Report for Ofcom

Spectrum opportunity cost calculations in parts of VHF Band I

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analysys mason

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1 Introduction to the study

The historic under-utilisation of VHF Band I spectrum, both before and after the implementation of the current AIP prices, suggests that the current AIP pricing may be too high.

Consequently, Ofcom has commissioned Analysys Mason to determine the opportunity costs for some of the spectrum in VHF Band I, specifically the frequencies:

- 55.75MHz to 60.75MHz
- 62.75MHz to 67.75MHz
- 67.8375MHz to 68MHz.

For the sake of convenience, throughout the remainder of this report these specific frequencies will be referred to collectively as 'Band I'. If referring to the entirety of VHF Band I (55.75–68MHz) we will refer to "VHF Band I" to avoid ambiguity.

Ofcom will use our opportunity costs estimates as a basis for setting AIP for the spectrum. In this study we have used a methodology consistent with those used in other similar studies:

- by Indepen in their calculation of opportunity costing for aeronautical and maritime spectrum[1] and terrestrial TV and radio broadcasting[2]

- as well as our own ongoing study detailing the opportunity costs of the spectrum allocated to programme making and special events (PMSE), which is due to be published later in 2009.

The remainder of this document is structured as follows:

- Section 2 provides an introduction to the characteristics and existing uses of VHF Band I spectrum.
- Section 3 outlines our approach to determining opportunity costs for Band I spectrum.
- Section 4 contains our opportunity cost calculations and reasoning.
- Section 5 is our conclusion.

1 Indepen Consulting Ltd, *Aeronautical and maritime spectrum pricing*, April 2007

2 Indepen Consulting Ltd, *Study into the potential application of Administered Incentive Pricing to spectrum used for Terrestrial TV and Radio Broadcasting*, October 2005

2 Introduction to VHF Band I

This section gives an overview of the physical properties of VHF Band I spectrum, as well as the applications which currently use the spectrum.

2.1 Characteristics of VHF Band I spectrum

For the purposes of this document VHF Band I is defined as the spectrum in the frequency range 55.75–68MHz. The low frequency and high wavelength result in the spectrum having good long-range signal propagation. This is potentially extremely useful, as information can be relayed to a large portion of the country using a relatively small number of sites.

However, the same physical properties also lead to significant disadvantages.

- Although mobile services could potentially use VHF Band I spectrum, in practice the antennas required are impractically large when compared to those suitable for other available bands.
- A significant disadvantage with VHF Band I spectrum is the relatively high level of interference encountered. Good long-distance propagation means that interference from other users can be felt from locations as distant as Canada. Besides deliberate use, additional interference can come from lightning strikes, electrical equipment (e.g. in street works, motors) as well as inter-modulation products from other pieces of telecommunications equipment.

There is currently an MoU in place between the UK and France (Great Britain–France or "G-F"), which states that each country has preferential use of alternating 200kHz blocks of spectrum (i.e. 16×12.5kHz channels) between 47MHz and 68MHz. In blocks where each country has preferential use, the field strength, calculated on the basis of 50% locations, 10% time, shall not exceed 6dBμV/m at 10 metres above ground level at all points 80km inside the neighbouring country.

In blocks where each country has non-preferential use, the field strength must not exceed 6dBμV/m at 10 metres above ground level at all points on the coastline of the neighbouring country. The G-F Band I MoU also requires that the aggregate interference from any impacting UK assignments also needs to be taken into consideration. There are currently no Band I MoUs between the UK and Belgium, the Netherlands or Ireland (G-BEL, G-HOL, or G-IRL).

2.2 Overview of the current uses of VHF Band I

Business radio

Business radio (BR) is currently allocated the frequencies 55.75–60.75MHz paired with 62.75–67.75MHz and 67.8375–68MHz, while the remaining frequencies in VHF Band I are allocated to the MoD and on a secondary basis to the PMSE band manager, the Joint Frequency Management Group (JFMG) as well as amateur radio use.

