunities for PMSE.

to market equipment that tunes to any new bands we make available before change of use of the 700 MHz band occurs.

## **PMSE users may need to improve their equipment and working practices**

- 7.27 Depending on what spectrum options the PMSE Review identifies for them, PMSE users might need to make some improvements to their equipment and working practices due to change of use of the 700 MHz band. These include:
- 7.27.1 using current PMSE equipment in a more spectrally efficient manner, for example by adopting best practice in both RF engineering and frequency calculation. This could improve spectrum efficiency significantly for some events, although gains would be limited for others;
  - 7.27.2 using new, more spectrally efficient and frequency agile equipment. This could include:
    - a) digital PMSE technology, which, while not suitable for all applications, is now mature to the point where it could benefit some users from its greater spectral efficiency. Digital equipment could be particularly useful for indoor events with high microphone channel-counts where lower power is appropriate e.g. musical theatre;
    - b) taking advantage of other recent advances in PMSE technology (e.g. low-intermodulation transmission modes) to optimise frequency planning, which may result in moderate increases in spectral efficiency; and
  - 7.27.3 managing spectrum demand and planning centrally for large events, feeding into decision-making at the event design phase.
- 7.28 Some of these changes are part of the long term development of the PMSE industry, e.g. adoption of digital equipment and taking advantage of advances in technology, and therefore would have happened anyway irrespective of our decision on the future of the 700 MHz band. However, some of the changes might not happen absent this re-plan. We have therefore attempted to quantify the cost only of those changes that are a direct consequence of change of use of the 700 MHz band. The changes which fall into this category are:
- 7.28.1 employing more RF engineers and increasing the skills and best practice of current employees. We estimate between 15 and 20 new RF engineers will need to be hired and between 20 and 30 current employees will need further training. We estimate the cost of these changes in working practices would be between £10m -13m in 2014 NPV over 20 years; and
  - 7.28.2 upgrading to more frequency agile equipment. As discussed above, our estimate of equipment replacement costs includes a mark-up to reflect the need for this upgrade.
- 7.29 We discussed these spectrum efficiency improvements in our consultation document. In its response, BEIRG argued that up to 1000 employees may need retraining.
- 7.30 The extent to which PMSE users need to re-train or recruit staff will depend on what spectrum is available to them following change of use of the 700 MHz band. The

sharing studies we have undertaken to date indicate that we should be able to ensure PMSE users have sufficient spectrum to continue operating without retraining or recruiting significant numbers of staff. We have not seen any evidence that would support us revising our estimate of potential upskilling costs. Indeed, given the outcome of sharing studies we have undertaken to date, it could be argued that our estimate is somewhat pessimistic.

## Section 8

# Conclusions and next steps

8.1 In the preceding sections, we have presented our assessment of the costs and benefits of change of use of the 700 MHz band. We now move on to draw this analysis together and set out our decision on the future of the band. We also discuss our plan for implementing this decision.

## **We have decided to change use of the 700 MHz band as soon as possible**

8.2 As demonstrated by table 6 below, our analysis indicates that the benefits of change of use of the 700 MHz band will outweigh the costs by a significant margin. As explained in section 4, we believe that a material proportion of the benefits will flow to citizens and consumers. We have therefore decided to proceed with change of use of the band.

8.3 When considering the balance of costs and benefits, it is important to note that there are a number of benefits which we have not been able to quantify but which could potentially be significant. Hence we believe there is potential for significant upside in our assessment of the benefits. On the other hand, we do not believe the costs are likely to exceed the range identified below.

**Table 6: Summary of estimated costs and benefits of change of use of the 700 MHz band<sup>44</sup> in 2014 NPV**

	<b>Benefits of change</b>		<b>Costs of change</b>	
Elements that we have quantified	Improvement in the performance that mobile users would experience particularly in rural areas and deep indoors	£390m-480m	DTT infrastructure modifications (including programme management costs, local TV replanning)	£420m-470m <i>(estimate in consultation: £350m-400m)</i>
			Consumer information scheme	£25m
	Reduction in costs of meeting increased demand for mobile data capacity from having to build and to operate fewer network sites	£480m-770m	Consumer aerial replacements	£3m-6m
			Cost of consumer time retuning TVs	£7m-10m
			Coexistence costs	£0-20m
			PMSE equipment replacement (including decommissioning costs)	£13m - 21m <i>(estimate in consultation: £6m - 18m)</i>
			DTT loss of value net of operating cost savings	£80m-100m
Reductions in consumer prices: a significant proportion of these network cost savings would likely be passed on to consumers		PMSE upskilling	£10m-13m	
<b>Total:</b> £900m-1.3bn of quantified benefits		<b>Total:</b> £550m-660m with potential for reduction as better information becomes available <b><i>(Estimate in consultation: £470m - 580m)</i></b>		
Elements that cannot be reliably quantified	Broader economic and social benefits from potential improvements in coverage if a 700 MHz award included a coverage obligation		WSD opportunity cost: current uncertainty over the deployment and take-up of WSDs does not support quantification and the change would be unlikely to have a material negative impact on white space availability overall	
	Use of centre gap: additional benefits would materialise, with several candidate uses but likely value uncertain			
	Access to new services: magnitude of benefits unclear. Could be very large, but could be zero			
	Increases in capacity for delivery of emergency services communications: magnitude of benefits unclear.			

<sup>44</sup> Costs ranging above £50m are rounded to the nearest £10m; costs do not sum to the total costs shown due to rounding.

	<b>Effect of unquantified benefits:</b> potential for significant upside over and above the quantified benefits	<b>Effect of unquantified costs:</b> not material to total costs
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- 8.4 The summary set out above models a scenario in which the 700 MHz band becomes available for mobile data at the beginning of 2022. However, we have also considered the impact of earlier change of use of the band. In general, we expect that the earlier the change occurs, the sooner MNOs will be able to deliver benefits such as improvements in network performance. For example the Analysys Mason model estimates that an earlier change of use in 2020 would increase the network cost saving and performance benefits by between £20m – 70m in the central range. Moreover, earlier change of use would bring us more closely into line with the plans of the other countries in Europe that are leading the drive to use the 700 MHz band for mobile data.
- 8.5 The costs of change of use will also tend to be higher (particularly in net present value terms) if a change of use occurs earlier. However, on balance we consider that any practical advantages to delaying are likely to be limited, and that changing use of the 700 MHz band at the earliest possible opportunity would be likely to deliver the optimum balance of costs and benefits.
- 8.6 Conversely, a delay in change of use risks reducing the benefits: if mobile operators face short-term pressure to meet rising traffic, and uncertainty about how much, if any, 700 MHz spectrum they will gain access to, they may respond by building more sites, incurring network costs which could otherwise have been avoided and hence reducing the value of 700 MHz spectrum when it is subsequently released.
- 8.7 This being the case our objective is to implement the change as soon as practicably possible. There are a number of factors which could influence the timing of change, including the speed with which it is possible to modify DTT transmission infrastructure and the speed of progress with international frequency planning negotiations. At this stage there is still too much uncertainty about some of these factors for us to commit to a specific implementation timetable. However, we believe that from a technical perspective it should be possible to release the 700 MHz band across the UK by the beginning of 2022, and potentially sooner.

## **We will now move on to develop an implementation plan**

- 8.8 Now we have made a regulatory decision on the future of the 700 MHz band, we will focus on developing a plan for implementing this decision. There are a number of aspects to the work we will do on implementation. We discuss these below.
- 8.9 **Securing international agreements:** We will work to secure the international frequency planning agreements that are needed to enable change of use of the 700 MHz band to take place. We discussed the international dimension to this programme of change in section 2.
- 8.10 **Replanning the DTT network:** We will work with broadcast stakeholders to develop a roll out plan for the DTT infrastructure modifications.
- 8.11 **Supporting DTT viewers:** As we discussed in section 6, we will work closely with Government, industry stakeholders and consumer groups to ensure viewers receive

appropriate information about and support with retunes, aerial changes and coexistence issues. The needs of vulnerable viewers will be a particular focus for us in this regard.

