Independent Audit of SPECTRUM HOLDINGS

Emerging Issues

A consultation document

July 2005

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Foreword

In the 2004 Pre-Budget Report the Chancellor of the Exchequer asked me to undertake an Independent Audit of Spectrum Holdings. In advance of my final report – due before the Pre-Budget report this year – we are consulting on the issues emerging from our work so far.

I am keen to get a wide range of responses to this consultation. This document will be of direct interest to a wide range of users, and I would welcome their views on the suggestions set out. But I would also like to hear from potential beneficiaries of the measures we are outlining – for example, commercial users (large and small scale) who may be able to utilise released spectrum or that opened for sharing.

Our terms of reference[1] cover spectrum used by the public sector and that used for fixed links, below 15GHz (where there is likely to be pressure on spectrum in the future). We have focused on bands with potential for civil use, where there might be scope to release them or open them up to shared use. Between now and our final report we will continue to work with the users of these bands on their future use and potential.

In parallel to our analysis of specific bands, we suggest a process through which public sector users of spectrum will need to take a thorough look at their spectrum requirements and how these are met, now and in the future. We also look at putting in a place a structure designed to incentivise those bodies managing or using spectrum to make more effective use of it – perhaps through introducing trading, or increasing band sharing. Pricing is also an important tool for ensuring that the value of spectrum use is recognised and more efficient use realised, and we will be exploring possibilities for making this more effective.

We are keen to hear views on all of the issues examined in this document. The consultation questions and how to respond, or contact us, are set out in Annex B.

Martin Cave

[1] Attached at Annex A in full, and available at www.spectrumaudit.org.uk

Chapter 1

Executive Summary

1.1 Introduction

The radio spectrum is a valuable resource for the UK. It contributes some £24 billion to the economy each year[2] and is essential for the operation of many areas of business, communications and key Government and public services.

The public sector is a significant user of spectrum, accounting to around 44 per cent of spectrum use between 0.174-15.23GHz.[3] Major public sector users such as the Ministry of Defence (MoD) have responsibility for managing significant holdings in valuable parts of the spectrum, often for essential safety of life and defence purposes.

At a time when market mechanisms are being introduced for commercial users of spectrum, this Audit will examine public sector use, looking at current holdings and identifying ways to improve the efficiency of spectrum management in those bands.[4] The Audit's remit also covers fixed links – identified as an area where the market alone might not maximise the value and efficiency of use of spectrum. This Emerging Issues paper flags up the key areas that the Audit is interested in, and invites comments on issues raised in these areas (which are summarised below). These views will inform our final report, due in the autumn.

Historically, allocations to public sector users have been made on a "command and control" basis by the regulator when needs arose. It is clear that such a system for new allocations is not sustainable going forward as market forces are introduced into spectrum management and the pace of technology development increases. As demand for spectrum has risen, and is likely to continue to do so, it becomes even more important to ensure that public sector holdings are managed and utilised in an effective and efficient way.

Significant steps have been made over the years to recognise the value of spectrum as an asset in the public sector and to ensure that efficiency in use is encouraged. The MoD in particular has worked cooperatively with the Radiocommunications Agency and now Ofcom (the Office of Communications) where there has been a need for civil access to their spectrum, and bands have been made available on a shared basis or released to civil management. Administered Incentive Pricing (AIP)

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[2] Ofcom Spectrum Framework Review Statement www.ofcom.org.uk/consult/condocs/sfr/sfr/

[3] The spectrum use figures in this document are based on summation of fractional bandwidths (defined as (Band Top-Band Low)/Band Centre), and for public sector use (not including broadcasting in this instance) count both significant use and band management responsibilities, while for non-public sector only significant use is counted. Fractional bandwidths have been used to better reflect the relative importance of 50 MHz at 400 MHz compared to 50 MHz at 15 GHz. Because of sharing, both between uses and users, the raw totals sum to above 100%, and the numbers presented have been scaled to represent the percentage of overall use that is attributable to the category in question.

[4] Throughout this document the concept of "efficient" use of spectrum will be used often. See the 2002 Review of Radio Spectrum Management (page 7) for an expansion of this term, covering technical and economic efficiency and efficiency in public policy terms. http://www.ofcom.org.uk/static/archive/ra/spectrum-review/index.htm

has also been introduced and applied to many public sector allocations to reflect the opportunity cost of their use.

This Audit will look at the next steps in this process to encourage efficiency of use. Our remit is to examine current holdings and use thereof, to explore both ways of making more spectrum available for commercial use in these areas and to ensure that ongoing incentive effects for making best use of spectrum are maximised (see Annex A for full terms of reference).

1.2 Analysis of specific bands

The Audit is focusing primarily, but not exclusively, on those bands below 15GHz, as experience suggests that these will be the most valuable for alternative use now and in the near to medium term future. Where specific issues are identified in a higher band this will however also be included in the Audit.

The Audit team have been examining some specific bands with the key public sector organisations which manage them, to ascertain current and potential future use and the scope for releasing bands (or part of them) or increasing sharing. These are covered at a high level in chapters 5 & 6 covering the Ministry of Defence and Civil Aviation Authority and listed, with current use, in Annex C. We will continue to discuss these bands with the organisations using them, and the Final Report will include a comprehensive audit of these bands, covering current and prospective future use, intensity of use and scope for releasing bands in whole or in part, or increasing sharing. These bands have been chosen because they were felt to offer most potential for civil utilisation. In the area of fixed links, several bands will be examined to determine whether current or future management processes are sufficient to deliver spectrally efficient outcomes (set out in chapter 11). We ask:

To judge potential demand, we would welcome views on the bands highlighted – listed in Annex C and detailed in the chapters on Ministry of Defence, Aeronautical and Fixed Links. Would possibilities for (i) sharing (including time limited or ad hoc sharing) or (ii) freed up bandwidth in these bands be of interest to other users? Are there other bands the Audit should examine?

1.3 Public sector access to spectrum

The introduction of trading and liberalisation, creating a spectrum market, necessarily has implications for public sector access to and use of spectrum. We look at processes and criteria for accessing spectrum where new needs arise, in the short to medium term before full trading, and in the longer term, where a fully functioning market could be expected to meet all but exceptional needs. The introduction of trading introduces both risks and opportunities for the public sector, and we examine these. For example, current spectrum rights and sharing arrangements for public sector users may need to be more carefully defined both to minimise interference and to take advantage of the commercial avenues opened up by trading. The application of Recognised Spectrum Access is a possibility we will be examining here. We ask:

Do you agree that public bodies should in general expect to meet future spectrum needs through the market? Are the process and criteria outlined a suitable means of deciding whether an administrative assignment should be made if this is not possible?

Licensing: We would be interested in views on the treatment of the Crown. Do you agree with the idea of using Recognised Spectrum Access (RSA) to define the rights of bodies covered by Crown immunity and enable tradability?

1.4 Strategy and future demand

In order to plan for effective use of spectrum, future needs must be identified. The Audit team has commissioned a study into future commercial demand to determine what the likely future needs will be and where they will fall. We are carrying out a parallel exercise on the public sector side on a bilateral basis with key users. Going forwards, in order to ensure that there is a process for identifying in good time where future needs may occur and how these need to be addressed, the Audit sees a greater role for Ofcom in collating market intelligence and the UK Spectrum Strategy Committee in expanding its role to develop a Forward Look for public sector spectrum. We ask:

Public sector demand: We would also welcome input into this consultation on likely future demand in the public sector and fixed links areas we have covered in this document.

Commercial market intelligence: In order that we do not overlook important future requirements below the 80% of users that our demand study is examining, we would be interested to hear views on likely future commercial demand, specifically those which may fall outside the scope of the commercial study.

We would welcome views on what information Ofcom could usefully collect in furthering its role to ensure the efficient use of public sector spectrum

1.5 Pricing

The Audit team is considering whether AIP as a tool could be made more sophisticated, better reflecting the value of use. AIP is currently not applied to some bands – typically navigation radar, NATO harmonised and managed and some aeronautical and maritime communications – and the Audit will examine further the case for introducing pricing in these bands and consider methodologies for doing so. Radar is a particular focus, as an area where valuable bands are being used by the public sector, in some cases without the opportunity cost of this being realised. We ask:

Do you agree with the principle that AIP should be introduced for (i) aeronautical and (ii) maritime navigation radar? If so what are your views on the best way to determine and impose AIP charges on radar?

Do you think there is scope through means other than pricing (e.g. technical regulations, better co-ordination) to enhance the utilisation and economic efficiency of radar bands?

Bands which are shared attract a rebate for public sector users – a positive step – but this is not applied in all cases, and there may be a case for applying a more rigorous methodology to recognise the benefits afforded by public sector users admitting others into their bands. In addition, there are issues of comparability in pricing between civil and military pricing, and between pricing for different types of

services, which we explore further. Alternatives to AIP are also considered, as well as the effectiveness of the current regime. We ask:

On the effectiveness of AIP:

- ***Do you agree that AIP should remain a primary mechanism for achieving efficient use of public sector spectrum?***
- ***Do you think there is merit in the mechanisms listed, or other alternative mechanisms to achieve efficient use of public sector spectrum, in addition to or instead of AIP?***
- ***How is this affected by Ofcom's proposals to move to greater market management of the spectrum?***

Do you agree that there is merit and potential benefit in exploring changes in AIP:

- ***To ensure the prices are kept up to date and reflect the current alternative use (e.g. bands currently charged as fixed which may be suitable for future mobile use)***
- ***To better reflect the real 'spectrum value curve' in and outside prime bands (c.f. band factor applied to commercial fixed links which is not applied to MoD fixed spectrum)***
- ***To provide a stronger incentive to public bodies to make more efficient use of their holdings (e.g. disposal or sharing; accounting changes that could best tie costs directly to use)***

We would welcome views on the economic rationale for and possible level of a system of 'freehold rents' or 'retainers' for bands which the MoD is not currently using but continues to hold a right to reclaim.

1.6 Sharing

Many public sector organisations already coexist with others in the same bands. The Audit team sees bandsharing as a valuable contribution to maximising use of spectrum, and is keen to explore ways of increasing the level of sharing in public sector bands. This consultation document sets out ways of addressing barriers to sharing. For example we invite views on the desirability and feasibility of a third party managing sharing and trading on behalf of public sector bodies as a solution to resource constraints on those organisations and a way of providing a commercial focus to what is otherwise seen as an operational necessity.

