Document 12/132b: Annex 3 to ComReg Document 12/132

Aegis Systems Limited and Plum Consulting Response Document

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Aegis Systems Ltd. and Plum Consulting's responses to the comments received from interested parties in response to 11/80a on the future of the 2.6 GHz radio spectrum band

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EXECUTIVE SUMMARY

This document provides Aegis Systems Ltd. and Plum Consulting's responses to the comments received from interested parties in response to ComReg's consultation Document 11/80, in particular the report published alongside it as Document 11/80a, on the future of the 2.6 GHz radio spectrum band. This ComReg consultation sought comments on the report, Document 11/80a that considered the technical feasibility of the 2.6 GHz band being shared by MMDS and Next Generation Mobile Broadband ("NGMB") systems and the costs and benefits of different timing options where the band is reallocated to alternative uses.

The analysis of the responses in respect of Document 11/80a have not led us to consider that any changes are required to either the content or the final conclusions.

1 INTRODUCTION

This document reviews and responds to the comments received from interested parties in response to ComReg's consultation Document 11/80, in particular the report published alongside it as Document 11/80a, on the future of the 2.6 GHz radio spectrum band. This consultation sought comments on a report, Document 11/80a, that considered the technical feasibility of the 2.6 GHz band being shared by MMDS and Next Generation Mobile Broadband ("NGMB") systems and the costs and benefits of different timing options where the band is reallocated to alternative uses.

The aim of this "Response Document" is the provision of information, opinions and commentary to ComReg on the comments received in respect of the Document 11/80a and provided in ComReg document 11/80s. Specifically the following sections address the comments received from:

eircom Ltd. and Meteor Communications Ltd.

Hutchison 3G Ireland Ltd.

L.A. Services

Telefonica O2 Ireland Ltd.

UPC Communications (Ireland) Ltd.

Vodafone Ireland Ltd.

2 EIRCOM AND METEOR COMMUNICATIONS LTD. COMMENTS

2.1 Introduction

The comments received from eircom and Meteor Communications Ltd specifically addressed the economic analysis.

It is noted that "eircom Group broadly supports the methodology used by Aegis and Plum in their cost benefit analysis" and "agrees with Aegis and Plum's definition of the two principal benefits" and "that the switching costs are the primary cost to be considered".

2.2 Analysis of Comments

Comments on net benefits calculations

At paragraph 5 on page 8 eircom Group says *"However, in reaching this conclusion Aegis and Plum appear not to consider in their calculation the consumer benefit created by the use of 2.6 GHz spectrum for NGMB, instead relying on the auction fees paid in recent auctions as a measure of the benefit generated by 2.6 GHz. eircom Group believes that if the consumer benefit of faster and cheaper mobile*

broadband is considered, the case to make 2.6 GHz available for NGMB beyond 2014 is even more compelling."

One would expect some of the benefit of 2.6 GHz spectrum in terms of faster and cheaper mobile broadband to be reflected in auction proceeds. However, eircom Group are correct in pointing out that an estimate based on auction receipts is likely to be a conservative estimate of the use of 2.6 GHz spectrum for NGMB. However, a conservative estimate of the value of spectrum for mobile broadband was sufficient, alongside other costs and benefits, to support a conclusion that reallocation would be efficient. Aegis and Plum did not therefore quantity the full value of additional benefits to consumers of faster and cheaper mobile broadband.

In conclusion, as stated in Document 11/80a, the assessment based on auction proceeds is conservative: *"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."*

3 HUTCHISON 3G IRELAND LTD. COMMENTS

There were no specific comments received from Hutchison 3G Ireland Ltd on the report except to "agree with the approach of allocating 2.6 GHz spectrum using a technology and service neutral competitive approach as outlined by Aegis and Plum".

4 L.A. SERVICES

4.1 Introduction

The comments received from L.A. Services specifically addressed the economic analysis.

4.2 Analysis of Comments

At paragraph 2 on the page after page 30 (unnumbered) LA Services says: ***"The Aegis and Plum is mainly a report on the best technical use of the 2.6 GHz band and takes little cognisance of what the Irish consumer needs or wants. It takes no account of any qualitative issues."***

The Aegis and Plum report does not focus on the best technical use of the 2.6 GHz band, but on the value of alternative uses of the band to the Irish consumer (which reflect their wants and needs) taking into account technical constraints in relation to spectrum sharing. The report also discusses a number of issues in qualitative terms including the impact on competition in relation to TV and NGMB, the benefits of higher speed mobile broadband and possible external social benefits from improved mobile broadband.

Aegis and Plum conclude in Document 11/80a that overall economic value, reflecting consumer needs, would be increased by reallocating spectrum from MMDS to NGMB. We also note that provided the spectrum allocation mechanism is a technology neutral auction the option of continued use of 2.6 GHz spectrum for MMDS would remain open as UPC would be able to bid for the spectrum.

At paragraph 3 on the page after page 30 (unnumbered) LA Services says: *"It does not deal with the fact that if MMDS goes there is only one pay TV provider…"*

The potential impact on competition in the TV market is highlighted and a comparison with concern about competition in other sectors, including the mobile sector, is also made. Aegis/Plum assessed the potential impact on competition in the TV markets and concluded that it would be likely to be negligible in the TV market given the small share of customers served by MMDS and national marketing and pricing of TV services.

However, in relation to the mobile data market the impact on competition is potentially greater as existing and anticipated spectrum excluding 2.6 GHz spectrum is insufficient to provide all operators with 2x20 MHz contiguous channels which would allow them to exploit the potential of LTE and all act as strong players in the market.

At paragraph 5 on the page after page 30 (unnumbered) LA Services says: *"While the Aegis and Plum report dealt with the cost of changeover it did not deal with the ongoing higher costs to customers associated with having Sky TV e.g. a service call from a Sky engineer costing €100 at present while callouts (and replacement parts) to MMDS customers are free."*

On-going service costs apply to both MMDS and alternative platforms, irrespective of the contractual relationship which determines the incidence of costs between producers and consumers. Explicit consideration of services costs would not therefore be expected to alter the conclusions of the analysis in terms of overall producer and consumer surplus.

5 TELEFONICA O2 IRELAND LTD.

There were no specific comments received from Telefonica O2 Ireland on the Aegis Plum report.

It is however noted that in the summary Telefonica O2 indicate that their preliminary view is they agree with the findings of Document 11/80a.

6 UPC COMMUNICATIONS (IRELAND) LTD.

6.1 Introduction

The comments received from UPC Communications (Ireland) Ltd. addressed both the technical and economic analysis in the Study Report. UPC also provided

additional inputs to ComReg which are outside the scope of this response document.

The following sections provide responses to the technical and economic aspects of the Document 11/80a in line with the comments received from UPC.

6.2 Analysis of Technical Comments

6.2.1 Response to comments 'Evaluation of the technical analysis undertaken by Aegis and Plum'

The following responses address the comments in Document 11/80s from UPC Communications (Ireland) Ltd. titled 'Evaluation of the technical analysis undertaken by Aegis and Plum' , starting on page 12 of its submission.

In the last paragraph of page 12 of its submission UPC Communications (Ireland) Ltd. says *" In the technical analysis section of the executive summary (page ES-2) Aegis and Plum state that five MMDS transmitters need to be turned off while in the next sentence they state that only three sites need to be turned off. While they state that those three MMDS transmitters "prohibit" the operation of NGMB in Dublin, their analysis does not prove that micro-cells or in-building solutions of the type we discussed in the previous section above could not be deployed."*

In response to the above at paragraph 2 of page ES-2 of Document 11/80a it states that:

"The implications of the technical analysis results have been examined in an example scenario for the Dublin area. This analysis, without terrain data[1], 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."

