dot·econ

Fixed links review

Assessment of responses to second consultation

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Executive Summary

This report considers responses to ComReg's second consultation on fixed links (ComReg Document 21/134) and comments on matters within the scope of DotEcon's previous report to ComReg (ComReg Document 21/134a).

Restructuring fixed links fees

In that report, we recommended that ComReg revise the formula used to determine fees for fixed links in the following main ways:

- In the existing regime, fees increase with bandwidth, but only up to 40 MHz, beyond which they do not increase further. We proposed that this cap be removed given the growing use of much wider bandwidths and the need to reflect their effect on potential spectrum scarcity.
- With regard to the pricing of various bands, the price per MHz would continue to decline for increasing frequencies, reflecting the greater availability of spectrum and inferior propagation in higher bands, but would do so continuously, rather than being grouped as they are in the current fee schedule.
- A congestion premium would continue to apply for particular bands and locations, but with a larger premium being applied.

Overall, the changes were intended to restructure the fees charged, rather than lead to an increase in the overall revenue raised by ComReg. Users would be impacted variously according to their current patterns of usage, with users of larger bandwidths tending to pay relatively more, and others relatively less.

The majority of respondents are supportive of the proposed changes. However, Three, who would be particularly exposed to higher charges due to its use of higher bandwidth links, made various complaints, as discussed below.

Screening for congestion

In our previous report, we set out a 'Grid Method' for identifying potential congestion by considering the use of frequencies by links passing through 1 km x 1 km squares. This provides a simple, but conservative, assessment method, as it does not fully consider the potential for links not to interfere if their directions are appropriately chosen. Some respondents were concerned that this metric might be directly applied to define areas where a congestion surcharge would apply. This is not the case, as this analysis would merely be a trigger for considering the *possibility* of congestion at a location. It is also intended to allow ComReg to monitor congestion trends and to make more information available to current and potential users to inform their choices.

Three considered that the number of application refusals would be a better method of assessing scarcity. However, congestion itself may discourage applications, especially if measures are adopted to

increase the information available if applicants to allow them to better assess which bands to use for fixed links. In our view, the grid method remains a useful means to create a simple and transparent metric to assess congestion, subject to these limitations. Virgin Media considered that the approach was reasonable given its limitations.

Fees formula that reflects the structure of opportunity costs

We also recommended a formula for setting the fees for fixed links based on frequency band, bandwidth used and whether a congestion surcharge was in force at congested locations. This formula included a provision to charge a higher per MHz charge for links using bandwidths smaller than those typically in use in a band, reflecting the potential for smaller bandwidth links to have a disproportionate impact by precluding the deployment of larger bandwidth links. With some caveats, this was supported by the majority of respondents. However, some operators were concerned that they would be exposed to higher charges. Three and JFK Communications were particularly concerned about the effect on their respective use of wider channels, especially in the 18 and 23 GHz bands given the difficulties of obtaining access to larger channels in lower bands. Three contends that congestion in the 18 GHz band is mis-assessed, and the proposed charges could sterilise use of larger links, especially in rural areas.

Three had a particular view that congestion was essentially binary, so bands should either attract an opportunity cost-based fee if congested, but not otherwise. We disagree with this characterisation as (i) there are substantial difficulties in measurement and assessment that mean there is not a bright line between congested and uncongested situations and (ii) in any case, fees should reflect longer run opportunity costs and, to some degree, the risk of future congestion, to provide incentives to efficiently guide current usage choices, especially given that these may be locked in for a considerable time once equipment is purchased.

Revisions to the formula take better account of demand and incidentally lower fees

Partially in response to these concerns, but also to improve the incentive properties of the proposed pricing formula, we have revised the methodology to recognise that there may be a mix of different bandwidths in use within a band, but with some largest bandwidth in common use (which may not be the most prevalent bandwidth in use). Use of bandwidths smaller than this bandwidth would then attract a higher per MHz charge, reflecting that larger bandwidths commonly chosen for new fixed links may be precluded. This creates a structure of charges with declining prices per MHz for larger bandwidths.

To reduce the impact of changes to the fee structure, we have then sought to structure charges to align the most prevalent (modal) bandwidth used in the most heavily used bands with existing changes. We have also updated the analysis to use more recent licence data, reflecting further switching to higher bandwidths.

Whilst we do not agree with Three that ComReg has "singled out" the 18 and 23 GHz bands for particular increases in fees, the overall effect of these revisions is to reduce the impact of the shift to the new fee structure.

We understand that ComReg would in any case need time to implement a new charging system. Therefore, and as requested by some respondents, some period of potentially 12-18 months would be needed before any changes could be made and existing fees would remain unchanged in the interim. New fees would then be phased in, potentially over a three-year period. However, we recommend that once the new fee structure begins to be phased in, indexation for CPI be applied to the entire fee.

We do not expect these changes to cause any significant migration of existing links (and any consequent disruption to licensees). However, they would provide better incentives for new users with a choice of band with better incentives for efficient use.

We suggest that ComReg apply a three-year review cycle for fixed links. This does not automatically mean that changes to fees would be needed, but the framework should allow changing circumstances to be taken into account by revising parameters within the fee formula and possibly also the definition of congestion areas.

1 Introduction

ComReg published its second consultation document of the fixed links bands review (ComReg Document 21/134), alongside DotEcon's report on our conclusions and recommendations for the fixed links licensing framework (ComReg Document 21/134a).

This report covers our assessment of the responses to that consultation, and updates or clarifications to our recommendations where necessary.

ComReg received ten submissions to the consultation and stakeholders provided comments on a range of issues related to the proposed new fee schedule and technical licence conditions. The remainder of this report is structured as follows:

- Section 2 covers congestion screening;
- Section 3 sets out the issues around the new fees and a proposed amendment to the fee formula;
- Section 4 discusses the process for phasing in and reviewing the fees;
- Section 5 assesses the comments on the channel widths available in the fixed links bands
- Section 6 covers band carrier aggregation; and
- Section 7 covers the other technical conditions on which respondents have commented.

Annex A lists the revised fees and parameter levels and also discusses some of the licence data that has informed our recommendations on setting the parameters.

2 Congestion screening

In our previous report, we proposed that, to assist with its monitoring of congestion within the fixed links bands, ComReg could use a 'grid method' for congestion screening. The grid method involves splitting Ireland into small grid squares (we used 1 km x 1 km), and for each band in each square checking the proportion of typical bandwidth[1] channels that are in use anywhere in the square (by links either passing through the square, or with one or both ends in the square).

There was no suggestion that ComReg should make any automatic changes to fees or any other aspect of the licensing framework on the back of this methodology (and ComReg gave no indication that it intended to do so).

This approach provides an indication of the spectrum available at given location that might potentially be available for the purposes of locating an endpoint for a new link. However, it is clearly based on simplifying assumptions about the interference environment; in particular, this ignores the topography and direction of links. This creates several potential, but countervailing, errors:

- in practice, a new endpoint for a link within a given square might not conflict with existing links passing through that square if its direction is appropriately chosen (though in many cases the potential user would not have such flexibility to choose direction and at some localities the surrounding topography may lead to links being in similar directions);
- links in adjacent or close squares could interfere with each other, but this potential is limited through the use of small grid squares,

Therefore, these simplifying assumptions tend on balance to give us a conservative picture of extent of available spectrum for new links at a given location on a retrospective basis.

The grid method cannot be considered to provide a complete picture of congestion and, as we have clearly suggested, should not be used as the only source of information when determining if any new congestion measures need to be introduced or if existing congestion measures could be removed. It is intended as a simple screening method, that could be used alongside a number of other indicators and monitoring tools, to identify areas/bands that might warrant further investigation from ComReg if it suggested there had been

[1] The typical bandwidth for a band is the modal channel width of links in the band. Except for the 38 GHz band, where the number of 28 MHz and 56 MHz channels is similar, and there is a reasonable expectation that 56 MHz channels will become the most common in the near future.

substantial changes in levels of congestion. Only following this further investigation would ComReg make any changes.

In Annex C to our report (ComReg Document 21/134a), we set out the full details of the methodology and the results based on the latest data available at the time – this did not suggest any changes to the bands that should be considered congested.

2.1 Comments from stakeholders

Several respondents to the consultation expressed concerns over the use of the Grid Method.

Three submitted that the Grid Method is not precise enough and would result in some areas unnecessarily incurring higher charges.

However, Three also does not believe it has sufficiently detailed information about the method to provide meaningful feedback, suggesting it needed to know, for example:

- whether the method considers how transmitters and potential interfered receivers may not have direct line of site between them (if not, then the approach could be overly conservative); and
- that quantitative evidence would be useful to demonstrate reliability.

Three submitted that a more reliable method would be based on the regularity of application refusals due to unavailability of interference free channels.

Three is also interested in understanding the purpose of using the Grid Method, questioning whether it is ComReg's intention to introduce additional congestion zones, which it suggests would further increase uncertainty around future pricing of fixed links.

Eir does not agree that the use of the Grid Method is appropriate, and believes a more granular system should be used, e.g. based on post code areas or CSO work place zones. It suggests that it is important that the defined congestion area is physically the minimum necessary geographic area.

Virgin Media states that, although the use of the Grid Method is not perfect, it seems an adequate method to monitor congestion and it agrees with the proposed implementation.

2.2 Assessment and recommendations

In response to the comments received, we first reiterate, as is clear from our report, that the Grid Method is neither proposed to be an automatic means of defining congested areas, nor intended to be

the main or sole justification for making changes to congestion measures, as detailed further investigation from ComReg would always be needed. The Grid Method is simply a tool to help with monitoring congestion, especially in terms of identifying trends.

Three appears to have misunderstood this point and has overlooked that both a full description of the methodology, and quantitative results using ComReg's licence data were already included in our report.[2] In any case, we can clarify that the methodology does not take into account the specifics of individual links or clusters of links (e.g. we do not check whether transmitters and receivers have a direct line of site), as doing so would be complex and unnecessary for the intended purpose. It is a screening method, and therefore it is appropriate to take a conservative approach to avoid missing anything important. Further detailed investigation by ComReg – taking into account the specifics of the interference environment – would determine whether or not additional congestion measures are ultimately required. The results of the Grid Method applied to current licence data (at the time of publishing) are included in the report alongside a formal description of the methodology.

