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Consultant's Report

Future use of 2.6 GHz radio spectrum band

Prepared for ComReg by Aegis Systems Limited and Plum Consulting Limited ("Aegis and Plum")

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Technical and Economic Study on Multipoint Microwave Distribution Systems and Next Generation Mobile Broadband Services in the Band 2500 – 2690 MHz

Final Report for ComReg

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EXECUTIVE SUMMARY

Introduction

In Ireland the 2.6 GHz band is currently used for the provision of Multipoint Microwave Distribution System (MMDS) Programme Services Distribution. Currently, there are ten MMDS regional licences held by UPC Ireland Ltd to provide TV services to non-cabled areas of Ireland and when combined these licences cover most of the country. The majority of the licences expire in April 2014 and there is provision in legislation for renewal of these licences for up to 5 years.

This report presents:

- the findings of a high-level technical feasibility study into the sharing potential between MMDS and Next Generation Mobile Broadband (NGMB) systems in the 2.6 GHz band based on co-channel sharing with geographic separation and adjacent channel sharing; and
- then considers the costs and benefits of different timing options where the band is reallocated to alternative uses, such as next generation mobile broadband. Two options are considered:
    - Option 1: End MMDS licence in 2014 with assumed reallocation of spectrum to mobile broadband
    - Option 2: End MMDS licence in 2017 with assumed reallocation of spectrum to mobile broadband.

We firstly discuss the technical sharing modelling and then consider the economics of different timing options.

Technical Analysis

In the technical analysis, the implications of interference paths between MMDS and NGMB transmitters and receivers have been investigated. To examine each interference path, static models based on typical geometry and RF parameter values have been developed. These models have been used to derive minimum separation requirements to assess the potential for co-existence in the same/different geographic area with co-channel/adjacent channel operating conditions.

The technical analysis results indicate that co-channel sharing scenarios involving MMDS transmitters and NGMB base station receivers require larger separation distances than adjacent channel sharing scenarios. For a typical MMDS transmitter (EIRP of 18 dBW/8 MHz[1] and effective antenna height between 100 and 300 metres), the minimum required separation distances from the edge of MMDS coverage area into NGMB base station receivers are between 45.6 and 67.5 km.

[1] The UPC site data indicates that 17 out of 22 MMDS transmitters use EIRP of 18 & 19 dBW/8 MHz.

Adjacent channel sharing requirements are determined by the Net Filter Discrimination (NFD) level which depends on transmitter and receiver selectivity masks. For an assumed NFD level less than 30 dB, the adjacent channel sharing is only feasible 15 km or more from the edge of MMDS coverage area (for an MMDS transmitter with an EIRP of 18 dBW/8 MHz and an effective antenna height of 200 metres).

The implications of the technical analysis results have been examined in an example scenario for the Dublin area. This analysis, without terrain data, showed that if an NGMB network is to be deployed in Dublin co-channel with the MMDS transmitters then it will be necessary to turn off five MMDS transmitters (Mount Oriel, Naul, Dunmurry, Ballyguile and Sleve Buoy) in the surrounding area. Adding the terrain data the interference issues persist such that interference from MMDS sites at Mount Oriel, Naul and Dunmurry prohibits the operation of NGMB systems in the Dublin area on a co-channel basis.

Alternatively, if adjacent band operation is considered MMDS transmitters need to be moved to channels that are away from NGMB channels to provide adequate NFD levels[2]. Under the current channel plans this is not feasible as all the channels are used in the Dublin area.

A number of mitigation techniques could be considered to improve the feasibility of MMDS and NGMB sharing. These include an interfering transmitter EIRP reduction, operation at the opposite polarisation, improved antenna discrimination and antenna downtilting. It was beyond the scope of this study to assess the impact of each mitigation technique though this could in principle be undertaken in further work using practical deployment scenarios.

Economic Assessment

In light of the technical analysis finding that sharing options are not likely to be feasible, the economic assessment focuses on an analysis of the costs and benefits of different policy options. A cost benefit analysis considers the incremental changes to costs and benefits in relation to a base case. Our base case scenario involves the renewal of MMDS licences by ComReg allowing continued service for the period to 2019. The policy options we have considered relative to the base case of continued MMDS operation until 2019 are:

- Option 1: End MMDS licence in 2014 with assumed reallocation of spectrum to mobile broadband
- Option 2: End MMDS licence in 2017 with assumed reallocation of spectrum to mobile broadband.

The results of the cost-benefit analysis are shown in Table 1.

[2] It is not possible to define the actual guard bands that would be needed between MMDS and NGMB channels as no information is available on the receiver selectivity but it is expected to be several MHz and it may also be necessary to add additional filtering to NGMB base stations.

On the benefits side, a range of values is given for high and low assumptions for the value of spectrum and the non-incurrence of MMDS operating costs, while on the costs side a range of values is given for high and low assumptions for consumer switching costs.

The net benefits of release of the band in 2014 (Option 1) are estimated to range from €16.8 to €41.5 million whilst the benefits of delaying the release of the band until 2017 (Option 2) range from €5.1 to €13.8 million (relative to delaying the release of the band until 2019). The broad range of estimated net benefits is due to the significant uncertainty about the values of key parameters, in particular, the value of spectrum. Nonetheless, it can be seen that ending MMDS licences in 2014 offers significant net benefits relative to extending MMDS licences to 2017 or 2019.

	Option 1 vs base case (2010 €m)	Option 2 vs base case (2010 €m)
Benefits		
Value of spectrum	6.3 - 25.5	2.4 - 9.6
Savings from non-incurrence of MMDS operating Costs	12.5 - 20.8	3.5 - 5.8
Total Benefits	**18.8 - 46.3**	**5.9 – 15.4**
Costs		
Set top box	0.6 - 2.7	0.2 - 0.8
Satellite Dish or terrestrial antenna (including installation)	1.0 - 1.7	0.3 - 0.5
Value of customer time taken to switch from MMDS to alternative	0.4	0.3
Total Cost	**1.9 - 4.8**	**0.7 - 1.76**
Net Benefits	**16.8 – 41.5**	**5.1 – 13.8**

Table 1: Results of Cost Benefit Analysis[3]

If MMDS licences expire in either 2014 or 2017 consumers would have the option to continue to receive TV service from alternative free or pay satellite services or

[3] Note rounding differences mean that figures in table do not exactly sum to totals.

terrestrial TV, though they would nevertheless face switching costs in terms of both time and money. However, we note that consumers who remain on MMDS (and numbers are currently declining at an average annual rate of around 15.5% per annum) would incur switching costs in 2019 in any event.

We also considered competition impacts in the broadcasting market. These would be negative and would likely be small, as MMDS comprises less than 7% of the current pay TV market and is declining.

There would likely be positive competition benefits for the mobile broadband market from making additional spectrum available, as additional spectrum could make consolidation in the mobile broadband market less likely and could enhance the ability of mobile broadband to compete more effectively with fixed broadband at the margin.

Overall we conclude that the benefits of early release of 2.6 GHz spectrum outweigh the costs under the range of assumptions (see section 4.9) we considered – some of which are judged to be conservative such as the benefits of mobile broadband.

However, we acknowledge the considerable uncertainties involved in this assessment such as the uncertainty regarding future demand for mobile broadband and spectrum demand, and the future prospects for MMDS. Also it is possible that one or more sharing options that we have considered might prove feasible following more detailed assessment. One approach open to ComReg would be to consider allocating 2.6 GHz spectrum using a technology neutral competitive process, allowing bids for both NGMB and MMDS use. This option would enable the market rather than ComReg to determine the use of the 2.6 GHz spectrum.

1 INTRODUCTION

This report presents the findings of a study undertaken by Aegis Systems Limited and Plum Consulting for ComReg into:

- the technical feasibility of sharing between multipoint microwave distribution systems (MMDS) and next generation multimedia broadband (NGMB) systems,
  - On a co-frequency basis
  - Adjacent channel
  - Geographical separation between the services
  - Combinations of the above; and
- the economic analysis of the costs and economic benefits to Ireland arising from the following situations:
  - the 2.6 GHz band being only available for MMDS for all or part of the period 2014 to 2019; and
  - the 2.6 GHz band being available for use on a WAPECS basis (but used for NGMB) starting in the period between 2014 and 2019 and ending in 2029.

In undertaking the study and compiling this report we have had regard to ComReg's objectives and obligations as they apply to our terms of reference. In particular we have considered ComReg's statutory objectives set out in Section 12 of the Communications Regulation Act 2002, especially those of ensuring efficient management and use of radio spectrum and promoting competition.

1.1 The 2.6 GHz band

ComReg's Radio Frequency Plan for Ireland[4] designates the band 2500–2686 MHz for use by Multipoint Microwave Distribution System (MMDS) Programme Services Distribution. The diagram below illustrates the current use of the 2.6 GHz band by MMDS services based on information provided in ComReg technical conditions documents ComReg98/67R and ComReg98/65R2.

[4] See ComReg document 08/90R

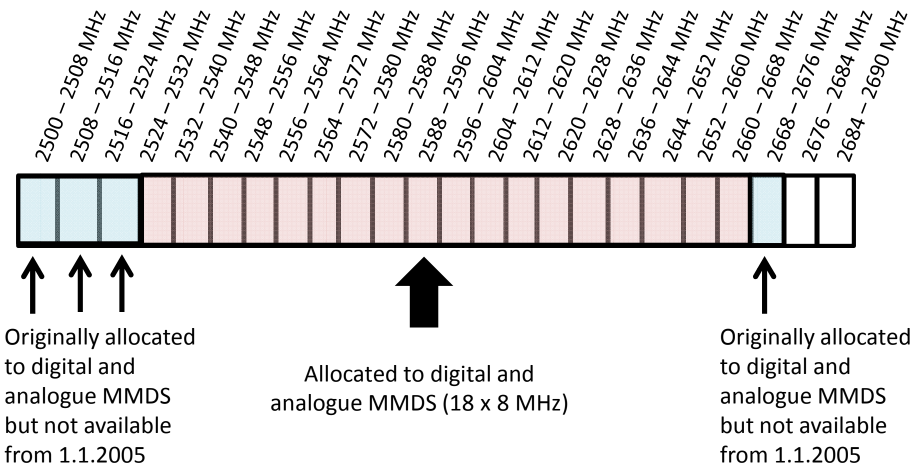

Figure 1: Current Use of 2.6 GHz Band in Ireland (Ref: ComReg98/67R and ComReg98/65R2)

The 2.6 GHz band is subject to EC Decision 2008/477/EC where conditions are set out in the form of in-block and out-of-block emission limits for harmonised use by electronic communications services. These conditions have been developed in the context of the EC's Wireless Access Policy for Electronic Communications Services (WAPECS) initiative. The EC Decision sets out a flexible spectrum arrangement for the use of this band. The duplex spacing for FDD operation is specified to be 120 MHz with terminal station transmission located in the lower part of the band. An example implementation of the band plan is illustrated in the following figure.

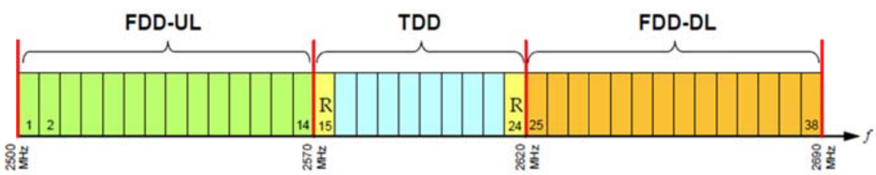

Figure 2: 2.6 GHz Band Plan (Ref: ECC Report 131)

The band plan is based on 5 MHz wide blocks. At the FDD/TDD border frequencies, two blocks are defined as restricted blocks where different technical conditions would be applied to minimise the interference potential.

Currently, there are ten MMDS regional licences held by UPC Ireland Ltd to provide TV services to non-cabled areas of Ireland. When combined these licences cover most of the country. The majority of the licences expire in April 2014 and there is provision in legislation for renewal of these licences for up to 5 years.

1.2 Spectrum in Ireland

To support the growing demand for mobile broadband it is widely accepted that there is a need for further spectrum to be released to the market. In Ireland there are ongoing mobile spectrum liberalisation projects; specifically the proposed joint award of 800 MHz (2 x 30 MHz) and 900 MHz (2 x 35 MHz) spectrum and the possible inclusion of 1800 MHz (2 x 75 MHz) spectrum in the same award process. This project would provide a total of 2 x 135 MHz to the market. However, 2 x 76.1 MHz is currently allocated to provide mobile services using GSM technology but over time it is expected that some or all of this spectrum would be refarmed to more spectrally efficient technologies such as LTE.

In this project ComReg proposes to award this spectrum in 2 x 5 MHz block sizes and the amount of spectrum that is available provides the potential for operators to amalgamate blocks into 2 x 10 MHz (or greater) allocations, which provides the benefit of supporting higher speed services. The ability to amalgamate a 2 x 10 MHz (or greater) spectrum allocation is also one of the advantages of the 2.6 GHz band.

Whilst the amount of spectrum that would be provided in this joint award is comparable to that available in the 2.6 GHz band there are other considerations (as outlined below) which suggest that there is likely to be demand for the 2.6 GHz band:

- Whilst the 800 MHz and 900 MHz bands are ideal for providing coverage the 2.6 GHz band is better suited for providing capacity at traffic hot spots. The 1800 MHz band has been used to provide both coverage and capacity in urban areas in Ireland.
- Part of the additional spectrum at 900 MHz and 1800 MHz may need to be used to facilitate refarming from existing 2G technologies.
- The 2.6 GHz band is harmonised on a global basis and would be used for international roaming.

1.3 Structure of the paper

Section 2 of the report provides information on the technical analysis undertaken; assumed system parameters, the modelling approach and the results together with conclusions. The technical analysis implemented during the course of this study is based on the derivation of minimum separation distances for co-channel and adjacent channel sharing scenarios. These limitations are required to bring the interference between MMDS and NGMB systems down to acceptable levels.

The results of the technical analysis have been used as inputs into the technical evaluation, provided in Section 3, of the feasibility of the four options below:

1. Co-channel sharing from 2014
2. Adjacent channel sharing from 2014
3. Assumed reallocation of spectrum to mobile broadband in 2014
4. Assumed reallocation of spectrum to mobile broadband in 2017

The outcome of this technical evaluation is used to identify those options which are considered in the economic analysis, presented in Section 4, against the base case or counterfactual scenario of continued MMDS use to 2019 utilising MPEG2 technology. There are a number of annexes. Annex A and B relate to the technical modelling. Annex C discusses spectrum supply and demand. Annex D looks at alternative TV platforms.

2 TECHNICAL ANALYSIS

The technical analysis aims to examine the implications of uplink and downlink interference paths. In the remainder of this section, the description of the modelling approach together with the summary of the technical analysis and conclusions are provided. Assumed parameters, together with detailed results, are provided in Annex A.

2.1 Interference Modelling Approach

The following diagram illustrates interference paths investigated in this study.

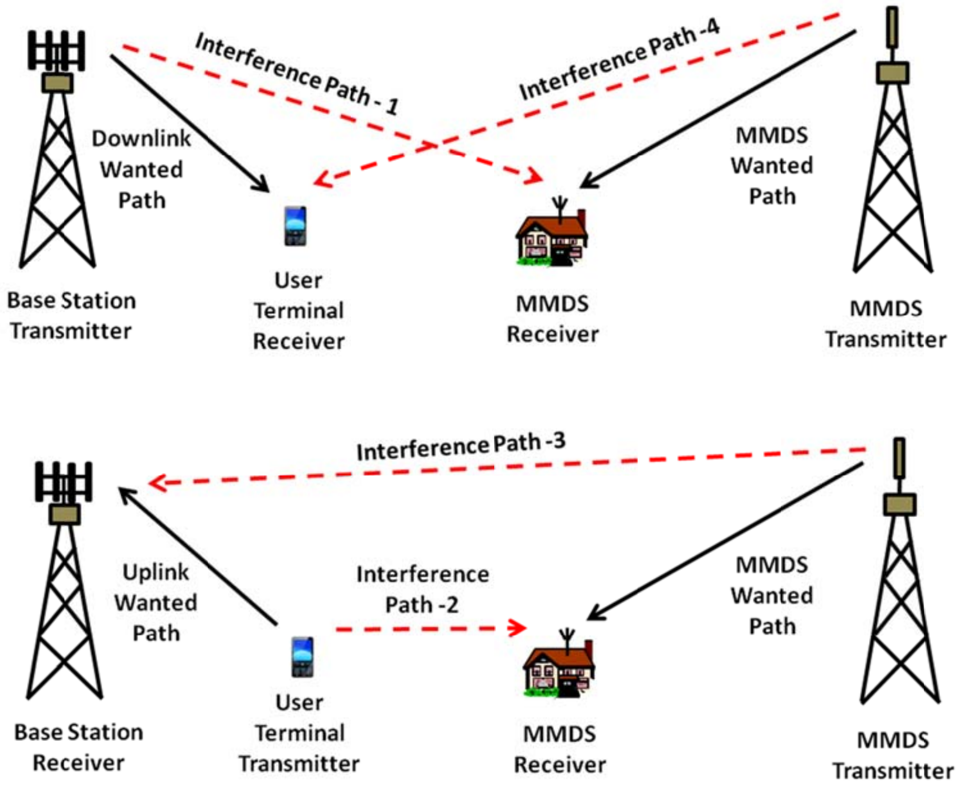

Figure 3: Interference Paths

As can be seen in the Figure above, four interference paths have been analysed. These are:

1) Interference from NGMB BS transmitter into MMDS receiver.
2) Interference from NGMB user terminal transmitter (NGMB MS transmitter) into MMDS receiver.
3) Interference from MMDS transmitter into NGMB BS receiver.
4) Interference from MMDS transmitter into NGMB user terminal receiver (NGMB MS receiver).

To examine each interference path, a base case static model has been developed. The base case models are based on typical geometry and RF parameter values as outlined in Annex A. These models have been used to derive minimum separation requirements for co-channel and adjacent channel operation conditions.

The calculated minimum separation distances are used to assess the potential for co-existence:

- in the same geographic area co-channel operating conditions
- in the same geographic area adjacent channel operating conditions
- in different geographic area co-channel operating conditions
- in different geographic area adjacent channel operating conditions.

In order to account for different deployment scenarios, the sensitivity of the technical base case analysis results (as discussed in Annex A) for different modelling parameters has been examined. The aim of the sensitivity analysis is to achieve generic conclusions that could be applied to a range of potential co-existence scenarios. In this context, the implications of EIRP levels (for example, macro, micro and pico NGMB system deployments), polarisation discrimination (for example, linear and slant polarised NGMB deployments) and antenna radiation patterns (for example, radiation patterns based on ETSI / CEPT standards and practical antennas) have been investigated.

2.2 Summary of Technical Analysis

In the analysis, separation distances between the interfering transmitter and victim receiver are calculated for various assumptions given in Annex A. These are then offset by MMDS coverage radius to determine the minimum required separation from the edge of the MMDS coverage area. Figure 4 illustrate example scenarios where the impact of co-channel interference from an NGMB BS transmitter into an MMDS receiver is examined.

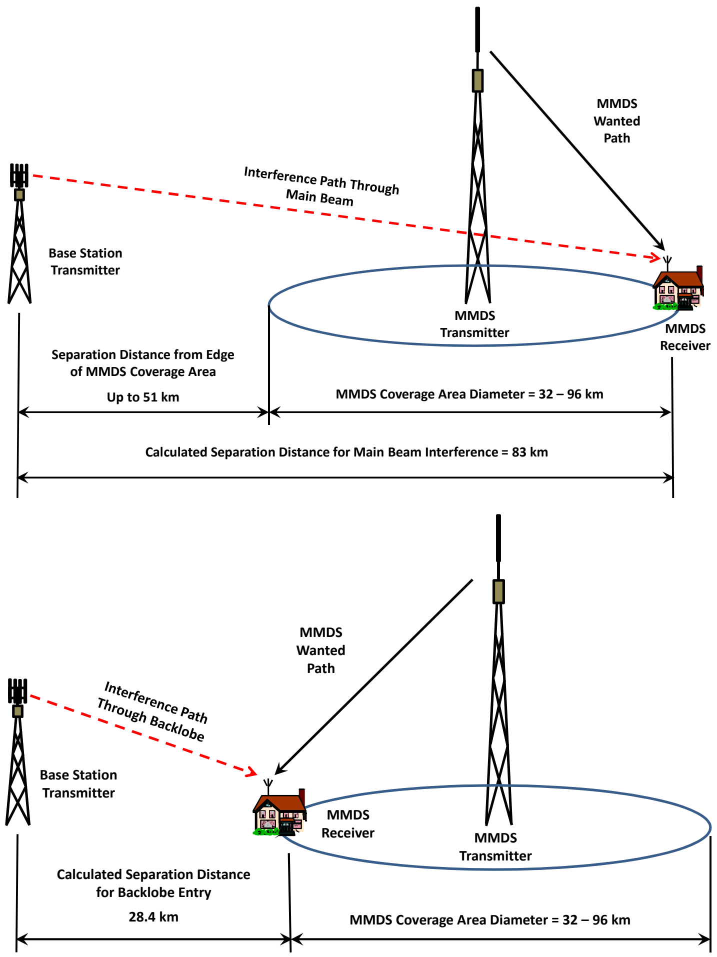

Figure 4: Interference Geometry
(NGMB BS Interference into Digital MMDS Receiver)

As can be seen, interference entries through the victim receiver antenna main beam and rearlobe have been considered. Calculated distances are then offset by the MMDS coverage area radius to determine the required separation from the coverage edge.