Our analysis showed that the inclusion or not of terrain data had an impact on the assessment of sharing between MMDS and NGMB services. If terrain data was not included, our analysis showed that it would be necessary to turn off five MMDS transmitters in Dublin and the surrounding area. With terrain data our analysis showed that just three of these MMDS transmitters needed to be turned off. Placing deployment restrictions on NGMB networks (for example, micro site and/or indoor deployment) as proposed by UPC Communications (Ireland) Ltd. may reduce the impact of interference but whether such restrictions will be acceptable to any

[1] Please note the text was not under lined in the original report but is done so for emphasis in replying to UPC's comments.

potential NGMB operator is questionable. Most importantly, the analysis results with terrain data shown in Section 2.3 of Document 11/80a (Figures 6 - 10on pages 16 – 18) indicate that the co-channel sharing in Dublin is not possible even when the interference criterion is relaxed by up to 30 dB (which may be attributed to various mitigation techniques including deployment constraints on NGMB networks).

From a practical deployment point of view this is not a surprising result given that the interference scenario involves a high power broadcasting transmitter (located well above the local terrain to maximise the potential coverage) operating co-channel with base stations of a cellular network which are to be deployed in the MMDS coverage area.

In the first paragraph of page 13 of its submission UPC Communications (Ireland) Ltd. says *"Aegis and Plum then go on to say that "a number of mitigation techniques could be considered to improve the feasibility of MMDS and NGMB sharing" and that "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". Here Aegis and Plum acknowledge (at least implicitly) that sharing in some form would be feasible. In doing so, in fact, Aegis and Plum acknowledge that their conclusions are incomplete and that further study could result in these conclusions being altered."*

In response to UPC Communications (Ireland) Ltd. points raised above it should be noted that the aim of the study was to assess the potential for sharing using generic sharing scenarios given that there are not any NGMB systems operational in the band 2500 to 2690 MHz. It was not intended to examine practical deployment scenarios to determine whether it would be possible to share on the basis of detailed coordination / deployment of mitigation techniques between MMDS and NGMB or through placing limitations on how NGMB might be deployed. This would be a major planning exercise involving system planning with terrain and clutter data over the planned coverage area targeted by the NGMB operators and was beyond the scope of the study.

However the outcome of the Study clearly identified that it was not possible to undertake co-channel sharing without, for example, imposing limitations on the deployment of NGMB and modifying the current coverage of the MMDS transmitters and adjacent channel was not feasible because MMDS utilises the majority of the 2.6 GHz band precluding any viable NGMB channel plan. This is summarised on pages ES-1 and ES-2 of Document 11/80a. Aegis and Plum still concur with this view.

Furthermore in Document 11/80a the implications of varying a number of modelling parameters (e.g. EIRP, antenna height, polarisation and antenna patterns) are examined in detail in using generic scenarios (see Table 2 for example, in Section 2.2.3, pages 11 and 12 where the results are summarised based on varying the modelling parameters).

The study team took a further step and analysed a specific scenario concerning the Dublin area using terrain data. As mentioned above, the results showed that the deployment of NGMB systems without coordinating with MMDS transmitters is not feasible.

In the second paragraph of page 13 of its submission UPC Communications (Ireland) Ltd. says *"Aegis and Plum acknowledge that ETSI have defined a transmitter mask in ETSI EN 300 744 giving a transmitter NFD of 50 dB. Despite this, Aegis and Plum also use an NFD of 30 dB in their analysis resulting in increased required separation distances, which has obvious negative implications for sharing."*

In response to the above input it should be noted that the term 'transmitter NFD' does not exist. In Page 7 of Document 11/80a, it is stated that

"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."

To provide further clarity the ETSI standard only specifies the transmitter mask. The NFD needs both the transmitter and the receiver selectivity masks. As there is no receiver selectivity data available the study assumed that the NFD is either dominated by the transmitter mask (which provides 50 dB signal suppression) or the receiver selectivity mask (which is assumed to provide 30 dB signal suppression to demonstrate the impact of relaxed NFD).

In the Document 11/80a, Figures 27, 30, 32 and 33 on pages 53, 57, 60 and 62 respectively, show the variation of separation distance against assumed NFD level. If the receiver selectivity data becomes available it can be used to more specifically assess the impact of interference. In other words, the report uses representative NFD levels (of 30 and 50 dB) to assess potential impact but the report also includes analysis results for NFD levels from 0 dB up to 100 dB.

However Aegis and Plum consider that the key issue is not the actual NFD levels that should be used but whether there is any potential for adjacent channel sharing. In Document 11/80a it states in paragraph 3 on page ES-2 that

" 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 . Under the current channel plans this is not feasible as all the channels are used [by MMDS] in the Dublin area."

The actual channel plans for MMDS are shown in Figure 1 on page 2 of Document 11/80a and the channel plans for NGMB are shown in Figure 2 also on page 2 of Document 11/80a. It can be clearly seen that there is no potential for adjacent channel sharing based on these two channels plans as the MMDS channels utilise

the majority of the 2.6 GHz band. Aegis and Plum still therefore affirm that adjacent channel sharing is not feasible as per the conclusions set out in Document 11/80a.

In the third paragraph of page 13 of its submission UPC Communications (Ireland) Ltd. says *"In the "mitigation measures" section Aegis and Plum acknowledge that micro and pico cell operation is feasible by stating that "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. Micro and pico cells usually operate below the clutter."*

The main conclusion of the technical analysis in Document 11/80a is that the sharing feasibility is dependent on the interference from MMDS transmitters into NGMB BS receivers as noted in the last paragraph on page ES-1 and repeated below:

"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 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."

As noted by UPC Communications (Ireland) Ltd. if base stations are limited to micro and pico cells and these are deployed below the clutter then the calculated separation distances will be reduced. This however places a significant constraint on the NGMB operator in their network roll-out and may still not be sufficient to avoid the need for detailed co-ordination.

The analysis with terrain in the Dublin region as described in Document 11/80a, pages 15 -18 shows that MMDS transmitters need to be turned off even when considering the scenario where there is a 30 dB mitigation factor included which is indicated by the yellow contour in Figures 6,7 and 8 at pages 16 and 17 in Document 11/80a. This indicates that terrain and clutter effects would need to introduce in excess of 30 dB additional loss for sharing to be feasible.

Aegis and Plum affirm that sharing on a co-channel basis is not feasible in Dublin without detailed co-ordination between the NGMB and MMDS operators.

In the fourth paragraph of page 13 of its submission UPC Communications (Ireland) Ltd. says *"In section 2.3.1 Aegis and Plum state that "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". Here Aegis and Plum provide explicit confirmation that there would be no barriers to geographic spectrum sharing in the 2.6 GHz band providing detailed co-ordination plans could be put in place."*

In our view the UPC Communications (Ireland) Ltd. statement that explicit confirmation is provided in Document 11/80a that there would be no barriers to

geographic sharing is not correct. The need to co-ordinate between the MMDS operator and a NGMB operator to facilitate geographic sharing, and the success of such, is a barrier. The implications of detailed coordination may reduce the potential of NGMB deployment in the band significantly and whether this would be feasible or place too many constraints on the roll-out of NGMB networks is outside the scope of the Aegis and Plum study and would need to be assessed by a NGMB operator with a proposal. It should be noted also that because MMDS occupies the majority of the 2.6 GHz band, as mentioned earlier in this Response, then all the NGMB operators that are licensed to use this band would need to agree with such a proposal and co-ordinate with the MMDS operator.

