
Report from the Independent Spectrum Broker: findings and policy proposals

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EXECUTIVE SUMMARY

Background

Under the leadership of Ofcom, the UK has been at the forefront of regulation and public policy in matters relating to spectrum. In Europe, Ofcom has championed the introduction of a more liberal approach to spectrum management, by allowing market forces to be more determinative of market outcomes. Ofcom was one of the first European regulators to identify a Digital Dividend resulting from the transition to digital terrestrial television broadcasting and has successfully advocated this position in Europe. Ofcom has also led in matters relating to innovative licence-exempt uses of spectrum, promoting the acceptance of ultra wideband (UWB) devices and devices using cognitive radio technology to utilise the unused white spaces created by high-power digital terrestrial television broadcasting.

The last year has seen a number of important developments affecting the mobile sector. These include:

- recognition in the interim Digital Britain report that enabling universal access to broadband should be a central aim of public policy¹.
- a continuing rapid take-up of mobile broadband. There are now over two million 3G modem² subscriptions active in the UK, and mobile handsets are increasingly making use of high speed data.
- the emergence of globally harmonised next generation mobile (NGM) standards. The first major commercial mobile WiMAX network is now active in the US. Furthermore, the standards have also been finalised for LTE, the successor to existing 3G.
- the development of a harmonised European band plan for mobile usage of the 800MHz band, this additional low frequency spectrum provides the possibility of truly national NGM networks

In this environment, Ofcom has been working to resolve a number of complex issues in mobile spectrum management, including the 2.6GHz awards, the Digital Dividend awards and the question of liberalising the use of existing mobile spectrum. However, given the entrenched differences of view within the industry on some of these issues and the importance of the recent developments outlined above, the Government in the interim Digital Britain report proposed a Spectrum Modernisation Programme to break the deadlock – in particular over issues associated with the distribution of so-called second-generation (2G) spectrum. Under this proposal I was asked to

¹ The report quotes a recent Ministerial Conference on e-Inclusion which concluded that broadband is now “an indispensable service for the effective participation in the global trade, economy, education, culture, politics and society”

² These modems are also known as ‘dongles’

perform the role of Independent Spectrum Broker (ISB). This report summarises the findings of the ISB, and proposes a way forward.

In the process of discussing the issues with stakeholders, I have come to the conclusion that a comprehensive approach to resolving the future of mobile spectrum may be possible and achieve more rapid progress towards the achievement of Digital Britain objectives. This means viewing collectively the future of all the blocks of spectrum suitable for two-way mobile communications, including:

- the already awarded 'second generation' (2G) mobile spectrum at 900MHz and 1800MHz
- the already awarded 'third generation' (3G) spectrum at 2.1GHz
- the as yet unawarded '3G expansion band' at 2.6GHz and
- the as yet unawarded 'Digital Dividend' at 800MHz

The rationale for an integrated approach derives largely from the fact that NGM technologies require large blocks of spectrum (either operated by a single party or multiple parties working collectively with contiguous spectrum) for their potential to be fully realised – blocks of 2 x 10 or (preferably) 2 x 20MHz – and that truly national high capacity networks require spectrum at both low and high frequencies. Addressing these requirements in an integrated way, if that can be achieved quickly, should give operators greater certainty over their future spectrum holdings whilst continuing to support a competitive market outcome. Consequently UK citizens and consumers could be amongst the first in Europe to benefit from the services offered over nationwide NGM networks.

Policy objectives

The thrust of this document therefore is that the Government may be able to adopt a holistic combination of policies towards mobile suitable spectrum which would achieve the Government's Digital Britain objectives more quickly than the regulatory approach open to Ofcom. These policies can remain true to the market-led and competitive approach that has been a feature of spectrum policy since 2004, but should also take other issues into consideration, in particular the speed with which certainty over future holdings of spectrum can be achieved. The policies should be built around three clear objectives, as follows:

- expediting the transition to next generation mobile to the benefit of consumers
- sustaining competition in the UK market by taking proportionate steps to limit the concentration of mobile suitable spectrum
- creating an environment where the availability of mobile broadband is increased in general and where it can play an important contributory role in achieving near-universal broadband

There are a number of ways the policy objectives can be achieved. At the moment, the package of proposals I favour is as follows:

- liberalising the 2G spectrum in the hands of the existing users to ensure that spectrum bands do not become fragmented and that decisions on which technologies to deploy are not rushed; but revising administrative incentive pricing³ (AIP) to reflect the full economic value of this spectrum
- re-aligning the upcoming mobile suitable spectrum auctions to provide operators greater certainty in building spectrum portfolios necessary to provide NGM services, through:
 - a separate auction of the TDD 2.6GHz spectrum suitable for WiMAX services before the end of 2009
 - co-ordinating the upcoming FDD suitable auctions at 2.6GHz and 800MHz to allow existing and new operators to build spectrum holdings in an integrated, strategic fashion
- extending mobile broadband coverage, and eventually achieving near-universal coverage of mobile broadband, by:
 - delivering near-universal access to NGM services by imposing regional coverage and access obligations on all three 2 x 10MHz blocks of the 800MHz. Each block would carry a basic national coverage obligation at a specified speed (say 2 Mbps) to be achieved by a specific date. Furthermore, each of the licences would carry greater coverage obligations, of perhaps 99% population coverage – as well as access obligations – at a specified speed in a specific geographic area of the UK to achieve near-universal coverage of NGM.
 - in the short-term operators extending 3G coverage in return for making the 3G licence term indefinite and allowing greater infrastructure sharing in rural areas
- encouraging balanced spectrum holdings and a competitive environment, between operators by applying ‘event-specific’ spectrum caps to the combined 2.6GHz and 800MHz auction:
 - by setting a temporary cap on overall mobile suitable FDD spectrum holdings per operator at 2 x 60MHz
 - by setting an additional temporary restriction on the current holders of sub-1GHz spectrum, so to obtain access to 800MHz spectrum they must give up an equivalent quantity of 900MHz spectrum

These restrictions should expire perhaps one year after the date of the combined auction

- action to increase the certainty to operators of the availability of sub-1GHz spectrum, including:
 - Government supporting Ofcom in taking all practical measures to expedite the clearance of 800MHz; the extra costs incurred in accelerating the clearance of channels 61 and 62 of television usage and channel 69 of PMSE usage would also serve to increase the value of the spectrum at auction

³ This is the charge applied to spectrum users who have not obtained spectrum at an auction, in order to incentivise efficient usage of spectrum

- achieving consensus on both the earliest date at which 800MHz will become available for NGM usage and the earliest date at which Vodafone and O2 will be able to deploy refarmed 900MHz; and adapting my proposals as appropriate:
 - if 900MHz spectrum is easily refarmed this might create a significant first mover advantage for the 900MHz operators. In this case some form of remedying measure might be necessary. Suggested variations on my proposals which might achieve a remedy are discussed below in Section 4.
 - If 900MHz is comparatively difficult to refarm this might increase the necessity for the 900MHz operators to be able to gain easier access to 800MHz than I have proposed with the sub-1GHz cap. Again, suggested variations on the sub-1GHz spectrum cap are discussed in Section 4.

The effect of these proposals should be to allow operators to either build LTE-suitable spectrum holdings (or if they prefer, to focus on developing existing 3G HSPA services) and to take on coverage obligations; and to do both of these in a way that encourages competition. The effects on existing operators would be as follows:

- Vodafone and O2 each already have access to 2 x 17.2MHz of sub-1GHz spectrum at 900MHz. They would be able to obtain 800MHz only if they were to give up an equal amount of 900MHz within a specified period. However, they would face few restrictions on bidding for 2.6GHz.
- Orange and T-Mobile each already have access to 2 x 30MHz of contiguous high-frequency spectrum at 1800MHz. They would be able to bid freely for 800MHz (or any 900MHz that Vodafone or O2 choose to give up). However, if they were successful in gaining 2 x 10MHz of low frequency spectrum, they would only be able to bid for an additional 2 x 10MHz of 2.6GHz, so as to remain within the spectrum cap. If they wanted access to a greater amount of 2.6GHz, they would have to relinquish 1800MHz or 2.1GHz.
- Three and any potential new entrants would be able to bid freely for 800MHz (or any 900MHz that Vodafone or O2 choose to give up) and 2.6GHz (or any 1800MHz that the 2G operators choose to give up) up to the maximum allowable per operator determined in the auction.

As mentioned above, the exact form of the spectrum caps applied to the combined 2.6GHz and 800MHz auctions may merit additional consideration. Variations on the proposals outlined above have been suggested by the existing operators, and these measures are discussed in Section 4.

In addition, my proposals are predicated on the continued presence of five independent MNOs operating in the UK market. However, it is important to acknowledge that, if consolidation were to take place before the combined award, then some elements of the proposals I make may be subject to change⁴.

⁴ The two most significant areas to be revisited would be the total spectrum cap, which may need to be increased, as well as the packaging arrangements for 800MHz, as two blocks of 2 x 15MHz may be better suited to a world of fewer MNOs. Other aspects of the proposals, such as the sub-1GHz restrictions are likely

Proposals of this type could be developed and finalised by BERR, leading to a Government direction to Ofcom. Although the mobile industry has had to cope with considerable uncertainty over issues associated with spectrum allocation over the past four years, this further effort to finalise proposals is worthwhile, as the prize is substantial. What is the prize? By expediting the introduction of and investment in nationwide NGM services, it is within the UK's grasp to achieve within five years mobile broadband at around 4 megabits per second across the UK as a whole and more than 50 megabits per second in many urban areas. This would bring the innovation and new services associated with mobile broadband to the whole of the UK and neatly complement fibre-delivered superfast broadband. This would in turn mean the transition to next generation broadband services would be both smoother and faster than seemed possible, even a year ago. This would put the UK at the forefront of commercially-deployed mobile technology around the world, delivering economic and social benefits that far outweigh the costs.

to remain relevant in their current form, as 900MHz holdings are concentrated in the hands of only two entities.

1. INTRODUCTION

In January 2009, a Wireless Radio Spectrum Modernisation Programme was proposed by the interim Digital Britain report. It was hoped that the programme would facilitate a so-called 'negotiated trading solution' to an apparently inequitable distribution of 2G (second generation) spectrum between the five mobile operators in the UK.

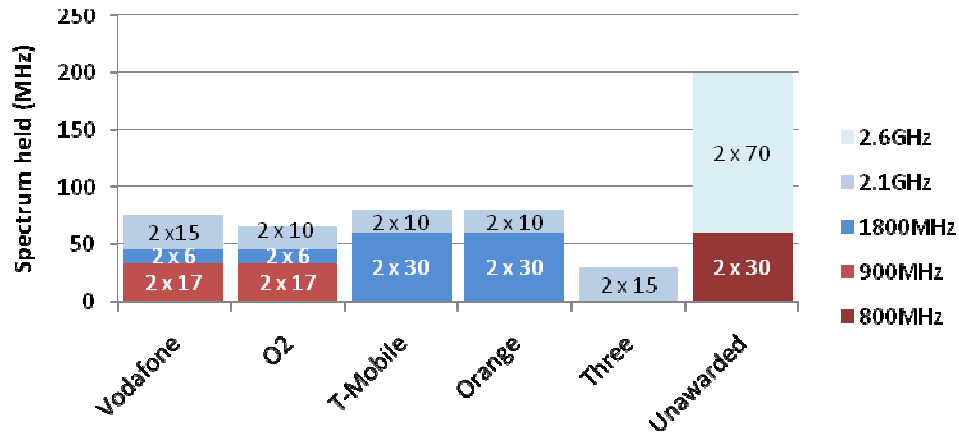
2G spectrum is the spectrum allocated to the first four mobile operators in the UK - O2 (then Cellnet) and Vodafone were granted 2 x 17.2MHz of paired 900MHz spectrum in 1983 and a further 2 x 5.8MHz of paired 1800MHz in 1991. T-Mobile (then One-2-One) and Orange started operations in 1993 and 1994 respectively with 2 x 30MHz of paired 1800MHz spectrum each. The licence conditions of this spectrum specify that only 2G GSM technologies can be deployed by the operators.

Three, the last mobile operator to enter the market in 2003, has no 2G spectrum at all.

Ofcom has a long standing policy of liberalising spectrum use - allowing both trading of spectrum and change of use, at the discretion of the users of the spectrum. This UK policy is mirrored by European policy. As a result of these policies and of developments in mobile technology, it has been apparent for some time that 2G spectrum could provide significant benefits by being re-deployed (or 'refarmed' - the term used by the industry and generally adopted in this report) using more advanced standards - either third generation (3G HSPA) or next generation mobile (NGM) standards, such as WiMAX, which has seen commercial deployments in higher frequency spectrum, and Long Term Evolution (LTE), the successor to 3G HSPA now close to commercial deployment.

Should the 2G spectrum be refarmed in the hands of the current users? Or should there be redistribution? (Both the current distribution of spectrum and aggregate amount held is uneven between the five existing operators, as shown in Figure 1 below). Existing users of the 2G spectrum wish to retain it and can deploy a variety of arguments as to why they should. Those without 2G spectrum can deploy arguments tending towards the opposite conclusion.

Figure 1 – Distribution of paired spectrum



The situation is further complicated by the fact that spectrum at different frequencies has different characteristics - the 2G spectrum at 900MHz is particularly valuable, because lower frequencies permit signals to cover longer distances and penetrate buildings more effectively than higher frequencies.

The questions associated with a possible re-distribution of 2G spectrum cannot be resolved simply on the basis of what Government or Ofcom thinks might be a good solution. Ofcom policies, which envisage the gradual establishment of clear property right for spectrum users, are coming into force over time and do not yet apply to 2G spectrum. Without attempting here to unpick in detail a complex legal picture, the current users of 2G spectrum cannot be denied the continued use of that spectrum arbitrarily and the prospect of legal challenge to any attempt to impose a redistribution is significant.

My terms of reference stated that the Government is "looking for the blocks to future auctions and liberalisation to be removed, historic spectrum allocations placed on a more even footing, better incentives for investment and development of services and a fair return for the tax payer from the new arrangements".