In the case of adjacent channel sharing scenarios, one of the key limitations is the lack of receiver selectivity data. In order to implement an adjacent channel interference analysis, a net filter discrimination (NFD) needs to be derived. NFD combines the transmitter mask and receiver selectivity. It specifies the magnitude of the signal suppression available at a given frequency offset between the transmitter and receiver due to filtering at both ends. The term ‘adjacent channel interference ratio’ (ACIR) corresponds to an NFD value at a certain channel spacing between the transmitter and receiver.

In order to overcome the lack of data coupled with the uncertainty of NGMB systems likely to be deployed in 2014 onwards, separation distances have been calculated for an assumed set of NFD values representing the combinations of various transmitter and receiver selectivity masks.

In the analysis of MMDS and NGMB co-existence, one of the most critical assumptions is the criterion assumed for the feasibility of co-channel and adjacent channel sharing. When deriving a maximum allowed interference level for the MMDS receiver the minimum wanted field strength value together with the required C/I ratio have been used (see 5.1.1 and specifically Table 16). These values are outlined in ComReg technical conditions documents for digital and analogue MMDS[5].

In the case of deriving a maximum allowed interference level for NGMB BS and MS receivers, it is noted that there is no explicit interference margin allowance to external interference from MMDS systems. Interference margins of NGMB links are generally associated with intra-system interference. It is therefore assumed that the interference margin that could be attributed to MMDS interference is limited to 0.4 dB corresponding to a maximum allowed interference level of 10 dB below the receiver noise floor.

For both MMDS and NGMB receivers, an additional allowance is made to ensure that the victim receiver is protected from propagation variations in wanted and interference paths.

Using the technical analysis results detailed in Annex A, the summary of co-channel and adjacent channel co-existence requirements are provided in the following sections.

2.2.1 Interference from NGMB into MMDS

2.2.1.1 NGMB BS into MMDS (Co-channel)

For the co-channel sharing, a separation of up to 51 km from the edge of MMDS coverage area is calculated for the NGMB BS interference. This distance is obtained from a scenario where an NGMB BS with an EIRP equal to the EC Decision limit (i.e. 31 dBW / 5 MHz) interferes with an MMDS receiver operating at a local clutter height of 10 m.

This situation may be improved based on the following:

- ***Reduced EIRPs*** (representing micro and pico deployments) then the required distance from the MMDS coverage area edge is below 13.5 km.
- NGMB system operates in the ***opposite polarisation*** of the MMDS system the distance from the MMDS coverage area edge becomes less than 25 km.
- ***MMDS receiver antenna height is 5 m below the local clutter height of 10 m*** then the separation from the edge of MMDS coverage area is less than 28.5 km.

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[5] Technical conditions for the operation of digital programme services distribution systems in the frequency band 2500–2686 MHz (ComReg98/67R, Revised June 2004).

Technical conditions for the operation of analogue programme services distribution systems in the frequency band 2500–2686 MHz (ComReg98/65R2, Revised June 2004).

2.2.1.2 *NGMB MS into MMDS (Co-channel)*

In the case of co-channel interference from NGMB MS transmitters operating at the EC Decision limit (i.e. 5 dBW/5 MHz), the required separation from the edge of MMDS service area is below 1.2 km in the urban case and 10.3 km in the rural case.

The situation may be improved based on the following:

- ***MMDS receiver antenna height is reduced (from 10 m to 5 m)***, the required distance from the MMDS coverage area edge becomes less than 70 m for the urban case and 6.7 km for the rural case.
- ***More practical EIRP levels*** specified for macro, micro and pico cells, then the required separation from the MMDS coverage area edge (when the MMDS receiver is at 10 m) is less than 0.59 km for the urban case and 5 km for the rural case.

2.2.1.3 *NGMB BS into MMDS (Adjacent Channel)*

For the adjacent channel sharing, if it can be assumed that an NGMB BS transmitter mask complying with the EC Decision limits is more dominant than MMDS receiver selectivity, an ***NFD level of 57 dB*** can be used in the analysis of the adjacent channel sharing feasibility. This, in turn, translates into a required separation (from the edge of MMDS service area) of 1.6 km when the MMDS receiver is at an assumed local clutter height of 10 m. On the other hand, if it can be assumed that the adjacent channel sharing is driven by the MMDS receiver selectivity resulting in an assumed ***NFD level of 30 dB***, then the required separation from the edge of MMDS coverage area is 8 km.

2.2.1.4 *NGMB MS into MMDS (Adjacent Channel)*

In the case of adjacent channel interference from NGMB MS transmitters, the required separation from the MMDS service area edge is below 170 m in the urban case and 1.45 km in the rural case if it can be assumed that an ***NFD of more than 30 dB*** is available and the MMDS receiver is at 10 m.

2.2.2 Interference from MMDS into NGMB

2.2.2.1 *MMDS into NGMB BS (Co-channel)*

For co-channel sharing with NGMB BS receiver, the minimum required separation distances (from the edge of MMDS service area) are less than 98.7 km for an MMDS EIRP of 32 dBW/8 MHz (which is the maximum level specified in ComReg technical conditions for an analogue MMDS transmitter).

The situation may be improved based on the following:

- ***Lower MMDS EIRP:*** separation distances are 67.4 km for an MMDS EIRP of 22 dBW/8 MHz (which is the maximum level stated in ComReg technical conditions for a digital MMDS transmitter) and 58.8 km for an MMDS EIRP of 18 dBW/8 MHz (which is the lower-end practical level based on the current

MMDS licensee site data) when the MMDS transmitter effective antenna height is at 200 m. The site data from the current MMDS licensee indicates that there is one transmitter serving analogue customers using an EIRP of 23 dBW/8 MHz for which the required separation from the edge of MMDS coverage area is less than 69.8 km.

- ***MMDS transmitter effective antenna height:*** If it can be assumed that the MMDS transmitter effective antenna height is 100 m, then the distances calculated for the 200 m effective height are reduced by approximately 13 km. In the case of an effective antenna height of 300 m the distances calculated for the 200 m effective height are increased by approximately 10 km.

2.2.2.2 MMDS into NGMB MS (Co-channel)

For the co-channel sharing scenarios with NGMB MS receiver, the minimum separation distances from the MMDS coverage area edge are less than 33 km for an MMDS EIRP of 32 dBW/8 MHz, 20 km for an MMDS EIRP of 22 dBW/8 MHz and 15 km for an MMDS EIRP of 18 dBW/8 MHz when the MMDS transmitter effective height is assumed to be 200 m.

2.2.2.3 MMDS into NGMB BS (Adjacent Channel)

For the adjacent channel sharing two different scenarios have been considered based on the assumed NFD level and in each case the impact of different MMDS EIRP levels considered.

If it can be assumed that the NFD mask is dominated by the MMDS transmitter mask (complying with ETSI DVB-T standard EN 300 744) and an assumed ***NFD of 50 dB*** is available then there is no separation requirement from the edge of the MMDS coverage area for MMDS EIRP levels less than or equal to 23 dBW/8 MHz when the MMDS transmitter effective height is assumed to be 200 m. When the EIRP value is 32 dBW/8 MHz, the required separation from the edge of MMDS coverage area is less than 8.1 km.

On the other hand, if the receiver selectivity is the determining factor in the NFD mask and an assumed ***NFD of 30 dB*** is available then the required separation from the edge of MMDS coverage area is less than 33 km for an MMDS EIRP of 32 dBW/8 MHz, 19.7 km for an MMDS EIRP of 22 dBW/8 MHz and 14.8 km for an MMDS EIRP of 18 dBW/8 MHz.

2.2.2.4 MMDS into NGMB MS (Adjacent Channel)

In the case of adjacent channel interference into NGMB MS receivers, there is no separation requirement from the edge of the MMDS coverage area if an assumed ***NFD of more than 30 dB*** is available and the MMDS transmitter effective height is 200 m.

2.2.3 Conclusions

Technical analysis results are summarised in Table 2.

Scenario	Separation Requirements from Edge of MMDS Coverage Area	
NGMB into MMDS (Co-channel)	NGMB BS with EIRP of 13 (micro) & 31 (macro) dBW/5 MHz interferes with MMDS receiver at 10 m	13.5 km (13 dBW/5 MHz) 51 km (31 dBW/5 MHz)
	NGMB Macro BS (EIRP = 31 dBW/5 MHz) interferes with MMDS receiver at 10 m operating on opposite polarisation	25 km
	NGMB Macro BS (EIRP = 31 dBW/5 MHz) interferes with MMDS receiver at 5 m	28.5 km
	NGMB MS with EIRP of 5 dBW/5 MHz interferes with MMDS receiver at 10 m	1.2 km (urban) 10.3 km (rural)
	NGMB MS with EIRP of 5 dBW/5 MHz interferes with MMDS receiver at 5 m	70 m (urban) 6.7 km (rural)
	NGMB MS with EIRP of –6 dBW/5 MHz interferes with MMDS receiver at 10 m	0.6 km (urban) 5 km (rural)
NGMB into MMDS (Adjacent channel)	NGMB Macro BS (EIRP of 31 dBW/5 MHz) interferes with MMDS receiver at 10 m	1.6 km (NFD = 57 dB) 8 km (NFD = 30 dB)
	NGMB MS with EIRP of 5 dBW/5 MHz interferes with MMDS receiver at 10 m when an NFD of 30 dB is available	170 m (Urban) 1.45 km (Rural)
MMDS into NGMB (Co-channel)	MMDS with EIRP of 32 dBW/8 MHz interferes with NGMB BS (MMDS effective antenna height 100, 200 and 300 m)	81.7 km (100 m) 98.7 km (200 m) 110 km (300 m)
	MMDS with EIRP of 22 dBW/8 MHz interferes with NGMB BS (MMDS effective antenna height 100, 200 and 300 m)	53.4 km (100 m) 67.4 km (200 m) 76.7 km (300 m)
	MMDS with EIRP of 18 dBW/8 MHz interferes with NGMB BS (MMDS effective antenna height 100, 200 and 300 m)	45.6 km (100 m) 58.8 km (200 m) 67.5 km (300 m)
	MMDS with EIRP of 18, 22 & 32 dBW/8 MHz interferes with NGMB MS (MMDS effective antenna height 200 m)	15 km (18 dBW/8 MHz) 20 km (22 dBW/8 MHz) 33 km (32 dBW/8 MHz)

Scenario	Separation Requirements from Edge of MMDS Coverage Area	
MMDS into NGMB (Adjacent channel)	MMDS with EIRP of 32 dBW/8 MHz interferes with NGMB BS (MMDS effective antenna height 200 m)	8.1 km (NFD = 50 dB) 33 km (NFD = 30 dB)
	MMDS with EIRP of 22 dBW/8 MHz interferes with NGMB BS (MMDS effective antenna height 200 m)	0 km (NFD = 50 dB) 19.7 km(NFD = 30 dB)
	MMDS with EIRP of 18 dBW/8 MHz interferes with NGMB BS (MMDS effective antenna height 200 m)	0 km (NFD = 50 dB) 14.8 km(NFD = 30 dB)
	MMDS with EIRP of less than equal to 32 dBW/8 MHz interferes with NGMB MS (MMDS effective antenna height 200 m)	0 km (NFD = 30 dB)

Table 2: Summary of Technical Analysis Results

On the basis of these results, the following conclusions can be drawn.

- Scenarios of MMDS co-channel interference into NGMB BS receivers require the largest separation distances. The site data from the current MMDS licensee indicates that 17 out of 22 MMDS transmitters use EIRP of 18 and 19 dBW/8 MHz. For an MMDS EIRP of 18 dBW/8 MHz, the minimum required separation distances from the edge of MMDS coverage area are between 45.6 and 67.5 km when an MMDS transmitter effective antenna height is assumed to be between 100 and 300 m.
- Adjacent channel sharing requirements are determined by the NFD level which depends on transmitter and receiver selectivity masks. When interference from MMDS (with an EIRP of 18 dBW/8 MHz) into an NGMB BS is considered, the separation requirement from the edge of MMDS coverage area is zero (if it can be assumed that the MMDS transmitter mask complying with ETSI EN 300 744 determines the adjacent channel NFD of 50 dB). If it can be assumed that the NGMB BS receiver is the dominant factor and an NFD of 30 dB is available, then the distance required from the edge of MMDS coverage area is approximately 14.8 km.
- A number of mitigation techniques could be considered to improve the feasibility of MMDS and NGMB sharing.
    - Reducing the interfering transmitter EIRP will decrease the required separation distances but at the expense of a reduced coverage area. This could have implications for MMDS depending on the geographic location of their users.
    - Operating on the opposite polarisation reduces separation distances particularly for on-beam interference. It should however be noted that mobile systems generally operate at slant polarisation

and this provides only limited polarisation discrimination at MMDS receivers.

  - If the receiver operates below the local clutter height an additional path loss can be applied, resulting in a reduced separation requirement. However, this would not be applied to scenarios involving antenna heights above the local clutter (e.g. MMDS into NGMB BS)[6].
  - Antenna radiation patterns with better off-axis signal suppression may improve the sharing feasibility for scenarios where requirements are not determined by on-beam interference entries.
  - Depending on the elevation radiation pattern, an antenna downtilting may also help to reduce required separations at the expense of a reduced coverage.

- It should be noted that the analysis of advantages that could be obtained from the above mitigation techniques can be best addressed using practical deployment scenarios which is outside the scope of this study.

2.3 Impact of Technical Analysis Results (Example Scenario)

In this section, implications of the technical analysis results are discussed in an example scenario. The map in Figure 5 shows 3G base station sites (small circles) and MMDS transmitters (black square points). Circles of 62, 75 and 84 km radius are drawn around Dublin. These correspond to separation distances calculated to protect NGMB base station receivers from MMDS transmitters (operating at 18 dBW/8 MHz) assumed to be located at 100, 200 and 300 metres effective heights, respectively. Note that the separation distances given in Table 2 correspond to 'the distance between the edge of MMDS coverage area and the NGMB BS receiver location' as illustrated in Figure 31. The circles shown in Figure 5 represent 'the distance between the MMDS transmitter itself and the NGMB BS receiver' hence the difference of 16 km (which is equal to the minimum MMDS coverage radius) between the results in Table 2 and circles in Figure 5.

[6] Whilst NGMB base stations may be deployed at low levels to provide hot spot coverage there is no guarantee this will always be the normal case.

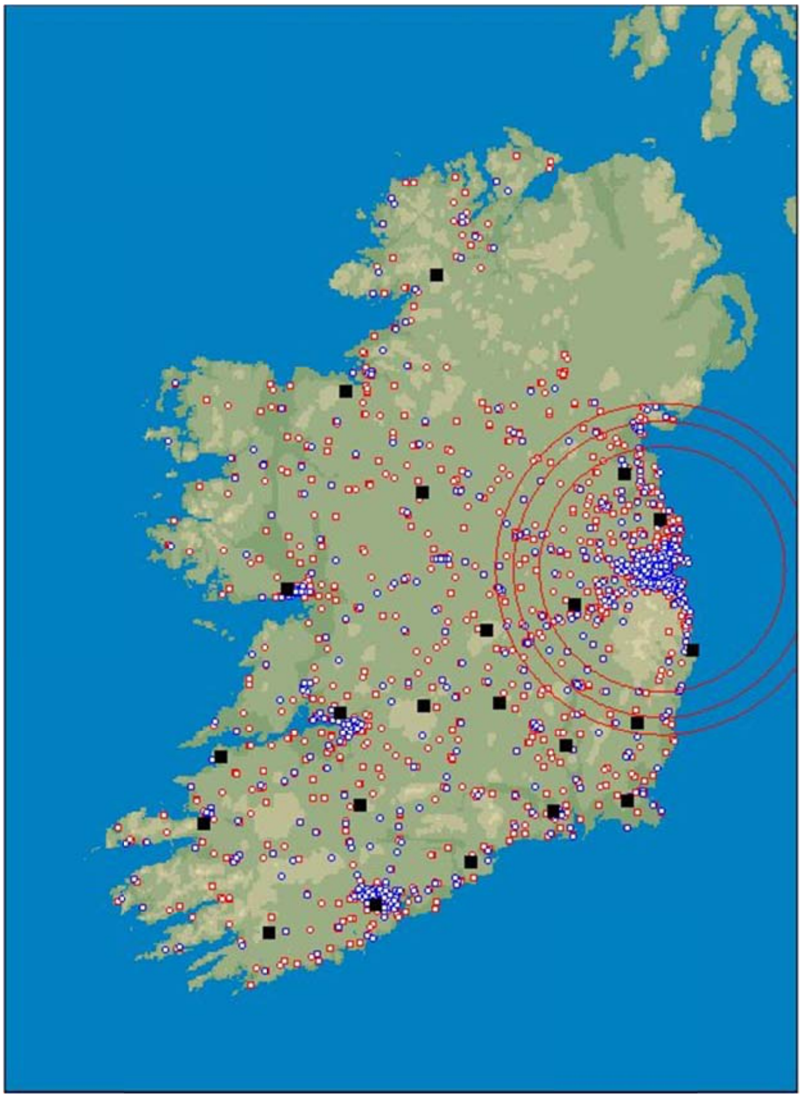

Figure 5: Example Scenario (Dublin) - Affected MMDS Sites

As can be seen, if an NGMB network is to be deployed in Dublin, co-channel with the MMDS transmitters, it will be necessary to turn off five MMDS transmitters (Mount Oriel, Naul, Dunmurry, Ballyguile and Sleve Buoy) if the MMDS transmitter is assumed to be located at an effective antenna height of 300 metres. Alternatively, if adjacent band operation is considered MMDS transmitters need to be moved to channels that are sufficiently far away from NGMB channels and as discussed in section 3 due to the current channel plans this appears to be infeasible.

If it can be assumed that the 84 km separation requirement (corresponding to an MMDS transmitter effective antenna height of 300 metres) removes the possibility of MMDS operation in counties of Dublin, Louth, Meath, Kildare and Wicklow and this could have a significant impact on the MMDS operator's customer base.

The interference analysis results suggest that interference from an MMDS transmitter into an NGMB base station receiver requires a large separation distance due to the transmitter and receiver heights involved. Further analysis has been undertaken to take account of terrain data on calculated separation distances. The analysis aims to determine the impact of emissions in the Dublin area from MMDS transmitters located in the counties surrounding Dublin. These include Mount Oriel, Naul, Dunmurry, Ballyguile and Sleve Buoy.

The following plots illustrate the results. In these plots, the red contour shows the area where the interference criterion of –142 dBW/5 MHz (i.e. 17 dBµV/m) is exceeded for more than 1% of time. In addition to the red contour, three more contours are shown. The blue contour indicates the area where an interference threshold of –132 dBW/5 MHz (representing 10 dB relaxed interference criterion) is exceeded. The green contour shows the area where a 20 dB relaxed criterion (i.e. -122 dBW/5 MHz) is exceeded. Finally the yellow contour shows the area where a 30 dB relaxed criterion (i.e. -112 dBW/8 MHz) is exceeded. It should be noted that the difference in contours could also be attributed to other factors by assuming that the interference criterion is fixed at -142 dBW/5 MHz. These may, for example, include a reduced power and/or smaller antenna gain.

