A cost benefit analysis of the change in use of the 700 MHz radio frequency band in Ireland

A REPORT PREPARED FOR COMREG

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Executive Summary

1.1 ComReg is currently considering whether to repurpose a proportion of the 470-790 MHz band (termed the 'UHF band' in this report) in Ireland, namely the sub-range 694-790 MHz ('700MHz band'), from its current use for Digital Terrestrial Television ('DTT') broadcasting and Programme Making and Special Events ('PMSE') to other uses, in line with relevant international harmonisation measures.[1] ComReg is also considering when and how such a repurposing might occur. ComReg has commissioned Frontier Economics to provide an analysis of the likely costs and benefits (including economic, social, and cultural costs and benefits) of a change of use of the 700 MHz band from DTT and PMSE to wireless mobile broadband services.

1.2 This analysis and its results are presented in this Cost Benefit Analysis (CBA) report. In summary, our analysis indicates that a repurposing of the 700 MHz band in 2018 would result in a positive net benefit with a Net Present Value ('NPV') of **€77m** (**€91m** if certain performance benefits are included). We are further of the view that other wider economic and societal benefits, which are not quantified in this analysis, may be significant and may even be larger than the estimated direct benefits.

1.3 We understand this analysis will be used as an input into ComReg's considerations as to whether, and if so, when and how, to repurpose 700 MHz spectrum.

Spectrum for wireless mobile broadband services

1.4 There is a growing user demand for wireless broadband and mobile data services, and spectrum is required by providers of such services in order to meet this demand. International agreements have been adopted to identify additional spectrum bands for such services. At the 2012 World Radiocommunication Conference (WRC-12) a decision was taken to allocate the 700 MHz band for mobile services on a co-primary basis with its existing allocation for DTT.

1.5 This decision could facilitate a repurposing of the 700 MHz band and Europe has made considerable preparations for this possibility. The Radio Spectrum Policy Group (RSPG) and the High Level Group (HLG), chaired by former Commissioner Pascal Lamy, have considered the future of the 700 MHz band. Both groups generally recommend a repurposing of the 700 MHz by around 2020, with some flexibility (plus or minus 2 years). The CEPT (the European Conference of Postal and Telecommunications Administrations) has also

[1] We note that ComReg has not made any decisions on the potential other uses of the 700 MHz band and that there are a range of potential uses including wireless (mobile) broadband communications, Public Protection and Disaster Relief (PPDR), PMSE, DTT and/or Machine to Machine services.

considered the 700 MHz band and it has developed harmonised technical conditions for wireless broadband services to be provided in the band, together with other advice to the European Commission ('EC') to assist it in its considerations. The EC is considering these views and other relevant information and stated its intention to make specific proposals regarding the coordinated release of the 700 MHz band in the EU, noting that it is particularly well-suited for ensuring the provision of wireless broadband services in rural areas, while accommodating the specific needs of audiovisual media distribution.

1.6 Many European countries have commenced their considerations of 700 MHz repurposing while five countries (Germany, France, the UK, Finland and Sweden) have gone further in that they have already decided to repurpose the 700 MHz band and or have commenced their 700 MHz authorisation process. Indeed Germany has already commenced its auction process which began in May 2015.

Increasing user demand for wireless mobile broadband services

1.7 The fast growing user demand for wireless broadband and mobile data services is common across Europe, including Ireland. For example, since Q4 2011 data use per smartphone user has increased in Ireland by 87% per year, on average, and data use per Mobile Broadband ('MBB') user has increased by 36% per year. User demand is expected to further increase as the penetration of devices (particularly 4G smartphones) increases. The increasing capabilities of such devices also means that data usage per device should continue to grow. This means that it would be important that sufficient spectrum is made available to efficiently meet this demand.

1.8 Taking these factors into account, our medium estimate is that user demand for mobile data could be 33 times its current level by 2035. This level of growth would correspond to a Compound Average Growth Rate (CAGR) of 18% for the period. The initial period of modelling up to 2025 has a higher CAGR of 28% falling to more conservative 9% for remaining years to reflect the inherent complexities of forecasting long-term growth.

Approach to the CBA

1.9 In assessing the costs and benefits of repurposing the 700 MHz band, from DTT and PMSE to wireless mobile broadband, we consider the NPV of the resulting costs and benefits measured up to 2035. We consider that the direct benefits would accrue to Mobile Network Operators (MNOs) in terms of the network cost savings which could be achieved as a result of them having 700 MHz spectrum, as well as the potential to provide better performance on the network. We also consider the likely costs of repurposing to incumbent DTT and PMSE service providers, mainly from having to replace certain equipment earlier than would otherwise be necessary, though there are also likely to be certain other

costs relating to DTT, such as having to replace some household aerials, having to retune some household set-top boxes and TVs, and having to run campaigns to inform the public of the changes. The social or cultural costs which could result from a repurposing of the 700 MHz band, particularly as to whether it could materially impact on the take up by users of the DTT service, is also considered.

Assessing the benefits to wireless mobile broadband

1.10 We considered two potential approaches to assessing the direct economic benefits to MNOs from a repurposing of the 700 MHz band. First, we developed a bottom up model of a mobile radio network to estimate the cost savings that could accrue to MNOs if they had 700 MHz spectrum. Second, we consider the potential for MNOs to use 700 MHz spectrum to increase the performance of their networks. The bottom-up model estimates the present value costs of a Radio Access Network that a hypothetical MNO would incur in order to meet network demand up to 2035, under two spectrum scenarios. The first scenario assumes that the MNO has access to 700 MHz spectrum while the second scenario assumes that it does not have access. The difference between the two estimates represents the network cost savings to MNOs as a result of having 700 MHz spectrum. We calculate that the network cost saving to be of the order of **€89 million** in the base case scenario and between €50m and €150m, respectively, in the low and high demand scenarios.

1.11 A further benefit could arise if MNOs should choose to increase performance in their networks by increasing capacity in cells where utilisation is high. We estimate that the avoided cost of not having to deploy additional sites - in order to get the same performance benefit that a MNO with 700 MHz spectrum would have - could amount to a further **€11m - €15m**. However, we also note that there is more uncertainty over these possible cost savings, since they would be conditional on MNOs making the necessary investments.

1.12 While the immediate, direct economic benefits of repurposing the 700 MHz band would likely pass to MNOs, in competitive markets a significant proportion of those benefits could be expected to be competed away over time, such that users would in time benefit in the form of improved and/or lower cost services.

1.13 It is also likely that a range of indirect benefits to the wider Irish economy and society could result from the greater mobile connectivity that may arise if incremental 700 MHz spectrum was used to improve the performance of networks. These indirect benefits relate to the impact that increased mobile connectivity, can have on economic productivity, employment, competitiveness and economic growth. To the extent that our analysis finds that incremental 700 MHz spectrum could improve the performance of networks, then such wider indirect benefits are also likely to occur.

1.14 Given that the wider benefits are necessarily more difficult to quantify to a high degree of confidence, this analysis does not attempt to estimate them.

The costs related to DTT services

1.15 The DTT platform in Ireland has been in operation since October 2010. In that time it has continued to add to its channel portfolio and the number of households which use DTT, in combination with other platforms, has remained steady in and around 40% penetration. We have engaged with 2rn (the DTT multiplex provider) to understand the costs it would face if the 700 MHz band was repurposed from its current use for DTT. These costs relate to having to invest in new equipment such as antennas and transmitters in order to accommodate the repurposing (in the future such investment would have to be made anyway but repurposing would require that it be made earlier than would otherwise be the case). We estimate that the incremental costs that 2rn would face would amount to **€9.4 million**, assuming a repurposing of 700 MHz spectrum in 2018.

1.16 In addition, we have estimated the cost of a public information campaign to inform DTT users of the changes resulting from the 700 MHz band being repurposed, and the costs users might need to incur. These user costs relate to having to replace some models of aerials and the time spent to retune set-top boxes. We estimate that both these costs would amount to approximately **€2.8m**.

1.17 We also considered whether a repurposing of the 700 MHz band could have wider social and cultural impacts, due to it causing significant churn from the DTT platform. Our analysis concludes that it is unlikely that there would be a significant impact on the take up of DTT as a result of the repurposing, such that any such wider social or cultural impacts would be likely to be negligible.

PMSE users

1.18 PMSE services in the 700 MHz band relate to the provision of equipment to support broadcasting, news gathering, theatrical productions and special events such as concerts and sport events. We estimate that the costs to PMSE users resulting from a repurposing of the 700 MHz band would be approximately **€262k**, assuming a repurposing of the 700 MHz band in 2018.

Summary of results

1.19 In the base case scenario, we identified costs of €12m compared to benefits of €89m (though benefits could be €14.5m higher if MNOs invest to increase network performance). This leads to a positive net benefit NPV of **€77m** (**€91m** if network performance investments are made). This positive NPV result is stable to all reasonable sensitivities tested, including combinations of sensitivities to the assumptions.

Executive Summary

Table 1. Costs and benefits of repurposing spectrum in 2018 NPV €m

Mobile Network cost savings	89
Potential mobile performance benefits	15
Total quantified benefits (inc potential performance) benefits	**104**
Total Quantified Costs	**12**
NPV benefit of repurposing 700MHz band	**91**

Other benefits

1.20 In addition, there are likely to be other benefits that could arise as a result of the repurposing of the 700 MHz band but which are not quantified as part of this study. These include:

- The use of the 700 MHz centre gap which consists of 25 MHz of spectrum. This could be used for services such as Supplemental Downlink (SDL), PMSE, Public Protection and Disaster Relief (PPDR) and Machine to Machine (M2M) services.

- The consumer welfare implications of greater demand for mobile services if the network cost savings lead to lower prices. In competitive markets, we would expect that network cost savings would partly be passed on to consumers in the form of improved and/or lower cost services and that if this occurred these benefits would increase demand and in so doing increase consumer welfare.

- The consumer welfare benefits that might accrue as demand for mobile services, applications, and devices is stimulated by greater network capacity. Our model has treated demand as an exogenous variable, whereas in fact demand for mobile services (and devices) is partly driven by the supply of network services. Increased network capacity will drive demand for more data intensive applications, and technologically advanced devices, which benefit from the use of the network capacity.

- Other indirect benefits could accrue to the wider Irish economy and society. These relate to the impact that increased mobile connectivity can have on

economic productivity, employment, competitiveness and economic growth. To the extent that our analysis finds that that incremental 700 MHz spectrum could improve the capacity and performance of networks, then such wider indirect benefits are also likely to occur.

1.21 Though we have not quantified these other likely benefits, they should not be discounted. They could be significant and some of them could even be larger than the quantified direct benefits, as relatively small changes in a country's growth potential can have significant benefits when taken as a proportion of the entire economy and compounded year on year. To the extent that our analysis finds that incremental 700 MHz spectrum could improve the performance of networks, then these wider indirect benefits are also likely to occur.

Earlier repurposing

1.22 The quantified benefits of a repurposing of the 700 MHz band are marginally smaller for earlier repurposing than later repurposing. This is because the quantified costs incurred by DTT and PMSE increase as the date of repurposing is brought forward. However, the quantified benefits to mobile are also higher if the date of repurposing is brought forward, though the increased quantified benefits of earlier repurposing to mobile do not fully offset the increased costs of DTT and PMSE.

1.23 As discussed above, this analysis does not include a range of unquantified other benefits, which may be significant and larger than the direct benefits. To the extent that these benefits are larger and more likely if spectrum is repurposed earlier, then these other benefits should be taken into account when assessing the appropriate repurposing date and could therefore be likely to support the case for early repurposing.

Conclusion

1.24 In conclusion, our base case scenario analysis indicates that a repurposing of the 700 MHz band would result in a positive net direct benefit NPV of **€77m** (**€91m** if performance benefits are included). In addition, our analysis indicates that other wider economic and societal benefits are also likely to result and, though they have not been quantified, these benefits could be very significant and could even be greater than the direct benefits. To realise the benefits of any repurposing of the 700 MHz band, the existing DTT and PMSE service providers will need to be migrated from the 700 MHz band. Our base case scenario yields total estimated costs of €12.4m for this migration.

Executive Summary

2 Introduction and background

2.1 ComReg is responsible for the management and use of the radio frequency spectrum in Ireland. ComReg is currently considering whether, when and how to repurpose a significant proportion of the 470-790 MHz band of spectrum in Ireland, namely the sub-range 694-790 MHz (or the '700Mhz band'), from its current use for Digital Terrestrial Television (DTT) broadcasting and Programme Making and Special Events (PMSE) to other uses in line with relevant international harmonisation measures.[2]

2.2 To consider this matter, ComReg has commissioned Frontier Economics to provide a cost benefit analysis (CBA) of the likely costs and benefits (economic, social, and cultural) of a change of use of the 700 MHz band from DTT and PMSE to mobile services.

2.3 This section describes the current use of the 700 MHz band in Ireland; provides some international background to the potential repurposing of the 700 MHz band; and summarises the approach to the CBA in this report.

Current use of the 470 – 862 MHz band

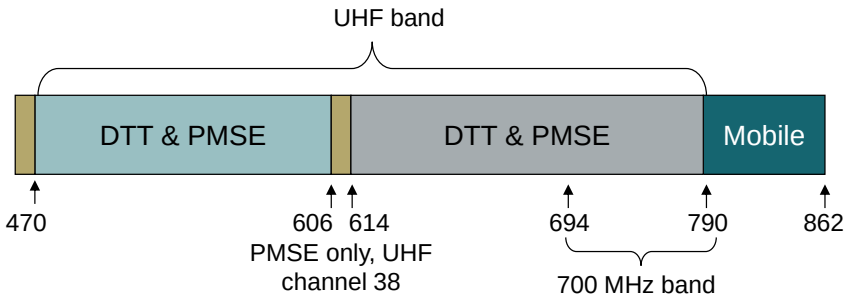
2.4 Spectrum in the 470 -862 MHz band is particularly valuable to users for its propagation properties. This is because it balances a number of attractive features:

- Unlike lower frequency spectrum, it can be used to transmit a high volume of data;
- For a given power, it travels further than higher frequency spectrum; and
- Compared to higher frequency spectrum, it penetrates more effectively obstacles such as walls, trees, and weather related obstacles (such as rain and clouds).

2.5 **Figure 1** below presents the current uses of the 470-862 MHz band in Ireland. It shows that currently this band is used for a mix of mobile, DTT and PMSE uses.

[2] We note that ComReg has not made any decisions on the potential other uses of the 700 MHz band and that there are a range of potential uses including wireless (mobile) broadband communications, Public Protection and Disaster Relief (PPDR), PMSE, DTT and/or Machine to Machine services.

Figure 1. The current usage of the 470-862 MHz band in Ireland



Source: ComReg

2.6 The 470 – 790 MHz part of this band is given over to and used by DTT and PMSE services. Throughout this document, the 470 – 790 MHz spectrum band is referred to as the 'UHF band', and the upper part of the UHF band incorporates the 700 MHz band.

2.7 The upper part (from 790 – 862 MHz or the '800 MHz band') of the 470-862 MHz spectrum band was previously given over to and used for broadcasting (analogue TV and DTT) and PMSE services in Ireland. However following an international repurposing process and ComReg's 2012 spectrum auction this band is currently used for mobile services

2.8 From 2015 the 700 MHz band will be allocated to DTT and Mobile on a co-primary basis and this may facilitate a change of use in the future.

Background to a potential repurposing of the 700 MHz band

2.9 ComReg's considerations are being made at a time when a number of other national regulatory authorities (notably UK, France, Finland, Sweden and Germany) have already announced that they intend to repurpose the 700 MHz band. Some jurisdictions, such as Germany, have already commenced their auctions process to assign licences in the 700 MHz band as early as 2015 even though the spectrum is not expected to be usable until 2017-18 at the earliest.

2.10 Below we describe some of the recent international harmonisation activities including: international agreements that support the use of spectrum; the European Conference of Postal and Telecommunications Administrations ('CEPT') reports and decisions on the 700 MHz and UHF band; the Lamy report for the European Commission ('EC'); the EU Radio Spectrum Policy Group ('RSPG') opinion on the 700 MHz band and the UHF band; the EC's proposals for the 700 MHz band; the 700 MHz activities in other member states; and the 700 MHz discussion in Ireland.

Introduction and background

International agreements on the use of spectrum

2.11 To meet the increasing consumer demand for wireless (mobile) broadband services, changes to international agreements have been adopted to identify additional spectrum bands for mobile services. These have included the repurposing or potential repurposing of specific spectrum bands such as the 800 MHz band and the 700 MHz band.

The 800 MHz band.

2.12 In 2012, the 790 – 862 MHz (the '800 MHz band') was repurposed in Ireland for mobile services. Prior to this repurposing, a change to international agreements was adopted to allow the use of the 800 MHz band for mobile services and harmonisation decisions were adopted by the CEPT and the European Union ('EU').