An alternative was the solution that Ofcom consulted on within the specific boundaries of the 2G reforming issue – namely, that O2 and Vodafone be required to relinquish a contiguous 2 x 5MHz block of 900MHz (between them) and that this is auctioned. At least one operator believed this may be difficult to impose in practice.

However, the more important point is that many operators argued forcefully that both an imposed solution of the type suggested and any negotiated solution that used the imposed solution as a starting point would be a missed opportunity, in light of the recent developments outlined above. At present, the plans within Ofcom to deal with the 2.6GHz award, the 800MHz award and 2G liberalisation are separate. Many informed commentators support this approach but the recent emergence of LTE as a near-to-deployment standard and the harmonised 800MHz band has changed the appropriate way forward in the minds of others – towards one that requires thinking about the entire relevant spectrum – not just 900MHz and 1800MHz, but also 2.1GHz, 2.6GHz and 800MHz (see Figure 2 for details).

Figure 2 – Spectrum description

Frequency Band (MHz)	Current use	Features
800	Analogue and digital terrestrial television (hence 'Digital Dividend')	Good for wide coverage with small number of base stations and in-building penetration
900	2G (Vodafone, O2)	
1800	2G (Vodafone, O2, T-Mobile, Orange)	Good for providing capacity for large numbers of end-users in dense (urban) environments.
2100	3G (Vodafone, O2, T-Mobile, Orange, 3)	
2600	Unused	

The 2.6GHz spectrum is internationally harmonised spectrum that has already been awarded in some European countries. It is high-frequency spectrum and as such will be used by operators to provide high-speed NGM services. Under the harmonised CEPT band plan it is divided into a paired component (2 x 70MHz) suitable for LTE and an unpaired component (50MHz) suitable for WiMAX. Ofcom was hoping to auction the 2.6GHz spectrum in summer 2008, but this has been delayed because of legal challenges by operators.

The 800MHz band has only recently emerged as a viable resource for mobile communications across large parts of Europe. It is low frequency spectrum and will largely share the propagation characteristics of 900MHz spectrum. The common European band plan envisages paired spectrum (2 x 30MHz) which is being standardised for use with LTE. Ofcom is currently consulting on the clearance of 800MHz.

Ofcom has taken a band-by-band approach to these areas, and, if the long-running disputes and current litigation can be resolved, this is likely to deliver a good outcome for UK citizens and consumers. However, taking a more integrated approach to these issues may bring some additional benefits, including:

- allowing the UK to take advantage more quickly of the economic and social opportunities offered by NGM services
- removing incentives that particular operators may have to hold up some elements of the process in order to delay progress on other issues
- addressing the important goals articulated in the interim Digital Britain report – of achieving universal broadband and near-universal mobile broadband coverage – which the current imposed liberalisation solution, and proposals for 2.6GHz and 800MHz, do not explicitly address

What became clear in my work is that the real issue is whether there is a comprehensive solution that will allow the UK to move ahead quickly, irrespective of whether such a solution is negotiated or imposed; and, if so, how might it be implemented? This report suggests there is such a solution and that there are practical steps to achieving it.

The rest of the report is structured in the following way:

- 2. Policy issues** A discussion of the broad policy issues affecting spectrum management and how these might be expressed in the context of formulating an alternative imposed solution
- 3. Policy objectives** Given the discussion of the issues, what are the legitimate and achievable objectives of public policy?
- 4. Mechanisms to achieve public policy objectives** The most promising mechanisms to achieve public policy objectives
- 5. Costs and benefits** A preliminary discussion of the cost and benefits of an alternative imposed solution.
- 6. Process questions** How a new imposed solution might be implemented
- 7. Conclusion** A summary of conclusions

2. POLICY ISSUES

This section is designed to give an overview of the issues that govern the formulation of policy towards spectrum management in general and 2G refarming in particular. In a short report, inevitably, it will gloss over some of the subtleties.

The following questions are covered:

- the tension between liberalisation and intervention and its relationship to refarming issues; (this is important background to the two subsequent issues covered)
- the timing issues associated with new uses for spectrum and the operational uncertainties created
- how to deal with competition issues
- increasing the coverage of mobile broadband

Liberalisation versus intervention

National governments largely make their own arrangements for spectrum management within their own borders - although, in Europe, both CEPT and (particularly) the European Commission also play significant roles. Internationally, some spectrum use is harmonised by the International Telecommunications Union (ITU), an agency of the United Nations, through a series of multilateral procedures.

Historically, national administrations have been in many instances slow, cautious and bureaucratic in their management of spectrum and, for the last twenty years, many economists and believers in a more market driven approach have suggested that spectrum, instead of being considered an inalienable public resource, should have property rights assigned to it. Such an approach would mean that spectrum users can buy and sell spectrum and change of use can be permitted (so long as such change of use creates no problems for other users).

This liberal approach was adopted by Ofcom in 2004. The intention was that different parts of the spectrum would become progressively tradable (i.e. can be bought and sold) and liberalised (i.e. change of use is permitted) and this would facilitate investment and, combined with the progressive release of cleared spectrum (e.g. 2.6GHz, the so-called 3G expansion band), usher in a period of experimentation and innovation with consequent economic benefits.

In reality, progress with trading and liberalisation has been limited so far. This is for various reasons. Very little spectrum has been traded in practice and, partly as a consequence, the freedom to change use has not been exercised. Also, not least due to litigation, new spectrum has been brought to market more slowly than anticipated. Probably the most important reason why trading for mobile spectrum has been slow to materialise is that liberalisation and trading cannot be implemented in the particularly valuable 2G spectrum until a new European GSM directive is agreed (this was expected to be in force by the end of 2009 but now may be further delayed).

Despite this, the direction of travel towards a more liberal approach to spectrum management has been endorsed by many policy-makers across Europe, notably in the European Commission. What is questioned however is how exactly the approach should be applied. Some uses of spectrum, if they are to develop at all, need internationally harmonised and available spectrum, running counter to the notion of change of use being determined at a national level – the example frequently quoted is mobile satellite which is by its nature cross-border. In other instances, international co-ordination is important in achieving prospective economies of scale to incentivise the development of standards and investment in equipment. Consequently, there is within the mobile industry a frequent debate between those who suggest that attempts at co-ordination, although well-intentioned, actually stifle innovation and those who argue that co-ordination and management, even by a Government or regulator, sometimes makes economic sense.

Two specific examples of this generic issue are described in the next two sub-sections.

Timing of new uses for spectrum

A number of technology options for delivering mobile broadband now exist and the position with each is as follows:

- | | |
|-----------|---|
| 3G (HSPA) | When 3G services were first launched, they did not live up to initial expectations due to a combination of low download speeds (maximum of 384kbps) and high latency (a measure of the time taken for requests for data to be acknowledged). However, the technology has since matured. The launch of 3G HSPA services, which currently offer headline speeds in the UK of up to 7.2Mbps, has led to an explosion in demand for mobile broadband since 2007 and over two million mobile broadband subscriptions are active. However, 3G HSPA technology suffers from a number of limitations: <ul style="list-style-type: none">• Cells ‘breathe’, that is, contract in size as more intensive use is made of the service, and so user experience at the edge of cells is highly variable• It is not based on IP, the standard internet protocol, and so latency is still high• It is reaching the end of its life-cycle and as such can expect to see few further improvements |
| WiMAX | WiMAX is a new mobile broadband standard which overcomes many of the limitations faced by 3G outlined above. WiMAX has currently been standardised for the 2.6GHz spectrum due for release across Europe. Although some substantial WiMAX deployments are taking place globally, most existing operators are awaiting the LTE standard. |
| LTE | LTE is a standard for mobile broadband developed as an evolution to 3G HSPA. Its development has been brought forward largely as a response |

to the competitive threat that 3G operators felt posed by WiMAX. LTE overcomes the limitations of 3G outlined above; it is far more robust, internet-centric and will be able to deliver peak data rates of over 300Mbps for some types of equipment. However for high speeds to be achieved, it will need to be deployed using large spectrum blocks. It will initially be deployed in the paired section of the 2.6GHz block but will eventually be usable in all currently used mobile bands.

It is largely the explosive growth of mobile broadband services that has led to increased attention on the question of 2G refarming. In this environment, the Ofcom view has been that the 2.6GHz auction is important to expedite, as it offers the chance to deploy additional 3G capacity, WiMAX and LTE. However, as the auction has been delayed (it was originally scheduled for the summer of 2008), two developments have made other commentators suggest that the original way of looking at the 2.6GHz auction should be revised - firstly, there is now a greater understanding of the limitations of 2.6GHz spectrum (which has great capacity but poor coverage properties) and secondly, there is a now widely-held view that multi-frequency LTE networks will be the norm, earlier rather than later, and that operators will use lower frequencies (such as 800MHz or 900MHz) to provide blanket coverage in rural areas and deep within buildings, and higher frequencies for extra capacity in hot spots.

This has meant that there is an argument that the 2.6GHz auction should be viewed differently – the 2.6GHz spectrum should be seen as part of the LTE story, alongside the spectrum that will become available at 800MHz, as well as potentially the refarmed 2G spectrum. In its most extreme form, all the key blocks of spectrum (800MHz, 900MHz, 1800MHz, 2.1GHz and 2.6GHz) should be viewed as having a role in LTE earlier than expected and, as a result, should be managed as a package.

One strong counter-argument has been that the merits of looking across all the spectrum bands in this way ignores the practical problems of deploying LTE at 800MHz in the near future - the spectrum's availability is very difficult to achieve rapidly and equipment will likewise take time to come to market. The detail associated with this debate is described in Annex 3, but some stakeholders are beginning to argue that in reality at least partial deployment of LTE at 800MHz is feasible in the 2011 to 2013 timeframe. This makes the argument for a more interventionist approach to all the spectrum bands stronger.

How to deal with competition issues?

Originally, there were two mobile competitors, Cellnet (now O2) and Vodafone. These companies were granted licences at 900MHz in 1983. Three other competitors were licensed at 1800MHz in 1991, although two of these subsequently merged, leaving Orange and One 2 One (now T-Mobile). These four and Hutchison 3G successfully bid for 2.1GHz in 2000.

A mobile marketplace with five network-owning mobile competitors is unusual, even in large, developed economies. Some operators suggest it is too many – returns are low in the UK, relative to

the rest of Europe, and (it is argued) this has inhibited investment: coverage and service levels are higher in some European countries, such as Sweden and Austria.

Other operators suggest that competition has been good for consumers – delivering low prices, subsidised handsets and (recently) innovation in the form of mobile broadband.

What is beyond doubt is that the economics of some of the five operators are challenging. As one would expect, different prescriptions are proposed to solve this: by the weaker players, a more equal distribution of spectrum, plus a regulatory level playing field; by the stronger players, consolidation.

Most policy-makers and regulators, even in an environment where intervention in markets has become more acceptable, seek to avoid over-engineering competitive outcomes. Nevertheless, within this mindset, there are a number of possible approaches, all with different degrees of intervention but none being, from a common sense perspective, overly interventionist. Two of these are articulated below:

The less interventionist approach. It is not the job of regulators to adjust constantly for the uneven distribution of resources between competitors. Although in the case of spectrum allocation, the distribution of spectrum was determined artificially (largely by licence awards), the unequal share of core resources is duplicated in many markets which function effectively and without any history of intervention. Consequently, balancing spectrum between existing players should not be a policy objective.

The more interventionist approach. Current spectrum allocations are heavily slanted in favour of the two longest-established players. They have benefitted in numerous ways - by having exclusive access to the most valuable spectrum, having held it cheaply for a longer time, and by being uncontested, relative (of course) to later entrants. While they have also risked a lot - by investing in and developing an untried technology - a modest attempt to level the playing field makes sense.

It is clear that competition can only be successful in delivering desirable outcomes for citizens and consumers when market operators have both the correct incentives and necessary resources to compete in the provision of a particular service. Mobile broadband in the UK is an instructive example. Regulatory intervention in the 3G auctions in 2000 created the opportunity for a new entrant, Three, to enter the market with broadly equivalent holdings of mobile broadband suitable spectrum, relative to the incumbents. This new entrant, with lower voice revenues to protect, has been instrumental in driving the consumer mobile broadband proposition. Indeed, this pattern of new entry driving the uptake of mobile broadband is replicated across Europe⁵.

In due course, imbalances in spectrum allocation will become a natural feature of the market – a trading environment typically creates this outcome, allowing different market shares and different

⁵ A Strategy Analytics report published in October 2008 showed that Austria, Sweden, Ireland, the UK, Spain and Italy, all countries where there has been new entry by a 3G operator, have higher mobile broadband penetration rates than in France and Germany, where new entry did not occur.

access to fundamental resources in the normal way. But, as discussed earlier, the trading environment is being introduced progressively and does not yet apply to 2G and 3G spectrum. So the question is not whether a rebalancing of spectrum is a good long term outcome but whether such a rebalancing will create a better starting point - from a consumer perspective – for whatever reallocation occurs thereafter.

The reasons for thinking a limited rebalancing makes sense are as follows:

- it is uncertain whether the holders of 900MHz spectrum have higher market shares because they are better, more innovative operators or because they entered the market early or because they hold cost efficient 900MHz spectrum.
 - if the first reason applies, in due course, the holders of 900MHz will, through superior performance, be in a position to acquire either additional spectrum or their competitors, delivering value to consumers through additional scale.
 - if either of the latter reasons apply, then a partial rebalancing of spectrum towards new or newer operators will give these operators a better chance to compete, again benefitting consumers. If a rebalancing of spectrum is identified as the way forward, then it should be time limited.
- once a more competitive environment has been created, the market can determine outcomes, subject to competition law.

Increasing the coverage of mobile broadband

Universal access to broadband has, until recently, not featured as a policy objective for Government. However, the Digital Britain process has put universal broadband as a central objective. However, universal broadband as a target is not yet fully defined - what is universality? It is unlikely to be 100%, but how far short of 100% is acceptable? And what is the target speed? 2Mbps was quoted in the interim Digital Britain report, but this is, at the time of writing, still a matter for discussion.