We agree with Three that monitoring rejected applications is one of the methods ComReg could use in addition to the Grid Method for assessing where congestion might be a problem. However, this would need to be assessed in the context of the other changes that ComReg is making, with the expectation that improvements to the application process and information policy will likely reduce the number of failed applications. Therefore, low numbers of failed applications would not necessarily indicate an absence of congestion but could be that operators are less likely to submit applications for bands/areas where they know there is congestion and their application is likely to be rejected.

We disagree with the assessment that using the Grid Method to screen for congestion in any way increases uncertainty for licensees. The potential for introducing or removing congestion measures over time was always a feature of the fixed links regime. This is clear from the fact the ComReg included congestion charges in the previous framework, established in 2009, and later closed the 13 GHz and 15 GHz bands in the congestion zone in 2014.

The development of a tool to help ComReg identify congestion (or reduced congestion) does not create any new options for ComReg to adjust congestion measures automatically, it merely supports management of congestion in a similar manner to today. Moreover, better/earlier identification of areas/bands where congestion appears to be emerging could in fact help to reduce the risk of additional congestion charges being introduced, or at least provide operators with an early warning, thereby reducing uncertainty over

[2] ComReg 21/134a, Annex C

fees. For example, ComReg could consider (subject to resourcing constraints and its broader information policy):

- Publish the results of the Grid Method (along with any other information, as appropriate, for monitoring congestion) so that operators can form their own expectations on the risk of future congestion in certain areas/bands (e.g. in its annual fixed links reports); and/or
- provide early notification to operators of any areas/bands that where congestion appears to be increasing to levels where further investigation and potential measures might be required.

In general, ComReg's proposals for an improved information policy (which may or may not include the Grid Method results) would give greater support to operators with predicting potential congestion charges, but also better enables them to make better use of the various available bands, thereby reducing the risk of congestion becoming an issue in the first place.

We also stress that, if new congestion areas were needed, the Grid Method would not define these – it is only to help identify broad areas in which congestion might be problematic. More thorough assessment would be required to define the specific areas considered congested. To be clear, the grids used in our congestion screening method are not the same as the OSI National Grid used by ComReg to define the existing congestion area. We could consider using alternative ways to split the country (e.g. those suggested by Eir), but:

- there is no obviously better alternative that we are aware of; and
- given the purpose of the Grid Method and the fact that ComReg can define new congestion areas that do not correspond precisely to Grid Method squares, there would be little value in doing so.

3 Fees

ComReg conducted a regulatory impact assessment (RIA) that covered three main options for fees:

- maintaining the existing fee schedule (Option 1);
- setting fees according to a formula, as a proxy for opportunity costs (Option 2); and
- charging full opportunity cost in congested areas and administrative costs elsewhere (Option 3).

ComReg discussed Option 3 in the early steps of the RIA and then judged that it was not a valid RIA option to be taking further. As a result, ComReg did not label administrative cost recovery with congestion charging (in acutely congested areas) as 'Option 3', but we do so here for convenience.

The RIA concluded that the following formula (proposed by DotEcon) best promoted efficient use of the spectrum when new links are installed

$$\text{Fee} = \max\left[x \times r_i \times c_{is} \times b(i,h), \quad A\right]$$

$$b(i,h) = \begin{cases} h & \text{if } h \geq \hat{h}_i \\ \hat{h}_i + m\left(h - \hat{h}_i\right) & \text{if } h < \hat{h}_i \end{cases}$$

where:

- i is the frequency band;
- s is the location;
- h is the bandwidth
- x is a parameter controlling the overall level of fees;
- r_i is a schedule of band factors, set so that per MHz charges are lower in higher frequency bands;
- c_{is} is a congestion surcharge that would at first apply to the 13-23 GHz bands in the congested area (it is equal to one outside of the congested bands/area);
- $b(i,h)$ is the 'effective bandwidth' for a link with bandwidth h in band i, where the typical bandwidth in that band is $\hat{h}_i$. Effective bandwidth is greater than the actual bandwidth if actual bandwidth is below the typical bandwidth in a band, such that links with bandwidth below the typical amount pay a higher per MHz fee, reflecting that any excluded users would likely want a wider channel; and
- A is the administrative cost floor.

We also recommended that P-MP systems be charged as if they were a collection of P-P links up to a point, and that additional spokes beyond that be charged at a reduced rate, because this is better aligned with opportunity cost principles. In particular, we suggested that the first eight 'spokes' from a P-MP 'hub' be charged the P-P fee set using the above formula, and that addition spokes pay 25% of that fee.

ComReg proposed initial parameter values such that, in general, the fees reflect the structure of long-term opportunity-costs across the available bands (i.e. with per MHz prices higher for lower bands to reflect the greater potential for scarcity in those bands) whilst keeping the fees for typical bandwidths in key bands broadly the same as under the current licensing framework. This largely drew on the opportunity cost estimates to set the relative prices across bands (i.e. the value of r_i for each band), with the exception being the 80 GHz band where using opportunity cost was not appropriate and instead the value of r_i was set to reflect the relative supply of spectrum between the 80 GHz and 42 GHz bands.

ComReg provisionally determined to set the parameter $c = 3$ for the 13 – 23 GHz bands in the congestion area. This represents an increase on the congestion surcharge currently applied by ComReg, but does not set the congestion surcharge at the full level of the opportunity cost estimates (which would require $c \approx 6$). These opportunity cost estimates are based on the assumption of acute scarcity (i.e. from the point of view of a user who could not access any of its preferred range of bands, meaning they reflect short run opportunity costs where there is congestion) and subject to a degree of uncertainty. For these reasons it was considered appropriate to set c at a relatively cautious level, with the potential to revise it at a later stage if there were evidence of this providing an insufficient incentive to control congestion.

The initial parameter values set by ComReg are summarised in the table below.

Table 1: Initial parameter values

Parameter	Initial value	Comments
x	1.3	Keeps fees charged to typical bandwidth links in the 11-23 GHz bands at roughly the same level
r_i	30 (1.3/1.4 GHz) 1 (42 GHz) 0.25 (80 GHz	r_i values for bands from 2-38 GHz vary linearly with the midpoint frequency of the band. Ratio of 30 derived from opportunity cost estimates
c_{is}	3 for congested bands in congested area 1 otherwise	
m	0.5	
A	100	Rounded up from estimate of average administrative cost per link of €67

3.1 Comments from stakeholders

Some stakeholders expressed broad agreement with ComReg's proposed approach to setting fixed links fees:

- Eir agrees with the general structure of the proposed new fee schedule, which in its view is consistent with promoting efficient use of spectrum, although it contests that the exact values of the parameters could be debated;
- Vodafone recalls that it proposed a nodal pricing solution, but recognises its suggestion may be more suitable for block licences;
- ESBN agrees that congestion charges are sensible, although it would prefer ComReg to increase the supply of spectrum for fixed links if further congestion arises in future, instead of using prices to "*choke off demand*";
- Virgin Media agrees with the surcharge proposed for the congested area, suggesting that it may help to free up spectrum that, in its view, is being hoarded under the current fee schedule.

Other stakeholders are concerned that some licensees would face substantial increases in fees on existing links and would like to see amendments to ComReg's preferred option to soften the impact. In most cases they suggest a more generous phasing in process, which is discussed in the following section.

ORCS and Wireless Connect observe that some operators will face a 5-12% fee increase, which they believe is unhelpful for smaller operators, particularly as they will (in their view, wrongly) face subsidised competition as a result of the NBP.

JFK Communications argues for a variation on ComReg's Option 2 that eases the increase in fees for wider channels in the 18 GHz and 23 GHz bands in rural areas. It contends that difficulties with obtaining 40 MHz and 56 MHz channels in 11 GHz and 13 GHz bands respectively (likely due to the positioning of its high sites in relation to other commercial transmission towers) mean it is forced to use higher bands instead (18 GHz and 23 GHz) with multiple hops. Whilst doing so allows it to use the larger channels available in the higher bands to achieve greater throughput, this comes at increased costs due to the greater number of hops, licences and equipment required. JFK notes that the proposed changes to fixed links pricing would increase its fees by 56%, which it argues is significant for a company operating in areas of low population density. JFK asks for the pricing to be reviewed, on the basis that it planned its network and infrastructure investments under the current pricing scheme, and proposes two potential variations to Option 2 that could be considered in its view:

- maintain current prices for the 18 GHz and 23 GHz bands in rural areas until congestion is a problem (based on a certain percentage being occupied within a given area/band); and
- apply the new fee structure but extend the transition period from three years to seven years for the 18/23 GHz bands in rural areas (effectively keeping those prices fixed for the next seven years).

Three is the only respondent to oppose the formula outright

Three is the only consultation respondent calling for ComReg to adopt one of the other RIA options. Three contends that the proposed approach fails to meet ComReg's objectives because it is disproportionate, increases uncertainty, and is a barrier to network rollout.

It also believes that the definition of the congested area is not precise enough, and that the proposed congestion charges are not justified by opportunity cost, because "*no opportunity cost consideration can arise where no applicant is being prevented from deploying links because there is insufficient supply*"[3] of spectrum, which it contends is the case in the 18 GHz band. In Three's view,

[3] Three response to ComReg 21/134, p.4

uniform congestion charges cannot be effective, because opportunity costs vary from link to link, and as a result, either:

- "*the licence fee will be below opportunity cost and have no effect*"; or
- "*it will be above opportunity cost leading to inefficiency*".

Three does not agree that the increase in fees is modest, noting that its own fees are set to face a large percentage increase and that the total amount of fees collected by ComReg can be expected to increase further over time because of growing demand for bandwidth. In relation to the level of the fees, Three also states that:

- ComReg has no basis for rounding up the administrative cost floor from €67 per link to €100;
- The value per MHz of fixed links spectrum is declining, as operators need to provide higher throughput without monetising it. If ComReg wishes to increase the fees for high bandwidth links relative to lower bandwidth ones, it should reduce fees for existing links.