- 8.12 **Future proofing consumer equipment:** We will work with industry stakeholders to ensure that, in so far as is reasonably possible, all equipment sold from now onwards is able to operate following the re-plan. There are four strands to our work in this area:
- 8.12.1 We are working to ensure that aerial installers advise customers who are replacing their aerials to buy wideband aerials;
  - 8.12.2 we are working to ensure that manufacturers ensure that TVs are designed in such a way as to make retuning as simple as possible;
  - 8.12.3 we are engaging with manufacturers with a view to ensuring that they make TV receivers more resilient to interference from mobile signals in adjacent spectrum bands; and
  - 8.12.4 as noted in section 6, we are encouraging international standards bodies to tighten restrictions on out of band emissions from mobile handsets.
- 8.13 **Safeguarding PMSE:** We will continue with our efforts to ensure that PMSE users retain access to sufficient spectrum following change of use of the 700 MHz band. We aim to conclude our PMSE Review in 2015.
- 8.14 **Engaging with Government on funding:** As we stated in section 2, we are liaising with Government about options for funding this programme of change.
- 8.15 **Designing and holding an auction:** In due course, we will design and hold an auction for the 700 MHz band. In our consultation document we floated the idea of holding this auction early, possibly as soon as 2016. The rationale behind this idea was two-fold. Firstly, an early auction would give MNOs early certainty as to what their future spectrum holdings would be, thereby enabling them to plan network deployments in a more economically efficient manner. Secondly, an early auction might create scope for mobile licensees to engage with DTT multiplex licensees in ways which could accelerate change of use and thereby increase the benefits of the change. By and large, consultation respondents were opposed to the idea of an early auction. For example, MNOs such as Vodafone argued that if we held an early auction it would be impossible for participants to ascribe a commercial value to the spectrum, given the uncertainty about future market developments. On balance, we currently consider it likely that we will hold this auction up to 2 years before the spectrum starts to become available. Holding the auction some time in advance of spectrum becoming available will give MNOs early certainty as to their future spectrum holdings. This will enable them to plan network investment more efficiently. However, we will keep this under review. If we were able to release the band on a phased regional basis then we might well need to hold an auction at an earlier stage.

## Annex 1

# Summary of responses to the May 2014 cost-benefit analysis consultation

A1.1 This annex summarises the arguments stakeholders made in response to our consultation on the future of the 700 MHz band, together with our responses to their submissions. The consultation closed on 29 August 2014 and we received 57 responses, seven of which were confidential.

A1.2 Organisations from whom we received non-confidential responses are listed below:

Amber Sound	DH Sound	Mr S Moffat
Association of Professional Wireless Production Technologies (APWPT)	Digital Mobile Spectrum Ltd	Motorola Solutions
Arqiva	Digital Outreach	Musicians Union
Autograph Sound Recording	Digital UK	Networked Television
The Broadcasting, Entertainment, Cinematograph and Theatre Union (BECTU)	Dynamic Spectrum Alliance	Mr David Palmer
British Entertainment Industry Radio Group (BEIRG)	Ericsson	Programme Planning Professional Ltd
The British Film Institute (BFI)	Everything Everywhere	Samsung
Brew PSE	Freesat	The Scottish Government
BT	Freeview	Sky
Channel 5	Mr J P Gilliver	SSE Audio Group
Commercial Broadcasters Association (COBA)	Global Mobile Suppliers Association	TDF
Communications Consumer Panel and ACOD	Huawei	Tech UK
Copsey	The Institution of Engineering and Technology (IET)	Three
	Isle of Man Communications Commission	VI Rental
	Mr Dave Lee	Virgin Media
	Mr Matthew	Vodafone
		The Voice of the Listener and Viewer

Communication Consultants  Ms Amanda Davies	McCarthy  Mamma Mia Sound Department  Mr Andrew Meadows	Mr Stuart Wilson
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A1.3 We also received a number of responses from individuals and 14 letters from the PMSE community in support of BEIRG’s response.

### **Our assessment of the costs and benefits of changing use of the 700 MHz band (CBA questions 1, 2 and 3)**

*Question 1: Do you have any comments on Analysys Mason’s approach to quantifying the network cost savings and performance benefits?*

*Question 2: Do you have any comments on the other benefits we have identified including the likely magnitude or how they may be quantified?*

*Question 3: Do you agree with our assessment of the likely benefits of changing use of the 700 MHz band?*

<b>Stakeholder comments</b>	<b>Ofcom response</b>
<p>The majority of respondents broadly agreed that the approach we took to assessing the benefits was reasonable. However, a number of respondents highlighted that there was significant uncertainty about some of the input parameters (e.g. demand for mobile data).</p> <p>Respondents had varying views on our assessment of the benefits of changing use of the 700 MHz band. Respondents from the broadcast and PMSE sectors tended to believe we had overstated the likely benefits. They gave a number of reasons for this:</p> <ul style="list-style-type: none"> <li>• BEIRG, Digital UK and Freesat argued that we had underestimated the extent of future Wi-Fi offload and therefore overstated the benefits of making</li> </ul>	<p>We recognise that there are uncertainties to our CBA. However, we consider that some level of uncertainty is inevitable, given the timescales involved with changing use of the 700 MHz band. As we noted in our consultation, we have reflected these uncertainties by modelling a wide range of scenarios for variables such as the changing demand for mobile data, developments in technology, and the extent of Wi-Fi offload. We consider that we have taken reasonable and proportionate steps to take into account the inherent uncertainty.</p> <p>We agree that there is significant uncertainty about the future role of Wi-Fi offload. We have tried to address this by considering a range of traffic forecasts and we continue to believe that our estimates are reasonable. We have assumed very significant offload, including some to femtocells, that grows to 77% by 2030 in the mid case.</p> <p>Analysys Mason’s approach has already</p>

- additional mobile spectrum available.
- Digital UK argued that Analysys Mason's approach did not consider advances in technology such as re-farming 2G or 3G (or both) capacity in coming years, which would clear valuable low frequency spectrum that could be used in a similar way as proposed for the 700 MHz band.
  - Digital UK questioned our assumption that 700 MHz clearance would lead to lower consumer tariffs and argued that this was not the experience following the release of 800 MHz. A confidential respondent also suggested that the clearance of the 800 MHz band did not provide any cost savings to consumers, but simply resulted in an additional, higher contract tariff for 4G services.
  - BEIRG considered that we had exaggerated the benefits of harmonisation of the 700 MHz band, suggesting that additional frequency bands increase handset complexity, reducing performance and thereby requiring an increase in the number of base stations.

taken into account the potential for re-farming 2G and 3G capacity and the effect advances in technology may have on network capacity. Broadly speaking, the approach estimates that any bands allocated to mobile broadband from 2014 will deploy LTE technology. For the remaining bands that are already in operation with 2G or 3G, the approach assumes that 2G and 3G will continue to be used until 2021, at which point they will convert to LTE (with the exception of the 2.1 GHz band). The assumed deployment of 3G and LTE between bands is summarised in Figure 3.10 of the Analysys Mason report.<sup>45</sup>

Given the competitiveness of the UK mobile market, we expect a significant proportion of the savings to be passed on to consumers through prices that are lower than they otherwise would have been. However, we recognise some of the cost savings may also be passed onto the government in the form of auction revenues. The recent 4G auction provides limited evidence on the impact of spectrum release on consumer prices because the auction coincided with the launch of 4G services in the UK, which enable a higher quality service. Therefore, it is difficult to disentangle potentially lower costs from the introduction of 4G services and the initial price premium over 3G. Moreover, there is some evidence that mobile operators will not sustain the price premium – for example, Three does not charge any such premium.

We do not believe that the UK's decision about change of use of the 700 MHz band will affect manufacturers' decisions about which bands to include in their handsets. Many countries around the world have already allocated or are planning to allocate 700 MHz to mobile, so handsets used in the UK are likely to have capacity to use 700 MHz regardless of the UK's approach. Therefore, we do not expect our decision to have a bearing on handset complexity. In addition, handsets are increasingly capable of supporting a very

<sup>45</sup> *Assessment of the benefits of a change of use of the 700 MHz band to mobile*, 27 October 2014. [http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/annexes/benefits\\_700MHz.pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/annexes/benefits_700MHz.pdf)

In contrast, the mobile respondents tended to consider that we had understated the benefits of change of use.