Parallel to the policy objective of achieving universal broadband is a policy desire to extend specifically the coverage of mobile broadband. As outlined above in the discussion of 3G technology, the advent of 3G HSPA has generated accelerating levels of demand in a short timeframe. Mobile broadband provides a number of benefits over and above fixed connections, including the ability to connect from anywhere and the emergence of new mobile, location based services. Extending mobile broadband nationwide would enable these services for citizens in areas which do not currently have access. Furthermore it would also bring wider economic benefits to these areas by enabling internet connectivity through their personal devices for visitors and businesspeople.

In addition, mobile broadband could also play a role in achieving the headline universality target, alongside fixed line, fixed wireless and satellite services. For example, rural and remote areas can be expensive for fixed broadband to serve. Furthermore, 'not-spots' are not always in rural and remote locations, particularly when it comes to higher speed not-spots - new, suburban estates are frequently some distance from a local exchange and are capable of receiving broadband but not a

2Mbps service. It may be that mobile has a role to play in providing coverage in both these situations. However, mobile also has limitations: the availability of backhaul and contention between users can limit the quality of service available to users.

There is also the question of the form of coverage obligations. Perhaps they should be attached to particular frequencies capable of broad coverage – 800MHz, for example. But need they be exclusively delivered at that frequency? Would it not be more efficient to let the user of the 800MHz frequency decide how to deliver the coverage obligation?

This section has discussed the issues - the next formulates the public policy objectives.

3. POLICY OBJECTIVES

A new imposed policy should meet the following policy objectives:

- expediting the transition to next generation mobile to the benefit of consumers
- sustaining competition in the UK market by taking proportionate steps to limit the concentration of mobile suitable spectrum
- creating an environment where the availability of mobile broadband is increased in general and where it can play an important contributory role in achieving near-universal broadband

Expediting the transition to next generation mobile to the benefit of consumers

This involves:

- signalling support for the deployment of next generation mobile
- giving operators the maximum flexibility on whether to deploy 3G HSPA or LTE
- expediting the release of the WiMAX suitable portion of 2.6GHz for auction
- viewing the 2.6GHz LTE suitable portion and 800MHz auctions as linked and as being part of an integrated process of achieving nationwide LTE
- accelerating actions which can speed up deployment of LTE at 800MHz

Sustaining competition in the UK market by taking proportionate steps to limit the concentration of mobile suitable spectrum

This involves finding mechanisms to allow new and spectrum-disadvantaged competitors to secure additional spectrum:

- more easily than others
- probably at both low and high frequencies

This should be done:

- (if possible) without excluding others from participating in auctions
- on commercial terms - in other words, there should be no implicit subsidy
- while recognising that this type of intervention should ideally not be repeated

Creating an environment where the availability of mobile broadband is increased in general and where it can play an important contributory role in achieving near-universal broadband

This involves:

- extending the coverage of mobile broadband in the UK:
 - through variations to existing 3G licences
 - through conditions attached to newly issued licences
- allowing mobile to play a potential role in the delivery of universal broadband access

4. MECHANISMS TO ACHIEVE PUBLIC POLICY OBJECTIVES

A large and diverse range of mechanisms have been suggested by stakeholders during discussions since the publication of the interim Digital Britain report, most of them designed to meet some or all of the objectives identified in the previous section. This section lays out the set of mechanisms I prefer for achieving the three objectives and a brief justification for choosing each. It also discusses some variants of my proposals suggested by the operators in my discussions with them. The more complete set of proposed mechanisms and a more detailed justification for the preferred set is contained in Annex 2.

Preferred mechanisms

Given the complexity of the issues, the different ways of trading off objectives and the conflicting commercial interests, it is inevitable that the set of mechanisms suggested here both will not please all operators and will be amenable to improvement. However, it is useful to identify a preferred set of mechanisms, as it will give operators and other interested parties something definite to react to. As explained later, if an alternative imposed solution is adopted as the preferred way forward, there will be a prior requirement to resolve some important outstanding issues (in particular, the timing issues associated with using sub-1GHz spectrum for mobile broadband). The chance to refine (or dramatically improve) these proposals should therefore arise in due course.

The preferred mechanisms are as follows:

- liberalising the 2G spectrum in the hands of the existing users to ensure that spectrum bands do not become fragmented and that decisions on which technologies to deploy are not rushed; but revising administrative incentive pricing⁶ (AIP) to reflect the full economic value of this spectrum

There is a danger that by clearing and disposing of 2 x 5MHz of 900MHz spectrum, both the operators acquiring and the operators clearing will make short-term decisions about the technologies to deploy in this band, as NGM technologies have fewer advantages over existing 3G technologies in narrower bands of spectrum. If operators were to launch rival 3G HSPA networks in the 900MHz band, this band may be rendered unavailable for NGM services for a significant period of time.

By not demanding clearance in an imposed timeframe, this measure will allow the existing 2G operators to refarm their 2G spectrum as they see fit, and not rush them into technology decisions that may be detrimental in the long-run to the UK's mobile broadband infrastructure.

⁶ This is the charge applied to spectrum users who have not obtained spectrum at an auction, in order to incentivise efficient usage of spectrum

Furthermore, as proposed by Ofcom in its most recent consultation document, 2G spectrum liberalised in the hands of existing users should be subject to revised administrative incentive pricing (AIP) to reflect the full economic value of the spectrum

- re-aligning the upcoming mobile suitable spectrum auctions to provide operators greater certainty in building spectrum portfolios necessary to provide NGM services, through:
 - a separate auction of the TDD 2.6GHz spectrum suitable for WiMAX services before the end of 2009
 - co-ordinating the upcoming FDD suitable auctions at 2.6GHz and 800MHz to allow existing and new operators to build spectrum holdings in an integrated, strategic fashion

The auction of 2.6GHz unpaired spectrum this year will allow WiMAX entrants quickly to deploy networks and to compete with existing data operators.

The co-ordinated auction of paired 800MHz and 2.6GHz will allow operators, especially those existing spectrum users without 2G spectrum (such as Three, PCCW and Qualcomm) and new entrants, to make coherent bids for the 800MHz and 2.6GHz spectrum necessary to roll out a viable NGM network. It will also signal the UK's commitment to NGM usage of the 800MHz band, providing an impetus to manufacturers of equipment to develop suitable equipment and to other administrations to speed up their own Digital Dividend processes.

- extending mobile broadband coverage, and eventually achieving near-universal coverage of mobile broadband, by:
 - delivering near-universal access to NGM services by imposing regional coverage and access obligations on all three 2 x 10MHz blocks of the 800MHz. Each block would carry a basic national coverage obligation at a specified speed (say 2 Mbps) to be achieved by a specific date. Furthermore, each of the licences would carry greater coverage obligations, of perhaps 99% population coverage – as well as access obligations – at a specified speed in a specific geographic area of the UK to achieve near-universal coverage of NGM.
 - in the short-term operators extending 3G coverage in return for making the 3G licence term indefinite and allowing greater infrastructure sharing in rural areas

These measures will ensure nationwide provision of next generation mobile broadband services. Advice from Arqiva and others suggests that because of the region-by-region process associated with digital switchover, it might be possible to launch mobile broadband services at 800MHz in a similarly phased fashion. As many of the regions switched over to digital TV early in the process are remote and rural, this may have particularly beneficial effects for the delivery of early universal broadband (although further technical evaluation of this is needed).

An alternative proposal, not emanating from an existing operator, is to award the 800MHz spectrum as two national blocks. One would be 2 x 20MHz, possessing universal coverage and access obligations, and the other would be 2 x 10MHz nationwide which would be only available to an operator which did not have any sub-1GHz spectrum. This proposal is given further consideration in Annex 2 along with all the other proposed mechanisms.

2.1GHz is not a practical frequency with which universal coverage can be achieved.

However, in the short-term, it may be possible to increase coverage beyond existing levels to bring the benefits of mobile broadband to more of the UK, with the extra investment financed by allowing greater network sharing and potentially making the existing time-limited 3G licences indefinite. This process should be undertaken as an integral part of any overall policy outcome of the Spectrum Modernisation Programme.

- encouraging balanced spectrum holdings and a competitive environment, between operators by applying 'event-specific' spectrum caps to the combined 2.6GHz and 800MHz auction:
 - by setting a temporary cap on overall mobile suitable FDD spectrum holdings per operator at 2 x 60MHz
 - by setting an additional temporary restriction on the current holders of sub-1GHz spectrum, so to obtain access to 800MHz spectrum they must give up an equivalent quantity of 900MHz spectrum

These restrictions should expire perhaps one year after the date of the combined auction

These event-specific measures will ensure that total spectrum capacity will not become too highly concentrated in the hands of any subset of operators at the outset of a liberalised environment. They will also ensure that holdings of sub-1GHz spectrum, which are crucial for delivering ubiquitous wide-area coverage, do not become overly concentrated in this transition phase.

- action to increase the certainty to operators of the availability of sub-1GHz spectrum, including:
 - Government supporting Ofcom in taking all practical measures to expedite the clearance of 800MHz; the extra costs incurred in accelerating the clearance of channels 61 and 62 of television usage and channel 69 of PMSE usage would also serve to increase the value of the spectrum at auction
 - achieving consensus on both the earliest date at which 800MHz will become available for NGM usage and the earliest date at which Vodafone and O2 will be able to deploy refarmed 900MHz; and adapting my proposals as appropriate:
 - if 900MHz spectrum is easily refarmed this might create a significant first mover advantage for the 900MHz operators. In this case some form of remedying measure might be necessary.

- If 900MHz is comparatively difficult to reform this might increase the necessity for the 900MHz operators to be able to gain easier access to 800MHz than I have proposed with the sub-1GHz cap.

Proposals which might achieve both these aims are discussed in the following subsection.

Government support for clearing channels 61 and 62 as quickly as possible is likely to involve expense, but will also increase the value of the spectrum being awarded.

Clearing the 800MHz band as quickly as possible will enable these services to be launched nationwide as quickly as possible, and will also reduce the competition concerns that might otherwise arise from the opportunity to provide either 3G HSPA or LTE at 900MHz earlier than at 800MHz

The preceding paragraphs have made clear how this particular set of mechanisms meets the public policy objectives set out in the previous section. But how would the operators be placed if these proposals were implemented?

The 900MHz operators would end up with substantially more frequency below 1GHz, in urban areas, than any others and they would have a more or less unrestricted opportunity to bid for 2.6GHz frequencies. However, they would have to grapple with the refarming challenge at 900MHz. After (say) a year, they could then buy additional spectrum or consolidate – subject only to competition law.

The 1800MHz-rich operators would be able to acquire spectrum at 800MHz but this would then constrain their ability to bid at 2.6GHz – if they are successful at the 800MHz auction, they will only be able to acquire 2 x 10MHz at 2.6GHz⁷. Again, constraints on spectrum acquisition or consolidation would cease after (say) a year.

Three and other non 2G users of spectrum (PCCW, Qualcomm, potentially buyers of the TDD spectrum at 2.6GHz) will be relatively unconstrained.

In addition, it is possible for Government or Ofcom to make this package more attractive by fine-tuning some of the mechanisms mentioned above. The coverage obligations associated with making the 2.1GHz licences indefinite could be either onerous or light. Equally, the revision of AIP could be managed in different ways.

⁷ The 1800MHz spectrum possessed by Orange and T-Mobile is increasingly being recognised as an important resource for the delivery of high speed LTE in the longer-term. Each has a relatively lightly used contiguous 2 x 30MHz block of spectrum and the propagation characteristics of 1800MHz are superior to those of 2.6GHz. In Hong Kong, SmarTone Vodafone is looking to deploy LTE using 1800MHz spectrum, http://www.unstrung.com/document.asp?doc_id=172748. Finland announced in April 2009 that it would be awarding further 1800MHz spectrum for use with LTE, <http://www.cellular-news.com/story/37171.php>.

As stated above, all the operators and some interested parties (for example, Arqiva) have contributed either their own versions of the set of mechanisms mentioned above or individual ideas. These are discussed and evaluated in Annex 2 along with further evaluation of the set of mechanisms described above. Below I run through ideas that were put forward as specific variations to the mechanisms described above.

Variations to the proposed mechanisms

The first two variations address concerns operating in different directions – first that the possible delay in the availability of 800MHz spectrum may disadvantage the successful bidders for 800MHz, and second that the challenges of refarming at 900MHz will disadvantage the holders of 900MHz. The third variation regards the level of the overall spectrum cap.

Competition concerns regarding the timing of 800MHz availability

Some of the non-900MHz operators suggested that competition concerns might arise from the eventual allocation of frequencies in sub-1GHz spectrum, due to the differences in timing of the availability of 800MHz and refarmed 900MHz. They argued that 900MHz spectrum can be brought into mobile broadband usage earlier than 800MHz will become available, and therefore the 900MHz operators would possess a crucial first-mover advantage. There is still some uncertainty as to when 800MHz will become available, and work is being done to assess this. More details are provided in Annex 3.

One method of addressing this advantage would be to link the date at which 900MHz could begin to be refarmed to the availability of 800MHz spectrum. Such a moratorium on refarming at 900MHz should not attempt to eliminate all differences in timing, as consumers will benefit from the launch of data services using refarmed 900MHz, but should seek to provide greater certainty to operators. For example, it could be set so that 900MHz spectrum can be refarmed only two years before 800MHz becomes available. It may be necessary, in the interests of non-discrimination, to extend a similar restriction to the holders of 1800MHz. However, due to the earlier availability of 2.6GHz there may be fewer competition concerns with higher frequency spectrum, and therefore such a restriction on 1800MHz may not be necessary⁸.

Another suggestion was that this potential issue could be remedied by the 900MHz operators providing wholesale access to non-900MHz operators for a limited time period. This wholesale access would have to continue for a period after 800MHz becomes available to allow the non-900MHz operators to transition users off the 900MHz network.