Three claims the change will be ineffective, and is based on a mistaken view of demand and congestion

Three argues that the changes are disproportionate, because the choice of band is not discretionary, and therefore the fee changes will not illicit a significant change in behaviour. It contends that 112 MHz channels are necessary to support current and expected future levels of traffic at 4G and 5G sites, and in particular that 56 MHz channels are too small to support 5G. As 112 MHz channels are not available in other bands (such as 13 GHz and 15 GHz), Three asserts that operators have no choice but to use the 18 GHz and 23 GHz bands, except where it is possible to use the 80 GHz band or a 26 GHz block licence. Three requests that ComReg re-evaluates the fees and the view that the change is roughly revenue neutral, taking bandwidth growth into account and setting 112 MHz as the typical channel width in all bands.

Three also disagrees with the level of and basis for the congestion charge. It claims that increasing the congestion surcharge from 1.2 to 3 is equivalent to sterilising the congestion area entirely in the 13 – 23 GHz bands. It is surprised that congestion is still a concern in these bands, given the use of fibre and higher frequency bands.

Three is particularly concerned about fees in the 18 GHz band which, in its view, are increasing because of what it considers is a mistaken view about congestion in the band. Three's 18 GHz fixed links are primarily distributed in low density, rural areas, whereas in urban sites it uses fibre or 80 GHz links. Three prefers the highest frequency band possible, subject to availability requirements, which is contrary to its understanding of ComReg's view that operators generally choose the lowest band where the required channel size is available. Three states that "*the risk of congestion in the 18 GHz and 23 GHz bands are grossly exaggerated. It is therefore contradictory to*

isolate these specific bands for price increases on the grounds of future congestion"[4].

Three would prefer an alternative approach to setting fees, although it is not entirely clear in its response what it believes that should be. For example:

- Three argues that its investments in existing fixed links were made on the basis of the current fee schedule, therefore "*Three is of the view that ComReg should retain the existing pricing structure that is already in place 'Option 1'*"[5]; whereas
- Three also implies that Option 3 (or similar) should be preferred, because while it recognises the role of opportunity cost-based fees, it argues that ComReg "*must not increase cost in areas where this is not required to ensure efficiency. This requires that (outside of congested bands) ComReg can only apply the administration fee*"[6].

3.2 Assessment and recommendations

We recommend a revised definition of effective bandwidth, but no broader changes to the method for setting fees

The proposed fixed links fees formula represents a restructuring of the fees, so that they create better incentives for operators installing new links to use the available spectrum efficiently. The fees for the most commonly used links will remain largely unchanged. Some operators would face substantial fee increases overall, mostly because they use large bandwidths and the proposed changes align fees more strongly with bandwidth used, whereas the current structure of fees does not increase with bandwidth beyond 40 MHz in use.

While there are over twice as many 55 MHz links as 110 MHz links in the 18 GHz band, and nearly five times as many 112 MHz links as 56 MHz links in the 23 GHz band, some operators make heavy use of the 110/112 MHz channels in those bands. Two of those operators – Three and JFK Communications – have raised concerns with the extent of the fee increases for large bandwidth links in rural areas. In particular, Three suggests that the proposals have failed to take into account how fixed links are likely to be used in the near future, and as a result believes the changes will be ineffective (e.g. it sees 112 MHz links as essential for 5G mobile backhaul). Three also disagrees that the fees are justified by opportunity costs.

Fees for 110/112 MHz links are low because the current fees do not properly account for bandwidth. In general, fees should increase with the amount of spectrum in use, to reflect the opportunity costs that

[4] Three response to ComReg 21/134, p.8

[5] ibid, p.3

[6] ibid, p.4

arise from other operators potentially being denied that spectrum, and this structure should also be in place where congestion has not yet arisen, so that fees include some measure of long run opportunity costs to incentivise efficient network planning. This applies throughout the country, because potential future congestion is difficult to forecast accurately and could be very localised (e.g. around key rural high sites), and it is not possible to make a simple rural/urban distinction as to where there is material potential for congestion. However, the current fee schedule has not kept pace with increases in demand for bandwidth – channels wider than 40 MHz were not available in any bands up to 38 GHz, with the sole exception of 55 MHz channels in the 18 GHz band[7], when ComReg devised the current fee schedule in 2009, but have since become common, and as a result licensees using 56 MHz channels or wider benefit from the fees being flat with respect to bandwidth beyond 40 MHz.

The new measure of effective bandwidth is more general, and better suited to likely future demand

As we are focused on incentives for new links, we agree with Three that ComReg should take a forward-looking approach when considering how to charge by bandwidth. Our initial proposal for calculating effective bandwidth works well if there is a clear 'typical channel' size that most new licence applications in the band are for, but in many bands there are three channel widths that each make up a significant proportion of new applications. Therefore, the situation is not as simple as there being a typical bandwidth for links that could be prevented by use of any smaller channel size.

Given this, instead of looking at typical bandwidth, we suggest ComReg uses two measures of bandwidth use in a band:

- *modal bandwidth* – the most common bandwidth in the band based on all live licences;
- *largest bandwidth in common use* – the largest bandwidth that is expected to be used by a significant proportion of new links in the band in the near future (i.e. unlike modal bandwidth, this measure is forward looking).

Using these, we propose a new measure of effective bandwidth for a link in band i using channel width h that is defined by a relationship between effective bandwidth for successive channel sizes (where the next largest channel size up is double the size):

$$b(i,h) = (1-m)h + m\,b(i,2h)$$

For *the largest bandwidth in common use* in the band, $\hat{h}_i$, effective bandwidth is set equal to link bandwidth (i.e. $b(i,\hat{h}_i) = \hat{h}_i$). The formula above can be successively applied to set the effective bandwidth for smaller bandwidths. For any larger bandwidth $h > \hat{h}_i$,

[7] The 55 MHz channels could "only be allocated when spectrum efficiency is justified". See ComReg 98/14R6

$b(i,h) = h$, as there is no effect of precluding use of larger channels, as these are not in common use.

With this more general definition of effective bandwidth, each time we double the bandwidth of a link, per MHz charges decline (at least up to bandwidths in common use). This provides an incentive for uses of smaller channels to take into account their effect in precluding larger channels. The strength of this incentive is set by the parameter m, lying between 0 and 1. Larger values of m lead to more sharply declining per MHz prices as bandwidth increases and so a stronger disincentive to use smaller bandwidths than those in common use.

The frequency gradient (determined by the values of r_i) is still applied across bands, but this is taken as setting the price per MHz for the *modal bandwidth* within each frequency band.[8]

We also recommend that neighbouring bands that are likely to be good substitutes are treated in a similar way to each other, even if licensing data shows slightly different patterns of use of the bands at present. Therefore, we propose that in all bands from 15 GHz to 42 GHz in which 110/112 MHz channels are or soon will be available, 110/112 MHz channels are taken as the largest in common use. In other bands, the largest in common use is the same as the modal bandwidth, except for 80 GHz (where 1 GHz channels are in common use, although 500 MHz is the modal channel size). However, as the frequency gradient is applied based on modal bandwidths, the largest bandwidth in common use can increase without changing the fees for smaller links.

The parameter m is not directly comparable to the previous version – we now propose $m = 0.25$

If ComReg adopts this revised definition of effective bandwidth, it should also review the level of the parameter m. This parameter controls how quickly per MHz charges decline as the channel size increases. The purpose of charging smaller links more per MHz is to provide incentives for operators of these smaller links to position themselves efficiently (e.g. by grouping together with other smaller operators or using bands where larger channels are not in common use). For these links to cause a loss of opportunity beyond a simple per MHz opportunity cost, it must both be the case that other operators want to install larger links in the band, and that the positioning of the smaller ones could potentially become fragmented (in the absence of such an incentive), blocking off wider channels. We suggest that $m = 0.25$ is a reasonable value to reflect the opportunity cost of smaller links, because it is in line with the

[8] As a result, the specific values of r_i for each band must change – the new parameter values are listed in Annex A.

current estimated effect of smaller links on the availability of wider channels in key bands.[9]

This revised approach to charging by bandwidth more consistently applies the opportunity cost principles to links of different sizes, and most importantly it is better able to deal with changes to the channel sizes that are in use going forward. Under this definition of effective bandwidth, fees for 110/112 MHz links would be lower than proposed in the consultation, reflecting the fact that, while they are not the modal bandwidth in the in any bands, they are expected to make up a significant proportion of the new fixed links licensed in the near future. Total fee payments for most users would be slightly lower than suggested in the consultation as a result of this change.

Respondents to the consultation have made several other specific comments about the fees. One of these – that the changes are a significant shock to operators who had invested on the basis of the existing fees – is mostly addressed by the phasing process, which we discuss in the following section. In the rest of this section, we address the remaining points on the fees.

ESBN's suggestion to increase the supply of spectrum in response to congestion is not realistic, because ComReg already makes available all spectrum that is assigned to fixed links by the CEPT; offering even more spectrum would mean departing from its general policy of alignment with CEPT decisions. Furthermore, simply opening new bands might not be of any benefit to fixed links operators if, for example, equipment is unavailable for those bands or the characteristics of the newly available bands do not meet the operators' needs. There is already a substantial amount of uncongested spectrum available in high frequency bands, and further bands may be opened to fixed links in future (e.g. 32 GHz and bands above 90 GHz). However, these are not perfect substitutes for the currently congested bands. Therefore, opening new bands will only alleviate congestion if the new bands are either:

- subject to significantly lower fees, to incentivise operators to switch from congested bands to the newly open bands (in which case opening new bands is not an alternative to congestion charges); or
- very similar to the congested bands.

We are not aware of any bands that could realistically be made available for fixed links that would help to alleviate the current congestion in the 13 – 23 GHz bands in the immediate future.

JFK is calling for some variation on Option 2, which would soften the impact of the fee changes for users of certain bands in rural areas.

[9] See Annex A for our estimates of 'fragmentation', which we measure as, for a given channel width and location, the proportion of channels that would be available if all existing links formed a contiguous block of spectrum, that are not available given the actual links installed.

First, we note that JFK's use of high bandwidth links in the 18 GHz and 23 GHz bands is the reason that its fees are set to increase significantly and that, as discussed above:

- it is appropriate for fees for these links to increase because the current framework does not adequately account for bandwidth in use in excess of 40 MHz (which is now much less that typical bandwidths in use in many bands); but
- 110/112 MHz links fees in those bands will be lower than set out in the consultation if the revised effective bandwidth formula is applied.

