Retuning and Relocating GSM1800 Spectrum Assignments in Ireland

ComReg Document 10/105b

Joint Report for ComReg

By

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Executive Summary

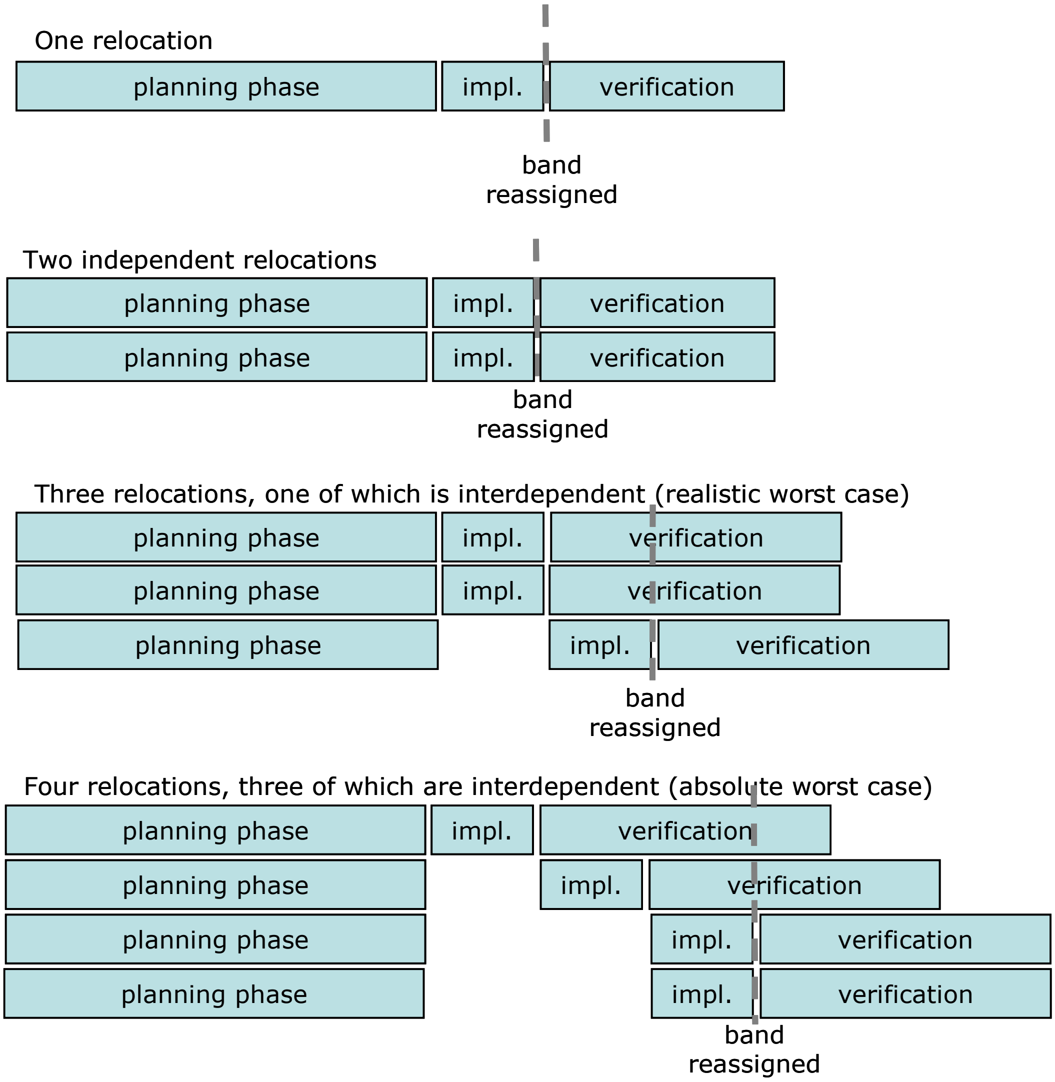
In the context of the potential liberalisation of 1800 MHz mobile spectrum in Ireland, the terms of reference for this study were to examine the timescales required by operators to 'relocate' their 1800 MHz networks, and to predict the costs that they might incur in doing so. Relocation scenarios have been examined assuming existing operators obtain 2x15 MHz of spectrum or more and so do not have to contend with the additional engineering consequences of adapting their existing networks to a reduced spectrum allocation at 1800 MHz.

Relocation of an 1800 MHz Network

A project to 'relocate' an operator's spectrum assignment would have a planning, an implementation and a verification phase.

In the case of multiple existing operators moving assignments, the implementation phases may be dependent on each other. In the 'realistic worst case' cited in the diagram below, three operator relocations would be necessary for existing GSM1800 licensees to reassign the 1800 MHz band.

The verification phase is undertaken after each operator has relocated to their new spectrum blocks and does not impact on the relocation exercises of the other operators.



Referring to the 'band reassigned' milestones in the figure above, this study concludes that the overall timescale for the three existing GSM1800 operators to complete their band reassignment activity will depend on the amount of inter-operator dependency that results from the block allocations decided by the auction process. The activity could complete in the following timescales:

- 4 months for planning and implementation for the 'two independent relocations' scenario shown in Figure 4
- Approximately 4.5 months for planning and implementation for the 'three relocations, one of which is interdependent' scenario
- Approximately 5 months for planning and implementation for the 'four relocations, three of which are interdependent' scenario.

The context of the 1800 MHz band reassignment is that reassignment of the 900 MHz band might have preceded the operation. A shorter planning phase, of perhaps 1 month's duration instead of 4 months, would be appropriate in the case where an operator has *recently* completed an identical relocation activity at 900 MHz. The shorter period is appropriate since the required processes would already have been tested during the 900 MHz band reassignment.

The implementation period is relatively short, generally overnight during a weekend. The subsequent verification activity of approximately 2 months occurs after the spectrum has been reassigned, and does not occur on the critical path to the 'band reassignment' milestone.

The relocation project will involve some engineering costs which can be split into labour cost and equipment cost categories. These categories of cost will both depend to some extent on the size of the network. Having stated some clear assumptions around the amount of labour required, its costs and relevant equipment costs, the study concludes that the engineering costs for a 'typically' sized Irish network[1] would be of the order of €240,000. An operator who had to relocate twice in quick succession under the 'absolute worst case' scenario would see increased engineering costs estimated at approximately €255,000. If, on the other hand, the 1800 MHz relocation project followed closely after an identical project to relocate the same operators 900 MHz network, then it should be possible to reduce the time required for the planning activity to around one month. The costs associated with the reduced project could be reduced to around €130,000.

Section 3.5 addresses the possible requirement of simultaneous GSM900 and GSM1800 retune / relocation for an operator. Although it is possible to implement the GSM900 and GSM1800 changes simultaneously on the operator network, this is unlikely to be their preferred approach. The likely best case time estimate here is an operator will implement their GSM900 changes and a month later, implement their GSM1800 changes. This would extend the complete retune / relocation for all operators by one month.

[1] As outlined in section 3.6: assumed to have around 1600 2G sites and 1000 3G sites, with 2G/3G site sharing. It is assume that of the 1600 2G sites in the network, 30% or 480 are equipped with 1800 MHz equipment

For a worst case estimation of the duration, the GSM900 changes would be implemented by all operators and then the GSM1800 changes would be implemented for all operators. This would effectively double the time required for retune / relocation in both bands compared to the case of one band only.[2]

Exclusion of Reduced Spectrum Scenarios from 1800 MHz Retuning and Relocation Study

The terms of reference for this study are to understand the implication of 'relocation' and 'retuning' in the 1800 MHz band. In a previous Red-M/Vilicom report (10/71c) concerning the 900 MHz band, three main scenarios in two classes were studied:

- 'Relocation' and 'retuning' of an existing spectrum allocation
- Adaptation to reduced availability of spectrum from 2x7.2 MHz to 2x5 MHz per operator.

In 10/71c, considerable effort was put into quantifying the impact of the reduced spectrum scenarios in relation to additional infrastructure required. In practice it is known that there are a large number of approaches that could be adopted by an operator in response to a reduction in spectrum availability. It was shown that relatively small changes in some of the input assumptions could result in large changes in the impact of the scenario on the operator.

Changes to 1800 MHz assignments will likely occur alongside changes in 800 MHz and/or 900 MHz assignments and the impact of changes in the 1800 MHz assignment almost certainly will depend on changes in the other band assignments. Operators currently have a relatively large 1800 MHz assignment (2 x 14.4 MHz bandwidth). Following a significant reduction in 1800 MHz assignment the GSM1800 layer might go from being a coverage limited service to an interference limited service. This would make changes in the quality of service very difficult to model without specific information of a confidential nature relating to an operator's network. GSM1800 networks are not generally deployed with contiguous national coverage, and it is therefore possible that the (confidential)

[2] It is assumed in section 3.4 that the planning phase for a GSM1800 retune / relocation could be reduced following a recent GSM900 retune / relocation. However, for the worst case scenario this assumption is not used.

operator network data could have a larger impact on the outcome of the scenario analysis than at 900 MHz. Without the express use of specific operator data (including site locations, traffic carried and traffic management strategies), it is not generally possible to identify the operator strategy or the impact of 1800 MHz assignment changes.