However, a moratorium on the refarming of 900MHz spectrum may be problematic to implement. In this case, the wholesale access measures might be used to allay competition concerns, especially

⁸ The precise duration of the moratorium on refarming 900MHz could be set at the time of the combined FDD 800MHz and 2.6GHz auction.

as the conditions and pricing for wholesale access can be made more or less favourable to the non-900MHz operators.

Competition concerns regarding the challenges of refarming of 900MHz

Both of the 900MHz operators believe that the sub-1GHz spectrum cap is too restrictive and they would therefore prefer a looser cap. A looser cap could take the form of each of the 900MHz operators agreeing to give up half the amount of 900MHz of any 800MHz they gain. So to bid for 2 x 10MHz of 800MHz they would have to be prepared to dispose of 2 x 5MHz of 900MHz. However, the overall spectrum cap would still apply. Other intermediate caps are also possible. For example, it might be decided that Vodafone and O2 would have to give up three-quarters the amount of 900MHz spectrum of any 800MHz gained. So to obtain 2 x 10MHz of 800MHz they would have to give up 2 x 7.5MHz of 900MHz.

The overall spectrum cap

One operator has suggested that the overall spectrum cap could be loosened to 2 x 65MHz of paired spectrum from its proposed level of 2 x 60MHz. This would make acquiring 2.6GHz spectrum easier for the current 1800MHz 2G operators. However, this would conversely increase the difficulty for non-2G operators to gain access to 2.6GHz spectrum.

5. COSTS AND BENEFITS

This section provides some high level assessment of the potential benefits and costs associated with the mechanisms outlined above in comparison to the counterfactual, which we assume to be the Ofcom imposed solution.

Benefits

The major benefits of the mechanisms which we outline above are:

- Earlier and more effective deployment of NGM services
- Contribution to universal broadband
- Greater competition
- Increasing the competitiveness of the UK

Expediting the clearance and auction of the 800MHz spectrum in a combined auction with the 2.6GHz spectrum, and allowing 900MHz spectrum to be refarmed at the operators' own pace, are both likely to accelerate the deployment of wide-area NGM in the UK. This is likely to lead to new services being available to businesses and citizens and will enable new business models and working practices based on high-speed mobile data.

By assigning universal coverage obligations to attractive 800MHz spectrum, full nationwide availability of mobile broadband will occur. This is likely to generate significant economic benefits for the areas which gain connectivity. Furthermore, it may also deliver a mobile infrastructure which will be able to compete with fixed line, fixed wireless and satellite operators in the provision of universal access. This may increase the competition for tenders to provide connectivity and thus reduce the cost to the taxpayer of any universal access commitment.

Taking short-term steps to ensure the wider distribution of spectrum will sustain the level of competition in the UK market. This is especially important as we are about to begin the transition to new mobile technologies which are likely to prove as economically fruitful as fixed technologies have been in the previous two decades. This increased competition may increase operators' incentives to roll-out new networks, clear existing spectrum and reduce prices to attract customers. These measures may all benefit end users of services in the UK.

All of the benefits described are aimed at increasing the speed of deployment and minimising the costs to the consumer of the transition to NGM services. They may increase the demand for products and services and as such are also likely to generate income for the Government in the form of increased tax proceeds. The establishment of a world-class mobile broadband infrastructure will also increase the UK's competitiveness.

Costs

The clearest costs that these mechanisms entail are the costs of expediting the clearance of the 800MHz band. There may be costs in clearing PMSE users from channel 69 and clearing channels 62 and 61 of DTT usage post-DSO. More work will need to be done to establish the magnitude of these costs.

The coverage obligations placed on 800MHz spectrum may have the effect of reducing the proceeds from the combined auction. However, the magnitude of this cost may not be particularly high as operators are looking to sub-1GHz spectrum to provide national mobile broadband coverage which is not feasible using 2.1GHz. One operator provided information that the cost of rolling out to 99% of the population using 800MHz would require in the order of £150m of capital expenditure and then £10m of yearly operational cost. However, it is only the incremental roll-out above that level which the operator would otherwise choose in the absence of coverage requirements that would be reflected in the depression of auction proceeds. This is likely to be substantially less than the figures stated above.

There will also be an opportunity cost to the exchequer from restricting the amount of spectrum that any one operator can hold. This is particularly likely to affect the 800MHz auction due to the tighter restrictions on bidding by Vodafone and O2, and result in lower auction proceeds. However, four factors mitigate this cost:

- Existing users of 2G and 3G spectrum may be prepared to bid more for spectrum in a combined auction than they would in separate auctions, as they are more likely to be able to control aggregation risks.
- A combined auction may attract new bidders more than two separate auctions, again because the aggregation risks are lower.
- The alternative to the proposals outlined above that should be considered may also involve a spectrum cap below 1GHz – Ofcom has previously suggested that such a cap may be necessary on competition grounds.
- Several stakeholders have suggested that a later auction of the paired 2.6GHz spectrum (with an auction in mid-2010 as opposed to later this year) may coincide with greater confidence and certainty in the overall economy. This may increase the bids made for this spectrum.

6. PROCESS QUESTIONS

This report has made the case for an alternative imposed solution. In that context, it is obviously important to address the issue of how such an alternative imposed solution might be implemented. The most important point to make is that it should not and could not be implemented arbitrarily. 'Should not' because, as the previous section makes clear, there are a large number of ways of achieving the policy objectives and the optimal approach may be identified through further analysis and discussion. 'Could not' because due process will clearly need to be abided by.

There are two sensible routes to implementation. The first is that Ofcom is persuaded of the arguments in this document and Ofcom and Government determine that the various possible outcomes are all within Ofcom's powers to deliver. In that case, this report would be an input into the final Digital Britain report and both reports would then be pre-cursors to an Ofcom consultation document. The second route is that Ofcom and/or Government decide that some possible outcomes might be easier to achieve with a Government direction to Ofcom. This would involve a similar process in the early stages, but the consultation document would be the formal responsibility of BERR and would need to be followed in due course by an affirmative resolution of both Houses of Parliament.

Any consultation issued by BERR could include and take forward the proposal which has been issued by Ofcom on spectrum liberalisation in its latest consultation document. If progress cannot be made along the lines that I have suggested, then the Ofcom imposed solution can act as a well argued alternative.

The completion of two important pieces of analysis and consensus building would assist in the making of a final decision. Firstly, the uncertainty about the timing of the usability and availability of 800MHz needs to be reduced. Ofcom should be the leading player in this but other parties (notably Arqiva and several of the operators) have strong opinions on this matter and should be included. Secondly, a common view of the difficulties of refarming at 900MHz needs to be arrived at. At the moment the 900MHz operators stress the operational and marketing challenges of this, while two at least of the other operators are sceptical of these arguments. A process needs to be established to ensure that a common view is arrived at on what is essentially a technical issue, albeit with significant commercial and competition issues.

One of the issues that is difficult to assess at this juncture is how this process would interact with a possible auction of the 2.6GHz spectrum. Ofcom hopes to do this in September of this year. However, assuming an alternative imposed solution gains the support of policy-makers, it is, in my view, probably the correct approach for me to develop the right answer to the bigger policy questions addressed in this report, rather than worry too much at this stage about the timing of the 2.6GHz auction.

7. CONCLUSION

This report has covered a lot of ground, but its conclusions can be summarised as follows:

- A number of developments in the mobile sector, including progress towards next generation mobile services and the recognised benefits of universality have prompted Government to appoint an Independent Spectrum Broker.
- The suggested objectives of this exercise are as follows:
 - expediting the transition to next generation mobile to the benefit of consumers
 - sustaining competition in the UK market by taking proportionate steps to limit the concentration of mobile suitable spectrum
 - creating an environment where the availability of mobile broadband is increased in general and where it can play an important contributory role in achieving near-universal broadband
- Discussions have shown that a negotiated solution to 2G refarming may not achieve the objectives and in any event is very difficult to conclude
- However, a new imposed solution might meet these objectives and a preferred set of mechanisms has been identified. These are likely to be refined and changed as they are considered in greater detail.
- The final package of measures can be implemented either through Ofcom's own processes or via a Government direction to Ofcom.
- There is a reasonable chance that the outcome will be a continuing competitive environment in mobile, a swift transition to next generation mobile and a significant increase in the coverage of mobile broadband. All of these will deliver benefits both to consumers and to wider society.

Annex 1: Reasons why a negotiated solution is unlikely

The interim Digital Britain Report suggested that the Wireless Radio Spectrum Modernisation Period should “resolve the future of existing 2G radio spectrum through a structured framework, allowing existing operators to re-align their existing holdings, re-use the spectrum and start the move to next generation mobile services”.

The main reasons why this has proved difficult to achieve are as follows:

- **acceptance of the original imposed solution**

If a negotiated outcome is not arrived at, the proposal in the February 13th Ofcom consultation document (Application of spectrum liberalisation and trading to the mobile sector – a further consultation) is that Vodafone and O2 be required to relinquish 2x5MHz of contiguous spectrum, this to be auctioned. Although neither 900MHz operator likes this proposal and both made clear that it would impose inconvenience on their customers and substantial costs, at least one operator was satisfied with its outcome.

- **a shared sense that an alternative outcome, not based on the Ofcom imposed solution, would constitute a better result for the UK mobile industry**

Initial briefings on the operators’ wishes at the beginning of this process suggested that one operator in particular was keen to access 900MHz for the deployment of 3G HSPA. In reality, it has become clear that all the operators want to look at the issues associated with 2G spectrum in the broader context of other spectrum that is due to become available – 2.6GHz and 800MHz. This is because, in the context of next generation mobile, being able to plan to acquire spectrum at different frequencies is very helpful. A negotiated solution that used the proposed Ofcom imposed solution as a starting point would not achieve this outcome.

- **the potential inducements on offer are not substitutes for an equitable distribution of spectrum**

The two inducements under discussion are an indefinite licence term for the 2.1GHz licences and a more liberal regime for infrastructure sharing. Although all the operators would appreciate the additional certainty offered by a licence extension, this concession was regarded by most operators as useful, rather than a catalyst to make a negotiated outcome happen. Infrastructure sharing is seen as something that is likely to happen anyway if there is a sufficiently good economic and commercial case.

Annex 2: Discussion of mechanisms designed to achieve competition, universality and fast transition to NGM

This annex outlines in more detail the mechanisms that have been suggested in discussions in the Spectrum Modernisation Programme. Specifically it contains:

- a discussion of the various mechanisms proposed that aim to address competition issues (**competition mechanisms**)
- a similar discussion on mechanisms aimed at universality issues (**universality mechanisms**)
- a similar discussion on mechanisms aimed at expediting the transition to next generation mobile (**mechanisms for fast transition to NGM**)

As some of the proposals made to me were done so confidentially, and for reasons of competition law, each of the proposals here is not identified as being associated with a particular organisation.

Competition mechanisms

As mentioned, a number of proposals have been put forward which might help to meet the competition objectives that we have set out. Some of these proposals are concerned only with particular bands of spectrum, whereas others seek a more holistic approach across spectrum bands. The timing and sequence of auctions also has important consequences for competition.

This section examines:

- Specific spectrum proposals – these are measures which propose action only in specific areas of spectrum
- Wider spectrum proposals – these measures take a more holistic approach across spectrum bands

Specific spectrum proposals

A number of solutions to potential competitive imbalances, both for low frequency access and overall spectrum capacity, have been suggested that focus only on specific spectrum bands.

Low frequency access

With regards to low frequency spectrum, the prime policy suggestions have come from Ofcom, in its published consultation document, and one other stakeholder. There has also been a suggestion of a specific restriction on the 900MHz operators in their ability to bid for 800MHz spectrum.

The Ofcom preferred solution is one of the options outlined in its latest consultation on spectrum liberalisation and trading, already mentioned in this report. The essence of this solution is that Vodafone and O2 would give up 2.5MHz of 900MHz spectrum each to form a cleared contiguous block of 2 x 5MHz of 900MHz spectrum. This block would then be auctioned.

A variation to Ofcom’s proposal might be to place access conditions on this block to ensure that other operators have access to this spectrum.

An alternative to the Ofcom proposal of forcing the 900MHz operators to relinquish spectrum might be to restrict their ability to gain further crucial sub-1GHz spectrum. One flexible approach to this is that Vodafone and O2 would be able to bid for 800MHz, but if successful at auction, they would be required to give up an equal amount of 900MHz spectrum within a specified period. Indeed this idea has already been proposed by Ofcom in the DDR consultation as one of a number of options to address potential competition concerns in connection with the award of 800MHz spectrum. This idea also forms part the event-specific total spectrum cap, which is part of the set of preferred mechanisms.

A stakeholder has developed a range of suggestions around access to 900MHz and 800MHz spectrum; these are outlined in Figure 3 below.

Figure 3 – Low frequency access solutions suggested by a stakeholder

Proposal	Details
A	All operators will be allowed to bid in the 800MHz auction; either individually or as part of a consortium. Concerns about competitive parity are addressed by requiring the successful bidders to offer access on reasonable terms.
B	As above but with a trade between Vodafone and O2 and an 1800MHz operator, if they require access to 900MHz spectrum before the UHF spectrum is available. This trade would require the 1800MHz operator to provide 2 x 5MHz of 1800MHz spectrum to each of Vodafone and O2 (2 x 10MHz in total) and a cash payment in exchange for 2 x 5MHz of 900MHz.
C	No 2G spectrum changes hands but operators launch a shared 3G HSPA network to cover unviable areas of the country using 900MHz spectrum by 2012. For example, Vodafone and O2 could partition the country, build a network and allow wholesale access or roaming to the other operators.

Proposal C also covers aspects of delivering wider access to mobile broadband; these aspects are discussed in more detail in the following section that deals with universality.

Overall capacity

With regard to the concerns around total spectrum capacity, one proposal has been made in relation to 2.6GHz spectrum. This proposal suggests that 2 x 15MHz be reserved for a non-2G operator in the auction. The auction could be arranged so that the price paid for the reserved block was equivalent on a per MHz basis to the non-reserved spectrum.