Band I spectrum is currently used lightly. This is illustrated by the fact that only 85 separate assignments were made in the year ending January 2009. Of these 85 assignments, over 80% were in the frequency range 67.94375–68MHz.[3] The assignments are defined as "on site speech and data systems" with the main examples being for:

- clock synchronisation – signals are sent to clocks from a central location ensuring that all clocks show the exact same time
- paging systems – systems allowing messages to be sent "one way" within a building or complex of buildings. The systems have an advantage over public mobile networks in that they continue to function even during emergency situations.

The remaining assignments were spread over the remainder of the available frequencies and were non-operational development assignments; these are secondary users of the spectrum and operate on a non-interference basis. The precise details of these non-operational assignments are confidential.

PMSE use

PMSE does not use any of the frequencies considered in this report but has been allocated the adjacent frequencies 60.75–62.75MHz and 67.75–67.84MHz (referred to within this document as PMSE Band I). JFMG only makes a small number of assignments in PMSE Band I: between October 2007 and September 2008 224 assignments were made in PMSE Band I. This is a low number compared to the much larger number of assignments (of the order of tens of thousands) which JFMG makes for PMSE in the UHF1 (425–450MHz), UHF2 (450–470MHz) and TV interleaved bands (470–550MHz and 630–790MHz).

PMSE assignments in PMSE Band I are for three main applications.

[3] The same narrow band of frequencies was used to maximise spectral efficiency, not for any specific reason relating to particular choices of frequency.

- Audio programme links – fixed, mobile, portable or airborne point-to-point links used to carry audio between locations. The distances over which audio is transmitted can vary from very short (e.g. within a studio) to much further (e.g. from an outside broadcast unit to a studio). Radio microphones using powers in access of 50mW also fall into this category.

- Talkback – voice communications used to relay instructions between individuals involved in the production of a programme or event. It can provide one- or two-way communication. An example includes an outside broadcast unit communicating with a studio.

- Audio Distribution Systems (ADS) – low-powered distribution systems used at sporting events to relay referee comments or broadcast commentary to spectators. This is not strictly PMSE use, and where used this is on a non-interference basis to PMSE.

3 Approach to determining opportunity costs

Our approach to determining the opportunity costs for the Band I spectrum is based on the method outlined by Indepen[4] in their previous work for Ofcom.

A high-level illustration of our approach to opportunity cost estimation is outlined in Figure 3.1.