Three and EE argued that, if change of use of the 700 MHz band resulted in a more symmetric division of sub-1 GHz spectrum, this could significantly enhance competition in the mobile market, thereby delivering significantly greater benefits than we have identified.

Vodafone considered that our estimate of the benefits represented the floor of the potential benefits because not all of the forecast data traffic may be realised if change of use of the 700 MHz does not occur. It submitted that building the necessary mobile sites to meet demand in congested areas is much more expensive than our modelling assumes, with site rental up to 15 times higher than for the average site. It also argued that in some areas it is prohibitively expensive or impossible to build sites, or that MNOs are unable to charge consumers enough to cover the cost of additional sites, even though consumers value capacity more highly than the cost. This implies that for some sites, the cost savings

wide range of bands. For example, the iPhone 6 supports approximately 15 distinct frequency bands, depending on the model, covering both frequency and time division variants of LTE.

Given the uncertainty involved with the timescales of change of use of the 700 MHz band, the approach taken in our consultation to quantifying the benefits of change of use of the 700 MHz band was necessarily cautious, and therefore it may be that the benefits are understated. We have also not sought to quantify a number of further benefits, such as improvements in mobile coverage, next generation emergency services communications, and the development of new services and technologies for consumers.

We have already noted that we expect that, through competition, some of the benefits of reduced costs will be passed on to consumers, but our overall conclusions are insensitive to the distribution of benefits between mobile operators, consumers, and Government (through auction revenue). If spectrum allocation were to encourage greater competition that led to further cost reductions, or investment and innovation, it would increase the benefits of change of use. We have not sought to quantify these dynamic effects.

We recognise the potential validity of Vodafone's point about more expensive mobile sites in congested areas which would mean that the cost savings provided by 700 MHz clearance would be higher than we have previously assumed. It would require further detailed analysis for us to assess the issue definitively. However, it is not necessary for us to do this because, insofar as this is true, it would tend to increase the estimate of benefits. There is also the possibility that in a small number of geographies it would be impossible or prohibitively expensive to meet demand without the use of the 700 MHz band. However, we are not in a position to

provided by 700 MHz clearance would be higher than our assumptions (which are based on an average site), and at others, use of 700 MHz would facilitate supply that would not otherwise occur. As such, it would provide no cost saving, but would instead provide additional benefits to customers, benefits to others that gain from customer use of data (such as internet retailers), and/or profits to MNOs. Vodafone argued that benefits to consumers would be likely to exceed the cost savings we noted.

Vodafone also submitted that small cells are likely to be connected via point-to-point radio rather than using wired backhaul solutions, and that such backhaul solutions have an opportunity cost of spectrum, which needs to be considered.

A number of respondents, including Ericsson, argued that we had overestimated the extent of future Wi-Fi offload (and therefore understated the benefits of change of use of the 700 MHz band).

Ericsson considered that additional value would be gained if PDDR use of the 700 MHz band was pre-emptive. Motorola also considered that, although we had identified potential PDDR use, we had not assessed the socio-economic benefits of reassigning spectrum to PDDR.

quantify the size of such effects. Insofar as they exist, they would also strengthen the case for change of use.

Our CBA made a simplifying assumption that in the absence of 700MHz clearance, MNOs would meet mobile demand through the deployment of macro sites. We noted that MNOs might well meet this demand using small cells, but also that the costs of these (per unit of capacity) are likely to be similar to the estimates included in our modelling. We do not consider that including the opportunity costs of spectrum used by point-to-point radio would have a significant impact on our analysis, but note that this would tend to strengthen the case for change of use.

We discuss PPDR in section 4 of the statement.

## Implications for the DTT platform and resulting costs (CBA questions 4, 5, 6 and 7)

*Question 4: Do you have any comments on our analysis of the implications change of use of the 700 MHz band would have for the DTT platform?*

*Question 5: Do you agree with our assessment of the likely costs of upgrading DTT transmission infrastructure?*

*Question 6: Do you have any comments on our assessment of the timeframes within which it might be possible to complete a DTT replan?*

*Question 7: Do you have any comments on our assessment of the loss of value from existing DTT services in case of change of use for the 700 MHz band?*

Stakeholder comments	Ofcom response
<p>Several of the broadcasters, including Channel 5, Digital UK, Freesat and Arqiva, argued that there was a risk some households would lose coverage as a result of change of use of the 700 MHz band. They argued that the CBA should make an allowance for the costs of remedying these losses.</p> <p>Arqiva argued that we had not identified any solutions to meet the challenges associated with re-planning local TV in particular, and was concerned that we might try to safeguard local TV coverage at the expense of retaining the coverage and capacity of the national multiplexes.</p> <p>Channel 5 was concerned that change of use of the 700 MHz band would limit the potential development of DTT as a platform as a result of the termination of the two temporary multiplex licences and the failure to mandate a change to DVB-T2. Arqiva also raised concerns regarding DVB-T2. It considered that it had not seen evidence to confirm that change of use of the 700 MHz band could be achieved without further migration to DVB-T2 and, until that evidence is published, DVB-T2 should</p>	<p>We address these concerns about coverage in Section 6 of the main statement.</p> <p>It will not be possible definitively to identify what spectrum is available for local TV until we have agreed a main station frequency plan (we aim to do this by end 2015). However, as we explained in Section 5 of our consultation, there are a range of technical options we could potentially use to re-plan local TV, including considering the local TV multiplex in the frequency planning process from the outset, reviewing its operating parameters alongside those of other multiplexes (with a view to optimising performance), or considering the role of a more robust transmission mode, such as DVB-T2. We aim to maintain a broad range of services on the national multiplexes with coverage broadly matching that achieved today, and we continue to believe it would be possible to achieve this in such a way that also enables the continued availability of a similar number of local TV services as delivered today.</p> <p>As explained in Section 5 of the main statement, the frequency planning studies we have undertaken indicate that we will be able to accomplish our objectives without migrating additional multiplexes to DVB-T2. We believe our decision leaves the DTT platform latitude to grow. If demand for capacity on the DTT platform were to increase in the future (either due to increases in demand for HD services or due to demand for more SD services), multiplex operators could meet this demand by migrating</p>

remain as a possible solution. It suggested that we had overlooked the role a switch to DVB-T2 could play when combined with clearance and asked us to evaluate this issue in greater detail.

Vodafone commented that a restructuring of DTT multiplexes could occur as a result of the introduction of Administered Incentive Pricing (AIP) in 2020, in which case many of the costs identified in our CBA would be attributable to DTT's response to AIP, rather than to 700 MHz clearance. Therefore, Vodafone considered that our analysis greatly overstated the costs of 700 MHz clearance, as we should have assumed that most of the costs of DTT clearance were not relevant to our CBA because DTT operators would incur these costs voluntarily, even absent an Ofcom or Government-led clearance programme, given our intention to introduce AIP.

more multiplexes to DVB-T2. However, we do not consider this to be a pre-condition for change of use of the 700 MHz band and believe that industry, rather than Ofcom, should take the lead in developing the roadmap for the future evolution of the DTT platform. We recognise that if demand did increase to a certain level, licensees would need to migrate more multiplexes to DVB-T2 in case of change of use of the 700 MHz band than the otherwise would have. We assess the opportunity cost of this in Section 5 of the main statement and use the cost of T2 transition as a proxy for the opportunity cost.