2.13 These CEPT and EU Decisions facilitated and subsequently required EU Member States (via the Radio Spectrum Policy Programme (RSPP) Decision[3] of 2012) to authorise the 800 MHz band for Electronic Communications Services (ECS) by 1 January 2013.

2.14 The RSPP Decision also discusses migration costs, and it is stated that:

- Member States should be allowed, where appropriate, to introduce compensatory measures relating to migration costs (recital 18);
- Member States may, where appropriate and in conformity with Union law, ensure that the direct cost of migration or repurposing of spectrum usage is adequately compensated in accordance with national law (article 6 (5).

2.15 Although the digital dividend (releasing the 800 MHz band) forms the context of these statements, the principles as laid out in the RSPP decision would also appear applicable to any repurposing of the 700 MHz band.

The 700 MHz band.

2.16 At the 2012 World Radiocommunication Conference ("WRC-12") a decision was taken to allocate the 700 MHz band on a co-primary basis to mobile alongside the existing allocation to DTT. This would take effect immediately after the WRC-15[4]. This means that the 700 MHz band will be globally allocated to mobile services.

2.17 The CEPT, the EU Radio Spectrum Policy Group (RSPG), the European Commission (EC) and Member States have considered this allocation in the 700

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3 See: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32012D0243

4 See: http://www.itu.int/en/ITU-R/conferences/wrc/2015/Pages/default.aspx

MHz band and made preparations for its potential repurposing as outlined below.

CEPT's reports and decisions on the 700 MHz and UHF band

2.18 To support the reallocation of the 700 MHz band and its potential repurposing, the CEPT has developed harmonised technical conditions for the 700 MHz band in the EU for the provision of wireless broadband and other uses and approved a CEPT Electronic Communications Committee (ECC) Decision (ECC Decision 15(01)[5]) which entered into force on 6 March 2015

2.19 These harmonised technical conditions have also been provided to the EC, via CEPT Report 53[6] as part of CEPT's response to the EC's 700 MHz mandate[7].

2.20 In addition CEPT has published a report (Report 224[8]) on a long-term vision for the UHF Broadcasting band, which determined that:

- cooperation between radiocommunication services is expected in the long term.
- the long term usage of the band 470-694 MHz is mainly foreseen for downstream audiovisual content distribution; and
- in order to facilitate different scenarios considered by the CEPT for the usage of the band 470- 694 MHz, it could be necessary to introduce more flexibility in the regulatory environment governing the use of this band to respond to different needs and requirements in different countries.

The Lamy report for the EC

2.21 In 2013 the European Commission mandated a High Level Group (HLG) under chairmanship of the former Commissioner Pascal Lamy to deliver strategic advice to the European Commission for the development of a European strategy on the future use of the UHF band. The HLG consisted of nineteen executive-level representatives from the mobile and broadcasting sectors, including the PMSE sector.

2.22 On the 1st of September 2014, the report of the HLG to the European Commission was published ('Results of the work of the High Level Group on

5 http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCDEC1501.PDF

6 http://www.erodocdb.dk/Docs/doc98/official/pdf/CEPTREP053.PDF

7 http://ec.europa.eu/information_society/newsroom/image/19_feb_2013_5787_7468.pdf

8 http://www.erodocdb.dk/Docs/doc98/official/pdf/ECCREP224.PDF

the future use of the UHF Band (470 – 790 MHz)', in short 'the Lamy report'). The HLG proposed the following[9]:

- The 700 MHz band (694-790 MHz) should be repurposed for wireless broadband, but with sufficient lead time to ensure a transition path that minimises cost for spectrum users and citizens and to accommodate the diversity in penetration levels of terrestrial broadcasting within Europe. This implies a time frame of around 2020, plus or minus 2 years.

- Regulatory stability should be ensured for broadcasting to continue its current use of the band 470-694 MHz, until 2030. This involves national, EU and international measures. In consequence, at the WRC 2015 (which will review and revise global spectrum-use rules) Europe should reject any plans for primary allocation of the 470-694 MHz band to mobile. Some flexibility could nevertheless be catered for through the development of 'down link only' technologies that give priority to primary broadcasting networks.

- A stock-taking exercise of UHF spectrum use should be performed by 2025, in order to take into account evolving consumer demand as well as new technologies, such as converged networks or large-scale roll out of optic fibre. This will give Europe the opportunity to re-assess where it stands and avoid any freeze of regulation compared to the rapid advance in technology and consumer behaviour.

2.23 On 12 April 2015 the 3 month public consultation period on the Lamy report closed.[10]

The EU RSPG's opinion on the 700 MHz and UHF band.

2.24 The RSPG is the high-level advisory group that assists the EC in the development of radio spectrum policy. In February 2015, it issued its final opinion on a long-term strategy on the future use of the UHF band (470-790 MHz) in the European Union.[11]

2.25 In relation to the 700 MHz band the RSPG opinion supports the provision of Wireless Broadband ('WBB') services and makes the following recommendations on the 700 MHz band transition and authorisation processes where it:

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9 See http://europa.eu/rapid/press-release_IP-14-957_en.htm

10 http://ec.europa.eu/digital-agenda/en/news/public-consultation-lamy-report-future-use-uhf-tv-broadcasting-band

11 http://rspg-spectrum.eu/wp-content/uploads/2013/05/RSPG15-595_final-RSPG_opinion_UHF.pdf

- recommends that the EC, in cooperation with the Member States, define as early as possible the harmonised technical conditions for the use of 700 MHz band by wireless broadband services and propose binding legislative measures (such as an RSPP) to set an authorisation deadline for making the 700 MHz band available for effective use by ECS in line with harmonised technical conditions.

- recommends that Member States should undertake the 700 MHz band transition process as soon as possible and make the 700 MHz band available for Wireless Broadband ('WBB') as early as possible to ensure that all necessary cross-border coordination agreements, including transitional arrangements, will be finalized at the latest by the end of 2017.

- supports making the 700 MHz band available for effective use by ECS by the end of 2020, noting that Member States may decide for duly justified reasons and without the need for derogation to delay the availability of the band by up to two years; and

- recommends that Member States should develop and communicate to stakeholders and neighbouring countries in due time, a framework for the migration of broadcasting services below 694 MHz, and also take into consideration all practicable efforts to accommodate the various timelines of their neighbours for migration.

2.26 In relation to the 470-694 MHz band, the RSPG opinion recognises that this spectrum band is mainly used for downstream audiovisual content distribution and it recommends that it remains as such for the long-term, even beyond 2030. In addition it recommends that:

  - the frequency band 470-694 MHz remains available for DTT in the foreseeable future, i.e. 2030; and

  - Member States should have the flexibility to use the 470-694 MHz band for WBB downlink, provided that such use is compatible with the broadcasting needs in the relevant Member State and does not create a constraint on the operations of DTT in neighbouring countries.

The EC's proposals for the 700 MHz band

2.27 Considering relevant information from CEPT, the RSPG, the Lamy Report, etc. the EC is also making preparations for the potential repurposing of the 700 MHz band. In particular:

  - in February 2013, the EC issued a mandate to CEPT requesting the development of harmonised technical conditions for the 700 MHz band for the provision of wireless broadband and other ECS services. As

discussed above, CEPT Report 53 has been submitted to the EC in respect of this mandate and this report constitutes a technical input to the EU-level political process; and

- in May 2015, the EC unveiled its plans to create a digital single market in the EU and stated its intention to make specific proposals regarding the coordinated release of the 700 MHz band, which it added is particularly well-suited for ensuring the provision of broadband services in rural areas, while accommodating the specific needs of audiovisual media distribution.

700 MHz proposals in other EU Member States

2.28 While many countries have commenced their planning of a 700 MHz transition process and started negotiations with their neighbours, a number of countries (namely the UK, France, Finland, Sweden and Germany) have progressed their 700 MHz considerations further and have either set an end-date for DTT and PMSE in the 700 MHz band and/or commenced the 700 MHz authorisation process:

- Germany commenced its auction for the 700 MHz band on 27 May 2015 and it expects the 700 MHz band to be available for use in the 2017-2019 timeframe[12];
- France has consulted upon the release of the 700 MHz band and it is working towards finalising a call for applications to assign the 700 MHz band, which it expect to issue in July 2015.[13]
- The UK has decided to make the 700 MHz band available for mobile use by the start of 2022 and earlier if possible.[14]
- Finland and Sweden have both set end dates for the use of DTT and PMSE in the 700 MHz band, being 1 January 2017 and 1 April 2017 respectively.[15]

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12 http://www.bundesnetzagentur.de/EN/Areas/Telecommunications/Companies/FrequencyManagement/ElectronicCommunicationsServices/MobileBroadbandProject2016/project2016_node.html

13 http://www.arcep.fr/index.php?id=8571&tx_gsactualite_pi1%5Buid%5D=1739&tx_gsactualite_pi1%5Bannee%5D=&tx_gsactualite_pi1%5Btheme%5D=&tx_gsactualite_pi1%5Bmotscle%5D=&tx_gsactualite_pi1%5BbackID%5D=26&cHash=ed82c17652f39a6f2022df4cea984d39&L=1

14 http://stakeholders.ofcom.org.uk/binaries/consultations/700MHz/statement/700-mhz-statement.pdf

15 http://www.cullen-international.com/

700 MHz discussions in Ireland

2.29 In Ireland the reallocation and potential repurposing of the 700 MHz band has been discussed by both the Department of Communications, Energy and Natural Resources ('DCENR') and ComReg.

2.30 The DCENR established a broadcaster stakeholder group to review the future of the UHF spectrum from a broadcast perspective, and in May 2014 the stakeholder group established by the DCENR published a report on the future use of UHF spectrum for broadcasting in Ireland.[16] This report provided recommendations in relation to national broadcasting policy and recommends that:

- the primary allocation of UHF Spectrum for broadcast purposes be maintained to allow for the continued provision and development of a national free-to-air DTT network and ancillary services until at least 2025.
- the provision of spectrum for such purposes beyond this date should be subject to review in light of technological, market, and regulatory developments in a timely manner in advance of this date; and
- any changes in spectrum allocation for broadcasting services arising as a result of international obligations should be introduced in such a way as to minimise the impact on broadcasters, transmission network operators and consumers;

2.31 In addition, the DCENR has commenced a review of national spectrum policy and a public consultation document was issued on 24 July 2014.[17] The future use of the UHF band is discussed in that consultation.

2.32 As part of ComReg's deliberations, it has also commenced its considerations of the 700 MHz band.[18] In relation to the 700 MHz transition planning ComReg is currently working towards the completion of a plan in collaboration with the BAI and 2RN and this plan is being discussed with neighbouring administrations, particularly Ofcom in the UK.

Approach to the CBA

2.33 ComReg has commissioned Frontier Economics to analyse the likely costs and benefits (including economic, social, and cultural costs and benefits) of DTT and

16 http://www.dcenr.gov.ie/NR/rdonlyres/9EF4EF11-AC3E-499C-95CB-2EEF414DAA21/0/ReportoftheUHFSpectrumPolicyReviewGroup.pdf

17 http://www.dcenr.gov.ie/NR/rdonlyres/8D2F913A-60C5-46C6-97A6-9DB8EEA4AB02/0/SpectrumConsultationDocument.pdf

18 See ComReg Documents 14/85 and 14/13.

PMSE users migrating out of the 700 MHz band with wireless (mobile) broadband services being the primary future use of the 700MHz band.

2.34 Benefits to mobile operators accrue primarily as a result of them being able to meet demand for mobile services at a lower cost than would be the case absent the 700 MHz band. Alternatively, incremental 700 MHz spectrum could enable mobile operators to offer enhanced performance which their customers value.

2.35 The potential benefits of a 700 MHz change in use will be assessed against the costs faced by existing users from the change in use. Changing the use of the 700 MHz band will lead to costs for existing DTT and PMSE users. The costs will relate to costs of DTT and PMSE providers changing or updating their equipment earlier than they might otherwise do, to accommodate the change in spectrum use.

2.36 The CBA will also consider potentially wider costs associated with a 700 MHz repurposing. These include costs to DTT users of updating aerial equipment and costs of informing DTT users of the implications of change in use, which could include consumers having to buy new aerials or re-tune their set top box. Where relevant, the CBA will also need to consider social or cultural costs which could result from a change in use if it materially affects take up of the DTT service.

2.37 The CBA assesses the costs and benefits up to 2035 using 2014 as the base year. Costs will be appropriately discounted to present values.

2.38 Where it is not possible to fully quantify costs to a reasonable degree of accuracy, the CBA will assess costs and benefits qualitatively and consider whether the qualitative costs and benefits are likely to affect conclusions.

The structure of the rest of this report

2.39 The remainder of this report is set out as follows.

- Section 3 considers the benefits to mobile of a change in use of 700 MHz broadband
- Section 4 quantifies the benefits to mobile operators of a change in use of 700 MHz broadband
- Section 5 considers the costs to DTT providers and users of a change in use.
- Section 6 considers the impact of a change in use on PMSE providers;
- Section 7 summarises our conclusions

2.40 This report is supported by the following annexes.

- Annex 1: Assumptions made in replacement estimating costs of repurposing 700 MHz from DTT

- Annex 2: Forecasts of growth in data traffic in the UK
- Annex 3: Modelling the network cost savings to mobile network operators of a change of use of the 700 MHz band (as a separate document)

Introduction and background

3 Benefits of 700 MHz change of use to wireless broadband

3.1 This section explains the benefits that could accrue to mobile operators and users following a change in use of the 700 MHz band.

- it describes how spectrum is used to provide wireless mobile broadband;
- it considers the current and projected demand for wireless mobile broadband; and
- it explains the benefits that could accrue to mobile operators and users as a result of a change in use of 700 MHz to wireless mobile broadband.

Use of spectrum for wireless mobile broadband use

3.2 Mobile broadband currently uses spectrum in four bands: 800 MHz, 900 MHz and 1800 MHz and 2.1 GHz. Following the merger of H3GI and Telefonica Ireland, which was cleared by the European Commission, there are now three Mobile network operators: Hutchison, Vodafone and Meteor) and **Table 2** below sets out their current spectrum assignments.

Table 2. Current spectrum assignment for mobile operators (paired spectrum)

	800 MHz	900 MHz	1800 MHz	2.1 GHz
Hutchison	10	15	35	30
Meteor	10	10	15	15
Vodafone	10	10	25	15

Note from EC decision on the commitments offered by Hutchison: Hutchison committed to divest five blocks of spectrum in the 900 MHz (2 x 5 MHz), 1800 MHz (2 x 10 MHz) and 2100 MHz bands (2 X 10 MHz) to one of two MVNOs, UPC or Carphone Warehouse, under certain conditions. The spectrum will be available for ten years, starting from 1 January 2016..

3.3 The spectrum used for mobile networks is not homogeneous. The propagation and coverage of spectrum is better at lower frequencies (i.e. the sub-1GHz bands) and is therefore more suitable for wide area, rural and in-building coverage. Frequencies above 1 GHz are generally referred to as "capacity bands" and are most commonly used to provide capacity in high usage areas. Operators

therefore typically use a mix of coverage and capacity spectrum to deliver voice and data services.

3.4 Given these propagation characteristics, the coverage radius around a mobile cell is much smaller for higher frequency spectrum than lower frequency spectrum. Therefore, an operator would need to use a greater number of cell sites to meet a given level of coverage using higher frequency spectrum than lower frequency spectrum. The costs of acquiring, building and maintaining cell sites would therefore make a Radio Access Network configuration using higher frequency spectrum more costly for an operator than a network using lower frequency spectrum.

3.5 For these reasons, to provide a comprehensive layer of coverage, mobile operators typically use sub 1 GHz spectrum such as the 800 MHz and 900 MHz bands. Where there are capacity constraints (in areas with larger population densities such as large towns and cities) lower frequency spectrum is supplemented with higher frequency (above 1 GHz).

3.6 Historically, prior to the Multi Band Spectrum Award (MBSA) in 2012, 900MHz and 1800 MHz spectrum was used in Ireland for 2G GSM services, whereas UMTS 3G services have been provided in the 2100 MHz band. Since the MBSA, spectrum rights have been offered in a technologically neutral approach. This means that UMTS 3G is also now provided in the 900 MHz band.

3.7 4G LTE services have been provided in both the 800 MHz and 1800 MHz bands and may also be provided in other frequency bands such as the 900 or 2100 MHz bands in the future.