However, we disagree with the suggestion that 18 GHz and 23 GHz links in rural areas should be treated differently to any other links. The relationship between fees in different bands has been set to incentivise users to spread out efficiently across the bands, helping to avoid potential congestion wherever possible. The only justification for treating the 18 GHz and 23 GHz bands differently in some areas (i.e. applying congestion charges to increase the price differential between those and the 11 – 15 GHz bands) is if acute congestion has arisen there (or is expected to arise in the near future), otherwise ComReg would undermine the principles behind the new fee structure. To that end we note that JFK has stated that it struggles to access wide enough channels in those bands, which must presumably either be because:

- it wishes to use 112 MHz channels, and is not willing or able to use multiple channels in the same band – this may be alleviated once the wider channels are available in the 15 GHz band; or
- there is a scarcity of spectrum (possibly in small areas around its own high sites, as it mentions).

If the latter is true, then that could raise a question over whether there are congestion issues that have been missed by the previous analysis. JFK has indicated that its operations are based in rural areas, suggesting that the issues it is experiencing occur outside the current congestion area and that there could be a potential need for defining a further congestion area, at least for the 11 GHz and 13 GHz bands. Our previous analysis did not suggest the need for any congestion measures in bands/areas where they are not already applied.

On that basis, we do not recommend adopting JFK's proposals to treat the 18 GHz and 23 GHz bands differently in rural areas. However, we recognise its point that investments have been made against the current fees, and that consider the more general version of its second suggestion (i.e. whether the length of the transition period is suitable) in the following section.

We note ORCS and Wireless Connect's comment that some rural operators face both fee increases and, in their view wrongly, subsidised competition from the NBP. The NBP mapping exercise is beyond the scope of this review, but we note that changes to fixed

links fees would not necessarily be effective in addressing ORCS and Wireless Connect's concerns, as the issue appears to be competition between WLL services provided over licence-exempt links and NBI.

Three has not taken the diversity of fixed links users into account

Three has put forward the broadest objections to ComReg's fee proposals, and overall, we:

- disagree that Option 2 is the wrong approach, because Three's claims that the changes will be ineffective does not reflect how other operators use fixed links; but we
- agree with Three on a number of its specific comments on the fee formula, in particular that it should take greater account of the likely future demand for fixed links – these points can be addressed by changes within the Option 2 framework.

Three does not see any efficiency reasons for charging above administrative costs except where congestion has already arisen, and it does not believe attempting to do so will have any effect, because in its view users cannot chose between different bands.

While we agree with Three that, if all users had no discretion over their choice of bands certain aspects of these changes would be ineffective[10], we strongly disagree that this is an accurate characterisation of demand for fixed links. In all bands below 80 GHz, the majority of licences issued in the last year have been for channels 56 MHz wide or smaller. Therefore, it cannot be the case that all operators are forced into the 18 GHz band in search of 112 MHz channels.

As Three alludes to in its discussion of opportunity costs, the value of one band over another varies from link to link – unless there is only one band with non-zero value, then there must be flexibility to use different bands. It may well be that Three is a relatively inflexible user, especially in the short run, but there is no evidence that all users are unable to efficiently spread out across bands in response to price signals, particularly as wider channels are opened in other bands. The purpose of changing the charging structure is to incentivise flexible operators to use cheaper bands, so that the more valuable bands are available for users who are reliant on them. However, the inflexible users must then be expected to pay something representing the cost of keeping other users out of the band. Notice that nowhere are we claiming that *all* users are flexible in their band choices, only that there are marginal users – typically new users installing equipment – which such a choice and for whom the relative pricing of different bands is relevant.

[10] In particular, there would be no need to be concerned about the frequency gradient providing appropriate incentives for choice of substitute bands. However, the issue of reflecting an appropriate gradient for bandwidth to discourage fragmentation into smaller channels, and charges to reflect congestion, assessed on a band-by-band basis would still remain.

These incentives for flexible operators are the reason for taking some notion of long-run opportunity cost into account in areas where congestion has not yet been an issue but may emerge in the absence of appropriate incentives. Future congestion and opportunity costs are uncertain. However, relying only on operators' anticipation of potential future congestion charges being applied at some later date is unlikely to encourage them to spread out across bands and make best use of the available spectrum. The fact that operators tend to be locked-in to a particular band once equipment is purchased for a link means that it is appropriate to give regard to these longer run risks of congestion.

There is potential for congestion in rural areas, implying that the long-run opportunity costs in rural areas may be above administrative cost, and therefore it is appropriate to put the proper incentives in place for rural operators. On the other hand, we recognise Three's point that the fees are to some extent 'blunt instruments', because they while there may be significant potential congestion in some rural areas (e.g. around key high sites), on some paths the probability of congestion arising, and therefore the long run opportunity cost, is low. However, it would not be feasible for ComReg to set fees that captured the precise opportunity cost for each and every link, nor for it to carve out areas of the country where it could be assumed that there is no potential congestion in the long run. Attempting to do so would increase complexity and reduce the predictability of the fees for operators – this was our reasoning for recommending a formula that proxies opportunity costs and applies this on a reasonable averaged basis instead of full opportunity cost pricing. We still believe that this justifies the overall structure of the new fees.

Three also disagrees with the way congestion charges are applied in the congested area, as in its view the charges will be ineffective because opportunity costs vary. It rightly points out that for some links the congested fee will be above opportunity cost and for others, below it, but this is the point. There will be a distribution of opportunity costs across operators, and some will choose other bands while others pay the congestion charge – there is not likely to be a sharp cut-off congestion charge level at which operators all users suddenly vacate the band. The task for ComReg is to set a fee that incentivises the right number of operators to use other bands or other means of connectivity, leaving the spectrum available for the users who place the greatest value on it. This does not need to be the full opportunity cost of those high value users, and this is part of the reason that the proposed congestion charge is significantly below the opportunity cost estimates.

Its claim that the congestion charges are no longer needed (e.g. because of the use of the fibre and the 80 GHz band) and will sterilise the 13-23 GHz bands is not consistent with our analysis or with feedback from other stakeholders. Their expectation is that links in

these bands will continue to be important for connecting the centre of Dublin to key high sites to the south: paths over which higher frequency bands and fibre are unlikely to be suitable alternatives in many cases. For those cases where use of a less congested band or fibre is a viable alternative, congestion charges may have a role in encouraging operators to switch away from the congested bands and free up valuable spectrum. There is some uncertainty about whether this level of congestion will persist in the future, but the evidence available to us suggests it is currently an issue now. ComReg can, and should, review this in the future and remove or reduce the congestion charge wherever and whenever appropriate, but in our view, it is very unlikely that the proposed congestion charges will sterilise the band in the meantime due to the relatively cautious approach to setting congestion charges relative to the opportunity cost estimates.

Some of Three's concerns are reasonable, but can be addressed within the Option 2 framework

Three rejects Option 2 out of hand, but its main concerns can be addressed through features of the proposed new fee regime. First, it notes that investment in already deployed links was based on the existing fee schedule, however this concern can be addressed with a sufficient notice period before the new fees apply in full, which we discuss in the following section. Second, it claims that the increase in fees for some links, particularly 18 GHz links using 110 MHz[11] channels outside of the congestion area, is disproportionate and does not reflect likely demand for fixed links going forward – we also agree that the fee formula could be made more suitable for likely future demand (i.e. by changing the definition of effective bandwidth), and that doing so would lead ComReg to reduce 110/112 MHz fees.

Three recommends that 112 MHz channels be considered the typical bandwidth in all bands (e.g. because these wider channels are critical for 5G backhaul), and re-evaluate the fees on that basis. Three's criticism that the proposals may not have accounted sufficiently for bandwidth growth is fair, but simply updating the typical bandwidths would not have resolved the issue. Although it is true that demand for 110/112 MHz channels has increased, only in the 18 GHz band is there any evidence from the licence data that this will soon be the most common channel width applied for in the band, and it is unclear whether this trend towards 110 MHz in the 18 GHz band will continue into the future; on one hand it may be accelerated by demand for 5G mobile backhaul, but on the other it could be dampened by the opening of 112 MHz channels in the 15 GHz band. On the basis of the evidence, ComReg could have justified increasing the typical channel in the 18 GHz band, but not in other bands. However, this would lead

[11] The 18 GHz band uses slightly different channel spacing to neighbouring bands, including e.g. 55 MHz and 110 MHz channels instead of 56 MHz and 112 MHz. Three often refers to 112 MHz channels, even though it is focused on the 18 GHz band, but for the purpose of discussing the principles behind the fees (as opposed to calculating exact prices) 110 MHz and 112 MHz can be used interchangeably.

to an anomaly in the price schedule across bands, with 56 MHz links being more expensive in the 18 GHz band than in the 15 GHz band.

This case of the 18 GHz band illustrates the general issue that, with the use of typical channels, ComReg could often find itself in a situation where it had to either:

- charge double the price of the next channel size down for a bandwidth that had recently come into common use: or
- suddenly place a surcharge on bandwidths previously identified as typical, even though they remained very common uses.

In some cases, neither of these would properly capture opportunity costs, whereas our new proposal to change the formula for effective bandwidth also reduces the 112 MHz fees. This revised definition of effect bandwidth it is more general, and more robust to changes that may occur in future in usage patterns, e.g. if differences emerge between neighbouring bands, or if larger bandwidths come into common use.

We have also clarified the terminology around bandwidths – we now refer to *modal bandwidths* (used to calibrate the level of fees), and *largest bandwidth in common use* (the point beyond which fees are linear in bandwidth). In our last report, we used the term 'typical bandwidth' for both of these, as they currently coincide in key bands, but this cannot be assumed to always remain the case as bandwidth demands increase.

Calibrating the overall level of fees

ComReg proposed to set the overall level of fixed links fees to keep the charges for commonly used links the same. For clarity, let '*calibration links*' refer to any link that is:

- in one of the 11-23 GHz bands;
- uses the modal bandwidth in that band (i.e. uses a 40 MHz channel in the 11 GHz band and a 56 MHz channel otherwise); and
- is not subject to a congestion charge.

Formally, the level of the fees, controlled by the parameter x, is the one that minimises the sum of square differences between the existing fees and the new fees, summed across all calibration links. Based on the licence data available at the time (and rounded to one decimal place), this gave $x = 1.3$.