As noted in our July 2013 statement on spectrum pricing for terrestrial broadcasting<sup>46</sup>, the potential clearance of DTT from the 700 MHz spectrum band meant that multiplex operators were unlikely to be able to respond effectively to the price signals provided by AIP. Therefore, in that statement we took the decision to delay the application of AIP until we had materially progressed our plans for the UHF spectrum. We identified 2020 as an indicative date for the introduction of AIP and noted that we would make firm proposals on the introduction of AIP nearer to this time. However, 2020 was an indicative date only, and we expect that the counterfactual proposed by Vodafone (where many of the costs of clearance would be borne voluntarily by DTT operators following the introduction of AIP) would take longer than the mechanism for clearance proposed in the main statement. As a result, the benefits of clearance would not be as great, as we believe that the benefits of change of use will be greater the sooner change happens. Furthermore, if we were to use the counterfactual suggested by Vodafone, we would have to amend the benefits as well as the costs identified in our CBA, as both would have been overstated. As it stands, our CBA reflects the total costs and benefits to society of change of use

<sup>46</sup> Ofcom, July 2013, *Spectrum pricing for terrestrial broadcasting*, <http://stakeholders.ofcom.org.uk/binaries/consultations/aip13/statement/statement.pdf>

There was some disagreement among stakeholders in relation to our assessment of the likely costs of modifying DTT transmission infrastructure. A confidential respondent noted that experience gained through previous broadcast infrastructure projects suggested that there is likely to be scope for lower costs. In contrast, the broadcasters tended to take the view that we had understated the costs. Arqiva considered that cost assumptions are highly uncertain until we undertake an Infrastructure Capability study, and it is therefore not appropriate to base any costs on the Reduced Scope option until more detailed technical analysis is complete. Digital UK agreed with Arqiva that it was not acceptable for us to have taken the Reduced Scope option.

Samsung considered that, for the assessment of costs, we should have assumed the migration to eight multiplexes, rather than six, as more channels will want to broadcast in HD than assumed and Ultra High Definition will become widespread in the next decade, requiring more spectrum. Samsung argued that while the migration to six multiplexes may be a natural evolution of the DTT platform, it should not be a de facto constraint. Therefore, Samsung believed we had understated the range of costs as a higher number of multiplexes would have a larger impact on upgrading DTT transmission infrastructure.

In relation to our assessment of the timeframes for a DTT re-plan, Arqiva agreed that our timescales were challenging but realistic. However, it noted that it was not yet able to support our suggestion that it may be possible to bring forward the timetable by up to two years, although it did not object in principle to the idea of accelerated

of the 700 MHz band.

We address comments on the cost of the infrastructure modifications in detail in Section 5.

As set out in our UHF Strategy Statement<sup>47</sup>, we believe that we can safeguard the benefits the DTT platform provides by allowing for the ongoing delivery of six national multiplexes. We have therefore assessed the costs of a re-plan that delivers six national multiplexes. We have, however, considered the opportunity cost of losing the two additional multiplexes; we discuss this in more detail in Section 5 of the main statement.

Our initial analysis and Arqiva estimates indicate that 2022 is a realistic date by which the 700 MHz band could be made available for mobile broadband on a national basis. However, our experience from previous broadcast infrastructure modification programmes suggest we may find ways to condense the timeline and, as noted in Section 4 of the main

<sup>47</sup> Ofcom, November 2012, *Securing long term benefits from scarce low frequency spectrum: UHF strategy statement*, [http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/statement/UHF\\_statement.pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/uhf-strategy/statement/UHF_statement.pdf)

clearance. However, BT stated it saw clear benefits in delaying the timing of a DTT re-plan beyond the 2022 date that we proposed. It suggested that a later release date for 700 MHz release would allow more time to assess the feasibility of alternative delivery platforms, to gain further confidence in projected growth in mobile data, to observe the migration from DTT to IPTV and understand whether fewer DTT multiplexes might be needed.

In relation to our assessment of the loss of value from existing DTT services, both Arqiva and Digital UK argued that we had not captured the full loss of value. Digital UK noted that our calculation did not factor in the lost value to customers of HD capacity, while Arqiva considered that we should have included any loss of value due to a reduction in DTT coverage that may occur if we do not secure our desired international outcome. Arqiva also submitted that we needed to reconsider our base case, suggesting a situation with five DVB-T multiplexes and three DVB-T2 multiplexes would be the most appropriate base case.

Vodafone suggested that, given we identified three possible scenarios in which the opportunity cost could differ, we should use a Real Option Valuation approach to correctly estimate the cost.

statement, we believe that the network cost saving benefits will be increased by between £10m – 50m in the central range if change of use took place in 2020 rather than 2022. We therefore aim to secure the release of the 700 MHz as soon as practicable and we will look for opportunities to bring change of use forward. We disagree with BT's assessment that we should delay the release of the 700 MHz band beyond 2022; we expect that the sooner change in use of the 700 MHz band occurs, the greater the benefits, as MNOs would be able to deliver benefits sooner, such as improvements in performance. A delay in change of use risks reducing the benefits, as MNOs may be under pressure to build more sites and incur network costs that they could otherwise have avoided. This would result in higher costs to consumers.

We discuss Arqiva and Digital UK's comments on opportunity cost in Section 5 of the main statement. We discuss their comments on coverage in Section 6 of the main statement.

Using a Real Option Valuation approach would require us to assign probabilities to the different scenarios, which are highly uncertain. We therefore do not consider this is a practicable approach to take. We focus in Section 5 on a scenario we consider more likely.

## Impact on DTT viewers and resulting costs (CBA questions 8, 9 and 10)

*Question 8: Do you have any comments on our analysis of the implications of potential changes for DTT viewers and for the platform? Are there any effects that may be important to viewers that we should consider further?*

*Question 9: Do you have any comments on our consideration of consumer information and support measures and on the factors we should focus on in the next stages of work?*

*Question 10: Do you have views on the activities that Ofcom and other stakeholders could undertake now to help ensure that DTT equipment that consumers might buy in the coming years is as future-proof as possible?*

Stakeholder comments	Ofcom response
<p>A number of respondents commented on our assessment of the costs of aerial replacement. Digital UK argued that in its assessment, between 100,000 and 400,000 homes could require some form of intervention, such as a new wideband aerial or adjustment to their existing aerial. It suggested that we should make provisions to cover the higher number in the range, given the uncertainties over the final frequency plan. Vodafone, in contrast, considered that our estimates for aerial replacement represented an upper bound for these costs.</p> <p>Digital UK also argued that the time taken for consumers to retune ranges between six minutes (for an automatic retune) and 13 minutes (for a more complex manual retune). It considered that our estimate of five minutes was therefore optimistic, and suggested that we use a benchmark of eight minutes. Digital UK also argued that we should take into account time taken re-tuning secondary sets.</p> <p>Digital UK also raised points regarding potential interference from mobile handsets. It suggested that the scale and impact of any interference from mobile handsets in the 700 MHz band to Freeview remain poorly understood, that it is harder to model with any certainty than interference in the 800 MHz band,</p>	<p>We deal with the costs of aerial replacement in Section 6 of the main statement.</p> <p>We discuss these comments in Section 6 of the statement.</p> <p>We discuss interference in further detail in Section 6 of the main statement.</p>

and that it will be harder to identify and remedy when it occurs. However, Digital UK agreed that our allowance of up to £20m for mitigating interference appears reasonable, providing it sits alongside a separately costed consumer support programme. A confidential respondent, in contrast, believed that the 800 MHz clearance indicated that cases of interference to DTT services are uncommon, and that we should consider this to avoid making unduly conservative predictions around interference.

Virgin Media noted that there was little discussion on the potential for interference to cable in our consultation and that we had not considered the potential wider effect of degradation of cable television signals.

The Voice of the Listener and Viewer raised concerns that the proposed 30% reduction in capacity for DTT following 700 MHz clearance would have a negative effect on the range of services it is possible to offer on the DTT platform.

Respondents broadly agreed with our approach to ensuring equipment bought by DTT viewers is future-proofed. Digital Outreach suggested that its anecdotal experience from Digital Switchover was that audience groups welcomed the digital tick mark scheme and questioned whether there was any intention to look at something similar in the case of 700 MHz clearance. BT suggested that the industry should move towards placing multicast capability in TV sets.

As explained in annex 10 of our consultation document, given our previous analysis in the context of 800 MHz, we think the likelihood of interference with cable being a material problem is low. In the case of consumer equipment, the natural replacement cycle is such that, to the extent that any equipment might be liable to interference (e.g. because of screening issues), the vast majority of such equipment will have been replaced prior to change of use of the band.