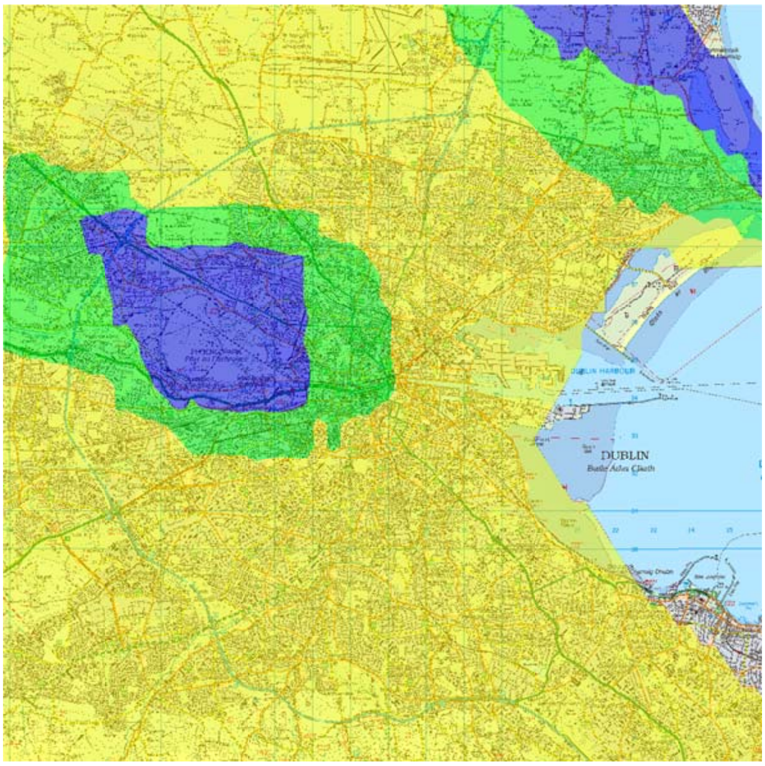

Figure 6: Interference over Dublin Area from Mount Oriel (EIRP = 18 dBW/8 MHz, Height Above Sea Level = 247 m)

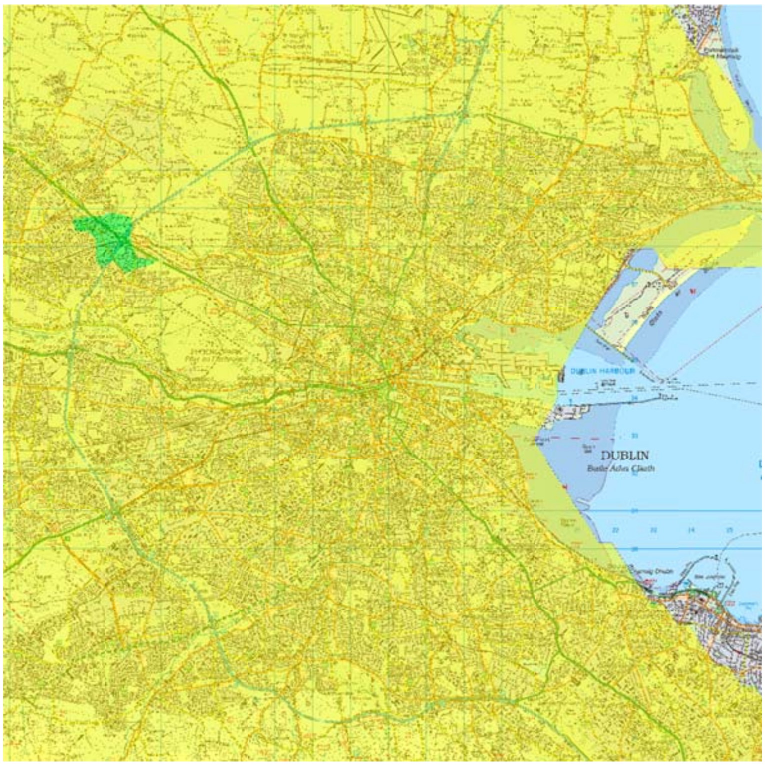

Figure 7: Interference over Dublin Area from Naul (EIRP = 24 dBW/8 MHz, Height Above Sea Level = 180 m)

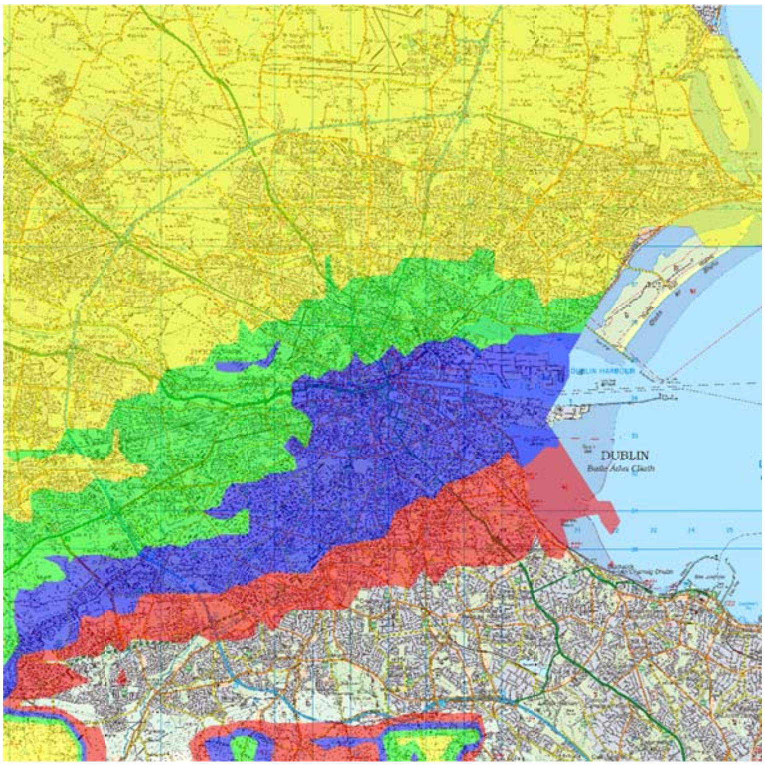

Figure 8: Interference over Dublin Area from Dunmurry (EIRP = 19 dBW/8 MHz, Height Above Sea Level = 231 m)

Figure 9: Interference over Dublin Area from Ballyguile (EIRP = 19 dBW/8 MHz, Height Above Sea Level = 188 m)

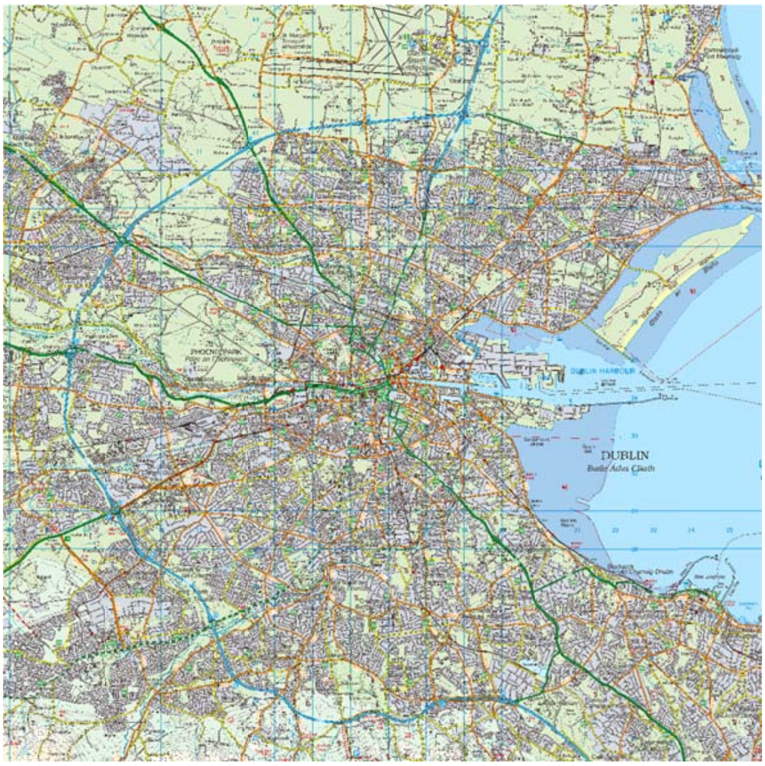

Figure 10: Interference over Dublin Area from Sleve Buoy (EIRP = 4 dBW/8 MHz, Height Above Sea Level = 213 m)

Results show that interference from an MMDS site located at Naul (Figure 7) is the most significant, as the Dublin area is covered even by the most relaxed interference contour (i.e. the yellow contour which indicates a 30 dB relaxed interference threshold). On the other hand, there is no interference threshold violation from emissions from an MMDS site located in Sleve Buoy (Figure 10) hence the map does not have any contours. Overall the analysis with terrain data indicates that while emissions from MMDS sites at Mount Oriel, Naul and Dunmurry affect most/all of Dublin area the impact of emissions from the site at Ballyguile is limited.

2.3.1 Conclusion on the Potential for Sharing in Dublin

It is not possible to advise on the potential for sharing between MMDS and NGMB in Dublin based on the above results as much depends on the potential for the MMDS transmitter equipment and / or antennas to be modified without overly impacting on the coverage provided where the majority of the MMDS users are located. There is of course the option of allowing the NGMB operators to utilise the 2.6 GHz spectrum in Dublin on the basis of detailed co-ordination with the MMDS operator. However, we would expect the burden placed on both the NGMB operators and current MMDS licensee would be such that this would not be an attractive option. Therefore it would be necessary to identify a geographic area within which the operators could deploy a NGMB network provided they meet a set of technical requirements while assuming the MMDS coverage areas are reduced.

3 TECHNICAL EVALUATION OF FEASIBILITY OF SHARING OPTIONS

This section takes the results of the interference modelling in Section 2 and combines it with the information on the technically feasible channel plans (Annex B) to see if there are technically feasible options in terms of co-channel or adjacent channel sharing that warrant a full cost benefit analysis, or whether the focus of the cost benefit analysis should be on spectrum reallocation scenarios.

3.1 Implications of Interference Modelling

3.1.1 Co-channel

The outcome of the sharing analysis demonstrates that co-channel sharing is mainly determined by interference from MMDS into NGMB base station receivers. Based on the typical MMDS transmitter EIRP, the minimum required separation distances from the edge of the MMDS coverage area into a NGMB base station receiver are calculated to be between 45.6 and 67.5 km.

The requirement for such separation distances means that it is unlikely to be feasible for the two services to share on a co-channel basis as MMDS has virtually contiguous coverage across Ireland. Taking Dublin as a specific example, as discussed in section 2.3 above, these separation distances could potentially require five MMDS transmitters to be turned off if a NGMB network is to be deployed in Dublin. Further analysis with terrain data indicates that there would be significant interference from three MMDS transmitters (Mount Oriel, Naul and Dunmurry) into Dublin with limited impact from Ballyguile and no impact from Sleve Buoy.

Whilst it might be possible to implement interference mitigation techniques (such as interfering transmitter EIRP reduction, use of opposite polarisations, improved antenna discrimination and antenna downtilting) each one would need to be assessed using practical deployment scenarios. Also to avoid the potential for interference it is likely there would be a need for detailed co-ordination between MMDS and NGMB.

It is therefore concluded that co-channel sharing may not be a feasible option.

3.1.2 Adjacent channel

The technical analysis indicates that adjacent channel sharing is feasible with a separation distance of at least 15 km from the edge of the MMDS coverage area to the base station. However, the sharing potential of the two services is dependent on the NFD level which depends on the transmitter and receiver selectivity masks. It will be necessary for MMDS transmitters to be moved to channels away from NGMB channels to provide adequate NFD levels or for additional filtering to be added to minimise the size of guard bands and / or to minimise the separation distances. The option of moving to channels away from NGMB is not feasible as the current channel plan uses either all the odd channels or all the even channels at a given MMDS site.

Therefore the only options for adjacent sharing will be to use a very limited number of TDD channels or for MMDS to deploy MPEG-4 to improve the compression and so reduce the spectrum required. This is discussed in the following section.

3.2 Channel Plan Options

3.2.1 Channel Plan with MPEG-2

If MMDS continues to use MPEG-2 compression and the existing radio frequency channels then there is limited spectrum that could be used to support NGMB as shown in Figure 11.

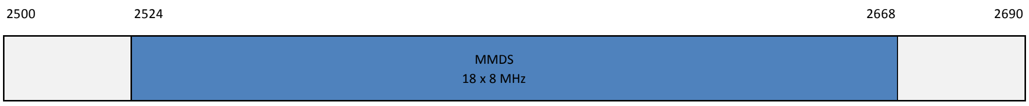

Figure 11: Current 2.6 GHz Channel Plan with MMDS (MPEG-2)

Depending on the required guard bands the maximum available spectrum would be 40 MHz, and potentially it could be significantly less depending on the NFD. Also it would not be possible to deploy FDD technology as the duplex spacing is greater than the 120 MHz FDD spacing obligation as set out in EC Decision 2008/477/EC, and as shown in the preferred 2.6 GHz channel plan for NGMB (shown below in Figure 12). It would therefore be necessary to use TDD in the available spectrum but that also does not match with the channel plan.

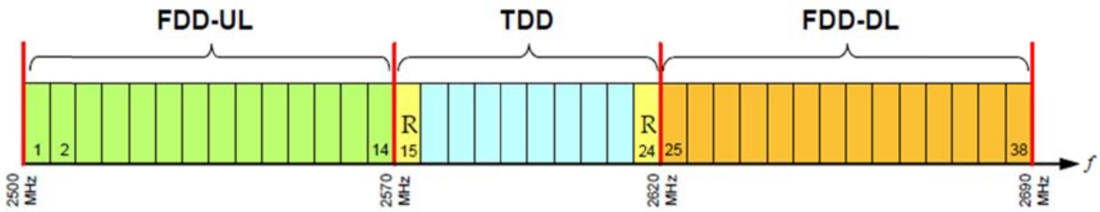

Figure 12: 2.6 GHz Band Plan (Ref: ECC Report 131)

It might be feasible to move the radio frequency channels allocated to MMDS and release TDD spectrum as shown in Figure 13.

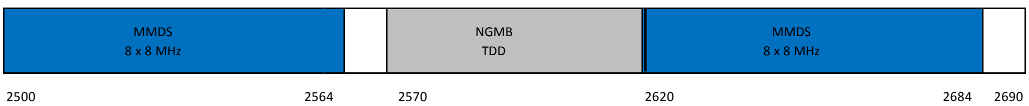

Figure 13: Example 2.6 GHz TDD Channel Plan with MMDS (MPEG-2)

There will, however, be a need for guard bands between MMDS and NGMB which will reduce the number of channels available for MMDS if the full 1 x 50 MHz of un-paired spectrum is to be released. Also to date in Europe there has been less interest in 2.6 GHz TDD spectrum[7] and the release of FDD spectrum with 120 MHz duplex separation appears to be the most attractive option.

It is therefore concluded that adjacent channel sharing is probably not attractive without migrating MMDS to MPEG-4, as there would be a very limited amount of spectrum available for NGMB and it would only be suitable for TDD.

3.2.2 Channel Plans with MPEG-4

It is expected that migrating to MPEG-4, which will require all user decoders to be replaced, will provide a spectrum reduction of around 50% assuming that the MMDS provider continues to deliver the same programme material channels as currently.

A number of possible radio frequency channel plan options are provided in Annex B. For example if it is assumed that the MMDS spectrum can be reduced from 18 to 9 off 8 MHz radio frequency channels, as shown in Figure 14 below, then there is the potential for a maximum of 2 x 45 MHz of FDD spectrum to be made available for NGMB. The amount of spectrum might be less depending on the need for guard bands between NGMB and MMDS.

Figure 14: Example 2.6 GHz FDD Channel Plan with MMDS (MPEG-4)

If there was at least 2 x 40 MHz of spectrum available, then that could support 4 operators each with 2 x 10 MHz. There is also a maximum of 1 x 25 MHz of unused spectrum that could possibly be used for TDD NGMB (with a 5 MHz guard band between FDD and TDD channels) or for 1 or 2 additional MMDS channels (depending on the guard bands that are needed).

Although deploying MPEG-4 will reduce the amount of spectrum needed by MMDS by about 50% while supporting the same programme material channels the investment in new set top boxes will not provide any, or only very limited, opportunities to provide high definition or further standard definition channels. It is therefore concluded that adjacent channel sharing based on migration to MPEG-4 may not be an attractive option.

3.3 Conclusions

Based on the results of interference modelling and considerations of feasible channel plans, we conclude that the various sharing options may not be attractive. The economic analysis in the following section therefore focuses its attention on reallocation options as opposed to the co- or adjacent channel sharing options.

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[7] In the Netherlands the TDD spectrum was not sold, in Norway Telenor combined un-paired spectrum to make paired and in Sweden the average price of paired spectrum was 4 times that of unpaired.

This is not to rule out co- or adjacent channel sharing, rather it points to the need for more detailed modelling of these options taking account of interference probabilities and realistic commercial deployment options in order to provide a basis for economic evaluation. However, such further technical and economic analysis might only be justified if there is real interest amongst stakeholders compared to the status quo or 2.6 GHz reallocation options.

4 ECONOMIC ANALYSIS

4.1 Introduction

The technical analysis has established that MMDS and NGMB sharing the 2.6 GHz spectrum is not likely to be feasible.

The economic analysis is therefore focused on the alternative uses of the spectrum; whether MMDS should continue to use the spectrum or whether it should be released for alternative uses, such as NGMB.

The current MMDS licences in the 2.6 GHz band expire between April 2012 and April 2014, with the majority expiring at the later date. Prior to the later date ComReg has to make a decision as to whether or not to renew the licences for a period of up to five years. However, if it is possible to design a competitive process to enable both MMDS and NGMB to compete for the spectrum this would allow ComReg to allocate the spectrum on the basis of market demand rather than deciding to allocate it to a particular use. On this basis it is not therefore necessary for the economic analysis to determine the best use of the spectrum as this can be determined by a competitive process.

Our analysis, however, is intended to assist ComReg to assess whether there is a case to renew the MMDS licence(s) or to use a competitive process to award the band in 2014. It is also possible for ComReg to renew the MMDS licence(s) for a period of less than five years and the economic analysis also assesses the impact of renewing the licence for a shorter period.

The economic analysis involves the following steps:

- Setting out the methodology for the cost benefit analysis, and defining a base case and the scenarios for analysis against this base case.
- Identifying the relevant costs and benefits.
- Explaining the methodological points which underpin the analysis.
- Evaluating the options.
- Explaining the underlying assumptions for estimating the parameters.
- Considering how each option impacts on competition.
- Performing a sensitivity analysis.
- Performing a qualitative distributional impact analysis.

4.2 Methodology

A cost benefit analysis considers the incremental changes to costs and benefits in relation to a base case. Our base case scenario involves the renewal of MMDS licences by ComReg allowing continued service for the period to 2019.

We have compared the costs and benefits of two other scenarios against this base case:

Against our base case[8] or counterfactual scenario of continued MMDS use to 2019 utilising MPEG2 technology we consider the following alternatives:

- Option 1: End MMDS licence in 2014 and release the 2.6 GHz spectrum for alternative uses (assumed to be mobile broadband) in April 2014, and
- Option 2: Extend MMDS licence to 2017 and release the 2.6 GHz spectrum for alternative uses (assumed to be mobile broadband) in April 2017.

The relevant time period under consideration is therefore 2014-2019. We have not taken into account costs and benefits beyond 2019 since the base case involves making 2.6 GHz available for mobile broadband beyond 2019.

4.3 Benefits and Costs

In undertaking this cost benefit analysis, the key practical issue is determining the relevant costs and benefits and how they differ under the two scenarios.

4.3.1 Benefits

There are two key benefits which we have considered in our analysis:

- The avoidance of the costs of operating MMDS over the relevant period (based on Section 4.9.3).

  If MMDS is no longer being provided, the costs involved in providing this service are no longer incurred by the MMDS provider. We have estimated that operating costs are likely to amount to between 30-50% of all revenues from MMDS customers. Using an estimate of the average revenue per customer per year we can estimate total revenues from MMDS services, and from that an estimate of MMDS operating costs that would no longer be incurred once the MMDS licence expires.[9]

- The value of 2.6 GHz spectrum if it is used to provide mobile broadband services rather than MMDS for the relevant time period.

[8] We considered whether the base case should involve MMDS with MPEG2. We reject the upgrade to MPEG4 option on the grounds that it involves an additional set top box transition compared to continuation with MPEG2, as all MMDS consumers would require a new set top box to receive MPEG4 and then a further change from 2019 for customers to receive TV from other sources (e.g. satellite). While upgrading to MPEG4 may or may not be commercially attractive for the MMDS operator on customer retention/growth grounds, it is more economically costly than the alternative of fully reallocating spectrum for NGMB in 2014, with little or no economic benefit. This is because customers can receive the service improvements from MPEG4 from other sources such as satellite TV. Therefore, from an economic perspective there is no gain to consumers, only the additional costs associated with change of set top boxes to enable MPEG4.

[9] In relation to NGMB, the relevant consideration is the cost of the service with and without 2.6 GHz spectrum. The benefits of this potential cost reduction are reflected in our analysis via the value attributed to 2.6GHz spectrum for NGMB use.

Given the propagation characteristics of the 2.6 GHz band, the most likely alternative use for 2.6 GHz band is to provide mobile broadband services. Therefore we have estimated the value of the band, using auction data from other countries where 2.6 GHz licences have been acquired by operators who provide mobile broadband services. Auction data is therefore used as a proxy for the value of the spectrum. Adjustments to the data have been made to take into account of differences in Ireland (e.g. population).

The estimation techniques used to estimate each of these benefits is presented below in Section 4.9.1, including any simplifying assumptions deemed necessary to undertake the analysis.

4.3.2 Costs

The key costs are the costs of MMDS customers switching from MMDS to an alternative pay TV platform. This will require new set top boxes and satellite equipment for each affected customer. Under the base case, in 2019 all remaining MMDS customers would require this new equipment to switch to an alternative pay TV platform. Therefore for the purposes of this CBA we are concerned with the cost of bringing forward switching by MMDS consumers from 2019 to 2014 (Option 1) or 2017 (Option 2).

The total switching costs will depend on three factors:

- The number of MMDS customers at the date of the switch to an alternative TV platform. Note we have used historical customer data to forecast the number of MMDS customers over the relevant time period.
- The cost of new equipment (set top box and satellite dish receiver with installation). Note we have obtained cost estimates for new equipment. As there are wide variations we have taken a low and high estimate. Our analysis includes the cost of set top boxes and satellite dishes, regardless of whether the new provider might partly or completely subsidise this equipment. This is because our analysis is focused on the economic cost, regardless of whether the customer or their provider pay for the equipment, and this is a cost that is incurred due to the switchover. Further, this cost will apply to all MMDS customers at the point in time when they switch.
- The amount of time takes to switch and the cost of this time for customers. Note we estimate the amount of time it would take to switch providers. Using a value of time from other studies, we can estimate total cost of this time for all affected customers.

The estimation techniques used to estimate each of these costs is presented below in Section 4.9.4, including any simplifying assumptions deemed necessary to undertake the analysis.

4.4 Methodological framework

In undertaking this analysis, we draw on a standard text on impact assessment by Boardman et al (2006)[10], guidance on impact assessment produced by ComReg[11] and our own development of practical impact assessment guidance for ERO.[12] Before considering each parameter in detail, we set out some methodological points which underpin the assessment of the costs and benefits of each of the different options.

The following methodological points are important to carrying out sound cost benefit analysis and have direct implications for this analysis:

- Incremental costs and benefits should be considered relative to a base case (or counterfactual). The base case is that the 2.6 GHz band is used for MMDS until 2019 as this is the latest date for extension to MMDS licences. The focus is on the difference between options not the overall costs and benefits of the base case or an alternative.
- An economic cost benefit analysis differs from a commercial analysis of options. The focus of an overall economic cost benefit analysis is on the value of alternatives collectively to end consumers and producers. Considerations which may be central to an individual service provider may be irrelevant for the purpose of this analysis, for example, who meets demand for TV services and who profits, and who meets demand for broadband access and who profits.[13] Further, revenue transfers (including taxes) are not directly relevant since they involve a gain to one party and an equal and offsetting loss to another party.
- Second round impacts that involve a redistribution of primary costs and benefits rather than net economic impacts should be ignored. [14] The exception to this general principle is genuine externalities which are not "internal" to the market, e.g. if mobile broadband facilitated improved information systems for social transport (both public transport and private sharing schemes) thereby reducing congestion and pollution associated with private transport, then such second round impacts should in principle

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[10] Boardman, Greenberg, Vining and Weimer. 2006. "Cost-benefit analysis – concepts and practice." Pearson International Edition. Third Edition.