Current and projected demand for spectrum

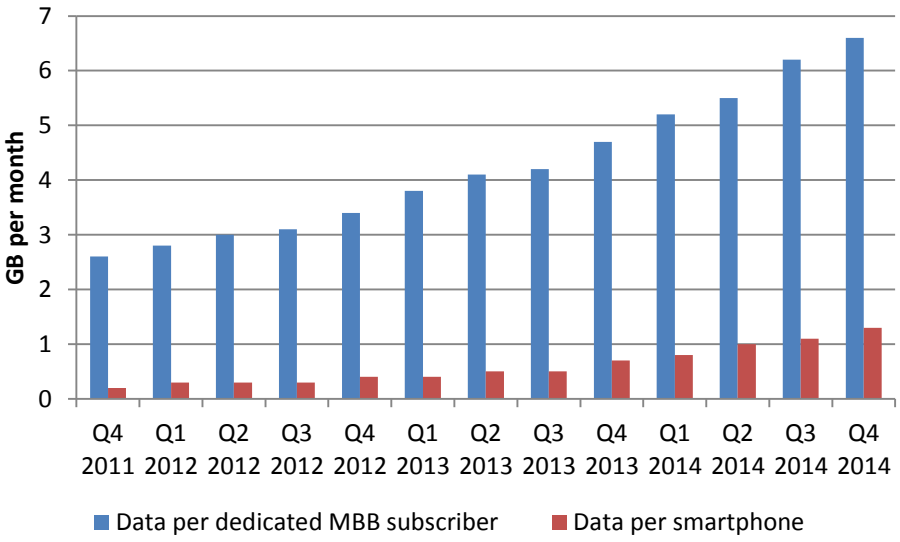
3.8 This section analyses demand for mobile data services. The growth in demand for mobile data is a good indicator of the demand for mobile spectrum in the future. It is therefore a key input into assessing the benefits of changing 700 MHz to mobile use. We set out below:

- Recent growth in demand for mobile data in Ireland
- Factors affecting demand for mobile data in Ireland
- Forecasts of demand for data in Ireland

Recent growth in demand for mobile data in Ireland

3.9 Demand for mobile data in Ireland has increased sharply in recent years. Since Q4 2011 data use per smartphone has increased by on average 87% per year, and data use per Mobile Broadband ('MBB') user has increased by 36% per year.

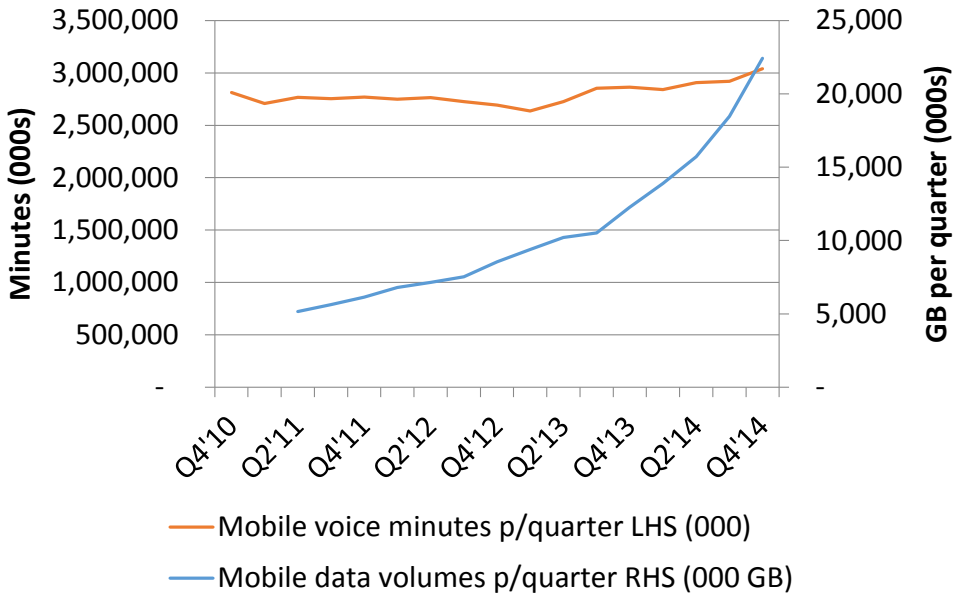
Figure 2. Monthly data volumes in Ireland per subscription Q3'12 – Q3'14



Source: ComReg

3.10 This is reflected in higher trends in mobile network use in Ireland as set out in **Figure 3**. It demonstrates that voice is growing slowly; whereas data volumes are increasing quickly.

Figure 3. Mobile voice and mobile data volumes in Ireland



Source: ComReg Key Data Report – Q4 2014.

Factors affecting demand for mobile data in Ireland

3.11 Some key factors which explain the large increase of mobile traffic include:

- increased 3G and 4G network capability and coverage; increased 3G and 4G smartphone penetration and improved user experience (data per smartphone user is typically larger than a GSM handset due to the larger range of internet services available);[19]
- penetration of video capable mobile devices is increasing;
- mobile internet usage is increasing; customers have access to more services online (shopping and transactions services) and expect to use any Internet application on their mobile devices as they do on their fixed connection;
- visual communications traffic is growing dramatically whether providing communications, audio-visual and video content or gaming;

[19] According to Cisco VNI 2014, the typical smartphone generated 37 times more mobile data traffic (819 MB per month) than the typical basic-feature cell phone (which generated only 22 MB per month of mobile data traffic).

Benefits of 700 MHz change of use to wireless broadband

- mobile data caps are rising and "all you can eat"[20] plans have been introduced; and
- there is a growing popularity of mobile over-the-top (OTT) services in Ireland.

3.12 Noting these factors **Table 3** below shows that per device traffic is expected to grow at significant rates in the near term.

Table 3. Summary of per device usage growth (MB per month)

	2013	2018
Non-smartphone	10.8	45
M2M module	61	451
Wearable device	78	345
Smartphone	529	2,672
4G smartphone	1,984	5,371
Tablet	1,374	5,609
4G Tablet	2,410	9,183
Laptop	2,455	5,095

Source: Cisco VNI Mobile 2014

3.13 On the other hand, some other offsetting factors could reduce mobile traffic volumes such as:

- mobile data offloading, where mobile operators use fixed networks and Wi-Fi to meet mobile data demand, where a user is in range of such a service;
- constraints of network capacity can limit demand for data as users avoid accessing certain applications where they know that network capacity is insufficient (this inevitably makes forecasting demand for capacity since demand is itself dynamically related to available supply).

[20] Subject to fair usage requirement of (15 Gb on the Three Network)

Forecasting demand for mobile data in Ireland

3.14 As set out above, demand for mobile data is likely to continue to increase, driven by a number of inter-related factors. It should be noted that each of these factors can affect the others. These include:

- increased device penetration;
- increased usage per device;
- population growth;
- WiFi offload; and,
- declining use of legacy technology handsets.

3.15 In forecasting mobile data use in Ireland, we have considered each of these factors.

Increased device penetration

3.16 As penetration of smartphones and other mobile devices continues to increase, so demand for mobile data will increase. There are different types of device that use mobile data networks. These can be categorised as:

- **Smartphones**, i.e. devices used to make and receive voice calls, but also used to provide mobile data services. Currently, mobile penetration[21] is 106% in Ireland, compared with 3G and 4G smartphone penetration of 72%[22]. As smartphone penetration increases (particularly 4G smartphones) up to the level of mobile penetration, so demand for mobile data will grow.

- **Other connected consumer devices**, such as tablets, laptops with dedicated in built mobile connectivity, or which can be connected using "dongle" (i.e. an external device, which provides mobile connectivity). Other connected devices could include laptops and notebooks with inbuilt connectivity; tablets; cars and other mobile services with mobile data connectivity. Typically the users of these devices have a higher demand for mobile data, partly as the devices can be used to watch and stream video at a higher quality, which is more data intensive.

- **M2M** ("Machine to Machine") devices. These are devices which communicate directly with one another with minimal or no human intervention. These devices can use mobile networks to communicate. Typically the demand for mobile data of a given M2M device is very low.

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21 Smartphones are a subset of mobiles.

22 Based on active 3G and 4G SIMS excluding dedicated mobile broadband SIMs.

Benefits of 700 MHz change of use to wireless broadband

While there are a large number of M2M subscriptions (there were 455,745 M2M subscriptions at the end of December 2014[23]) the average use of data for each M2M subscription is very low and amounts to less than 1% of total network traffic[24]. Given the very low level of demand for M2M data, we have excluded M2M from our analysis for the purposes of this modelling.[25]

Increased usage per device

3.17 As set out above (**Figure 2**) Irish users are continuing to increase their use of mobile data. These trends are expected to continue. The increase in use per device is driven by a number of interrelated factors. First the increasing diffusion of devices with ever greater processing power enables more complex and data intensive applications to be used. Second, increases in network capacity have increased expectations and consumer demand.

Population growth

3.18 The Central Statistics Office (CSO) projects a small amount of population growth each year. The CSO estimate six population projections which are estimated using different combinations of fertility and migration assumptions. The midpoint projection method M2F1 is used in the CBA model to minimise the risk of over or under estimating the size of the market in future years.

WiFi Offload

3.19 The actual required capacity of mobile networks also depends on how much traffic is actually offloaded via Wi-Fi onto fixed broadband networks. Mobile networks will attempt to actively manage capacity by offloading traffic onto fixed networks as well as a greater use of public Wi-Fi networks.

The use of legacy technology handsets

3.20 Although in the long-term most mobile bands are expected to migrate to LTE, in the near and mid-term there will still be demand for 3G/HSPA+ and GSM given the handset market. It takes time before LTE capable devices will reach the same price-point of 3G/HSPA+ devices and further time for end-users to have all upgraded to LTE capable devices. Therefore in the near- and mid-term mobile operators do require a coverage band for 3G/HSPA+ and for LTE. Also support of legacy GSM is likely to require some 900 MHz band spectrum for an extended period of time.

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23 ComReg 15/27

24 ComReg.

25 Using similar logic, 2G data is also excluded from the model.

Other factors that will affect demand for spectrum in Ireland

3.21 In addition to the factors set out above there are a number of uncertainties in demand for spectrum. These factors are discussed for context but not explicitly modelled in our assessment. These include:

- A 2 x20MHz spectrum block in a coverage band
- Network sharing
- International harmonisation will lead to economies of scale

A 2 x 20MHz contiguous spectrum block in a coverage band

3.22 For mobile operators there are two important considerations in terms of developing their spectrum strategy for mobile broadband:

- Spectrum below 1 GHz to provide cost-effective coverage
- A large block of spectrum, typically at least 2x20 MHz to provide cost-effective capacity. Typically large block of spectrums are only available in the mobile bands above 1 GHz.

3.23 The "3GPP standard" has already standardised "LTE-Advanced Carrier Aggregation" between different bands. This means that, where available, it is possible to offer LTE using small non-contiguous blocks of spectrum in different bands.[26]

3.24 Furthermore, from a business perspective it could be attractive for mobile operators to have 2x20 MHz in one of the three coverage bands (700, 800 or 900 MHz) since it could offer greater performance and capacity than an equivalent amount of non-contiguous spectrum (See para 3.30 onwards). For example, while acquiring 2x20 MHz in the 700 MHz band would be attractive to a MNO it may have little need for an additional 2x10 MHz in one of the other coverage bands. A theoretical scenario could be that each of the three operators could attempt to trade spectrum to achieve a 2x20 MHz holding in one of the three coverage bands.

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26 For example: 900 MHz could be used as coverage band alongside 1800, 2100 or 2600 MHz as capacity bands; 800 MHz as coverage band and 1800, 2100 or 2600 MHz as capacity bands; also it is possible to combine 800 and 900 MHz. For band 28 (APT-700, the likely candidate to be adopted in Europe at least for the lower 2x30 MHz of this band) the following Carrier aggregation modes have been defined in 3GPP: 700 MHz as coverage band and 1800 MHz as capacity band; 700 MHz as coverage band and 2100 MHz as capacity band; 700 MHz as coverage band and 2600 MHz as capacity band. However up until 3GPP release 12 there is no standard for Carrier Aggregation between 700 MHz and 800 or 900 MHz. This might be added to the 3GPP standard at a later point in time but for now it doesn't allow carrier aggregation of 700 and for example 800 MHz spectrum.

Benefits of 700 MHz change of use to wireless broadband

3.25 Therefore as 2G and 3G technologies are phased out, as consumer handsets adopt LTE standards, we could see operators seeking a 2 x 20 MHz contiguous spectrum block in either the 700, 800 or 900 MHz bands.

Network sharing

3.26 Another factor impacting spectrum demand would be spectrum and network sharing. If two or more operators decide to build a joint network for the coverage of rural Ireland that could result in significant synergies. Such a scenario could unfold in the 700 MHz band.

3.27 Network sharing is already present in the Irish market, and recently, Eircom signed a new network sharing agreement with Hutchison. The new agreement will run to 2030 and commits funding to create a shared network of over 2000 sites while there is no transfer of assets and spectrum will not be shared.

International harmonisation will lead to economies of scale

3.28 Economies of scale enabled by international harmonisation of the 700 MHz band leads to cheaper LTE devices (including smartphones and tablets) while also making international roaming easier. This could quicken the migration of customers to LTE handsets with a 700 MHz capability compared to other low frequency bands.

3.29 CEPT's channelling arrangements for 700 MHz band in Europe (as detailed in ECC Decision 15(01) which entered into force on 6 March 2015) maximises inter-regional harmonisation with the Asia-Pacific Telecommunity (APT) 700 MHz band plan, as developed in the Asia Pacific Telecommunity and adopted in many parts of the world. The APT-700 band plan already has widespread global backing and major economies of scale are anticipated. Several Asian countries have started service in the APT-700 band while most Latin America countries have embraced the APT-700 band plan, instead of the FCC 700 band plan as used in the US and Canada.

3.30 By April 2015 already 92 devices with APT-700 support have been launched. For example both main iPhone 6 models have default support for band 28, APT-700 band plan. As long as Europe fully adopts the lower 2x30 MHz of the APT-700 band plan the device market would benefit from the global developments in the APT-700 ecosystem.

International harmonisation allows benefits to arise sooner

3.31 Absent the international harmonisation of the 700 MHz band that has already occurred, the benefits for Ireland in proceeding with a repurposing of the 700 MHz band would be slow in arsing. However, the economies of scale do not really depend upon adoption in Europe alone since other continents have already taken a leading role in establishing the ecosystem. The industry expects APT-700 to become a very widespread and popular band plan with the associated benefits

of economies of scale. Ireland can therefore benefit from those economies even if other European countries would be following later.

3.32 As discussed earlier other 700 MHz spectrum assignments are anticipated. A number of countries (namely the UK, France, Finland, Sweden and Germany) have either set an end-date for DTT and PMSE in the 700 MHz band and/or commenced the 700 MHz authorisation process. For example:

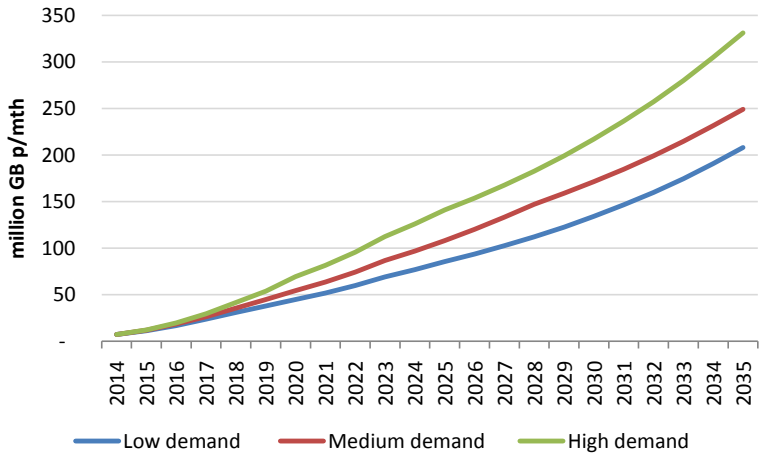
- Germany commenced its auction for the 700 MHz band on 27 May 2015 and expects the 700 MHz band to be available for use in the 2017-2019 timeframe;
- France has consulted on release of the 700 MHz band and is working towards finalising a call for applications to assign the 700 MHz band which it expects to issue in July 2015;
- the UK has decided to make the 700 MHz band available for mobile use by the start of 2022 and earlier if possible; and,
- Finland and Sweden have both set end-dates for the use of DTT and PMSE in the 700 MHz band, being 1 January 2017 and 1 April 2017, respectively.

Demand projections for mobile data in Ireland

3.33 Based on the assumptions made, we have projected demand for mobile data in Ireland over the assessment period in a low, medium and high scenario. These scenarios relate specifically to the 3G and 4G technologies currently in use and do not consider the introduction of new generations of mobile technologies such as 5G or 6G. These projections are set out below.

Benefits of 700 MHz change of use to wireless broadband

Figure 4. Projected demand for mobile data in Ireland (million GB per month)



Source: Frontier Economics

3.34 In the three scenarios demand for mobile data increases. The assumptions underpinning the scenarios are explained below. All the scenarios share common assumptions about population growth, and growth in use of Wi-Fi offload onto fixed networks.

Medium demand growth (base case)

3.35 In the medium scenario the model assumes that smartphone penetration increases to close to the current level of mobile penetration by 2028, and assumes that penetration of other connected devices is maintained at the level of the current MBB penetration. Arguably, this assumption is conservative as we might expect increased levels of penetration of connected devices (as more consumers have multiple devices which are increasingly connected to mobile networks) in the future. On the other hand MBB penetration in Ireland has gradually been declining.