If 55/56 MHz fees are kept at a similar level, then 110/112 MHz fees will increase relative to the current fee schedule, albeit by less than suggested in the consultation, as a result of the revised effective bandwidth formula. Three submits that the increase in fees in high bandwidth links in the 18 GHz band in rural areas overstates the potential congestion. It also recommends that the fees for 56 MHz links are reduced if ComReg wants to increase the differential between 56 MHz and 112 MHz fees. We agree with Three that for some links, the level of the fees is likely to be above that which is required by the opportunity cost of that specific link, but as above

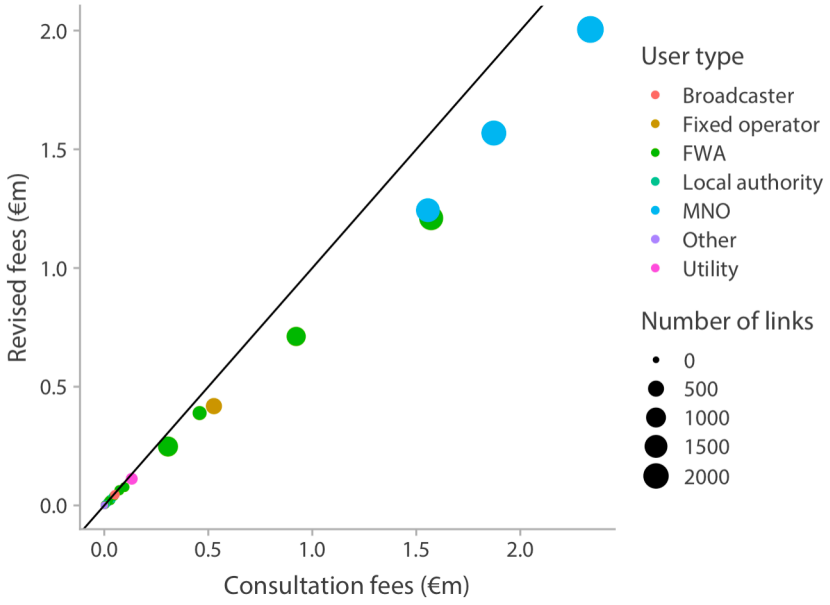
this is necessary as full opportunity cost pricing for every link is not possible. Furthermore, it is possible that the average charge across links outside of the congested area does not match their average opportunity cost. Nevertheless, we do not recommend changing the approach to setting the level of fees because:

- there is no obviously better way of doing so (e.g. we cannot reliably estimate long-run opportunity costs based on forecast congestion);
- the current (overall) level of fees appears not to have choked off demand, and will fall in real terms before the fees are phased in;
- keeping fees for 112 MHz links constant would require a large drop in the overall level, which could have unintended consequences;
- setting fees too low would prevent the changes from creating any strong incentives; and
- future reviews of the parameter values grant ComReg an opportunity to use the information it has gathered from operators' response to the fee restructuring to make any further adjustments deemed necessary.

However, we recommend that ComReg recalibrates the fees based on more recent licence data. Doing so would lead to a reduction in the level of the proposed fees, with $x = 1.2$ now being the value that best keeps fees for calibration links at a similar level. This change arises because the new usage data effectively leads to a reweighting over the bands because the number of 56 MHz links in the 18 GHz band has increased. From the point of the draft decision onwards, ComReg should then avoid further recalibrating, to maximise certainty for operators regarding the new fees to be introduced.

Figure 1 compares the total annual payments by operator under the revised fee proposals (i.e. applying the new effective bandwidth formula and recalibrating the level of fees) with those under the fees set out in the consultation documents. Both of the proposed changes lower the general level of the fees. The exact fees for common bandwidths in all bands are listed in Annex A.

Figure 1: Revised fee proposals against fees set out in consultation documents



We believe that the changes to the effective bandwidth formula and the recalibration of the fees – which take into account growth in demand for the 18 GHz band, and the fact that 112 MHz channels are in common use – should largely resolve Three's concerns with the new fees.

Three also makes other points against the proposed new fees, which are partly based on a misunderstanding of some elements of the fee proposals, and partly on an assertion that the changes increase uncertainty over fees, which we do not agree with. Three is incorrect to suggest that:

- ComReg has 'singled out' the 18 GHz and 23 GHz bands when discussing uncongested fees. Instead, the increase in its uncongested 18 GHz fees is mostly a result of the removal of the arbitrary effective 40 MHz cap on bandwidth charges in the current fees scheme, and is not a congestion charge; and
- Rounding the administrative cost floor to €100 is not based on an attempt to raise revenue. It is based on uncertainty around administrative costs and fluctuations in demand, and the impact on revenue is negligible (fees in the lightly used 1.3 GHz, 1.4 GHz and 42 GHz bands are at the floor, as are those for relatively small bandwidths in a range of other bands, but rounding the administrative cost increases revenue by only 0.2%).

Three describes the new fees as a barrier to network rollout, because some fees increase by a large proportion, and because the changes are unpredictable. With the changes suggested above, the increases in fees for large bandwidth links are well justified by opportunity cost considerations and the anachronistic nature of the current limit on

further charges for bandwidth above 40 MHz. In any case, fixed links licence fees are only a small part of the costs of rolling out a mobile network and it does not follow automatically that an increase to these by some proportion would undermine Three's network. There will be a significant period over which the fees are phased in, largely eliminating any concerns that the details of the fee changes might be difficult to predict when Three installs new links. Three has not given any further explanation of why this will be a barrier to network rollout, nor has either any other mobile network operator expressed similar concerns.

Three also claims that the proposals increase uncertainty around fixed links fees. However, we disagree with this, first because Three is mistaken on how the Grid Method relates to the changing of congestion charges (as explained in Section 2), and second because the fact that the fee regime might be subject to improvements over time should not come as a surprise to Three, nor be overly disruptive if operators are given sufficient notice (as discussed in Section 4).

4 Phasing and review timelines

Fixed links fees should incentivise efficient use of the spectrum and be predictable over the lifetime of a link – because changes under the new formula would only be to a limited and transparent set of parameters, it can meet both of these aims. Furthermore, ComReg is largely restructuring fees (rather than changing the level), the changes will net out for many users.

Of course, there will be a small number of users who see significant changes in their fees (e.g. because they use larger bandwidths than average), and it is appropriate to mitigate the shock to these users if it can be done without compromising the incentive properties of the new fees. In particular, ComReg has proposed to phase in the new fees over a three-year period, applying the weighted average of the old and new fees (i.e. 1/3 of the new fees in the first year, 2/3 in the second, and fully applying the new fees from the third year onwards).

Once the new fees have been phased in, ComReg would be able to assess the effect they have had on demand (noting that there is currently uncertainty around the best parameter values). From then on, it could review the parameter values periodically, taking into account changes in demand.

4.1 Comments from stakeholders

Some stakeholders are satisfied with the period for phasing in fees, and have offered comments on the appropriate review windows:

- Eir agrees phasing in fees is appropriate and suggests initial review after six years (i.e. three to phase in, then further three years);
- ESBN suggests a major review of the fixed links regime every five years, and interim reviews as required; and
- Vodafone and Virgin Media both believe a three year review cycle is appropriate.

Part of Three's objection to the proposed new fees relates to the effect on existing links. Three states that the increase in cost is unavoidable for links that have already been deployed, because operators cannot readily switch existing links to new bands and will act as a barrier to further rollout. Three claims that this is because the change increases uncertainty – it changes the basis on which investment was made, and Three might have made different decisions had it faced the new fee schedule at the time.

Notwithstanding its general opposition to the proposed new fees, Three submits that the phasing in period is insufficient, e.g. because many links have recently been installed and have a useful life of

seven or eight years. If ComReg decides to change the fee schedule, Three suggests it would be better either to only apply the new fees to new links, or to have a more generous phasing in schedule in which:

- the old fees applied for the first three years following ComReg's decision;
- in the fourth and fifth years, the fee that applies is the simple average of the old and new fee; then
- from the sixth year onwards, the new fees apply in full.

Enet also has concerns about the new fees if they are phased in as proposed. It claims that the assessment of the effect on operators of the new fees is incomplete if it does not consider migration costs, and that if these costs are taken into account, ComReg and DotEcon would not have reached the conclusion that the fees are largely revenue-neutral. It also notes that some of its contracts that rely on fixed links would become loss-making as a result of the fee changes (in some cases even without considering migration costs).

Enet argues that the principle of accurate expectations of fees over the lifetime of a link should apply to existing links as well as new ones, and therefore the proposed changes do not meet the objectives of predictability and promoting long-term investment. Enet suggests it would be better to adopt an asymmetric approach to phasing in the fees, where:

- decreases are phased in over three years; but
- increases are phased in over five years.

As set out in Section 3, JFK Communications agrees with many of the points used to justify the new fee formula, but is concerned about the resulting increase to its own fees, highlighting that it has planned and invested on the basis of existing fees. It proposes two modifications to the proposals for introducing a new pricing scheme, one of which is to have a phasing in period of seven years instead of three for the 18 GHz and 23 GHz bands in rural areas.

4.2 Assessment and recommendations

We remain of the view that, going forwards, the new fee formula will reduce uncertainty for fixed links operators and improves incentives when installing new links. We accept that the benefits of predictability over fees when making network investments also apply to existing links, but with rolling licences that run for a number of years, there is always a need to periodically review fees and make adjustments if necessary in response to changes in technology and demand.

Therefore, whilst it is reasonable for operators to not expect new fees to be applied overnight, they should already be aware of the

potential for adjustments during the life-span of existing infrastructure, especially as there is never likely to be a time to make the improvements that coincides with the investment cycles of all users. Forthcoming changes to the fees could also have been reasonably anticipated by operators given ComReg's commitment to review the fixed links licensing regime as part of its 2019-2021 Radio Spectrum Strategy Management Statement (RSMSS), which was published in December 2018.[12]

Nevertheless, as the new fees are introduced, there is a trade-off between:

- providing sufficient notice of the details of the new fees to operators of existing links; and
- avoiding watering down the efficiency benefits of the new fees by pushing them off into the future.

We believe that the proposed three-year phase in period strikes the right balance, not least because licensees will have been given notice of the fee changes well before the phase in process begins. If ComReg's Decision on the fixed links regime is to apply the new fee formula and the proposed phasing in period, there will necessarily be an implementation period following the Decision before the new fees apply, as well as some gap between the conclusion of the implementation period and when fixed links fees are due (which varies between users). Given this, and our understanding of the likely timelines for the implementation period, the total process of introducing the new fees in full is likely to be closer to four years than three. Even before the start of the implementation period, there will be a significant period of time between the publication of the Draft RIA and the final Decision, throughout which operators are aware of the structure of the new fees (albeit without the degree of certainty they will have during the implementation period).