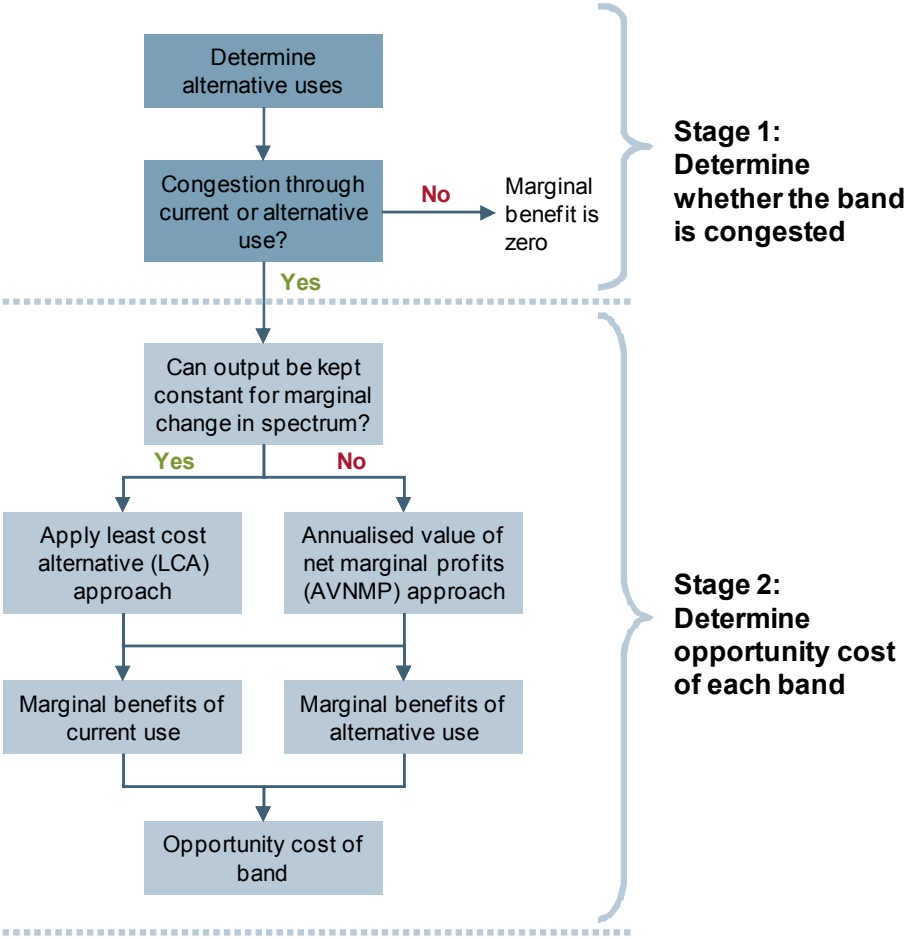

Figure 3.1: Proposed methodology to determine opportunity costs [Source: Analysys Mason]

Our approach has been aided by a number of discussions held with members of the industry. This has helped us to understand the current level of demand for Band I spectrum, how this demand could potentially evolve over time, and any applications which could make use of the spectrum in the future.

[4] In their three reports: "*An economic study to review spectrum pricing*" February 2004, "*Study into the potential application of Administered Incentive Pricing to spectrum used for Terrestrial TV and Radio Broadcasting*" October 2005, and "*Aeronautical and maritime spectrum pricing*" April 2007.

The remainder of this section explains in more detail the calculations and analysis involved in each stage.

3.1 Stage 1: Determining whether Band I is congested

The first stage is to assess whether there is currently congestion in Band I. If it is determined that the band is uncongested and will continue to be uncongested, even with the introduction of alternative uses, then the marginal benefit of the spectrum is zero.

Congestion is defined as a situation in which there is demand for spectrum from one or more uses which leads to there being insufficient spectrum for all users. Therefore, congestion can originate either from existing or from alternative (and potentially more efficient) uses of spectrum. It is therefore important to assess all possible uses and then determine whether congestion is likely to occur. If the conclusion of this assessment is that the band is likely to be congested, there is a non-zero marginal benefit and AIP should be applied to the band.

A typical method of determining whether congestion is currently present is to study the effects of removing one increment of spectrum. If the spectrum leads to any existing uses not being able to operate then congestion is present. Likewise, when determining whether congestion is present after the deployment of an alternative use the effect of removing an increment of spectrum on both existing and alternative use would need to be studied. If removal of an increment leads to either existing or alternative uses being unable to operate then congestion is present.

3.2 Stage 2: Determining opportunity cost based on marginal benefits

Should we determine that either the existing or alternate use leads to congestion, then the second step is to derive the marginal benefits to all relevant current and alternative uses of Band I spectrum.

The marginal benefit of spectrum is defined as the incremental benefit of using that particular spectrum opposed to either another frequency or a non-spectrum alternative. We suggest that two different methods can be employed to determine marginal benefits; this is consistent with previous studies for Ofcom:

- **the least cost alternative (LCA**) – This approach assumes that there is no reduction in output (no output would be lost by switching to an alternative). Marginal benefits are purely determined from the difference in cost between using the current spectrum and using the *least cost alternative* option.

- **the annualised value of net marginal profits (AVNMP)** – This approach assumes that a reduction in output will be caused by switching to an alternative. Marginal benefits are consequently determined by the combined loss of revenue (the output) and increase in cost of

the next best alternative. These inputs will be fed into a business plan in order to find the *annualised value of net marginal profits*.

The opportunity cost of the band is derived from the marginal benefits of all current and alternative uses. If the marginal benefits from current use are the highest value, we set the opportunity cost of the band at this level. In cases where the marginal benefits of an alternative use is higher, we set the opportunity cost of a band at the midpoint between the marginal benefits of current and the highest value alternative use.

This approach is in line with that applied by Indepen in their reports "*An economic study to review spectrum pricing*" February 2004, "*Study into the potential application of Administered Incentive Pricing to spectrum used for Terrestrial TV and Radio Broadcasting*" October 2005, and "*Aeronautical and maritime spectrum pricing*" April 2007. Further details can be found in these reports.