3.36 The model assumes that current rates of annual growth in per device data traffic gradually fall from current levels (of 91% / 41% for smartphones / MBB per year) to around 10% per year by 2024; and a slower rate of annual growth from this point.

3.37 In 2035, the total data traffic carried on 3G and 4G mobile networks will reach 33 times their current levels. This level of growth corresponds to a Compound Average Growth Rate (CAGR) of 18% for the period. The initial period of modelling up to 2025 has a higher CAGR of 28% falling to more conservative 9% for remaining years to reflect the inherent complexities of forecasting long-term growth.

Low demand growth scenario

3.38 In the low growth scenario, penetration is assumed to increase to the same point as the medium scenario, but at a slower pace. The rate of smartphone penetration increases to close to the current level of mobile penetration by 2035.

3.39 Likewise the rates of growth of data use per device are assumed to reduce more quickly, than in the medium scenario.

3.40 In the low scenario by 2035, the total data traffic carried on 3G and 4G mobile networks will reach 23 times their current levels with a CAGR of 16.5% for the period.

High demand growth scenario

3.41 In the high demand scenario the penetration of mobile devices is assumed to be higher than in the medium scenario. It is assumed that by 2025 the penetration rate of smartphones is 120%; and the penetration of other connected devices increases to 20% (from 9.3%).

3.42 In the high scenario by 2035, the total traffic data carried on 3G and 4G mobile networks will reach 47 times their current levels with a CAGR of 20% for the period.

Benefits of 700 MHz change of use to wireless broadband

4 Quantifying benefits to wireless broadband

4.1 This section quantifies the benefits to wireless broadband of a potential change of use of 700 MHz spectrum to mobile.

4.2 The immediate, direct economic benefits of a change of use of the 700 MHz band are likely to pass to the MNOs, who should be able to use their increased spectrum holdings to save costs and improve the performance of their networks. In a competitive market these direct economic benefits should then flow through to users, in the form of improved and/or lower cost services. Finally, there are likely to be a number of indirect other benefits to the wider Irish economy and society, as described below.

4.3 Mobile data services are a key element in Ireland's communications infrastructure. There are currently 5.8m mobile SIMs in use in Ireland[27]. These include smartphone users, dedicated mobile broadband connections and M2M uses. ComReg estimates that there are approximately 3.3m smartphones in use in Ireland. This represents 68% of all mobile subscriptions or a smartphone penetration rate of 72%.

4.4 Data volumes are increasing as smartphone penetration increases: in three years data use per smartphone users has risen to 1.3 GB per user per month[28] and is growing at a rate of 87% per year. While MBB data volumes are 6.6 GB per user per month and are growing at a rate of 36% per year.

4.5 In order to keep pace with the continued growth in demand for mobile broadband services outlined in Chapter 2, new technological solutions based on radio spectrum are continually being developed[29]. The potential repurposing of 700 MHz spectrum, alongside other spectrum releases, and the roll out of fibre broadband in rural areas[30] all form part of Ireland's strategy to support the economic benefits that can accrue from broadband as demand for data continues to grow.

4.6 We have considered two potential approaches to assess the economic benefits that mobile operators place on 700 MHz spectrum. First, we have developed a bottom up model of mobile radio networks to estimate cost savings that could accrue to operators as a result of having incremental spectrum. Second, we

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27 Q4 2014. ComReg 15/27 page 7.

28 Q4 2014. ComReg 15/27 page 61.

29 ComReg (2014) Strategy Statement for Electronic Communications page 17.

30 On 25 April 2014, Minister for Communications, Energy and Natural Resources, Pat Rabbitte TD, announced that the Government has committed to a major telecommunications network build-out to rural Ireland, with fibre as a cornerstone of its investment under the National Broadband Plan. See DCENR Further information available at http://www.broadband.gov.ie/

consider the potential for operators to use 700 MHz spectrum to increase the performance of their networks.

4.7 As we explain below, this analysis considers the direct impact that incremental 700 MHz spectrum could have on mobile operators and subscribers. However, there are likely to be a range of indirect benefits which could result from greater mobile connectivity; use of the centre gap (for SDL or PMSE); a demand response to increased capacity; the consumer welfare implications of lower prices.

4.8 Annex 3 sets out the approach taken to estimating the benefits and assumptions used in more detail, and provides the results of sensitivity testing of the results to plausible high and low estimates of the key assumptions (and of combinations of some of the key assumptions).

Network cost savings as a result of 700 MHz spectrum

4.9 Our analysis uses a bottom up model to estimate the present value costs of a Radio Access Network that a hypothetical mobile operator would require in order to meet network demand for voice and data up to 2035. The model considers these costs under two spectrum scenarios. In one scenario it is assumed that the operator has access to 700 MHz spectrum in addition to its other available spectrum holdings (the factual scenario), while in the other scenario it is assumed that it only has access to its other available spectrum holdings (the counterfactual scenario). In both scenarios, the other available spectrum holdings consists of spectrum in the existing mobile spectrum bands currently assigned in Ireland and spectrum in the spectrum bands that may be made available in the future. The costs are expressed in the net present value.

4.10 We set out below our overall modelling approach, the approach to modelling demand, the approach to modelling RAN capacity, and the results.

Modelling approach

4.11 The model separately considers mobile demand and the mobile radio access network (RAN) capacity to meet that demand. The model considers the costs of incremental cell site infrastructure; expected demand for mobile capacity; baseline network configuration and technical parameters; network technologies; and spectrum holdings. The model considers the network costs that a hypothetical operator would save by utilising fewer cell sites in its network as a result of holding 700 MHz spectrum in addition to its other spectrum holdings.

4.12 For both the factual (assuming the operator has access to 700 MHz spectrum) and counterfactual (assuming no 700 MHz spectrum) scenarios, the approach to modelling the network cost benefits is as follows.

Quantifying benefits to wireless broadband

1. From a 2014 base, the network capacity is modelled for a baseline number of cell sites. These cell sites provide network coverage and a baseline level of network capacity.

2. The model estimates two types of network demand from a 2014 base.

    a. First, network demand that can only be met with lower frequency spectrum (sub 1GHz spectrum), i.e., demand for indoor and deep indoor coverage and rural coverage at the edges of a cell (in the model this is labelled "indoor" demand).

    b. Second, network demand that can be met using any frequency spectrum, i.e. either low or high frequency spectrum (in the model this is labelled "outdoor" demand).

3. The network demand is then distributed across the network into five traffic demand areas, and the model considers whether the "indoor" or "outdoor" demand exceeds the available capacity in each traffic demand area.

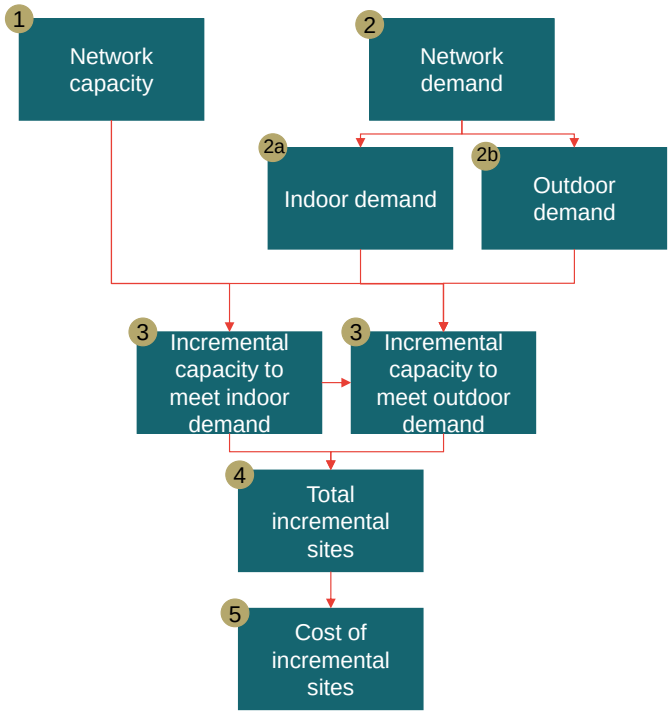
4. Where the available capacity is insufficient to meet the network demand, the model determines the required increase in base stations (and thus cell sites) necessary to meet demand.

4.13 Finally, the model determines the cost of these incremental cell sites.[31]

4.14 The approach is set out in full in Annex 3 and schematically illustrated below.

[31] Note in the factual scenario the cost of upgrading sites to support the use of 700 MHz is also included.

Figure 5. Schematic of the approach to modelling the need for incremental base stations to meet demand



Simplifying assumptions

4.15 The model makes a number of simplifying assumptions which are explained below.

- The model assumes that all co-existence issues with the UK on the 700 MHz band are resolved, as otherwise there could be large parts of Ireland where the 700 MHz band might experience a strong UK DTT signal.

- The model assumes, in line with the findings of the European Commission that, given the remedies accepted by the merging parties, the Irish mobile market dynamics will be broadly unchanged by the recent merger. That is, levels of investment, price trends, share of subscribers and overall subscriber growth. will conform to historic levels. It takes into account the recent passive network sharing deal announced by Three and eircom. While the European Commission commitments provide for the possibility of a new MNO, the model assumes that the number of operators remains fixed at three MNOs.

Quantifying benefits to wireless broadband

- The model assumes there are three national networks who each have an equal share of 700 MHz spectrum (2 x 10 MHz each).

- The model assumes that operators will continue to make spectrum efficiencies in line with future LTE and HSPA releases. We have not specifically factored in the impact of a structural change in efficiency related to the introduction of new generations of mobile technologies such as 5G or 6G.

4.16 Further assumptions on the mobile benefits model are set out in Annex 3.

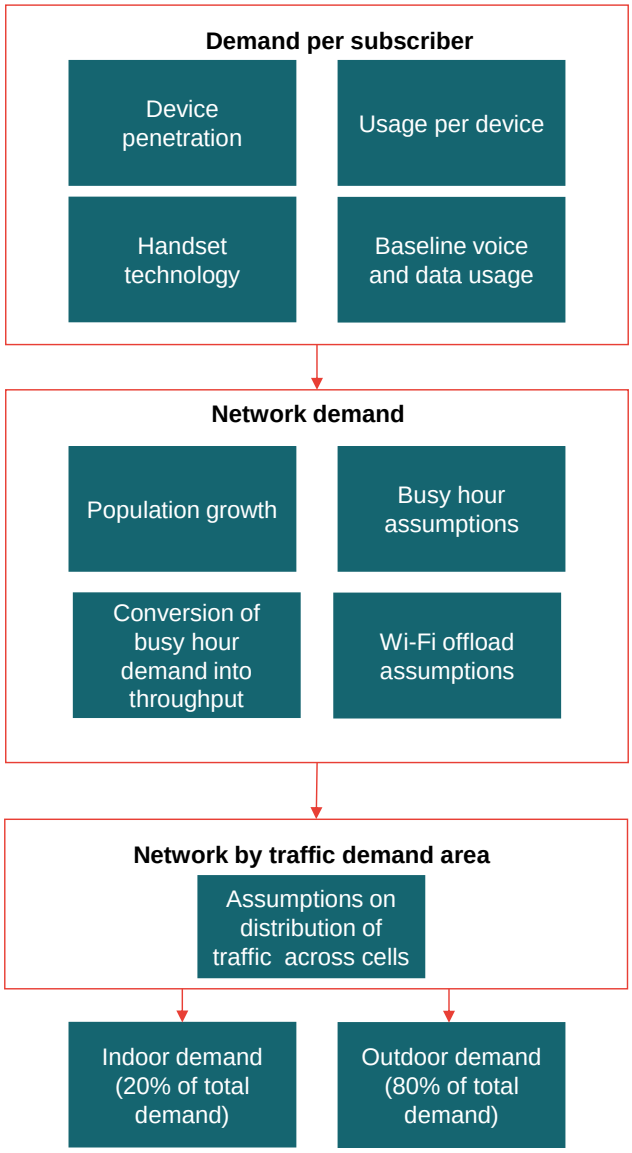
Time period used

4.17 The model assesses the costs and benefits until 2035. The costs are presented on a Net Present Value (NPV) basis using a 2014 base, with 2015 prices.

Demand

4.18 The approach to modelling demand is set out in **Figure 6** below. The model estimates current mobile use, and projects this forward based on the projections of population growth and growth in mobile data and voice demand outlined in section 3.

Figure 6. Demand module



4.19 The model estimates demand for a hypothetical operator in Ireland, assuming there are currently three operators, each with symmetric spectrum holdings and market shares. We make assumptions on the roll out of consumer handset technologies.

4.20 The model assumes that a proportion of demand can only be met using sub 1GHz spectrum. This is related to the propagation characteristics of sub 1GHz spectrum which means that it is used to provide high quality indoor coverage (since it is more able to penetrate objects than higher frequency spectrum); and it

has a larger geographic coverage since for a given power it can reach further and provide coverage at the edge of cells.

Mobile radio access network capacity

4.21 The approach to modelling network capacity is described below. Network capacity is separately modelled for sub-1 GHz spectrum and for higher frequency spectrum. This is because the model estimates the demand for "indoor" demand (which can only be met with sub-1GHz spectrum) and "outdoor" demand which can be met with any spectrum band.

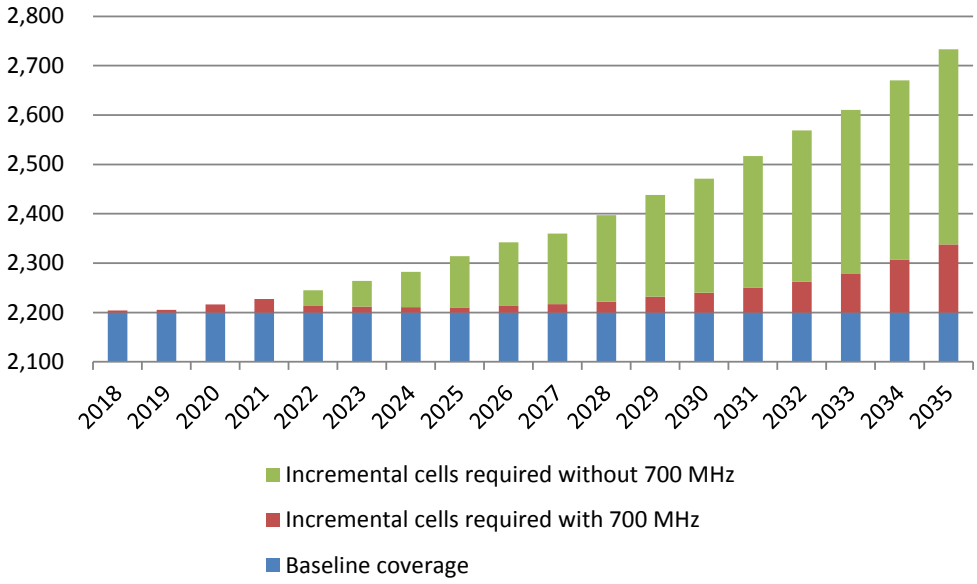
4.22 In order to model the capacity of the network the model separately estimates the capacity in each traffic demand area for each technology. As the model assumes that traffic demand is unevenly distributed across different cells this means that a small number of "heavily utilised" cells carry a disproportionate amount of mobile traffic.

4.23 For each traffic demand area, the model then considers the additional number of base stations that that would be required to provide sufficient capacity to meet demand without using 700 MHz spectrum (i.e. the additional network infrastructure that would be needed in place of using 700 MHz spectrum to meet demand).

4.24 Finally for each traffic demand area, the model estimates the number of mobile networks cell sites that would not be required if operators were able to use instead 700 MHz spectrum. The difference in costs between the two modelled radio access networks (with and without 700 MHz spectrum) represents the network cost savings benefit with incremental 700 MHz spectrum.

4.25 **Figure 7**, below shows the number of base stations required to meet demand assuming the mid case demand.

Figure 7. Number of sites required – mid demand scenario, 2018 repurposing



Results of the modelling

4.26 The estimated network cost savings that would accrue to an operator over this period as a result of them requiring fewer base stations are as set out in **Table 4** below. These represent the network cost savings that a hypothetical operator would achieve up to 2035 by utilising incremental 2 x 10 MHz of 700 MHz spectrum. The cost savings are multiplied by three to estimate the total economic benefit.

4.27 We assume that the 700 MHz spectrum is put to use.

4.28 The costs of repurposing the mobile Radio Access Network in the model to enable 700 MHz spectrum are significant at about €7.5k per base station which reflect the costs of an incremental 700 MHz carrier.

Quantifying benefits to wireless broadband

Table 4. Estimated NPV network cost savings as a result of 700 MHz spectrum (€m)

	Medium (base case)	Low	High
2018 (base case)	**89**	**50**	**150**
Early repurpose (2017)	89	50	151
Late repurpose (2022)	87	49	144

Source: Frontier Economics - 2015 prices

4.29 Our modelling shows that there is a significant positive NPV benefit as a result of the repurposing of spectrum in all demand scenarios regardless of the repurposing date. It also shows that earlier repurposing dates lead to higher benefits as a proportion of cells are already highly utilised and 700 MHz spectrum can be used in these cells to meet growing demand.