Wider spectrum proposals

In addition to the proposals above, which concentrate on specific areas of spectrum, a number of proposals have been made which affect a wider range of spectrum. These either focus on 2G spectrum, or more broadly deal with all mobile suitable spectrum.

2G spectrum proposals

The most comprehensive proposal for a re-distribution of 2G spectrum from a stakeholder involves Vodafone and O2 releasing 2 x 7.5MHz of 900MHz each, with 2 x 5MHz going to each of T-Mobile, Orange and Three. Furthermore, T-Mobile and Orange release 2 x 7.5MHz of 1800MHz each, with 2 x 5MHz going to Vodafone, O2 and Three.

Figure 4 and Figure 5 below shows how spectrum is distributed before and after the implementation of this plan.

Figure 4 – Existing spectrum holdings

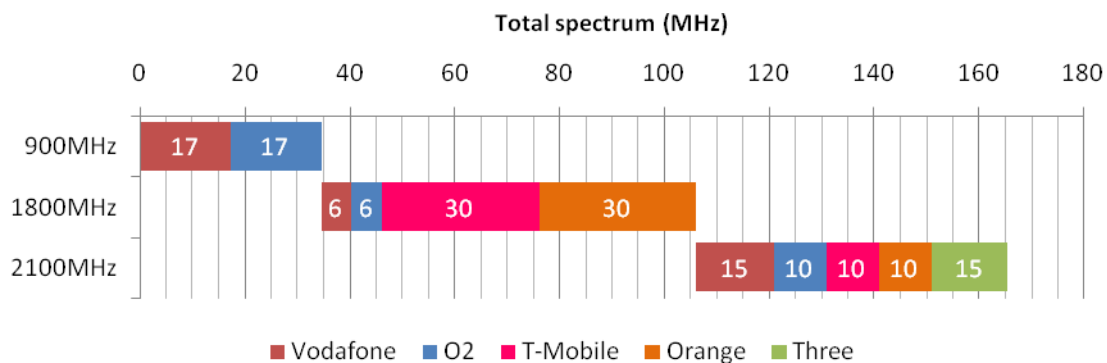
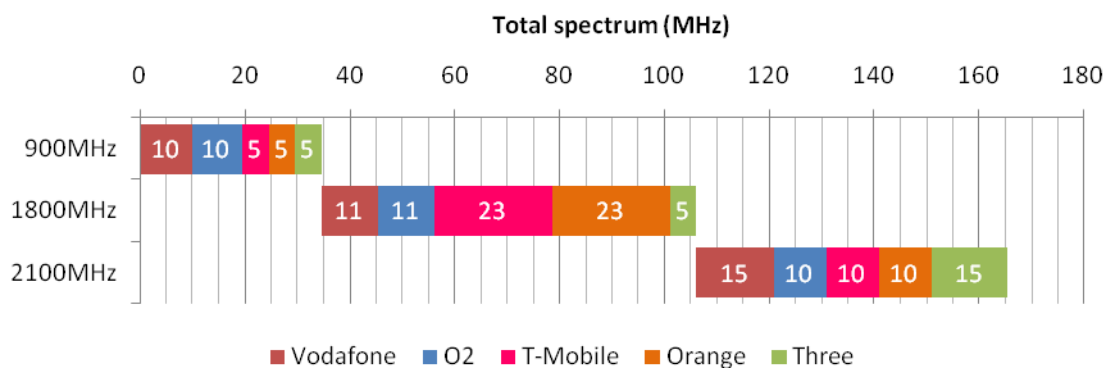


Figure 5 – Spectrum holdings under a stakeholder's 2G re-allocation



All mobile spectrum solutions

A number of proposals have been suggested which deal with the totality of mobile spectrum, including the as yet unawarded 800MHz and 2.6GHz bands. These proposals include:

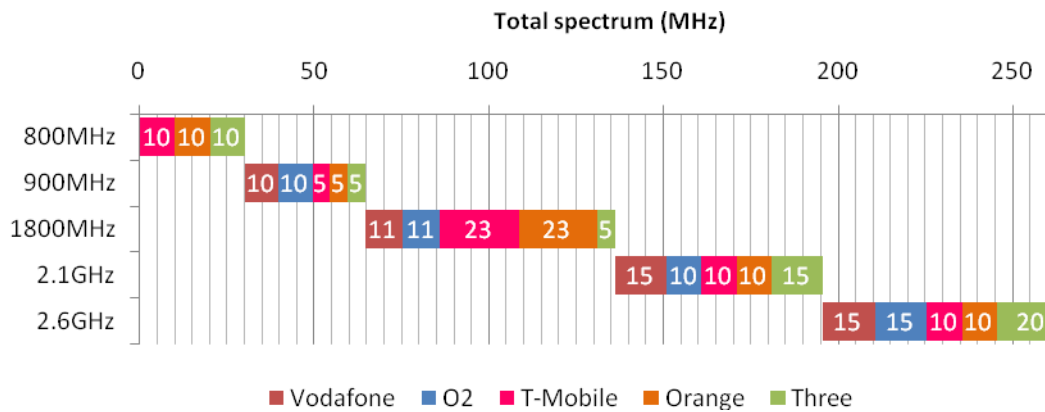
- Three allocations suggested by different stakeholders
- The notion of an event-specific total spectrum cap (part of my preferred set of solutions)

The allocation specified by one stakeholder entails the following elements:

- Identical 2G spectrum re-allocations as in the 2G proposal represented in Figure 5 above, in addition,
- 800MHz spectrum to be allocated in the following way:
 - 2 x 10MHz each for T-Mobile, Orange and Three
- 2.6GHz spectrum to be allocated in the following way:
 - 2 x 10MHz each for T-Mobile and Orange
 - 2 x 15MHz each for Vodafone and O2
 - 2 x 20MHz for Three

This would result in the following spectrum outcome:

Figure 6 – Spectrum holdings under a stakeholder’s broad spectrum re-allocation

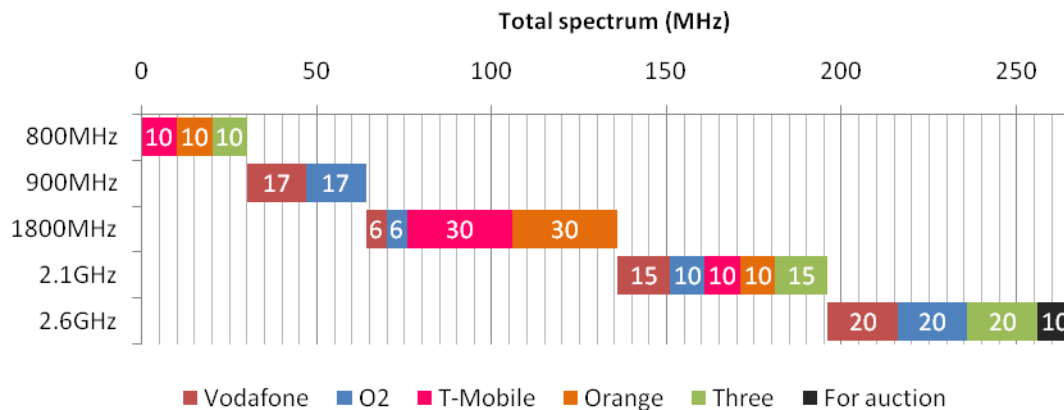


A second stakeholder suggested a different allocated outcome. This would involve:

- 2G spectrum liberalised in the hands of the existing operators
- 800MHz spectrum to be allocated in the following way:
 - 2 x 10MHz each for T-Mobile, Orange and Three
- 2.6GHz spectrum to be allocated in the following way:
 - 2 x 20MHz each for Vodafone, O2 and Three
 - 2 x 10MHz auctioned

This would result in the following spectrum outcome:

Figure 7 – Spectrum holdings under a second stakeholder's broad spectrum re-allocation



A third stakeholder has also suggested a broader solution which does not involve any re-distribution of 2G spectrum. It is similar to the proposal above except that 2.6GHz would be auctioned and not allocated and that priority would be given to T-Mobile, Orange and Three.

A wider spectrum solution which seeks to address the potential competition issues identified in a way which does not require allocations to existing operators, and is part of my preferred set of proposals, is the proposal of an event-specific total spectrum cap. The aim of this cap would be to recognise that the liberalisation of 2G spectrum provides varying competitive advantages to each of the 2G operators, and to ensure that the era of liberalised tradable spectrum begins competitively. The cap is event-specific since it would only apply during and for a limited time after the awards of 800MHz and 2.6GHz spectrum. It is not intended to restrict the subsequent evolution of the sector through competition and market forces.

The event-specific total spectrum cap would consist of two parts:

1. A time-limited (say) one year restriction on the total level of spectrum that any one operator may have access to after the awards of 800MHz and 2.6GHz:
 - a. No operator is permitted to have more than **2 x 60MHz** of paired mobile-suitable spectrum in total after the award(s); if necessary, other paired spectrum (in multiples of 2 x 5MHz) must be given up to remain within this cap. The operators would be able to keep the proceeds from the sale of spectrum given up.
 - b. In the case of acquired 2.6GHz, the operator to give up spectrum must do so within (say) 2 years of the end of the auction
2. A further restriction on the holders of 900MHz spectrum, due to the specific propagation characteristics of sub-1GHz spectrum:
 - a. The existing 900MHz operators are free to bid for 800MHz, but must give up an equal amount of 900MHz if they are successful. The operators would be able to keep the proceeds from the sale of spectrum given up.

- b. In the case of acquired 800MHz, Vodafone or O2 must give up 900MHz spectrum within (say) 3 years of the end of the auction.

At present, the holdings of paired spectrum are shown below in Figure 8:

Figure 8 – Paired spectrum holdings by each of the MNOs

(MHz of paired spectrum)	Vodafone	O2	T-Mobile	Orange	Three
900MHz	2 x 17.2	2 x 17.2	-	-	-
1800MHz	2 x 5.8	2 x 5.8	2 x 30.0	2 x 30.0	-
2.1GHz	2 x 14.8	2 x 10.0	2 x 10.0	2 x 10.0	2 x 14.6
Total	2 x 37.8	2 x 33.0	2 x 40.0	2 x 40.0	2 x 14.6

Under the event-specific spectrum cap, Vodafone and O2 would not be able to obtain 800MHz unless they were to give up an equal amount of 900MHz within a specified period. However, they would be able to bid for at least 2 x 20MHz of 2.6GHz each, up to the maximum per operator determined in the auction.

Orange and T-Mobile would be able to bid freely for 800MHz (or the 900MHz that would be given up by Vodafone or O2 if they were to bid for 800MHz), up to the maximum per operator determined in the auction. However, if they were successful in gaining 2 x 10MHz of 800MHz or 900MHz, they would only be able to bid for 2 x 10MHz of 2.6GHz so as to remain within the spectrum cap. If they wanted a greater amount, they would have to relinquish an equal amount of 1800MHz or 2.1GHz.

Three and any potential new entrants would be able to bid freely for 800MHz (or the 900MHz that would be given up by Vodafone or O2 if they were to bid for 800MHz), up to the maximum per operator determined in the auction. Even if it were successful in gaining 2 x 10MHz of 800MHz or 900MHz, it would still be able to bid for a full 2 x 20MHz of 2.6GHz and remain under the total spectrum cap.

Auction timing

The timing and sequencing of awards can have significant consequences for competition, especially for new entrants facing aggregation risks in building up suitable spectrum holdings for deploying new services.

Current auction timeline

Ofcom's current position is:

- a policy to auction the 2.6GHz spectrum as soon as the legal challenges are cleared, which it hopes will be possible by September 2009
- a proposal to award the 800MHz in late 2010 alongside the rest of the Digital Dividend.

The 2.6GHz auction will award the whole of the 2.6GHz band in a way that allows the split between paired and unpaired spectrum to be determined by the market.

Ofcom has yet to decide how and when the 800MHz spectrum will be awarded. When it was thought that a smaller range of frequencies would be available and there was little interest in Europe in harmonisation, Ofcom proposed a combined auction of all Digital Dividend spectrum on a technology and application neutral basis. If it is decided to proceed with clearance of the whole of the 800MHz band Ofcom intends to re-consult on the most appropriate structure and timing of the Digital Dividend awards.

Reconfigured auction timeline

An alternative policy process, part of my preferred set of solutions, could be created by modifying the award processes:

- auction the centre 50MHz as TDD suitable 2.6GHz as soon as possible
- auction the outer 2 x 70MHz as paired FDD 2.6 spectrum in a combined auction with the 2 x 30MHz of paired 800MHz spectrum, all in a mobile suitable configuration in mid- 2010 (separate from the auction of the remaining Digital Dividend spectrum)

By stepping back from the two complex auctions currently proposed for 2.6GHz and the Digital Dividend, we can create three simpler auctions.

Summary and evaluation

Below is a high-level evaluation of the ideas set out above.

The narrow spectrum solutions outlined were:

- For low frequency competition
 - The Ofcom proposal
 - Restricting total Vodafone and O2 holdings of sub-1GHz spectrum
 - The stakeholder's proposals
- For overall spectrum capacity
 - Reserved 2.6GHz for a non-2G operator

Ofcom's proposal has been under development for over a year and is well understood. It would broaden access to sub-1GHz spectrum to three operators but would otherwise leave a number of issues unresolved, such as eligibility for and access to 800MHz and total spectrum capacity. Ofcom is, however, considering these longer-term issues in the context of its consultations on the Digital Dividend and has as yet made no decision in this regard. The consequences of Ofcom's solution for universality and NGM services are discussed further in the following sections.

Restricting the total sub-1GHz spectrum that the incumbent 900MHz operators can hold, rather than forcibly revoking existing 900MHz holdings, goes further towards ensuring a genuinely competitive

outcome in low frequency spectrum. Although insufficient on its own to meet the competition objectives, it may form part of the solution.