As we explain in Section 5 of the main statement, we remain confident that it will be possible to re-plan DTT in a way that safeguards the benefits associated with the DTT platform as a whole. We do not expect the change will cause a material reduction in the range of services currently available on the platform and aim to ensure a broad range of services on six national multiplexes with coverage broadly matching today continues following change of use of the 700 MHz band.

We describe our approach to equipment future proofing in Section 8 of the statement.

<p>Ericsson, however, submitted that it was not clear that advocating use of wideband aerials before we have confirmed the new band plan is in consumers' best interests.</p>	<p>As noted in Section 6 of the main statement, most aerials sold today are wideband aerials. In our plans to ensure consumer equipment is adequately future proofed, we are not encouraging consumers to immediately purchase wideband aerials, but are instead ensuring that consumers who are in any event replacing their aerial are advised to buy a wideband aerial. As wideband aerials are capable of receiving frequencies across the entirety of the spectrum used for DTT, they will be able to operate following the re-plan. Our advice to consumers to buy wideband aerials is consistent with the advice we gave, for example, for digital switchover.</p>
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**Implications for PMSE and resulting costs (CBA questions 11 and 12)**

*Question 11: Do you have any comments on our assessment of the impact change of use of the 700 MHz band would have on PMSE?*

*Question 12: Do you have any comments on the mitigations for loss of access to the 700 MHz band including whether we have correctly identified the replacement bands suitable for further study and whether we have correctly identified actions that the PMSE industry could adopt to improve spectrum efficiency?*

<b>Stakeholder comments</b>	<b>Ofcom response</b>
<p>BEIRG and Digital UK submitted that we had underestimated the PMSE equipment cost. First, they argued that our assessment of the lifespan of PMSE equipment was inaccurate. They suggested that higher-end PMSE equipment used by professionals tends to have a lifespan of at least 20 years, rather than the 15 years we suggested.</p>	<p>In relation to equipment lifespan, we estimated in Annex 12 of our consultation that PMSE equipment has an asset life of ten to 15 years. The bottom of this range was the figure provided by a survey of PMSE users, including professional users using higher-end equipment. Fifteen years was also the figure used in the earlier channel 69 funding scheme. This figure was based on a survey of manufacturers and responses to the funding consultation. Although BEIRG submitted that higher-end equipment has an asset life of at least 20 years, it was unable to provide any evidence to support an asset life of higher than 15 years in response to our requests. We do not therefore have a basis on which to increase our estimate.</p>

<p>BEIRG also submitted that we were incorrect to assume that any PMSE equipment replaced between now and 2022 will not need to be replaced at a later date as a result of the change of use of the 700 MHz spectrum. Digital UK submitted that, as PMSE users cannot know the configuration of interleaved spectrum ahead of 700 MHz clearance, they will have to buy equipment ahead of clearance with no guidance as to whether it will be usable afterward. BEIRG agreed that it was possible that equipment purchased over the next eight years would be at risk of becoming redundant following 700 MHz clearance.</p> <p>BEIRG also submitted that PMSE users would incur other costs, in addition to the equipment costs we included. These include the costs of planning and carrying out equipment replacement and installation, while minimising disruption to the shows in which PMSE equipment is used. It submitted that for the earlier 800 MHz clearance programme, this process had cost one large company over £100,000.</p> <p>BEIRG welcomed the identification of replacement bands for possible PMSE use in the future but highlighted concerns with the propagation characteristics in higher frequency bands.</p>	<p>We discuss our assumptions on when PMSE users will be able to buy equipment that is capable of operating following change of use of the 700 MHz band in Section 7.</p> <p>We recognise that additional costs exist for PMSE users alongside equipment costs and discuss these in Section 7 of the statement.</p> <p>We continue to consider all options for use of alternative spectrum. We are looking at a range of options for replacement bands and are aware of the technical challenges, as discussed in more detail in section 7.</p>
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## Impact on spectrum availability for white space devices (CBA question 13)

*Question 13: Do you have any comments on our assessment of the impact of the change of use of the 700 MHz on the TVWS availability?*

Stakeholder comments	Ofcom response
<p>A number of respondents commented on our assessment of the impact of 700 MHz clearance on TVWS availability. Arqiva considered that, as we based our CBA on the single hop DTT plan that does not include local TV services, the</p>	<p>As noted in Annex 13 of our consultation, we consider it would be premature to include details of infrastructure operating at relatively lower powers, such as relay transmitters or local TV services, until our</p>

<p>extent of the reduction in TVWS availability cannot be calculated without detailed network planning. However, it suggested that the local TV multiplexes would be likely to constrain further the TVWS availability and that we should undertake a phase of work to understand the full impact on WSDs from relay transmitters and local TV.</p> <p>Sky argued that we had not calculated the opportunity cost of precluding WSD use of the 700 MHz band, and that such a calculation would be necessary to ensure that our CBA delivers the most appropriate policy outcome. Both Sky and Dynamic Spectrum Alliance submitted that we should explore ways of opening more spectrum for licence-exempt use.</p> <p>BT agreed with our assessment that the DTT re-plan would leave opportunity for TVWS applications and considered that there was no need to make additional provisions for licence-exempt applications. Everything Everywhere considered that TVWS was not relevant to our CBA as it has no commercial deployments, and therefore the impact of change of use of the 700 MHz band on TVWS would be insignificant.</p>	<p>international discussions regarding the overall requirements for DTT following a potential change are more developed. Although we acknowledge that introducing local TV services to the single hop plan would reduce the overall TVWS availability, we would not expect their addition to have a material effect on overall TVWS availability. Furthermore, we will not seek to ensure the continued delivery of the interim multiplexes, which would ensure the availability of more spectrum for WSDs.</p> <p>As noted in Section 8 of our consultation and explained in the introduction, overall we do not expect TVWS availability to reduce as a result of change of use of the 700 MHz band. Therefore we do not consider there is a material opportunity cost.</p>
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## Summary of costs (CBA questions 14, 15, 16 and 17)

*Question 14: Do you agree with our use of the Spackman method for discounting both the costs and benefits of change of use?*

*Question 15: Do you agree with our approach of estimating the cost of early replacement or should we be considering the full cost? Do you have any comments on how we have estimated the costs of early equipment replacement?*

*Question 16: Do you agree with our overall assessment of the costs of change of use of the 700 MHz band?*

*Question 17: Do you have any comments on our assessment of the impact of earlier or later change of use of the 700 MHz band?*

Stakeholder comments	Ofcom response
<p>A number of respondents commented on Ofcom's use of the Spackman method for discounting costs and benefits. Digital UK considered that our use of the Spackman approach implicitly assumed that Government would not deploy public funding in support of a change of use of the 700 MHz band, but that private firms would fund capital costs. Both Digital UK and Arqiva asked us to clarify that our use of the Spackman approach did not pre-judge a decision from Government as to whether public funds would be deployed and asserted their opinion that multiplex operators and consumers should not incur any of the costs of 700 MHz clearance.</p> <p>Vodafone stated that, although it was relatively unconcerned with our use of the Spackman method, it considered we had erred in our approach. It argued that our use of the Spackman method leads to an understatement of the benefits relative to costs.</p> <p>Arqiva and Digital UK disagreed with our overall assessment of the costs of change of use of the 700 MHz band in a number of areas. They argued that DTT infrastructure costs (and programme management and local TV costs) should not be calculated on the basis of earlier replacement as many of the costs are transitional costs specific to 700 MHz change of use (such as temporary masts and labour).</p> <p>Arqiva and Digital UK also considered that our estimate of the asset life of DTT infrastructure is unduly short and that DTT infrastructure typically has an asset life of much longer than 25 years –</p>	<p>Our use of the Spackman method means that we included private financing costs both within our estimates of the costs of DTT clearance and within our estimates of the costs that mobile operators will avoid as a result of 700 MHz spectrum becoming available for mobile use. In the without-700 MHz scenario, mobile operators would privately fund the costs incurred, so it is appropriate to include financing costs in our estimate of costs avoided in the 700 MHz clearance scenario (that is, the benefits of clearance). While it has not yet been determined how DTT clearance will be funded, our estimate of clearance cost also includes financing costs. This is not intended to indicate that multiplex operators will necessarily bear (and privately fund) the costs of being relocated further down the spectrum band. We clarify that decisions about possible public funding are a matter for Government.</p> <p>Since the Spackman method includes financing costs in both the costs and benefits of clearance, we do not consider that we have understated the benefits as a result of the discounting method used.</p> <p>We note that the costs identified by Arqiva and Digital UK are still involved in the replacement of equipment and not necessarily specific to change of use of the 700 MHz band. For example, replacing an antenna at a site that requires a temporary mast during 700 MHz clearance is still likely to require a temporary mast to replace it at the end of its asset life. The same is true of the labour costs. We therefore do not believe this is a reason to use the full costs, rather than the cost of earlier replacement.</p> <p>We have revised our assumptions on asset life in the light of the information provided by Digital UK &amp; Arqiva and have modified our CBA accordingly. We discuss this in Section 5 of the main</p>