A study has been commissioned on behalf of the Audit to scope out the potential for new bandsharing techniques which might open up more possibilities for sharing, the results of which will be included in the Audit's final report.

Before any new sharing arrangements can be accepted on safety and security grounds, a high level of certainty based on thorough demonstration and testing will be necessary. The Audit is therefore also looking at whether the current test and development process is sufficiently flexible to facilitate this type of activity. The Spectrum Efficiency Scheme (SES) is a useful tool for researching new developments at an overview level, and we are also keen to receive views on whether this could be made more effective. We ask:

Would the existence of a third party intermediary to facilitate sharing between public sector organisations and other public/commercial bodies be likely to

increase the possibilities afforded by sharing? What roles should such a body have?

Would individual users find it useful to be able to negotiate over sharing/trading arrangements either directly with the MoD or organisation acting on their behalf?

What impact does the possibility of restrictions to be imposed in a time of civil emergency have on the attractiveness of sharing MoD spectrum?

The Audit team would welcome any views on how existing users can be assured that sharing will not compromise ongoing safety-critical or essential use, including through equipment standards, testing, management of liberalisation and appropriate operational and technical parameters.

Test & Development: The Audit would welcome any views on the effectiveness of the current T&D licence regime and how this might be improved. It would also welcome views from existing users on how much flexibility here would be considered reasonable.

The Audit team are interested in the potential for more sharing in the bands used by the public sector. Are there techniques or services in which you believe there is particular potential? For example, what are your views on the technological, operational and economic feasibility of sharing between radar and other technologies?

1.7 Incentive effects

The Audit team recognise that major public sector users of spectrum currently work positively and cooperatively with the regulator over their use of spectrum. However, beyond this – carried out on the basis of goodwill – and the application of AIP, there are no real incentives on these bodies to consider reducing their holdings or using their allocations more effectively. This paper sets out ideas for establishing a stronger incentive structure for public bodies and their spectrum use, considering the retention of income generated from utilising this asset, incorporation into commercialisation strategies and target setting.

1.8 Organisational

Processes internal to an organisation may have the unintended effect of encouraging the status quo in what could be a more dynamic environment in spectrum allocation and use, or even of acting as a barrier to forward planning of needs. Procurement and charging processes are examined in this regard, with a view to ensuring that those responsible for the operational use of spectrum have a real financial interest in making sure that use is efficient and spectrum holdings are released where possible. Sharing information about spectrum use and needs and coordinating spectrum management within an organisation are also examined.

1.9. Fixed Links

Included in our Audit as an area where the market may not deliver the most efficient outcome, as the nature of the licences granted may impede the delivery of spectrum to a higher value potential user through trading and liberalisation, we look at the nature of fixed links bands, examine some specific instances and ask:

The Audit team would like to hear from any prospective band managers who have considered, or would consider, band management in a fixed links band to hear views on potential barriers.

We would welcome views on the merits of the listed approaches to regulator intervention.

We would welcome views on whether a Technology "Spend to Save" scheme would be of benefit, and views on the Spectrum Efficiency scheme generally, including whether its scope could usefully be expanded.

1.10 International

Finally, this paper examines some of the European and international issues associated with public sector spectrum. We discuss the nature of international obligations and constraints which may prevent the UK from acting autonomously – for example in freeing up bands for alternative use or introducing new sharing arrangements, and set out some issues relevant to Audit considerations. We also set out the need for clarity to be established over the process for establishing UK positions to take to international fora to ensure effective representation.

We would welcome views on whether the issues highlighted accurately represent those likely to be key at an international level in taking forward the Audit's interests as outlined in this consultation document.

1.11 Broadcasting

The audit is not looking at broadcasting spectrum given the parallel agenda for analogue switch-off and conversion to full digital transmission. However, there are broadcasting-related uses in other areas of the spectrum, e.g. programme making or fixed links, which may fall within the holdings that the Audit is looking at.

Chapter 2

Public sector spectrum: acquisition and trading

2.1 Government Spectrum Policy Co-Ordination

Lead responsibility for coordinating Government spectrum policy is held by the UK Spectrum Strategy Committee (UKSSC), a standing Cabinet Office body. It is jointly chaired by DTI and MoD - an arrangement which allows issues relating either to public sector or commercial users to be resolved under neutral chairmanship - and has wide cross-Government membership. [5] The UKSSC structure is also the forum for coordinating international spectrum policy between Government and Ofcom. UKSSC has a number of interdepartmental subcommittees,[6] all of which have an Ofcom chair and Secretariat, apart from the PSSPG, which has an independent chair funded by Ofcom.

As Ofcom is not a Government department it is unable to be a formal member of UKSSC, instead being officially 'in attendance' at meetings, playing an important role linked to its depth of spectrum policy expertise and lead role in the subcommittees.

Ofcom is not obliged to abide by UKSSC decisions but most are implemented on a consensus basis following Ofcom input. The 2003 Communications Act (s5) grants the Secretary of State powers of ministerial direction over Ofcom for reasons of national security, public safety and health, compliance with international obligations and international relations. In practice it is likely that any formal direction would be made by the DTI Secretary of State after coordination through UKSSC to ensure that it represented Government consensus.

2.2 Spectrum Trading

Ofcom has set out a clear policy direction[7] towards implementing a market forces approach to spectrum management to help to encourage more efficient use. This will be achieved primarily through the introduction of trading and liberalisation:

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[5] Defence and Aviation are reserved matters; therefore the MoD and DfT (supported by CAA) represent UK interests in these areas at UKSSC. Historically, Scottish Office managed emergency service spectrum in Scotland, but with devolution this function transferred to Scottish Executive. There is no devolved responsibility for emergency services spectrum in Wales or NI.

[6] National Frequency Planning Group (NFPG): Responsible for maintaining the UK's Frequency Allocation Table. It also clears within government ECC Decisions with implications for the UK's radio spectrum.
National Frequency Assignment Panel (NFAP): Operates under the NFPG and considers requests for frequency assignments and maintains the National Frequency Register (NFR).
Working Group on Radio Site Clearance Policy (WGRSCP): Operates under NFPG and agrees policy and procedures for radio transmitters that could potentially cause harmful interference to essential or safety-of-life services.
Public Safety Spectrum Policy Group (PSSPG): Dedicated body to co-ordinate Emergency Services' spectrum needs. Independent chair funded by Ofcom and Ofcom secretariat.
International Frequency Planning Group (IFPG): Prepares the UK position for the next ITU World Radiocommunications Conference. Includes external non-government members.
International Broadcast Planning Group (IBPG

[7] Most recently in the Spectrum Framework Review (SFR) Statement http://www.ofcom.org.uk/consult/condocs/sfr/sfr/, and SFR Implementation Plan

- *Trading* entails allowing licence holders to transfer some or all of their rights and obligations to third parties. Trading is already live in some licence classes and Ofcom plans a phased introduction for other services over the next few years.

- The *liberalisation* agenda seeks to relax unnecessary restrictions on technology specification and other conditions attached to licences, including permitting applications for change of use. We agree with Ofcom's view that liberalisation should extend to public and commercial holders and use of spectrum unless there is a compelling argument otherwise. Where there is for instance a need for international harmonisation and interoperation, liberalisation may be undesirable or unfeasible.

The chapter explores the impact of trading and liberalisation – presenting both challenges and opportunities - on the public sector.

2.3 Role of the market in meeting new public spectrum needs

Our discussions with the MoD, CAA and others suggest there could be a number of pressures for additions to as well as disposals of public spectrum holdings in the medium-term. Historically, allocations to public sector users were made on a "command and control" basis by the Government when needs occurred. Many of these holdings date back several decades and were made when there was limited pressure on the spectrum - this is no longer the case.

There have also been more recent assignments to public sector users, mandated through the UKSSC structure, on a non-market basis. For example in the process of updating and consolidating their communications systems, emergency service users have, following a competitive procurement process, been allocated new spectrum in recent years (in this case spectrum was released from NATO use, in turn releasing other bands from legacy emergency service use as they migrated here). However there is a risk that these decisions may be driven more by the needs and interests of an individual public sector user than by the wider impacts on economic efficiency. Public procurement timescales can be long, and while there is the potential for administrative assignment of a particular band to the public sector in the short to medium term this could in the meantime inhibit alternative use of that spectrum.

Ofcom considers that auctions are generally the best mechanism for assigning spectrum that has been released for reuse to the regulator, but also acknowledges its own role in enabling essential public safety and national security needs to be met. As more spectrum is opened up to the market it is likely that trading will eventually replace refarming via the regulator as the main method of realising efficient use of the spectrum.

In an era of high and growing spectrum demand and where Ofcom may not have direct access to suitable spectrum bands, it is clear that relying on a command and control approach of administrative assignment to meet future public sector spectrum needs is not sustainable. In addition, the process of administrative assignment is unlikely to be economically optimal or the best means of exposing public sector users to the full cost of their spectrum use. **The Audit therefore believes that in future administrative assignment should be used only in exceptional circumstances and only be used there is an essential requirement, no workable alternative and a full consideration of the wider economic implications.**

There are several factors suggesting that a market based approach should be workable for the public sector in the long term, including that procurement timescales are likely to mean that the body has a long lead time in which to consider and acquire the necessary spectrum for new equipment. In addition public sector organisations are increasingly using commercial networks for some of their services, and as bespoke communications options are arguably becoming increasingly expensive and inferior compared to the commercial mainstream, may do more in future where this does not compromise operational, safety and security requirements.

Where there may be barriers specific to the public sector in acquiring spectrum through the market, relating for example to affordability and certainty, there are potential measures available to Government and Ofcom to address these, which the Audit will be considering. These include:

- Allowing departments to budget for spectrum acquisition costs over a longer timescale to aid affordability of purchases through auction or trading;
- Where a need is proven, Government could undertake to make funds available to purchase spectrum (noting that departments have set budgets and access to additional funding only in exceptional cases, and that this shouldn't preclude competition);
- In order to meet public policy concerns, conditions such as auction price matching may need to be introduced to ensure that public sector bidders did not lose out in gaining some allocation in an auction where their demand was deemed critical. This would however need to be considered very carefully as such moves could preclude a fair and successful auction;
- For some services, for instance fixed links, there may be scope for allocating public bodies licences in shared bands alongside commercial users. This is already the case for some public bodies such as local authorities but might be extended to uses such as public safety services backhaul if the required levels of protection and future certainty can be provided.