6.2.2 Response to comments under 'Co-channel: NGMB base station transmitter into MMDS receiver'

In the section titled 'Co-channel: NGMB base station transmitter into MMDS receiver' on pages 13, 14 and 15 of its submission UPC Communications (Ireland) Ltd. says *"In their analysis Aegis and Plum appear to have assumed that the micro and pico antennas are pointing directly at the MMDS receiver antenna. In section 5.2.1, for example, they state that "at each azimuth, it is assumed that the NGMB BS is pointing at the MMDS receiver." In reality this would not be the case as micro-cell antennas usually have a large downtilt to prevent interference with the rest of the network.*

Aegis and Plum also fail to specify in their report what antenna height they used when performing predictions relating to the micro and pico cell antennas. Micro cell antennas are usually at or below surrounding building heights which will have a dramatic impact on the propagation of the NGMB signal. Aegis and Plum's own analysis shows this and it is included in the next section.

Based on their findings and the architecture of a micro cell it should be feasible to use NGMB co-channel with MMDS providing the NGMB was only rolled out in urban areas with some co-ordination between the MMDS and NGMB operators."

The UPC Communications (Ireland) Ltd. statement that the Document 11/80a does not specify the antenna heights used in the analysis is incorrect as the analysis takes account of antenna height differences. The MMDS receiver is assumed to be at 10 metres and the BS transmitter is assumed to be at 30 metres and these parameters are listed in Document 11/80a Table 16, page 42, and Table 17, page 44, respectively. When calculating interference into the MMDS receiver, the implications of elevation patterns (given in Section 5.1.1 & 5.1.2) are taken into consideration and accordingly antenna down-tilt is included in the calculations. Given the difference in the assumed antenna heights, the antenna down-tilt at a NGMB base station is likely to increase the interference as the off-axis angle at the interfering transmitter towards the victim receiver will be reduced.

The statement re feasibility of NGMB operators to deploy micro cells with some co-ordination with the MMDS operator has already been addressed earlier. The requirement for co-ordination to facilitate geographic sharing is viewed as a barrier and would need to be assessed by a NGMB operator.

Furthermore, the interference analysis presented in the report clearly concludes that the feasibility of sharing is determined by the 'MMDS transmitter into NGMB base station receiver' interference scenario as detailed in Document 11/80a in the last paragraph on page ES-1.

6.2.3 Response to comments under 'Co-channel: NGMB mobile station into MMDS receiver'

In the section titled 'Co-channel: NGMB mobile stations transmitter into MMDS receiver' on pages 15 and 16 of its submission UPC Communications (Ireland) Ltd. says *"Based on the minimum EIRP level of –32.5 dBW / 5 MHz Aegis and Plum calculate the separation distance to be only 100 m for the urban case and 800 m for the rural case. Based on the co-channel NGMB base station and mobile station into an MMDS receiver results, micro and pico cells solutions should be possible in a geographical sharing situation where the NGMB network is only rolled out in dense urban environments."*

In Document 11/80a, Section 5.2.3.2, on page 56, interference analysis results were provided for different EIRP levels. The separation requirements quoted in the comment above correspond to the lowest NGMB EIRP level. Even with this level, NGMB mobile terminals require separation distances of greater than100 metres around the MMDS receivers. Given that NGMB user terminals are mobile the reinforcement of geographic separation from victim MMDS locations would not be possible.

Furthermore, interference analysis presented in the report clearly concludes that the feasibility of sharing is determined by the 'MMDS transmitter into NGMB base station receiver' interference scenario as noted previously in this document.

6.2.4 Response to comments under 'Co-channel: MMDS transmitter into NGMB base station'

In the section titled 'Co-channel: MMDS transmitter into NGMB base station' on page 16 of its submission UPC Communications (Ireland) Ltd. says *"In section 2.2.2.1 of their report, Aegis and Plum state that the minimum separation distance is less than 98.7 km from the edge of the MMDS service area. However in this analysis they have used an MMDS EIRP of 32 dBW / 8 MHz which is the maximum level specified in ComReg technical conditions for an analogue MMDS transmitter.*

UPC stated in its response to the Call for Input June 2010 that the analogue switchover to digital provision was completed on both MMDS networks (Chorus and NTL) in 2002 so there is no reason for Aegis and Plum to perform analysis with an EIRP greater than the maximum permitted digital MMDS level

of 22 dBW / 8 MHz. That is the maximum level stated in ComReg technical conditions for a digital MMDS transmitter.

While it is not implicitly stated by Aegis and Plum, it has to be assumed that all analysis of MMDS interference into NGMB base stations is done on the basis that the base station is a macro site with a 17dBi gain antenna at a height of 30 m and that both antennas are directly facing each other. This is a worst case scenario and is guaranteed to require the greatest separation distance. In this respect, no analysis has been presented by Aegis and Plum regarding potential interference into a NGMB micro or pico cell where the NGMB base station antenna has a substantially lower gain and the antenna is in the clutter."

The response from UPC Communications (Ireland) Ltd. is incorrect as the analysis has used a typical MMDS transmitter EIRP of 18 dBW /MHz as shown in the following text from Document 11/80a, page ES-1:

"For a typical MMDS transmitter (EIRP of 18 dBW/8 MHz 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 (The UPC site data indicates that 17 out of 22 MMDS transmitters use EIRP of 18 & 19 dBW/8 MHz)."

Also the following text from Document 11/80a contained in the first conclusion of the technical analysis (Section 2.2.3), page 12:

"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 an 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",

clearly shows that the study conclusions are based on the most representative MMDS emission level. In addition, the analysis does take account of elevation patterns at both ends as already covered earlier in this document. Most importantly, the analysis results with terrain data shown in Section 2.3 of Document 11/80a (Figures 6 - 10) indicate that the co-channel sharing in Dublin is not possible even when the interference criterion is relaxed by up to 30 dB (which may be attributed to various mitigation techniques including deployment constraints on NGMB networks).

From a practical deployment point of view this is not a surprising result given that the interference scenario involves a high power broadcasting transmitter (located well above the local terrain to maximise the potential coverage) operating co-channel with base stations of a cellular network which are to be deployed in the MMDS coverage area.

6.2.5 Response to comments under 'Co-channel: MMDS transmitter into NGMB mobile station'

In the section titled 'Co-channel: MMDS transmitter into NGMB mobile station' on page 16 of its submission UPC Communications (Ireland) Ltd. says *"In section 5.3.3 of the Aegis and Plum report, the statement "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" appears to be based on the assumption that the MMDS EIRP is 32 dBW / 8 MHz. Aegis and Plum then go on to say that "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". While the distances are similar in these two statements, the first distance, i.e. 33.1 km, refers to the distance from the coverage area while the second, 35.5 km, refers to the distance between the transmitter and receiver. This may cause confusion as the two comparisons are not similar; the distance from the coverage area with the correct EIRP (22 dBW / 8 MHz) is actually 19.9 km."*

The following table and text is taken from Section 5.3.3 of Document 11/80a and clearly illustrates that a range of different MMDS EIRP levels have been used to calculate the required separation distances between an MMDS transmitter and a NGMB mobile station receiver:

"

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 on an example Stella Doradus radiation pattern."

As can be seen the comment below the table refers to all results in the table which are based on 'separation between the transmitter and receiver'. In the case of a MMDS transmitter with an EIRP of 22 dBW/8 MHz then the required separation would be 19.9 km as noted by UPC Communications (Ireland) Ltd. The second paragraph refers to an additional result with different antenna radiation pattern. This result is also expressed in terms of 'separation between the transmitter and receiver' to be consistent with the results given in the table.