Other Benefits

4.30 This analysis does not attempt to quantify a number of other benefits that are likely to result from a repurposing of the 700 MHz band as these are more difficult to quantify to a high degree of confidence. Such unquantified, yet likely and possibly significant, benefits include:

- The use of the 700 MHz centre gap, which consists of 25 MHz of spectrum. This could be used for services such as SDL, PMSE, PPDR and M2M services.

- The consumer welfare implications of greater demand for mobile services if the network cost savings lead to lower prices. In competitive markets, we would expect that network cost savings would partly be passed on to consumers in the form of improved and/or lower cost services, and that if this occurred these benefits would increase demand and, in so doing, increase consumer welfare.

- The consumer welfare benefits that might accrue as demand for mobile services, applications, and devices is stimulated by greater network capacity. Our model has treated demand as an exogenous variable, whereas in fact demand for mobile services (and devices) is partly driven by the supply of network services. Increased network capacity will drive demand for more data intensive applications, and technologically advanced devices, which

benefit from the use of the network capacity.Other indirect benefits for the wider Irish economy and society relating to the impact that increased mobile connectivity can have on economic productivity, employment, competitiveness and economic growth. To the extent that the analysis finds that that incremental 700 MHz spectrum could improve the performance of networks, then these wider indirect benefits are also likely to occur.

Modelling the impact of increases in network performance

4.31 This section considers the scope to use 700 MHz spectrum to increase network performance for the benefit of consumers. Increased network performance would be likely to have a number of tangible benefits to consumers with faster network performance being likely to be valued more highly by consumers.

4.32 The 700 MHz spectrum could be used to increase network performance in two different ways.

- First, it may enable larger blocks of contiguous sub-1GHz spectrum which could be used to significantly increase performance.
- Second, operators could increase performance in parts of their networks by increasing capacity, and thereby reducing utilisation.

Larger block of contiguous sub-1 GHz spectrum to increase performance

4.33 LTE enables operators to take advantage of significant enhanced network performance capabilities across their network where operators can utilise larger blocks of contiguous sub-1 GHz spectrum.

4.34 For example as illustrated in **Figure 8** if an operator were able to use 20 MHz of contiguous sub-1 GHz spectrum to provide LTE services:

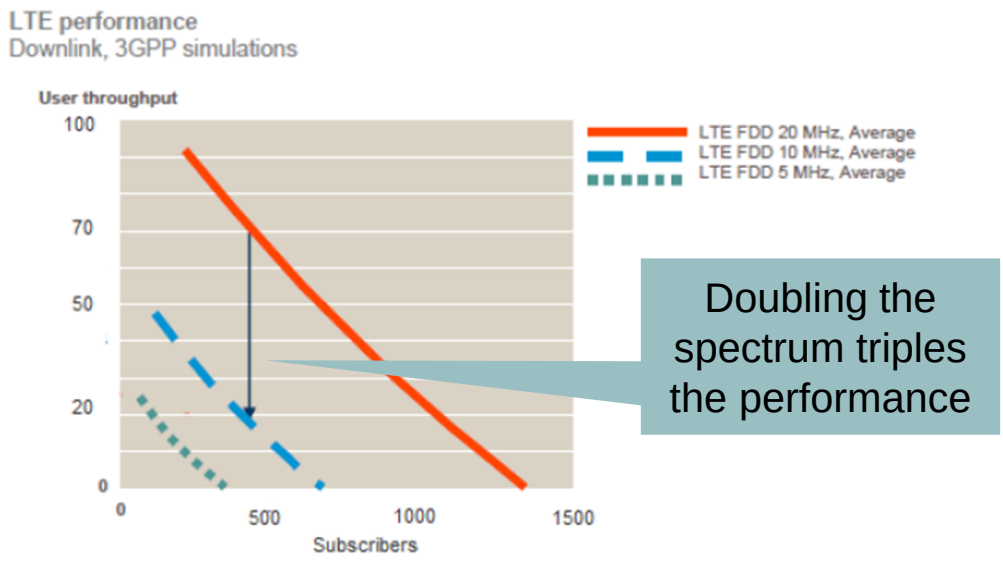
- it could **triple the current performance** offered by a 10 MHz block of LTE services; or
- it could provide **approximately 3.5 times the capacity** (as a result of doubling the spectrum).

4.35 It would not incur the incremental equipment costs associated with using an additional spectrum band, since the existing radio transmitter equipment could be used (though there may be an increase in licence fees as a result of using more spectrum with the equipment).

4.36 The increase performance of using larger blocks of spectrum to deliver LTE services is illustrated in **Figure 8** which shows how LTE performance in a given cell increases as the amount of spectrum used increases.

Quantifying benefits to wireless broadband

Figure 8. Simulated LTE performance



Source: Ericsson submission to MED Digital Dividend Discussion paper, MED Spectrum Reallocation in the 700 MHz digital dividend band in New Zealand

4.37 With the current assignments of the 800 MHz and 900 MHz bands and the existing use of these bands for 2G, 3G and 4G services, operators have limited scope to trade spectrum in order to create a contiguous block of 20 MHz of sub 1 GHz spectrum for LTE.

4.38 The provision of incremental 700 MHz spectrum increases the scope for operators to trade spectrum to increase their holdings of *contiguous* sub-1GHz spectrum, and take advantages of the benefits outlined in **Figure 8**. This is because the release of the 700 MHz band could result in an additional 30 MHz of sub-1 GHz spectrum.

4.39 Given the uncertainty in how or when such an outcome could be achieved this analysis does not directly model the value of such performance enhancements.

Increasing performance by investing to lower utilisation

4.40 A further source of potential performance enhancement could arise if operators chose to increase performance in their networks, by increasing capacity in cells where utilisation[32] is high.

4.41 As set out above demand is not evenly distributed across a network's cell sites. Typically a small number of sites carry a disproportionately large amount of traffic.

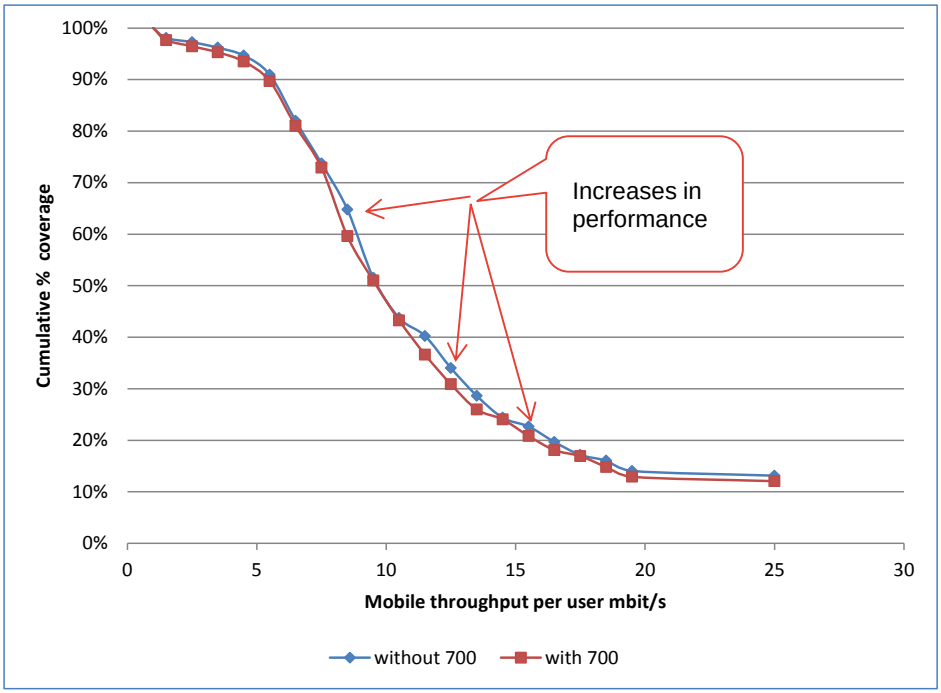
32 Cell "utilisation" can be defined as the proportion of available capacity that is used.

4.42 In congested and heavily loaded cells the performance available to consumers, measured by throughput, is diminished compared with uncongested cells. The prime reason for a reduced throughput is the fact that the number of Resource Blocks[33] available for allocation will decrease when there are more concurrent users. A secondary reason is that there can be a higher interference load when the neighbouring cells are also heavily loaded. This can result in users having to use a lower order modulation (fewer bits per symbol) within the still available Resource Blocks and a lower user throughput. These two effects, fewer Resource Blocks in combination with a reduced throughput per Resource Block due to spectrum loading/interference, together decrease the performance.

4.43 In its recent statement on the costs and benefits of repurposing 700 MHz spectrum Ofcom estimated the potential for incremental 700 MHz spectrum to be used to reduce cell utilisation, and thereby improve performance at peak times when cells were congested. This is illustrated in **Figure 9** below which compares the average performance achieved on the network to meet a given demand with and without 700 MHz spectrum. By choosing to use incremental 2x10 MHz of 700 MHz spectrum to reduce utilisation, instead of increasing capacity, Ofcom's modelling showed that average network performance was enhanced to a degree. From analysis of Ofcom's modelling we estimate that the throughput achievable (at peak times) for users on average increases by up to 3%, though certain groups of users will receive higher performance increases.

33 "Resource block" defines a discrete amount of network capacity that can allocated to a user at a given point in time.

Figure 9. Increase in performance as a result of increasing capacity



Source: Analysys Mason (2014) Figure 5.2

4.44 If an operator chose to increase capacity in its network to realise these identifiable performance enhancements, it could do so by either increasing the amount of spectrum, or by building more network equipment. The use of 700 MHz spectrum, may enable operators to increase capacity in this way, at lower cost.

4.45 In practice, the decision of whether operators would choose to increase network capacity in this way to improve performance will depend on the degree to which they believe it would be profitable to do so.

4.46 This in turn would depend on two factors:

- First, the **degree to which consumers value the performance enhancements.** The benefits to the operator of increasing performance could manifest themselves in a number of ways: lower customer acquisition costs, increased ARPU, lower churn. We have not determined the value that consumers place on being able to access a network with improved performance characteristics as described in **Figure 9**. The value that consumer's place on incremental service will be depend on consumer's sensitivity to perceived improvements in performance at peak times. The extent to which consumers can perceive the improvement as described in **Figure 9**, and in turn place a value on such a performance enhancement,

will affect the likelihood that operators will choose to invest in the necessary network capacity in order to realise the performance benefits.

- Second, it will depend on the costs of increasing capacity, in order to reduce utilisation.

4.47 In its assessment Ofcom notes that one way to measure the potential benefit of enhanced performance that could be enabled by using 700 MHz spectrum to increase capacity, is to assess the avoided costs of using 700 MHz spectrum to increase capacity in order to increase the performance of the network ("avoided costs of performance enhancement").

4.48 Ofcom notes that such an estimate may either underestimate or overestimate the potential benefit. If users place a value on the increased network performance (described in **Figure 9**) which is greater than the costs avoided in enabling the increases, then the avoided cost approach could underestimate the value of increased performance. Whereas if user value of the incremental performance benefits were less than avoided costs, then this approach would overestimate the performance value of 700 MHz spectrum.

4.49 Ofcom considered that the balance of risks was evenly balanced such that the investment costs of increasing capacity was equally likely to be greater of less than the value of the performance savings as set out in **Figure 9**.

4.50 As shown in **Table 5** we estimate in the base case that the economic benefits to the MNOs would be of the order of €15 million, in terms of the cost savings from using 700 MHz spectrum resulting in increased network performance. That is, if the MNOs were to seek to replicate these cost saving benefits by other means, it would cost circa €15 million to do so.

Table 5. Implied cost avoided assuming lower utilisation and higher performance (€m)

	Base case	low demand	high demand
Cost savings related to network capacity at current levels of performance	89	50	150
Cost savings related to network capacity with lower utilisation / higher performance	104	60	165
Incremental cost savings with lower utilisation / higher performance	**14.5**	**11**	**14.9**

Source: Frontier Economics

Relevance to any future 700 MHz award

4.51 Our model has considered the costs of rolling out cell sites in order to replicate the benefits of added capacity and performance from repurposing the 700 MHz band. It should be noted that while operators may take similar considerations into mind when valuing the 700 MHz band for the purpose of an award process, there are a number of differences as to why the value obtained in an award could be different.

4.52 Firstly, this model assumes that there are three identical hypothetical operators. In reality, the three operators currently operating in Ireland have a different network configurations and unit input costs. Each of the three operators has different customer and usage profiles with different user expectations therefore the demand for spectrum will vary across operators.

4.53 Secondly, the commercial plans of operators will also vary and each is likely to have different views on how the market will develop. As described below certain operators may also place an additional value on the 700 MHz in terms of the enhanced services it can provide to customers who value additional performance and have a willingness to pay for such services.

Finally, should the 700 MHz band be included in an award process with other additional bands, the extent to which any such spectrum is substitutable or complimentary will ultimately have an impact on the final valuation of the 700 MHz band.

5 Costs to DTT of a 700 MHz repurposing

5.1 This section considers the impact of a 700 MHz spectrum repurposing on DTT. It considers the impacts (economic, social, and cultural) of DTT migrating out of the 700 MHz band on providers and TV viewers generally, including users of RTÉ's DTT service. In doing so it is necessary to consider the market context of DTT services in Ireland, and its role in supporting certain policy objectives.

5.2 The section:

- provides a descriptive overview of the TV market including DTT in Ireland;
- presents the methodology used to assess the costs of a change in use of the platform;
- assesses the impact of a change in use of DTT spectrum comprising:
  - costs to DTT providers (2rn);
  - costs to consumers (e.g. costs of retuning or aerial costs);
  - costs of information campaigns to inform consumers; and
- considers the impact of a change in use of DTT spectrum the ability of DTT to meet wider public policy goals.

Overview of the Irish TV services including DTT

5.3 In Ireland TV services are provided via a number of platforms including Irish Free to Air ('FTA') platforms (Saorview and Saorsat), the pay TV platforms (Sky's satellite, UPC's cable and emerging IPTV services) and the UK FTA platforms (FreeSat and Freeview). Almost 99% of households have a TV (amounting to 1,583,000) in January 2015.[34] In January 2015,

- 38% of TV homes received an Irish DTT service (i.e. Saorview and Saorsat), although Irish terrestrial DTT-only homes represented 10% of all TV homes; and
- cable/satellite platforms were present in 83% of households.

5.4 There are a number of Irish TV services which are carried on the Irish FTA and the pay TV platforms.

[34] Nielsen TV Audience Measurement (TAM) Establishment Survey.

- RTÉ, Ireland's national television and radio broadcaster, owns and controls the national Public Service Broadcasting free-to-air television and radio networks. On Saorview it offers **RTÉ One (HD), RTÉ Two (HD), RTÉ One+1, RTÉ News Now**, and **RTÉ junior**. RTÉ's TV services are also available on the pay TV platforms.
- **TV3:** The channel was launched in 1998 as Ireland's first commercial broadcaster. It has been available on Saorview since 29 October 2010, and is also available on the pay TV platforms.
- **TG4:** A Gaelic language public service broadcaster. The channel was launched on 31 October 1996. It has been available on Saorview since 29 October 2010,, and is also available on the pay TV platforms .
- **3e:** A free-to-air general entertainment channel operated by the TV3 Group in Ireland, who operates TV3 and its sister channel 3e. 3e was launched January 5, 2009. It has been available on Saorview since 29 October 2010 and is also available on the pay TV platforms.
- **UTV Ireland:** A general entertainment channel in Ireland that is owned and operated by UTV Media's subsidiary UTV Ireland Ltd. The channel has been available on Saorview since 1 January 2015, and it is also available on the pay TV platforms

5.5 The section below describes the various TV platforms.

Irish FTA TV platforms

DTT (Saorview)

5.6 The DTT service is provided without subscription by Saorview, the national free-to-air network. It was introduced in 2010, fully replacing the analogue network in 2012 and covers 98% of the population. An outline of the legal and legislative background to the DTT platform is set out in Annex 3.

5.7 The DTT transmission network is provided and operated by 2rn, which is wholly owned by RTÉ. RTÉ provides multiplexing services to programme services wishing to broadcast on DTT. Saorview is the public brand of the DTT service in Ireland and is also owned by RTÉ.

5.8 The DTT network was built at the cost of about €60m and it operates exclusively in the UHF band, from 470-790 MHz. The current DTT spectrum plan for the UHF band provides for 9 DTT multiplexes, thus it is possible to accommodate the six DTT multiplexes as required by legislation within the UHF DTT spectrum plan, together with other services ancillary broadcasting. Due to its higher spectrum efficiency, Saorview was able to provide more programme services than the analogue terrestrial TV network. Indeed, a single DTT multiplex used the same amount of spectrum as each analogue TV channel but

Costs to DTT of a 700 MHz repurposing

could carry the equivalent of 8-10 SD TV programme services or 3-4 HD TV programme services.