<p>typically 50 years.</p> <p>Arqiva and Digital UK also suggested that, as the multiplex operators have no certainty in the future of the DTT platform beyond c.2026, there are no plans to replace DTT infrastructure in the future, and therefore the application of the early replacement cost is inappropriate.</p> <p>Finally, Arqiva and Digital UK suggested that, given the long asset life and that infrastructure is relatively new, it is unclear if the normal rate of maintenance would change if infrastructure was replaced as a result of change of use of 700 MHz.</p> <p>The majority of the mobile respondents agreed with our proposal that we should seek to implement a change of use of the 700 MHz band at the earliest possible opportunity. A confidential respondent supported our analysis that the earlier a change of use occurs, the greater the benefits are likely to be. Three strongly recommended an earlier change of use, by 2020 or earlier, which it suggested would bring additional benefits to consumers in the form of stronger competition, lower prices and improved quality and innovation.</p> <p>Ericsson submitted that the optimum timing of release of the 700 MHz band is linked to the existing rollout of 800 MHz and subsequent upgrades. It also noted that the changes to allow Emergency Services use of the network are a material factor in determining timing.</p>	<p>statement.</p> <p>We note that there is uncertainty around the future of the DTT platform. However, for our counterfactual we have assumed the 470 MHz-694 MHz band continues to be used for DTT indefinitely and this remains our best estimate.</p> <p>Our CBA included no allowance for reduced maintenance costs as a result of early replacement, so this issue does not affect our results.</p> <p>We recognise that there is significant uncertainty over the future roll out of mobile networks and we have tried to reflect this uncertainty in our analysis. The availability of different spectrum bands will affect the exact benefits of making spectrum available. However, we do not think the availability and rollout of any particular band will have an impact on our overall conclusion that earlier change of use is likely to generate the greatest benefit. Overall, we are not aware of any new evidence causing us to change our analysis of the benefits in our consultation.</p> <p>We agree that, if some of the 700 MHz spectrum is made available for Emergency Services use, the timing of the rollout of this network will have an impact on the benefits of change of use. However, such use is still highly uncertain and therefore we continue to include this as part of the unquantified benefits of change of use.</p>
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**Our proposals (CBA questions 18 and 19)**

*Question 18: Do you agree with our proposal that we should make the 700 MHz band available for mobile broadband?*

*Question 19: Do you agree with our proposal that we should seek to implement this change at the earliest possible opportunity?*

Stakeholder comments	Ofcom response
<p>The majority of respondents broadly agreed with our proposal to make the 700 MHz band available for mobile broadband at the earliest opportunity, providing that any disruption to DTT viewers resulting from change in use is minimised. A number of respondents argued that either Government or the MNOs should pay the costs of change and that broadcasters, PMSE users and viewers should not bear any of the costs.</p> <p>However, most PMSE respondents disagreed with our proposal. BEIRG submitted that the MNOs already have sufficient spectrum to satisfy their demands. It highlighted Ofcom data from 2011 suggesting that there is unused spectrum in many parts of the country. It argued that, rather than be given access to additional spectrum, MNOs should more efficiently use what is already available. BEIRG also questioned whether it was plausible to expect customers to demand, and pay for, such high volumes of data traffic as we have forecast.</p>	<p>Decisions on public funding are a matter for Government. We do not consider them in this document. We are, however, discussing this matter with Government and will have regard to consultation responses when engaging in these discussions.</p> <p>In principle, clearance of the 700 MHz band would result in lower benefits if it were possible to meet forecast mobile demand at a lower cost than modelled in the CBA by simply using spectrum more efficiently, however, we do not think this is possible. Data from 2011 may not accurately reflect the current total of unused spectrum as operators have continued to rollout 3G services and started the rollout of 4G since we published this data. In addition, we expect MNOs' use of existing spectrum to further increase significantly in response to increased demand before it is possible to make the 700 MHz band available. Moreover, the benefits of change of use are geographically concentrated in areas of high population where spectrum is already heavily used. A need for 700 MHz spectrum in certain areas is therefore consistent with the existence of unused spectrum in other parts of the country.</p> <p>As set out in the main statement, our base case forecast is that the overall levels of traffic will grow by around 45 times between 2014 and 2030. We expect this data growth to come not only from increased traffic per smartphone user, but also from increased penetration of smartphones and other mobile broadband devices, and from the growth of new services such as machine-to-machine.</p> <p>In response to BEIRG's request we have shown the per user traffic forecasts used to construct the mid case of the Analysis</p>

<p>BEIRG raised concerns that we have yet to clearly specify alternative bands for PMSE use and submitted that suitable alternative sources of spectrum must be allocated to PMSE users before we take any final decision on whether the 700 MHz band will be cleared.</p>	<p>Mason forecasts in Table A1.1 below. For illustration, one hour of HD video could consume 1GB of data.<sup>48</sup> Therefore, the Analysys Mason forecast is consistent with the average smartphone user watching 5 hours of video a month in 2030.</p> <p>At the same time as growing penetration and use per subscriber, we expect that the average cost of data per GB to consumers will fall over time. We think that these price falls are likely because of the strength of competition in the UK mobile sector, combined with technological improvements, and the spreading of common costs across larger demand. This means that some per-user growth in data use will be accommodated even without any increase in per-user spending, and that further data may be available at low cost.</p> <p>We discuss these concerns in Section 7 of the main statement.</p>
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**Table A1.1 Post offload traffic per subscriber**

	2015	2020	2025	2030
Smartphone user	0.5	1.8	3.8	4.9
Mobile broadband (MBB) user	4.6	13.4	25.4	29.7

## Timing of an auction (CBA question 20)

*Question 20: If, as a result of this consultation, we decided to go ahead with the proposed changes, what factors and evidence should we take into account when considering whether to hold an auction near to the time of availability of the spectrum or earlier?*

A1.4 In general, respondents opposed the idea of an early auction. We discuss their comments on this issue, and our response to them, in Section 8 of the main statement.

<sup>48</sup> We note that improvements in video compression standards could reduce data consumption. However, at the same time there is a general move towards higher resolution devices that could encourage streaming of Ultra HD content.