For these reasons, and given the increased number of potential scenarios involving reduction of available spectrum at 1800 MHz as compared to 900 MHz and the lower ‘scarcity factor’ of 1800 MHz spectrum compared to 900 MHz, no attempt at quantitative analysis of such scenarios has been undertaken.

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1 Introduction

The Commission for Communications Regulation (ComReg) has responsibility for the management of Ireland's radio spectrum. ComReg is currently involved in an ongoing consultation process in relation to, amongst other things, the methodology for assignment of spectrum rights for use in the 800 MHz, 900 MHz and 1800 MHz bands, the auction format and the associated details and processes for the assignment of those rights of use such as a spectrum realignment period. Two of the existing 1800 MHz licences expire at the end of 2014, and the other 1800 MHz licence expires in June 2015. There is currently a contiguous unassigned block of 2 x 26.4 MHz at the lower end of the band.

Red-M and Vilicom recently completed a study focused on the 900 MHz band, examining some of the potential engineering impacts on existing operators of a range of auction outcomes postulated by ComReg. This document has been published by ComReg as document 10/71c (The 'Red-M/Vilicom Report'). At about the same time as 10/71c was completed by Red-M and Vilicom, ComReg published consultation document 10/71 "800 MHz, 900 MHz & 1800 MHz spectrum release". In this ComReg consults on a proposal to run an auction for 800 MHz and 900 MHz bands at the same time and notes that 'there are arguments for and against the inclusion of the 1800 MHz band in a joint award process with the 800 MHz and 900 MHz bands'. Document 10/71 seeks views on whether the '1800 MHz band (should) be included in a joint auction with the 800 MHz and 900 MHz bands'.

The purpose of this document is to provide a companion document to the Red-M/Vilicom report 10/71c which considered retuning and relocation at 900 MHz. This document deals with the relocation of the 1800 MHz band and considers the likely timeframes required for existing GSM1800 MHz operators to "retune" and/or "relocate" their respective networks within the 1800 MHz spectrum band. In this context, "retuning" means altering the frequencies within an operator's existing spectrum assignment, and "relocation" means moving to a spectrum assignment other than that currently assigned to an operator.

In order to provide continuity of service for all existing 1800 MHz operators, retuning and relocation activities may have to take place in several stages. If Operator A acquires spectrum currently occupied by Operator B, then B must vacate the spectrum before it can be occupied by A. This document therefore considers not only the activities and likely timescales of an individual operator, but also the total activity required.

Retuning and relocation activities are most challenging where a spectrum assignment is reduced. There are a large number of potential outcomes of a joint auction process releasing spectrum in the 800 MHz, 900 MHz and 1800 MHz bands. This document is not intended to speculate on the full range of possible outcomes, how these outcomes could be managed and how much any associated engineering processes would cost to implement. The document confines itself to the costs for a retune or relocation activity within a typical Irish mobile network.

2 Background

2.1 1800 MHz Spectrum Assignments and Proposed Release

In Ireland there are currently three GSM Licensees in the 1800 MHz band. These are: Meteor Mobile Communications Limited ("Meteor"), Telefónica O2 Ireland Limited ("O2") and Vodafone Ireland Limited ("Vodafone"). Each of these GSM licensees is currently assigned 2 x 14.4 MHz of 1800 MHz spectrum, as outlined in Figure 1 below.

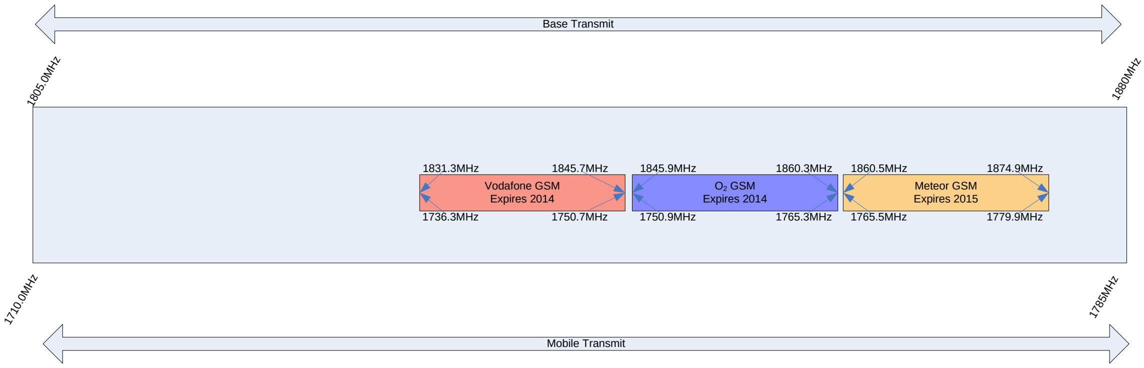

Figure 1: The 1800 MHz band and the current GSM licensees' assignments

ComReg consultation document 10/71 consults on the high level question of whether the 1800 MHz band should be included in a joint auction with the 800 MHz and 900 MHz bands but does not propose a detailed auction format for the 1800 MHz band.

For the purposes of this document, it is assumed that the entire spectrum allocation (2x75 MHz) in the 1800 MHz band would be made available for liberalised technology neutral use as 15 lots of 2x5 MHz, as shown in Figure 2.

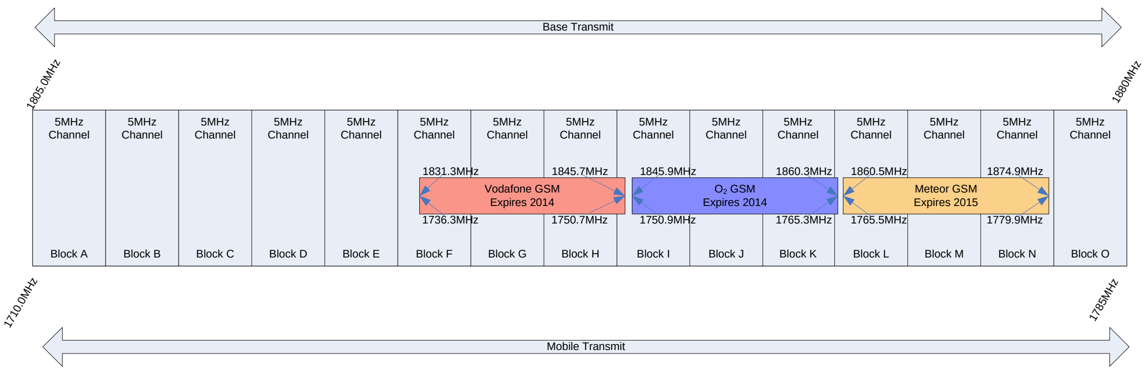

Figure 2: 1800 MHz liberalised band plan (hypothetical)

Existing operators have 2x14.4 MHz allocations (excluding assigned guard bands) that are not aligned with the 5 MHz boundaries now proposed. Although Meteor's current assignment would not cross over a 3x2x5 MHz boundary, they might still be required to 'relocate' even if they obtained 2x15 MHz of spectrum in the auction, as the auction process might not guarantee them their existing spectrum and it could also be desirable to avoid fragmenting the 1800 MHz spectrum allocation by isolating Block O.

Most mobile terminal equipment in use in Ireland is 'dual band' (2G) or 'tri band' (3G) capable and so can use spectrum in the unused 1800 MHz blocks when instructed to do so by the network.

2.2 Guard Bands

In the existing GSM1800 spectrum assignment shown in Figure 1, ComReg assigned frequencies to operators allowing for a guard band of 0.2 MHz between adjacent operator assignments. Each GSM carrier occupies a bandwidth of 0.2 MHz[3], so this means that within 14.4 MHz of assigned frequency, an operator can use 72 channels. The effect of introducing the guard band along with other licence constraints is to allow each operator to make use of his spectrum assignment without regard to how the spectrum in the adjacent block is used. In other words, operators in adjacent spectrum blocks do not need to co-ordinate their use of spectrum, with the attendant risks and uncertainty that could arise.

When a band is allocated for use by a single technology use, it can be effective to assign guard bands in this manner. In the case of technology neutral assignments such as those proposed in the liberalised 1800 MHz spectrum award, guard bands cannot be pre-determined as they depend on the radio technology used within each assigned frequency block. This point is illustrated in Figure 3, which considers the case of GSM and UMTS coexistence in adjacent spectrum blocks assigned to different operators. The separation requirements used in Figure 3 come from the Annex to EC decision 2009/766/EC[4] which states that a centre-frequency carrier separation of 2.8 MHz or more between a neighbouring UMTS network and a GSM network is required 'in the absence of bilateral or multilateral agreements between neighbouring networks without precluding less stringent technical parameters if agreed among the operators of such networks'. The same Annex indicates that a carrier centre frequency separation of 5 MHz or more between two neighbouring UMTS networks is required. As the carriers and spectrum blocks are both 5 MHz wide, UMTS carriers can occupy the assigned spectrum without wastage.