Furthermore, the respondents' comments on the phasing in process were based on the fees as set out in the consultation documents, but the amendments discussed above (i.e. recalibrating the level and revising the formula for effective bandwidth) lower the fees relative to what was previously proposed. This also mitigates the shock to existing licences.

On that basis, we believe that a three-year phasing in process is appropriate, however if ComReg were to consider a more cautious approach, a short extension of the period prior to phasing in changes (e.g. by formally having a period of 12 to 18 months in which it committed to not changing fees) would not be unreasonable. There is no obvious point that perfectly balances the two objectives, but any extension should not be overly long, otherwise it risks overly delaying the benefits of the new regime.

[12] ComReg 18/118

We note that this is structurally similar to Three's proposal to leave a gap between the Decision and the phasing in of the new fees, but with a shorter gap than the three years it suggests.

Indexing fees for inflation

ComReg has a policy of indexing its spectrum fees for inflation (measured using CPI). This does not apply to the existing fixed links fees, because they predate the indexing policy, but the new fixed links fees will be indexed. However, this indexing would not begin until the phase in process does, which means that fees would fall in real terms prior to the end of the implementation period (i.e. the initial level of the new fees will continue to be set to keep fees for common links at a similar level to the nominal level of fees set in 2009).

As a point of clarification, we do not think it is appropriate or consistent to mix two licence fee structures, only one of which is indexed. Therefore, we recommend that once the phase in process begins, ComReg indexes both the new fees and the old fees.

Migration costs

The intention of the new fee structure is to incentivise operators to efficiently position new links within the bands. The proposed uncongested fees are well below opportunity cost estimates, which were calculated based on the cost to a user of being excluded from its preferred band when installing new links. Even the congestion fees are modest compared to the upper end of the opportunity cost estimates. Therefore, we would not expect the new fee structure to result in widespread migration of existing links into other bands, especially where a congestion charge does not apply. Migration costs actually incurred because of the proposed changes are therefore expected to be low.

Accounting for migration costs would not change our statement that the fee changes broadly net out, because:

- it was only in relation to fees for existing links, under the assumption of no migration; and
- if migration were to occur, this would be because new fees plus migration costs for a given migrated link would be less than current fees, so overall costs would never be worse than not migrating at all.

Alternative phase in processes

Two proposals would not only change the duration of the phase in process, but would also treat certain classes of links differently, namely Three's proposal to only apply the new fees to new links and JFK's suggestion to extend the process only for rural 18 GHz and 23 GHz links. Ultimately, we do not believe that either of these amendments are necessary, because the proposed process (which in all will take around four years) is sufficient.

We see no reason that operators in specific areas/using certain bands would need even greater notice of the new fees. On the contrary, if JFK is having difficulty accessing spectrum in the 11-15 GHz bands,

we think pushing off the incentives the new fees would create further into the future would be counterproductive.

Although not explicitly stated by Three, in our view applying new fees only to new links would be an alternative to phasing the fees in over several years (as opposed to also phasing in the new fees for new links), as the benefit of slowing the introduction of new fees only relate to existing links. However, we disagree that the new fees should only apply to new links, because:

- charging old and new links differently might undermine competition (e.g. by allowing incumbent operators to operate at a lower cost);
- it creates an incentive to defer rollout of new links for as long as possible, which may prevent efficient investment and delay improvements to services; and
- there may be practical issues in distinguishing between new and old links given that licences can be rolled over and amended (e.g. to increase bandwidth).

Review period

We believe that an initial three-year review cycle is likely to be appropriate, to ensure ComReg is able to react to any changes, if necessary, in a timely manner. This review would not only cover prices, but also the congestion measures applied (e.g. if congestion quickly and significantly eases in the congested bands then ComReg could consider removing congestion charges from some bands/areas, with little benefit from applying them for longer than necessary).

It is important to note that a review by ComReg does not automatically mean that further changes to the fees will be made. Indeed, the intention is that the new fee structure is appropriate for meeting ComReg's objectives and that no further changes are necessary. However, the impact of the new fees cannot be known for certain in advance and it is important that ComReg has the opportunity and ability to adjust parameters in the fee formula if it observes that there is a need and justification for doing so. In that sense, it is important to not leave too long a gap before the first review and between reviews, at least during the initial stages of the new regime, so that ComReg can react appropriately.

5 Channel widths available

ComReg aligns its fixed links band plans with the relevant CEPT/ITU recommendations for the band. We recommended that ComReg update its band plans to include wider channels available in the most recent versions of the recommendations (i.e. by opening 112 MHz channels in the 15 GHz band), and consider opening even wider channels via a 'channel merge', where there are provisions for this in the relevant CEPT recommendation. In Annex 1 to ComReg 21/134, ComReg listed all the bands where it would consider opening wider channels – the wider channels would be:

- 28 MHz in the U8 GHz band;
- 56 MHz in the L7 GHz, U7 GHz and U8 GHz bands;
- 59.3 MHz in the L6 GHz and L8 GHz bands;
- 80 MHz in the U6 GHz and 11 GHz bands;
- 112 MHz in the 15 GHz band;
- 220 MHz in the 18 GHz band; and
- 224 MHz in the 23 GHz, 28 GHz and 38 GHz bands.

5.1 Comments from stakeholders

Virgin Media, Three, Vodafone and Eir all welcomed ComReg's proposals to open wider channels, which they see as in keeping with CEPT/ITU decisions and growth in demand for bandwidth.

JFK did not comment specifically on ComReg's proposals as set out in Annex 1 but expressed a preference for wider channels to be made available in the lower bands, allowing it to achieve higher capacity over longer distances. Specifically, JFK states that it would prefer to use:

- 80 MHz channels in the 11 GHz band; and
- 56 – 112 MHz channels in the 13 GHz band.

However, ESB is concerned that opening wider channels will increase congestion (which it suggests is already an issue up to 11 GHz), and notes that while wider channels are important for MNOs, but they are not required by all operators. It suggests that wider channels should only be opened in the 13 GHz band and above, whereas high-capacity links over long distances are better served by fibre.

5.2 Assessment and recommendations

We recommend that ComReg goes ahead with its plans to open wider channels in all bands listed in Annex 1 of its consultation document, in line with the channel recommendations in ITU and CEPT recommendations.

We expect that these wider channels would mostly be used in the bands from 11 GHz upwards and we agree with ESB that availability of smaller channels remains important for many fixed links use cases. However, we do not believe that opening wider channels increases the risk of congestion (e.g. because absent wider channels, operators could still demand access to more bandwidth by licensing adjacent channels). If anything, opening wider channels in a range of bands (alongside an updated pricing formula) may alleviate congestion if operators view this as increasing the range of bands that are suitable for their needs (and, therefore, spread out more efficiently across bands) or enables better organisation of assignments within bands. Furthermore, fibre might not be available over all routes where operators wish to use long-range, high-capacity links and therefore should not be used as a justification for restricting access to wide channels.

We also note that our analysis has not found evidence of congestion in any of the bands up to and including 11 GHz. If, in the views of ESB or other stakeholders, there are congestion issues in these bands, it may merit further investigation from ComReg.

Regarding JFK's comments on the channels it would like to use, we first note that 56 MHz channels are already available in the 13 GHz band, and that 80 MHz channels in the 11 GHz band are compatible with CEPT/ITU guidelines on channel merges, and are being considered by ComReg. This leaves JFK's request for 112 MHz channels in the 13 GHz band, but these would not be consistent with current CEPT recommendations, even if using channel merges. JFK has not presented, nor do we see, any strong justification for deviating from ComReg's general policy of following CEPT and ITU recommendations by opening 112 MHz channels in the band. We expect that JFK will have other options to support high capacity, long range links, especially if:

- the other 11 GHz and 13 GHz channels that JFK prefers are available;
- 112 MHz channels are opened in the neighbouring 15 GHz band; and
- if JFK is unable to access enough spectrum (even by using adjacent channels) in the 11 GHz and 13 GHz band and is unable to use the 15 GHz band, this is more likely to be a congestion issue rather than one that can be fixed by changing the band plans.

We, therefore, do not recommend that 112 MHz channels are opened in the 13 GHz band.

6 Band carrier aggregation

Band carrier aggregation (BCA) involves pairing spectrum in two bands (most commonly 18 GHz with 80 GHz), in order to achieve both high capacity and high availability. ComReg consulted on whether any of the technical guidelines prevented this technology from being deployed and should therefore be relaxed, for example by:

- only applying the minimum path length requirement in the higher frequency band; or
- only applying the availability requirement in the lower frequency band.

We did not recommend that there be any special provisions in the fee regime for BCA links, on the basis that they have a similar effect on spectrum availability as two separate links, and because there is no clear need to incentivise the use of the technology by discounting the fees. The potential improvements in capacity are likely to be sufficient to incentive operators to use BCA where efficient.

6.1 Comments from stakeholders

Respondents were generally supportive of changes that support the use of BCA, which they agree could promote efficient use of the spectrum. Three and Virgin Media welcomed proposals to do so, with Three specifically agreeing that the availability requirements should only apply to the lowest band, that the higher band should be assessed based on potential interference, and with all of the conclusions from CEPT Report 320 (on BCA) that ComReg referenced.

Enet and ESB are interested in using BCA, but question whether the proposed licensing framework is suitable for this technology:

- ESB asks whether this would require two separate licences and two separate payments; and
- Enet claims that the current licence structure prohibits use of BCA and suggests that needing to pay for two licences makes the economics of deploying the technology more challenging.

6.2 Assessment and recommendations

ComReg should relax the technical conditions for BCA links

Our recommendation was that ComReg should consider relaxing the technical conditions for BCA links (in particular link length and availability requirements), but that feedback from operators was required before coming to a detailed proposal. There is general support for stakeholders for facilitating the use of BCA where this

can lead to a more efficient use of spectrum, and Three gave the most specific comments on the technical conditions, suggesting that availability requirements should not apply to the higher frequency band.