If steps such as these are taken within the context of a liberalised spectrum management framework, we do not regard the possibility of high prices as an obstacle to acquisition of spectrum by the public sector, because in a properly functioning market the level of prices will reflect the value of alternative uses. The public sector would acquire spectrum, as it does other inputs, at commercial rates.

2.4 Process for Approving Non-Market Allocations

As trading and liberalisation have only recently started to be introduced, the Audit considers it to be too early for a mandatory approach to sourcing essential requirements through the market to be introduced. Therefore there needs to be a process for making non-market allocations in cases where the market cannot deliver. Ideally this would be a transitional tool and then available in exceptional cases of need (e.g. for security and safety requirements unable to be met in another way).

Listed below is an illustrative procedure which might be followed within the UKSSC structure to ensure that an application for a non-market assignment of spectrum is only granted where genuinely necessary and then through a ministerial direction. A benefit of this process would be that Ofcom's independence is not compromised and Ofcom is not asked to make and defend decisions which are ultimately at Government behest. Where the criteria were not fulfilled or the UKSSC or Secretary of State were not prepared to issue a ministerial direction as an agreed Government view, the department would have to meet its requirement through the market. We are in favour of a system where any directions would be issued by the DTI (Ofcom's

'sponsor' department) rather than the Secretary of State of the Department requesting the spectrum, in reflection of the fact it would be a cross-Government decision.

The process outlined below would apply to large and contentious requirements. Where for instance minor assignments are being made on a first-come-first-served basis or there is no significant potential for distortion, the matter can be agreed within the relevant UKSSC sub-group. This might also apply for example where the Government had made legally-binding international commitments and there was nothing to gain from a re-assessment of the merits of a change or requiring a formal ministerial direction. This process assumes that there are mechanisms in place for addressing potential barriers such as financial issues, as above.

Box 1: Criteria for administrative assignment

1. The department concerned would need to make an initial request to UKSSC or the relevant subgroup for a non-market allocation. For further consideration this would have to meet the following criteria:
    - Demonstration of safety or security critical requirement, or mandatory international obligation
    - Demonstration that needs cannot reasonably be met through existing allotments or allocations, including through more intensive use of existing bands
    - Demonstration that needs cannot reasonably be met through the market
    - No alternative means of providing service

2. Escalate from subgroup to UKSSC if the subgroup considers these criteria are satisfied. Government should then liaise with Ofcom through UKSSC to obtain Ofcom's view, including an assessment of the value of the spectrum, the market impact of an administrative allocation, legal questions, and whether Ofcom have appropriate spectrum available.

3. If the UKSSC concluded after advice from Ofcom that an administrative allocation should be made, the DTI Secretary of State should issue a ministerial direction under the 2003 Communications Act instructing Ofcom to make the spectrum available:
    - If spectrum was available Ofcom could then assign this
    - If there was no spectrum available, Government would have to guarantee to provide Ofcom with the funds to make spectrum available, through a standard trade or licence revocation, with

In an environment where market mechanisms are the basis for spectrum management, in addition to the economic reasons for a rigorous process of justification being needed there will also need to be careful consideration of whether a non-market allocation can be legally justified. In particular, before instructing Ofcom to make an administrative assignment Government would need to satisfy itself that the process is compliant with European rules on spectrum assignment and state aids, which require competitive awards to be "open, transparent and non-discriminatory". We understand that there are more difficulties making a spectrum award if the recipient is not covered by Crown immunity (see below for more detail) and therefore needs to be licensed.

If the process required Ofcom to compensate an existing user, the assignment procured by ministerial direction could prove to be an expensive option and consideration would need to be given as to the source of funding for this.

Do you agree that public bodies should in general expect to meet future spectrum needs through the market? Are the process and criteria outlined a suitable means of deciding whether an administrative assignment should be made, if this is not possible?

2.5 Civil Contingencies

The Cabinet Office is currently coordinating a project on behalf of UKSSC to define suitable arrangements for responding to public sector spectrum requirements in case of civil emergency. The Audit is interested in how this process will deliver to the military, security and emergency services the capabilities they need in emergency situations through an orderly co-ordination with key civil users, so that for instance public cellular networks can keep operating where possible. We will keep in touch with the process as it develops.

2.6 Future public sector needs

While UKSSC is effective at dealing with ad hoc issues affecting public sector use of spectrum, there is currently no process for coordinating future strategy or spectrum requirements for the public sector as a whole.

The Audit team is of the view that this is a role which could be performed, for the public sector, by UKSSC. Such a 'Forward Look' should be produced and published every two years and should include:

1. Description of current use
2. Changes to be made to allocations e.g. handing over management of bands
3. Changes to spectrum management e.g. introduction of trading or leasing
4. Quantitative predictions and justifications for future spectrum needs (the identification of which could lead to consideration of how to address them and possibly the start of the process identified above for seeking new spectrum).

Consideration would need to be given as to whether parts of the strategy should not be published – for example due to commercial or security sensitivities. It is important that the strategy is ultimately approved and owned by Government. However there will also need to be an advisory role for Ofcom, perhaps through a role on a dedicated working group under the UKSSC.

We are discussing bilaterally with public sector bodies where they think future demand is likely to lie and on what scale***. We would also welcome input into this consultation on likely future demand in the public sector and fixed links areas we have covered in this document.***

2.7 Market intelligence

The Audit team has commissioned a study into future demand.[8] Given the time period in which it is necessary to complete the study, the study is limited to the main

[8] We are discussing potential public sector demand bilaterally with the users themselves.

80 per cent of users. The study focuses on the next ten years but also projects to 20 years. ***In order that we do not overlook important future requirements, we would be interested to hear views on likely future commercial demand, specifically that which may fall outside the scope of this study.***

Box 2: Demand study

Conclusions from this study will be incorporated into the final report. Interim findings, just received by the Audit team, indicate that:

- On a base case macro scenario, taking into account the most likely outcomes from all services examined, there will be demand for around an additional 2GHz of spectrum below 15GHz by 2015 and a further 1-3GHz of additional spectrum by 2025, for the main commercial services
- Demand for cellular services is heavily dependant on traffic forecasts, which are being examined in more detail in advance of the final report. As identified in Ofcom's Spectrum Framework Review: Implementation Plan, additional spectrum is planned to be release in the next few years (including 190 MHz of spectrum in the 2.6 GHz band) which will go some way to meeting future demand
- The majority of demand for additional spectrum for fixed links is likely to be in bands above 15GHz, although certain specific bands below 15GHz may run out of capacity
- There is likely to be demand for additional spectrum for broadband wireless access – the scale of this will depend on the economics of providing the services in competition with wireline (or similar) broadband services
- Broadcast satellite services, fixed satellite services and possibly mobile satellite services will generate demands for more spectrum – by far the greatest demand seems likely to come from demand for more spectrum for satellite TV to facilitate the widespread introduction of HDTV services
- Demand for terrestrial TV will increase – the scale of this will depend on demand for additional commercial channels and HDTV. Mobile TV is also projected to generate additional demand
- Spectrum shortages will be greatest at frequencies <1GHz (such spectrum is ideal for lower-cost wide-area coverage). Spectrum between 1GHz and 6GHz will also be in heavy demand for mobile and broadband wireless applications.

In the future, given the importance of information in facilitating a well functioning market, the Audit team considers that there is a role for Ofcom in regularly and systematically collecting market intelligence to inform decisions on regulator or government action in guiding new developments.

The Audit will consider further what form this might take. This could for example involve developing scenarios on the evolution of the market; or identifying future developments – e.g. technologies or international developments. Although the Audit's interest in Ofcom's role here focuses on background intelligence to facilitate more effective use of public sector spectrum, this clearly has a wider relevance beyond the public sector and we will discuss this further with Ofcom.

The services assessed in the study comprise broadband fixed wireless, fixed links, mobile cellular services (inc mobile TV), satellite (fixed, mobile and broadcasting) and terrestrial television broadcasting

We would welcome views on what information Ofcom could usefully collect in furthering its role to ensure the efficient use of public sector spectrum.

2.8 Trading of existing public sector spectrum

In line with the first Cave Review, and Ofcom's statements on spectrum trading, we agree that trading and liberalisation should be enabled across the spectrum except where there are compelling public policy reasons to do differently. Organisations such as the MoD have large holdings of 'prime' spectrum that is potentially of high value to other users. If they are able to gain directly from making their unused or under-utilised spectrum available to the market, it could provide an additional powerful incentive to make effective use of spectrum holdings. There are both risks and opportunities for the public sector with the introduction of trading but there would be no compulsion for a public body to enter into trading or liberalisation activities - these would be entirely voluntary. As mentioned in chapter 5, some public sector users do have concerns about how interference management will work under this new regime. Under Ofcom's current timetable trading would be rolled out to most classes of public sector licences in stages over the next few years:

- Ministry of Defence: Ofcom considers that MoD requirements may impose restrictions or coordination requirements affecting the potential scope or value of trading but that there are no definitive barriers to trading per se. Spectrum previously released by the MoD has been vital in enabling the development of many important sectors including mobile telephony. The relatively sporadic use of some military spectrum suggests that there may also be potential for short term leasing in peacetime or between training exercises, to complement the long-term secondary sharing that Ofcom already licences in a number of MoD bands.

- Aviation and maritime: Ofcom intends to work with the CAA and MCA to decide on the feasibility of trading for ground based aviation and maritime coastal communication rights of use, with a decision being made by 2007. In the radio navigation licence class, Ofcom has said that trading of rights of use would be introduced between 2007 and 2009. In all cases, tradability would be permitted only within the constraints of international harmonisation.

- Emergency services: Ofcom's Trading Statement set out that trading will be introduced in emergency services spectrum but not before 2006, to allow questions regarding the future organisation and assignment of spectrum to be resolved. Issues include service interoperability and NATO constraints in some bands.

- Other 'public' service users: There are other 'quasi-public' users of spectrum (for example transport organisations) who may claim preferential treatment in terms of spectrum allocation for public policy reasons. These organisations are free to trade if their licence class is included in the Ofcom timetable. If allocations have been preferential, and by administrative allocation, then the windfall issue applies as below.