[3] The term 'bandwidth' is used loosely. GSM carriers centre frequencies are assigned on a fixed raster of 200 kHz.

[4] 'Commission Decision of 16th October 2009 on the harmonisation of the 900 MHz and 1800 MHz frequency bands for terrestrial systems capable of providing pan-European electronic communications services in the Community'

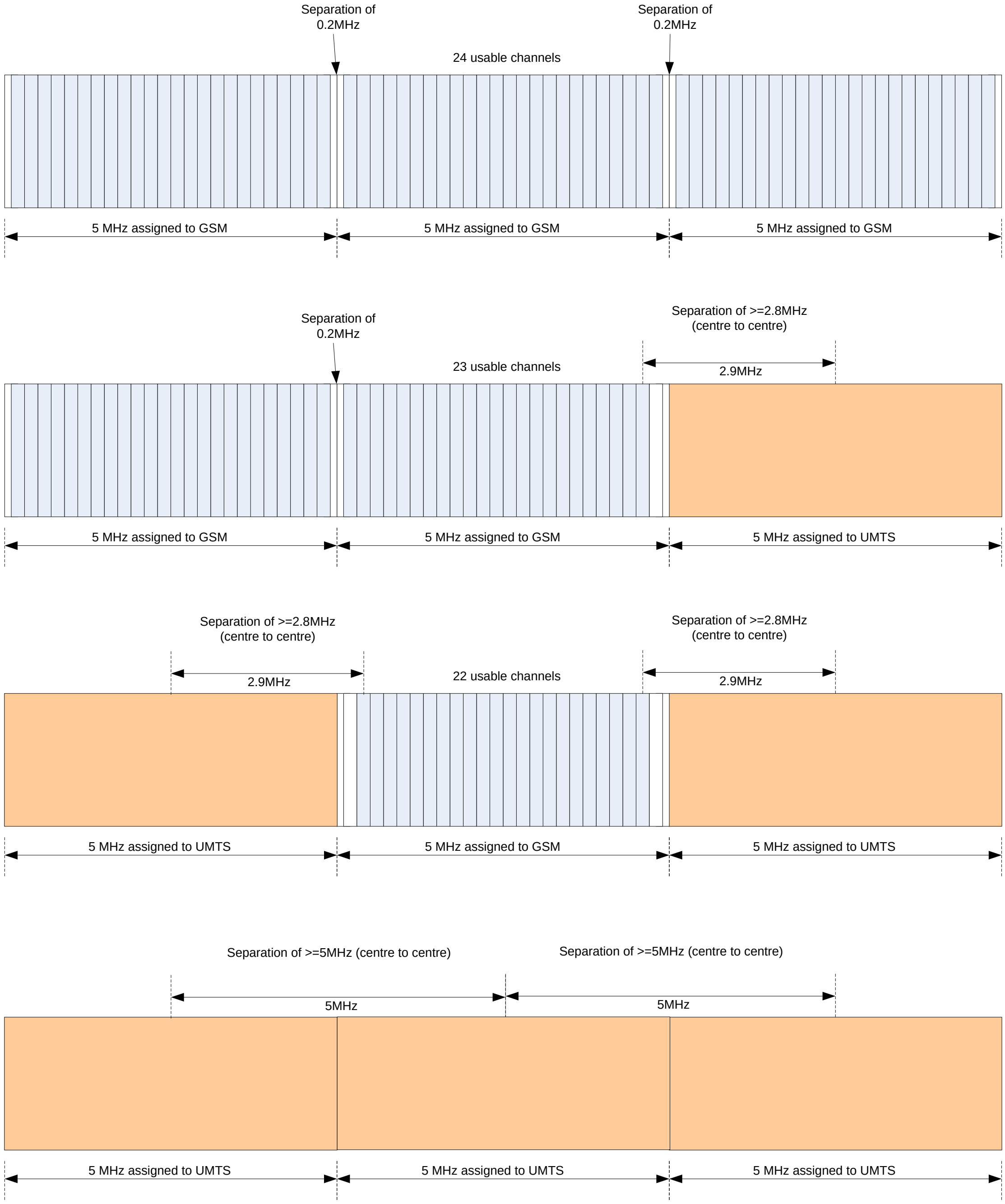

Figure 3: UMTS and GSM Guard Bands for Uncoordinated Operation[5]

[5] In Figure 3, the centre to centre separation between UMTS and GSM carrier blocks is shown as 2.9 MHz. The actual separation to the first GSM channel shown as 'usable' is either 2.8 MHz or 3.0 MHz, as the centre frequencies of both GSM and UMTS carriers are on the same 0.2 MHz raster.

The conclusion from Figure 3 is that heterogeneous co-existence of GSM and UMTS is inefficient in the absence of such bilateral or multi-lateral agreements. To allow for uncoordinated operation, the guard band must be sufficient to accommodate the most stringent scenarios. These would typically include mobiles from an uncoordinated operator on the edge of its cell being very close to the cell of a victim operator, including the possibility of interference from multiple interferers. Co-ordination activity, could then, for example, attempt to ensure that such scenarios cannot occur in practice.

Operators who currently hold 2x14.4 MHz of spectrum for 2G use and who managed to obtain three 2x5 MHz blocks of spectrum at auction in the 1800 MHz band would be able to 'relocate' or 'retune' their networks so that they could continue to use at least their existing number of channels (72) without the additional constraints of co-ordination.

For example, consider Block A from 1710 MHz to 1715 MHz adjacent to Block B from 1715 MHz to 1720 MHz. The UMTS carrier centre frequency in Block A is at 1712.4 MHz or 1712.6 MHz. The first GSM carrier shown in Figure 3 as 'usable' has a centre frequency of 1715.4 MHz. 1715.4 - 1712.6 MHz = 2.8 MHz, meeting the separation requirements from the annex to the EC decision. 1715.4 MHz - 1712.4 MHz =3.0 MHz, exceeding the requirements. If it is known by the user of Block B, through coordination or otherwise, that the UMTS carrier centre frequency in Block A is at 1712.4 MHz, then the GSM carrier at 1715.2 MHz can be used since 1715.2 MHz - 1712.4 MHz = 2.8 MHz.

2.3 GSM1800 in Multi-Band Operation

All Irish mobile operators with spectrum in the 1800 MHz band have also built GSM900 networks. As 1800 MHz signals do not propagate as far as 900 MHz[6], 900 MHz has been preferred for build-out in rural areas. In urban areas, 900 MHz has advantages as these signals penetrate buildings more effectively than 1800 MHz signals. Capacity constraints of 900 MHz networks have encouraged operators to build 1800 MHz cells in areas of high traffic demand. In terms of network economics, when network capacity demand increases, it is cheaper to build additional 1800 MHz capacity into an existing 900 MHz cell site than it is to build additional sites.

This means that there is no contiguous national coverage at 1800 MHz, and that 1800 MHz frequencies are used principally to relieve network capacity in areas of high demand. Demands on 1800 MHz for this type of use could increase if 900 MHz liberalisation resulted in an overall reduction of spectrum allocated to an operator at 900 MHz. Two scenarios at 900 MHz that could result in such an increase in demand were considered in document 10/71c, for example, and are:

- A reduction in 900 MHz spectrum allocated to an operator from 2x7.2 MHz to 2x5 MHz
- An increase in 900 MHz spectrum allocated to an operator from 2x7.2 MHz to 2x10 MHz, associated with an introduction of UMTS900 occupying 2x5 MHz, and a consequent reduction in spectrum allocated to 2G use to 2x5 MHz.

Although the result of liberalisation auctions in other spectrum bands will have an impact on spectrum an operator’s spectrum requirements at 1800 MHz, the liberalised 800 MHz, 900 MHz and 1800 MHz spectrum bands are not directly ‘substitutable’ in the short term. In particular

- As 1800 MHz is in the very early days of liberalisation, only 2G infrastructure and mobiles are currently available in the band. Practically all of the existing handsets can make use of additional 2G spectrum at 1800 MHz. It would be possible to

[6] Advantages for the use of 900 MHz come from a number of sources, which include 6 dB less transmission loss in free space, reduced in-building penetration loss of 3-4 dB (typical), and potentially 3 dB extra uplink power (2 watt GSM900 mobiles vs. 1 watt GSM1800 mobiles).

make both UMTS and LTE equipment available in the 1800 MHz band in the medium term, but existing handsets would not support the band/technology mix and new handsets would need to be introduced into the network to make the spectrum useable in liberalised form.

- 1800 MHz spectrum has similar propagation characteristics to existing spectrum in the 2100 MHz band, which is inferior in relation to the 800 MHz / 900 MHz bands. For 2G use, existing 1800 MHz and 900 MHz spectrum allocations can be substituted, as long as the inferior propagation characteristics of the 1800 MHz band can be accommodated by appropriate network design.
- As 800 MHz spectrum has not been made available before, there is no equipment of any type (infrastructure or mobiles) in Ireland that operates in this band. As the band is likely to be widely available and the spectrum has similar (favourable) propagation characteristics to existing spectrum in the 900 MHz band, it is anticipated that equipment will become commercially available for use in the near future as a result of the desire of both the operators and the equipment vendors to make use of this band.