Therefore, we recommend that ComReg removes the availability requirement for the higher frequency band in a BCA system, and reserves the option to relax minimum link length requirements for the lower frequency band. To do so, applicants need to specify that they intend to use BCA (and possibly provide evidence as part of their application, if required by ComReg to verify they are using the technology).

Whether a BCA link officially requires one or two licences is a matter for ComReg

Enet's and ESB's comments went beyond the technical conditions, requesting more information or changes to the licence structure and fees for BCA links.

First, provided that the technical conditions are suitable and that the application process is sufficiently straightforward, we do not think it is of much importance whether an operator officially holds one licence or two for a BCA link. For example, an operator might want to avoid being issued a licence for only one of the bands (which would be possible if the application was processed as one for two independent links), but provided that applicants can instruct ComReg of this preference, it does not matter whether ComReg issues a single BCA licence, or two licences, but with a commitment not to issue a licence for one band unless it is possible to issue a licence in both bands (for operators proposing to use BCA). Therefore, we consider it a matter for ComReg whether it issues multiple licences for BCA links.

Fees should not be discounted for use of BCA

Second, we do not see a case for actively encouraging use of this technology by discounting fees (as opposed to facilitating its use by operators wishing to use it under the proposed fees, by applying appropriate technical conditions). There is no spectrum management reason to incentivise all links to have backup in another band. Nor are we convinced that discounts to the fees would be pivotal in determining whether the technology is taken up in cases where BCA is most likely to be efficient, because:

- the prospect of more reliable, higher capacity services already incentivises use of the technology;
- band aggregated links have the same effect on spectrum availability as two separate links in different bands – any discount that could justifiably be applied (e.g. based on the link being marginally less likely to increase potential congestion) would be difficult to calculate precisely, but would likely be small; and
- in almost all cases, one of the bands used for BCA links would be in a high frequency band which is subject to relatively low fees, and as a result we would not expect licence fees to make the technology prohibitively expensive.

Therefore, we do not recommend any changes to the fees for BCA links.

7 Other technical licence conditions

Our report also included a review of the technical conditions and licence structure. We found that ComReg is generally well aligned with international standards, but should consult on reducing or removing the high/low search radius for 80 GHz links. It also invited views on elements of the technical guidelines for which we did not expect would need to change, including:

- the use of automatic transmit power control (ATPC);
- minimum link length requirements;
- maximum transmit power;
- transmission capacity; and
- antenna requirements and equipment class.

7.1 Comments from stakeholders

Respondents also supported the reduction of the high/low search radius in the 80 GHz band, and Three and Virgin Media favoured its removal for that band. Furthermore, Three explains that ignoring that links within some radius may not have line of sight of each other is inappropriate for 80 GHz links, which are typically deployed in built up urban environments. Eir suggests the radius should be reduced for various bands. ESB has no view on the 80 GHz band but notes more generally that avoiding high/low conflicts is important, but that the search radii should not be too large. It suggests ensuring location data is accurate.

Most respondents are satisfied with the existing minimum path lengths, and do not recommend any changes. However, ESB suggests that the policy should be made more flexible, by reducing minimum lengths by 20% and applying the rule as a guideline rather than a hard restriction.

Eir disagreed with the use of transmission capacity requirements, and instead suggests that licences should be based on frequency and bandwidth, with the licensee left to determine capacity based on link design requirements.

7.2 Assessment and recommendations

High/low conflicts

In our first report we had not formed a view on whether it was better to reduce the high/low search radius for the 80 GHz band or to remove it entirely. The responses on this point from stakeholders were helpful and, where they made specific comments, suggested removing the restriction altogether. Therefore, we recommend ComReg removes the restriction for the 80 GHz band.

We did not recommend any changes to the high/low search radius for lower frequency bands, as ComReg's policy was well aligned with the small number of regulators that apply a similar policy. Stakeholders have not provided any specific views on changes for lower bands, and therefore we recommend that the high/low search radii for all bands other than 80 GHz remains unchanged.

Minimum path lengths

The minimum path lengths set by ComReg are well aligned with policies in other European countries, and supported, at least in principle, by all respondents. On the other hand, while ESB gives examples of potential extenuating circumstances in which it may be appropriate to licence links that do not meet link length requirements (e.g. where there is a lack of available spectrum or tower space in specific locations), it does not provide any evidence or strong reasoning for reducing link lengths across the board.

Therefore, we do not agree with ESB that the minimum path lengths should be reduced by 20%, and we do not think it is likely that an operator would regularly find itself in a position where it was unable to use any fixed links band because of some combination of the minimum path lengths in one band and propagation characteristics of higher frequency ones. ComReg could retain the option not to enforce the minimum path length requirement in exceptional circumstances, where the applicant could demonstrate it had no other reliable option, and at ComReg's sole discretion, but overall we do not think these cases are likely to occur very often and recommend that minimum path length restrictions continue to be applied as they are.

Other points

Eir's suggestion to leave the determination of transmission capacity to the licensee is not aligned with international practice, and it has not given any justification for the proposal. Therefore, we do not think ComReg should adopt the suggestion.

The other areas of ComReg's technical guidelines are in line with international best practice, as discussed in our report. We welcome the responses from stakeholders that confirm that further changes to the technical guidelines are not required. Therefore, we do not have any further updates to our recommendations.

Annex A Revised fees and parameters

We have proposed a new formula for calculating expected bandwidths, which replaces the typical bandwidths in the previous version with two distinct measures, the:

- *modal bandwidth* – used to set the level of the fees; and the
- *largest bandwidth in common use* – used to determine the point at which fees become linear in bandwidth.

This formula also changes the role of the parameter m, and the appropriate values of the r_i (although neither the intuition nor the formal definition of r_i changes). Therefore, we set out all of the new parameter values in this annex.

A.1 Licensing data

First, we look at ComReg's licensing data from July 2022 to identify modal bandwidths and bandwidths in use. We concentrate on the bands from 13 GHz upwards; in all of the bands up to 11 GHz, at least two thirds of live links are links with the modal channel size, and the overwhelming majority of newly issued links are for modal bandwidth channels.

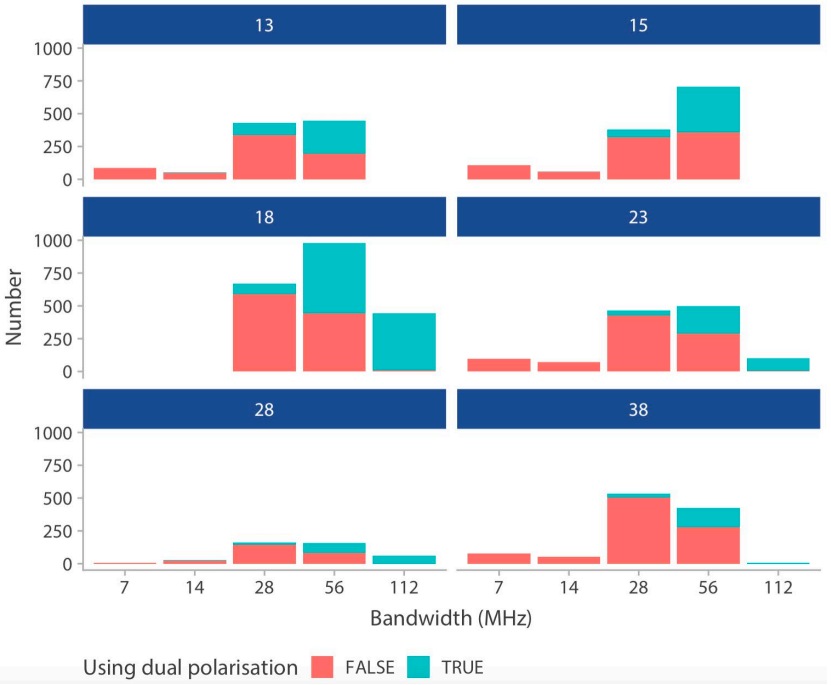
There are several ways in which we could treat dual polarisation links when counting licences and finding modal bandwidths. We could count:

- the channels in use, and therefore unavailable to other users, by counting e.g. a dual polarisation 56 MHz link as one 56 MHz link;
- the bandwidth in use, assuming that e.g. a dual polarisation link was equivalent to a single polarisation link of twice the channel width; or
- count the second polarisation as an additional link, if we are interested in the demand for bandwidth, but not willing to assume that a dual polarisation link is the same as using a wider channel.

The first of these is the most useful for determining what channel sizes are in use, because it reflects the amount of spectrum that is denied to other users and because no fees are charged for use of the second polarisation. It is also less prone to giving somewhat counterintuitive results that arise from operators who use wide channels also being more likely to use dual polarisation (as shown in Figure 2). In particular, counting bandwidth in use can suggest reducing the typical bandwidth, because some high bandwidth links are counted against a separate channel size that is not available in the band, whereas counting links the use both polarisations as two

links has the opposite problem, by overcounting high bandwidth links that would not exclude any additional users from the band. Therefore, we the use channels in use measure for all data and figures presented below.

Figure 2: Number of live links by band (GHz)



Note: For simplicity, channels in the 18 GHz band are presented as if they were the same width as similar channels available in other bands (e.g. a 55 MHz channel is listed as a 56 MHz channel).

In the table below, we show the proportion of links that use channels that are the typical size (as listed in our previous report), half the typical size, or double the typical size. In most cases the typical channel size is equal to the modal channel size, with the exception of:

- the 28 GHz band, which is a result of changes in the licence data since our last report was written; and
- the 38 GHz band, for which, at the time of our last report, it appeared likely that 56 MHz channels would soon become the modal channel width in the band.