As outlined below there are currently a number of legal, practical and financial uncertainties that could act as a barrier to the trading of public sector spectrum. In our opinion it should be a priority for Ofcom and Government to enable public sector spectrum holders to trade should they wish to do so. We expect a key element of the final recommendations of this Audit to be a consideration of how to remove any remaining obstacles to public sector spectrum trading. This is likely to include a

proposed timetable for agreeing clearly defined rights and incentives for public sector spectrum holders and enabling trading.

2.9 Licensing Issues

'The Crown' does not need or hold WT Act licences for spectrum due to Crown immunity'[9]. In the case of WT Act licences, the Crown includes Parliament, the Crown's ministers and servants. Normally, the Crown's servant is limited to a core central government department reporting to ministers, for example the MoD. Other public agencies and bodies (e.g. public safety services) might not be included (this is decided on a case-by-case basis dependent on factors such as funding, and decision making).

For bodies covered by Crown immunity to engage in spectrum trading, greater clarity will be needed on both the nature of the rights these bodies currently hold and the parameters within which a potential purchaser of the spectrum would have to operate. Related issues are explored further in chapter 4 on sharing, including a MoD concern that there is inadequate clarity on the extent to which they have primacy within shared bands and whether trading of secondary rights could lead to harmful levels of interference. We have identified a number of possibilities for enabling the holdings of bodies covered by Crown immunity to be better defined and to enable trading and potentially leasing:

- Enable licensing: The Crown does not need to be granted rights to operate, such as a spectrum licence, unless Parliament specifically says that such permission is required. In theory this means that the Crown could hold a standard spectrum licence, but only following a change in the WT Act.
- Issue RSA (Recognised Spectrum Access): RSA is not formally a licence but in practice defines many of the same parameters (see chapter 10 for an explanation of RSA). Sections 159 and 163 of the 2003 Communications Act allows Ofcom to make grants of RSA to bodies covered by Crown immunity. Holders of an RSA may seek its conversion to a licence e.g. at the point of sale to a commercial user, so trading would be possible. Areas which would need clarification include setting transmission parameters (which may not be defined in an RSA in the same way as a licence)
- Hold the licence in an SPV (Special Purpose Vehicle): The Crown/government department could set up a holding company to hold its spectrum and be licensed for it. This licensed spectrum could then be traded.
- Use a commercial third party: the Crown body could contract a commercial company to manage and use the spectrum and potentially to trade it.

As an interim or fallback measure departments could release spectrum to Ofcom and with Treasury agreement the proceeds could be awarded to the department that had released the spectrum. It is not clear that this is feasible or desirable compared to enabling trading more directly. Whether the spectrum was sold by the previous holder or auctioned by Ofcom could also affect the speed with which the spectrum was redeployed, the packaging, and also the level of proceeds.

In advance of our final report, we will work further with Ofcom to investigate the legal and practical feasibility of these options. Our initial view is that convertible RSA looks

[9] For more information on the treatment of the Crown see http://www.ofcom.org.uk/radiocomms/ifi/licensing/licensing_policy_manual/what_is_Crown_body?a=87101

to be the most attractive option for enabling the spectrum holdings of bodies covered by Crown immunity to be defined and made tradable.

We would be interested in views on the treatment of Crown bodies. Do you agree with the idea of using Recognised Spectrum Access (RSA) to define the rights of bodies covered by Crown immunity and enable tradability?

2.10 Incentives

Ofcom currently intend to continue charging Administered Incentive Pricing (AIP) on both tradable and non-tradable spectrum. To date pricing has been the primary economic mechanism used for managing and incentivising effective use of public sector holdings. The benefit derived from disposal of spectrum is currently the avoidance of future AIP charges. The Audit believes that in principle public bodies disposing of spectrum should also be allowed to benefit in some way from revenues from trading. In particular this looks reasonable if public bodies will generally be obliged to acquire new spectrum in the market in future.

Given the nature of public sector budget constraints, the source and destination of funds to buy, sell or hold spectrum and the extent to which departments can spread the cost or benefit of one-off transactions are likely to have a major effect on their capacity and willingness to engage in spectrum trading. It could also impact on the likelihood of managing their spectrum holdings dynamically rather than retaining legacy spectrum bands and systems. We are discussing these issues with HM Treasury, who are ultimately responsible for these decisions, and we aim to develop and agree outline principles for inclusion in the Audit's final report. A related issue, discussed in more detail in Chapter 3, is that spectrum is not currently treated as an asset on departmental balance sheets and we will be exploring further whether this might be desirable.

One option is for MoD or others to exploit their spare spectrum assets through the Wider Markets Initiative, which encourages public sector bodies to maximise the value in their spare assets by exploiting them commercially – within certain rules. The department gets to keep the income generated as an incentive. This is an option that was flagged for further investigation in the Government Response to the 2002 Cave Review but was not taken forward. Treasury's initial view is that there do not appear to be any barriers in principle and the Audit team will be seeking clarity on whether spectrum as an asset is eligible for this initiative.

There is a question over whether there should be different treatment for windfall benefits that have arisen by selling public sector spectrum acquired by non-market administrative allocation. Ofcom do not intend to draw any distinction in trading rights applied to commercial spectrum holdings acquired by administrative allocation and those acquired by auction (although with AIP continuing to be paid where applied). The Audit and Treasury will wish to consider this point further but as many public sector spectrum holdings are long-standing and we would want full market incentives to minimise spectrum holdings to apply as widely as possible, it is not clear that it would be economically beneficial to differentiate treatment of trading receipts on this basis.

2.11 Spectrum Management Resources

Throughout this chapter we have suggested an enhanced role for public bodies in the management of their spectrum. While we think that changes are necessary given the

nature and value of the resource involved, the Audit realises that this will have resource implications for the organisations involved. We will be considering the priority assigned, and resources dedicated to spectrum management as we develop our final recommendations.

Chapter 3

Spectrum Pricing

3.1 Background to Spectrum Pricing

Ofcom can levy charges on spectrum users for two purposes: to recover its own administrative costs, and to promote the efficient use of the spectrum (through Administered Incentive Pricing, or AIP). The introduction of AIP represented the first move to using market mechanisms in spectrum management in the UK and since 1998, the use of AIP has been progressively rolled out to the majority of licence classes and public sector use. AIP is an important mechanism for fulfilling Ofcom's general duty to promote the efficient use of spectrum where there is excess demand. AIP fees are designed to equal the marginal value of spectrum based on its opportunity cost. This implies that those users to whom spectrum is worth less than AIP will give it up, ultimately leading to the transfer of spectrum to those who value it the most.

Alternatively, licence fees for each sector are set to cover some of Ofcom's direct cost instead of AIP where for example use of spectrum is heavily shared with no set limit to the number of users, where there is no excess demand, or where use of the spectrum is mandated internationally and inflexible.[10]

In response to a recommendation by the 2002 Cave Review that AIP should be applied at more realistic levels and more comprehensively across spectrum uses, the Government hired a consortium led by Indepen to update NERA and Smith System's original spectrum valuation work[11]. From April 2005 and in response to this study, Ofcom is rolling out an amended methodology for determining AIP, setting each AIP fee in relation to both the value of the spectrum in existing uses and its value in other potential uses for each band.[12] There are variances to the fee e.g. if the band is particularly congested the price increases.

Ofcom estimate the total revenue from spectrum fees[13] in 2005/6 will be around £166m, comprising:

£69m	2G Mobile Network Operators
£55m	MoD (up from £23.5m in 2004/05)
£19m	Fixed Links (£15m in 2004/05)
£9m	Private and Public Access Business Radio
£3m	Airwave, Police, Fire and other Government use (including Airwave replacing services previously funded by the Home Office)
£11m	Rest, including bulk licences (maritime, amateurs etc.) and Broadcasting

[10] No fees are set for services which are licence exempt. An increasing number of spectrum uses are exempt (e.g. cordless phones, Wi-Fi, low power devices) as radio becomes more sophisticated.

[11] 'An economic study to review spectrum pricing', Indepen, Aegis Systems and Warwick Business School , February 2004, www.ofcom.org.uk/research/industry_market_research/m_i_index/spectrum_research/independent

[12] see the Ofcom Pricing Statement http://www.ofcom.org.uk/consult/condocs/spec_pricing/statement/?a=87101

[13] Fees go to the consolidated fund through DTI. DTI appropriate-in-aid from the fees to pay for spectrum regulation up to a certain level.

Ofcom's spectrum management costs are around half this total, or £85m per year. The bulk licences are issued on a cost recovery basis but for mobile and the MoD in particular, AIP significantly exceeds Ofcom's spectrum management costs, reflecting instead the economic value of the spectrum held.

3.2 Public Sector Pricing

Most public sector spectrum bands are currently subject to AIP on a comparable basis to the commercial sector. The effectiveness of AIP and other incentives to maximise efficiency of spectrum use going forward is a key consideration for our Audit.

Pricing is currently the primary spectrum efficiency tool for the public sector, and may continue to be so if the impact of trading and liberalisation on decision making is more limited than in the commercial sector. Considerable progress has been made since 2002, including a recent extension of the MoD's spectrum charges. However there are still some gaps in the application of economic incentive pricing which are explored below. The Audit recognises the importance of maintaining transparency in pricing procedures and certainty to enable long-term forward planning, and will bear these in mind as it considers any changes to the pricing regime.

The basis of charging the public sector, and specifically the Crown, is Section 163 of the 2003 Communications Act[14], which states that: "The Secretary of State may…make payments to OFCOM of such amounts as he considers appropriate in respect of… use by or on behalf of the Crown…". The approach used to date has been for RA and now Ofcom to discuss and agree the basis of the annual fee with the body in question, in consultation with HM Treasury and using a notional equivalent commercial licence fee. This arrangement does not have a clear formal basis and as such has relied on consensus. It is therefore not clear what would happen in the event of a dispute over charging. Our view is that there needs to be greater clarity over the institutional mechanics of both public sector fee setting and dispute resolution. This has particular relevance for trading of public sector spectrum and our proposals that pricing should be extended.

We are in favour of formalising the pricing of Government bodies' spectrum. This is linked to the licensing issues outlined in Chapter 2 and the main options include:

- The use of RSA (Recognised Spectrum Access) to formalise spectrum rights and charges in place of a standard licence
- A Memorandum of Understanding between the departments concerned and Ofcom – possibly through UKSSC and with Ofcom facilitation.