The status of equipment availability on a per-technology basis band by band has been considered in more detail by ComReg in consultation 10/71.

2.4 "Relocation" Versus "Retuning"

In the 1800 MHz band, the current assignments of Vodafone and O2 are not aligned with the spectrum block boundaries proposed in Figure 2. Following an auction process Vodafone and O2 would always be required to relocate or retune if they obtained no more than 2x15 MHz of spectrum at 1800 MHz.

If Vodafone obtained spectrum blocks F, G & H and O2 obtained blocks I, J and K, they would 'retune' rather than 'relocate' their networks as much of their existing spectrum allocation would remain unchanged. Vodafone would have to move its spectrum allocation to lower frequencies by at least 800 kHz (or reassign four ARFCNs[7]) and O2 would have to move their allocation to lower frequencies by at least 400 kHz (or reassign two ARFCNs). There are two potential approaches that each operator could adopt for this task

- Treat the task as a 'relocation'. In this case the methodology described for Scenario 1 (section 3 on page 21) would apply.
- Use a similar methodology, but limit the retune to cells and neighbours using the affected channels.

Which approach to take would depend on how intensively the affected channels are used in the current network. If the channel were used only selectively, for example as part of a microcellular or in-building pool, then the simplest approach might be to limit the retune to the affected cells and their neighbours.

If the affected channels are used extensively in Vodafone's and O2's 1800 MHz macro-cellular networks (as is most likely the case[8]), it might be simpler to treat the retune task as a Scenario 1 relocation / retune, because the affected cells and their neighbours would then constitute a large proportion of the network. It would not be generally advisable to merely replace the affected channels with other unused channels in the network. Channel groups

[7] The 'ARFCN' is the GSM channel number. ARFC numbering is a GSM numbering scheme which uniquely identifies the frequency channel across multiple bands.

[8] As there is an unused guard channel between Vodafone's and O2's current assignments, there would have been nothing to prevent Vodafone and O2 making extensive use of the channels at the edge of their assignments and over quite extensive areas.

are generally arranged with regard to adjacent channel interference, and it is best practice to avoid as much adjacent channel interference as possible. Adjacent channels are not used at the same time within cells or in co-located cells on sectored sites. For the same reasons, second adjacent channels are also avoided wherever possible. Simply replacing channel the affected channels in the plan with other channels from elsewhere in the operators' assignment would not guarantee that optimum adjacent channel interference performance of the network would be maintained.

In order to simplify the analysis, the estimates in section 3 below assume that the methodology of a 'relocation' is used even where a potentially simpler 'retune' may be appropriate. In other words, no simplification of the activity is assumed just because the spectrum assignment is being moved 400 kHz / 800 kHz rather than to a different spectrum block. The analysis is therefore 'worst case' in this regard.

2.5 Outline Scenario to Study

The terms of reference for this study are to understand the implication of 'relocation' and 'retuning' in the 1800 MHz band. In the Red-M/Vilicom report (10/71c), three main scenarios in two classes were studied:

- Scenario 1, 3[9]: relocation and retuning of an existing spectrum allocation
- Scenario 2: adaptation to reduced availability of spectrum in the band (2x7.2 MHz to 2x5 MHz)

In principle, these same scenarios are applicable to 1800 MHz, and the same approach to Scenario 1 has been adopted. This report therefore follows the same construction, but with consideration limited to the 1800 MHz band instead of the 900 MHz band.

In Red-M/Vilicom report 10/71c, considerable effort was put into quantifying the impact of Scenario 2 in relation to additional infrastructure required. In practice it is known that there are a large number of approaches that could be adopted by an operator in response to a reduction in spectrum availability. It was shown that relatively small changes in some of the input assumptions could result in large changes in the impact of the scenario on the operator. As a result, analysis carried out for scenario 2 for the 900 MHz assignments is deemed not appropriate for the 1800 MHz assignments for the following reasons.

- The analysis for the 900 MHz network was taken in isolation of any other changes in an operator's spectrum assignment. Changes to 1800 MHz assignments will likely occur alongside changes in 800 MHz and/or 900 MHz assignments for operators. This increases the permutations of overall assignments, and as the 1800 MHz band is currently used for capacity offload from the 900 MHz band the impact of changes in the 1800 MHz assignment almost certainly will depend on changes in the other band assignments.

- Currently, operators have a relatively large 1800 MHz assignment (2 x 14.4 MHz bandwidth) and overall the 1800 MHz band carries proportionately less traffic per MHz than the 900 MHz band. The result is that the quality of service on the

[9] Scenario 3 is a Meteor specific 900 MHz scenario which is not applicable to 1800 MHz.

GSM1800 band is relatively very good, with the service generally being limited by signal level (before the call is handed over to the 900 MHz layer). Therefore, following a reduction in 1800 MHz assignment (e.g. from 2 x 14.4 MHz to 2 x 5 MHz) the GSM1800 layer might move from being a coverage limited environment to an interference limited environment. This would make changes in the quality of service (and any remedy) very difficult to model without specific information of a confidential nature relating to an operators network.

- GSM1800 networks are not generally deployed with contiguous national coverage, and it is therefore possible that the (confidential) operator network data could have a larger impact on the outcome of the scenario analysis than at 900 MHz. Without the express use of specific operator data (including site locations, traffic carried and traffic management strategies), it is not generally possible to identify the operator strategy or the impact of 1800 MHz assignment changes.

- In order to model scenario 2 at 1800 MHz, it is more important to have an understanding of the statistics of localised peak traffic density than average capacity.

Given this added complexity and the increased number of potential scenarios at 1800 MHz (2x14.4 MHz to 2x15 MHz , 2x10 MHz, 2x5 MHz or 2x0 MHz), and the lower ‘scarcity factor’ of 1800 MHz spectrum compared to 900 MHz, no attempt at quantitative analysis of the equivalent of Scenario 2 has been performed.

3 Scenario 1 – GSM Licensee assigned 2 x 15 MHz spectrum (or more)

3.1 Introduction

In this scenario, an existing GSM licensee is assigned slightly more spectrum than they currently occupy. The operator currently has 2x14.4 MHz of spectrum (72 GSM carriers). An operator obtaining 2x15 MHz of spectrum might have access to up to 75 carriers, though if they chose with neighbouring operators to deploy them in an 'uncoordinated' manner they would need to assign one carrier as a guard-band which would mean that 74 carries would become useable.

Instances of this scenario are

- The new spectrum assignment fully overlaps the operator's existing assignment (for instance, Meteor is assigned blocks L, M and N in Figure 2). This is the most trivial case as the operator has no immediate actions to perform[10].

- The new spectrum assignment partially overlaps the operator's existing assignment (for instance, Vodafone is assigned blocks F, G and H in Figure 2.). For the purposes of this document, this scenario is called '*retuning*' the frequency assignment. The operator needs to decide the best way to accommodate the new frequency assignment and ensure all of the existing frequencies are vacated. The operator would move his existing 2G network to the new frequency assignment, and may subsequently choose to liberalise his spectrum by freeing up contiguous spectrum for 3G or LTE operation.

- The new spectrum assignment includes none of the existing assignment (for instance, Vodafone is assigned blocks A, B and C in Figure 1). For the purposes of

[10] The operator may choose to liberalise his spectrum in the medium term by freeing up 5 MHz of contiguous spectrum for 3G operation. This would involve steps similar to those described in Scenario 2 of Red-M/Vilicom report 10/71c although the operation could be simplified as it could take place in the medium term after migration of some of the 2G capacity demand to existing UMTS networks.

this document, this scenario is called '*relocation*' of the frequency assignment. Just like the 'retuning' scenario, the operator would move his existing 2G network to the new frequency assignment, and may subsequently choose to liberalise his spectrum.

Depending on the operation of any 'spectrum cap' rules that might apply in the 1800 MHz band[11], an operator might obtain more than 2x15 MHz of spectrum. As long as the operator obtains at least as much spectrum as his existing allocation, the 'retune' or 'relocate' activities remain largely the same and the results of this section can be applied.

The planning and implementation of the 'retuning' and the 'relocation' scenarios are very similar. In the case of high efficiency cell planning structures such as 1x1 fractional re-use, all cells would be affected to some degree irrespective of whether the network needed to be 'relocated' or 'retuned'. Although it would be possible to construct some migration scenarios where '*retuning*' affected only a subset of cells in the network, it is quite likely that a complete translation of all frequencies from one assignment to another would be the simplest to achieve for both the 'relocation' and 'retuning' examples. This is because the reconfiguration of the base stations in the network to use different frequencies can be achieved by a network data-fill[12] change at the Operation and Maintenance Centre (OMC), and those migration strategies where there is a single global relationship mapping, a frequency in the old assignment to a corresponding frequency in the new assignment represent the simplest possible manipulation of the network data set. Such a strategy is always possible when an operator with 2 x 14.4 MHz of spectrum obtains at least three contiguous blocks of spectrum. The case where the three blocks are not contiguous represents a slightly more complex case, but is less likely as it is assumed that the spectrum auction design would have a second stage similar to the auction format proposed in ComReg document 09/99 for the 900 MHz band. The second stage is designed to achieve a spectrum assignment of contiguous spectrum blocks if that type of assignment is valued by the operators.