## Annex 2

# Summary of costs

- A2.1 In the body of the statement we set out our assessment of the different costs we have identified as arising from a change of use of the 700 MHz band. In this annex, we bring these costs together and explain how we have adjusted them to ensure they are treated consistently in our CBA. We also explain how the estimates have changed in the light of the responses we received to our consultation document.
- A2.2 In total, we estimate that the economic costs related to 700 MHz change would be between £550m - £660m (2014 PV). In this range we try to take into account uncertainties surrounding a number of the key factors; in particular the DTT band plan. Table A2.1 shows a breakdown of the costs, alongside some key assumptions that underlie them.
- A2.3 Our assessment of the costs assumes that change of use would conclude in 2022. If it were brought forward we would expect the present value of the costs to increase; if it were delayed we would expect the present value of the costs to fall, because the costs would be delayed (and so lower in PV terms), and also because fewer households would need to replace their aerials. However, we do not expect the overall costs would vary greatly between an earlier or later change of use. In particular, the most substantial cost in our analysis, DTT infrastructure costs, is not very sensitive to the year of change of use.
- A2.4 We have discounted costs and benefits using the method set out in Spackman (2004), designed for discounting where there are private costs and public benefits:
- A2.5 For capital costs incurred by private firms we first convert them into annual costs at the company's cost of capital (WACC). We have used a simple flat annuity formula to annualise the capital costs incurred by private firms, plus financing costs. Second, we discount the annualised costs, and any non-capital costs and benefits back to 2014 using the rate of social time preference (STPR).
- A2.6 Where costs are not incurred by firms, we discount at the STPR.
- A2.7 This approach is consistent with the 2012 conclusions of the Joint Regulatory Group (JRG), of which Ofcom is a member. The JRG concluded that in most cases where there are private costs but public benefits the Spackman approach is appropriate.
- A2.8 The Spackman approach only differs from discounting all costs and benefits at the STPR when capital costs are funded by private firms. In our CBA, the Spackman approach therefore affects the DTT infrastructure costs, PMSE replacement costs and DTT opportunity cost. We also use it to discount the network cost savings and performance benefits. Using the Spackman approach has the result of increasing both the benefits and costs of change of use relative to the case of discounting purely at the STPR.

**Table A2.1: Summary of costs of change of use of the 700 MHz band in 2022**

<b>Cost category</b>	<b>Estimated cost (PV, 2014 prices)</b>	<b>Key assumptions</b>
DTT infrastructure costs	<ul style="list-style-type: none"> <li>• <b>£420m - 470m<sup>49</sup></b> including the cost of bringing forward infrastructure changes and programme management</li> </ul>	<ul style="list-style-type: none"> <li>• Uses Arqiva's 'reduced scope' estimates of £310m for the single hop and £360m for the COM SFN plans for national DTT, plus £20m for local TV replan</li> <li>• Programme management cost £20m for Arqiva or Multiplex operators, £10m for government (undiscounted 2014 prices)</li> <li>• Assets on average have a life of 43 years, and were installed in 2010</li> </ul>
Consumer aerial costs	<ul style="list-style-type: none"> <li>• <b>£3m - £6m</b> cost of early replacement of aerials</li> </ul>	<ul style="list-style-type: none"> <li>• 68% of households use DTT platform as primary feed on at least one set</li> <li>• Aerials replaced in 2020 on average</li> <li>• 75-80% take-up of wideband aerials by 2020, and 2-10% portable aerials<sup>50</sup> meaning 105,000 - 110,000 grouped aerials would need to be replaced</li> <li>• Average aerial cost of £150 (undiscounted 2014 prices)</li> <li>• Average asset life of 25 years</li> </ul>
PMSE equipment costs	<ul style="list-style-type: none"> <li>• <b>£13m - £21m</b> including <b>£0.3-0.5m</b> of decommissioning costs</li> </ul>	<ul style="list-style-type: none"> <li>• Asset lives and equipment costs from survey<sup>51</sup></li> <li>• Where asset life is unknown, assume an average of 10-15 years</li> <li>• 20-50% upgrade costs to reflect need for more efficient use of spectrum</li> <li>• Decommissioning costs are 5% of equipment replacement (but not upgrade) costs</li> </ul>
Consumer information costs	<ul style="list-style-type: none"> <li>• <b>£25m</b> consumer information costs</li> <li>• <b>£7m - £10m</b> cost of consumer time in retuning equipment</li> </ul>	<ul style="list-style-type: none"> <li>• Consumer information costs around six times that of the clearance of channel 61 and 62, because more channels affected - £30 million (undiscounted, 2014 prices)</li> <li>• 14-20m households will need to retune between 2019 and 2021</li> <li>• Average retuning time 5 minutes</li> <li>• Value of time based on value of non-commuting leisure time provided by the Department of Transport<sup>52</sup>, updated for real GDP growth</li> </ul>
Coexistence costs	<ul style="list-style-type: none"> <li>• <b>Between zero and £20m</b></li> </ul>	

<sup>49</sup> Within this, government programme management costs are discounted at the social time preference rate.

<sup>50</sup> See the consultation document, *Annex L: Indoor aerials: contextual quantitative insights*, 2013, Kantar Media: <http://stakeholders.ofcom.org.uk/consultations/700MHz/>

<sup>51</sup> See the main body of this statement for more detail

<sup>52</sup> [http://www.dft.gov.uk/webtag/documents/expert/pdf/U3\\_5\\_6-Jan-2014.pdf](http://www.dft.gov.uk/webtag/documents/expert/pdf/U3_5_6-Jan-2014.pdf)

<b>Cost category</b>	<b>Estimated cost (PV, 2014 prices)</b>	<b>Key assumptions</b>
Loss of value	<ul style="list-style-type: none"> <li>• <b>£80m - £100m.</b> Change of use of the 700 MHz band would reduce the spectrum that could be used for DTT.</li> </ul>	<ul style="list-style-type: none"> <li>• Possible counterfactual in which more DTT channels are provided than at present</li> <li>• Upper bound of loss of DTT value, from not meeting this demand, is the cost of upgrading to be able to meet it (less resulting operating cost savings)</li> <li>• Costs (undiscounted 2014 prices) include <ul style="list-style-type: none"> <li>○ consumer equipment (7.9m items, with 10 year asset life, costing £30-£150 each)</li> <li>○ information campaign (£100m)</li> <li>○ DTT infrastructure costs (£30-50m)</li> </ul> </li> <li>• Change of use of the 700 MHz band would be unlikely to have a material negative impact on white space availability</li> </ul>
PMSE upskilling costs	<ul style="list-style-type: none"> <li>• <b>£10m - £13m.</b> The impact of PMSE having access to less spectrum could be mitigated through a number of actions, including re-training existing RF engineers and/or recruiting new RF engineers</li> </ul>	<ul style="list-style-type: none"> <li>• Mitigation costs for PMSE: <ul style="list-style-type: none"> <li>○ 10 largest hiring companies employ an additional RF engineer, plus an additional 5 - 10 freelance RF engineers needed in the UK</li> <li>○ average annual RF engineer salary of £45,000<sup>53</sup></li> <li>○ additional training and resulting higher-skilled salary for 20 - 30 test engineers and technicians, costing approximately £10,000 per year</li> </ul> </li> </ul>
<b>Total</b>	<b>£550m - £660m</b>	<ul style="list-style-type: none"> <li>• Spackman method of discounting, which adds financing costs where relevant</li> <li>• WACC of 5% for PMSE costs and 7.7% for DTT costs (pre-tax real)<sup>54</sup></li> <li>• Where relevant includes only the cost of bringing forward asset replacement</li> </ul>

<sup>53</sup> Salary information is based on a survey of RF engineering jobs on Connectus, Just Engineers and Techno Jobs in December 2013.

<sup>54</sup> The PMSE figure is the same as used in a previous PMSE equipment funding scheme – see Clearing the 800 MHz band, Funding for moving programme-making and special events from channel 69, Ofcom 2010: [http://stakeholders.ofcom.org.uk/binaries/consultations/pmse\\_funding/statement/statement.pdf](http://stakeholders.ofcom.org.uk/binaries/consultations/pmse_funding/statement/statement.pdf) The DTT figure comes from the Analysys Mason report for Administered Incentive Pricing: See Analysys Mason and Aegis Systems, March 2013, *Opportunity cost of the spectrum used by digital terrestrial TV and digital audio broadcasting*: <http://stakeholders.ofcom.org.uk/binaries/consultations/aip13/annexes/report.pdf>

## Changes since the consultation

A2.9 We have made a number of changes to our estimate of the costs associated with clearance of the 700 MHz band in response to evidence stakeholders provided in response to our consultation. Overall, these changes increase the estimated economic costs of clearance by around £80m (accounting only for the costs of bringing equipment replacement forward).

**Table A2.2 Headline change in the cost estimates**

Total changes to the estimated costs of clearance (£m)	Economic costs of bringing replacement forward (PV, 2014 prices)
Consultation total	470-580
Statement total	550-660
Total change	80

A2.10 There have been six changes to the cost estimates. Table A2.3, below, summarises their effect on our estimate of the economic costs of clearance.