In the section titled 'Co-channel: MMDS transmitter into NGMB mobile station' on page 17 of its submission UPC Communications (Ireland) Ltd. says *"Aegis and Plum's analysis in section 5.3.3 shows that a separation of 35.9 km is required between the MMDS transmitter and the NGMB mobile station. The only MMDS transmitter this close to Dublin city centre is the one located in the Naul, County Dublin. To ensure co-channel operation with micro cells in Dublin the Naul MMDS antennas may require additional downtilt to ensure that the interference is within the required limits. Analysys Mason has already conducted a study for UPC to show that this solution is technically feasible and full details of this study have already been shared with ComReg."*

Interference analysis presented in Document 11/80a clearly concludes that the feasibility of sharing is determined by the 'MMDS transmitter into NGMB base station receiver' interference scenario. Interference between the MMDS transmitter and the NGMB mobile station is less critical. The analysis results with terrain data shown in Section 2.3 of Document 11/80a (Figures 6 - 10) indicate that co-channel sharing in Dublin is not possible even when the interference criterion is relaxed by up to 30 dB (which may be attributed to various mitigation techniques including deployment constraints on NGMB and MMDS networks).

6.2.6 Response to comments under 'Adjacent channel: NGMB base station transmitter into MMDS receiver'

In the section titled 'Adjacent channel: NGMB base station transmitter into MMDS receiver' on page 17 of its submission UPC Communications (Ireland) Ltd. says *"Aegis and Plum state that "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". However they also include an analysis with "an assumed NFD level of 30 dB" without explaining how they arrived at the level of 30dB. The only explanation in section 5.2.2 is "if it is assumed that the adjacent channel NFD is dominated by receiver selectivity at an assumed level of 30 dB"."*

In Document 11/80a on page 7 it is stated that

"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."

In Document 11/80a, the EC Decision limits were used to derive the transmitter mask. The NFD needs the transmitter and the receiver selectivity masks. As there is no MMDS receiver selectivity data available the study assumed that the NFD is either dominated by the NGMB base station transmitter mask (which provides 57 dB signal suppression) or the MMDS receiver selectivity mask (which is assumed to provide 30 dB signal suppression to demonstrate the impact of relaxed NFD).

In Document 11/80a, Figure 27 on page 51 shows the variation of separation distance against assumed NFD level of up to 100 dB for the interference scenarios involving NGMB base station transmitters and MMDS receivers. If the receiver selectivity data becomes available it can be used to assess the impact of interference more realistically using the data provided in Figure 27. In other words, the report uses representative NFD levels (of 30 and 57 dB) to assess potential impact but the analysis results for NFD levels from 0 dB up to 100 dB are also included.

Further point to note, are Document 11/80a states on page ES-2:

" 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. Under the current channel plans this is not feasible as all the channels are used in the Dublin area."

Furthermore, interference analysis presented in Document 11/80a clearly concludes that the feasibility of sharing is determined by the 'MMDS transmitter into NGMB base station receiver' ***co-channel*** interference scenario.

6.2.7 Response to comments under 'Adjacent channel: NGMB mobile station transmitter into MMDS receiver'

In the section titled 'Adjacent channel: NGMB mobile station transmitter into MMDS receiver' on page 17 of its submission UPC Communications (Ireland) ***Ltd. says "In section 2.2.1.4 it is only the results with an NFD of 30 dB that are presented and these show that the required separation from the edge of MMDS service area is 170 m for the urban case and 1.45 km for the rural case. Again in this conclusion Aegis and Plum appear to have used the maximum ECC permitted mobile station EIRP rather than the "more practical" ITU EIRPs. In section 2.2.3 of their report, Aegis and Plum conclude that an "NGMB MS with EIRP of 5 dBW/5 MHz interferes with MMDS receiver at 10 m when an NFD of 30 dB is available", (The "10m" refers to the MMDS receiver antenna height).***

When dealing with the mobile station the NFD masks are not as well defined and analysis with two values, 30 and 50 dB, is presented in section 5.2.4."

The analysis provided in Document 11/80a is based on the permitted NGMB mobile station EIRP, which is worst case and used within ECC sharing studies, and lower values would reduce the required separation distances. However these calculated distances are **not** the determining factor in the assessment of sharing feasibility as the potential for co-existence is determined by the 'MMDS transmitter into NGMB base station receiver' ***co-channel*** interference scenario. Therefore the conclusion that geographic sharing is not feasible is not impacted by any modifications that might be made to mobile transmitter EIRP values.

The NFD levels of 30 and 50 dB are used in Document 11/80a as the representative values. In addition, Figure 30 on page 57 of Document 11/80a includes separation distances corresponding to 0 to 50 dB NFD levels.

Further point to note, the report states that (page ES-2)

" 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 . Under the current channel plans this is not feasible as all the channels are used in the Dublin area."

Further in the section titled 'Adjacent channel: NGMB mobile station transmitter into MMDS receiver' on page 18 of its submission UPC Communications (Ireland) Ltd. says *"The conclusions in section 2.2.3 do not include the results when the 50 dB NFD is analysed, which, as can be seen in Table 5 above, produces more favourable results."*

The conclusions Table in Document 11/80a is necessarily concise but information is also provided that considers other values of NFD and as mentioned above Figure 30 in Document 11/80a includes separation distances corresponding to 0 to 50 dB NFD levels.

6.2.8 Response to comments under 'Adjacent channel: MMDS transmitter into NGMB base station'

In the section titled 'Adjacent channel: MMDS transmitter into NGMB base station' on page 18 of its submission UPC Communications (Ireland) Ltd. says *"In section 2.2.2.3 of their report Aegis and Plum state "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)" then an NFD of 50 dB can be assumed. With this NFD there is no separation required when the MMDS EIRP levels less than or equal to 23 dBW/8 MHz with an MMDS transmitter effective height assumed to be 200 m.*

However they then go on to perform a prediction with an assumed NFD of 30 dB and an MMDS EIRP of 32 dBW / 8 MHz where the required separation is 33 km. There is no explanation as to why the NFD should be 30 dB and again have used the analogue maximum EIRP. This simply has the effect of increasing the required separation."

In Section 2.2.2.3 on page 10 of Document 11/80a it states that:

*"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**[2] 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**[3] 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."*

The 33 km distance mentioned in the comment corresponds to an NFD level of 30 dB (which is assumed to represent the receiver selectivity domination in the NFD) and an EIRP level of 32 dBW/8MHz (which is the maximum allowed MMDS EIRP). In the same section in Document 11/80a, distances for lower EIRP values are also included as seen above. For example, an EIRP level of 18 dBW / 8 MHz requires 14.8 km separation if the NFD is dominated by the NGMB base station receiver at an assumed level of 30 dB.

Once more it is worth noting that the adjacent channel sharing is not feasible due to the MMDS channel plans that are based on the use of all channels at MMDS sites. Furthermore, the co-existence is determined by the 'MMDS transmitter into NGMB base station receiver' ***co-channel*** interference scenario.

In the section titled 'Adjacent channel: MMDS transmitter into NGMB base station' on page 18 of its submission UPC Communications (Ireland) Ltd. says *"In section 5.3.2 of their report Aegis and Plum state that "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".*

With an NFD of 50dB the required separation is 24.1 km while with an NFD of 30 dB the required separation is 49 km. However, as already discussed above, Aegis and Plum appear to have based these conclusions on the maximum analog EIRP of 32 dBW / 8 MHz not the maximum digital EIRP of 22 dBW / 8 MHz."

[2] Emphasis added.

[3] Emphasis added

In Document 11/80a on page 60 Figure 32 shows the results for a set of MMDS EIRP values as shown below so the conclusions are not based on the MMDS analogue EIRP.