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[11] ComReg consultation document 10/71 does not consider the question of spectrum caps in the 1800 MHz band.

[12] 'Network Data-fill' is the combination of all configurable parameters of the equipment to ensure that the network works as a coherent whole and as designed. There is a large quantity of configurable parameters on a modern mobile network which control all aspects of the network's operation.

3.2 Inter-Operator Dependency

There are three main situations in which inter-operator dependency arises as a result of retuning or relocation.

- An operator cannot move to his target spectrum if it is currently occupied until it is vacated by the other operator. Any operator assigned spectrum in blocks A-E & O should relocate first as these blocks are currently unoccupied, followed by any of the remaining operators. The relocation of all three existing operators into 2 x 15 MHz of spectrum can be accomplished with as little as two independent[13] relocations or as many as *four*[14] relocations of which three are interdependent. Assuming a second round auction format avoids this absolute worst-case, the most complicated practical case, considering that both existing operators and new entrants might obtain spectrum at 1800 MHz would be *three* relocation activities of which one is interdependent[15].

- Co-ordination with other operators who are national roaming partners, and who need to implement any network changes in synchronism.

- Inter-operator dependency along national borders. The networks must co-ordinate their use of spectrum with operators north of the border who share the same spectrum.

[13] Example of two independent relocations: Meteor stays where they are (assigned blocks L-N), Vodafone relocates to spectrum blocks F-H and O_2 relocates to spectrum blocks A-C. The Vodafone and O_2 relocations are not dependent on each other and can occur in parallel.

[14] Example of four relocations of which a maximum of three are inter-dependent: O_2 is assigned blocks M-O, Meteor is assigned blocks J-L and Vodafone is assigned blocks G-I. In this unlikely worst case, each operator ends up taking spectrum partially occupied today by another operator. As a result a fourth relocation is required. The sequence of events could be: Meteor vacates existing spectrum allocation to unused blocks. O_2 then occupies blocks M-O, and then Meteor and Vodafone occupy their respective allocation in blocks G-L.

[15] Example of three relocations of which one is interdependent: Meteor is assigned blocks M-O, O_2 is assigned blocks J-L and Vodafone is assigned blocks E-G. O_2 is dependent on Meteor's move, but Vodafone is not.

Figure 4 illustrates the effect of inter-operator dependency on the overall activities required to organise the 1800 MHz band plan after spectrum reassignment.

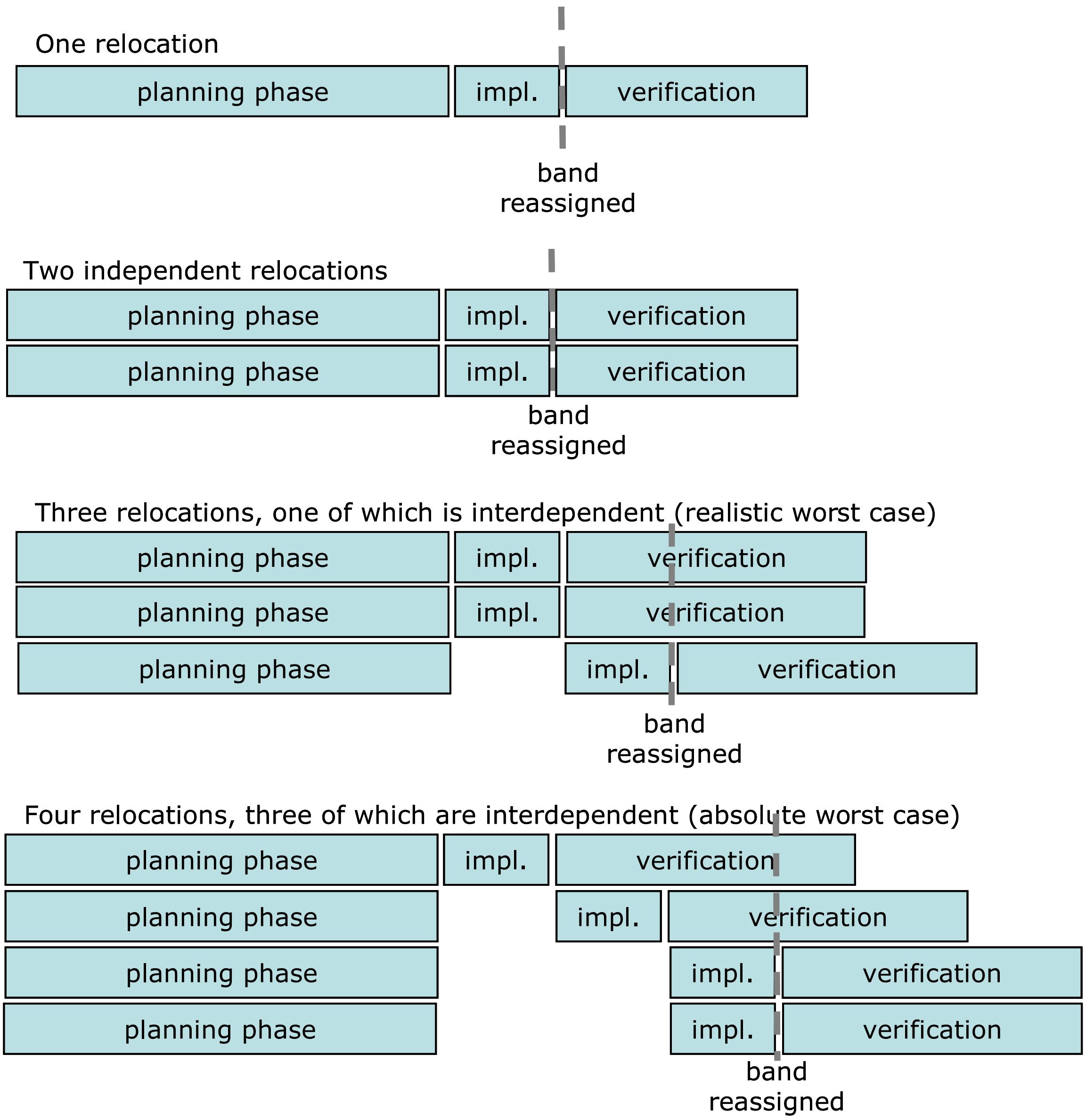

Figure 4: High Level Project for Relocation and Retune activities (not to scale)

In Figure 4, a relocation and re-tune activity is split into three distinct phases, which are:

- **Planning Phase**: During this phase no retune or relocation activity takes place, but other engineering activities on the network are completed. During the planning phase the network enters a period of 'lockdown' so that the network data-fill remains stable for a period, and reference performance of the network can be established.

- **Implementation Phase**: During this relatively short phase (typically overnight at a weekend), the network is retuned or relocated to the new frequencies. In the early stage of this process a roll-back might be contemplated if there are serious issues. When the implementation is complete, the network has been relocated or retuned.
- **Verification Phase**: Post implementation, this is a phase where the network Grade of Service, call drop rates, etc., are monitored for long enough to identify whether there are any residual issues that need attention. The network 'lockdown' continues so that issues relating to the relocation/retune can be isolated from other issues associated with network changes.

In relation to inter-operator dependency, Figure 4 indicates that

- Operator planning phases can occur in parallel, as there is no dependency from one operator to another. Significant amounts of the planning exercise can be completed before the operators know exactly which spectrum blocks they have been allocated, since the assigned spectrum block affects only a small part of the activity.
- Implementation phases may need to occur sequentially, so that each operator is relocating / retuning to spectrum which is freely available. At the end of the final implementation phase, all 1800 MHz spectrum has been reallocated.
- Verification phases will start post implementation, and operators can run verification in parallel as there is no dependency of one operator to another.

3.3 Engineering Activities for Scenario 1 Relocation / Retune

This section outlines the engineering activities that are required for a relocation / retune.

3.3.1 Planning Phase

The following activities need to take place.

- Identify all major upgrade projects on the network, and ensure that these can be planned around the lockdown period. Networks that are managed by engineering teams on a regional basis might require a central team to coordinate this activity.
- Test the relocation / retune processes at the OMC. Typically the relocation / retune process will involve interrogating the data-fill of the live network at the OMC, modifying the data-fill off line, and loading the modified data-fill back onto the network during the implementation period. The only parts of the data-fill that need to be modified during a relocation / retune activity will be those relating to frequency of operation, but changes will have to be made on the GSM900, GSM1800 and UMTS networks. The list of parameters that need to be changed includes BCCH assignment, TCH assignment & hopping sequences, neighbour cell lists & Base Station Identity Code[16] BSIC. A 'dry run' can be performed using sanity checking tools to ensure that the modified data loads correctly on test infrastructure maintained in the operators offices. This test infrastructure is normally used to verify new software releases before they are implemented in the field. Sanity checking tools will normally identify any inconsistencies in the network data, and may highlight issues with the existing network that should be resolved before implementation[17].
- Co-ordinate with national roaming partners. Roaming partners need to know which frequencies are in use in the cells of the other network to perform a handover to that network. The planning activity will include agreeing arrangements for communicating the modified data-fill and verifying processes for loading this

[16] The Base Station Identity Code is a cell identifier used within the GSM system.