**Table A2.3: Breakdown of the change**

Change to:	Parameter change		Increase in economic costs versus consultation document (£m, PV, 2014 Prices)	
	Consultation	Statement	Low	High
DTT Asset life assumed <sup>55</sup>	25 years	43 years	55	62
Government programme management costs <sup>56</sup>	0	£10m	8	8 <sup>57</sup>
Whether it is assumed that PMSE equipment replaced before clearance needs to be replaced again <sup>58</sup>	no	yes	6	2 <sup>59</sup>
PMSE decommissioning costs (% of equipment replacement but not upgrade costs) <sup>60</sup>	0	5%	0.3	0.5
Aerials replacement date assumed <sup>61</sup>	2022	2020	1	2
Underlying infrastructure costs correctly inflated from 2013 to 2014 prices <sup>62</sup>	no	yes	5	6
Overall change			76	81

<sup>55</sup> See paragraphs 5.27-5.31 of the statement

<sup>56</sup> See paragraph 5.25 of the statement

<sup>57</sup> This is figure is lower than our £10m real cost estimate because we have discounted it at the social time preference rate.

<sup>58</sup> See paragraphs 7.7-7.12 of the statement

<sup>59</sup> The effect is greater in the low scenario since this assumes a shorter asset life, meaning that a higher number of replacements are assumed to occur before clearance

<sup>60</sup> See paragraphs 7.15-7.19 of the statement

<sup>61</sup> See paragraphs 6.12-6.19 of the statement

<sup>62</sup> See table 4 on page 34 of the statement

# Glossary of terms

<b>3GPP</b>	The 3rd Generation Partnership Project - Collaboration between groups of telecommunications associations, to make a globally applicable third-generation (3G) mobile phone system specification within the scope of the International Mobile Telecommunications-2000 project of the International Telecommunication Union (ITU).
<b>4G</b>	Fourth generation mobile phone standards and technology
<b>AIP</b>	Administrative Incentive Pricing
<b>CAI</b>	Confederation of Aerial Industries. A trade association representing aerial installers and manufacturers in the UK.
<b>CBA</b>	Cost-benefit analysis
<b>CCP</b>	The Ofcom Communications Consumer Panel is the independent research and policy advisory body on consumer interests in telecommunications, broadcasting and spectrum markets (with the exception of content issues).
<b>CEPT</b>	The European Conference of Postal and Telecommunications Administrations
<b>CFI</b>	Implementing Ofcom's UHF strategy consultation 'Future use of the 700MHz' call for inputs published April 2013
<b>COM</b>	Commercial multiplex. Three of the six UK-wide DTT multiplexes that do not carry any of the public service broadcaster channels.
<b>Communications Act</b>	The Communications Act 2003, which came into force in July 2003.
<b>dBm</b>	The power ratio in decibels (dB) of the measured power referenced to one milliwatt (mW).
<b>DME</b>	Distance measuring equipment is a transponder-based radio navigation technology that measures slant range distance by timing the propagation delay of VHF or UHF radio signals.
<b>DSO</b>	Digital switchover. The process of switching over from analogue television or radio broadcasting systems to digital. Television DSO completed in 2012.
<b>DTG</b>	The Digital Television Group -The DTG is an industry association for digital television in the UK. The DTG publishes and maintains the technical specifications for the UK's Freeview and Freeview HD platforms (the 'D-Book'), and operates a digital television receiver test centre.
<b>DTT</b>	Digital Terrestrial Television - Broadcasting delivered by digital means. In the UK and Europe, DTT transmissions use the DVB-T and DVB-T2 technical standards.
<b>DVB-T</b>	Digital video broadcasting – Terrestrial. A standard for terrestrial transmission of digital television developed by the DVB consortium
<b>DVB-T2</b>	Digital video broadcasting – Terrestrial 2. The latest digital terrestrial

transmission technology developed by DVB.

<b>EU</b>	European Union
<b>GHz</b>	Gigahertz. 1,000,000,000 (or $10^9$ ) oscillations per second
<b>GI</b>	Geographic Interleaved spectrum. Spectrum that is unused in a particular area by transmitters in a multi-frequency network.
<b>HD</b>	High Definition - A television or other video service with at least 720 lines of vertical resolution. This higher resolution picture raster can provide enhanced quality and more detailed pictures, particularly on larger displays
<b>IPTV</b>	Internet protocol television. The term used for television and/or video signals that are delivered to subscribers or viewers using internet protocol (IP), the technology that is also used to access the internet. Typically used in the context of streamed linear and on-demand content, but also sometimes for downloaded video clips
<b>ITU</b>	International Telecommunications Union - Part of the United Nations with a membership of 193 countries and over 700 private-sector entities and academic institutions. ITU is headquartered in Geneva, Switzerland.
<b>LTE</b>	Long Term Evolution. Part of the development of 4G mobile systems that started with 2G and 3G networks. Aims to achieve an upgraded version of 3G services having up to 100 Mbps downlink speeds and 50 Mbps uplink speeds.
<b>MFN</b>	Multi-frequency network -A network of transmitter sites in which each transmitter uses a different frequency from its neighbours.
<b>MHz</b>	Megahertz. A unit of frequency of one million cycles per second.
<b>MNO</b>	Mobile network operator
<b>MPEG</b>	Moving Picture Experts Group. A set of international standards for compression and transmission of digital audio-visual content. Most digital television services in the UK use MPEG2, but MPEG4 offers greater efficiency and is likely to be used for new services including TV over DSL and high-definition TV.
<b>MMS</b>	Mobile Satellite Service
<b>NPV</b>	Net present value
<b>OOB</b>	Out of band activity outside of a defined telecommunications frequency band, or, metaphorically, outside some other kind of activity.
<b>PMSE</b>	Programme-making and special events. A class of radio application that support a wide range of activities in entertainment, broadcasting, news gathering and community events.
<b>PPDR</b>	Public Protection and Disaster Relief. Includes emergency services such as the fire brigade and police.
<b>PSB</b>	Public service broadcasting or public service broadcaster. The Communications Act in the UK defines the PSBs as including the BBC, ITV1 (including GMTV1), Channel 4, Five and S4C
<b>PV</b>	Present value
<b>R &amp; D</b>	Research and development

<b>RF</b>	Radio frequency
<b>RSGP</b>	Radio Spectrum Policy Group - High-level advisory group that assists the European Commission in the development of radio spectrum policy.
<b>RTÉ</b>	Raidió Teilifís Éireann. Ireland's national public-service media organisation.
<b>SD</b>	Standard Definition -The lower, and currently most common, of the picture resolutions used for television broadcasting. Standard definition TV services in the UK and Europe have a vertical resolution of 576 (interlaced) lines.
<b>SDL</b>	Supplemental down link
<b>SFN</b>	Single Frequency Network. A transmission network where all transmitters operate on the same frequency.
<b>SLAs</b>	Service level agreements
<b>STB</b>	Set-top box is an information appliance device that generally contains a TV-tuner input and displays output connects to a television set and an external source of signal, turning the source signal into content in a form that can then be displayed on the television screen or other display device. They are used in cable television, satellite television, and over-the-air television systems, as well as other uses.
<b>STPR</b>	Social time preference rate
<b>TG4</b>	A public service broadcaster for Irish-language speakers.
<b>TVWS</b>	TV White Spaces
<b>UHF</b>	Ultra High Frequency. The part of the spectrum between 300 MHz and 1 GHz.
<b>Wi-Fi</b>	Commonly used to refer to wireless local area network (WLAN) technology, specifically that conforming to the IEEE 802.11 family of standards. Such systems typically use one or more access points connected to wired Ethernet networks which communicate with wireless network adapters in end devices such as PCs. It was originally developed to allow wireless extension of private LANs but is now also used as a general public access technology via access points known as "hotspots".
<b>WRC</b>	World Radiocommunication Conference. The WRC reviews and revises the Radio Regulations, They are held every two to three years.
<b>WSDs</b>	White space devices, which make use of transmission frequencies that are nominally allocated to other services but which are unused in the vicinity of the device.