The stakeholder's solutions are largely designed to permit access to low-frequency spectrum even if ownership is concentrated. However, wholesale access is not the same as genuine competition to provide the lowest cost service. Therefore, although these ideas may be useful short-term measures to prevent anti-competitive behaviour whilst alternative spectrum becomes available, they are not a substitute for a diversity of access to sub-1GHz spectrum.

The proposed reservation of 2.6GHz spectrum for a non-2G operator would help to ensure wider access to high capacity spectrum. However, this measure is somewhat of a blunt instrument as it does not distinguish between the differences in the positions of the 2G operators. T-Mobile and Orange have the ability to free up greater capacity using 1800MHz spectrum than Vodafone and O2 can using 900MHz. Although equipment for LTE using 1800MHz is likely to come on line later than that using 2.6GHz, a number of nations and operators are beginning to pursue aggressively this proposition⁹.

The wider spectrum solutions set out above were:

- 2G spectrum solutions
 - A stakeholder's re-allocation
- All mobile spectrum
 - Three allocations suggested by different stakeholders
 - event-specific total spectrum cap

The stakeholder's 2G spectrum re-allocation requires the clearance and re-distribution of large blocks of 2G spectrum. It is likely to impose large costs, especially on the 2G operators, and have the somewhat perverse effect of leaving the non-900MHz operators with cleared blocks of 900MHz whereas the 900MHz operators would be disadvantaged.

The stakeholders' suggestions which seek to allocate the entire mobile spectrum have varying merits in terms of their competitive outcome. However, it is unlikely that any solution which blocks the prospect of new entry would prove acceptable, or even legal.

The event-specific total spectrum cap has a number of attractive features:

- It provides a guarantee of diversity in spectrum holding below 1GHz, with potentially three non-900MHz operators gaining access to spectrum at this band
- It recognises the differences between 2G operators in relation to overall spectrum holdings
- It ensures that a non-2G operator will have guaranteed access to at least 2 x 10MHz of 2.6GHz or 1800MHz spectrum
- It is simple and transparent

⁹ In Hong Kong, SmarTone Vodafone is looking to deploy LTE using 1800MHz spectrum, http://www.unstrung.com/document.asp?doc_id=172748. Finland announced in April 2009 that it would be awarding further 1800MHz spectrum to use for LTE, <http://www.cellular-news.com/story/37171.php>.

However, there are also concerns. There are timing differences between the availability of 800MHz and 900MHz. The key questions are whether this timing disparity would damage competition, and if so whether ex-post competition law could be a sufficient safeguard for non-900MHz operators.

In terms of spectrum timing, the combined auction process outlined above has a number of advantages. However, the main reasons for supporting this arrangement are:

- At least one WiMAX operator can launch its mobile broadband network as soon as possible
- The combined 800MHz/2.6GHz auction provides an enhanced opportunity for parties to acquire portfolios of high and low frequency spectrum, especially benefitting those who do not possess 2G spectrum
- The UK can signal its clear commitment to 800MHz mobile broadband

My preferred approach

Due to the factors outlined above the approach of an event-specific total spectrum cap is likely to lead to the most satisfactory competition outcome. However, some timing issues remain unclear, such as the dates of availability of 800MHz. Reducing these uncertainties, and doing everything possible to expedite the clearance of the 800MHz band, is likely to have significant benefits in terms of competition and availability of services.

On the question of auction timing, there are arguments which favour re-aligning the auction timeline as outlined above.

Transition mechanisms

In this section we consider the mechanisms that have been suggested to ensure that the UK can quickly adopt NGM services and deliver them in their most potent form. There are very few specific proposals, but many of the mechanisms outlined above may have a significant impact in this area.

This section begins with a discussion of the technology choice currently facing operators, and then considers the UK's spectrum holdings and the possibilities for deployment. It then goes on to look at how some of the suggested mechanisms might affect the technology choices that will be made by operators.

The technology choice

At present all five of the UK's MNOs offer 2G and 3G voice and data services, Three does not have its own 2G network and roams onto Orange's 2G network where its 3G network does not have coverage.

For 2G services, the 900MHz spectrum used by Vodafone and O2 has provided these operators with a significant cost advantage, as fewer base stations have been required to provide full nationwide coverage. It has also provided better indoor coverage.

For 3G services, all operators use the 2.1GHz spectrum that they obtained at auction in 2000. Therefore, for 3G data services, it is the operators with a denser network of base stations who have gained a coverage advantage. All of the MNOs now offer 3G HSPA services (some are still in the process of upgrading from 3G HSDPA services) with download speeds of between 3.6 – 7.2Mbps.

In response to dramatically increasing demand for data services, 3G HSPA technology is now beginning to be deployed in new frequency bands, such as 850MHz in the US and Australia and 900MHz in Estonia. Deployment at lower frequencies has the advantage of providing better coverage in rural areas and deep in buildings. Furthermore, the underlying technology is also continuing to evolve, with 3G HSPA evolution as the next and potentially final step of the 3G HSPA technology chain. 3G HSPA evolution will provide a theoretical peak speed of 42 Mbps on the downlink close to a cell site. However, speeds nearer the cell edge are unlikely to significantly faster than current 3G HSPA.

As outlined above, LTE, the next evolution of GSM technology, is now nearing commercial deployment. LTE will initially be deployed in 2.6GHz spectrum but will eventually be deployable in a number of bands, including 700MHz, 800MHz, 900MHz, 1800MHz and 2.1GHz. LTE overcomes a number of limitations in 3G technology and will provide a responsive high-speed internet-centric mobile data experience. Unlike 3G HSPA, LTE is able to be deployed in bandwidths ranging from 2 x 1.25MHz to 2 x 20MHz. It will work best in larger bandwidths, eventually offering downlink speeds of 138Mbps and 277Mbps in 2 x 10MHz and 2 x 20MHz channels respectively¹⁰.

In my view, operators in the UK are likely to continue to update the existing 3G services they offer at 2.1GHz with updates to the existing 3G HSPA technology. In the 900MHz and 1800MHz spectrum, once liberalised, they will have the choice of deploying either 3G HSPA or LTE. In 800MHz and 2.6GHz spectrum, they will most likely deploy LTE.

The UK's spectrum resources

Low frequency spectrum suitable for LTE

- 800MHz. The Digital Dividend spectrum will provide 2 x 30MHz of contiguous spectrum
 - Suitable (for example) for one 2 x 20MHz LTE carrier and one 2 x 10MHz NGM carrier, or
 - three 2 x 10MHz NGM carriers
- 900MHz. This consists of 34MHz of spectrum, already used for 2G services. To add to the complications of refarming for new technologies, or freeing up spectrum for third parties,

¹⁰ These downlink speeds will be available with 4x4 multiple-in multiple-out (MIMO) antennae configuration.

this is not split into contiguous blocks between Vodafone and O2 but is interleaved in small slices between the operators.

- Considerable investment (especially in urban centres) will be required to free up contiguous spectrum.
 - Freeing up 2 x 10MHz by **2011** would cost Vodafone and O2 £100-180m in total
 - Freeing up 2 x 20MHz by **2011** would cost Vodafone and O2 £300-900m in total¹¹
- However, clearing this spectrum over a longer period of time would substantially reduce the costs involved.

Therefore, with low frequency spectrum, after the clearance of 800MHz and some of the 900MHz spectrum, the UK can at most deploy two 2 x 20MHz carriers and one 2 x 10MHz carrier, or five 2 x 10MHz carriers.

High frequency spectrum suitable for LTE

- 2.6GHz. This consists of 190MHz of clear spectrum. The harmonised CEPT band plan divides this into 2 x 70MHz of outer spectrum and 50MHz of unpaired centre spectrum. The former would be:
 - suitable (for example) for three 2 x 20MHz LTE carriers and one 2 x 10MHz carrier, or
 - seven 2 x 10MHz LTE carriers, or other combinations
 - the 50MHz of unpaired spectrum suitable for WiMAX, but not for LTE.

An alternative configuration to the CEPT band plan would allow for configurations which could split the spectrum in different proportions between paired and unpaired spectrum.

- 1800MHz. This consists of 72MHz of spectrum, already used for 2G services.
 - Investment (especially in urban centres) will be required to free up contiguous spectrum for NGM.
 - Freeing up 2 x 20MHz (enough for one 2 x 20MHz LTE carrier) by **2011** would cost T-Mobile and Orange £40-70m
 - Freeing up 2 x 40MHz (enough for two 2 x 20MHz LTE carriers) by **2011** would cost T-Mobile and Orange more, although Ofcom's analysis has not calculated this cost
 - However, clearing this spectrum over a longer period of time would reduce the costs involved.

Therefore, with high frequency spectrum the UK can deploy three 2 x 20MHz carriers immediately following the 2.6GHz auction and potentially five in total once 40MHz of 1800MHz has been cleared.

Proposals involving re-allocations of 2G spectrum

¹¹ According to Ofcom's calculations

Ofcom's proposal, as well as a number suggested by the MNOs, involve Vodafone and O2 jointly giving up at least 2 x 5MHz of spectrum. This might have a significant effect on the technology options adopted by the MNOs.

Under Ofcom's proposal, Vodafone and O2 would clear and jointly give up at 2 x 5MHz of 900MHz spectrum by 2011. In a 2 x 5MHz channel, LTE would not be able to be used to its fullest potential and would have minimal advantages over 3G HSPA. Therefore, it is likely that the operator winning this spectrum would seek to deploy 3G HSPA. In my conversations with the 900MHz operators, they have stated that they would seek to clear an additional 2 x 5MHz each so that they too can launch 3G HSPA services and not be at a competitive disadvantage to the winning operator.

This would firmly establish 3G HSPA in the 900MHz band in the UK, and would extend 3G coverage in rural areas and in not-spots within cities

However, this may have the consequence of retarding the deployment of LTE in the 900MHz band for a number of years. If Vodafone and O2, after jointly clearing 2 x 5MHz of 900MHz to be auctioned to another operator, were to clear a further 2 x 5MHz each for 3G HSPA, then they would be left with just 9.5MHz of spectrum each in which to provide 2G services. Clearing any further spectrum for LTE would be very costly. Furthermore, as 900MHz 3G HSPA equipment becomes established, it would become difficult for any operator to clear the spectrum they were using for 3G HSPA for LTE. In any case, the advantages of LTE over 3G HSPA in a 2 x 5MHz carrier are not pronounced.

The 800MHz band would then become the primary focus of low-frequency LTE deployment. It is likely that all five MNOs would desire access to it for LTE services. However, there is only 2 x 30MHz of spectrum available in this band, and if all five operators were to win some spectrum, there would be significant fragmentation and only one would emerge with a 2 x 10MHz carrier. This would prevent the deployment of full-potency wide coverage LTE.

Proposals not involving re-allocations of 2G spectrum

Some of the other proposals outlined above do not involve re-allocations of 2G spectrum. These include the restrictions on Vodafone and O2 bidding for 800MHz, the access proposals put forward by a stakeholder in Figure 3 above and my preferred mechanism, the event-specific total spectrum cap.

The restrictions on Vodafone and O2 bidding for 800MHz and the event-specific total spectrum cap would both result in Vodafone and O2 retaining full access to 900MHz and three other parties (possibly the three other MNOs) gaining access to 800MHz.

Under this scenario, the incentives for all the operators would be different than in the re-allocation scenario outlined above.

The 800MHz MNOs would be seeking to roll-out and deploy 800MHz nationwide as soon as possible. Nationwide, the 800MHz band would become available by the end of 2013 under the current DSO plan or the end of 2012 if the clearance of channels 61 and 62 were accelerated. However, if channel 69 could be cleared by the second-half of 2012, after the Olympics, then one of these 2 x 10MHz blocks would become available almost nationwide at that point, though its usability still needs to be ascertained.

Vodafone and O2 would therefore face a significant choice. In one possibility they could, as above, clear spectrum to deploy 2 x 5MHz 3G HSPA channels. This might give them an advantage over their rivals in the near-term. However, this would still mean that the deployment of LTE in the 900MHz spectrum would become difficult and that, come the deployment of 800MHz LTE networks, they would be at a disadvantage. In the other possibility they might choose to clear spectrum to deploy LTE rather than move to 3G HSPA. As the more advanced LTE technology can be deployed in variable channel widths, they could begin with a smaller LTE channel whose size could be increased as more spectrum were cleared. Clearing the full 10MHz would take them longer and require a greater investment but would allow them to compete with the 800MHz operators. Furthermore, they would be incentivised to do this as quickly as possible, as they could gain a brief advantage over their 800MHz rivals, if they could launch LTE services before the end of 2013 or 2012. However, the choice of which technology to deploy in the liberalised spectrum would remain entirely theirs.

Summary and evaluation

There are some finely balanced choices facing operators and policy makers at the moment, and these will have significant repercussions for the amount of low-frequency spectrum that the UK can dedicate to NGM services.

It appears that solutions which re-allocate 900MHz spectrum, especially smaller amounts such as 2 x 5MHz, will have the effect of pushing usage of that band towards 3G HSPA. This may most likely result in the 900MHz band being reserved for 2G and 3G HSPA services for the foreseeable future.

If 900MHz spectrum is not re-allocated, the incentives of each of the operators can significantly differ. In the case where the 800MHz spectrum is obtained by new or non-900MHz operators, this may provide the 900MHz operators a greater incentive to clear 900MHz spectrum for LTE services.

My preferred approach

As important as clearing the 800MHz spectrum quickly is to ensuring competition, it is equally important in allowing the smooth transition to LTE.

Due to the factors outlined above, the re-allocation of 900MHz spectrum, especially in small block sizes, is likely to limit the amount of low-frequency spectrum that will be available for LTE services in the foreseeable future.

The packaging of new spectrum for award should also respect the importance of larger block sizes and contiguous spectrum for NGM services.

Universality mechanisms

The policy objective associated with universality is to further the deployment of mobile broadband generally and potentially allow it to play a meaningful role in achieving the Government's targets for universal broadband access. We have received a number of proposals from stakeholders which seek to utilise either 2.1GHz, 900MHz or 800MHz spectrum to achieve greater mobile coverage.