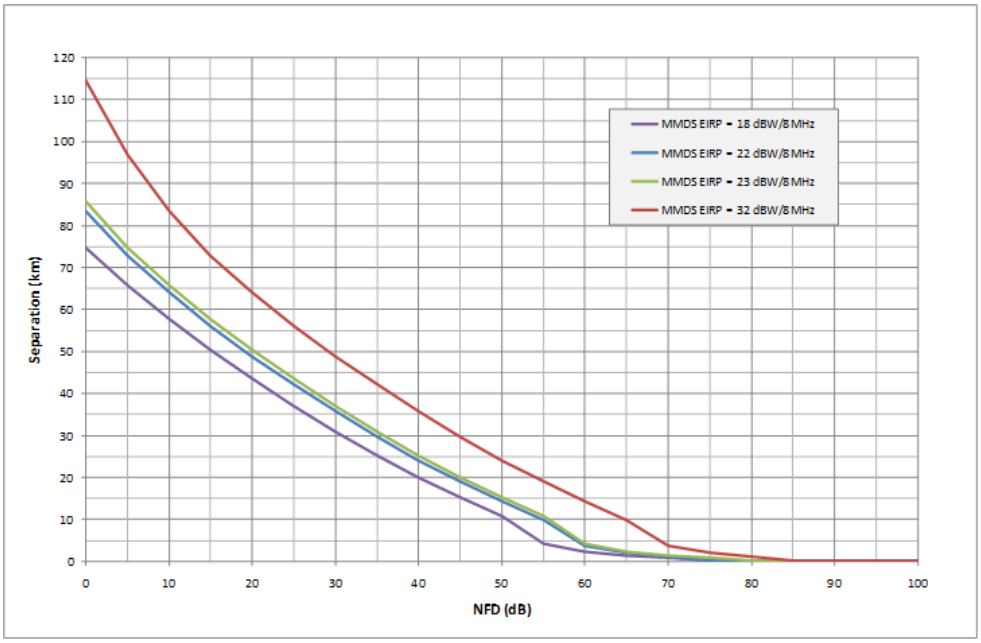


Figure 32: Variation of Separation Distance with NFD (Digital/Analogue MMDS Transmitter Interference into NGMB BS Receiver)

As mentioned earlier in this document the main conclusions of Document 11/80a are based on an MMDS EIRP level of 18 dBW / 8 MHz which represents 17 out of 22 MMDS transmitters.

Once more it is worth noting that the adjacent channel sharing is not feasible due to the MMDS channel plans that are based on the use of all channels at MMDS sites. Furthermore, the co-existence is determined by the 'MMDS transmitter into NGMB base station receiver' ***co-channel*** interference scenario.

In the section titled 'Adjacent channel: MMDS transmitter into NGMB base station' on page 19 of its submission UPC Communications (Ireland) Ltd. says *"It is worth noting also that in section 2.2.2.3 Aegis and Plum report the result as the required separation from the edge of the MMDS coverage area while in section 5.3.2 they report the result as the required separation between transmitter and receiver."*

In Section 5.3.2, of Document 11/80a it states that:

"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."

As stated above the results are reported in terms of distance from the edge of the MMDS coverage area and there is therefore consistency between sections 2.2.2.3 and 5.3.2 in Document 11/80a

In the section titled 'Adjacent channel: MMDS transmitter into NGMB base station' on page 19 of its submission UPC Communications (Ireland) Ltd. says *"Again the prediction assumes the NGMB is a macro site base station, no analysis has been presented regarding potential interference into a NGMB micro or pico cell where the NGMB base station antenna has a substantially lower gain and the antenna is closer to the clutter."*

It would be expected that a NGMB operator would wish to deploy a range of base stations (macro. micro and pico) and therefore the baseline analysis has been based on a macro cell assumption. However it should be noted that the previous responses above in respect of the feasibility of adjacent channel note that this is not a viable option because the MMDS channel plans are based on the use of all channels at MMDS sites. Furthermore, the co-existence is determined by the 'MMDS transmitter into NGMB base station receiver' *co-channel* interference scenario. Response to comments under 'Adjacent channel: MMDS transmitter into NGMB mobile station'

6.2.9 Responses to comments under 'Adjacent channel: MMDS transmitter into NGMB mobile station'

In the section titled 'Adjacent channel: MMDS transmitter into NGMB mobile station' on page 19 of its submission UPC Communications (Ireland) Ltd. says *"In section 2.2.2.4 Aegis and Plum state that there is no separation required from the edge of the MMDS coverage area for an NFD of 30 dB. In section 5.3.4, however, they state that the there is a separation requirement of 15.4 km between the transmitter and the receiver."*

In Document 11/80a in Section 5.3.4 on page 61, it is stated that:

"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."

It is therefore correct in section 2.2.2.4 of Document 11/80a to state there is no separation required between the edge of the MMDS coverage area and the NGMB receiver in the case of a NFD of 30 dB.

6.2.10 Response to comments under 'Conclusions on Aegis and Plum's technical analysis of spectrum sharing'

In the section titled 'Conclusions on Aegis and Plum's technical analysis of spectrum sharing' on page 20 of its submission UPC Communications (Ireland) Ltd. says *"In summary, it is UPC's position that the technical*

analysis carried out by Aegis and Plum on the possibility of spectrum sharing in the 2.6 GHz band greatly overstates the possibility of interference between MMDS and NGMB services under each of the scenarios examined. As we have shown, Aegis and Plum's analysis utilises a number of erroneous base assumptions (in particular in the way different EIRP levels are used) which means that predicted output figures (in particular in relation to separation distances) are greatly overstated.

In addition, Aegis and Plum appear to have taken no account of the possible co-existence of MMDS and NGMB where the latter is deployed to provide additional in-building capacity using micro and pico cells. Indeed, Aegis and Plum do not appear to have taken sufficient (or, indeed, any) account of demand drivers for mobile broadband spectrum more generally and what mobile operators' strategies in this regard is likely to mean for the demand for 2.6 GHz spectrum to support NGMB services between now and 2019. This is an issue we now discuss in more detail as we consider issues relating to the economic analysis that is contained in the Aegis and Plum report."

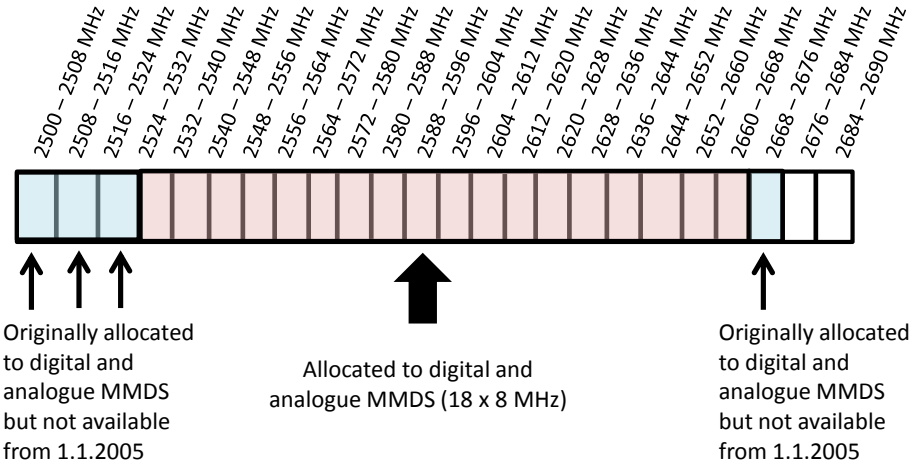
The points raised by UPC Communications (Ireland) Ltd. in their conclusions on Document 11/80a replicate those already responded to in this document.