[17] Such inconsistencies sometimes arise between areas managed by different regional operation teams for example, and the relocation / retune process offers a good opportunity to sanity check the entire network.

information onto the network of the roaming partner, although as there will be a synchronisation process in place to ensure this happens routinely, the difference is the scale of the changes.

- Identify all radio equipment that cannot be modified during the implementation or planning phases. Such equipment may include band selective repeaters (discussed in section 4.3). As these need to be modified or replaced by site engineering visits during the implementation phase and immediately following the relocation / retune of the rest of the network, areas of the network that rely on this equipment will suffer network outages. It is important during the planning phase therefore to ensure that the correct inventory is ordered and in stock, and that there is sufficient engineering resource to complete the site visit activity in a short time. Where, for example, the in-building systems of important corporate customers are dependent on such infrastructure, liaison with the customer would be planned so that any enabling installation works could be pre-arranged and any final site visit could take place out of hours immediately following the relocation / retune.
- All band-selective repeaters tuned to the old band need to be turned off as if they are left (for example if their location has been forgotten) and not known about they would potentially cause interference as they will be incorrectly configured for the new operator in the band
- Implement a disaster recovery plan in case of failure
- Generate the final data-fill
- Produce staff and resource plan for Implementation and Verification phases.

These activities are identical to the activities that were identified in Scenario 1 of the Red-M/Vilicom report 10/71c relating to a network relocation at 900 MHz. There is no essential difference between the operation at 900 MHz and 1800 MHz, though it should be noted that

- As the relocation / retune processes are essentially identical at the OMC whether the equipment is 900 MHz or 1800 MHz, an operator who had recently completed a similar 900 MHz relocation activity could shorten the planning phase because the OMC processes would have already been recently tested. If an operator uses network equipment from a different vendor for his 900 MHz and 1800 MHz networks, then the details of the activity could be different and any differences would need thorough testing. Similar considerations would apply if the equipment used at 900 MHz and 1800 MHz was from the same vendor but of a different generation.

3.3.2 Implementation Phase

This is a critical and high-pressure phase of the relocation/retune. All GSM1800 cells in the network will be taken out of service, have their data-fill modified, and then be brought back up again. Each cell in the network will therefore suffer a network outage, and so it is essential to plan the implementation for a relatively quiet time on the network. The preferred time is generally early in the morning over a weekend[18], so that the rest of Sunday is available for early verification of the network and essential engineering activity. The GSM900 and UMTS cells will have considerable parameter changes implemented, but should not require any network outage.

With a large network consisting of tens of thousands of individual cells, some sites may fail to respond as expected. These can be monitored centrally and several attempts can be made to reboot them. If all else fails, it may be necessary to send an engineering team out. In terms of costs of the actual implementation phase, the cost of having engineering teams on standby out of hours is likely to be the dominant factor. The number and location of these teams will be determined during the planning phase.

During the early part of the implementation phase, focus will be on network status and confirming that all cells in the relocated / retuned network are operational. In the latter stages, focus will turn to verifying that the network is operating as expected.

[18] The expected time for the network to recover would typically be in the range of 1-3 minutes per cell, with an overall time from start to finish of 1-3 hours. Precise details are dependent on both the type and configuration of the equipment used and the network topology.

3.3.3 Verification Phase

During the verification phase two key inputs can be used to determine whether the network is operating as expected

- Network generated Grade of Service (GOS) statistics: An estimation of whether the network is operating as expected can be deduced by comparing the GOS statistics and the locations of all events such as dropped calls with the reference network performance established during the planning period.
- Customer complaint calls fielded by the Customer helpdesk: Customers used to having service in particular areas are very sensitive to any network changes, and customer complaint calls provide a useful input to determine where service has been lost (for example due loss of a repeater).

Following monitoring of network statistics, a small drive-test and optimisation campaign would probably be undertaken to analyse in depth any areas of the network causing concern. This testing would be localised in nature and intended to identify particular issues causing problems. It would not be necessary to undertake a large scale national drive test process.

3.4 Timescales

The following timescales are reasonable for the outline activities presented in the sections above.

- Planning: A total planning phase of approximately four months might be required[19]. As the planning phase does not completely depend on the exact details of which block of spectrum will be assigned, an operator that knows they will be assigned 2 x 15 MHz of spectrum from the first stage of the auction can then begin to plan.
- Implementation: The relocation / retune could be performed over one weekend. The following week could be used for essential maintenance activity, such as

[19] Although as discussed in paragraph 3.3.1, a reduced period of 1 month could be sufficient if the operator in question have recently completed an identical operation at 900 MHz.

removal of redundant repeaters, so that the following weekend would be available for the next operator to relocate / retune.

- Verification: A verification phase of, say, 2 months would be sufficient to verify that the relocated network is operating successfully. Bearing in mind that the verification is not on the critical path for other operators and that the intensity of the verification could reduce substantially in the few days following implementation, the exact duration of this phase is not of critical importance.

Referring to the 'band reassigned' milestones in Figure 4, the overall timescale for the three existing operators to complete their band reassignment activity will depend on the amount of inter-operator dependency that results from the block allocations decided by the auction process. The activity could complete in the following timescales:

- 4 months for planning and implementation for the 'two independent relocations' scenario shown in Figure 4[20].
- Approximately 4.5 months for planning and implementation for the 'three relocations, one of which is interdependent' scenario.
- Approximately 5 months for planning and implementation for the 'four relocations, three of which are interdependent' scenario. In this scenario it would be advisable to allow for a contingency of an additional week in case one of the operator re-assignments goes wrong to the extent that it needs to be rolled back and tried again the following week.

The subsequent verification activity of approximately 2 months occurs after the spectrum has been reassigned, and does not occur on the critical path.

Figure 5 shows a 'to scale' version of the high level project plan of Figure 4 using the timescales and dependencies established in this section. The start date of the project shown in Figure 5 is relatively arbitrary as operators can commence the planning phase in advance of the auction.

[20] Reducing to around one month if both operators involved have recently completed an identical activity in the 900 MHz band (see section 3.3.1)

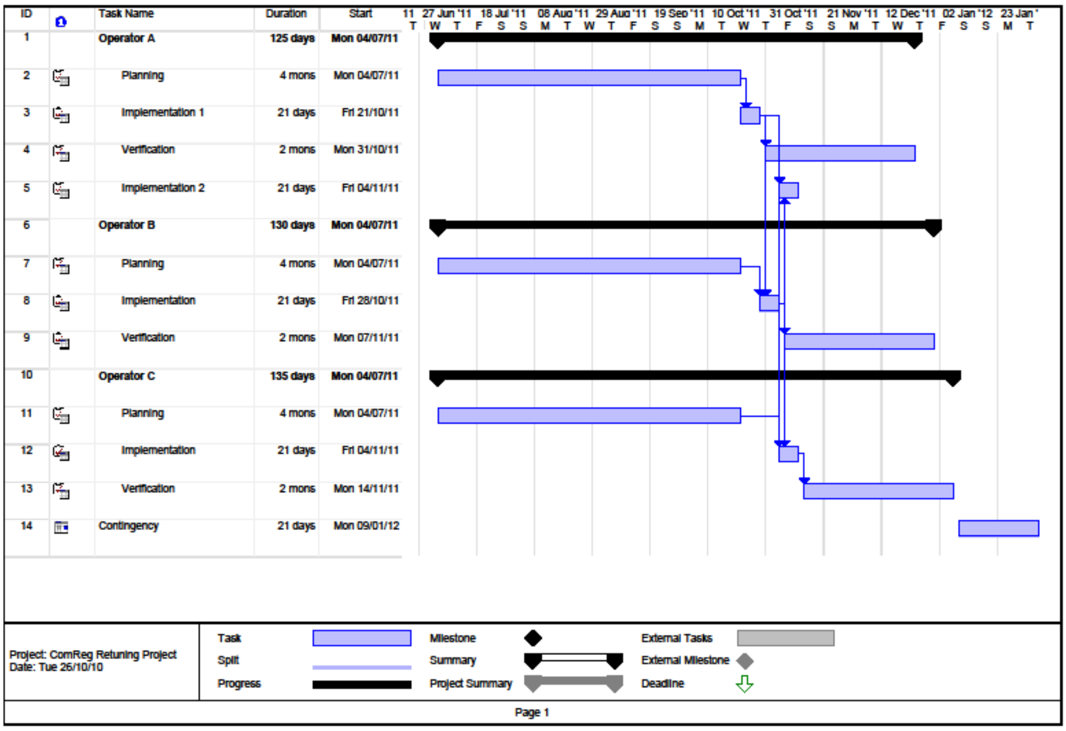

Figure 5: High Level Project for Relocation and Retune activities (to scale)

3.5 Simultaneous Changes to GSM900 and GSM1800 Assignments

In the particular case of changes to an operator's GSM900 and GSM1800 assignments, channel relocation / retuning may be required to both bands at approximately the same time.