[11] ComReg. August 2007. Guidelines on ComReg's approach to regulatory impact assessment. http://www.comreg.ie/_fileupload/publications/ComReg0756a.pdf

[12] Plum Consulting. August 2009. "Impact assessment framework." http://www.plumconsulting.co.uk/pdfs/Plum_Aug09_Impact_assessment_framework.pdf

[13] These considerations would be relevant if they involved a material change in the overall level of competition in the market since competition promotes efficiency and innovation.

[14] These second round impacts are referred to as pseudo-externalities or pecuniary externalities. As Boardman *et al* put it: "*We can, and indeed, should ignore impacts in undistorted secondary markets...*" (page 113). Baumol and Oates. 1988. "The theory of environmental policy." Second edition. Cambridge.

be counted. In practice it may be difficult to estimate the magnitude of such second round impacts. For instance, we make the simplifying assumption that the difference in incremental external social value between the use of 2.6 GHz spectrum for mobile broadband compared to TV is zero (see Section 1.81 below).

4.5 Option 1: Release 2.6 GHz Spectrum Band in 2014

4.5.1 Results

As noted above, we have considered low and high values for a number of parameters where appropriate.

The results indicate that there are net benefits from the release of the 2.6 GHz spectrum band in 2014, and these range between €16.8 to €41.5 million.

	Low (2010 €m)	High (2010 €m)
Benefits		
Value of spectrum	6.3	25.5
Saving from non-incurrence of MMDS operating costs after 2014	12.5	20.8
Total Benefits	**18.8**	**46.3**
Costs		
Set top box	0.6	2.7
Satellite dish receiver (including installation)	1.0	1.7
Value of customer time taken to switch from MMDS to alternative	0.4	0.4
Total Cost	**1.9**	**4.8**
Net Benefits	**16.8**[15]	**41.5**

Table 3: Results of Cost Benefit Analysis for Option 1 versus the Base Case

4.6 Option 2: Extend MMDS licences to 2017, Release 2.6 GHz Spectrum Band in 2017

4.6.1 Results

The net benefits of Option 2 are estimated to be between €4.8 and €13.8 million.

[15] Note rounding differences mean that figures in table do not exactly sum to total.

	Low (2010 €m)	High (2010 €m)
Benefits		
Value of spectrum	2.4	9.6
Saving from non-incurrence of MMDS operating costs after 2017	3.5	5.8
Total Benefits	**5.9**	**15.4**
Costs		
Set top box	0.2	0.8
Satellite dish receiver (including installation)	0.3	0.5
Value of customer time taken to switch from MMDS to alternative	0.3	0.3
Total Cost	**0.7**	**1.6**
Net Benefits	**5.1**	**13.8**

Table 4: Results of Cost Benefit Analysis for Option 2 versus the Base Case

4.7 Option 1 versus Option 2

Based on our analysis, the extension of MMDS licences from 2014 to 2017 (Option 2) would reduce the total benefits and the total costs. The benefits are reduced because the spectrum is available for mobile broadband for a shorter period of time. The costs of switching are lower due to the expected decline in MMDS subscriber volumes by 2017.

Therefore the results suggest that Option 1, whereby the MMDS licences expire in 2014, is more beneficial relative to extending licences to 2017.

	Low (2010 €m)	High (2010 €m)
Net Benefits (2014) – Option 1	16.8	41.5
Net Benefits (2017) – Option 2	5.1	13.8
Cost of delayed decision to 2017	11.7[16]	27.6

Table 5: Comparison of Options 1 and 2

4.8 Impact on Competition (Option 1 versus Option 2)

The impact on competition is the same for both options except these impacts are deferred in the case of Option 2.

Non-renewal of the MMDS licences and the reallocation of spectrum to mobile broadband would impact on competition in the broadcast and broadband markets.

In the broadcast market a platform for viewing TV programme material would be removed thereby reducing competition. However, this reduction does not apply

[16] Note rounding differences mean that figures in table do not exactly sum to value.

nationally. Further, there are both pay and free to air alternatives to MMDS. MMDS customers currently account for around 7% of the pay TV market and we forecast that this will decline to about 4% by 2014.[17] Further consumers have free to air terrestrial and satellite options.

In the broadband market additional spectrum could have two beneficial impacts:

1. Additional spectrum may make entry more likely and/or exit/consolidation less likely (as a motive for consolidation may be to achieve wide spectrum channel widths and higher performance and capacity).
2. To the extent that additional spectrum reduces the cost and increases the quality of mobile broadband, it could compete more effectively with fixed broadband at the margin.

However, it is recognised that, as part of ongoing spectrum liberalisation projects, ComReg is planning to jointly award spectrum in the 800 MHz and 900 MHz bands and possibly the 1800 MHz band[18] which may impact on demand for the 2.6 GHz band, see Section 1.2. The availability of spectrum in a range of bandwidths (including 800, 900 and 1800 MHz) is a common feature across many markets and will be reflected in auction outcomes and is therefore taken into account in our analysis. It is unclear to what extent that spectrum at sub 1 GHz is a substitute or complement to 1800 MHz and 2600 MHz. The availability of sub 1 GHz spectrum may reduce the cost of services and improve quality and this in turn may create demand for 1800 MHz and 2600 MHz to provide additional capacity in congested areas. In other places, sub 1 GHz capacity may substitute for 1800 MHz and 2600 MHz spectrum.

The competition impacts, in terms of alternatives, coverage and customer numbers, for the broadcast and broadband markets in Ireland are summarised in Table 6.

[17] Current data based on ComReg Q3 2009 market data report.

[18] See ComReg Document 10/105.

	Broadcast Market	Broadband Market
Impact of reallocating spectrum	Elimination of MMDS platform	Enhancement of mobile broadband platform in terms of speed, capacity and reduced cost in areas of high traffic density (not just large urban areas) Improved mobile broadband service versus other broadband platforms Increased likelihood of entry/avoidance of consolidation for mobile broadband
Alternatives	Terrestrial (digital with HD before 2014) Free satellite Pay satellite Internet TV (limited by fixed network quality and mobile broadband capacity[19])	Fixed & Fixed Wireless broadband Cable in some urban areas Satellite (with capacity constraints) Existing mobile broadband services using non 2.6 GHz spectrum
Coverage	Outside of cable areas	Nationwide
Customers	Estimated 35,000 MMDS customers in 2014 with annual decline of 15.48% pa based on historic trend	All wireless data device users – may exceed half of all mobile phone owners within five years given smart phone growth

Table 6: Comparison of Competition Impacts in Broadcast and Broadband Markets

4.8.1 Wider External Social Costs and Benefits

In relation to the wider social costs and benefits we note that mobile broadband is capable of supporting a wide range of services including individual health monitoring, emergency response service use of video and social transport information services that have wider social benefits.[20] However, we make the simplifying and conservative assumption that the incremental external social value from additional spectrum for mobile broadband is zero, relative MMDS.

The wider external social costs and benefits are the same for both options except these impacts are deferred in the case of Option 2.

[19] Under the National Broadband Scheme, Hutchinson 3G Ireland Ltd offers packages with data caps of 25 GB per month.

[20] Brian Williamson. 2010. "Nomadicity and the evolution of applications, networks and policy". Forthcoming in *Australian Journal of Telecommunications*, November.

4.9 Parameter Values: Estimates and Assumptions

We now discuss how the parameters in the model are estimated and the assumptions we have made to simplify the analysis where necessary. In particular, we have estimated a low and a high value for relevant parameters.

4.9.1 Value of spectrum

The value of 2.6 GHz spectrum for NGMB reflects the scope for improved service in terms of speed and capacity, and the scope to reduce the costs of meeting demand by substituting spectrum for additional base stations. We have estimated a low and high estimate for the 2.6 GHz band. The lower value of the spectrum (€6.3 million) is estimated based on econometric analysis of outcomes of 2.6 GHz spectrum auctions by DotEcon.[21] This analysis identifies a specific coefficient for 2.6 GHz spectrum per head of population. We have applied this co-efficient to Irish population data to estimate the value of 140 MHz of 2.6 GHz spectrum and then derived the value of the spectrum for the 2014–19 period. Under this approach, the 2.6 GHz spectrum has a value of €0.0466 per MHz pop or €6.3m for the period 2014–19. We also considered the simple average from a range of 2.6 GHz auctions which gave an estimate that was almost identical to the result of the econometric analysis.

The high value is based on benchmarking with competitive auction outcomes. The high value is based on outcomes of a number of 2.6 GHz in Hong Kong, Sweden and Denmark which have been considered to be competitive.[22] Using this approach, we estimate the value of the 2.6 GHz spectrum as €25.5m or €0.19 per MHz pop – around four fold higher than the low value.

Parameter	Value (low)	Value (high)
Value of 2.6 GHz spectrum per MHz per capita	€0.0466 per MHz pop[23] This equates to €6.3million.	€0.1883 per MHz pop[24] This equates to €25.5 million.

Table 7: Spectrum Value Assumptions

We undertook a sense check on the above spectrum values based on auctions by drawing on the general observation that the availability of additional spectrum for mobile broadband should mean that an operator requires less base stations to meet demand, other things being equal. Therefore with additional suitable spectrum, operators should benefit from a reduction in the overall operating costs of mobile

[21] Dotecon (17 September 2010), Award of 800 MHz and 900 MHz spectrum, Update report on benchmarking, ComReg Document 10/71b.
[22] Richard Marsden, Eimear Sexton and Arisa Siong, "Fixed or flexible? A survey of 2.6 GHz spectrum awards", *Intermedia,* Institute of International Communications, October 2010, Volume 38 Issue 4.
[23] ComReg 10/71b, page 30.
[24] Richard Marsden, Eimear Sexton and Arisa Siong, (October 2010).

broadband services as less base stations are required. We use the base station costing used by Ofcom in its cost modelling for spectrum liberalisation[25].

Using this observation, we consider the number of base stations that would need to be avoided if additional spectrum were available to justify the spectrum values at auction. This calculation is based on a trade-off between the purchase of additional spectrum or the roll out of further base stations by an operator. The low estimate of spectrum value (€6.3 million) would imply the avoided cost of approximately 155 base stations (i.e. around 30 base stations per year)[26], while the upper value (€25.5 million) would be consistent with the avoided cost of approximately 630 base stations (i.e. around 120 base stations per year) over the period 2014–19. We have assumed that no new sites are required and that opex costs are avoided for half of the 2014–19 period.

Parameter	Value (low)	Value (high)
Base station cost	£25,000 equipment plus opex at €5,000 per year	£50,000 site acquisition cost plus £25k equipment plus opex at 10% of site acquisition costs

Table 8: Estimates of base station costs

We are of the view that none of the above three methods is likely to capture the full value associated with mobile broadband. Consumer benefits in terms of capacity and speed which are in addition to cost reduction benefits are not valued in our analysis. Therefore our approach to valuing the benefits of mobile broadband is conservative.

4.9.2 Forecasted number of MMDS subscribers 2014-2019

An input into the calculation of switching costs is the forecasted number of MMDS subscribers over the relevant time period. Firstly we considered historic quarterly data on the number of MMDS subscribers from 2008 – 2010. The most recent data available is for Q3 2010.

[25] Ofcom. February 2009. Annex 15 on *"Technical Study of the Effect of Frequency on 3G Infrastructure Costs"* http://stakeholders.ofcom.org.uk/binaries/consultations/spectrumlib/annexes/annex15.pdf

[26] We have assumed base station costs of €31,700, based on Ofcom's 2009 estimate of base station costs, adjusted for equipment inflation -2.5% and translated into euros.

Period	MMDS subscribers
Q1 2008	101,700
Q2 2008	96,320
Q3 2008	92,878
Q4 2008	88,933
Q1 2009	85,315
Q2 2009	81,835
Q3 2009	78,448
Q4 2009	74,300
Q1 2010	72,100
Q2 2010	69,500
Q3 2010	66,900

Table 9: Historic MMDS subscriber volumes

The average annual decline in quarterly volumes between 1st quarter 2009 to 3rd quarter 2010 compared to the previous year was 15.48%. We have used this to forecast future subscriber volumes.

We have also included *indirect cable customers* whereby content is fed to a group of cable customers utilising MMDS. We have assumed that service to these customers is also discontinued once the MMDS licences expire. In practice, it may be feasible to maintain service to these customers via a fibre connection or a satellite link to the head end. In this case, the cost will be lower than we have assumed in our analysis. The most recent data available is that there are 21,000 indirect cable customers.

The table below presents our forecasts for future MMDS subscriber volumes based on an annual decline of 15.48% for second quarter of each year. We have included indirect cable subscriber volumes of 21,000 in our calculation for the total number of subscribers affected by switch off of MMDS.[27] We have assumed a constant volume of indirect cable subscribers over the period 2014-2019 as we do not have historic data on cable subscriber volumes.

[27] Indirect cable subscriber volumes have been provided to Aegis/Plum by ComReg.

Period	MMDS subscribers	Indirect cable	Total Subscribers
2011	58,743	21,000	79,743
2012	49,650	21,000	70,650
2013	41,965	21,000	62,965
2014	35,470	21,000	56,470
2015	29,980	21,000	50,980
2016	25,339	21,000	46,339
2017	21,417	21,000	42,417
2018	18,102	21,000	39,102
2019	15,300	21,000	36,300

Table 10: Forecast MMDS subscriber volumes

4.9.3 Savings resulting from non-incurrence of MMDS operating costs

We have estimated the savings resulting from the non-incurrence of MMDS operating costs if MMDS services are no longer provided i.e. if the operator was to cease providing MMDS services, these costs would be avoided. We have assumed that the operating costs of providing MMDS are between 30% (used for low scenario) to 50% (used for high scenario) of current MMDS revenues. We estimate MMDS revenues based on a TV service price of €24.75 per month per customer. This is a mid-point in the range of digital TV services and is the price of analogue services. Based on total MMDS customers of 69,500 (excluding indirect cable customers), in Q2 2010 this equates to approximately €20.6 million in revenues per annum. We have excluded indirect cable customers from this calculation, as the cost of providing capacity to the cable head end is likely to be different from providing services to end customers via MMDS. We also assume that operating costs are declining in line with falling volumes of MMDS customer numbers. This is a conservative assumption as some costs may not fall in line with falling volumes.

As stated in the methodological points in Section 4.4, we focus on the first round impacts in the TV and NGMB markets. This means that the reduction in operating costs from closure of MMDS should be counted as a benefit. However, the impacts on suppliers of services to the MMDS operator for providing MMDS should not be counted, since the reduction in costs associated with their purchase has already been counted as a benefit in relation to first round impacts.

4.9.4 Switching from MMDS to Alternative TV platforms

There are costs involved in switching from MMDS to an alternative TV platform. The key elements of the switching cost estimate used in our analysis are:

- The volume of customers at the date of the switch (see Table 10);
- The cost of equipment (new set top boxes, satellite dish receiver and installation); and

- The value of customer time involved in making and implementing the switching decision.

Our cost estimate is based on calculating the cost of bringing forward the switch from 2019 to 2014 (Option 1) or 2017 (Option 2). This means that the cost estimate is the net cost of switching in 2014 less the cost of change in 2019. This is because customers would have to switch under the base case in 2019 and our concern is the incremental cost of bringing forward the switchover to 2014.

Cost of new equipment required to switch to alternative TV platforms

All customers switching from MMDS to an alternative TV platform are assumed to require a new set top box and satellite dish receiver with installation. The cost of set top boxes and satellite dish receivers with installation are used to estimate the equipment costs of a customer to switch from MMDS to an alternative service. As there are a wide range of potential set top boxes with varying degrees of functionality, and satellite dish receivers, we have included a high and low value for them.

Our analysis includes the cost of set top boxes and satellite dish receivers regardless of whether the new provider might partly or completely subsidise this equipment. This is because our analysis is focused on the economic cost regardless of whether the customer or their provider pays for the equipment; a cost is incurred due to the switchover.

Parameter	Value (low)	Value (high)
New equipment required by MMDS customers switching to alternative TV platforms:		
1. Set top box cost[28]	€56	€250
2. Satellite dish receiver cost (including installation)[29]	€90	€159

Table 11: Switching cost assumptions

Individual consumers will place different valuations on alternatives to MMDS delivered TV services. Those customers who have previously switched clearly value alternatives more highly than the MMDS service whilst those who remain/adopt the MMDS service do not. However, customers who have not switched are still likely to place some value on alternative TV services. We assume that the value difference between the benefits to customers on MMDS versus

[28] Low value from DCMS/DTI (20 December 2005), Memorandum on the Costs and Benefits of Digital Switchover (converted from pound to euro using exchange rate of £1 = €1.126) and High value for Triax Terrestrial - Satellite HD Combi Receiver from GPTV, http://www.gptv.ie/buy_sat4free_74.html#

[29] Low value from Maplin (converted from pound to euro using exchange rate of £1 = €1.126) http://www.maplin.co.uk/Module.aspx?ModuleNo=227935&C=Froogle&U=227935&T=Module viewed on 25 October and high value from Freesat i.e. http://www.freesat.ie/index.php?cat=Satellite_Installer viewed on 25 October 2010.

alternative platforms is half of the switching cost on average – consistent with an assumption that the benefit for individual customers ranges from zero to the full switching cost (for those who are just indifferent). Assuming a uniform distribution of benefits between zero and the overall switching cost, then the net switching cost is half the actual switching cost on average. This assumption is consistent with DCMS/DTI costing of the costs and benefits of digital switchover in the UK.[30]

Value of Time

The value of leisure time and the estimate of time for a customer to switch are inputs into the value of customer time lost through switching. We have assumed that it would take 2 hours to switch. The value of leisure time, obtained from another study, is estimated to be €6.10 per hour.

Parameter	
Value of leisure time for consumers[31]	€6.10 per hour
Time taken by consumer to switch	2 hours

Table 12: Value of time assumptions

4.9.5 Producer surplus

The loss of producer surplus for the MMDS operator is likely to approximate the gain in producer surplus to alternative TV platform providers from customers migrating to these alternative TV platforms. Broadcast platforms have high fixed costs and low incremental costs related to customer care so incremental customers involve significant incremental profit. For this reason, we assume that, even though customer switching between operators will involve a significant redistribution, overall producer surplus is unchanged and there is no net impact.

4.9.6 Financial assumptions

The discount rate is used to compare costs and benefits in different time periods. The inflation rate is used to index costs over time.

[30] DCMS/DTI, "Supplementary memorandum on the costs and benefits of digital switchover", 20 December 2005.
[31] National Roads Authority (March 2008), Project Appraisal Guidelines, Appendix 6 – National Parameters Value Sheet, page 5.

Parameter	
Real discount rate[32]	4%pa
Inflation rate[33]	2% pa

Table 13: Financial assumptions

4.10 Sensitivity Analysis of Option 1

We have undertaken a sensitivity analysis to identify how the results of the cost-benefit change if key input assumptions and parameters are varied. Our analysis has used a broad range of input values, so we assess the impact on the analysis of using the low benefit with high costs and vice versa. The results of the five scenarios considered as part of the sensitively analysis are presented in Table 14 below.

	Net benefits €m
Option 1: MMDS licence ends 2014 (low estimate)	16.8
Scenario 1: Low benefits/high costs	14.0
Scenario 2: Lower spectrum value	13.7
Scenario 3: MMDS Incremental costs 50% of low value	10.6
Scenario 4: Consumer switching time of 5 hours	16.3
Scenario 5: Satellite Dish (including installation) cost of €250 per dish.	16.2

Table 14: Results of Sensitivity Analysis

The results in Table 14 suggest that even if the high end of the costs and the low end of the benefits materialise (Scenario 1), the result is only slightly lower than Option 1, low estimate.

We tested the impact of lower spectrum values on the estimated net benefits (Scenario 2). We assessed the impact of the spectrum being only 30% of the low value in 2014 and 2015 and 60% of the low value in 2016 to 2019. This tests the sensitivity of our analysis to potential variations in the value of the 2.6 GHz band in Ireland. We still find a net benefit of €13.6m from MMDS licence expiry in 2014, which suggests that outcomes of the CBA are robust to a range of spectrum values.

The results of the CBA are most sensitive to potential variations in the costs of operating the MMDS platform (Scenario 3). Our sensitivity test assumes that the

[32] Department of Finance, Ireland, Project Discounts and Inflation Rates, http://www.finance.gov.ie/viewdoc.asp?DocID=5387&CatID=56&StartDate=1+January+2010&m= , viewed on 25 October 2010.
[33] Department of Finance, Ireland, Project Discounts and Inflation Rates, http://www.finance.gov.ie/viewdoc.asp?DocID=5387&CatID=56&StartDate=1+January+2010&m= , viewed on 25 October 2010.

costs of the MMDS are 50% of our low value in the CBA i.e. 15% of current MMDS revenues. This reduces the net benefits of 2014 switch off to €10.6m.

We test the impact of increasing the time involved in consumer switching from 2 to 5 hours (Scenario 4) and increasing the high cost of an installed satellite dish from €159 to €250 (Scenario 5). Both of these changes have little impact on the overall net benefits.

We conclude that the findings of our CBA are robust to significant changes in key input parameters and in particular are not sensitive to lower values of spectrum for mobile broadband.

4.11 Qualitative distributional Impacts

The above analysis considers the net impact of alternative uses of 2.6 GHz spectrum. In this section, we consider the distributional impacts on various stakeholders of releasing 2.6 GHz spectrum in 2014 for mobile broadband and discontinuing MMDS.