It is important to recognise that sharing studies need to make use of both regulatory and practical deployment data, if available. Where there is lack of data reasonable assumptions need to be made to arrive at conclusions. The analysis presented in Document 11/80a is comprehensive and incorporates both regulatory and practical data and there has been no information presented by UPC that would lead Aegis and Plum to modify the conclusions from the technical study.

UPC Communications (Ireland) Ltd.'s main argument that geographic sharing can be realised is based on imposing regulatory deployment limitations on the NGMB systems (e.g. deployment of micro/pico cells below the clutter) and co-ordination between the MMDS and NGMB operators. The practical scenario based on the analysis of interference in the Dublin area shows that sharing will not be feasible without removing MMDS transmitters even with a 30 dB mitigation factor. The report does not contain any erroneous base assumptions. Analysis and conclusions are primarily based on practical deployment data. Also sensitivity analysis has been used to understand the potential impact of different parameters (e.g. NFD values).

6.3 Summary in relation to technical assessment

It is important to realise, as noted in the individual responses to UPC Communications (Ireland) Ltd's comments above, that there is no potential for adjacent channel sharing between MMDS and NGMB as the MMDS deployments utilise the majority of the 2.6 GHz band as shown in the figure below, taken from Document 11/80a:



Whilst there is some limited spectrum available either end of the 18 MMDS channels these do not match with the proposed duplex arrangements for NGMB in the 2.6 GHz band.

Therefore the potential for sharing in Document 11/80a has focused on co-channel deployment of MMDS and NGMB. The key determinant of whether sharing can be supported is the MMDS into NGMB base station scenario. This scenario has been examined in Document 11/80a using the actual MMDS transmitter EIRP values (18 & 19 dBW/8 MHz) provided in the UPC site data. In addition in the Dublin area the analysis has been undertaken based on the terrain data and it is concluded that interference from MMDS sites at Mount Oriel, Naul and Dunmurry would prohibit the operation of NGMB systems. It would therefore be necessary to place deployment restrictions on NGMB networks (for example micro site and / or indoor deployment) or undertake detailed sharing studies on a site by site basis as the operator's networks are rolled out. Whether the latter would be feasible or practical is questionable and the risk / barrier of adopting such approaches would need to be assessed by the NGMB operators. .

6.4 Analysis of comments on calculation of net benefits

6.4.1 Response to comments under 'Executive Summary'

"In UPC's opinion, such a conclusion cannot possibly be supported as it is based on a gross overstatement of the economic benefits of using the 2.6 GHz spectrum band for NGMB services in the period 2014 – 2019 and a significant underestimation of the cost to the Irish economy of the early closure of UPC's MMDS service. In its response to the Call for Input, UPC submitted economic evidence to ComReg showing that the benefits of retaining the 2.6 GHz band for MMDS up to 2019 far outweighed those that would accrue if it were re-assigned for use to support the provision of NGMB services." Page 2 of UPC executive summary.

The Aegis/Plum economic assessment is based on an assessment of the incremental benefits and costs of retaining 2.6 GHz spectrum for MMDS versus

reallocation for NGMB. This is the correct approach to economic impact assessment.[4] In contrast, in their response UPC:

- Counts the costs of running MMDS as a benefit of MMDS. This is not a valid approach to cost benefit analysis since costs are a cost rather than a benefit.
- Does not consider the incremental costs and benefits of customers both alternatives, MMDS and NGMB, instead focussing on the incremental benefits of 2.6 GHz NGMB (in contrast to other frequencies such as 1800 MHz) and the full benefits of MMDS TV services (rather than the difference in benefits compared to alternative TV services). The correct approach is to compare incremental benefits of 2.6 GHz spectrum in relation to both MMDS and NGMB.

In conclusion, the framework for analysis set out Sections 4.3 and 4.4 of Document 11/80a is sound. In contrast, the UPC opinion, supported by analysis by Analysys-Mason, adopts a different incorrect approach to economic cost-benefit assessment.

Whilst this is the fundamental difference between the UPC opinion and the Aegis and Plum economic assessment we also comment on some of the specific points of detail in relation to the comments by UPC on the economic analysis below.

6.4.2 Response to comments under 'Issues relating to the economic analysis contained in the Aegis and Plum report'

In the first bullet on page 21 UPC state: ***"The assessment of the economic benefits of the 2.6 GHz spectrum if used for the provision of mobile broadband services between 2014 and 2019 considerably overstates the economic value that would arise in practice. This is because the assessment simply utilises a benchmark of auction prices achieved in 2.6 GHz auctions in other European countries. We believe this approach considerably over-estimates the economic value that would arise in Ireland in view of…"***

UPC list specific considerations as sub-bullets to the above. There are three points to consider in relation to the arguments here:

- First, as a matter of principle whether estimates based on auction proceeds overestimate or underestimate benefits of spectrum use for NGMB.
- Second, whether there are clear differences between Ireland and other countries from which auction values are drawn that suggest values would be lower or higher in Ireland.
- Third, there are likely to be competition benefits in the mobile broadband market from availability of additional contiguous spectrum to support

[4] Regarding methodology see, for example, Boardman, Greenberg, Vining and Weimer. 2006. Cost-benefit analysis – concepts and practice. Pearson.

multiple operators offering higher speed lower cost services that are not reflected in auction proceeds.

In relation to the first point there are grounds for considering that auction proceeds may underestimate the economic value of NGMB. There are two reasons for this view.

- Bidders know that they will not capture fully the benefits of faster services (due to the availability of wider contiguous spectrum channels with 2.6 GHz spectrum) and lower costs (as spectrum can substitute for additional base stations and in-building solutions as pointed out by UPC on pages 9 and 10) as higher revenues since some of these benefits will ultimately accrue to consumers as lower prices and/or improved service at a given price. Bidders would not therefore be expected to bid the full economic value of spectrum.
- Bidding may not be fully competitive and will not therefore reflect the full benefits that bidders do expect to capture.

In principle therefore we conclude that realised spectrum auction values provide a conservative estimate of the economic benefits of spectrum use for NGMB, as stated in the original Aegis and Plum analysis. In relation to the second point it is not obvious on *a priori* grounds that the value of NGMB will be lower in Ireland than in other countries. The Aegis and Plum analysis also considered more than one estimate of spectrum value, with the lower estimates based on econometric analysis by Dotecon of possible explanatory factors influencing spectrum value, with relevant variable values for Ireland substituted into the Dotecon equation.

In relation to the third point, the benefits in terms of greater competition in the mobile broadband market (and the broadband market more generally) from having sufficient spectrum to support multiple operators with 2x20 MHz contiguous channels may be significant and will not be reflected in auction proceeds. We note that realistic expectations in terms of the availability of other spectrum including the 1800 MHz spectrum discussed by UPC would not offer substitute contiguous 20 MHz channels for all of the operators currently in the Irish market. We also note that in a number of other countries where LTE has been deployed at 1800 MHz it has also been deployed at 2.6 GHz, for example Finland.

The conclusion of the Aegis and Plum analysis was robust to a low value for spectrum as a lower bound estimate of the value of NGMB. The conclusion in the Executive Summary of Document 11/80a stands, namely that *"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."*

In sub-bullet 4 on page 21 UPC state *"There is considerable uncertainty over the future demand for spectrum for the provision of mobile services. By encouraging ComReg to auction the 2.6 GHz spectrum now (considerably in*

advance of when it is actually likely to be needed, even if the highest traffic forecasts are taken into account), the mobile operators could be seeking to acquire the spectrum at considerably lower prices than would be paid during an auction in (for example) 2018…"

There is considerable uncertainty over demand, however, LTE tends to be deployed at 2.6 GHz where 2.6 GHz spectrum is available, so whilst there is uncertainty over the level of spectrum demand there is strong evidence of demand. In addition, future demand uncertainty is likely to increase rather than decrease the value of 2.6 GHz spectrum for NGMB today. The reason for this is that demand may turn out lower or higher than anticipated, and the option of utilising additional spectrum should demand turn out to be high is valuable. If 2.6 GHz were not made available in 2014 then the option of utilising it for NGMB between 2014 and 2019 would not be available i.e. there is a foregone option value that is greater if there is considerable uncertainty.