3.3 Military

The MoD pays AIP on much of its spectrum. MoD fees now represent about 30% of Ofcom's total spectrum fees income, in keeping with the large scale of its spectrum holdings. An indicative breakdown of these charges is given at Annex F. The MoD's annual spectrum fee has recently increased, from £23.5m in 2004/05 to £55m in 2005/6. This is due to a combination of:

- A widening of the scope of charging
- An increase in the AIP level for some services

[14] http://www.opsi.gov.uk/acts/acts2003/20030021.htm

- The reclassification of the bands between 2.31 GHz – 2.45 GHz from fixed to the much higher mobile rate.

There is evidence that the increase in charging has already had an effect on MoD behaviour and the MoD have released some under-utilised spectrum since the 2002 Cave Review. Some of the spectrum outlined for release in the SFR Implementation Plan was formerly held by the MoD and has been released over the years; a small number of bands mentioned in the Implementation Plan remain under MoD's overall management.

There are two key areas of MoD spectrum that are not currently charged, NATO-managed and some radar bands. As noted below for aviation, the 2002 Cave Review and Ofcom have concluded that there is an economic case for charging at least some types of radar bands and services. However both civil and some military radar bands currently remain zero-priced. We think there is a strong case for taking forward the design and implementation of radar pricing and the options are covered in detail in Chapter 7. It is not yet clear whether the pricing structure for military radar bands should be the same as for civil.

3.4 NATO-managed Band

Some bands are internationally harmonised among NATO members and consequently have restrictions on the scope for unilateral action by the UK to convert to alternative civil use. There is one band (225-400MHz) which is managed directly by NATO rather than the UK and has not been charged for to date. Other bands in common use across NATO countries but managed nationally in the UK (such as 4.4–5 GHz, 8-8.4 GHz and 14.62-15.23 GHz) are charged at the fixed rates.

The option of charging the 225-400 MHz band has previously been considered and following the first Cave Review, a 'shadow' charge was calculated for this band (the level of the potential charge was calculated at the appropriate rate and noted, but not actually imposed). This issue will be re-examined in the 2006 Spending Review, and our Audit will examine the rationale for a further extension of pricing. The MoD has worked constructively with the RA and Ofcom to enable some commercial use at the margins of the NATO bands, largely on a shared basis. Any pricing decision should not be seen as penalising the MoD for showing flexibility and should include adequate discounts for the civil sharing that takes place.

3.5 Fixed/mobile

There is currently a very large discrepancy between the pricing level applied to the MoD for bands badged for AIP purposes as fixed and mobile (£240-396k / MHz for mobile, £2-3.9k / MHz for fixed) as highlighted in Annex F. On this basis there are very large financial implications for the MoD from Ofcom's decision on whether the opportunity cost for individual radar bands should be charged at a 'fixed' or 'mobile' basis. Presently this decision is made by considering alternative use. However, given the moving boundary of what is commercially feasible and the potentially high value of the 3GHz radar band (which is wide and in the area being considered internationally for 4G mobile), possibilities for change include:

- A more gradual roll-off between the current cliff edges of 'fixed' and 'mobile' to more closely reflect the likely value of different bands to potential alternative civil users. Civil fixed links pricing incorporates a 'band factor' which imposes higher charges on lower frequencies where demand is higher and the opportunity cost

greater. There is no such 'band factor' in military pricing, where the same 'per MHz' charge applies across all 'fixed' spectrum.
- How spectrum opportunity cost is defined. For example, in considering possible alternative use, should this be calculated on the basis of what is technologically possible, or what is currently permitted by international treaty?
- We will also compare military and commercial rates, to see if they are equivalent (due to the adjustment factors applying to commercial mobile operators these rates may differ).

3.6 MoD Sharing and Leasing

In a number of shared bands, Ofcom recognises the benefits derived from the MoD allowing secondary civil shared use by implementing a 25% or 50% reduction in fees. These reductions have been determined by Ofcom in discussion with the MoD. The current system does provide an incentive to the MoD to allow sharing. However there are currently no fixed criteria for determining discounts and the size of the rebate is not directly linked to the value of the secondary sharing. This is an element of charging which could usefully be considered as part of any MoU agreed and which the Audit will be considering further.

There appears to be scope to make additional refinements to encourage the MoD to set sharing conditions which increase the potential benefit for secondary sharers, for example by the following means:
- The MoD receiving some or all of the proceeds derived from spatial and temporal sharing, organised directly or through contracting out to a band manager.
- Ofcom could base MoD fees for their shared rights on some form of 'sharing algorithm' in a variant of the method used for geographically shared civil bands
- If spectrum is released to the market by auction on a secondary shared basis with the MoD, the reduction on the MoD's fees from the full amount should bear some relation to the sums realised (alternatively the MoD could sell secondary rights itself, but this may not be practical).

Where the MoD has agreed to its spectrum being licensed out on a time limited basis but reserves the right to reclaim the band for its own use in future (see chapter 5 for discussion of the 3.4 GHz band) it is economically desirable for the MoD to reveal at as early a stage as possible if they are willing to give up the band permanently - there is currently no incentive for the MoD to make an early decision.

The Audit therefore thinks it is worth exploring the possibility of introducing a system of 'freehold rents' or 'retainers' for bands which the MoD is not currently using but continues to hold a right to reclaim and would welcome views on the economic rationale for and possible level of such a charge. This could be set at a percentage of the AIP for the band. There would be an advantage for MoD in that they would retain some 'property rights'.

3.7 Aeronautical

Spectrum use in support of aviation is not currently subject to AIP and licences for systems both on the ground and in aircraft are priced on a nominal administrative cost-recovery basis. The rationale and options for imposing incentive pricing on aeronautical communications and radar are covered in detail in chapters 6 and 7. Our initial view is that there is a strong case for Ofcom to push forward with designing and implementing incentive pricing for radars, civil and military, that reflects the opportunity cost of their presence.

There are a number of difficult issues concerning how best to implement aeronautical pricing, including determination of alternative uses in the short or the long-term, the realistic scope for spectrum savings through the implementation of more modern technologies and within international constraints, and whether pricing should be imposed directly by Ofcom on individual users or cascaded through a band charge on the regulating body.

3.8 Maritime

Most maritime bands are internationally harmonised by the ITU and IMO, and much of the maritime spectrum is heavily and unpredictably shared between users licensed in different countries. Most fees are low and cost-based. Ofcom are proposing the replacement of annual licensing of ships' equipment with lifetime licences. The effect of these changes is likely to be to reduce licence revenues but also Ofcom's licensing costs. The Audit's view is that Ofcom needs to be careful that deregulation does not have the unintended consequence of precluding the possibility of introducing AIP in the future if there is a rationale for it.

There is limited scope to refarm in most maritime uses without considerable international negotiation, with the exception of re-using maritime radar frequencies inland, since most land-based maritime equipment is common with internationally-mobile ship-mounted equipment. Where there is scope for this type of geographical sharing it would probably be for Ofcom to set the conditions and licence secondary users. Inland maritime radar coverage could possibly be incorporated into a similar pricing and assignment system to that suggested for aeronautical radar.

3.9 Public Safety Services

The mobile systems used by the emergency services are subject to AIP at the commercial rate. To date the spectrum costs of Home Office managed spectrum, around £3m per annum, have been met by the Home Office. From 2005/06 Airwave O2 Ltd (a commercial company providing the service under licence) are also being charged AIP on their existing spectrum on a comparable basis to the public mobile networks. Airwave O2 Ltd and its users have also requested the allocation of part or all of the vacant 410-415 MHz and 420-425 MHz paired bands. Ofcom is currently considering the options set out in the SFR:IP, and if part of the spectrum was awarded to the emergency services administratively, following a competitive procurement process, there is a question over how it should be priced. See Chapter 9 on public safety services for more detail.

3.10 Other Public Sector Users

There are a wider range of other quasi-public sector users including the public safety services, Transport for London, Railtrack and local authorities, who are generally licensed and priced on a standard commercial basis.

Science services include radio astronomy, where incentive pricing is not currently applied. This area is likely to be the first application of RSA (Recognised Spectrum Access) – see chapter 10 for details.

3.11 Fixed Services

Fixed links are licensed on an individual basis rather than giving national or regional rights to a given band of spectrum. The charge for each link is based on an algorithm that reflects characteristics including the bandwidth used and the path length to arrive at an estimate of the opportunity cost. In the light of Indepen's work and further internal analysis, Ofcom has decided to simplify the process for calculating fixed link fees somewhat. Under the new algorithm the average charge is increasing by around 15%.

We agree with Ofcom's view that spectrum efficiency should be achieved through the market where possible. However the Audit is looking at fixed links because the nature of the licences granted means that it may not be possible to deliver the spectrum to a higher value potential user through trading and liberalisation. The view the Audit takes on the case for spectrum clearance projects will depend in part on the view that we take on the likely effectiveness of pricing. As part of this consideration we are looking at the comparability of overall pricing levels between fixed links and adjacent spectrum bands.

If a technologically-neutral auction could be conducted with band management of fixed links as an option it could provide the means of effectively determining the competing relative value of mobile and fixed links use. Ofcom is currently giving consideration to the issue of band managers and how they could be licensed. The impact on competition will need to be assessed as part of this.

3.12 Future of AIP

Before trading, the role of AIP in encouraging efficiency was effectively the same for the commercial and public sectors. Ofcom considers that AIP should continue with the advent of spectrum trading, as AIP can continue to promote greater efficiency, and believes that trading should not be impaired if AIP fees are set conservatively. AIP also clearly remains useful in areas where trading may not (yet) be possible, e.g. some public sector holdings. We have some concerns that if Ofcom determine that a 'conservative' pricing level is optimal for encouraging trading and maximising economic benefits in the commercial sector, the level of AIP could be below that needed to maximise efficiency of public sector use. Generally, the principle of pricing the commercial and public holders on the same basis is a sound one. However, it is also important to maintain appropriate incentives for the public sector. Any discrepancy in commercial and public pricing systems is also likely to lead to complications with trading. The role that AIP will play in a market based system is not yet entirely clear and the Audit will consider this issue further.

The level of AIP will be updated in future (Ofcom has proposed a review in 3 years for mobile and a similar timescale for fixed links). In a parallel agenda, Ofcom is introducing Recognised Spectrum Access (RSA) for some services, under which a fee would be levied to grant some protection rights to reception. We will be looking in more detail at how this could apply to the public sector. Ofcom is also working on longer-term plans for applying pricing to the broadcasting industry (an issue outside the scope of our Audit).