Using 2.1GHz spectrum

The propagation characteristics of 2.1GHz spectrum make it unsuitable for attempting to achieve universal mobile broadband coverage. According to figures published by Ofcom, to achieve 99% population coverage would require almost 3 times as many sites as using 900MHz spectrum.

However, 2.1GHz can play an important intermediate step in extending the coverage of mobile broadband, especially in the short-term prior to the refarming of 900MHz and the availability of 800MHz. Subsequent to the conclusion of any policy process, it may be in the interest of citizens and consumers for the Government and Ofcom to re-examine the 3G licences and specify a greater coverage requirement, in exchange for the investment certainty provided by indefinite licences.

Using 3G HSPA in 900MHz spectrum

The first proposal we received is an extension of Ofcom's current policy proposal. Under this proposal, universal coverage and open access obligations are placed upon the 2 x 5MHz channel of 900MHz that Vodafone and O2 jointly release.

The second proposal was mooted by two stakeholders. Under this proposal, Vodafone and O2 do not give up any 900MHz but instead launch a shared HSPA network to cover the unviable areas on 900MHz spectrum by 2012. There are a number of different ways this could be done. For example, Vodafone and O2 could partition the country, build a network and wholesale (or allow roaming) to the other operators.

Using LTE in 800MHz spectrum

Using LTE in the 800MHz band to deliver universality objectives is subject to the availability of the spectrum, as well as the specific mechanisms that might be employed.

Usage timescales

A harmonised band plan has been agreed for LTE at 800MHz. However, there are barriers to its usage.

Firstly, there is the question of equipment availability. Until a few weeks ago, there was a large degree of uncertainty as to when LTE equipment would appear for the 800MHz band. However, in March 2009, 3GPP, the official LTE standards setting body, set up a working group to finalise the specification of 800MHz LTE. This means that the first commercial equipment should be available from late-2010 to mid-2011. This 2011 date corresponds with representations that have been made by equipment manufacturers to stakeholders.

Secondly, there is the question of spectrum availability. The full 2 x 30MHz of LTE suitable spectrum at 800MHz will not be available until the end of 2013, or the end of 2012 if the clearance of channels 61 and 62 can be accelerated. However, it may be that some early use of this band is possible.

If Channel 69 could be cleared feasibly of PMSE use by the second half of 2012, it would open up a 2 x 10MHz LTE channel that could be available nationwide from that date. Ofcom's DDR PMSE team is currently giving consideration to options for, and the issues raised by, the potential early clearance of channel 69 in some or all of the country.

Television channels 61 and 62 will be progressively cleared from April 2011 onwards and this nominally frees up the remaining 2 x 20MHz of 800MHz spectrum for LTE uses. However, the roll-out of LTE may be limited by the interference from analogue TV and DTT in other parts of the country still using channels 61 and 62. Ofcom and Arqiva are conducting work in this area, and I recommend that a concerted effort at answering these questions should be a key short-term priority.

Proposals

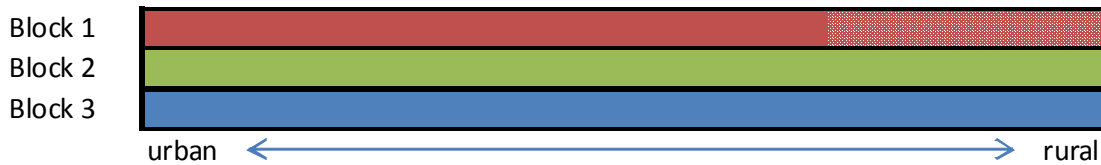
One set of proposals seeks to attach coverage and access obligations to certain blocks of 800MHz spectrum. These include:

- Obligations on one block
- Differential obligations on all three blocks
- Obligations on an enlarged block
- Obligations on an enlarged rural block
- Utility network

These obligations could be simply attached to one of the blocks of 800MHz that will be auctioned, and the blocks could simply be three block of 2 x 10MHz. This is shown in Figure 9 below

Figure 9 – Coverage and access obligations placed on one 2 x 10MHz block of 800MHz spectrum

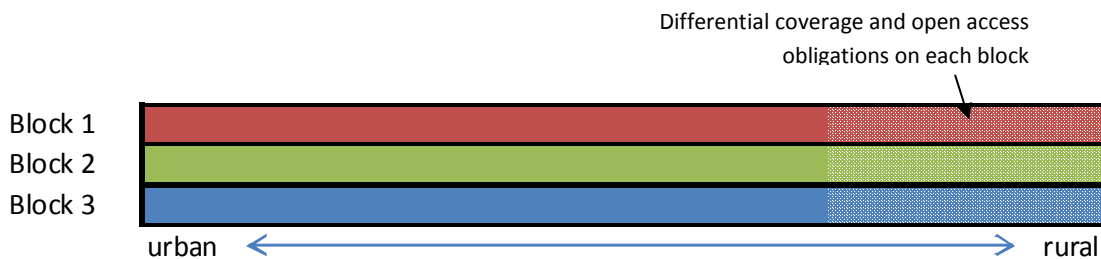
Coverage and open access obligations on
Block 1 in rural areas
↓



This diagram is designed to illustrate that the acquirer of Block 1 would have to meet certain coverage obligations and offer access to competing networks in more rural areas.

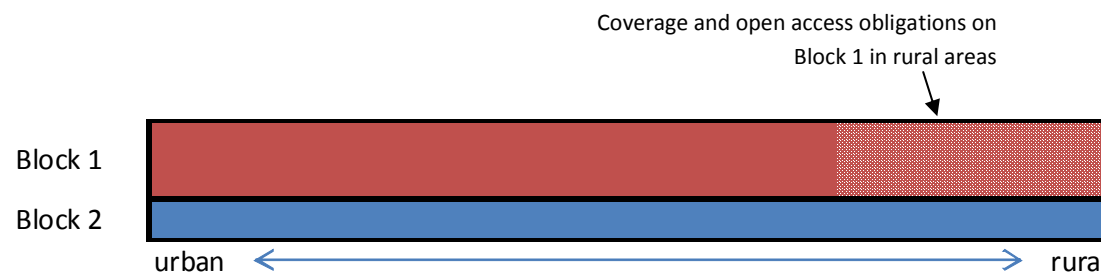
A variation on this option imposes certain coverage and access obligations on each of the 800MHz blocks. This is my preferred option. These obligations could extend to different parts of the country, so for example, Block 1 might have obligations in Scotland, Block 2 might have obligations in the North of England, the Midlands and Northern Ireland and Block 3 might have obligations in the South and South-West of England and in Wales. This is shown in Figure 10 below

Figure 10 – Differential coverage and access obligations on each of the blocks



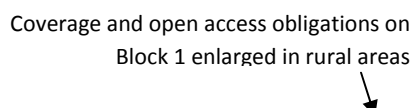
Instead of awarding the 800MHz as three blocks of 2 x 10MHz, it could, instead, be awarded as two blocks, one of 2 x 20MHz and one of 2 x 10MHz. This is shown in Figure 11 below.

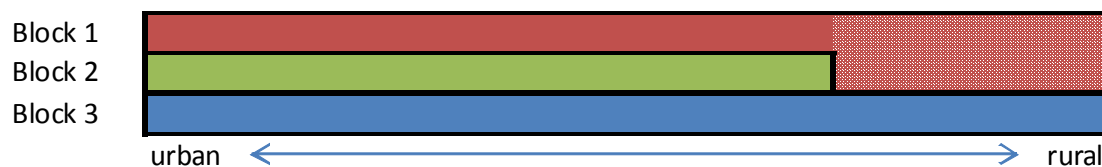
Figure 11 – Coverage and access obligations placed on one 2 x 20MHz block of 800MHz spectrum



However a variant of the two arrangements above would involve an enlarged rural spectrum holding in Block 1, as shown in Figure 12 below

Figure 12 – Coverage and access obligations placed on one 2 x 10MHz block of 800MHz spectrum, enlarged in rural areas

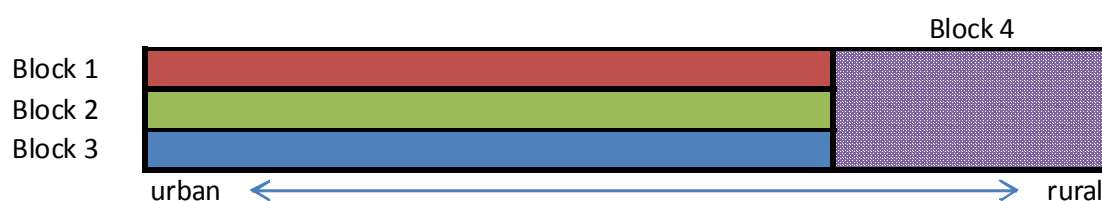




This shows that Block 1 has 2 x 10MHz of exclusive spectrum in urban areas, but has access to 2 x 20MHz in rural areas, which it must deploy with coverage and open access obligations. Block 2 would consist of 2 x 10MHz of private spectrum in urban areas, but would not extend to rural areas. Block 3 would consist of 2 x 10MHz of private spectrum nationwide.

A very different approach has been suggested by two parties. They have proposed that the 800MHz spectrum is divided geographically to create 4 blocks, as illustrated in Figure 13 below.

Figure 13 – A separate rural block of 800MHz spectrum



Under this scheme, the entire 800MHz spectrum in rural areas would be award to a neutral host – or ‘utility’ – network. The utility network operator would build out in rural areas and other operators and MVNOs would buy access services.

Summary and evaluation

A high-level evaluation of the ideas set out above is presented below.

The universality solutions outlined were:

- Using 2.1GHz spectrum
- Using 900MHz spectrum
 - Obligations on released 900MHz block
 - Vodafone and O2 to build shared 900MHz 3G HSPA network
- Using 800MHz spectrum
 - Obligations on one block
 - Differential obligations on all three blocks
 - Obligations on enlarged block
 - Obligations on enlarged rural block
 - Utility network

2.1GHz is not suitable spectrum for delivering rural coverage. However, extending existing 3G coverage using 2.1GHz is a desirable aim, especially in the short-term before the availability of

800MHz and refarmed 900MHz. 2.1GHz may prove especially useful in bringing broadband coverage to the urban and sub-urban not-spots.

Therefore, in addition to any broader policy outcome from the Spectrum Modernisation Period, greater coverage obligations on the 3G operators could be agreed and this investment facilitated by indefinite licences.

3G HSPA deployed at 900MHz has a number of attractions. It is a well understood, mature technology that can deliver a good broadband experience (one that is better than satellite). However, there are also some concerns, including:

- The unreliability of 3G HSPA, especially under heavy loads when cell-shrinkage can cut-off users at the edge of coverage
- Concerns over making large investments in a technology that is nearing the end of its commercial life-cycle

Furthermore, although Orange has suggested that it could deliver near-universal coverage using 2 x 5MHz of 900MHz spectrum for 3G HSPA, other stakeholders have expressed scepticism. This is especially due to the limited capacity of 2 x 5MHz and the inherent limitations of 3G HSPA (such as cell breathing under load). This would be a challenge faced by any operators holding a 2 x 5MHz channel with coverage obligations, especially if using 3G HSPA.

If 900MHz spectrum were not to be revoked and Vodafone and O2 were to roll out a shared network using this spectrum, then they may be able to clear more than 2 x 5MHz for use in rural areas. This would make a 3G HSPA network more resilient and cheaper to build. However, the inherent limitations of 3G HSPA still apply. Furthermore, this possibility raises the important question of whether the existence of this network in rural areas would prevent 900MHz spectrum being used for LTE in urban areas.

A number of stakeholders have expressed the view that 800MHz spectrum and LTE may be the best combination with which to deliver future-proof mobile broadband to currently under-served areas. However, there has been disagreement about timing and approach. It is clear that understanding how much 800MHz spectrum may be used and in what timeframe is a challenging piece of work. However, Ofcom and others are currently analysing this problem, and I recommend that a sustained effort need to be made to understand this issue.

As to the form of delivery, it would appear that using at least 2 x 15MHz of the available spectrum would provide a benefit to any entity looking to roll out a rural network and therefore differential obligations on each of the blocks, the enlarged rural block, the 2 x 20MHz national block or the utility network ideas are likely to be preferable to the obligation on one 2 x 10MHz national block.

The utility network has advantages as it would have the greatest possible spectrum resource to deploy in rural areas. However it would also present some difficulties as it would be the only choice that 800MHz operators would have to have coverage in rural areas. Therefore, potential price

controls might be needed. Furthermore, this network would also need to be coordinated with three other networks so as not to cause harmful interference and dead spots. In terms of awarding this spectrum, it is likely that a Government subsidy might be needed for the operator of such a network.

The national 2 x 20MHz block would enable maximum speed LTE to be rolled out in rural areas. Furthermore there would also not need to be coordination between different operators operating on the same frequencies. However, the operator obtaining the 2 x 20MHz block is likely to end up with the greatest amount of sub-1GHz spectrum and consequent speed and cost advantages. These advantages is likely to be especially pointed in mobile broadband, as it will take time and significant expense for the 900MHz operators to clear spectrum to compete. Furthermore, the spectrum caps outlined above to deal with competition issues at the beginning of the transition to a liberalised regime are not readily compatible with a proposal to issue a 2 x 20MHz block of 800MHz.

The enlarged rural block offers the advantages of ensuring competition within urban markets whilst at the same time providing sufficient spectrum holdings to an operator in rural areas to roll out an effective network. However, the operators possessing blocks 1 and 2 in Figure 12 above would need to coordinate their spectrum holdings. There would also be the important question of how urban and rural were defined and how the interference boundary would be managed between the enlarged rural and urban only operators.

The differential obligations on each of the 2 x 10MHz blocks has the advantages of not requiring frequency sharing between operators in different geographies and also shares the burden of rural roll-out between operators. Furthermore, it does not prevent operators from combining their frequency holdings, and obligations, subject to competition law. An additional advantage is that three operators rolling out rural coverage in different areas of the country are likely to achieve blanket coverage more quickly than a single player.