In the bullet point on page 22 UPC state: *"The costs to the Irish economy of ComReg closing down UPC's MMDS services prior to 2019 are considerably underestimated."*

In sub-bullets to the above UPC list specific consideration including the investment UPC could make in HDTV services, competition, jobs, expenditure and wider societal benefits.

UPC note that with investment in DVR boxes and with a more substantial investment in HDTV UPC could stabilise or grow the customer base respectively. We note that, whilst improving service quality would be expected to reduce the decline in customer numbers, doing so would involve a cost – investment – that may have a limited life assuming 2.6 GHz spectrum is reallocated in 2019 rather than 2014. There would also be time costs for customers in making the transition to a new UPC service, as there would for transition to an alternative service provider. We also note that customers can achieve higher service quality including HDTV by switching provider.

Taking the above factors into account, we would not expect consideration of a scenario in which customer numbers are higher to 2019 due to greater investment in enhancing MMDS service quality to make a material difference to the overall estimation of costs and benefits of reallocating 2.6 GHz spectrum for NGMB.

In relation to the argument regarding competition in the Irish TV market we reiterate the finding of the original Aegis/Plum study that given the small and declining number of customers on MMDS and national pricing of services (which face competition from cable outside MMDS areas), we would not expect the absence of MMDS services to have a material impact on competition in the TV market in Ireland. Further, as noted earlier, additional spectrum for NGMB would promote competition in the mobile broadband market and wider broadband access market.

In relation to jobs, both TV services and NGMB support jobs. In terms of both the quantity and quality of jobs in Ireland the option in terms of spectrum use that maximises overall economic benefit is likely to be the one that offers the greatest benefit in terms of economic welfare for people in Ireland – including employment prospects.[5]

In relation to the expenditure incurred by UPC Aegis/Plum correctly consider a reduction in such expenditure to be a benefit if spectrum were reallocated. It is wrong to argue, as UPC does, that expenditure is a benefit rather than a cost for the purposes of impact assessment.

UPC also notes that no account is taken of wider societal benefits of MMDS service. The Aegis/Plum study noted that *"we make the simplifying and conservative assumption that the incremental external social value from additional spectrum for mobile broadband is zero, relative MMDS."*

Given the diverse and growing applications of mobile broadband we expect that relative to MMDS it will over time offer greater external benefits. However, given the uncertainty involved in assessing such benefits, for MMDS or NGMB, we felt a qualitative conclusion in relation to the relative magnitude of such benefits was appropriate.

Finally, we note that the number of MMDS customers has continued to decline. At the time of the Aegis/Plum study the latest available estimate was 66,900 for Q3 2010. A more recent estimate for 31 December 2011 from UPC puts the number at 55,100[6] out of a total of 1,584,000 TV homes in Ireland.[7] As the number of MMDS customers declines the costs of switching the remaining customers to alternative platforms declines and any net benefits that might be attributed to continued MMDS provision decline.

UPC also make additional comments in relation to the price of alternative services, the number of hours required to migrate to a new platform and services costs.

In relation to the price of alternative services we note that migration is on-going with falling customer numbers on MMDS. Therefore those who are migrating consider that the benefits of migrating – net of any price difference - exceed the costs of migrating. We take this into account in our modelling by assuming that the average cost net of differences in net benefits of migrating is half way between zero and the

[5] Illustrative of the economic and employment potential of mobile devices and applications is the April 2012 announcement by Apple (predominantly a mobile device and service company) to employ an additional 500 people in Cork. We note that this expansion does not relate to the development of mobile services in Ireland *per se*, but to the expansion of a support base for the wider European market. Nevertheless it illustrates the opportunities been created in relation to mobile. http://www.irishtimes.com/newspaper/finance/2012/0421/1224315008559.html

[6] http://www.lgi.com/pdf/UPC-Holding-BV-2011-RESULTS.pdf

[7] http://www.comreg.ie/_fileupload/publications/ComReg1220.pdf

cost of migrating i.e. the average forced migration would involve a cost greater than zero but less than the switching cost since they would derive a net benefit from switching.

In relation to the number of hours required to migrate UPC propose that at least 5 hours is more realistic than our assumption of 2 hours. The Aegis/Plum study included sensitivity analysis, including sensitivity analysis of assuming that migration involves 5 hours of consumer time (which we consider to be on the high side). It was found that this had very little impact on estimated net benefits. We note that if migration times are higher they may also be higher for consumers adopting an upgraded MMDS service which would reduce the net benefits of a service upgrade, for example, to HDTV.

In relation to services costs we note that these apply to both MMDS and alternative platforms, irrespective of the contractual relationship which determines the incidence of costs between producers and consumers. Explicit consideration of services costs would not therefore be expected to alter the conclusions of the analysis in terms of overall producer and consumer surplus.

6.4.3 Response to comments under 'Use of the 1800 MHz band to deliver the economic benefits of mobile broadband services'

In paragraph 4 on page 23 UPC state*: "In this section we provide further details in support of our concern that the economic benefits arising from use of the 2.6 GHz band for mobile broadband services are massively overstated in the Aegis/Plum study."*

On pages 25-27 UPC refer to the availability of other spectrum (particularly 1800 MHz spectrum).

The availability of multiple wide and contiguous spectrum channels for LTE would likely be constrained in the absence of 2.6 GHz spectrum. There is therefore a benefit from having 2.6 GHz spectrum available independent of overall capacity.

We also note that since the previous analysis additional information from LTE deployments points to deployment in the 2.6 GHz band even where other spectrum, including 1800 MHz spectrum, is available.

6.4.4 Response to comments under 'Limited demand for 2.6 GHz spectrum in other European countries'

At the time of the Aegis/Plum study, it was noted that LTE had or was intended to be deployed at 2.6 GHz in Norway, Sweden and Germany. Current data points to a proliferation of LTE deployments at 2.6 GHZ including, from October 2011 in Europe, Denmark, Austria, Finland, Armenia, Hungary, Portugal and Croatia.[8] As a rule once 2.6 GHz spectrum is made available for NGMB services deployment follows rapidly, including in a number of countries where deployment at 1800 MHz is

[8] PolicyTracker. 1 April 2012. "The LTE story: new launches by spectrum band."

also occurring. 2.6 GHz spectrum is a key band for LTE and will also therefore be important for roaming.

6.4.5 Response to comments under 'Estimated demand for 2.6 GHz spectrum in Ireland up to 2019'

In relation to demand between 2014 and 2019 we first reiterate that where available deployment at 2.6 GHz tends to occur quickly – in other words there is demand in the near term. Further, far from having most value closer to 2019, constraints on re-farming of other mobile spectrum in the near term may imply a higher value early in the period than later (if mobile data demand continues to grow post 2019 then demand would ultimately increase again). We do not therefore accept the argument that the value of 2.6 GHz in Ireland will be greatest post 2019 rather than in the nearer term.

In relation to mobile data growth we note that the most recent Cisco mobile data forecast published in February 2012 showed that growth over the previous year had exceeded the previous forecast marginally at 133% versus 130% respectively.[9] To 2016 Cisco forecast a compound average growth rate of 56%, above the upper end of the range of forecasts mentioned by UPC. LTE, given the higher level of service quality and lower cost per GB of data carried, is expected to stimulate demand.