In the longer-term, Ofcom are also considering the potential for moving towards technology-neutral 'per MHz' pricing to replace the current bespoke fee structures for different licence classes. This idea may fit well with the nature of military and other

public sector use. A further option is to move towards AIP based on recent market information such as the price of auctioned or traded spectrum. The value of spectrum derived in this way may currently be difficult to estimate but it can be expected to become clearer and more stable as the market develops.

3.13 Effectiveness of Pricing

There is some anecdotal evidence that pricing has had a positive impact on public spectrum management, for instance through the MoD giving up spectrum bands when subject to steep increases in pricing. However Ofcom have comparatively limited evidence on the overall impact of AIP. Given the importance of AIP in spectrum management we think further research into the impact of AIP would be helpful.

3.14 Funding Spectrum Charges

The real incentive effect of AIP on the public sector and consequently resulting improvements in economic efficiency are likely to depend in large part on how departments and Treasury fund AIP charges. If the process is simply one of recycling budgets and charges then the effect of AIP is questionable. This raises questions about the budgeting process and delegating of costs and benefits, which we will be investigating further.

As a general principle we think it would undermine the effectiveness of the economic signals delivered by AIP if departmental budgets were continually varied directly in parallel with changes to their AIP bill. Under normal circumstances departments are expected to absorb the effects of changes to the costs of other inputs (for example fuel) and the same should be true of spectrum such that there is greater pressure to economise when the opportunity cost of the public use is greater.

However some of the changes to AIP we are exploring could potentially have a significant impact on the scope and level of pricing applied to major public sector spectrum users, e.g the MoD. Where a substantial increase in spectrum charging results from a one-off change in the basis of the charging system rather than a change in market value there is an argument for giving a one-off increase in baseline funding so that the level of public service provision can be maintained. This should not compromise the future incentive effect of AIP (benefiting from or having to met any future changes to the pricing level after this one-off change) if it was clear this adjustment related to the step change. Pricing of aeronautical radar and communications would also have financial implications for the aviation industry which would have to be absorbed or passed on in some form.

3.15 Alternatives to AIP

In the short to medium term we expect AIP on public sector spectrum to be maintained and extended, supplemented by the possibility of gains from trading. However it is worth also considering other options for incentivising the public sector, which include:

- Treat spectrum as an asset subject to capital charges: Spectrum holdings are not currently treated as a capital asset on departmental balance sheets and so do not incur non-cash capital charges. We will investigate the option of treating spectrum as a standard ‘asset’ further. It is not clear that this would necessarily impose a better incentive than exists at present through AIP unless the level was set higher, which could be hard to justify. However if departments acquire spectrum

at auction, which may not be subject to AIP, it may be desirable for this to bite as an ongoing annual cost rather than a one-off charge.

- Trading only: Where spectrum is traded that is still subject to AIP, the tradable value will be reduced in relation to the cost of future AIP payments. If spectrum was no longer subject to AIP, or it did not prove possible to extend AIP to bands where it is not currently levied, the spectrum should command a comparatively high price. Subject to the incentives issues outlined elsewhere in this document, if AIP was removed gains from trading would provide a sharper incentive.
- Activist command and control: The Audit endorses the trend to market management of spectrum. However in the past significant releases of public sector spectrum, particularly from the military, were achieved in the absence of economic incentives through identification of under-used military bands where there was alternative demand. There may be a role for the periodic review of public sector spectrum needs recommended in Chapter 2 to identify under-utilised bands with Ofcom assistance, and mandate the body that currently holds the spectrum to give it up (or release it by facilitating an alternative). It could be argued that a process of mandating spectrum clearance without the ability to gain from trading is reasonable where public sector spectrum was originally acquired through administrative assignment not the market.
- Auction all spectrum: There is also an argument that it is preferable to set the price of all spectrum through the market directly rather than the proxy of AIP, and that the only means to achieve this in a manner which does not give excessive benefits to incumbents is to auction all the spectrum, including bands currently held by the public sector. It is however not clear this is workable or desirable, for example considering the levels of investment by incumbents to operate in these bands.

The Audit's initial view is that, while trading rights could provide a good additional incentive, it is not currently clear that any of the alternative options is more attractive than the retention of AIP, refined on the basis we have suggested above. The Audit agrees with the fundamental aim and process of AIP, and that there is a clear justification for continuing to price public sector spectrum. We will consider these issues further.

Effectiveness of AIP:

- ***Do you agree that AIP should remain a primary mechanism for achieving efficient use of public sector spectrum?***
- ***Do you think there is merit in these or other alternative mechanisms to achieve efficient use of public sector spectrum, in addition to or instead of AIP?***
- ***How is this affected by Ofcom's proposals to move to greater market management of the spectrum?***

Do you agree that there is merit and potential benefit in further exploring changes in AIP:

- ***To ensure the prices are kept up to date and reflect the current alternative use (e.g. bands currently charged as fixed which may be suitable for future mobile use)***
- ***To better reflect the real 'spectrum value curve' in and outside prime bands (c.f. band factor applied to commercial fixed links which is not applied to MoD fixed spectrum)***
- ***To provide a stronger incentive to public bodies to make more efficient use of their holdings (e.g. disposal or sharing; accounting changes that could best tie costs directly to use)***

Chapter 4

Sharing

4.1 Introduction

Spectrum is a finite resource. Technology developments can help improve spectrum efficiency, but it is generally the case that as new applications and platforms are developed, then at least as much bandwidth is required to deliver the new services as user expectations also rise. Bands with attractive propagation characteristics are becoming increasingly congested and demand for spectrum in these areas is likely to exceed supply in the future.

The Audit is examining specific bands with the major public sector and fixed links users of spectrum to ascertain whether there is scope for release for alternative use. The Audit will pursue work in this area, but is also keen to look at ways of making better use of allocations which cannot be completely released through increasing the users and services which can be deployed in a given band – increasing "sharing" possibilities. This will include consideration of whether new, 'reactive' technologies have the potential to introduce new sharing possibilities.

4.2 Sharing arrangements

International Telecommunications Union Radio Regulations (RR) recognise the principle of sharing between different uses and users by allocating multiple primary and secondary status services in many bands. The RR allocations define the radio services, and their priorities, that must be recognised between countries. An individual country can choose to accommodate one, some or all of these services, and in the case of more than one, is likely to implement a regulatory framework to ensure successful coexistence. An individual country can also deviate from the RRs provided that its national use does not interfere with the services of another country that is operating in accordance with them (any interference from that country in accordance with RR must also be accepted). A country may also seek to agree through the ITU a footnote recognising additional or different use in that band if international recognition is sought.

Sharing on a more restricted basis, for example, by geography, can be agreed through national regulators. For example, Ofcom can facilitate commercial use through a sharing arrangement with the MoD. Occasionally, other public sector users will approach MoD directly and agree similar arrangements.

The main holder of the spectrum will normally wish to continue to protect its ongoing or future expected use. This can be done by imposing restrictions - perhaps operationally (time, geographic or usage) or technically (power, height).

As demonstrated in the box below, public sector users already operate effective sharing arrangements. The MoD shares many of its bands, for example with amateur radio, wireless access systems/short range devices, and with users from other parts of the public sector e.g. the Emergency Services with the TETRA communications system, and Metrological aids. The MoD also has common usage of several radar bands with the Civil Aviation Authority (CAA).

Box 3: JFMG

A good example of effective sharing is that managed by JFMG, a company contracted by Ofcom to manage spectrum for Programme Making and Special Events (PMSE). Much of this spectrum is shared with the MoD. PMSE requirements for a specific event are generally well defined, and geographically and temporally restricted – for example, providing coverage for sports events or a music concert. As such, they make a good candidate for sharing with public users with fixed locations and well defined parameters e.g. MoD; with the added advantage of having a single point of contact should problems occur and dispute resolution be required (e.g. interference problems).

When a request is made by a PMSE organisation for spectrum, a computer-based geographic information system processes frequency and bandwidth requirements, the parameters of the transmitters (e.g. power levels) and proposes a suitable band for use, for which a licence is issued. Restrictions may be applied to this, for example the application of exclusion zones where transmission is not permitted, or height restrictions. Ofcom sets the fee levels to be applied – these are dependent on bandwidth, time used and the band in question (higher prices for more in-demand bands). MoD benefit from a fifty per cent reduction in their spectrum fees where they share with PMSE.

Coordination is not always easy – for example with a major event like a Grand Prix, there will be numerous demands over a restricted geographical area. An advantage of this system is that the authorisations it issues are for short term use – so it is inherently able to respond to changes required by MoD in terms of new equipment, change of use or short-term periods of both unavailability and opportunity.

4.3 Incentives

To provide an incentive for sharing, where the MoD shares with other users it usually receives a rebate on its fees. The extent to which the level of sharing accommodated by the MoD is truly reflected in the calculation of its charges, and whether the incentive effects of this could be improved, is considered in the Pricing chapter.

4.4 Third party intermediary

Although organisations such as the MoD and CAA are willing to consider new sharing possibilities, they are less keen to consider promoting increased sharing themselves. The reasons for this are understandable: where the organisation in question has as its core mission a national security or safety-critical role, it may be reluctant to consider discretionary activities outside of this. In the case of sharing, in particular, an organisation may feel it puts at risk its core mission by engaging in such an activity.

To progress the agenda of increased sharing there are several issues to consider, including the resource for engaging in this activity, setting parameters of the sharing activity to a level that is acceptable in terms of safety and security while remaining attractive, and the incentivisation for an organisation to consider sharing its bands. The latter is covered in the Pricing chapter.

The Audit team feel that the first two issues could be at least partially resolved through the use of an intermediary to facilitate sharing between public sector users and other public or commercial organisations. We are considering the arrangements which would be involved in this, and how this would be funded. For example, it may be possible for the initial process to be funded as an enhancement to the SES while the level of buy in from industry, public service providers, other stakeholders and markets is assessed. The body would have to maintain close contact with the organisations it was representing, plus the regulator and Government (through UKSSC and its sub-committees) where necessary e.g. in agreeing parameters for sharing. Possible roles for such a third party organisation could include:

- **Information** collection about spectrum allocations and usage
- **Monitoring** of usage over time, perhaps building up a picture of use and therefore highlighting areas of low intensity/no use (recognising the problems attached to measurement noted below)
- **Negotiating parameters** of sharing arrangements between incumbents and new entrants, through a database or directly in more detail for more complex arrangements. This could include pre-emption arrangements where needed
- Administering a **charging regime** for sharing, collecting charges from users to benefit the organisation permitting this use
- Facilitating **trades,** including on a short-term basis.