Typically, an operator might prefer not undertake such tasks simultaneously due to the workload involved and the increased risks to the network performance. Also, a period of three or four weeks might be planned between the changes to each band to allow for monitoring of each band independently.

The timescales for planning, implementation and verification are detailed in section 3.4, above, estimate one month additional planning for GSM1800 changes subsequent to recent GSM900 changes. This would allow the GSM1800 changes to be completed one month after the GSM900 changes.

With this, a retuning / relocating program for GSM900 and GSM1800 "simultaneously" for all operators would require an estimated minimum of one additional month compared to retuning / relocating one band only.

At worst case, the GSM900 and GSM1800 retune /relocation could be completed separately. That is, firstly the GSM900 retune / relocation is completed by each and every operator and then the GSM1800 retune / relocation can proceed. In addition, a full duration for the planning period (4 months) for the second band retune / relocation could also be assumed. At worst estimate, the retune / relocation of GSM900 and GSM1800 should take twice the time period as for one band, as outlined in section 3.4, above.

3.6 Cost Modelling

An outline estimate of the engineering costs to complete a retune/relocation activity for a benchmark mobile network in Ireland is shown in Figure 6.

Task	Detail	Who	Man Days (8hr shift)	Ave Cost / md	Total (Euros)	Qty	Unit Cost	Total Cost	Notes
Planning									
Project Team	0.5 FTE 4 month	Project Management	43	950	41166.667				1
	2 * 0.75 FTE 4 month	Engineering / RF / Network Operations	130	800	104000				2
Equipment	Band Selective Analogue Repeater					5	2500	12500	3, 7
	Band Selective Digital Repeater					5	4900	24500	4, 7
Implementation									
	Datafill - 3man team - weekend	Network Operations	6	700	4200				
	8 2-man Implemenation Teams - 5 day week * 20%	Field Operations	24	600	14400				5, 7
Verification									
Project Team	0.75 FTE 2 month	Project Management	33	950	31350				
	0.5 FTE 2 month	OMC-R / Service Management	31	700	21700				7
	2-man Implementation Team - as required	Field Operations	6.7	600	4000				
	Drive Tests / Optimisation	Field Operations	10	600	6000				6
Sutotals					226816.67			37000	
Overall Total					**263816.67**				

1. Project Manager responsible for all activity. 'FTE' = full time equivalent
2. Resource not full time on project
3. e.g. Axell Analogue repeater user selectable and tunable (unmanaged). Assume 1 in 50 2G sites supports a repeater that requires replacing. Assume average 2G site count of 1600.
4. e.g. Axell Digital repeater 12-sub bands (managed). Assume 1 in 50 2G sites supports a repeater that requires replacing and 50% of these are replaced with digital repeaters.
5. Assume 10% of 2G sites need a visit during the implementation period and each team can visit 4 sites per day.
6. Assume 5 days total drive test with 2 man teams.
7. Assume 30% of 2G sites have 1800MHz equipment deployed

Figure 6: High Level Cost Estimates for Scenario 1

The cost estimate in Figure 6 of around €265,000 is based on a 'typical' Irish network which is assumed to have around 1600 2G sites and 1000 3G sites, with 2G/3G site sharing. It is assume that of the 1600 2G sites in the network, 30% or 480 are equipped with 1800 MHz equipment. The model considers the number of man-hours of project management, engineering and field operations activity required, as well as considering the number of band selective repeaters that might be required to operate in the new band. Labour rates are assumed as shown for each activity.

In the scenario example of Figure 5, Operator A must complete a 'double implementation' activity. The model in Figure 6 predicts that the cost for this operator would be around €285,000, as the costs for the implementation activity are incurred twice.

If, on the other hand, the 1800 MHz relocation project follows closely after an identical project to relocate the operators 900 MHz network, then paragraph 3.3.1 concludes that it should be possible to reduce the time required for the planning activity to around one month. The costs associated with the reduced project (around €156,000) are shown in Figure 7[21].

[21] It is assumed that the 900 MHz relocation has been completed so that there is no opportunity for the verification activities to be merged.

Task	Detail	Who	Man Days (8hr shift)	Ave Cost / md	Total (Euros)	Qty	Unit Cost	Total Cost	Notes
Planning									
Project Team	0.5 FTE 4 month	Project Management	11	950	10450				1
	2 * 0.75 FTE 4 month	Engineering / RF / Network Operations	33	800	26400				2
Equipment	Band Selective Analogue Repeater					5	2500	12500	3, 7
	Band Selective Digital Repeater					5	4900	24500	4, 7
Implementation									
	Datafill - 3man team - weekend	Network Operations	6	700	4200				
	8 2-man Implemenation Teams - 5 day week * 20%	Field Operations	24	600	14400				5, 7
Verification									
Project Team	0.75 FTE 2 month	Project Management	33	950	31350				
	0.5 FTE 2 month	OMC-R / Service Management	31	700	21700				7
	2-man Implementation Team - as required	Field Operations	6.7	600	4000				
	Drive Tests / Optimisation	Field Operations	10	600	6000				6
Sutotals					118500			37000	
Overall Total					**155500**				

1. Project Manager responsible for all activity. 'FTE' = full time equivalent
2. Resource not full time on project
3. e.g. Axell Analogue repeater user selectable and tunable (unmanaged). Assume 1 in 50 2G sites supports a repeater that requires replacing. Assume average 2G site count of 1600.
4. e.g. Axell Digital repeater 12-sub bands (managed). Assume 1 in 50 2G sites supports a repeater that requires replacing and 50% of these are replaced with digital repeaters.
5. Assume 10% of 2G sites need a visit during the implementation period and each team can visit 4 sites per day.
6. Assume 5 days total drive test with 2 man teams.
7. Assume 30% of 2G sites have 1800MHz equipment deployed

Figure 7: High Level Cost Estimates for Scenario 1 with reduced planning resource

The model in Figure 6 and Figure 7 is identical to the model used in Red-M/Vilicom report 10/71c to estimate the costs for a 900 MHz relocation. The predicted cost for 1800 MHz relocation is lower because it is assumed that 480 of the total of 1600 sites in the representative network operate at 1800 MHz. As a result, fewer repeaters need to be replaced, less implementation resource is required to visit troublesome sites and the service management and field operations resource required in the verification phase is also reduced.

For the overall estimate given in Figure 6, roughly 76% of the total cost relates to man-hours and 24% to new equipment. It should be borne in mind that in those cases where band selective repeaters are replaced with multi-technology remotely tuneable repeaters (discussed in section 4.3), part of the investment could be considered to be in preparation for future liberalisation of the 1800 MHz spectrum, and the cost is therefore not solely attributable to the relocation / retuning activity.

4 Equipment in Use in Ireland

4.1 Introduction

The following paragraphs are a reduced version of similar considerations contained in Red-M/Vilicom report 10/71c. Only the information relevant to operation in the 1800 MHz band is included in the following sections.

The degree of difficulty and the associated costs of a network relocation / retune can be greatly impacted by the existing equipment used by network operators. If, for example, a network operator is assigned a block of spectrum that is not compatible with some of their existing equipment, then that equipment would need to be replaced. The replacement activity would increase both the time required and the costs associated with the relocation / retune. Fortunately, with only minor exceptions, the equipment currently used in Ireland is sufficiently modern to operate across the entire 1800 MHz band.

The types of equipment in the network pertinent to a relocation are:

- Base Stations: The base station and coupling options need to support the new 1800 MHz spectrum block allocated to the operator.
- Repeaters: Repeaters come in various types and many of the common lower cost variants will not support relocation / retune and would therefore need to be removed or replaced. The extent of use of repeaters varies across networks, but all operators are likely to be affected by this issue to some extent.
- Mobiles: If mobiles support the 1800 MHz band at all, then they must support the entire 1800 MHz band. Mobile equipment should not therefore prevent an operator from performing a network relocation / retune.

4.2 Base Station Equipment

4.2.1 Introduction

Base station (BTS) equipment supports simultaneous use of a number of GSM channels to increase capacity. Typical carrier counts in a GSM network would vary from around 2 to more than 8, with the upper limit determined by the amount of spectrum available to an operator and the network hardware capabilities.

In a BTS a ‘combining’ function is required to combine the carriers onto a smaller number of antennas. Two types of combining have traditionally been used: wideband *hybrid* combiners and narrowband *cavity* combiners. Cavity combiners offer lower insertion loss. Hybrid combiners are in almost universal use in 1800 MHz networks in Ireland because they have lower complexity, impose fewer restrictions on the network channel plan and support synthesised frequency hopping is used to maximise capacity in a GSM network.

The use of modern base station equipment along with wideband combining in Irish mobile networks allows operators to perform a relocation / retuning exercise with less impact on the mobile network.