Whilst a precise forecast is impossible very high levels of data growth are plausible,[10] and more spectrum will lower the costs of meeting such demand.

Finally, in relation to demand for 2.6 GHz spectrum for NGMB, we note that if it turns out that mobile operators do not value the spectrum sufficiently highly UPC could retain the spectrum by bidding for it at auction.

6.4.6 Response to comments under 'Loss of revenue to the Irish Exchequer'

On page 30 and 31 UPC state: ***"In view of the uncertain demand for 2.6 GHz spectrum, now may not be the appropriate time for auctioning of the band in order to optimise the overall value for Ireland… In view of these uncertainties, it is likely that the mobile operators may place a lower value on the spectrum than would be the case closes to 2019 when UPC's licences would expire, in the event that they were renewed. It would therefore be better for ComReg to hold an auction once the demand for the spectrum is clearer – at which stage the Irish Exchequer (and ultimately all Irish citizens) will benefit from the true underlying value of the spectrum."***

[9] http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

[10] http://www.plumconsulting.co.uk/pdfs/Plum_Insight_Jan2011_Mobile_data_growth_-_too_much_of_a_good_thing.pdf

The value of 2.6 GHz spectrum is uncertain, as is the manner in which its value may change over time. However, we note that before other spectrum can be re-farmed 2.6 GHz spectrum may be more valuable i.e. in the near term.

Revenue also accrues not just or in particular from spectrum auctions but from the taxation of value added throughout the Irish economy. Overall value added – in effect the tax base – is most likely to be maximised if 2.6 GHz spectrum is allocated to the use that maximises overall economic surplus. The question of what approach maximises revenue (or revenue potential) to the Exchequer is therefore subsumed by the wider question of maximising economic value.

Finally, we note that in cost benefit analysis it is appropriate to consider gains in terms of reduced economic costs of taxation but not the full net revenue impact on the Irish Exchequer as this is a "transfer" rather than a net economic impact.

6.4.7 Response to comments under 'Economic costs arising from non-renewal of UPC's licences'

In paragraph 3 on page 31 UPC state: *"the study…considers the loss of UPC's on-going expenditure in Ireland as a benefit rather than a cost…"*

Aegis and Plum count the loss of UPC's ongoing expenditure as a benefit because it is correct to count foregone costs as a benefit in an assessment of economic costs and benefits.

6.5 Summary in relation to economic benefit assessment

The key differences between the UPC assessment and the Aegis/Plum assessment are that UPC count the costs of MMDS provision as a benefit of continued provision whilst Aegis/Plum count the costs of MMDS provision as a cost of continued provision; and UPC consider the full benefits of MMDS based TV as a benefit whilst Aegis/Plum consider the incremental benefits versus alternative TV platforms to be negligible and focus on the costs of switching from MMDS to alternatives. The Aegis/Plum approach in relation to both aspects is conceptually the correct approach for economic impact assessment.

In relation to market development and new information compared to the original study we note that mobile data demand has continued to increase, LTE has been widely deployed at 2.6 GHz where 2.6 GHz spectrum has been made available, whereas demand for MMDS in Ireland has continued to decline.

Finally we note that whilst the estimated net benefits of reallocating spectrum from MMDS to NGMB remains valid in our view, that should MMDS be the higher value use of 2.6 GHz spectrum then UPC would have the option of retaining 2.6 GHz spectrum by out bidding mobile operators at auction. Allowing the option of reallocation therefore appears both well founded and leaves open to the possibility that MMDS turns out to be the most highly valued use to 2019.

7 VODAFONE IRELAND LTD.

7.1 Introduction

The comments received from Vodafone addressed both the technical and economic aspects of the Report. Vodafone considered the technical study to be over conservative but considered the "scope and overall and methodological approach of the cost-benefit analysis (CBA)" to be correct and "that the assessment is sufficiently comprehensive in its assessment of all the relevant impacts of the options considered".

7.2 Analysis of Technical Comments

In the first bullet point of Vodafone's comments on the 'Technical Evaluation of Sharing Options' on page 3 of the response included in Document 11/80s it says *"Vodafone notes that the Aegis and Plum study itself recognises (section 2.1.1 of the report) that required separation distances for next generation mobile broadband with pico cell application will be much lower than those for base stations operating with an EIRP equal to the EC Decision limit."*

In Section 2.2.1 of Document 11/80, the report summarises the analysis of interference from NGMB into MMDS and as Vodafone's comment states, the implications of reduced EIRP were also examined. This information could be used to understand the potential for interference in the case NGMB uses smaller cells in the 2.6 GHz band. It is however worth noting that interference into NGMB base stations was the key scenario affecting the feasibility of sharing.

In the second bullet point of Vodafone's comments on the 'Technical Evaluation of Sharing Options' on page 3 of the response included in Document 11/80s it says *"The maximum allowed interference levels for base stations and user terminals used in the assessment, as detailed in Table 17 of section 5.1.2 of the report, are very conservative, and while it may not be an ideal scenario, a mobile operator using these frequencies in urban areas would expect to tolerate interference levels considerably higher than the parameters used in the Aegis analysis."*

In Document 11/80a a value of -10 dB for I/N has been used as this is the approach widely used in sharing studies where there is no established criterion. It should be noted that the analysis of interference into the Dublin area, taking into account terrain, considers a 30 dB mitigation factor based on the interference threshold shown by the yellow contour in Figures 6-10 in Section 2.3 of Document 11/80a (pages 16 – 18). These figures demonstrate the impact of potential relaxation in the assumed criterion.

In the third bullet point of Vodafone's comments on the 'Technical Evaluation of Sharing Options' on page 3 of the response included in Document 11/80s it says *"It is unclear how the effects of urban clutter have been evaluated in*

implementing the effect of propagation from MMDS transmitters outside Dublin into the city's urban area."

The analysis used generic propagation models as detailed in Section 5.1.3 of Document 11/80a. Furthermore, the analysis of interference into Dublin area takes account of the terrain data as described in Section 2.3 of document 11/80a. The detailed modelling with urban clutter would move the analysis towards consideration of specific NGMB system deployment scenarios which was beyond the scope of the study.

7.3 Analysis of Economic Comments

In paragraph 4 on page 4 Vodafone say*: "Vodafone notes however that the estimate of the value of the 2.6 GHz spectrum is based on an econometric benchmark analysis carried out by DotEcon of outcomes of 2.6 GHz spectrum auctions in other countries". Expressed concern "that spectrum values estimated from the use of this benchmarking analysis are not appropriately adjusted to reflect the Ireland specific factors relevant to accurate valuation of this spectrum. However Vodafone notes that the sensitivity analysis carried out in the Aegis and Plum report indicates that the findings of the CBA are not sensitive to lower values of spectrum for mobile broadband".*

The purpose of the Aegis/Plum study is to assess the balance of costs and benefits of use of 2.6 GHz spectrum for NGMB versus MMDS in the period 2014-2019. The spectrum values utilised in the study are intended as a conservative proxy for economic benefit only.

8 CONCLUSIONS

Aegis and Plum have reviewed all responses received to the published Document 11/80a that relates to the technical analysis of the potential for sharing between multipoint microwave distribution (MMDS) and next generation multimedia broadband (NGMB) systems and the economic analysis of the costs and benefits of different timing options for the reallocation of the band.

Reviewing the comments and considering new information since Document 11/80a was prepared leads us to reaffirm the conclusion in Document 11/80a that: *"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."*

Further, as noted in Document 11/80a, were anyone to doubt the conclusions of the economic cost-benefit analysis: "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."