Would the existence of a third party intermediary to facilitate sharing between public sector organisations and other public/commercial bodies be likely to increase the possibilities afforded by sharing? What roles should such a body have?

Would individual users find it useful to be able to negotiate over sharing/trading arrangements either directly with the MoD or organisation acting on their behalf?

The Audit team would welcome any views on how existing users can be assured that sharing will not compromise ongoing safety-critical or essential use, including through equipment standards, testing, management of liberalisation and appropriate operational and technical parameters.

4.5 Defining boundary conditions for sharing

Under the command & control approach, Ofcom typically makes a judgement as to whether two or more services can share the same spectrum. It does this by conducting technical studies to determine the probability of interference between the two services, and then would typically consult with the existing and proposed new users. If sharing appears appropriate it would set technical limits on emissions for all those sharing the spectrum and would investigate any cases of interference. This sort of sharing is widely used, for example, between fixed and satellite links in a number of bands.

Under the new market forces approach, proposed for around 70% of the spectrum under Ofcom management, Ofcom would not expect to intervene itself to add shared users to a band. Instead it would be the decision of the licence holder as to whether they wished to allow shared use. They might do so, for example, if the shared user made some payment to them for the access to the spectrum. They would use the procedures set in place by spectrum trading to allow access. It would be the

responsibility of the licence holder to determine the appropriate technical parameters for the shared use. Ofcom would not expect to be involved in cases of interference between the licence holder and the new shared user, although it would still investigate other interference issues in the band. Any rights provided to the shared user would need to fit within the overall spectrum usage rights that Ofcom is developing for the band in question.

Some public sector spectrum users have expressed concerns about these plans, worrying that existing rights and operations may be negatively affected, or they may not always be appropriately identified as having an interest. In this context, sharing may be less attractive for public sector bodies as it may be seen as further increasing the risk of interference. RSA is one way of registering existing use, and requiring this to be taken into account, which might help here. However, the Audit team is also of the view that Ofcom needs to be clear about the roles and responsibilities of users and the regulator in agreeing coexistence conditions for new incumbents, where there is a change of use, or ensuring protection of existing uses, and may need to become more involved in the process to seek to avoid problems before they arise for public sector users. For some public sector users e.g. with safety critical systems, this is particularly necessary.

It is also recognised that, following the setting of initial parameters for sharing, there will need to be ongoing coordination (probably including a role by the regulator) to continue to manage coexistence. See also the MoD chapter for discussion of codifying sharing arrangements.

4.6 Test and Development

Ofcom grants two forms of non-operational licences, one for trials and demonstrations and the other for testing and scientific development. Requests for such licences come to Ofcom, who negotiate access with existing users. Licences are then issued on a non-interference, no protection basis. 300-400 Test and Development (T&D) licences are issued annually, charged on a nominal cost recovery basis (£50). Incumbents can object to licences being issued if interference would be caused to their systems. Although generally a high proportion of licences are granted, and refusals may be for good reasons, some bands may be hard to access.

This applies to both commercial and public sector bands (for example around a third of T&D licences are for development of military equipment – not only for UK MoD but also for export). Current Ofcom proposals are to continue the process of issuing licences with the advent of trading and liberalisation.

Given the need to test potential new sharing compatibilities, the Audit team is keen that the T&D regime should encourage innovation, should not be adversely affected by the introduction of trading and liberalisation and that access to as wide a range of bands as possible (noting that there is no presumption that being allowed to test in any given band gives any indication of future rights to operate production equipment there) should be facilitated in this way.

The Audit would welcome any views on the effectiveness of the current T&D licence regime and how this might be improved. It would also welcome views from existing users on how much flexibility here would be considered reasonable.

Box 4: The UWB example

The recent approach to the safety and interference testing of ultra-wideband (UWB) can be highlighted as an example of the public sector responding to commercial pressures in a practical way. The nature of UWB technology may facilitate new forms of sharing, and is the subject of international interest. A test programme has been set up, based on the requirement for protection of public safety but taking into account the commercial requirements of UWB proponents, which has received support from all sectors. The initiative by the CAA to establish a definitive data set was supported with resources from Ofcom and subsequently supported by industry and other interested stakeholders.

By involving safety authorities at the earliest opportunity and gathering evidence applying the strictest quality regime and an arduous review process to the results, a programme of testing has been started. This method of working enables existing users and proponents of new technologies to work together towards a common aim of more efficient spectrum usage. Recognising that the characteristics of other systems will necessitate different forms of testing, this model nonetheless outlines how cooperative working can be facilitated and could work for future sharing test programmes.

4.7 Scope for sharing: measurement of use

Measuring the intensity of use of spectrum is not straightforward. For example, one-off measurements may not capture sporadic transmissions, and passive receivers will not be detected as they are not transmitting. [15] However, it does appear likely that there are bands where a low level of use (or localised use) by the incumbents could point to the possibility of sharing with other users on a more dynamic basis. Monitoring the environment with a greater degree of sophistication – to determine actual use or coverage rather than just assignments - could open up possibilities for sharing through division in terms of time, power and/or location. There would however need to be consideration given to any security concerns about use of this information.

Ofcom does carry out sporadic monitoring exercises, but as noted above, it is difficult to build up a comprehensive picture of use from these. Ofcom plans to build up a UK-wide capacity for any-time, real-time monitoring of the use of spectrum. The Audit supports this intention, and is interested in whether such a measurement capability could have benefits beyond just interference management (as Ofcom plan), for instance to be used as part of a system coordinating more dynamic sharing. This could even be linked to some form of trading system.

4.8 Current and future sharing

Bandsharing is not a new concept. For many years there has been interoperability between different users and services in the same bands, as exemplified in this chapter.[16] There are various ways that sharing can take place, and the complexity of these systems has increased over the years.

[15] see Spectrum Framework Review Statement Annex E for an example of measurement and explanation of limitations

[16] and see for example Study into Mixed Sharing – Converged solutions, Roke Manor Research for Ofcom, April 2004

New technologies under development may enable more 'intelligent' sharing, where the sharing is brought about by an entitlement to transmit in spectrum for which a third party has been granted a licence. Two types of entitlement have been proposed, namely:

- Entitlement in time. A cognitive radio looks for momentarily unused parts of the spectrum, makes use of the spectrum and then vacates it before the licence holder wishes to use it. This may be done by agreement between users or through the use of technology which seeks out currently unused frequency bands. In the later case, it is known as "cognitive radio" or, somewhat erroneously, "software defined radio" (SDR)[17]; and

- Entitlement in power. This is the entitlement to transmit in a frequency band used by existing services at very low power levels such that their use of the spectrum will not be materially affected. One technology that potentially enables this is ultra-wideband (UWB).

Spectrum is also available for use by Licence Exempt systems, where the regulator allows free access to the spectrum, although normally with restrictions on power levels (making it most suitable for short-range devices for example). It is therefore up to the users themselves to coexist with other services and users and is another way of effectively 'sharing' spectrum.

There are three Spectrum Efficiency Scheme research and development projects[18] relevant to this area, which the Audit team will follow with interest. These cover: interference cancellation; novel methods of sharing; and Software Defined Radio.

In addition, to support the Audit's interest in the development of bandsharing as technology progresses and sharing techniques are pioneered, a study has been commissioned into the future potential for bandsharing. One focus of this work is to examine the possibilities for sharing in the more commercially valuable radar bands. Work is well advanced in this area and we are optimistic that the result of the report will highlight new sharing potentials. This report will be completed in time to feed into the Audit's Final Report.

If it is shown that some new methods of bandsharing are technologically possible, it is likely that benefit would be significantly increased if this could be enabled more widely e.g. recognition and approval through EU and international procedures. The Audit would therefore examine the regulatory, international, standardisation and operational frameworks which would need to be addressed in order to bring the technology into operation, and will make recommendations accordingly.

The Audit team is interested in the potential for more sharing in the bands used by the public sector. Are there techniques or services in which you believe there is particular potential? For example, what are your views on the technological, operational and economic feasibility of sharing between radar and other technologies?

[17] Software Defined Radio (SDR) can be defined as a radio whose characteristics are set by software, not hardware, which as a result can be changed considerably to adapt to situations.
[18] for more detail see http://www.ofcom.org.uk/research/technology/ses/ses_0405?a=87101

Chapter 5

Ministry of Defence

5.1 Introduction

The Ministry of Defence (MoD) is the biggest single user of spectrum in the UK, managing, or with a significant interest in, around 33 per cent of spectrum use in the bands the Audit is examining (around 75 per cent of the public sector use).[19] Allocations to defence are determined through interdepartmental machinery under the UKSSC, which has Ofcom in attendance. Assignments are managed by the MoD itself.

Although the MoD has autonomy to manage its own spectrum, it works closely with Ofcom in respect of any bands which are, or might in the future be, shared with civil users or released for such use. The MoD also need to keep Ofcom informed about aspects of their existing usage, even in MoD-exclusive bands, and of future requirements, due to Ofcom's responsibility to represent all UK interests in the main international fora dealing with spectrum. Where the MoD needs to register internationally its use of assignments (for example for satellite networks) Ofcom is responsible for submitting these as the UK administration in the ITU. The MoD pay fees for the spectrum they use and the establishment of the appropriate fee requires detailed band-by-band discussions between Ofcom and the MoD.

As discussed below, the Audit team recognise that the MoD needs a high degree of assurance of access to spectrum to carry out its required defence and other activities. However, taking into account the restrictions that this must necessarily impose, we are of the view that there is scope for improving the effectiveness of the MoD's use of spectrum in a number of areas, including through their procurement and charging processes, internal coordination and information sharing, better use of some specific bands and increased bandsharing.