	Positive	Negative	Neutral
Urban broadband consumers	2.6 GHz spectrum likely to improve capacity and speed, and increases competition for mobile broadband.		
Rural broadband consumers	Larger blocks e.g. 2x20 MHz may enable higher speed mobile broadband in areas where 2.6 GHz rolled out.		
Urban television			No expected impact, as they still have access to Cable and Sky pay TV platforms
Rural television		Loss of choice between SKY and UPC pay TV. However, these consumers are still able to access full range of pay TV services on Sky and most consumers also able to access new DTT service and other alternative TV platforms such as Free Satellite.	
Sky	Incremental benefit from additional MMDS customers who switch to Sky.		

	Positive	Negative	Neutral
RTE	Incremental benefit from additional MMDS customers who switch to RTE's DTT service.		
UPC		Loss of profits from MMDS service	
Mobile operators	May benefit from additional revenues from provision of better quality services, but in a competitive market these gains are likely to be passed onto consumers.		
Government			Gains revenue from auction of 2.6 GHz, but may lose on VAT revenue from customers switching to Sky.

Table 15: Distributional Impacts

The key beneficiaries of the release of 2.6 GHz spectrum for mobile broadband are mobile broadband consumers, who will benefit from enhanced competition. This will benefit both urban and rural consumers. Urban consumers will benefit from additional capacity, which will enable improved quality of service and lower cost of provision. In a competitive market, these cost benefits will be passed onto consumers in the form of lower prices. Rural consumers will benefit in areas that 2.6 GHz services are rolled out, as 2.6 GHz spectrum will provide for large contiguous blocks of spectrum and so will enable higher speed broadband services. This is particularly beneficial, given low fixed broadband speeds in rural Ireland.[34] There may also be additional competition benefits in the mobile broadband market from the access to additional spectrum. Mobile operators may also gain from offering an enhanced range of services, although incremental profits may be limited due to extent of competition.

Sky and RTE are likely to benefit from increased take up of their TV services as MMDS customers switch to their alternative TV platforms.

The key loser from the release of spectrum is likely to be UPC, as it will lose incremental profits from the operation of the MMDS platform. Additionally rural pay TV customers will no longer have the choice between pay TV platforms; however, they are likely to be able to access a full range of TV services on Sky as well as additional services not currently available on MMDS such as DVRs and HDTV.

[34] Department of Communications, Energy and Natural Resources, "Next Generation Broadband – Gateway to a knowledge Ireland, 2009. http://www.dcenr.gov.ie/NR/rdonlyres/F9B1D956-358D-4870-AA99-DD25A4417F59/0/NextGenerationBroadbandPaperGatewaytoaKnowledgeIreland.pdf

4.12 Conclusion

The economic analysis compared two options with different timing for the release of the 2.6 GHz band for alternative uses. Our analysis shows that the net benefits of MMDS licence expiry in 2014 are higher than in 2017. We have also considered the impact on competition under both options and the distributional impacts. Our findings are robust having considered a sensitivity analysis.

5 ANNEX A: DETAILED TECHNICAL ANALYSIS

This Annex provides the interference modelling assumptions together with the analysis results for each scenario examined.

5.1 Interference Modelling Parameters

5.1.1 MMDS Parameters

The MMDS modelling parameters are primarily based on information given in the following documents.

- Technical conditions for the operation of digital programme services distribution systems in the frequency band 2500–2686 MHz (ComReg98/67R, Revised June 2004).
- Technical conditions for the operation of analogue programme services distribution systems in the frequency band 2500–2686 MHz (ComReg98/65R2, Revised June 2004).
- Sharing and adjacent band compatibility between UMTS/IMT-2000 in the band 2500–2690 MHz and other services (ECC Report 45, February 2004).
- Sharing studies in the 2500–2690 MHz band between IMT 2000 and fixed broadband wireless access systems including nomadic applications in the same geographical area (ITU-R Report M.2113).

ComReg technical conditions on digital and analogue MMDS state that the maximum EIRP is 22 dBW/8 MHz for digital and 32 dBW/8 MHz for analogue transmitters. MMDS site data provided by UPC Ireland indicates that there is one currently operational analogue transmitter and its EIRP is 23 dBW/8 MHz. Furthermore, 17 out of 22 digital sites operate at 18 or 19 dBW/8 MHz. Therefore, the range of EIRP values considered in the analysis is 18–32 dBW/8 MHz.

For digital MMDS, the minimum field strength is specified to be 46 dBµV/m for DVB-T and 56 dBµV/m for DVB-C. The associated C/I requirement is 25 dB for DVB-T and 35 dB for DVB-C. These figures together with an antenna gain of 22 dBi result in a maximum allowed interference level of –132.5 dBW/8 MHz for both DVB-T and DVB-C. For analogue MMDS, the minimum field strength is 66 dBµV/m and the C/I requirement is 45 dB. These figures together with an antenna gain of 22 dBi also result in a maximum allowed interference level of –132.5 dBW/8 MHz. Therefore, an interference criterion of –132.5 dBW/8 MHz has been assumed for both digital and analogue MMDS receivers.

The following table summarises assumed MMDS parameter values.

Frequency	2600 MHz
EIRP	18–32 dBW/8 MHz
Bandwidth	8 MHz
Transmitter Effective Antenna Height	100, 200 & 300 m
Receiver Antenna Gain	22 dBi (including losses)
Receiver Antenna Height	5 & 10 m
Maximum Allowed Interference Level	–132.5 dBW/8 MHz (based on C/I of 25 and 35 dB for digital MMDS and C/I of 45 dB for analogue MMDS)

Table 16: MMDS Parameters

Three MMDS receiver antenna patterns have been used in the modelling. The first pattern is based on a DN4 type directional antenna specified in ETSI EN 302 326-3 V1.3.1. In addition to the ETSI pattern, envelope patterns have been fitted to example MMDS receiver parabolic and planar antennas supplied by Stella Doradus. The following diagrams illustrate the patterns in elevation and azimuth planes. It should be noted that the azimuth patterns are assumed to be symmetrical for off-axis angles between 180 – 360 degrees.

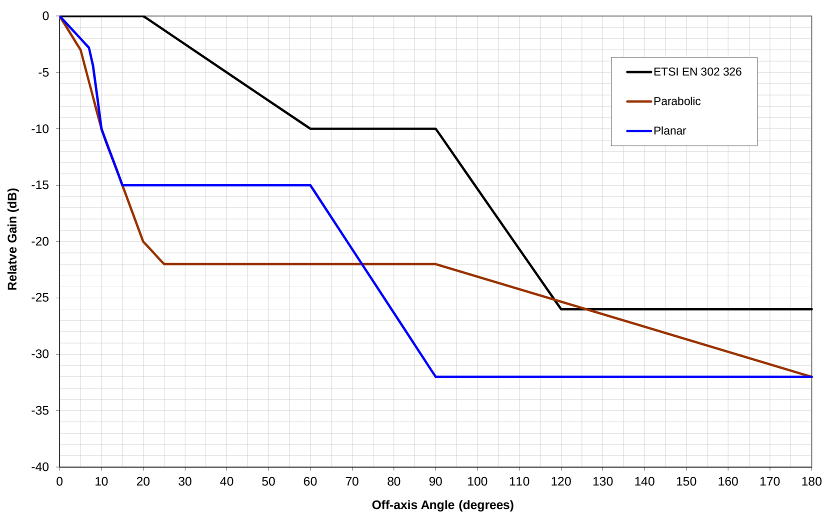


Figure 15: MMDS Receiver Antenna Elevation Patterns

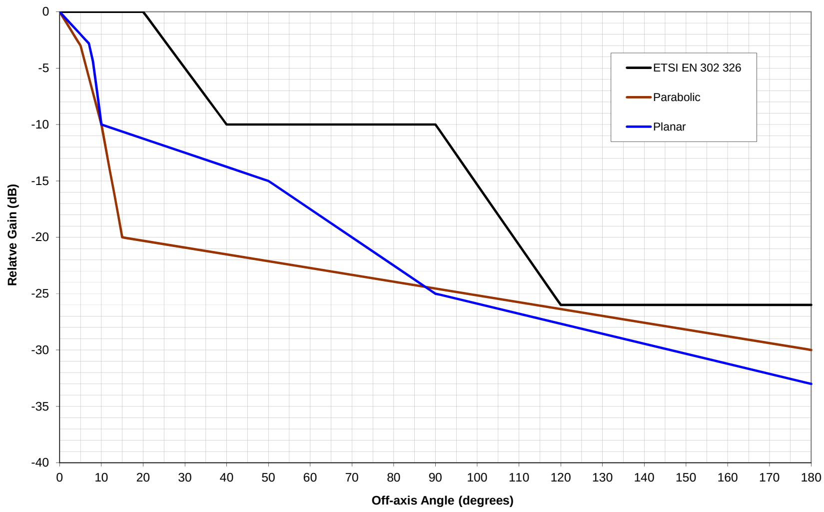


Figure 16: MMDS Receiver Antenna Azimuth Patterns

The MMDS operator site data indicates that 17 out of 22 sites deploy omnidirectional antennas. Therefore, MMDS transmitters are assumed to be represented by the omnidirectional antenna in the azimuth plane. For the elevation plane, two symmetric elevation patterns have been assumed.

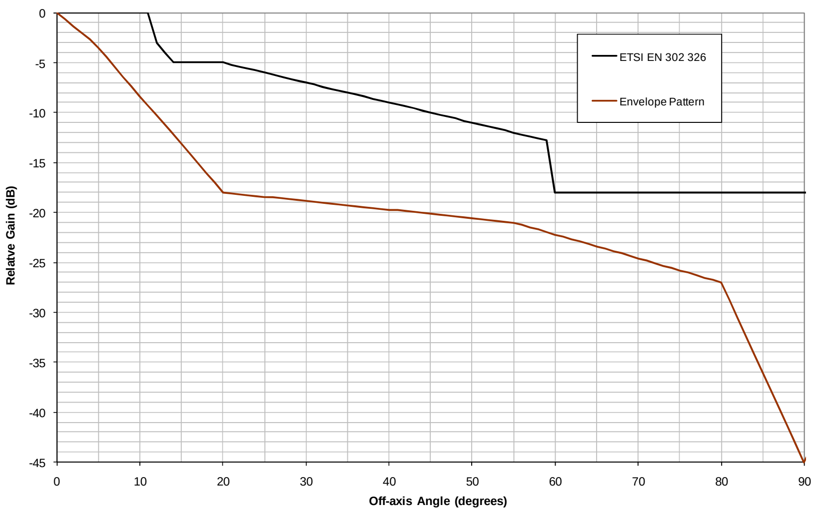


Figure 17: MMDS Transmitter Antenna Elevation Patterns

5.1.2 NGMB Parameters

The NGMB modelling parameters are mainly obtained from following documents.

- Harmonisation of the 2500–2690 MHz frequency band for terrestrial systems capable of providing electronic communications services in the Community (EC Decision 2008/477/EC, June 2008).

- Identification of common and minimal (least restrictive) technical conditions for 790–862 MHz for the digital dividend in the European Union (CEPT Report 30, October 2009).
- Sharing studies in the 2500 – 2690 MHz band between IMT 2000 and fixed broadband wireless access systems including nomadic applications in the same geographical area (ITU-R Report M.2113).

It is noted that there is no explicit external interference margin allowance associated with MMDS interference. Interference margins for NGMB are generally associated with intra-system interference. It is therefore assumed that the interference margin that could be attributed to the MMDS interference is limited to 0.4 dB corresponding to a maximum allowed interference level of 10 dB below the receiver noise floor.

In order to reflect different deployment scenarios (e.g. macro, micro and pico cells), a range of EIRP values have been considered. Assumed parameter values are outlined in table below.

Frequency	2600 MHz
Base Station EIRP	–3 to 31 dBW
User Terminal EIRP	–32.5 to 5 dBW
Bandwidth	5 MHz
Base Station Effective Antenna Height	30 m
User Terminal Antenna Height	1.5 m
Base Station Receiver Noise Figure	5 dB
User Terminal Receiver Noise Figure	9 dB
Base Station Receiver Noise Floor	–132 dBW
User Terminal Receiver Noise Floor	–128 dBW
Base Station Antenna Gain	17 dBi (including losses)
User Terminal Antenna Gain	0 dBi (including losses)
Base Station Maximum Allowed Interference Level	–142 dBW (based on 0.4 dB Margin to MMDS Interference)
User Terminal Maximum Allowed Interference Level	–138 dBW (based on 0.4 dB Margin to MMDS Interference)

Table 17: NGMB Parameters

NGMB user terminal is assumed to be omnidirectional in both azimuth and elevation planes. NGMB base station is also assumed to be omnidirectional in the azimuth plane. The following elevation patterns are assumed for the base station based on ITU-R Rec.1336 and CEPT Report 30.

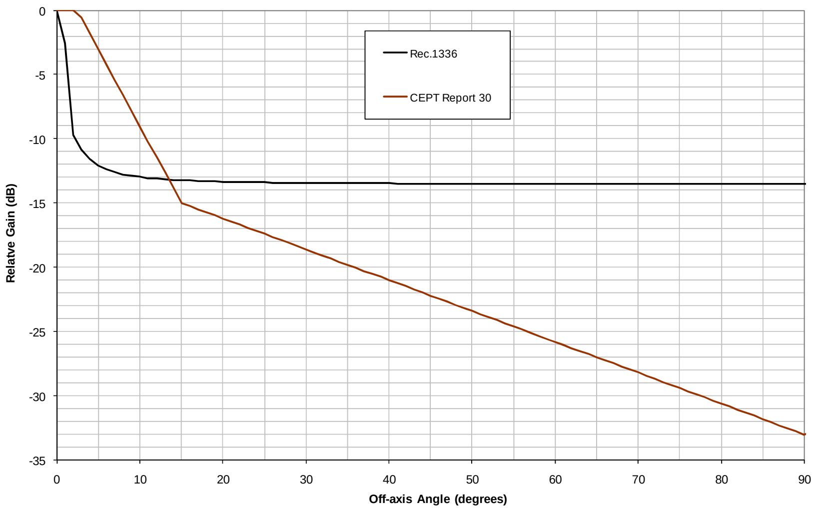


Figure 18: NGMB Base Station Elevation Patterns

5.1.3 Propagation and Coverage Related Parameters

Median interference path losses have been modelled using ITU-R Rec.1546 and Extended Hata models. ITU-R Rec.1546 is widely used for point-to-area predictions for terrestrial services up 3 GHz. Therefore, interference paths from NGMB BS and MMDS transmitters have been analysed using this model. Interference from NGMB MS is examined using Extended Hata model which is more suited for point-to-point interference paths. Separation distances obtained for median path loss provides protection for 50% of time. In order to make sure that victim receivers are protected for higher percentages of time an additional margin is introduced into the calculations so that the required separation is larger to account for the variation in propagation statistics.

In order to calculate the additional margin, it is assumed that the variations in the wanted and interference paths are log-normally distributed with a standard deviation of 5.5 dB. The margin for the required percentage is then obtained from a joint log-normal distribution representing uncorrelated propagation variations in wanted and interference paths. For the NGMB system, it is assumed that links are required to be protected for 95% of time. The calculated margin is 12.8 dB. For the MMDS system, the required percentage is assumed to be 99% in line with the ComReg technical conditions[35]. The calculated margin is 18.1 dB.

ComReg technical conditions state that MMDS employs vertical and horizontal polarisations. It is further stated that the main beam polarisation discrimination is 19 dB and a polarisation discrimination of 6 dB can be applied outside of the main

[35] Technical conditions for the operation of digital programme services distribution systems in the frequency band 2500–2686 MHz (ComReg98/67R, Revised June 2004)

Technical conditions for the operation of analogue programme services distribution systems in the frequency band 2500–2686 MHz (ComReg98/65R2, Revised June 2004 beam if the interference is from the opposite polarisation. In general, NGMB systems use slant polarisation. This implies that a polarisation discrimination of 3 dB can be applied if the victim system operates with vertical or horizontal polarisation. Furthermore, the NGMB user terminal is likely to be deployed within multipath environments and therefore it is reasonable to assume that no polarisation discrimination applies to those scenarios where a user terminal is modelled.

ITU-R Rec.1546 path loss calculations require an effective transmitter antenna height as an input. The effective height takes account of the average terrain height above ground level surrounding the transmitter. Furthermore, the losses are defined at receiver heights that are equal to the local clutter height. Typical local clutter heights are 10, 20 and 30 m depending on the environment where the receiver is assumed to be operating (e.g. rural, suburban and urban). For a receiver assumed to be operating at below the local clutter, a simple algorithm is defined to determine the additional loss applicable due to clutter effects.

5.2 Analysis of Interference from NGMB into MMDS

Implications of NGMB base station (BS) and mobile user terminal (MS) interference have been investigated on the basis of the modelling approach and assumptions outlined in this report.

5.2.1 Co-channel Interference from NGMB BS into Digital/Analogue MMDS Receiver

5.2.1.1 Technical Base Case Scenario

Separation distances required to satisfy the criterion of I = –132.5 dBW/8 MHz have been calculated for the co-channel operation. Initially, it is assumed that the NGMB BS is transmitting at the level of 31 dBW/5 MHz which is the maximum limit specified in EC Decision 2008/477/EC. Furthermore, the BS antenna is assumed to be represented by Rec.1336 and the MMDS receiver antenna is represented by ETSI EN 302 326. It is also assumed that the NGMB system operates with slant polarisation which results in 3 dB polarisation discrimination at the MMDS receiver antenna.

The following plot illustrates calculated separation distances at every 30 degrees azimuth around the MMDS receiver using the Rec.1546 propagation model together with an additional loss margin of 18.1 dB to account for the variation in propagation statistics. At each azimuth, it is assumed that the NGMB BS is pointing at the MMDS receiver. Separation distances are then calculated by taking account of antenna patterns at both ends. The MMDS receiver antenna is assumed to be at the local clutter height of 10 m.

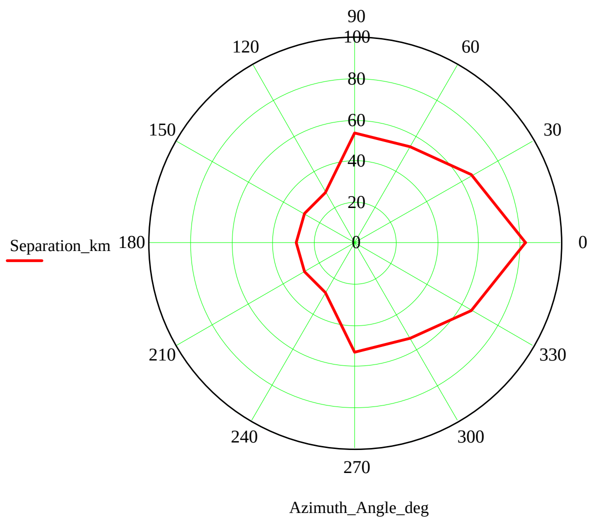


Figure 19: Separation Distances
(NGMB BS Interference into Digital/Analogue MMDS Receiver)

The results indicate that:

- when the interference entry is through the MMDS receiver main beam the required separation is 83 km
- when the interference entry is through the back of MMDS receiver antenna the required separation is 28.4 km.

The ComReg technical conditions document (ComReg 98/67R) states that the MMDS coverage areas vary between radius of 16 and 48 km. This in turn implies that the geographically separate co-channel operation requires up to 51 km separation from the edge of MMDS coverage area when the interference entry is through the MMDS receiver main beam. This is illustrated in the diagram below.

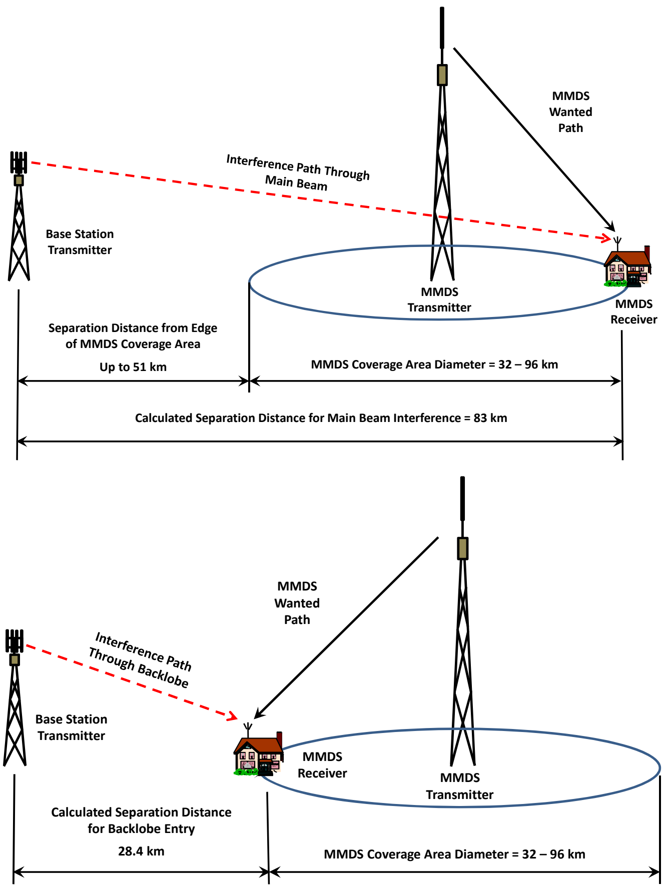


Figure 20: Interference Geometry
(NGMB BS Interference into Digital/Analogue MMDS Receiver)

5.2.1.2 NGMB BS EIRP Sensitivity

NGMB system parameters given in ITU-R Report M.2113 suggest that the EIRP level assumed in the base case scenario (i.e. 31 dBW / 5 MHz) could be considered as an appropriate value for rural and macro cell applications. In the case of micro cell applications, a maximum transmit power level of 8 dBW and an antenna gain of 5 dBi is suggested. For pico cells, a maximum transmit power level of –3 dBW and an omnidirectional antenna gain of 0 dBi is assumed. Using these parameters, the analysis has been repeated and calculated distances are shown in the following diagrams. It is assumed that the MMDS receiver antenna is at the local clutter height of 10 m.