5.9 Saorview currently operates two DTT multiplexes. Initially only one multiplex was available for the service. The second public service multiplex ("mux") was launched with the introduction of RTÉ One HD on 16 December 2013. The service now offers a number of programme services, such as RTÉ One HD, RTÉ Two HD, TV3, TG4, RTÉjr, RTÉ One+1, RTÉ News Now, 3e, UTV Ireland as well as a digital teletext service and the national RTÉ radio programme services. Saorview is the only TV platform in Ireland which exclusively transmits Irish channels.

5.10 2rn expects the demand for DTT from broadcasters to continue to increase up until at least 2030[35] and, assumes that Ireland will need at least three national multiplexes (muxes) within the medium term. There is potential for other services to come onto the platform and HD services may be launched by TG4 and TV3.[36]

5.11 RTÉ's 5 year plan includes the development of an on-demand service using Saorview and broadband service providers[37]. The current name of the service is Saorview Anywhere. This would provide access to the RTÉ Player and a number of new IPTV services that RTÉ may launch with suitable commercial providers. The new "anywhere" service may also include both TG4's and TV3's on demand services.

Saorsat

5.12 In 2012, 2rn established a digital satellite service called Saorsat for those households unable to receive Saorview – about 2% of households. This service offers RTÉ and TG4 services only. Saorsat broadcasts a spot beam from KA-SAT focused on Ireland, preventing overspill content rights issues for RTÉ in the UK. The digital satellite service is the primary means of viewing in less than 5,000 households.

Irish pay TV providers

5.13 Pay TV penetration in Ireland is the second highest in Europe after France, with 70% of households subscribing to such services, predominantly either to digital satellite services provided by BSkyB Ireland, or digital cable services from UPC, although eircom also offers a pay TV service in conjunction with its broadband

[35] http://www.comreg.ie/_fileupload/publications/ComReg1413s.pdf

[36] O&O Advisory (2013), "Prospects for commercial digital terrestrial television in the Republic of Ireland".

[37] http://static.rasset.ie/documents/about/rte-strategic-plan-full-redacted-version.pdf

service. BSkyB, UPC and eircom provide "triple-play" bundles (combinations of TV, phone and broadband).

UK services affect the Irish TV market

5.14 Given its proximity to the large UK market, the shared language and similar cultural interests, a proportion of viewing in Ireland is to UK programme services. UK programme services are able to leverage relatively high content budgets (which reflect the much larger home market) which can be used to supply programming to Ireland.

5.15 The presence of imported UK programme services inevitably affects the popularity and profitability of Irish programming and programme services.

5.16 UK services are available in the Irish TV market through both the pay TV and UK based free-to-air platforms (i.e. Freeview or Freesat).

UK channels on pay platforms

5.17 BSkyB Ireland, UPC and the emerging IPTV platforms (e.g. eVision from eircom) provide access to UK-licensed channels through their pay TV platforms. These channels include the UK PSBs and their spin-off programme services, basic free TV channels and pay channels. The BSkyB platform distributes these programme services throughout the whole island, while the coverage of the other pay TV platforms varies.

5.18 Moreover, Sky and UPC offer the possibility of inserting an alternate Irish advertising stream into those programme services transmitted on their platform targeted to the Irish market.

Channels on UK based FTA platforms

5.19 Irish viewers who live near the UK border or in some parts of the east coast are able to receive UK TV programme services due to the UK DTT (Freeview) signal "overspill" from Northern Ireland or the west coast of Wales and Scotland. In addition, Irish viewers can receive UK TV programme services via the UK FTA satellite platform (Freesat) which provides coverage across the whole of the island.

5.20 Some Irish TV programme services are also broadcast on the UK DTT (Freeview) in Northern Ireland. On 29 May 2012 the UK Government confirmed that TV viewers in Northern Ireland will be able to watch TG4 and RTÉ One and Two on Freeview from Northern Ireland-based transmitters following digital TV switchover. This means that some customers in Ireland can access Irish content by taking a UK DTT service.

Costs to DTT of a 700 MHz repurposing

Public policy objectives related to TV

5.21 There are a number of public policy objectives which relate to TV and the Irish DTT platform plays an important role.

- **Universal coverage**. The DTT platform ensures that public service broadcasting programme services (PSBs) are made universally[38] available throughout Ireland, without any subscription charge. The existence of a free-to-air multi-channel platform drives social inclusion by ensuring that all citizens have access to a range of television and radio services at minimal cost.

- **Plurality and diversity of Irish content and Gaelic language content**[39]. The DTT platform enables public service content to be supplied universally throughout Ireland. In this way, it helps secure plurality of provision of Irish content in the wider broadcasting market, especially relevant for news[40].

- **Promotion of competition with other TV platforms.** DTT plays an important role in helping secure plurality of TV platform ownership. Platform operators, through their control of vital distribution channels, have an opportunity to influence the range and content of the services they distribute.

Assessing the impact of spectrum change of use

5.22 We now consider the impact of change in use of spectrum from the perspective of DTT mux operators, consumers of DTT services and broadcasters.

Methodology

5.23 In order to assess the costs for all stakeholders that are faced by repurposing spectrum we compare the costs incurred in the factual (spectrum would be repurposed for mobile use between 2017 and 2022) and counterfactual (spectrum would not be repurposed to mobile).

5.24 The difference between the costs incurred in the factual and the counterfactual represents the costs of spectrum repurposing. This is because the difference captures the costs that would not be incurred in the absence of repurposing.

5.25 We consider costs faced by providers and consumers of TV services.

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[38] Section 130 (1)(b)(i)(II) of the Broadcasting Act 2009.

[39] Section 130 (1)(a)(ii) of the Broadcasting Act 2009.

[40] Section 114 (3)(a)(b) of the Broadcasting Act 2009.

Costs to DTT mux operators

5.26 For DTT mux operators, a change in use of spectrum would lead to it incurring costs of replacing equipment, retuning, or commissioning new sites or decommissioning existing sites.

5.27 We assume that the costs associated with a change in use are primarily the costs of early replacement. If the 700 MHz band were no longer available then some of operators' equipment would have to be replaced. Had a change in use of spectrum not taken place, this equipment would be replaced when it reached the end of its asset life. Bringing this investment forward represents an economic cost to DTT operators.

Impact on consumers

5.28 Consumers will also face costs if migration means they will have to replace the TV equipment in their homes. We estimate the number of consumers that would be affected as well as the time and cost they will incur as part of the replacement. These costs are only incurred in the event of repurposing, i.e. in the factual, and not in the counterfactual.

5.29 The impact of repurposing 700 MHz spectrum on consumers may have a knock-on effect on the future demand for DTT.

Impact on the DTT platform and wider DTT costs

5.30 If consumers churn from the platform as a result of the spectrum repurposing it could affect the popularity of the platform for consumers and broadcasters and the spectrum repurposing could lead to cultural or social costs.

5.31 We now consider each of these costs in turn.

Impact on the DTT platform and costs to DTT mux operators

5.32 700 MHz spectrum is currently used by the DTT Mux operator (2rn) to provide DTT programme services as part of Saorview. We have considered the costs that 2rn would incur as a result of a change in use of the 700 MHz spectrum.

Approach to estimating the costs to DTT mux operators of spectrum repurposing

5.33 The costs to 2rn of the 700 MHz spectrum being repurposed are primarily the costs of early replacement of equipment which cannot be used to broadcast TV services in the UHF band below the 700 MHz band.

Costs to DTT of a 700 MHz repurposing

5.34 These costs are estimated by subtracting the NPV of the costs that would be incurred in the factual (if the 700 MHz band is repurposed) from the NPV of estimated costs in the counterfactual (if the repurposing did not take place).

5.35 Replacement costs have been annualised over the average asset life of DTT equipment (13 years) using a straight line annuity formula. This enables a comparison of the profile of costs under the factual and the counterfactual.

Key assumptions

5.36 In order to estimate the costs that would be incurred by 2rn if 700 MHz spectrum were repurposed we gathered data from 2rn. 2rn provided a high-level, site-by-site description of the costs it anticipates in the event of repurposing. The estimate of costs makes a number of assumptions. These are:

- **The proportion of equipment that needs to be replaced**. 2rn's central assumption was that not all equipment would need to be replaced when 700 MHz spectrum is repurposed. Equipment which does not need to be replaced would be replaced at the end of its useful life.

- **The asset life of existing equipment.** 2rn estimated the existing asset life of its equipment.

- **The number of muxes in operation when the spectrum is repurposed**. In line with 2rn's plans the cost estimates assume three operational muxes, although only two muxes are currently operational.

- **Opex**. The above plans also included an estimate of the operating expenditure (opex) that would be incurred alongside the capital expenditure of replacing assets. The opex included a 10% cost for project management, network engineering, frequency planning, site surveying, coverage surveying etc, and a one-off cost of €650,000 associated with simulcast that would be incurred in the year of repurposing.

- **The WACC is used to discount this stream of costs and obtain the NPV**. The WACC used for the analysis is ComReg's estimate of the WACC in current broadcasting markets A and B (8.11% pre-tax nominal WACC)[41]

- **Value of decommissioned equipment.** We assume that the equipment that is made redundant due to 700 MHz being repurposed has no resale

[41] The cost modelling uses the proposed pre-tax, real WACC for RTÉ as per the "Review of Cost of Capital", ComReg, 18 December 2014. Available at http://www.comreg.ie/_fileupload/publications/ComReg14136.pdf . All costs are assumed to be incurred at the end of each calendar year.

value and is completely written off. This is also assumed for all assets that are replaced in both the factual and the counterfactual.

5.37 More detailed assumptions are provided in Annex 1.

Results: Cost to DTT Mux Operator

5.38 Assuming that the spectrum is repurposed in 2018 the analysis described above estimates that 2rn would incur incremental costs amounting to €9.4m in 2015 prices (the assessment period runs to 2035).

5.39 The incremental costs that the DTT Mux operator 2rn would face were 700 MHz spectrum repurposed amounts to .

Sensitivity testing the results

5.40 The results of the modelling have been sensitivity tested by varying a number of the assumptions in the model.

Year of repurposing

5.41 The base case assumes that the spectrum will be repurposed in 2018. The modelling has assessed the impact of an earlier repurposing of spectrum between 2017 and 2022.

5.42 Earlier repurposing of 700 MHz spectrum increases the costs to DTT providers, since a greater proportion of equipment is required to be replaced early.

Costs to DTT of a 700 MHz repurposing

Table 6. Impact of different repurposing dates on the DTT Mux operators costs

	€m
2017	10.8
2018 (base)	9.4
2019	8.0
2020	6.7
2021	5.4
2022	4.3

Source: Frontier

Proportion of equipment that would need to be replaced

5.43 The base case model applies 2rn's best estimate of the proportion of equipment that it would replace. It assumes partial replacement of existing equipment at some sites.

5.44 This analysis has also sensitivity tested a "maximum cost" plan which would involve complete replacement of its existing equipment at each site. The model assumes that all equipment at all sites would have to be replaced at the time of repurposing.

Table 7. Impact of different 'proportion of equipment to be replaced' assumptions on the DTT Mux operators costs

	€m
Base – partial replacement	9.4
Assume full replacement	12.8

Source: Frontier

Remaining asset life of existing equipment

5.45 2rn's assessment of costs noted that there was some uncertainty over the remaining asset life of existing equipment. The lower the remaining asset life of 2rns' equipment, the lower the costs it would incur as a result of repurposing. This is because more of that equipment would be replaced in the counterfactual (where the 700 MHz band is not repurposed). Our analysis of 2rn's estimates has

also sensitivity tested the costs of repurposing 700 MHz band, assuming equipment is replaced in the "maximum replacement year" that is possible for each asset (rather than the 2rn's best estimate of the remaining asset life of its equipment as in the base case). This assumes that replacement costs for the equipment at each site are incurred in the year in which the last piece of existing equipment at that site reaches the end of its asset life[42] (i.e. it conservatively estimates remaining asset life).

Table 8. Impact of different 'asset life of existing assets' assumptions on the DTT Mux operators costs

	€m
Base – 2rn central estimate	9.4
Max possible asset life	15.9

Source: Frontier

Number of muxes

5.46 The base case estimates assume three operational muxes in line with 2rn's plans. As sensitivity, this model has assessed the impact of assuming 2rn only operates two muxes (2rn currently has two muxes in operation), and four muxes (we note that under both the factual and counterfactual scenarios the spectrum plan will provide for six muxes consistent with legislation).

[42] For instance, imagine there are 3 assets at a site- Assets A, B and C. If A and B are due for replacement in 2021 but C is only due for replacement in 2022, then we assume that all three assets will be replaced in 2022.

Table 9. Impact of different 'number of operational Muxes' assumptions on the DTT Mux operators costs

	€m
Base (three muxes)	9.4
Two muxes	7.4
Four muxes	11.3

Source: Frontier

Impact on DTT consumers

5.47 There were 607,000 Saorview households in January 2015 of which 164,000 were Irish DTT-only (i.e. Saorview or Saorsat) homes. Repurposing the 700 MHz band might lead to costs for consumers and this could affect the future demand for DTT services.

Potential DTT consumer costs from spectrum repurposing

5.48 Irish households could bear costs as a result of a repurposing of 700 MHz spectrum including:

- replacement of aerials;
- retuning set top boxes;
- other costs such as the installation of filters.

5.49 We go through them more in detail, providing an estimate for each of them.

Costs from replacing aerials

5.50 As 700 MHz spectrum repurposing involves a change in the frequencies used by DTT[43] a small proportion of DTT households may need to replace their aerials.

5.51 Most of the aerials sold today are "wideband aerials" and 2rn estimates that wideband aerials and group A aerials are used by an estimated 48% of Irish households[44]. As wideband aerials can receive signals transmitted at any frequency in the UHF band, the 700 MHz spectrum migration would mean that households with these aerials would not need to replace them. For group A

43 Spectrum across DTT channels 21 to 59 is currently used by Saorview. A 700 MHz repurposing would require Saorview to be provided with spectrum within DTT channels 21 to 48.

44 Source: 2rn estimate of A and W aerials, though there is some uncertainty in this estimate.

aerials the optimal range the is outside of the 700 MHz band and we assume that all group A DTT transmission sites remain in group A.

5.52 However, "grouped aerials" are only able to receive signals transmitted on a subset of frequencies within the UHF band (e.g. Group B and Group C/D aerials[45]). With the spectrum repurposing, these aerials may not receive the full range of DTT services anymore.

5.53 2rn estimates that around half of aerials are Group B and Group C/D aerials and it estimates that 15% of these aerials (i.e. 7.5% of all aerials nationally) would need replacing. However, this estimate may be regarded as a "high" estimate. This is because in most cases, provided the grouped aerial has been installed well, the impact is only likely to affect a very small proportion of aerials at the edges of the coverage area as opposed to the full coverage area. This is because most grouped aerials, and in particular aerial groups B and C/D, still can receive frequencies outside their group although at a reduced antenna gain, and relatively minor changes in the position of the set top box can mitigate the impact for indoor aerials.

5.54 We note that in Ofcom's Consultation on future use of the 700 MHz band[46] that in the UK a similar proportion (43%) of aerials were non-wideband or grouped aerials. Ofcom considered that approximately between 80,000 and 90,000 aerials may need replacing out of a total universe of approximately 20m households that are forecast to access DTT on either a primary or secondary set in 2022. This approximates to about 0.5% of UK DTT households.

5.55 Noting that the 700 MHz repurposing is only likely to affect consumers with B and C/D aerial groups who are at the edge of the DTT coverage area, we assume in our central scenario that 1% of Group B and Group C/D aerials (i.e. 0.5 % of all aerials nationally) would need replacing. We note that this appears to be a realistic estimate and is consistent with the assumptions used in a similar assessment by Ofcom of aerials in the UK.

5.56 Assuming that it will cost around 3,700 households €250[47] each to replace and install an aerial in 2018, this would imply a net present value cost of **€0.68m in 2015 prices**.

5.57 The costs vary depending on the assumptions used:

- If the cost of the cost of replacing the aerial was €150 the cost would be **€0.41m**

45 The optimal operating range of each grouped aerial is DTT Channels 21-37 (Group A), DTT Channels35-53 (Group B) and DTT Channels48-68 (Group C/D).

46 Ofcom (2014) Consultation on future use of the 700 MHz band

47 Source: 2rn.

- If the repurposing occurred in 2017 the costs would be **€0.68m** or if the repurposing occurred in 2018 the costs would be **€0.68m**
- If the percentage of grouped aerials that needed replacing was 5%, then the costs would be **€3.4m**

Costs of retuning

5.58 DTT set top boxes and televisions are tuned in order to receive signals coming from specific frequencies. Those frequencies are likely to change with the spectrum re-plan and viewers in those areas would need to retune their set top boxes in order to watch DTT programme services.