Table 2: Common channel sizes - channels in use

Band (GHz)	Typical bandwidth (MHz)	Live links (% with channel width)			Links issued in last year (% with channel width)		
		Half typical	*Typical*	*Double typical*	*Half typical*	*Typical*	*Double typical*
13	56	42.4	44		45.7	47.7	
15	56	30.2	56.5		34.1	60.5	
18	55	32.1	46.8	21.1	28.1	35.6	36.4
23	56	37.7	40.1	8.3	35.9	39.9	18.4
26	28	1.5	98.5		0	100	
28	56	38.9	38.4	14.7	36.5	27.8	33
38	56	48.5	38.7	0.5	46.3	42.6	0
42	56	36.4	54.5				
80	500	28	56.9	14.4	24.1	45.1	29.3

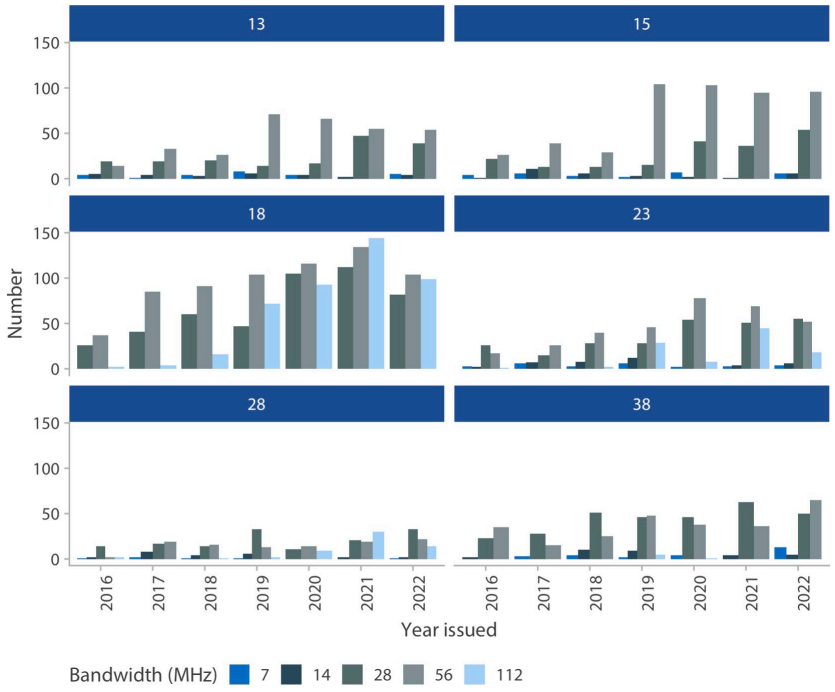
Typical channel sizes are no longer a feature of the fee formula, but we include them in the table above to help illustrate what would happen if we simply reviewed the typical channel sizes without modifying the formula. The only case where there would be grounds for increasing the typical channel to 110/112 MHz would be the 18 GHz band (based on licences issued in the last year, and the trend towards these licences shown in Figure 3 below.

Table 3: Fees under old effective bandwidth formula with 110 MHz as the 18 GHz typical channel width

Band (GHz)	28 MHz	56 MHz	112 MHz
13	1,096	1,461	
15	1,026	1,368	2,736
18	1,457	1,748	2,331
23	742	990	1,980
28	530	706	1,413
38	186	247	495

Table 3 shows that with only that change, fees for 56 MHz channels (and indeed smaller bandwidths) would not be monotonic in frequency, and would be significantly higher in the 18 GHz band than in the 15 GHz band, even though we would expect these links to be good substitutes.

Figure 3: Newly issued links by band (GHz) – channels in use



Note: 18 GHz channel sizes presented as nearest equivalent. 2022 links are from the year to mid July. Only includes bands where 55/56 MHz channels are available and new licences have been issued in the last year.

A.2 New parameter values

Bandwidth parameters are set taking into account substitutability of the bands for marginal users

In Table 4, we list the parameter values that are specific to a band. For the modal bandwidths and the maximum bandwidth in use, the values are mostly derived from the licensing data, but with the additional principle that neighbouring bands should be treated in the same way if there is good reason to believe that they are strong substitutes, therefore, for example:

- The maximum bandwidth in common use in the 15 GHz band is 112 MHz, even though this channel has not yet been opened – this is because the band is likely to be a close substitute to the 18 GHz band when ComReg does open 112 MHz channels; whereas
- This principle is not relevant to the 26 GHz band, because no channels greater than 28 MHz are available, and there is no expectation that they will become available (e.g. because part of the band is used for 26 GHz block licences, and because the band has been identified for 5G use).

By extension, we recommend that the maximum bandwidth in use is non-decreasing with respect to the frequency of the band for substitutable bands. Higher frequency bands typically have a greater supply of spectrum, but inferior propagation characteristics to lower frequency bands, and the fee regime is likely to be more futureproof if the parameters take these fundamental characteristics into account instead of relying on current demand data. Therefore, we suggest setting 112 MHz as the maximum bandwidth in common use in the 38 GHz and 42 GHz bands, even though these channels have predominantly been used in the 18-28 GHz bands thus far. The same principle of treating substitutable bands in the same way applies to modal bandwidths.

Setting m based on the likelihood of blocking off larger channels

The parameter m should be set to bring fees for smaller links into line with their opportunity cost, which could exceed the opportunity cost per MHz of larger links. In our first report of this review[13], we considered a measure of fragmentation in a band which is one minus the ratio of:

- the number of channels of that size that could be assigned, given the links currently installed in the band; and
- the number of channels of that size that could be assigned if all existing users formed a contiguous block of spectrum.

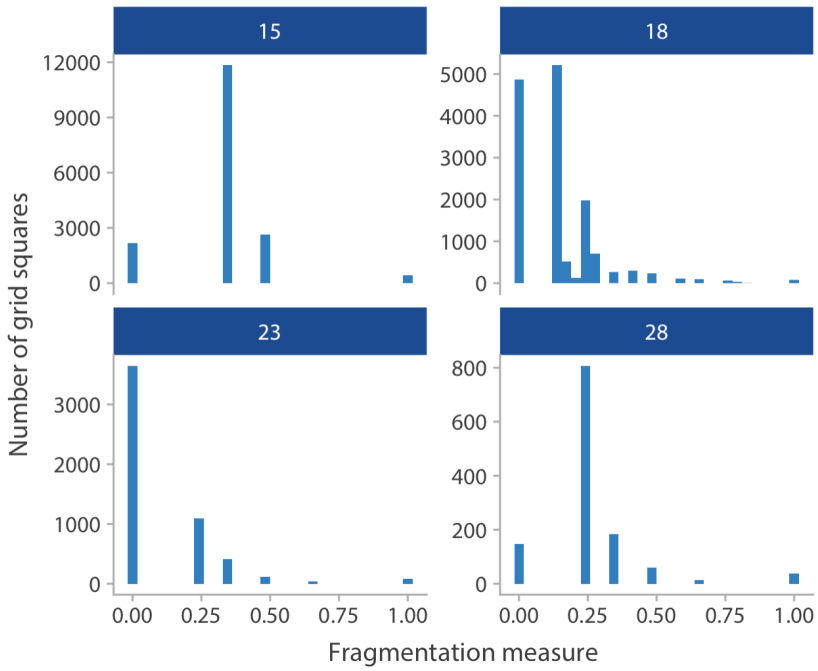
We place a 1km x 1km grid over Ireland and calculate this measure of fragmentation for each grid square where there is at least one link in the relevant band. We use the same grid and simplifying assumptions as for the Grid Method for congestion screening, where if a channel is used by any link passing through a grid square, it is

[13] ComReg 20/109a, Annex C

assumed to be unavailable to new links. The results of this exercise for the heavily used bands in which 112 MHz channels are or soon will be available are summarised in Figure 4.

In many areas and bands, it is possible to install 25% fewer 112 MHz links than it would be if all existing links formed a contiguous block. Under the assumption that there could be a similar fragmentation going forward, we recommend that ComReg sets $m = 0.25$.

Figure 4: Fragmentation histograms by band (GHz) – effect on 112 MHz channels



Note: 15 GHz histogram uses sample band plan

Band factors need to be adjusted to apply the frequency gradient to modal bandwidths

We had previously recommended that the values of r_i be set so that the ratio between per MHz fees in the 1.3/1.4 GHz and 42 GHz bands was 30 (based on opportunity cost estimates) and the charges decreased linearly as the midpoint frequency in the band increased. We have now adjusted the values so that the same frequency gradient applies to the modal bandwidth fees – this is simply an update that ensures the formula is correct, our proposed change to the effective bandwidth definition does not affect the fees for modal bandwidth links.

To illustrate how this change works, consider a simple example with a band that had $r_i = 10$ under the old version of the formula, where 56 MHz is the modal bandwidth, and 112 MHz is the maximum bandwidth in common use. The fee for a 56 MHz links is €560. For simplicity, suppose that we still have $m = 0.5$, then it is now the case that effective bandwidth of a modal bandwidth link is $b(i, 56) = 84$. Then the new value of $r_i = 6.67$, so that the fee for a 56 MHz links is

still €560. Effective bandwidth for a 28 MHz link in this band, $b(i, 56) = (28 + 84)/2$ = 56, and the fee for this link would be €373.

The other parameter values are;

- $x = 1.2$;
- $m = 0.25$;
- $c_{is} = 3$ if band i in area s is subject to a congestion charge, and $c_{is} = 1$ otherwise; and
- $A = 100$.

Table 4: Band specific parameter values

Band (GHz)	Modal bandwidth (MHz)	Maximum bandwidth in common use (MHz)	r_i
1.3	1	1	30
1.4	0.5	0.5	30
2	14	14	29.5
L6	29.65	29.65	26.6
U6	40	40	26.2
L7	14	14	25.8
U7	28	28	25.6
L8	29.65	29.65	25.3
U8	7	7	25.0
11	40	40	23.0
13	56	56	21.7
15	56	112	16.3
18	55	110	14.1
23	56	112	11.8
26	28	28	12.5
28	56	112	8.4
31	28	28	8.6
38	56	112	2.9
42	56	112	0.8
80	500	1000	0.2

A.3 New fees

Under the revised parameter values and formula for effective bandwidths, the fees for modal bandwidth links in each band, as well as for links with channel sizes half or double the modal bandwidth, are presented in the table below.

Table 5: Fees (EUR) for links not subject to a congestion charge

Band (GHz)	Modal bandwidth (MHz)	Fee – half modal	Fee – modal	Fee – double modal
1.3	1		100	
1.4	0.5		100	100
2	14	310	495	
L6	29.65		947	1,894
U6	40	786	1,257	2,514
L7	14		434	868
U7	28		861	1,722
L8	29.65		901	1,802
U8	7	131	210	420
11	40		1,105	2,210
13	56	913	1,461	
15	56	753	1,368	2,189
18	55	641	1,166	1,865
23	56	544	990	1,584
26	28	263	421	
28	56	389	706	1,130
38	56	136	247	396
42	56	100	100	108
80	500	100	150	240