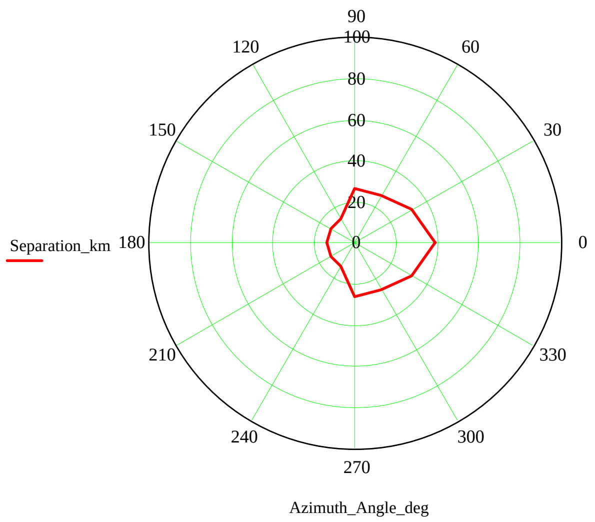


Figure 21: Separation Distances (NGMB Micro BS Interference into Digital/Analogue MMDS Receiver)

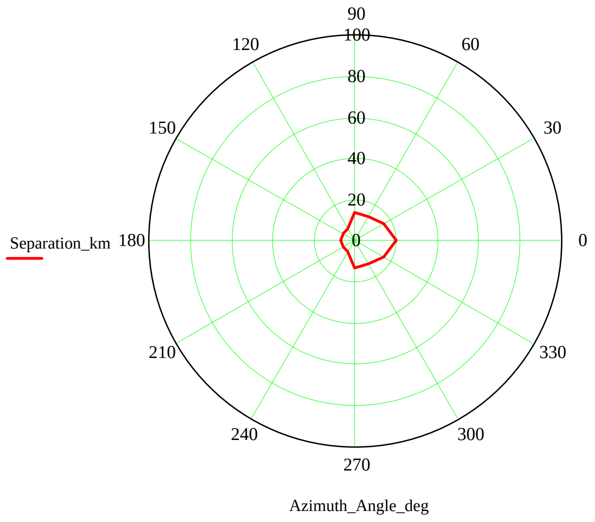


Figure 22: Separation Distances (NGMB Pico BS Interference into Digital/Analogue MMDS Receiver)

The summary of results is given in table below for macro, micro and pico cell NGMB BS transmitters.

NGMB Cell	Separation for Main Beam Interference Entry (km)	Separation for Rearlobe Interference Entry (km)
Macro	83	28.4
Micro	39.1	13.5
Pico	20.5	6.6

Table 18: NGMB BS EIRP Sensitivity

If the MMDS coverage area of radius of 16–48 km is considered the main beam separation distance from the edge of MMDS service area is less than 7.1 km for the micro cell and the pico cell does not require a separation distance. On the other hand, interference entries through the back of the MMDS receiver antenna require 13.5 km separation for the micro cell and 6.6 km for the pico cell.

5.2.1.3 *Receiver Antenna Height Sensitivity*

To examine the MMDS receiver antenna height sensitivity, the receiver antenna height is reduced from 10 m to 5 m. Assuming that the receiver is located in a rural area and the local clutter height is 10 m, a height correction of approximately 7 dB is calculated from Rec.1546 to account for an additional loss due to clutter effects. The results are shown in the following figure.

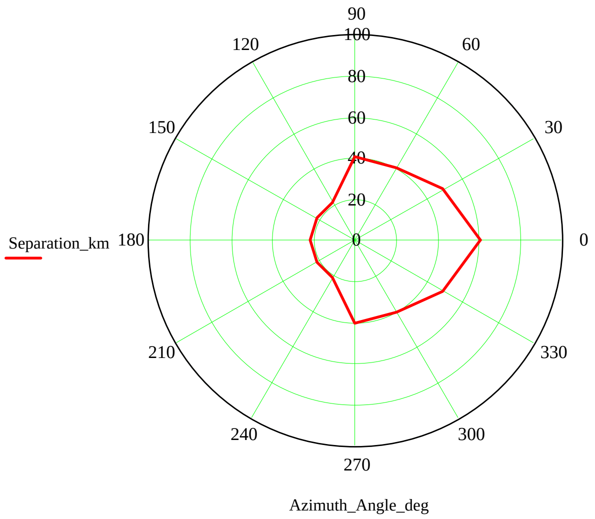


Figure 23: Separation Distances
(NGMB BS Interference into Digital/Analogue MMDS Receiver at 5 m Height)

The main beam interference results in 60.5 km separation while the rearlobe entry results in 21.3 km separation from the BS transmitter. If these results are offset by the MMDS coverage area, the required minimum separation from the edge of MMDS coverage area is less than 28.5 km.

5.2.1.4 Antenna Pattern Sensitivity

The sensitivity of results to antenna patterns has been examined using the BS transmitter antenna given in CEPT Report 30 and MMDS receiver antennas based on example parabolic and planar antenna radiation pattern envelopes. Results are shown in diagrams below for an assumed MMDS receiver antenna height of 10 m.

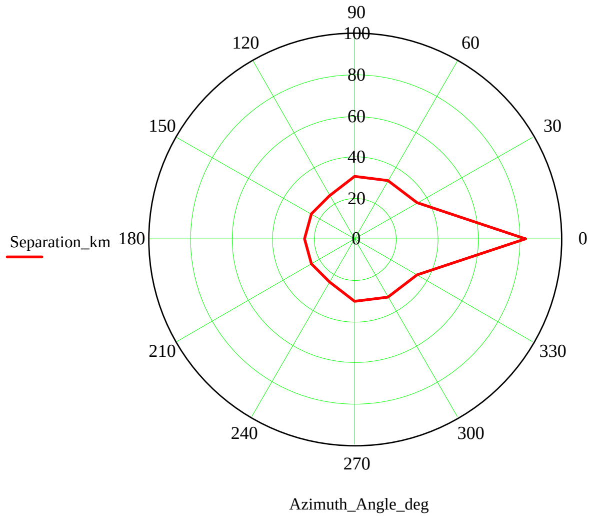


Figure 24: Separation Distances (NGMB BS Interference into Digital/Analogue MMDS Parabolic Receiver)

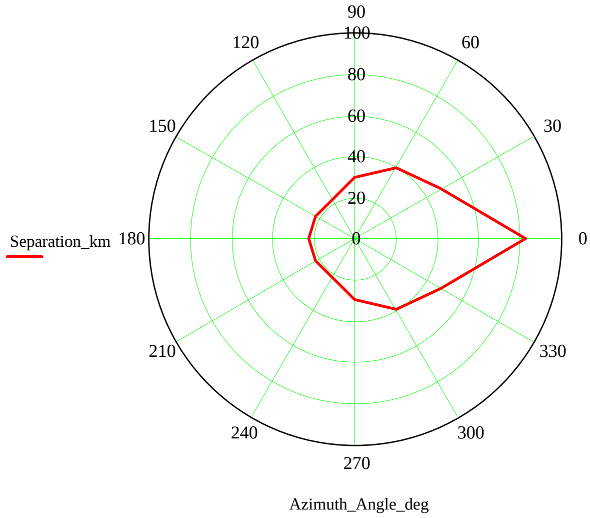


Figure 25: Separation Distances (NGMB BS Interference into Digital/Analogue MMDS Planar Receiver)

The comparison of the above diagrams against the base case scenario results suggests that while separation distances for a number of azimuth angles have been reduced by up to 30 km the required separation for the interference entries through the antenna rearlobe has reduced from 28.4 km to 24.1 km in the case of parabolic antenna and 22.2 km in the case of planar antenna.

5.2.1.5 *Polarisation Sensitivity*

The results presented so far assume that the NGMB system operates with slant polarisation while the MMDS system operates at either linear or vertical polarisation. The ComReg technical conditions document (ComReg 98/67R) states that a polarisation discrimination of 19 dB can be considered for the receiver antenna main beam and 6 dB outside the main beam if the interfering signal is at an orthogonal polarisation. Although imposing a linear polarisation operation on NGMB systems may not be practical an analysis has been implemented for orthogonally polarised interference entries.

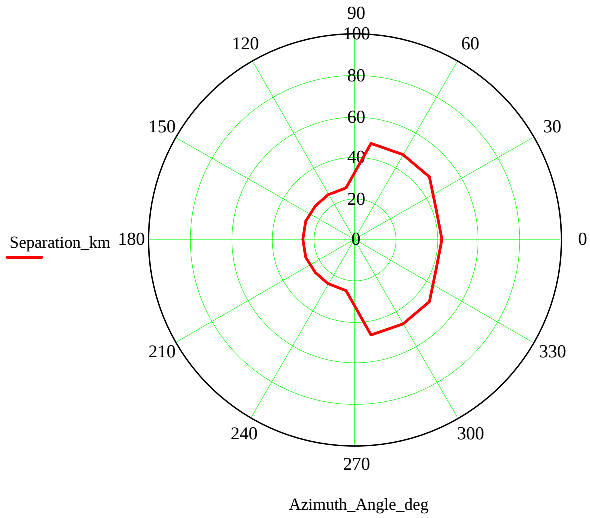


Figure 26: Separation Distances (NGMB BS Interference into Digital/Analogue MMDS Receiver, Orthogonal Polarisation)

The results show that, for an assumed MMDS receiver antenna height of 10 m, an additional 16 dB discrimination available for the main beam entries reduces the separation from 83 km to 42.3 km. If the MMDS coverage area of a radius of 16 – 48 km is considered the main beam separation distance from the edge of MMDS service area is less than 10.3 km. Furthermore, the separation (from the edge of MMDS service area) for the interference through the back of the MMDS receiver antenna is reduced from 28.4 km to 25.1 km due to an additional 3 dB polarisation discrimination.

5.2.2 Adjacent Channel Interference from NGMB BS into Digital/Analogue MMDS Receiver

One of the key limitations of the standards is the lack of receiver selectivity data. In order to implement an adjacent channel interference analysis, a net filter discrimination (NFD) needs to be derived. NFD combines the transmitter mask and receiver selectivity. It specifies the magnitude of the signal suppression available at a given frequency offset between the transmitter and receiver due to filtering at both ends. The term 'adjacent channel interference ratio' (ACIR) corresponds to an NFD value at a certain channel spacing between the transmitter and receiver.

In order to overcome the lack of receiver selectivity data coupled with the uncertainty of the NGMB systems likely to be deployed in 2014 onwards, separation distances have been calculated for an assumed set of NFD values representing the combinations of various transmitter and receiver masks.

For the assumptions used in the base case scenario, the variation of required separation distance with NFD values in the range 0–100 dB has been derived. Calculations are carried out using 5 dB increments in the NFD level. It is assumed that the MMDS receiver antenna is at the local clutter height of 10 m.

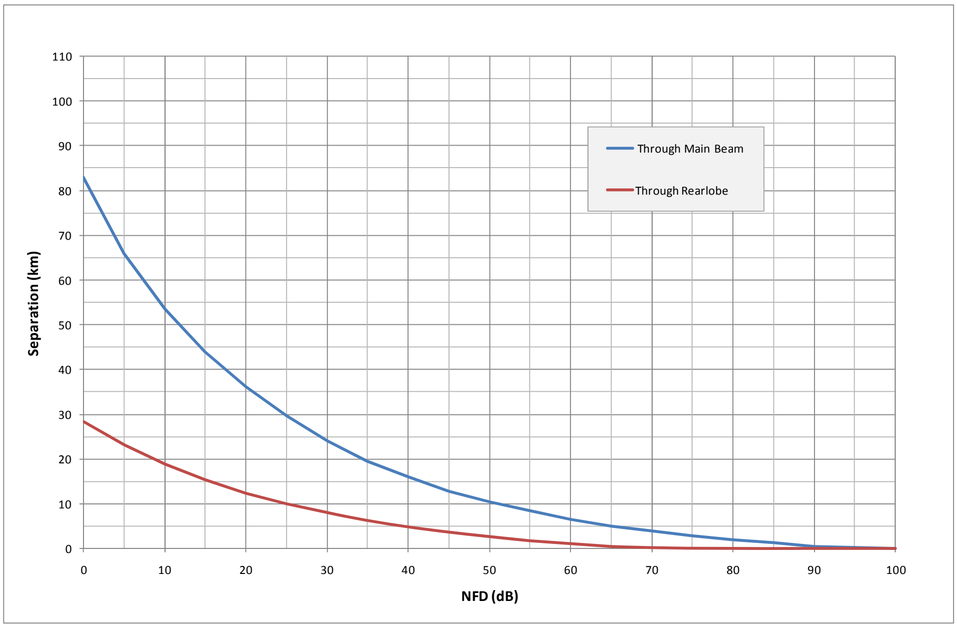


Figure 27: Variation of Separation Distance with NFD
(NGMB BS Interference into Digital/Analogue MMDS Receiver)

From the plots, the following conclusions can be drawn.

- An NFD value of 0 dB corresponds to the co-channel sharing scenario for which calculated separation distances are 83 km for the main beam interference and 28.4 km for the rearlobe interference.
- The main beam interference values need to be offset by the MMDS coverage area diameter (which varies between 32–96 km) if the separation from the edge of MMDS coverage area is to be determined.
- Therefore, in many cases (particularly in scenarios where the MMDS coverage area is large), interference through the back of the MMDS receiver antenna dominates the sharing feasibility as these scenarios are based on the geometry where the MMDS receiver is located at the edge of the MMDS service area closest to the NGMB BS transmitter and no offset due to MMDS coverage area is applied.

- According to the block edge masks defined in EC Decision 2008/477/EC, there is a 57 dB difference between the in-band and out-of-block emissions for the baseline FDD deployment scenario.
- If it is assumed that the NGMB transmit mask operates at the block edge mask defined in the Decision and dominates the corresponding NFD (i.e. the receiver selectivity is more relaxed than the transmit mask and therefore the NFD which combines the transmitter and receiver mask is dominated by the transmitter mask) the required separation is approximately 7.5 km for the main beam and 1.6 km for the rearlobe interference entries.
- Considering that the MMDS coverage diameter is between 32–96 km the required separation from the edge of the MMDS coverage area is determined by the rearlobe interference entry which is 1.6 km. Therefore, the adjacent channel operation with 1.6 km separation from MMDS coverage area edge is feasible if it can be assumed that an NFD of 57 dB due to the transmitter and receiver selectivity masks is applicable.
- If it is assumed that the adjacent channel NFD is dominated by receiver selectivity at an assumed level of 30 dB the required separation is 24.1 km for the main beam and 8 km for the rearlobe interference entries. When the offset due to the MMDS coverage area is considered the required separation is determined by the rearlobe interference entry which is 8 km from the edge of the MMDS service area.

5.2.3 Co-channel Interference from NGMB MS into Digital/Analogue MMDS Receiver

5.2.3.1 Base Case Scenario

NGMB MS is assumed to operate at an EIRP level of 5 dBW/5 MHz which is the maximum level specified in EC Decision 2008/477/EC. Given that the transmitter is likely to be located in multipath environments no polarisation discrimination is applied at the MMDS receiver. The transmit antenna is assumed to be omnidirectional in both azimuth and elevation planes while the MMDS receiver antenna is based on ETSI EN 302 326.

The following plots illustrate calculated separation distances required to satisfy the interference criterion at every 30 degrees azimuth around the MMDS receiver (located at 10 m) for assumed extended Hata urban and rural propagation models together with an additional loss margin of 18.1 dB to account for the variation in propagation statistics. In practice, it is likely that the interference path will include both urban and rural sections.

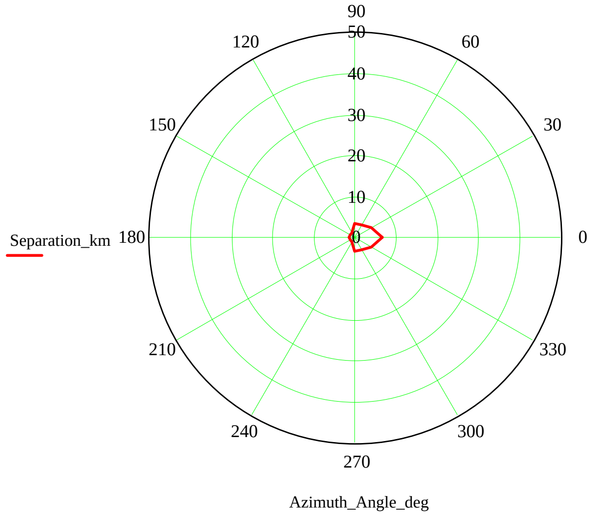


**Figure 28: Separation Distances
(NGMB MS Interference into Digital/Analogue MMDS Receiver, Urban)**

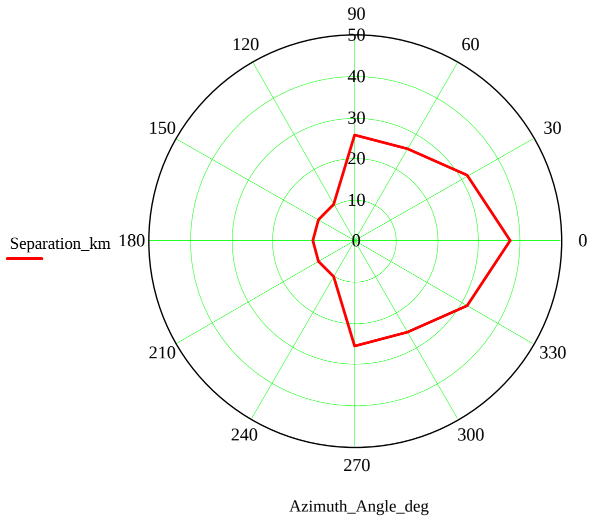


**Figure 29: Separation Distances
(NGMB MS Interference into Digital/Analogue MMDS Receiver, Rural)**

For the urban case, the main beam interference requires 6.7 km separation while the interference entry through the back of the receiver antenna requires 1.2 km separation. For the rural case, corresponding distances are 37.8 and 10.3 km. When the MMDS coverage area diameter (32–96 km) is taken into consideration these results suggest that, for the assumed set of parameter values, the co-channel operation is feasible with geographic separation from the edge of MMDS coverage area between 1.2 and 10.3 km depending on the environment in which the interference path is travelling.

5.2.3.2 *NGMB MS EIRP Sensitivity*

The base case scenario assumes that the NGMB MS EIRP is 5 dBW / 5 MHz. ITU-R Report M.2113 suggests a maximum EIRP level of –6 dBW / 5 MHz. Furthermore, typical average EIRP levels of –21.7 dBW/ 5 MHz (rural), –22.5 dBW / 5 MHz (macro), –23.4 dBW / 5 MHz (micro) and –32.5 dBW / 5 MHz are specified. Table below summarises the calculated separation distances for each EIRP level for an assumed MMDS receiver antenna height of 10 m.

NGMB MS EIRP (dBW / 5 MHz)	Separation for Main Beam Interference Entry (km)		Separation for Rearlobe Interference Entry (km)	
	Urban	**Rural**	**Urban**	**Rural**
–6	3.28	24.7	0.59	5
–21.7	1.17	9.8	0.21	1.8
–22.5	1.11	9.3	0.2	1.7
–23.4	1.05	8.8	0.19	1.6
–32.5	0.58	4.8	0.1	0.8

Table 19: NGMB MS EIRP Sensitivity

The results indicate that more practical EIRP values lead to reduced separation requirements between the NGMB MS transmitter and MMDS receiver. When the MMDS coverage area diameter is taken into consideration, the required separation from the edge of MMDS coverage area is less than 0.59 km for the urban case and 5 km for the rural case.

5.2.3.3 *Receiver Antenna Height Sensitivity*

Separation distances have been re-calculated by reducing the MMDS receiver antenna height from 10 m to 5 m. The results are compared in the following table.

MMDS Receiver Height (m)	Separation for Main Beam Interference Entry (km)		Separation for Rearlobe Interference Entry (km)	
	Urban	**Rural**	**Urban**	**Rural**
10	6.7	37.8	1.2	10.3
5	0.17	30.4	0.07	6.7

Table 20: Separation Distances for 10 & 5 m MMDS Receiver Antenna Heights

For the MMDS receiver antenna height of 5 m, when the MMDS coverage area is taken into consideration, the required separation from the edge of MMDS coverage area is less than 70 m for the urban case and 6.7 km for the rural case.

5.2.4 Adjacent Channel Interference from NGMB MS into Digital/Analogue MMDS Receiver

As in the case of NGMB BS, separation distances have been calculated for an assumed set of NFD values which could be attributed to various transmitter and receiver mask combinations. It is assumed that the MMDS receiver antenna height is 10 m.