5.59 Consumers will not incur any tangible costs in performing the retune. However, we have estimated the cost of the time spent conducting a retune. Retuning allows households to retain access to all channels after changes in the line-up of DTT multiplexes. We assume that in Ireland on average each DTT household would need to spend five minutes to retune. This is done by using the remote control and following the relevant menu on the TV. We have estimated the opportunity cost of the time spent retuning.

5.60 This is based on an estimate of the value of non-commuting leisure time that viewers would spend doing other activities instead of retuning. Based on this, we calculate that the time lost in retuning would result in a NPV cost of around **£0.45m in 2015 prices**[48].

Other potential costs

5.61 We note that there may be other costs incurred as a result of the repurposing of spectrum. This is related to the potential for filters to protect viewer reception from interference from mobile use in the 700 MHz band or from Public Protection and Disaster Relief (PPDR) directly above or below the 470 to 694MHz band. We understand that filters which attach to a set top box are approximately €20 each.

5.62 It is difficult to estimate the number of filters that may be required. However, we note that the number of filters that have been required to protect viewers from mobile use in the 800 MHz is low. We have therefore not directly quantified the costs of filters which we consider are likely to be low.

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48 This is based on the projected universe of DTT households (730k) having to spend 5 minutes per person having to retune, and a value of time of €8.48 per hour. Costs are discounted using an estimated social time preference rate of 3.5%.

Costs from public information campaigns

5.63 In order to inform households that they would need to retune their TV reception equipment it would be necessary to mount an information campaign. Typically, this would include advertising and direct help (for example via a phone line offering advice).

5.64 We have taken the costs that were incurred as a result of 2012 Digital Switch Over (DSO) as a benchmark to estimate the costs of a 700 MHz repurposing public information campaign.

5.65 There were two main providers of public information during the DSO. These were: DCENR and RTÉ. DCENR costs amounted to €2.7m which paid for an information campaign which included research, media, PR, information booklets, a helpline and website to increase awareness of digital switchover and the date for analogue switch off[49]. RTÉ's estimate of its costs were around €3.5m to €4m which included staff, creative production, RTÉ airtime, leaflets and point of sale material, co-promotions with retailers, the website and the call centre[50]. Therefore in total approximately between €6.2m and €6.7m was spent on public information at DSO.

5.66 However, we note that the 2012 DSO costs may overstate the costs of a public information campaign necessary as a result of the repurposing of 700 MHz spectrum. This is for the following reasons:

- Consumers had to incur costs as a result of DSO related to the purchase of new set top box equipment (this could include the direct costs of the set top box as well as inconvenience and shopping costs). Therefore consumers would require more information to inform them of the reasons why they might have to incur costs, and to persuade them of the benefits of incurring such costs. In contrast the majority of consumers will not incur any direct costs as a result of the repurposing of 700 MHz spectrum.
- The DSO process was more complex for consumers than a retune related to the repurposing of 700 MHz spectrum. At DSO, consumers had to change the technology used to receive DTT and therefore the communications message was complex. By contrast, the retune related to the repurposing of 700 MHz spectrum is much less complex. Consumers need only to manually retune their set top box which we estimate could take on average about five minutes while a small

49 Source: http://www.dcenr.gov.ie/NR/rdonlyres/5A7ACD96-7DD7-4B5A-B731-19460F3E24C5/0/DSOFinalreport.pdf

50 Source: RTÉ

percentage of DTT households (we estimate 0.5%) would need to replace their aerial.

- The DSO information costs in Ireland might be considered particularly high given the unusually short period of switchover in Ireland compared to other countries. The DCENR noted that *"Ireland's switchover period, from 26 May 2011 to 24 October 2012, was the shortest switchover period of any country in the European Union"*[51]. By contrast the UK launched DTT in 1998 and completed switchover in 2012, fourteen years later.

5.67 On the other hand, we recognise that in Ireland at DSO there was a motivating factor which encouraged consumers to buy a new set top box as this enabled them to access more channels including a HD channel and a time-shifted version of RTÉ One. In contrast, for the 700MHz repurposing viewers will not necessarily be incentivised into retuning by accessing more channels.

5.68 On balance, given the clear qualitative difference in the communications message at DSO compared with the 700 MHz repurposing, it is appropriate to down-weight the communications costs incurred as a result of DSO by at least a factor of three. While Irish consumers may not that accustomed to DTT retunes, they are straightforward, and free to implement and common in other jurisdictions.

5.69 Therefore we assume that the 700 MHz repurposing will require some communications costs totalling £2.15m in 2018. The present value of these costs is **£1.66m** assuming they are discounted with RTÉ's WACC.

Impact on demand for DTT

5.70 In this section we consider how the consumer costs will affect demand for the DTT platform. Consumer costs could cause consumers to churn from the DTT platform. This in turn could lead to cultural or social impact as a result of reduced viewer demand for DTT.

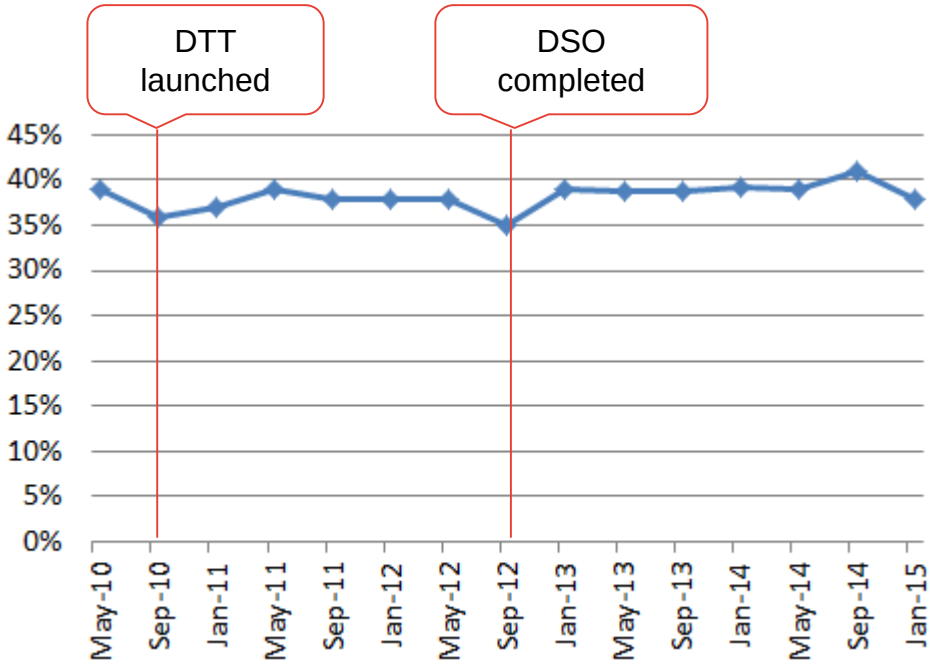
5.71 As set out in the preceding sections, with a 700 MHz repurposing the existing DTT services can be accommodated with no output changes to the DTT services being provided. However, consumers will have to retune their DTT set-top box and televisions and a small number of households (we estimate 0.5%) may incur the costs of a new household aerial. Some of these households may decide to churn from the platform rather than incur the costs of a new aerial.

5.72 We have examined the number of households that churned from the Irish terrestrial (i.e. analogue and digital) TV platform at DSO as a benchmark for the numbers of potential churners. If the costs incurred with DSO had led to a

51 http://www.dcenr.gov.ie/NR/rdonlyres/5A7ACD96-7DD7-4B5A-B731-19460F3E24C5/0/DSOFinalreport.pdf

significant and lasting fall in the number of households that use terrestrial TV services as they migrated to other TV platforms, then this might suggest that costs of aerial installation could lead to a similar effect. **Figure 10** shows the proportion of households that received their TV service via an aerial from May 2010 to January 2015. In fact what we observe is that at DSO there was a reduction in the proportion of households which used terrestrial TV services, but this was quickly reversed. The proportion of DSO households that use an aerial to receive their TV services is now slightly higher than that at DTT launch.

Figure 10. Percentage of households receiving terrestrial TV



Source: Nielsen.

5.73 Based on the assumption that 1% of group B and C/D aerials (i.e. 0.5% of all aerials nationally) need replacing, we assume that 5% of DTT-only homes who require new aerials and 10% of multi-platform homes who require new aerials would churn from the DTT platform[52]. Given the information on limited DTT churn following DSO, 10% churn is a conservative assumption. This would reduce the total number of DTT homes by less than 0.1% or around 551 households.

52 It is reasonable to assume that it is more likely for multi-platform homes to churn as they will already have access to alternative platforms.

5.74 We conclude that this level of churn is unlikely to have a material impact on the public policy objectives of the DTT platform. Therefore the social and cultural costs of the repurposing 700 MHz spectrum are negligible.

6 Costs to PMSE of a 700 MHz repurposing

6.1 PMSE services in the 700 MHz band relate to the provision of equipment to support broadcasting, news gathering, theatrical productions and special events such as concerts and sport events. ComReg issues temporary licences with a maximum length of six months for spectrum use for PMSE. These are generally issued for the duration of a specific event. There are a number of users of PMSE services in Ireland including some UK-based operators.

6.2 Spectrum used for PMSE services is used primarily for wireless microphones and in-ear monitoring systems. These transmit at low power (maximum ERP of typically 10-50 mW) with a channel spacing of 200 kHz.

6.3 In Ireland, PMSE is assigned on a secondary basis in the UHF band from a range of options. Channel 38 (606-614 MHz) is dedicated to PMSE use. Additionally, there is interleaved spectrum in bands between those assigned for DTT use. Finally, PMSE users could also use DTT channels that are currently unused.

Estimating the costs to PMSE users

6.4 To estimate the PMSE costs, we sent a survey to a number of the largest users of PMSE in Ireland (RTÉ, Mongey Communications, Autograph, TVM, TV3 and TG4).

6.5 As with the estimation of the costs to the DTT Mux operator, we consider two scenarios in order to estimate the costs to PMSE users should a repurposing of the 700 MHz band take place:

- **The factual-** Under this scenario, 700 MHz spectrum would be repurposed for mobile use between 2017 and 2022.
- **The counterfactual-** Under this scenario, 700 MHz spectrum would not be repurposed to mobile.

6.6 The difference between the costs incurred in the factual and the counterfactual represents the costs of spectrum repurposing to PMSE users. This is because the difference captures the costs that would not be incurred by those users in the absence of repurposing.

6.7 The costs to PMSE users of repurposing the 700 MHz band are primarily the costs of replacing equipment earlier than would otherwise be the case. If repurposing did not take place, then existing equipment that operates in the 700 MHz band would be replaced when it reaches the end of its useful life. Repurposing the band would require early replacement of this equipment.

6.8 There has been a decision at the EU level to implement a harmonised band of spectrum for PMSE services in the 823 to 832 MHz and 1785 to 1805 MHz bands.[53] It is therefore possible that PMSE users in Ireland would replace or retuned existing equipment to operate in these bands, even if the 700 MHz band is not repurposed. This would imply that the same replacement costs would be incurred in both the factual and the counterfactual, because even the counterfactual would require early replacement. In this assessment, however, it is conservatively assumed that there is no early replacement in the counterfactual.

6.9 The costs to PMSE users include capital expenditure on replacing assets that have useful lives of different length. Consequently, the costs are incurred at different points in time, and these are annualised over the lifetime of the asset using a straight-line annuity formula. The net present value of the costs is calculated using the discounted cash flow method.

6.10 To estimate the present value, an appropriate discount rate is needed. For PMSE operators, we have used a Weighted Average Cost of Capital (WACC) because it would represent the opportunity cost for the expenditure they will incur in the process of repurposing.

Implications of 700 MHz repurposing in the UK and elsewhere

6.11 Some of the users of PMSE in Ireland such as Autograph primarily operate out of the UK. Given the expected repurposing of 700 MHz in the UK, these users would incur costs associated with repurposing in the UK. The incremental costs of replacing equipment in Ireland may therefore be lower for these users.

6.12 In a similar manner, touring companies that come to Ireland from elsewhere have their own equipment and this may or may not have to be replaced due to the 700 MHz repurposing processes adopted elsewhere. The incremental costs of replacing equipment in Ireland may therefore also be lower for these users.

Implications of the quantity of UHF spectrum available for PMSE

6.13 At the moment, in the UHF band PMSE users can use either interleaved spectrum, unused DTT spectrum or channel 38 dedicated to PMSE use on a secondary basis.

6.14 While this is sufficient spectrum for current PMSE use, this may no longer be the case if DTT demand for spectrum increases. We have considered the costs if only 30 MHz of the remaining UHF band will be assigned to PMSE.

6.15 For PMSE users that currently use analogue equipment that operates in the 700 MHz band, 30 MHz is unlikely to be sufficient to carry on operations. In this

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53 See "Commission Implementing Decision 2014/641/EU of 01/09/2014 on spectrum use by wireless audio PMSE", 28 August 2014. Available at http://ec.europa.eu/digital-agenda/en/news/commission-implementing-decision-01092014-spectrum-use-wireless-audio-pmse

Costs to PMSE of a 700 MHz repurposing

case, these PMSE users may have to adopt digital equipment in order to use the assigned spectrum more efficiently.

6.16 Currently we are aware of only Mongey Communications that has made the switch to digital.

6.17 RTÉ has provided its estimate for the costs of replacing its analogue equipment with digital. Given that RTÉ is one of the biggest user of PMSE equipment in the UHF band in Ireland, its costs of replacement would likely represent a large percentage of the replacement costs for the industry.

Modelling the cost of 700 MHz repurposing to PMSE

6.18 This section provides more details on the data received from PMSE users, the assumptions made as part of estimating the costs in the event of repurposing as well as the results from of this analysis.

Data received from PMSE users

6.19 From a survey of some of the largest users of PMSE in Ireland (RTÉ, Mongey Communications, Autograph, TVM, TV3 and TG4), we received, at the time of writing this report, responses from four operators.

6.20 To estimate the costs that would be incurred in the factual and the counterfactual, we requested information on:

- The estimated costs of retuning/replacement of equipment if 700 MHz spectrum is repurposed
- The estimated costs of replacement if the spectrum is not repurposed. This would be the cost of buying new equipment when the current assets reach the end of their lives
- The expected year in which the current set of equipment would reach the end of its life.

6.21 These costs varied between users. The repurposing of previously available 800 MHz spectrum in 2012 to mobile meant that a number of PMSE users had recently replaced their equipment. Some users have bought equipment that operates in the 600 MHz band. Consequently, the impact of 700 MHz not being available for PMSE for these users is limited.

6.22 Other users, such as RTÉ, replaced the old 800 MHz equipment with new equipment that operates in the 700 MHz band. Consequently, RTÉ estimate that almost 60% of their current equipment would have to be replaced if the 700 MHz is repurposed. Also, given that RTÉ has purchased most of its equipment recently, this equipment has several years of useful life left (the average asset life for PMSE equipment is approximately 7 years). Therefore, the 700 MHz band

being repurposed would lead to this equipment having to be replaced much in advance of the end of its natural life.

General Assumptions

6.23 We only have data from a subset of users of PMSE equipment in Ireland, albeit a number of the biggest users of PMSE equipment. Therefore, we have pro-rated our final overall cost estimates to account for this. We have estimated a range for the results by first assuming that the costs incurred by these four PMSE users represent 50% of the total costs of the PMSE industry in Ireland. We have used the same WACC as that assumed for DTT users in order to discount the stream of costs and calculate the NPV. Given that one of the biggest PMSE users in the UHF band is RTÉ, which also owns 2rn (the DTT operator), it is reasonable to assume that the overall WACC for PMSE users is the same as that for DTT. Conversely, it could be argued that the WACC for PMSE users is actually higher than that of DTT operators because their operations tend to be smaller and so may not benefit from economies of scale. However, assuming the same WACC as that for the DTT operator is conservative because using a higher WACC for PMSE would lead to a lower NPV cost estimate.

6.24 A key assumption in the modelling is the assessment of whether users have to switch all their existing equipment to digital equipment (currently some may be analogue). Where there is sufficient spectrum in the PMSE band users will not have to switch all their equipment to digital, since existing analogue equipment will operate. However, if the band is high utilised (for example if there are five or six DTT muxes in operation), then PMSE providers will have to switch all their equipment to more efficient digital equipment.

6.25 In the base case we assume that there is sufficient spectrum in the PMSE band such that users do not have to switch to digital equipment.

6.26 Costs in the factual are estimated assuming that repurposing takes place between 2017 and 2022.

6.27 For the counterfactual, PMSE users provided the estimated cost of replacing the equipment if repurposing did not take place. Some users specified the year of natural replacement. Others gave us the average asset life on their equipment. For these users, we conservatively assumed that all the equipment was new rather than being in the part-way through of its life cycle. This appears to be a reasonable assumption because most users have new equipment as a consequence of the 800 MHz band having been repurposed recently.