My preferred approach

Due to the factors outlined above an agreement between the operators to extend and improve existing 3G coverage in exchange for the certainty of an indefinite licence would help improve citizens' access to broadband. Furthermore, this could be coordinated so that, where possible, the urban and suburban not-spots are the areas which benefit from extended coverage.

800MHz spectrum is the most likely to deliver future-proof mobile broadband in more rural areas. There are a number of potential solutions to packaging and access obligations which help to deliver near-universal access, and in consultation the strengths and weaknesses of each. However, at the present time differential obligations on each of the 800MHz blocks would appear to be a proportionate way in which to achieve universal NGM coverage.

Annex 3 – Timing issues around spectrum

This annex explores in greater detail some of the timing issues which surround the availability of spectrum and equipment suitable for use in particular bands.

3G HSPA equipment

Equipment is widely available for 3G HSPA. At present it is only widely available for the 2.1GHz and 900MHz bands available in the UK. Most of the deployments worldwide have been in 2.1GHz spectrum but 900MHz implementations are coming online.

Evolved 3G HSPA equipment is starting to come to market and a number of operators are beginning to implement networks. However, as many features of evolved 3G HSPA require a network equipment upgrade, some operators are suggesting that they may bypass this step in the evolution of 3G HSPA and move straight to an NGM technology.

WiMAX equipment

Mobile WiMAX equipment is available for the 2.6GHz and 3.5GHz bands and networks are launching in a number of locations around the world. However, at present, WiMAX equipment only operates in TDD unpaired spectrum and is not available for lower frequencies. In the UK, the most suitable spectrum for potential WiMAX use is spectrum in the 2.6GHz band.

LTE equipment

The LTE standard was finalised in 2008 and a number of commercial deployments are planned, with commercial availability of services expected to commence in 2010. In Norway and Sweden, LTE is being rolled out in 2.6GHz by Telia-Sonera and in the US it is being introduced in the 700MHz band by Verizon Wireless. It is in these two bands that equipment is first likely to appear but LTE is already standardised for 900MHz, 1800MHz and 2.1GHz.

LTE has not as yet been standardised for the 800MHz band. However, in March 2009 3GPP established a working group to finalise the specification of LTE in the CEPT 800MHz band plan. Their work should complete by September 2009 at the earliest and December 2009 at the latest. A good working assumption is that the first commercial equipment should be available 12-18 months after the completion of the specification, therefore late 2010 to mid 2011. The 2011 date corresponds with affirmations made by equipment manufacturers to mobile operators. To be clear, this date corresponds to the availability of base station equipment and dongles. It may be some time before handsets would be available which used the 800MHz band.

The 2G spectrum

The 2G spectrum is at present used for 2G voice and narrowband data services. A number of operators in Europe have expressed a desire to progressively clear these bands for data-centric services (such as 3G or NGM). However, the process of clearing this spectrum is complex and expensive. Ofcom's figures for the costs of clearance are outlined in the mechanisms annex above.

The 3G spectrum

The 3G spectrum is used for 3G data services, and reports suggest that all of the MNOs are beginning to fully deploy their available spectrum in some areas. With the growing popularity of 3G services it seems unlikely that 2.1GHz will be refarmed for other uses in the UK in the near future.

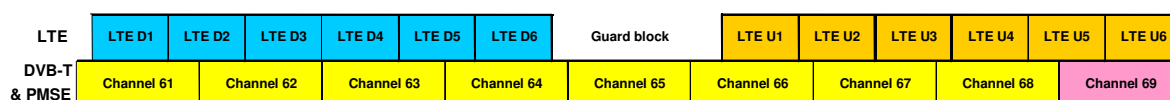
2.6GHz spectrum

2.6GHz spectrum is not used in the UK at the moment. It would be available to use as soon as it is awarded. Ofcom plans to award the band using a mechanism which would allow the split of the band between paired and unpaired use to be determined by the market. In my preferred set of measures I suggest using the CEPT harmonised band plan which fixes the division between paired and unpaired spectrum.

800MHz spectrum

Figure 14 below shows how the provisionally agreed channels for LTE usage map to the existing DTT channels.

Figure 14 – CEPT LTE 800MHz band plan and DTT channelisation



After DSO completes, in some regions Channels 61 and 62 will remain in use. Where channel 61 is used, the 2 x 5MHz LTE blocks 1 and 2 will not be usable. Where channel 62 is used, the 2 x 5MHz LTE blocks 2 and 3 will not be usable. PMSE usage in channel 69 prevents the 2 x 5MHz LTE blocks 5 and 6 from being used.

The major concern about using LTE in areas where channels 61 and 62 had been cleared was the risk of co-channel interference from areas where these channels were still being used for high-powered DTT broadcasts (both nationally and from abroad) into the mobile downlinks.

If PMSE users, who are geographically concentrated, could be cleared from Channel 69 by the second half of 2012 then a 2 x 10MHz block suitable for mobile communications would become available nationwide. However, this could impose some costs on PMSE users and were Government to consider such a move, compensation and assistance to users might provide for a smoother transition.

From mid-2011 onwards, the second 2 x 10MHz LTE block (LTE blocks 3 and 4 in the diagram), would become increasingly available in central and south-east England in areas where channel 62 is not being used.

Further work on the level of resilience LTE could display to DTT transmissions from neighbouring areas is being conducted by Ofcom and Arqiva. The initial view from Arqiva is that the spectrum will be usable in areas shielded by terrain from television transmissions using overlapping ranges of frequencies. However, more detailed results are awaited.

Annex 4 - About the author

Kip Meek is Chair of the Ingenious Consulting Network and a board member of Ingenious Media. Ingenious Media is a provider of media and telecoms investment and advisory services. Kip is also Chair of the Broadband Stakeholder Group, a group set up to advise the UK government on broadband issues. In addition to the above, Kip is a director of RadioCentre, the body representing commercial radio in the UK and of Phorm, a pre-revenue start-up that is attempting to build a business around better targeted advertising on the internet.



Prior to joining Ingenious, he was at Ofcom where he held a variety of responsibilities, including chairing the European Regulators' Group. Before joining Ofcom, he was Managing Director of Spectrum Strategy Consultants.

Glossary

- 1800MHz** This spectrum uses 1710-1785MHz to send information from the mobile handset to the base station (uplink) and 1805-1880 MHz for the other direction (downlink).
- In the UK, Orange and T-Mobile hold 2 x 30MHz each of this spectrum, and Vodafone and O2 hold just under 2 x 6MHz each.
- 2.1GHz** This spectrum uses 1920-1980MHz to send information from the mobile handset to the base station (uplink) and 2110-2170MHz for the other direction (downlink).
- In the UK, all five of the current mobile operators won access to this band in the 2000 auctions. Vodafone and Three have access to 2 x 15MHz each of this spectrum, the others have access to 2 x 10MHz.
- 2.6GHz** This spectrum consists of 190MHz of cleared spectrum. The harmonised CEPT band plan defines a paired element, suitable for LTE, and an unpaired element, suitable for WiMAX.
- The paired element uses 2500-2570MHz to send information from the mobile handset to the base station (uplink) and 2620-2690MHz for the other direction (downlink).
- The unpaired element uses 2570-2620MHz for both uplink and downlink.
- This spectrum was due to be auctioned by Ofcom in the summer of 2008 but legal action by operators has prevented its disposal. Ofcom's web page for this award can be found at <http://www.ofcom.org.uk/consult/condocs/2ghzawards/>
- 2G** 2G mobile phone systems provided three major benefits over the old analogue services. 2G phone conversations were digitally encrypted, 2G systems were significantly more efficient on the spectrum allowing for far greater mobile phone penetration levels; and 2G introduced data services for mobile, starting with SMS text messages.
- All of the UK operators, apart from Three, operate 2G networks.
- 3G** 3G is the third generation of telecommunication hardware standards and

general technology for mobile networking, superseding 2G. It is based on an International Telecommunication Union (ITU) family of standards.

3G networks enable network operators to offer users a wider range of more advanced services while achieving greater network capacity through improved efficiency of spectrum use. Services include voice telephone and broadband wireless data.

In the UK, the UMTS version of 3G is used by all operators.

3G HSPA

HSPA is a revision of the original 3G UMTS standard introduced in 2007. It improves the end-user experience by increasing peak data rates up to 14Mbps in the downlink and 5.8Mbps in the uplink. It also reduces latency and provides up to five times more system capacity in the downlink and up to twice as much system capacity in the uplink.

It is a composite of two standards, HSDPA (high speed downlink packet access) and HSUPA (high speed uplink packet access).

800MHz

This spectrum is becoming available for mobile and other uses in many countries across Europe because of the move to digital terrestrial television broadcasting. In its probable mobile configuration this spectrum will use 832-862MHz to send information from the mobile handset to the base station (uplink) and 793-823MHz for the other direction (downlink).

In the UK, Ofcom has been dealing with 800MHz as part of its Digital Dividend Review (DDR) project. The relevant documents can be found at <http://www.ofcom.org.uk/consult/condocs/800mhz/>

900MHz

This spectrum uses 890-915MHz to send information from the mobile handset to the base station (uplink) and 935-960MHz for the other direction (downlink).

In the UK, Vodafone and O2 hold just over 2 x 17MHz each of this spectrum.

Administrative incentive pricing (AIP)

The charging of annual fees for the holding of spectrum that reflect the opportunity cost of the holding of that spectrum. The primary purpose in applying AIP is not, in general, to achieve any specific short-term change in the use of spectrum. Rather, it is to ensure that the holders of spectrum fully recognise the costs that their use imposes on society by holding spectrum (or seeking to acquire additional spectrum), when making decisions.

CEPT

The European Conference of Postal and Telecommunications

Administrations - CEPT - was established in 1959 by 19 countries, which expanded to 26 during its first ten years. Original members were the monopoly-holding postal and telecommunications administrations. CEPT's activities included co-operation on commercial, operational, regulatory and technical standardisation issues.

As a response to the convergence in the telecommunications sector and the requirements of the information society, the two committees dealing separately with radiocommunications and telecommunications were replaced by the Electronic Communications Committee.

FDD

Frequency-division duplexing (FDD) means that the transmitter and receiver operate at different carrier frequencies. The station must be able to send and receive a transmission at the same time, and does so by altering the frequency at which it sends and receives slightly.

Current 2G and 3G systems in use in the UK use FDD, as will LTE.

GSM

GSM (Global System for Mobile communication) is a digital mobile telephony system that is widely used in Europe and other parts of the world. 2G services based on GSM technology were first launched in Finland in 1991. Both 3G UMTS and LTE belong to the GSM family of standards.

GSM directive

This is the Council Directive 87/372/EEC which restricts the use of part of the 900MHz spectrum band to GSM access technologies only.

In November 2008 the European Commission published a proposal to amend this Directive to open the frequency band to advanced mobile data and multimedia services such as 3G HSPA and LTE. This will increase the number and choice of wireless services available in the EU, expanding wireless services coverage and reducing network deployment costs.

The new Directive is likely to come into force in 2009.

Hot spots

Geographic areas of high demand for voice and data services, such as train stations, sports venues and central business districts.

International harmonisation

The process by which the usage of certain frequency bands for a particular purpose is agreed internationally. International harmonisation is important in providing the scale necessary for cheaper terminals to be manufactured.

LTE

3GPP long-term evolution (LTE) is a standard for mobile broadband developed as an evolution to 3G HSPA. It incorporates the same standards as used by the internet (IP) to deliver an experience similar to using a fast

wired connection.

LTE overcomes the limitations of 3G; it is far more robust, internet-centric and will be able to deliver peak data rates of over 300Mbps for some types of equipment. However for high speeds to be achieved, it will need to be deployed using large spectrum blocks. It will initially be deployed in the paired section of the 2.6GHz block but will eventually be usable in all currently used mobile bands.

MNO	Mobile network operator.
Mobile broadband	A term which represents cellular systems which are able to deliver a broadband service (greater than 1 Mbps). Unlike Wi-Fi hotspots, which serve only a small defined area, mobile broadband provides true wide-area broadband connectivity.
NGM	Next generation mobile (NGM) is an unofficial term describing standard such as LTE and WiMAX, which represent an evolutionary step over existing 3G technologies. The main benefits of NGM systems are greater efficiency of use of spectrum, the incorporation of standard internet protocols and the promise of far greater speeds for end-users.
Not spots	<p>These are areas of particularly poor mobile coverage situated within areas of otherwise good mobile coverage.</p> <p>A number of reasons can result in not spots, including particularly shielded terrain in cities and areas where planning permission for base stations is difficult to obtain.</p>
Paired spectrum	See FDD
PMSE	Programme Making and Special Events users often use the radio spectrum for wireless microphones and television cameras.
Sub-1GHz spectrum	Spectrum below 1GHz is particularly suitable for providing wide-area coverage in rural areas and deep in-building penetration in built-up areas. Access to sub-1GHz spectrum can significantly reduce network costs for an operator.
TDD	Time-division duplexing (TDD) is the application of time-division multiplexing to separate outward and return signals. It allows two-way communication using the same spectrum for uplink and downlink. TDD has a strong advantage in the case where the asymmetry of the uplink and downlink data speed is variable. As the amount of uplink data increases,

more bandwidth can dynamically be allocated to that and as it shrinks it can be taken away.

WiMAX is currently standardised to use TDD.

UMTS

Universal Mobile Telecommunications System (UMTS) is one of the third-generation (3G) mobile telecommunications technologies, which is also being developed into a 4G technology. UMTS is standardized by the 3GPP, and is the European answer to the ITU requirements for 3G cellular radio systems. It is the most widely used version of a 3G technology.

Unpaired spectrum

See TDD

WiMAX

WiMAX is a new mobile broadband standard which overcomes many of the limitations faced by 3G. WiMAX has currently been standardised for the 2.6GHz spectrum due for release across Europe. It incorporates the same protocols as used by the internet (IP) to deliver an experience similar to using a fast wired connection.

Although some substantial WiMAX deployments are taking place globally, most existing operators in developed countries are awaiting the LTE standard.