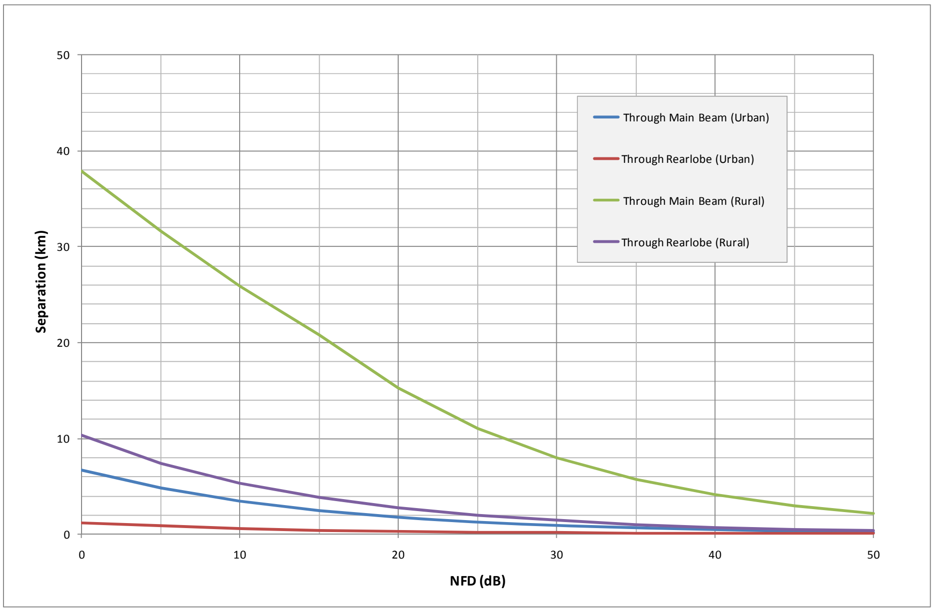


Figure 30: Variation of Separation Distance with NFD (NGMB MS Interference into Digital/Analogue MMDS Receiver)

Distances calculated for the main beam entry are not a limiting factor when the MMDS coverage area diameter is considered. For the rearlobe entries, adjacent channel operation requires less than 170 m for the urban interference path and 1.45 km for the rural interference path (from the edge of MMDS coverage area) when an NFD of at least 30 dB is available. At an NFD of 50 dB, corresponding separation distances from the MMDS coverage area edge are 70 and 390 m.

5.3 Analysis of Interference from MMDS into NGMB

The impact of MMDS interference on NGMB BS and MS receivers has been examined using a number of interference scenarios.

5.3.1 Co-channel Interference from Digital/Analogue MMDS into NGMB BS Receiver

5.3.1.1 Base Case Scenarios

For the digital MMDS case, the maximum MMDS transmit EIRP is specified to be 22 dBW/8 MHz in ComReg technical conditions (ComReg 98 / 67R). UPC data on currently operational MMDS transmitters suggest that typically EIRP levels are between 18–24 dBW in an 8 MHz channel. In the case of analogue MMDS, the maximum EIRP is 32 dBW/8 MHz. Furthermore, it is noted that there is one currently operational analogue MMDS transmitter operating with an EIRP of 23 dBW/8 MHz.

The MMDS transmitter antenna elevation pattern is assumed to be represented by ETSI EN 302 326. The NGMB BS receiver antenna elevation pattern is represented by Rec.1336. In the azimuth plane, it is assumed that both antennas are omnidirectional. 3 dB polarisation discrimination is included assuming that the NGMB system operates with a slant polarisation. The analysis uses the Rec.1546 propagation model together with an additional loss margin of 12.8 dB to account for the variation in propagation statistics.

On the basis of assumptions summarised above, the following separation distances (between the MMDS transmitter and NGMB BS receiver) are calculated for an assumed MMDS transmitter effective antenna height of 200 m.

MMDS EIRP (dBW in 8 MHz)	Separation Between MMDS Transmitter and NGMB BS Receiver (km)
18	74.8
22	83.4
23	85.8
24	88.3
32	114.7

Table 21: MMDS EIRP Sensitivity (Interference into NGMB BS Receiver)

Using the largest calculated separation, it can be concluded that the distance from the edge of MMDS coverage area is less than 98.7 km if the MMDS coverage area radius of 16–48 km is taken into consideration, as shown in diagram below.

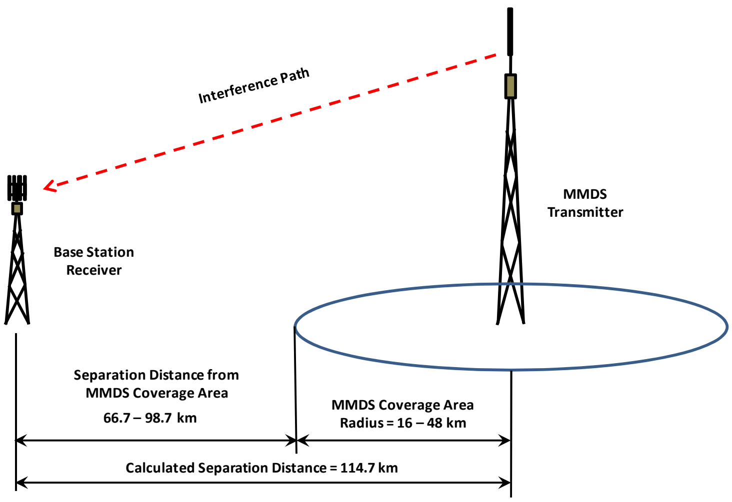


Figure 31: Interference Geometry (MMDS Transmitter into NGMB Receiver)

It should be noted that there is no distance variation with geometry as the receiver antenna is assumed to be omnidirectional in the azimuth plane and the elevation pattern is assumed to be symmetrical.

5.3.1.2 *MMDS Transmitter Height Sensitivity*

MMDS transmitter data provided by ComReg indicate that the MMDS site height is between 176–695 m (above sea level) except the site at Rathfadden which is at 74 m. Typically, these sites are located on the top of a hill with little or no obstruction in the surrounding area. The ITU-R Rec.1546 propagation model uses the effective antenna height as an input parameter. The effective antenna height is the average height above the ground level up to 15 km from the transmitter. The implications of MMDS transmitter effective antenna height have been examined for assumed effective antenna heights of 100, 200 and 300 m.

MMDS EIRP (dBW in 8 MHz)	Separation Between MMDS Transmitter and NGMB BS Receiver (km)		
	MMDS Transmitter Effective Antenna Height		
	100 m	200 m	300 m
18	61.6	74.8	83.5
22	69.4	83.4	92.7
23	71.6	85.8	95.2
24	73.9	88.3	97.9
32	97.7	114.7	125.9

Table 22: MMDS Transmitter Effective Antenna Height vs. Separation Distance

When the above distances are offset by the MMDS coverage area radius the required distance from the edge of the MMDS coverage area is less than 53.4 km for 100 m, 67.4 km for 200 m and 76.7 km for 300 m if the assumed MMDS transmitter EIRP is 22 dBW/8 MHz.

5.3.2 Adjacent Channel Interference from Digital/Analogue MMDS into NGMB BS Receiver

The variation of required separation with an NFD level has been derived for NFD values in the range 0–100 dB for different MMDS EIRP levels for an assumed MMDS transmitter effective antenna height of 200 m.

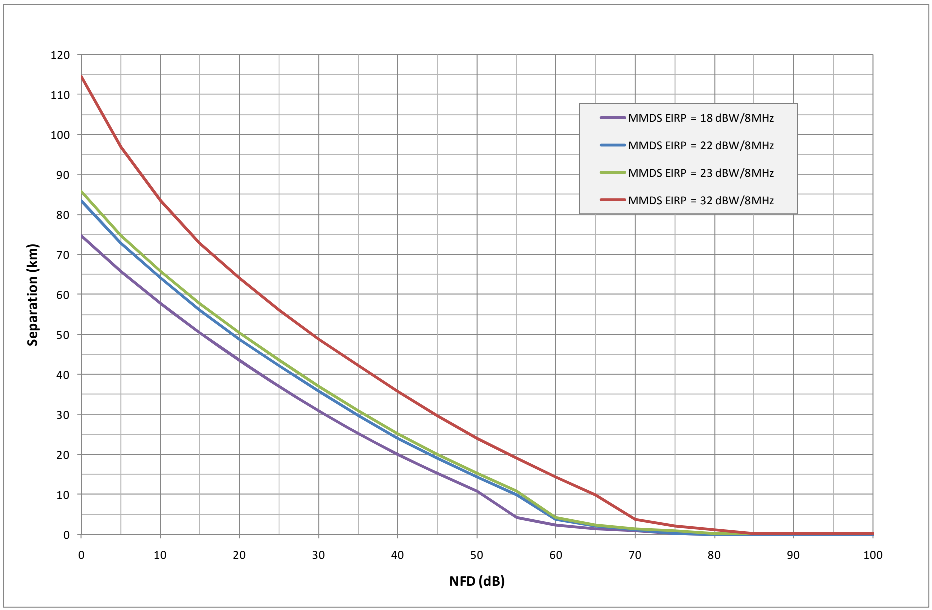


Figure 32: Variation of Separation Distance with NFD (Digital/Analogue MMDS Transmitter Interference into NGMB BS Receiver)

ETSI EN 300 744 (V1.6.1) provides emission masks for DVB transmitters. These masks indicate that the signal is suppressed by 50–80 dB in the adjacent channel relative to the in-band signal level. If it can be assumed that emission mask is dominant in the NFD mask the required separation between the MMDS transmitter and NGMB BS receiver becomes less than 24.1 km for adjacent channel sharing. On the other hand, if it can be assumed that the receiver selectivity is the determining factor in the NFD mask the required separation between the MMDS transmitter and NGMB BS receiver is approximately 49 km for an assumed NFD level of 30 dB.

If the MMDS coverage area radius of 16–48 km is considered an NFD of 50 dB implies that there needs to be up to 8.1 km separation requirement from the edge of MMDS coverage area. In the case of an NFD of 30 dB, the distance from the edge of the MMDS coverage area is less than 33 km.

5.3.3 Co-channel Interference from Digital/Analogue MMDS into NGMB MS Receiver

The required separation distance between an MMDS transmitter and an MS receiver has been calculated for a number of assumed MMDS EIRP values for an assumed MMDS transmitter effective antenna height of 200 m. It is assumed that the transmitter antenna elevation pattern is ETSI EN 302 326 and the receiver antenna is omnidirectional in both azimuth and elevation planes. It is also assumed that the median path loss is Rec.1546 and there is an additional 12.8 dB loss margin which is attributed to the variation in propagation statistics. Furthermore, a height loss of 12 dB is included in the calculations to account for the additional clutter loss due to the victim antenna height of 1.5 m (Ref: ETSI EN 101 190). No polarisation discrimination is assumed as the mobile receiver is assumed to be located in multipath environment.

MMDS EIRP (dBW in 8 MHz)	Separation Between MMDS Transmitter and NGMB MS Receiver (km)
18	31.1
22	35.9
23	37.1
24	38.4
32	49.1

Table 23: MMDS EIRP Sensitivity (Interference into NGMB MS Receiver)

If the MMDS coverage area radius of 16–48 km is taken into consideration the required separation from the edge of the MMDS coverage area is less than 33.1 km.

Further calculations have shown that the distance between the MMDS transmitter and the MS receiver is 35.5 km for the MMDS EIRP of 22 dBW / 8 MHz if the transmitter antenna elevation pattern is represented by an envelope based an example Stella Doradus radiation pattern.

5.3.4 Adjacent Channel Interference from Digital/Analogue MMDS into NGMB MS Receiver

Variations in the separation distance as a function of NFD have been derived for different MMDS EIRP levels for an assumed MMDS transmitter effective antenna height of 200 m.

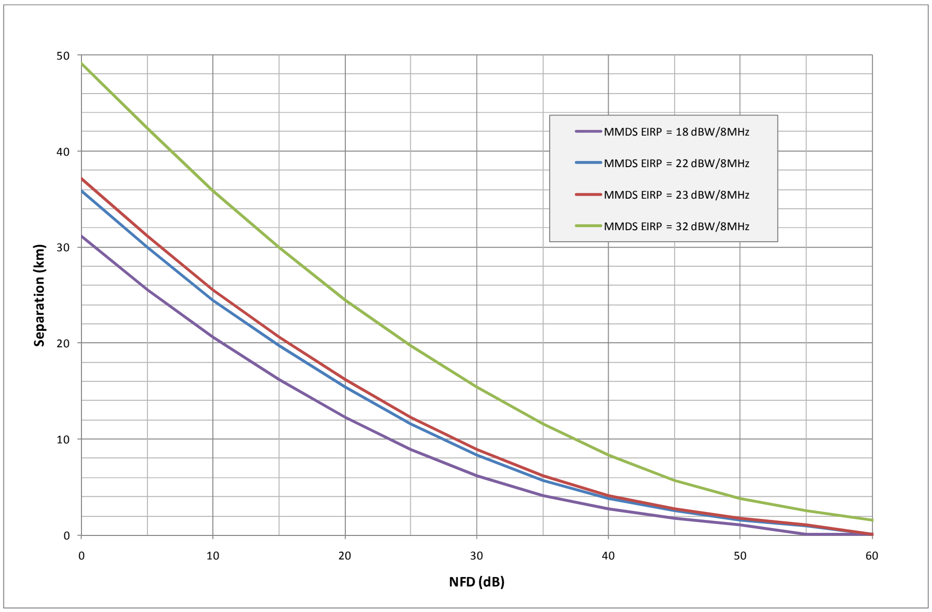


Figure 33: Variation of Separation Distance with NFD (Digital/Analogue MMDS Transmitter Interference into NGMB MS Receiver)

In this case, if an NFD level of greater than 30 dB is available the required distance between the MMDS transmitter and the NGMB MS receiver for the adjacent channel operation is less than 15.4 km. When the MMDS coverage area radius is considered there is no separation requirement from the edge of the MMDS coverage area.

6 ANNEX B: CHANNEL PLAN CONSIDERATIONS FOR DEPLOYMENT OF MMDS AND NGMB

6.1 Introduction

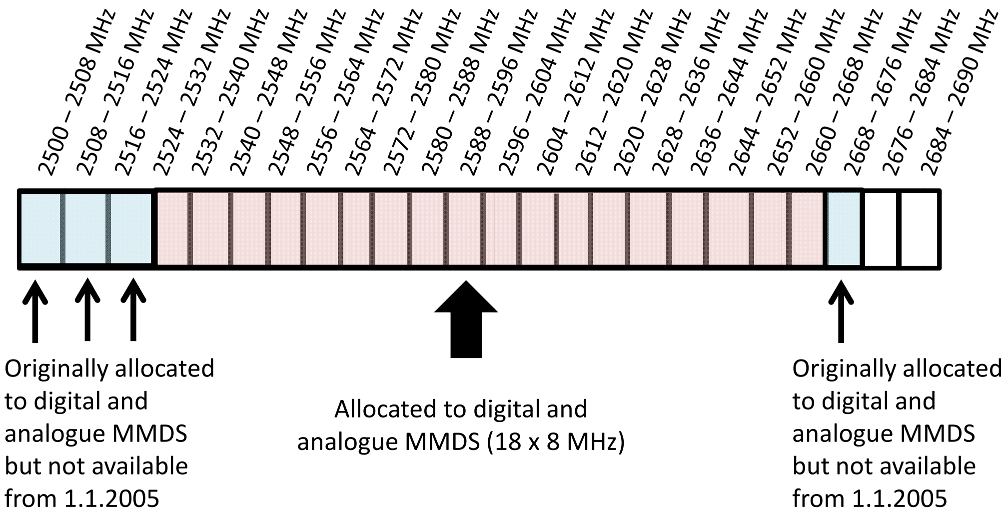


Figure 34: Current Use of 2.6 GHz Band in Ireland (Ref: ComReg98/67R and ComReg98/65R2)

Currently MMDS is operated in eighteen unpaired 8 MHz channels. There are six unpaired 8 MHz channels that are not currently used.

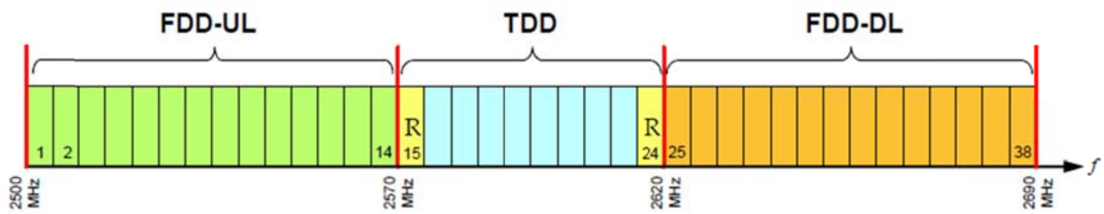


Figure 35: 2.6 GHz Band Plan (Ref: ECC Report 131)

The band plan for NGMB is based on 5 MHz wide blocks. The ITU presented 3 possible options for the 2.6 GHz band plan but there has been a bias towards Option 1 (a mix of TDD and FDD) which is shown above and was included in the ECC Report 131. There are also channel plans for just FDD (ITU Option 2) and flexible FDD / TDD (Option 3).

In the band plan shown in the figure above at the FDD/TDD border frequencies, two blocks are defined as restricted blocks where different technical conditions are applied to minimise the interference potential. There are a total of fourteen paired 5 MHz channels (2 x 70 MHz) with a duplex spacing of 120 MHz. This could potentially allow, for example, 3 operators to have access to 20 MHz paired bandwidth each and the remaining operator to have 10 MHz paired bandwidth. It is expected that the main interest will be in obtaining paired (FDD) 2.6 GHz[36] spectrum as currently there is little or no use of the un-paired (TDD) 2 GHz spectrum that was awarded previously and the prices bid to date for the un-paired spectrum have been considerably lower. For example, in the Netherlands the un-paired spectrum was not sold.

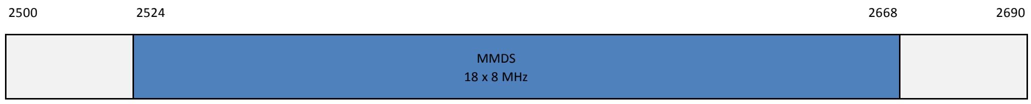
6.2 Consideration of Different Options for Use of 2.6 GHz Band

The figures below consider a number of different options for the use of the 2.6 GHz band.

We have assumed that it will be necessary for any solution to conform with the 120 MHz duplex spacing required for the FDD operation of NGMB. If that was not the case it would be necessary to have a bespoke solution for Ireland which would not be a viable option. It was noted that Telenor combined the un-paired spectrum they won to provide paired spectrum with a 120 MHz spacing.

It should also be noted that the guard band required between NGMB and MMDS will depend on the NFD (transmitter and receiver selectivity masks). There is the potential to add extra filtering but this might not be an attractive option so the number of channels available to MMDS and / or NGMB may be less than indicated in the figures below.

Retain MMDS in existing allocation



Although there is un-used spectrum between 2500 and 2524 MHz and 2668 and 2690 MHz and it is located within the planned paired (FDD) spectrum allocation for NGMB it does not provide the necessary 120 MHz duplex separation. The only option would be to deploy TDD-LTE and that would provide a total of 20 MHz of spectrum, depending on the necessary guard bands between the two services, at each end of the band and this is not consistent with the preferred channel plan.

Modify existing MMDS allocation

In this case by moving part of the MMDS allocation down into the bottom channels it has operated in previously it provides for 2 x 20 MHz of paired (FDD) spectrum for NGMB with the necessary 120 MHz duplex separation. MMDS still has access to the 18 off 8 MHz channels. One of the advantages of the 2.6 GHz band is the potential to deploy 10 MHz channels to support broadband services and this option

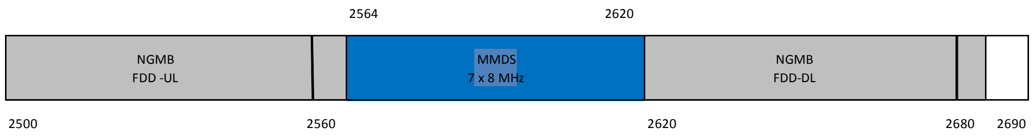
[36] There is the possibility that 2.6 GHz TDD-LTE equipment will become available.

might lead to, for example, just two operators acquiring 2 x 10 MHz of spectrum each or four operators each acquiring 2 x5 MHz. In the latter case if MMDS no longer uses the spectrum in the longer term there may be a need to move the operator's allocations to maximise the usage of the available spectrum.

Upgrade MMDS to MPEG-4

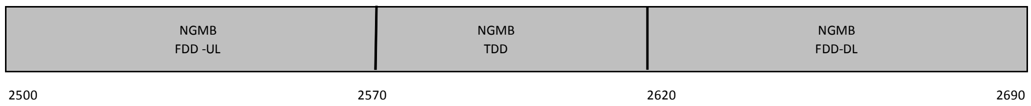
It is assumed that upgrading digital MMDS from MPEG-2 to MPEG-4 will reduce the number of channels required from 18 to 9 off 8 MHz channels as there will be increased capacity available in each channel. NGMB could then be deployed in 2 x 45 MHz (FDD) spectrum allowing all 4 operators to have access to 2 x 10 MHz each with a remaining 2 x 5 MHz block. There will be 1 x 20 MHz of unused spectrum in the upper half of the band which might be suitable for NGMB TDD (e.g. TDD-LTE), allowing for a 5 MHz guard band between FDD and TDD NGMB.

Upgrade MMDS to MPEG-4 and reduce number of available channels



In this option the number of channels available to MMDS is reduced to 7 and that will impact on the programmes that can be delivered. However, MMDS will mainly be operating within the allocation identified for NGMB TDD spectrum and it means that 2 x 60 MHz of spectrum will be available for NGMB FDD.

Remove MMDS



In this option MMDS is removed from the band and the full 2 x70 MHz is available for paired (FDD) NGMB and also 1 x 50 MHz for TDD NGMB.

7 ANNEX C: SPECTRUM SUPPLY AND DEMAND

This Annex considers spectrum supply and demand in Ireland and in other European countries where the 2.6 GHz band has been awarded.

Existing and planned spectrum availability for mobile broadband needs to be considered alongside the potential benefits of releasing 2.6 GHz. Digital switchover and the release of UHF spectrum post 2012 is now established policy and liberalisation of 900 MHz and 1800 MHz spectrum is anticipated. Further un-paired spectrum at 2.1 GHz is available. However, from a comparative perspective this is the position in much of Europe.