4 Opportunity cost estimates

4.1 Congestion in Band I caused by existing uses

The first part of our methodology is to review whether congestion is currently present in the spectrum. We go through each current use in turn and come to an overall view on the congestion of the band.

4.1.1 On-site speech and data systems

Within the year ending January 2009, 74 assignments were made for on-site speech and data systems with the main applications being clock synchronisation and paging systems. All of these assignments are for 12.5kHz increments between 67.94MHz and 68MHz.

On-site speech and data systems are low-powered devices and as such users do not favour the Band I blocks where the UK has preference over France. The exception may be on the south coast of England where the use of UK preferential blocks would ensure that interference is not caused to users in France.

Whether congestion is present in the band was determined by seeing if removing one increment of spectrum would cause a reduction in the number of applications which could use the spectrum. In this case an increment of 12.5kHz is appropriate as all assignments are made for this bandwidth.

We conclude that should one 12.5kHz increment of spectrum be removed from the Band I, then all affected assignments could move to different regions of the allocation and no output would be lost. Even if the increment removed were in the range 67.94–68MHz, the affected assignments would have no problem moving because, as we noted in Section 2.2, all assignments are allocated in this range for spectral efficiency reasons and not due to a fundamental difference in the usability of the spectrum.

Assignment growth over the last few years has been minimal. We do not anticipate growth in assignments over the next few years. Paging systems have been available in these frequencies for a number of years (and indeed demand for paging services is now often met by the use of other applications e.g. SMS). Clock synchronisation services, including GPS-based systems, are now available in other parts of the spectrum. We believe that a decrease in clock synchronisation assignments is more likely than an increase.

In conclusion we believe that there is currently no congestion and none is likely to occur due to the growth of on-site speech and data systems.

4.1.2 Non-operational development assignments

As mentioned in Section 2.2 there were fewer than 20 non-operational development assignments made in the year ending January 2009, for scientific and experimental purposes. Many of these assignments are for low-powered devices and as such do not favour the Band I blocks where the UK has preference over France. As non-operational development assignments are currently offered on a secondary and non-interference basis they do not contribute to the overall congestion of the band.

The services currently using the spectrum for non-operational development could be considered as alternative uses to on-site speech and data systems in the Band I spectrum. However, even if they were to gain access, there is more than enough spectrum to incorporate both these services (at least at current levels of use) and on-site speech and data systems, without leading to the band being congested.

4.1.3 Conclusion

Although there are a number of different current uses for the Band I spectrum, only a small portion of the spectrum is actually utilised. Of the assignments made in the spectrum, only a small number of these users would rather have UK preferential spectrum.

Accordingly we believe that there is currently no congestion from these uses and we do not see any occurring in the foreseeable future.

4.2 Congestion of Band I caused by potential alternative uses

Given that we have determined that existing uses do not lead to congestion of Band I, we now have to determine whether if the introduction of alternative uses would lead to congestion of the band.

During the recent consultation, "*Radio Restricted Services and 55 to 68MHz: A consultation",* Ofcom asked what alternative uses there could be for Band I spectrum, there were only a few suggestions. Based on usage of similar spectrum and the consultation, we have identified a number of potential alternative uses:

- programme making and special events (PMSE)
- audio distribution systems (ADS)
- scanning telemetry
- business radio.

4.2.1 Programme making and special events (PMSE)

As mentioned above, PMSE currently has access to 2.09MHz of spectrum between the frequencies 55.75MHz and 68MHz, used primarily for audio programme links.

PMSE devices are generally low powered and as such do not favour the Band I blocks where the UK has preference over France. The exception may be on the south coast of England where the use of UK preferential blocks would ensure that interference is not caused to users in France.

This band of PMSE spectrum is currently under-used and we do not believe that any congestion is present. Even at peak times during large events which do use this range, such as the Open Golf Championship, demand never meets capacity.

Over the last four years[5] the number of assignments which JFMG has made in these frequencies has only increased at an average of 3% per annum, with a total of 224 assignments made in the year ending September 2008. Based on this information we can reasonably assume that congestion is not likely to occur in the foreseeable future.

Our views are backed up by two other sources.