As there are relatively large amounts of spectrum available at 1800 MHz, the spectrum can support particularly large base station configurations. In some networks, site configurations with in excess of 40 transceivers supporting over 300 simultaneous calls (Erlangs) are not unknown[22]. Larger configurations might tend to result from migration of capacity from the 900 MHz network following early liberalisation, combined with access to a relatively large amount of available spectrum at 1800 MHz.

Unfortunately, increased hybrid combining losses coupled with relatively poor propagation at 1800 MHz compared to 900 MHz can mean that link budget and range can be further compromised on very high capacity 1800 MHz sites. Traditional approaches to overcoming increased combining losses are to use lower loss forms of combining (such as cavities), to use larger numbers of transmit antennas or to implement some form of ‘cell

[22] The author is not aware of any such configurations in Irish mobile networks.

tiering' architecture to accommodate the higher loss but only on a subset of the transceivers. All of these approaches can have their own significant disadvantages, and as a result, not all operators will have the same policies.

4.2.2 Ericsson

All of the Irish GSM mobile operators use some Ericsson equipment and Ericsson is the largest supplier to the Irish mobile operators. Ericsson currently supplies three series of BTS equipment:

- RBS2000 series. This is a modern GSM base station family, which supports the entire 1800 MHz band and all 'advanced' GSM features such as Slow Frequency Hopping.
- RBS3000 series. This is a modern 3G base station family, which can provide a combined 2G/3G site when deployed alongside an RBS2000.
- RBS6000 series. This is Ericsson's newest modular base station family. Introduced in 2008/09, the RBS6000 series supports both GSM and 3G technologies through a range of modules. According to Ericsson, operators who deploy an RBS6000 are well placed to liberalise the use of their GSM900 spectrum as they can deploy GSM equipment now and upgrade to 3G later through the addition of plug in modules. Ericsson's marketing claim is that the RBS6000 will also support migration to LTE through plug-in modules. It is not known when or if the RBS6000 will support 3G in the 1800 MHz band.

Older versions of Ericsson equipment, such as the RBS200 range, could have presented some restrictions to network relocation / retune. Where operators originally had these types of equipment, they have now been replaced. Ericsson acquired the GSM assets of Nortel, and the same comment applies to older Nortel equipment such as the S4000.

Meteor, O2 and Vodafone are understood to have deployed a mixture of RBS2000, RBS3000 and RBS6000 equipment. RBS2000 and RBS6000 both support network retune / relocation without restrictions.

4.2.3 Nokia Siemens Networks (formerly Nokia)

Nokia Siemens Networks offer a 'Flexi Multiradio BTS', marketed as a module based multi-technology family in a similar manner to the Ericsson RBS6000. None of the existing 2G operators currently deploy this equipment.

Nokia previously had a larger presence in the Irish market, with the Ultrasite and IntraTalk GSM base station families deployed by both O2 and Vodafone. Although these older product families are now in various stages of being replaced and do not support 3G access, they do not pose any significant restrictions to network relocation / retune.

4.2.4 Alcatel Lucent (formerly Lucent)

Alcatel Lucent offers a 9100 Multi-Standard base station, marketed in the same manner as the Ericsson RBS6000 and the NSN Flexi BTS. This equipment is not deployed in the Irish market.

Earlier 2G lucent 'Flexent' equipment has been deployed. Although this older product family is expected to be replaced, it does not pose any significant restrictions to network relocation / retune.

4.3 Repeaters

4.3.1 Introduction

Repeaters offer network operators the ability to increase network coverage without the full cost of adding an additional cell site. Repeaters do not need to be connected to the backhaul transmission network, but do not offer any additional network capacity as a result. A repeater can be a flexible tool to improve coverage in otherwise 'hard to reach' areas such as underground car-parks, where expected capacity demand may be insufficient to justify an additional cell.

Simple repeaters can be relatively low cost but are not remotely tuneable or even, in some circumstances, not remotely managed for faults.

4.3.2 Band Selective Repeaters

Band selective repeaters are generally used in situations where large numbers of frequency carriers are to be repeated. They have the advantage of supporting base station synthesized frequency hopping and are therefore the most common type of repeater deployed in Irish mobile networks.

In order to avoid compromising other mobile networks, band selective repeaters are generally tuned to an operator's individual spectrum assignment. This means that when this spectrum assignment changes, the repeater needs to be retuned (if possible) or replaced. As many of the simpler band selective repeaters cannot be retuned in the field, they need to be replaced.

Repeater manufacturers such as Powerwave (formerly Allgon) and Axell Wireless now provide repeaters with remotely adjustable band filters. This feature allows new frequency plans to be adopted easily and remotely, which eliminates the need to visit any repeater sites. These types of equipment are not universally deployed because they have been introduced more recently and because they are more expensive. They are, however, increasing in relative popularity both because of availability and the because of the fact that some models can support both 2G and 3G.

It is therefore estimated that most, if not all, of the existing band selective repeaters would have to be removed from the network following a relocation / retune. If these repeaters were still required, they would have to be replaced with new equipment either specifically designed for the new spectrum block, or by a repeater of remotely tuneable design.

4.3.3 Channel Selective Repeaters

Channel-selective repeaters are commonly used in off-air applications where high selectivity is important. The high selectivity allows higher output power, and reduces the chance of rebroadcasting noise and interference.

The disadvantage of channel selective repeaters is that they are inflexible in response to evolving capacity demand and they do not support Slow Frequency Hopping. Channel selective repeaters are affected by any changes to the donor cells frequency assignment, not just by a relocation / retuning activity. When a mobile operator has lots of spectrum and can dedicate some channels for special coverage purposes, this is disadvantage can be accommodated. For these reasons channel selective repeaters are much less commonly used in Irish mobile networks than in other applications such as Private Mobile Radio (PMR) where their restrictions are less important.

It is therefore estimated that most, if not all, of the existing channel selective repeaters would have to be removed from the network following a relocation / retune. If these repeaters were still required, they would probably have to be replaced with new band selective equipment either specifically designed for the new spectrum block, or by a band selective repeater of remotely tuneable design.

4.3.4 Other Equipment

Other equipment such as passive diplexers / triplexers have been used as site specific solutions to retrofitting 3G equipment to an existing 2G site. They allow multiple base stations to be connected to a single feeder, and when used along with items such as dual-band cross polar antennas, provide a way of adding 3G equipment to an existing 2G site whilst minimising additional site works and visual impact. The 3G and 2G equipment does not have to be from the same manufacturer.

Increasing use of multi-technology BTS such as Ericsson's RBS6000 means that the prevalence of such site specific solutions is decreasing. Most such site solutions are expected to have been designed to support the entire spectrum band, and so should not pose significant restrictions to a relocation / retune on the network. If some site specific passive elements needed to be replaced, this activity could be done during the early planning phase of the relocate / retune project.

4.4 User Handsets

All mobiles that support the 1800 MHz band at all must support the entire 1800 MHz band, and so do not affect an operator's ability to perform a relocation / retune on the network.

5 Glossary

2G	2nd Generation mobile phone technology, such as GSM
3G	3rd Generation mobile phone technology, such as UMTS
ARFCN	Absolute Radio Frequency Channel Number. A channel numbering scheme which uniquely identifies the frequency channel.
BCCH	Broadcast Common Control Channel. A signal used by mobiles to determine where they are in a GSM network
BSIC	Base Station Identity Code
BTS	Base Transceiver Station. The basic radio building block of a GSM network.
Coordinate	The process by which network exchange mutual information on how their frequency assignments are used in order to help prevent mutual interference.
Downlink	The radio link from BTS to mobile handset.
Dual Band	Using more than one frequency allocation together. (e.g. GSM 900 and GSM 1800)
Erlang (E)	An erlang (E) is a dimensionless unit of traffic on a telephone network equivalent to 1 call in progress.
(Frequency) Allocation:	Entry in the Table of Frequency Allocations of a given frequency band for the purpose of its use by one or more radio communication services. This term is also be applied to the frequency band concerned
(Frequency) Allotment	Details of how a frequency is to be used within an allocation.
(Frequency) Assignment	The part of an allocation or allotment awarded to an individual organisation by the regulator.
GOS	Grade of Service
GSM	Group Special Mobile, the 2G mobile phone standard used in Ireland.
OMC	Operation and Maintenance Centre. A network element used to control the others through human interaction.

Retuning	For the purposes of this document and related document 10/71c, “retuning” means altering the frequencies of operation of the network within an operator’s existing spectrum assignment or where there is some overlap
Relocation	For the purposes of this document and related document 10/71c, “relocation” means moving to a spectrum assignment in a band other than that currently assigned to an operator.
TCH	Traffic Channel
TDMA	Time Division Multiple Access. A GSM system is a TDMA system because the GSM carrier is split into timeslots.
Timeslot	A subdivision of a GSM carrier. Each GSM carrier is subdivided into 8 timeslots.
Transceiver	A transceiver (’‘transmitter – receiver’) is a basic hardware building block of a BTS, supporting simultaneous radio transmission and reception occupying one channel of spectrum
UMTS	Universal Mobile Telecommunications System, the 3G mobile phone standard used in Ireland.
Uncoordinated	See Coordinated.
Uplink	The radio link from mobile handset to BTS.