We note that future demand for mobile broadband and the implied demand for spectrum for mobile broadband are uncertain, mobile traffic has seen rapid growth in recent years. Further, whilst future demand may be uncertain such uncertainty in itself may raise the value of spectrum for NGMB since spectrum acquired in the near term may have a positive "option value" should high traffic growth continue (and the option to acquire spectrum in future when demand is clearer may not be available when needed).

We consider the following indications of potential demand for 2.6 GHz spectrum in Ireland including a qualitative assessment of potential demand in Ireland relative to other countries:

- Auction outcomes where 2.6 GHz spectrum has been acquired for mobile broadband.
- 2.6 GHz network rollout in countries where 2.6 GHz spectrum has been made available for mobile broadband.
- Indicators of mobile broadband market development in Ireland and relative to other countries.
- Analysys Mason study on cost reduction potential from additional spectrum.

However there are some indications of demand in Ireland and elsewhere, and in recent spectrum auctions mobile operators have paid to acquire 2.6 GHz spectrum in circumstances not dissimilar from Ireland in terms of existing and anticipated availability of other spectrum for NGMB services (including existing 900, 1800 and 2.1 GHz spectrum and UHF spectrum freed up by TV digital switchover).

We set out in the following sections the current situation re spectrum availability in Ireland and why access to 2.6 GHz may be attractive and a qualitative picture in terms of mobile broadband development in Ireland to help judge the likelihood and extent of demand for spectrum including 2.6 GHz in the period 2014–2019 in Ireland. In the next section we consider possible benchmarks for the value of 2.6 GHz spectrum.

7.1 2.6 GHz Spectrum Awards in Europe

The band 2500–2690 MHz was designated for terrestrial services at WRC-2000 on a global basis and is identified as an IMT-2000 expansion band. The spectrum has been awarded in a number of European countries as shown in the table below. It is interesting to note that a mix of FDD and TDD spectrum has been offered and this is generally in line with the ITU Option 1 band plan, which is the same as the one in ECC Report 131, where there is 2 x 70 MHz (FDD) in the paired bands 2500–2570 / 2620–2690 MHz and 1 x 50 MHz (TDD) in the band 2570–2620 MHz. In the Netherlands the un-paired spectrum was not sold and in Norway Telenor combined un-paired spectrum that it could combine to make paired spectrum with 120 MHz duplex spacing.

Country	Operator	Paired spectrum (MHz)	Un-paired spectrum (MHz)	Date
Austria	3 Austria	2 x 20	1 x 25	September 2010
	ONE (Orange)	2 x 10		
	Telekom Austria	2 x 20	1 x 25	
	T-Mobile	2 x 20		
Denmark	3 Denmark	2 x 10	1 x 25	May 2010
	TDC Mobil	2 x 20		
	Telia Denmark	2 x 20	1 x 15	
	Telenor	2 x 20	1 x 10	
Finland	DNA	2 x 20		November 2009
	Elisa	2 x 25		
	Telia Sonera	2 x 25		
	Pirkanmaan Verkko Oy		1 x 50	
Germany	E-Plus	2 x 10	1 x 10	May 2010
	O2	2 x 20	1 x 10	
	T-Mobile	2 x 20	1 x 5	
	Vodafone	2 x 20	1 x 25	

Country	Operator	Paired spectrum (MHz)	Un-paired spectrum (MHz)	Date
Netherlands	KPN	2 x 10		April 2010[37]
	Vodafone	2 x 10		
	T-Mobile	2 x 5		
	Ziggo 4	2 x20		
	Tele 2	2 x 20		
Norway	Hatslund Telecom	2 x 15		November 2007
	Netcom (Telia Sonera)	2 x 20		
	Telenor[38]	2 x 40		
	Craig Wireless System Ltd		1 x 50	
Sweden	3 Sweden	2 x 10		May 2008
	SULAB (Tele2 & Telia Sonera)	2 x 20		
	Telenor	2 x 20		
	Telia Sonera	2 x 20		
	Intel		1 x 50[39]	

Table 24: 2.6 GHz Spectrum Awards

7.2 2.6 GHz Network Roll-out

It is important to note that the majority of the 2.6 GHz spectrum has only recently been awarded or is still to be awarded in Europe. Therefore the expectation would be that there would be few networks deployed in the 2.6 GHz band. However, Telia Sonera has launched LTE services, on a commercial basis, in Norway (beginning in

[37] The un-paired spectrum was not sold.

[38] Telenor acquired unpaired blocks that it could pair using 120 MHz duplex spacing.

[39] Average price of paired spectrum 0.16 € per MHz per POP, unpaired spectrum 0.04 € per MHz per POP.

Oslo) and Sweden (beginning in Stockholm). In both countries Telia Sonera already has access to a significant amount of spectrum in other bands, as shown in the table below, although the 800 MHz spectrum has not yet been awarded which could also be used to deploy LTE[40].

[40] Source: Wireless Intelligence.

	900 MHz	1800 MHz	2 GHz	2.6 GHz
Telia Sonera Norway	2 x 14.2 MHz	2 x 16.6 MHz	2 x 15 MHz	2 x 20 MHz
Telia Sonera Sweden	2 x 10 MHz	2 x 23 MHz	2 x 20 MHz	2 x 20 MHz

Table 25: Available Spectrum in Norway and Sweden

In Germany it was announced that Telefonica O2 planned to start LTE network deployment in Halle (East Germany)[41] in the 800 MHz and 2.6 GHz bands in September 2010.

7.3 Development of Mobile Broadband in Ireland

In Ireland a number of observations can be made which help with a judgement as to whether mobile data traffic growth in Ireland is likely to be typical or above or below average, in particular:[42]

- DSL household penetration is relatively low at 63.1% of households in Q2 2010. Further, the performance of DSL is relatively poor with around 46% of subscribers receiving less than 2 Mbps[43] and numbers of households for whom DSL is not available. This may have helped mobile broadband to become established in the market.
- Mobile broadband adoption is high with 30.3% of internet subscribers having mobile broadband (figure below) and year on year growth to Q2-2010 of 41% (FWA penetration is also significant, though declining). Further, 29% of people said that they connected using mobile broadband at home – suggesting a degree of substitution which may involve higher data use than complementary use of mobile broadband alongside fixed.

[41] Source: Nokia Siemens news release.

[42] ComReg. 20 September 2010. Irish Communications Market – Key Data Report. Q2 2010. http://www.comreg.ie/_fileupload/publications/ComReg1073.pdf

[43] Akamai. 1st Quarter 2010 Report. The State of the Internet, Volume 3(1). Note that this is a larger proportion than estimates based on advertised/contracted speeds.

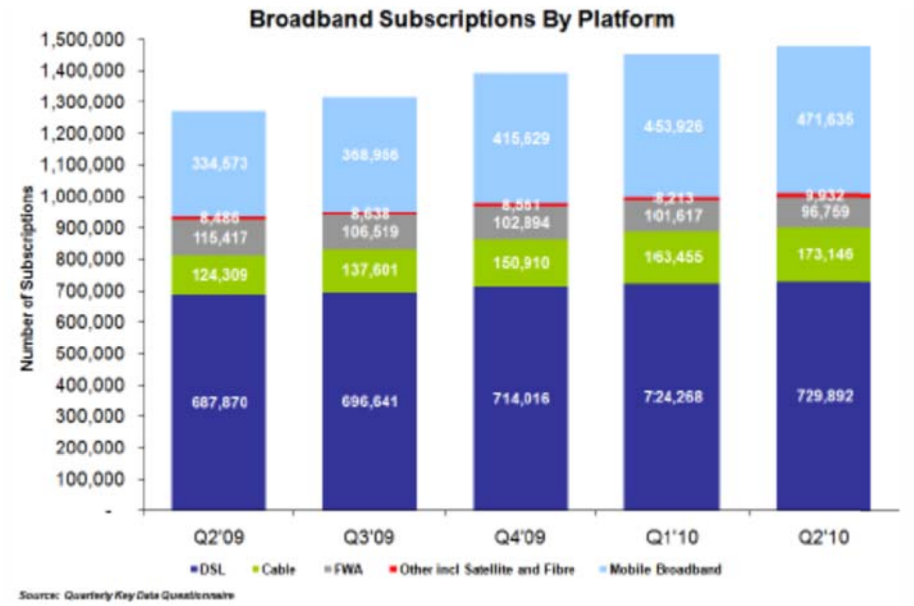


Figure 36: Growth of Mobile Broadband (top bar) in Ireland

- Mobile broadband adoption in Ireland is comparatively high compared to other European member states (see Figure below).[44]

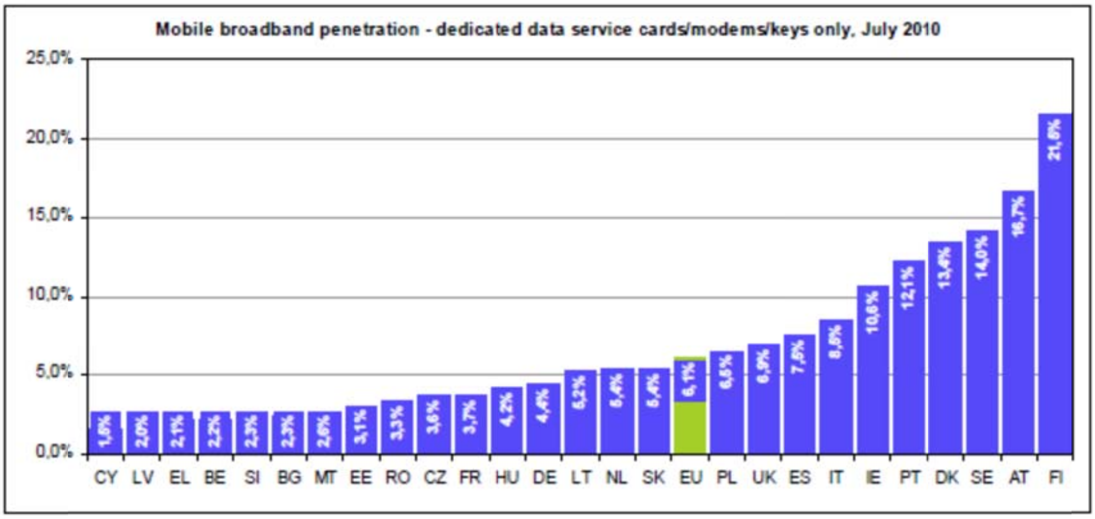


Figure 37: Mobile Broadband Penetration

- FWA and mobile broadband will play a particularly prominent role in broadband provision in areas outside main population centres given poor availability of fixed broadband. The National Broadband Scheme involves provision of universal service by Hutchinson 3G Ireland Ltd utilising wireless and satellite technology covering approximately 234,000 residential, commercial and business premises in approximately one-third of electoral districts.[45]

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[44] http://ec.europa.eu/information_society/newsroom/cf/itemlongdetail.cfm?item_id=6502

[45] http://www.three.ie/nbs/

For mobile broadband 2.6 GHz is expected to be used to provide capacity where demand is high (rather than wide area coverage) and to provide wide channel widths harmonised for LTE to support high capacity and speed. Additional spectrum can also be expected to lower the cost of service. Operators are starting to roll out LTE networks and offer commercial services in the 2.6 GHz band and the use of 2.6 GHz likely to include not just dense urban areas but also smaller towns and locations such as airports where demand is high.

7.4 Analysys Mason for the UK Broadband Stakeholder Group

Another check in relation to demand for 2.6 GHz is a report by Analysys Mason for the UK Broadband Stakeholder Group on the costs and capabilities of wireless technologies. This report discusses the need for spectrum and the potential cost savings if additional spectrum were available.[46] Whilst the study focuses on wireless in a fixed wireless access mode, the broad conclusions should be applicable to mobile broadband. In particular, the study notes that:

"Although the UK's five mobile licensees already have substantial paired spectrum holdings at 900 MHz, 1800 MHz and 2100 MHz, they are constrained in their ability to use them to support new high-speed terrestrial wireless broadband services by the need to support existing services. The planned allocation of the new 800 MHz and 2.6 GHz frequencies will alleviate the shortage of terrestrial wireless spectrum to some extent; however if additional spectrum were to be made available then costs could be reduced below the level that we have estimated..."

Further, Analysys Mason considered the impacts of doubling the quantity of spectrum available in each band on service costs. The results are shown in the Figure below.

[46] Analysys Mason. October 2010. The costs and capabilities of wireless and satellite technologies – 2016 snapshot. Page 23.
http://www.broadbanduk.org/component/option,com_docman/task,doc_view/gid,1246/Itemid,63/

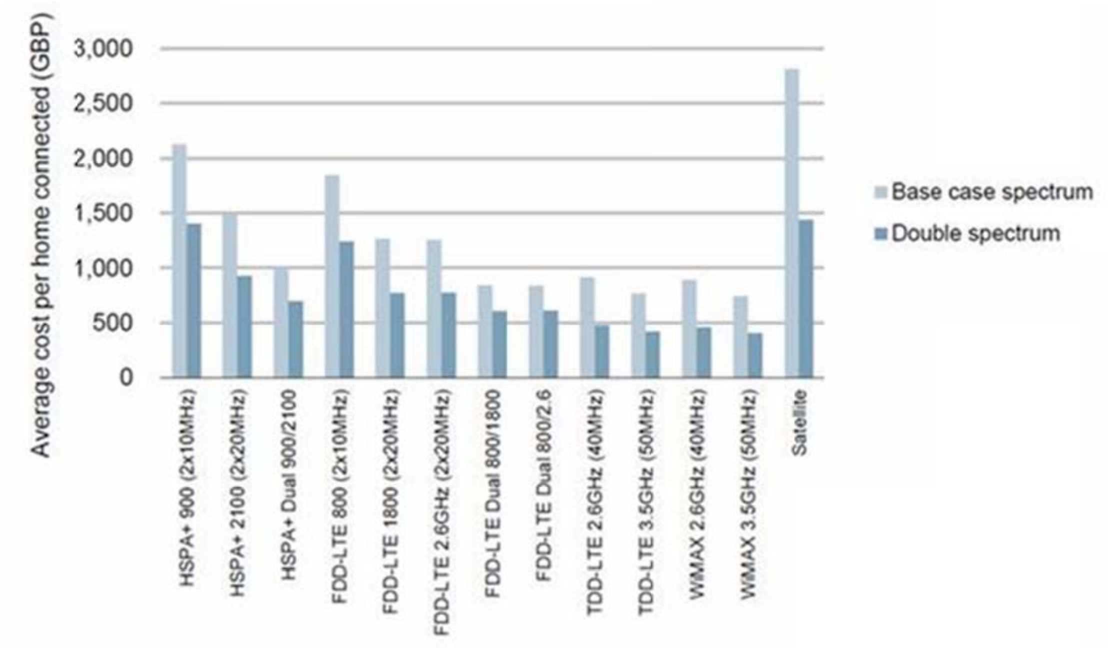

Figure 38: Impact of Doubling Spectrum Availability on Costs

It indicates that even were 800 MHz, 900 MHz, 1800 MHz, 2.1 GHz and 2.6 GHz spectrum available for mobile broadband doubling the quantity of spectrum available in any one of these bands would reduce costs by between 27% and 39% for FDD technologies. In other words, there isn't a simple cut-off beyond which mobile broadband has sufficient spectrum, rather there is a trade-off between spectrum availability, capacity and costs.

7.5 Spectrum in Ireland

The spectrum that is available to support mobile broadband in Ireland is covered in Section 1.2 of the report and is repeated below for completeness:

To support the growing demand for mobile broadband it is widely accepted that there is a need for further spectrum to be released to the market. In Ireland there are ongoing mobile spectrum liberalisation projects; specifically the proposed joint award of 800 MHz (2 x 30 MHz) and 900 MHz (2 x 35 MHz) spectrum and the possible inclusion of 1800 MHz (2 x 75 MHz) spectrum in the same award process. This project would provide a total of 2 x 135 MHz to the market. However, 2 x 76.1 MHz is currently allocated to provide mobile services using GSM technology but over time it is expected that some or all of this spectrum would be refarmed to more spectrally efficient technologies such as LTE.

In this project ComReg proposes to award this spectrum in 2 x 5 MHz block sizes and the amount of spectrum that is available provides the potential for operators to amalgamate blocks into 2 x 10 MHz (or greater) allocations, which provides the benefit of supporting higher speed services. The ability to amalgamate a 2 x 10 MHz (or greater) spectrum allocation is also one of the advantages of the 2.6 GHz band.

Whilst the amount of spectrum that would be provided in this joint award is comparable to that available in the 2.6 GHz band there are other considerations (as outlined below) which suggest that there is likely to be demand for the 2.6 GHz band:

- Whilst the 800 MHz and 900 MHz bands are ideal for providing coverage the 2.6 GHz band is better suited for providing capacity at traffic hot spots. The 1800 MHz band has been used to provide both coverage and capacity in urban areas in Ireland.
- Part of the additional spectrum at 900 MHz and 1800 MHz may need to be used to facilitate refarming from existing 2G technologies.
- The 2.6 GHz band is harmonised on a global basis and would be used for international roaming.

8 ANNEX D: ALTERNATIVE TV PLATFORMS

Our analysis assumes that all customers are able to switch to an alternative supplier of pay TV or free to-air TV services (such as Irish DTT 'Saorview' and 'Freesat' service and/or video on demand services). Both Sky and UPC currently provide a full range of Pay TV services. It is difficult to directly compare the price of services available on each platform, due to the difference in pricing structure between the operators and the difference in service between Sky Ireland and UPC MMDS. MMDS customers are unable to receive HD services and most MMDS customers cannot access Digital Video Recorder (DVR) services. Further details of the TV services delivered in Ireland are discussed below.

8.1 Irish TV Platforms

8.1.1 UPC MMDS Services

UPC provide a range of digital TV services as set out in the table below.[47]

	Analogue	Digital Value Pack	Digital Extra Pack	Digital Max Pack
Price per month	**€24.75**	**€20.75**	**€30.00**	**€33.75**
Number of TV channels	18 (estimate)	55	87	106
Connection Self-install	Zero for online orders	Zero for online orders €20 for non-online orders €30 for analogue customers	Zero for new customers €20 for non-online orders €30 for analogue customers	Zero €20 for non-online orders €30 for analogue customers
Connection -Site visit		€10	€10	€10
Fee for non-return of set up box upon cancellation	€150	€150	€150	€150

Table 26: UPC TV Services

[47] Source: http://www.upc.ie/television/ Viewed on 8 October 2010. Sample Address: Victoria Court, Cusack Road Ennis Clare.

8.1.2 Sky Ireland Services

Sky Ireland offers a range of TV services as set out in the table below.[48]

	Variety					
Price per month	**€23.00**	**Additional €2.00 per pack**	**Additional €12.00–16.00**	**Additional €15.00**	**Additional One €19.00 Two €19.00 Both €34.00**	**Additional One €14.00** Two **€14.00 Both €28.00**
Number of channels	30 (estimate)	Approx. 15 channels in each pack				162
HD	Additional € 15.00 per month	Additional € 15.00 per month	Additional € 15.00 per month	Additional € 15.00 per month	Additional € 15.00 per month	Additional € 15.00 per month
Multiroom Viewing	Additional €20.00 per month	Additional €20.00 per month	Additional €20.00 per month	Additional €20.00 per month	Additional €20.00 per month	Additional €20.00 per month
Connection Self install	Standard fee is **€**30 but with special offer is currently zero	n/a	n/a			

Table 27: Sky Ireland Services

8.2 Freesat/Irish DTT

FreeSat service offers a 140 TV and radio channels from the BBC and ITV, but it does not have RTÉ One, RTÉ Two, TV3 and TG4. However, Irish DTT was launched as trial service on 29 October 2010 and will be fully launched in Spring 2011[49] Initially, SAORVIEW will provide RTÉ One, RTÉ Two, TV3, TG4 and RTÉ Newsnow; however, RTÉ propose to provide further channels including HD content.

There are set up boxes available which are sufficient to receive Irish DTT content along with FreeSat service. It is also possible to use separate set top boxes and

[48] Source: https://skyireland.sky.com/roi/site/tvpackages?DCMP=ilc-roiStorefront viewed on 8 October 2010.

[49] RTE statement, http://www.rte.ie/saorview/ viewed on 2 November 2010.

dishes to receive the two services.[50] RTÉ will also offer satellite services for 2% of Ireland that is unable to receive DTT.

8.3 Internet Based TV

An alternative to switching from UPC MMDS to other broadcast platforms would be to access television services via the internet such as Magnet Entertainment or Apple TV. Magnet Entertainment offers a range of TV services including a basic service via the internet to PCs. Apple TV provides a video on demand (VOD) service via the internet. VOD services provided via broadband are likely to continue to develop and grow in the future.

However, for many rural MMDS subscribers, broadband speeds may be insufficient to access TV services. International research suggests that 46% of Irish broadband customers have average broadband speeds of less than 2Mbit/s.[51] A standard definition MPEG2 video requires a data rate of 3Mbit/s and high definition video service requires around 8Mbit/s.[52] While this is expected to decline over time and more advanced digital technologies such as MPEG4 increase efficiency by 1.5 to 2.0 times, it is likely that significant proportion of rural MMDS subscribers may be unable to access suitable VOD services by 2014.

[50] http://ezinearticles.com/?How-to-Get-the-Irish-DTT-and-Freesat-Channels-on-a-Single-Satellite-Receiver&id=4841317 viewed on 8 October 2010.

[51] Akamai (2010), The State of the Internet, Volume 3, Number 1, 1st Quarter 2010.

[52] EBU Technical Review – 2009 Q4.