- Quotient Associates, in their December 2006 report *"Supply and demand of spectrum for Programme Making and Special Events in the UK",* estimated that by 2014 there would still be no congestion in this region of the frequency range.
- JFMG's response to the recent consultation, "*Radio Restricted Services and 55 to 68MHz: A consultation*", did not suggest allocating additional Band I spectrum to PMSE, suggesting that the PMSE community has enough spectrum to meet their needs.

We conclude that the potential for PMSE use would not cause congestion in Band I.

4.2.2 Audio distribution systems (ADS)

As mentioned above, in 2006 a successful ADS trial began where services could be offered in PMSE Band I spectrum (on a non-interference basis to other PMSE users).

ADS devices are generally low powered and as such do not favour the Band I blocks where the UK has preference over France. The exception may be on the south coast of England where the use of UK preferential blocks would ensure that interference is not caused to users in France.

Due to this spectrum-sharing arrangement, ADS cannot be used at events where PMSE is heavily used.

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5 October 2004 until September 2008

A number of responses to the Ofcom consultation "Radio Restricted Services and 55 to 68MHz: A consultation" suggested that ADS could be allocated its own spectrum in the current Band I allocation. However, within the same consultation Ofcom stated that during the trial no interference problems occurred with ADS sharing spectrum with PMSE and believes that the two can currently co-exist.[6] Since the date of the consultation, ADS uptake has been sufficiently slow that there is no current need to provide additional ADS spectrum outside of the PMSE allocation.

If, in the future, ADS demand was to increase to a sufficient level so that specific Band I assignments were required then we believe that such needs would be relatively limited in number and unlikely to lead to spectrum congestion given the amount of spectrum currently unused in Band I.

We conclude that potential ADS use would not cause congestion in Band I.

4.2.3 Scanning telemetry and similar systems

Scanning telemetry incorporates a range of applications which involve remote monitoring and remote control. Telemetry can be relatively interference tolerant and can deal with high levels of interference: e.g. if necessary signals can be resent at a later time. Scanning telemetry systems aiming for wide-area coverage will use high power at the central scanners, and systems seeking national coverage will operate near the south coast, so they will seek to use UK preferential blocks under the MoU.

Scanning telemetry is currently used in other bands such as VHF Band III and the 450–470MHz range (UHF2). Additional future demand from existing scanning telemetry users (e.g. for remote monitoring of water levels) is likely to use the existing bands in order to make use of the economies of scale in existing infrastructure (central scanners etc).

New systems are a possibility. From discussions with Ofcom, we believe that even if one or two new national coverage systems each using a significant amount of spectrum (e.g. 2×2MHz) were to be deployed in Band I there is sufficient spectrum so that they could be accommodated in the UK preferential blocks without causing congestion.

4.2.4 Business radio

Business radio has the option to use this Band I spectrum but they choose not to, favouring higher frequencies in the UHF1 (425–450MHz) and particularly UHF2 (450–470MHz) bands. Should business radio start to utilise the spectrum, there could be users who would deploy high-powered,

[6] Radio Restricted Services and 55 to 68MHz policy statement, paragraph 2.9, "In light of this demand and the fact that the trial has shown that ADS and PMSE spectrum can co-exist (and thereby better reflect our general duty under the Communications Act to secure "the optimal use for wireless telegraphy of the electro-magnetic spectrum") we proposed to introduce a more permanent arrangement for ADS."

wide-area coverage systems. The small number of users who deploy such systems close to the French border will favour UK preferential spectrum.

Relatively high levels of interference, combined with large antenna sizes make Band I a less attractive option when compared to UHF1 and UHF2. The majority of business radio equipment available uses these bands.

Current levels of AIP in the band do not appear to be the limiting factor, as we understand that the band was under-used even before AIP was introduced.

We believe that demand for business radio in Band I is unlikely to significantly increase.

5 Conclusion: Opportunity cost of Band I spectrum

There is currently no congestion in Band I spectrum (either preferential or non-preferential) and we do not expect congestion to occur in the foreseeable future from either current or alternative uses in either the UK or France preferential blocks.

We conclude that as there is not likely to be congestion in any Band I spectrum, the opportunity cost of the spectrum is zero. Accordingly we recommend to Ofcom that access to the spectrum should be charged for based on administration costs alone.