6.28 The average asset life on PMSE equipment is five to seven years. Consequently, most of the current equipment would need to be replaced by 2021.

Costs to PMSE of a 700 MHz repurposing

Results: cost of 700 MHz repurposing to PMSE

6.29 We estimate that, over an assessment period running to 2035, PMSE users are likely to incur costs of **€262k**, if repurposing takes place. The asset lives of PMSE equipment are five to seven years and most equipment is replaced by 2021. This leads to all costs falling within the period of assessment, even when annualised over the life of the asset.

6.30 By varying some of the assumptions, we have tested how sensitive these results are likely to be. Based on this, we estimate that costs to PMSE users from repurposing 700MHz spectrum could range from €51k to €436k.

- The costs are dependent on the year in which repurposing takes place. Early repurposing (2017) increases costs to €361k, whereas delaying repurposing (to 2020) reduces costs to €82k (and if the repurposing is delayed to 2022, the repurposing can be accommodated at zero cost, since the PMSE suppliers would upgrade equipment which is compatible with lower frequency spectrum).

- The base case assumes partial replacement as some of the equipment can be reused. However, if full replacement is required (if for example all six DTT muxes are in use and PMSE providers require all digital equipment) then costs increase to €410k.

- The results depend on the assumption made on the proportion of equipment that is identified in the survey. The base case assumes 50% of equipment is identified in the survey. We also test a lower assumption (30%) which increases costs to €436k. A higher assumption (of 80%) reduces costs to €164k.

7 Summary of results

7.1 In this section we summarise the results of the cost benefit analysis where the 700 MHz spectrum band is repurposed for mobile wireless broadband services.

Demand for mobile data will grow and lead to increased demand for spectrum

7.2 Growth in mobile data demand increases the demand for spectrum. While the precise scale of mobile data demand growth is unknown, it is likely to increase for a number of reasons, including:

- the increase in 3G and 4G network capability and coverage;
- the growing penetration of 3G and 4G smartphones;
- the increase in penetration of video capable mobile devices;
- the increase in mobile internet usage; customers expect to use any Internet application on their mobile devices as they do on fixed connection;
- the dramatic growth in visual communications traffic, whether providing communications, audio-visual and video content or gaming;
- mobile data caps are rising and "all you can eat"[54] plans have been introduced;
- the growing popularity of mobile over-the-top (OTT) services in Ireland.
- user experience is improving.

7.3 Our analysis is based on three mobile data demand scenarios, with the medium (base case) demand scenario assuming that the total data traffic carried on 3G and 4G mobile networks will reach 33 times their current levels by 2035. This corresponds to a CAGR of 18% for the modelling period, with the initial period up to 2025 having a higher CAGR of 28% and the remaining years having a CAGR of 9%.

7.4 Our modelling shows that there is a significant positive NPV benefit as a result of the repurposing of spectrum in all demand scenarios, regardless of the repurposing date, but earlier repurposing dates lead to higher benefits.

7.5 The present value of 2 x 30 MHz of 700 MHz spectrum to mobile operators, as measured by network costs saved is estimated to **be between €50m and €150m**

[54] Subject to fair usage requirement of (15 Gb on the Three Network)

depending on the demand scenario, with a base case estimate of €89m for a 2018 repurposing date[55].

7.6 In addition, repurposing 700 MHz may lead to increases in network performance which could benefit consumers. It could for example increase the likelihood that operators hold larger blocks of continuous sub-1GHz spectrum which could significantly improve capacity and performance in all areas of Ireland compared with the same amount of non-contiguous sub 1GHz spectrum. Furthermore operators could use the 700 MHz spectrum to increase performance in parts of their networks by increasing capacity, and thereby reducing utilisation. This in turn could lead to smaller, but identifiable performance enhancements. If operators chose to increase the capacity and performance of their network in this way, 700 MHz spectrum would enable them to do so at lower costs. Compared to the counterfactual of no repurposing, these performance enhancements could be delivered at a reduced cost, with the cost difference amounting to a further **€11m - €15m**.[56] However, there is more uncertainty over these cost savings, since they are conditional on operators making the necessary investments.

DTT can be accommodated at lower UHF spectrum with no loss of service

7.7 The DTT platform has only been in operation since October 2010. In that time it has continued to add to its channel portfolio and the number of households which used DTT in combination with other platforms has remained steady in and around the 35-41% penetration rate. As such DTT forms an important role in delivering public policy objectives such as the provision of universal coverage of Irish TV content, the plurality and diversity of Irish content and Gaelic language content, and the promotion of a competitive and vibrant Irish TV sector.

7.8 On a forward looking basis there is the potential for more channels to be added to the platform, alongside new services such as an on demand IP based platform. As the platform grows in channels and capability it may attract households who churn off Irish pay TV services. 2rn expects the demand for DTT from broadcasters to continue to increase up until at least 2030 and, assumes that Ireland will need at least 3 national multiplexes (muxes) within the medium term.

7.9 Based on information provided to us by 2rn we estimate that it would face costs from repurposing of between €4m and €11m and in our central case we assume costs of **€9.4m in 2015 prices. This assumes spectrum is repurposed in 2018 and three muxes are operational at the time.** The lower costs relate to later

[55] See **Table 5**.

[56] See **Table 5**.

Summary of results

repurposing (in 2022) and higher costs relate to sooner repurposing in 2017, which is the earliest possible repurposing date given a two year implementation.

7.10 In addition consumers could have to replace aerials. We have conservatively assumed that up to 1% of Group B and Group C/D aerials would need replacing in 2018, which would lead to costs of **€0.68m in 2015 prices**.

7.11 Furthermore consumers would face costs retuning their TV services in 2018. This could lead to costs of **€0.45m in 2015 prices**.

7.12 Assuming the costs of the information campaign to support retuning 700 MHz repurposing was a third of the costs of the DSO public information costs, we estimate that costs of an information campaign in 2018 could be **£1.66m in 2015 prices.**

7.13 This report has carefully considered whether the repurposing of 700 MHz spectrum to DTT services could lead to social or cultural costs if consumers churn from the platform as a result of the spectrum reassignment. We conclude that a very small percentage of consumers (less than 0.1% of DTT households) might churn from the platform, and we therefore concluded that the social or cultural costs would be negligible.

PMSE users can be accommodated

7.14 PMSE services in the 700 MHz band relate to the provision of equipment to support broadcasting, news gathering, theatrical productions and special events such as concerts and sport events. We have estimated the costs to PMSE users to be approximately **€262k** assuming a repurposing in 2018.

Summary of cost benefit analysis

7.15 **Table 10** below summarises the results of the CBA based on a 2018 repurposing and a modelling period up to 2035.

7.16 In the base case scenario, costs of €12m are estimated compared to benefits of €89m (though benefits could be €15m higher if MNOs invest to increase network performance. This yields a positive NPV of €77m (€91m if MNOs invest to increase network performance). This positive NPV result is stable to all reasonable sensitivities tested, including combinations of sensitivities to the assumptions.

Table 10. Summary results of the cost benefit analysis (NPV)

Category	Base €m	Low €m	High €m
Benefits of repurposing 700MHz band			
Network cost savings	89	50	150
Potential performance benefits	14.5	11	14.9
Total quantified benefits (inc potential performance) benefits	**103.5**	**60**	**165**
Costs to repurposing 700MHz band			
Transmission Infrastructure costs (2rn)	9	4	21
User aerial costs	0.68	0.4	3.2
Retuning of DTT receiver equipment	0.45	0.4	0.5
Public Information	1.66	1.2	5.0
PMSE costs	0.26	0.0	0.44
Total Quantified Costs	**12.4**	**6.4**	**30.3**
NPV benefit of repurposing 700MHz band	**91.1**	**54.6**	**134.6**

Other Benefits

7.17 This CBA has not attempted to quantify a number of other potential benefits such as:

- The use of the 700 MHz centre gap, which consists of 25 MHz of spectrum. This could be used for services such as SDL, PMSE, PPDR and M2M services.

- The consumer welfare implications of greater demand for mobile services if the network cost savings lead to lower prices. We would expect that network cost savings would partly be passed on to consumers in the form of improved and/or lower cost services and that if this occurred these benefits would increase demand and in so doing increase social welfare.

Summary of results

- The consumer welfare implications that might accrue as demand for mobile services, applications, and devices is stimulated by greater network capacity. Our model has treated demand as an exogenous variable, whereas in fact demand for mobile services (and devices) is partly driven by the supply of network services. Increased network capacity will drive demand for more data intensive applications, and technologically advanced devices, which benefit from the use of the network capacity.

- Other indirect benefits which could accrue to the wider Irish economy and society. These relate to the impact that increased mobile connectivity can have on economic productivity, employment, competitiveness and economic growth. To the extent that the analysis finds that that incremental 700 MHz spectrum could improve the performance of networks, then these wider indirect benefits are also likely to occur.

7.18 Given that the wider benefits are necessarily more difficult to quantify to a high degree of confidence, this CBA does not attempt to estimate them. Nonetheless, they should not be discounted, particularly as they could be significant and perhaps even be larger than the quantified direct benefits, as relatively small changes in a country's growth potential can have significant benefits when compounded year on year.

7.19 To the extent that incremental sub-1 GHz spectrum could be used to improve network performance in rural areas, which are currently less well served by high speed fixed broadband infrastructure, compared with urban areas, then the benefits to these users are likely to be particularly significant.

Earlier repurposing

7.20 The quantified benefits of a repurposing of the 700 MHz band are marginally smaller for earlier repurposing than later repurposing (**Table 11**). This is because the quantified DTT and PMSE costs increase as the repurposing is brought forward. However the quantified benefits are also higher if the date of repurposing is brought forward, thought the increased quantified benefits of earlier repurposing to mobile, do not fully offset the increased costs of DTT and PMSE.

7.21 However, it should be noted that this analysis does not include a range of unquantified other benefits as discussed above. These other benefits may be significant and could even be larger than the direct benefits. To the extent that these benefits are larger and more likely if spectrum is repurposed earlier, then these other benefits should be taken into account when assessing the appropriate repurposing date and could therefore be likely to support the case for early repurposing.

Table 11. Impact of later repurposing NPV €m

	2017	2018 (base)	2022
Mobile benefits (network costs)	89	**89**	87
Quantified costs (DTT and PMSE)	14	**12**	6.6
Total	**75**	**77**	**80**

Summary of results

Annexe 1: Assumptions made in estimating costs for DTT users of repurposing 700 MHz spectrum

7.22 We lay out an assessment of whether the assumptions made in estimating the DTT costs that would be incurred in the event of 700 MHz being repurposed are a reflection of what is likely to be incurred or conservative.

Table 12. Assumptions made in DTT modelling

Assumption	Description
Transition takes place while three muxes are on-air	It is uncertain if demand for DTT will increase to an extent that would necessitate three muxes. Therefore this assumption is likely to lead to an overestimation of costs. We have also modelled the costs under assumptions of two and four operational muxes.
Simulcast is required at all sites where channels must change during the transition period (i.e. 3+1 transmitters, combiners, filters, cooling systems etc)	There are lower cost alternatives to simulcast at all sites, for instance a site-by-site channel change. However, this would not be appropriate in Ireland because of the nature of 2rn's network. The coverage from different antennas overlaps, making it necessary to migrate nationally rather than one region at a time.
3+1 new transmitters are required at each site in the maximum cost scenario.	This assumption requires each site to have 1 spare set of equipment. There is a lower cost alternative where there is just one spare transmitter which is shared among multiple sites in the event of failure. However, this would not be feasible in carrying out a complete national simulcast rather than a region-by-region migration.
Separate antennas are required for simulcast at all Main Sites and High Powered Relays where channels are changing	This assumption is reasonable given the technology used by 2rn.
Existing reserve antennas can be modified for use as temporary simulcast (except for Kippure and Clermont Carn where they need	

to be replaced first)	
Sufficient electrical power is available at all sites to cope with simulcast of 3 full power muxes	
Up to 3 additional relay sites may be required to repair coverage	
An estimated 5 x Highly directional antennas have been included in the total cost for the current plan to allow off-air reception in more congested spectrum. 10 x Highly directional antennas and 5 x new microwave links have been included in max cost scenario. No account has been made for mast/tower upgrades to accommodate the highly direction antennas or microwave links.	These assumptions are reasonable in light of a definite frequency plan and migration timetable not having been decided yet.
Weightings have been applied to the estimated costs to account for unknowns in the frequency plan	
10% has been added to the total cost to cover project management, network engineering, frequency planning, site surveying, coverage surveying etc.	
Standard operational costs like electricity and maintenance in the year of simulcast will be approximately €650,000	
Antenna radiation patterns will not change from current systems	
SAORVIEW Households at 41% at time of switch-over	
Viewers use grouped receive antennas based on the analogue TV groups at switch-off	
All group A transmission sites will remain on group A.	
Viewers' antennas are not optimally installed such that 1% of all group B and C/D households are within 3dB of loss of coverage requiring a new installation.	Approximately 15% of households lie within about 25dB of the minimum receive level. 20dB is an estimate of poor installation, bringing viewers to about 3dB from loss of coverage. This is a conservative assumption as it is likely that the percentage of viewers

Annexe 1: Assumptions made in estimating costs for DTT users of repurposing 700 MHz spectrum

	affected and so the costs associated with this will be lower. The actual number of households that will suffer from noticeable interference will be far less than 15%.

Annexe 1: Assumptions made in estimating costs for DTT users of repurposing 700 MHz spectrum

Annexe 2: Forecasts of growth in data traffic in the UK

7.23 We have examined analysts' forecasts of the UK demand for mobile data in order to inform our assumptions of potential growth data demand in Ireland. We consider estimates from Cisco, Real Wireless and Analysys Mason.

7.24 The Analysys Mason and Real Wireless models forecast demand as a function of the data use of mobile handsets, the penetration of mobile handsets. The key assumptions in the Real Wireless model are set out in the tables below.

Real Wireless

7.25 Real Wireless identifies three different scenarios for the long term growth in demand for mobile data in the UK between 2012 and 2030, reflecting the uncertainties in future demand. [57]

- *Low growth scenario:* the demand for mobile data flattens out after 2015 and total UK traffic volumes in 2030 reach 20 times their current level. The main assumptions behind this hypothesis are high costs of capacity and/or a lower quality of service once capacity limits are reached. As a consequence, low quality applications such as instant messaging and mobile payments would dominate mobile data usage, instead of rich web media and video.

- *Medium growth scenario:* the demand for mobile data would keep on increasing at current annual growth rates until 2020. From this year onwards, it would start to slow down as data and video-capable devices would reach the full consumer penetration and traffic consumption per device would peak. In 2030, total UK traffic volumes would reach 80 times their current level.

- *High growth scenario:* the demand for mobile data would continue to rise significantly up to and beyond 2020, with total UK traffic volumes in 2030 reaching 300 times their current level. This scenario assumes a rapid uptake in high resolution mobile video from HD to 3D, with an increasing demand for 3D experiences and high resolution video gaming. In such a case, Real Wireless assumes than all the key drivers of growing mobile data demand keep on existing and increasing in the future.

7.26 The assumptions used in the Real Wireless model are set out below.

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57 Analysys Mason (2014), "Assessment of the benefits of a change of use of the 700 MHz band to mobile".

Table 13. Components of traffic forecasts from the Real Wireless model

	Market device penetration (MB/sub/mth)		Traffic per device (MB/sub/mth)		
	Smartphone	MBB	Smartphone	MBB	Offload proportion
2015	90%	37%	340	2738	42%
2025	190%	187%	935	10787	46%
2035	256%	222%	2020	34589	51%
2040	297%	245%	2967	61700	53%

Source: Analysys Mason 2014

Analysys Mason

7.27 Analysys Mason estimates that demand would continue to grow, but with a flatter pace compared to the high and medium scenarios identified by Real Wireless.

7.28 This forecast is based on assumptions related to traffic volume growth and offloading to Wi-Fi. The analysis assumes an increasing amount of offload traffic over time, which explains why its forecast for the mobile data demand is flatter compared to Real Wireless' high and medium growth scenario.

Annexe 2: Forecasts of growth in data traffic in the UK

Table 14. Components of traffic forecasts from the Analysys Mason model (medium scenario)

	Market device penetration (MB/sub/mth)		Traffic per device (MB/sub/mth)		
	Smartphone	MBB	Smartphone	MBB	Offload proportion
2015	66%	13%	4291	34017	64%
2025	98%	24%	20735	122497	76%
2035	100%	25%	33125	166040	77%
2040	100%	25%	37670	178640	77%

Source: Analysys Mason 2014

Cisco

7.29 Cisco's forecast predicts that the UK mobile data traffic will grow 12-fold from 2011 to 2016, with a compound annual growth rate of 65%. This analysis takes into account the high growth in mobile data usage over the past few years and assumes it will continue to increase over time.

Annexe 3: Modelling the network cost savings to mobile network operators of a change of use of the 700 MHz band

Annexe 3 is a separate report.

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