5.2 Nature of use

The MoD require spectrum for numerous uses, including communications, navigation, surveillance, weapon guidance, targeting and fusing, through radio, satellite and radar systems. Many of the MoD bands are NATO harmonised. Under NATO treaty obligations, some bands are reserved exclusively throughout NATO or at least NATO Europe for defence use, and others are identified for defence use but with some degree of national flexibility. The increase in deployment of coalition forces for conflict resolution and peacekeeping has increased the need for bandwidth to support the coordination of operations, and this must often be alongside continuing local civil use outwith conflict.

Although MoD use in a battlefield situation is likely to be in a territory outside the UK (and therefore not confined by the MoD's UK allocations), the MoD need their UK frequencies for UK Base operations, including counter terrorism, Force preparation and training purposes, the support of visiting forces and equipment testing and maintenance. The fact that equipment may only be used sporadically in the UK still means that the relevant band needs to be available when that usage arises. The

[19] Excluding navigation use. See footnote 3 for derivation of statistics.

Audit team is interested in whether, in these circumstances, there may be alternative uses for that band e.g. through periodic sharing arrangements.

In addition, there is an increasing emphasis on information provision in a battlefield situation – for example, with information needing to be relayed back to the UK by satellite- and this increase is likely to continue, with need for infrastructure and operational links back in the UK. The MoD also needs to be able to deploy radio systems in times of national crisis if necessary, in support of or as a substitute for conventional public safety and other critical services. This requirement has to be able to co-exist with regular commercial and other non-defence radiocommunications services.

We have concentrated on those bands clearly and publicly labelled as MoD spectrum. However, we are aware of other uses – for example for national security purposes – not reflected in this way. This use, which is covert by necessity, will have implications for issues the Audit is looking at such as defining rights and sharing.

5.3 Technology

Modernisation of the Forces through developments such as Network Enabled Capability is planned to enhance operational capabilities but will also have a significant effect on needs for spectrum. As military technology progresses, higher performance and increased information provision will generally equate with higher bandwidth, increasing the demand for spectrum. Over recent years MoD has achieved significant manpower and equipment savings – to an extent this has been founded on being able to deploy forces to greater effect through improved sensing, information supremacy and dissemination, all of which require greater use of spectrum.

Examples of possible future developments include:

- There is substantial interest in Software Defined Radio as applied to the Services. The UK is for example looking with interest at the US Joint Tactical Radio Systems programme, which aims to specify a single communications system to be used in all US Forces for many roles. UK/US interoperability and the integrity of UK use of radio frequencies will be crucial. Such systems could employ higher modulation to achieve higher data rates in the same bandwidth where the density of use permits, and also tune to use bands not otherwise in use at that time.
- Unmanned Aeronautical Vehicles (UAVs) are another new and growing area, and are heavily reliant on spectrum for their operational control and data links.

MoD's forward plans mean that there will be more demand for spectrum for their core activities. As such they are wary of giving up any current rights to spectrum. The MoD consider that some of their existing bands are congested, and they are looking at more dynamic ways of managing their spectrum in the future to meet both their training and operational needs. MoD do not currently envisage making requests for additional spectrum outside their current bands in the short to medium term, instead concentrating on re-use within their existing allocations. We will discuss with the MoD over the coming months their likely future demand for spectrum.

5.4 MoD management of spectrum

MoD has a team which acts as a central point of contact for MoD spectrum usage – Defence Spectrum Management (DSM). DSM coordinates assignments within MoD

bands and makes assignments to users. Where possible frequency bands are allotted to be managed locally by the front line commands.

At present, this coordination function is performed on a predominantly ad hoc basis, using the knowledge of those in the central unit and referring to local frequency managers where necessary. MoD envisages that this will change as the nature of demands on spectrum increase and become more complex. We agree with the MoD's assessment that new methods of coordination and information sharing within the organisation are necessary and will discuss with MoD over the coming months how this might best be done.

Areas we will be looking at include the use of planning tools, software records-management, monitoring systems and modelling tools. MoD's priority in improving coordination is to manage battlespace planning more effectively, and accommodate current and anticipated demand within current (or expected) allocations. These developments are likely to require a stronger central coordination function. The Audit team feels that the improved knowledge and dynamic management that this could facilitate might also open up new possibilities, for example in sharing and trading.

5.5 Procurement

Where procurement processes specify an output, it is for the contractor to deliver that through the means it chooses, and the cost and acquisition of the inputs to deliver that outcome are the responsibility of, and at the risk of, the contractor. In the case of spectrum, however, spectrum as an input is not included in the deliverables for a contractor but instead must normally be found from existing MoD allocations. This makes the stage at which spectrum requirements are considered in the procurement process an important element of determining how effectively those allocations can be used in future.

There is currently no adequate requirement for spectrum requirements to be considered at any stage of the MoD procurement process. MoD's equipment procurement focuses on meeting user requirements – i.e. initial requirement definitions are technology-neutral and will not specify frequencies that equipment must operate on, or the type of systems that the service should be provided through. Procurement teams are expected to discuss likely requirements with DSM once the project is in train. For example, if there are competing bids to produce equipment then DSM may be asked for a view on the proposals in terms of their frequency requirements. Whole life cycle cost calculations for projects should include the cost of spectrum (as with other inputs), but there is currently no established formula or procedure for producing such a cost estimate. Potential contractors might not always be aware of spectrum issues or the information that is available to them on this issue.

MoD procurement programmes are often lengthy, and equipment once procured is often expected to have long in-service life, and work with other equipment with overlapping procurement and in-service timeframes. It is recognised that if MoD is to incorporate spectrum requirements in a meaningful way and effectively in its procurement process, it needs to have appropriate long-term spectrum availability goals. Careful consideration is also needed of the cost and planning implications of any changes suggested to the current system, e.g. how through-life spectrum costs can be estimated and planned with some certainty at the procurement go-ahead stage.

In the US[20], new guidance is being developed for the capital planning (procurement) process, which will require agencies to incorporate the value of spectrum as a resource cost in their analysis of the business case for their proposed investment. This would mean, for example, that a system that is more expensive to purchase but is less spectrum intensive could prove to be the better through-life investment. MoD are themselves considering how spectrum considerations could be better factored into the procurement process. We see the procurement process as important in contributing to more effective spectrum use in two respects: (i) exposing the cost implications of using spectrum and (ii) contributing to a better medium to long term picture of future requirements to ensure more effective forward planning of assignments and any need to seek additional spectrum.

The Audit team are therefore in favour of consideration of spectrum requirements being introduced at an earlier stage in the MoD procurement process, as with other input factors. We will continue to discuss this with the MoD. We are also interested in the procurement processes in play in other areas (e.g. aeronautical) and will also be looking further at these.

Increased military use of commercial, off-the-shelf (COTS) equipment is often cited as beneficial for cost reduction and providing rapid introduction of improved functionality. COTS equipment still needs to go through the first stage of the MoD procurement process to establish the case for procurement, but, as above, this does not lead to a clear consideration of future spectrum requirements. We understand from MoD that there is not a high level of reliance on COTS for radio equipment. However, we will be looking at this further as we examine the overall procurement cycles. Multi-band COTS equipment could find use in the military if there were a probability of finding free bands in operational scenarios. Over the years the MoD have increasingly made use of commercial operators to provide specific services or secure service through market (where spectrum considerations are already taken account of). As the spectrum market develops, and new spectrum by necessity must be secured through the market, it may be that the MoD chose to use this commercial route more frequently.

5.6 Pricing

The MoD pays Administered Incentive Pricing (AIP) on much of its spectrum. Charges are calculated at rates comparable to those charged for the private sector. Their fees currently represent about 30% of Ofcom's total spectrum fees income and the annual spectrum fee has recently increased, from £23.5m in 2004/05 to £55m in 2005/6. See Annex F for an indicative breakdown of the charges and chapter 3 on pricing for more discussion of MoD pricing, including the possibility of extending charges to NATO managed and some radar bands and the comparability of pricing between bands deemed to be fixed and mobile and between civil and military.

There is no formal evidence about the efficacy or otherwise of AIP, although there have been instances of the MoD releasing bands following a planned increase in pricing for that band, which indicates that some form of incentive effect is in play. However, spectrum fees are currently borne by the central spectrum unit in MoD. It is therefore debatable whether the true incentive effects of using spectrum bearing a cost bites in the right place – i.e. with those who are best placed to determine actual usage (current and future) with full knowledge of the cost implications of doing so. Changes discussed above with regard to strengthening the central coordination

[20] see for example http://www.ntia.doc.gov/osmhome/osmhome.html

function in MoD may help in improving this situation. If this did not materialise, an alternative would be to cascade charges within the organisation to those making procurement or exercise-planning decisions. We will be discussing further with MoD whether internal charging could be revised to sharpen incentive effects.

5.7 Leasing/licensing

The 2002 Cave Review recommended that MoD should explore opportunities for leasing out its spectrum, possibly for limited periods of time, to other users, for example where the MoD had no current (but might have future) need. Since the Review there has been one example of a time limited licence, with a fifteen year licence of parts of 3.4-3.6GHz to a commercial company, agreed through Ofcom. In this case, MoD gave approval for Ofcom to licence part of this band. However, this is not really a 'lease' in the sense that the spectrum does not automatically revert to MoD at the end of the fifteen years - this arrangement was agreed on the basis that MoD would be able to negotiate a return of this spectrum if there were an operational need.

3.4-3.6GHz will be an interesting test case in this respect – one of the reasons MoD give for not pursuing other such opportunities (as well as not seeing it as their role to identify ways of maximising use of their spectrum by allowing use by civil users, which they see as historically the regulator's role), is that they have concerns that if they concede that they do not need a certain band for a time, then it will be harder to get the spectrum back to MoD management at the end of the licence period. MoD are planning to use this in the future and so will need to make the case for this band to revert to their control.

The Audit is considering the merits of attaching a 'freehold' charge for any spectrum leased out, to be paid by the band holder during the leasing period. This would have the benefit for an organisation like MoD of clearly marking their ownership of that band; whilst at the same time maintaining an incentive to fully consider whether the band is still required or could be disposed of (see also Pricing chapter).

5.8 Sharing

MoD shares bands with a number of other public sector users, as set out in chapter 4 on Sharing. Many sharing arrangements pre-date the introduction of AIP.

Rebate system

As above, we will consider whether changes can be made to the pricing regime to make it more attractive for MoD to admit sharers into a band. In all cases, the decision on whether to enter into bandsharing, and the arrangements put in place to manage this, must of course be for MoD.

Currently, where MoD has agreed sharing arrangements with other public sector users they are normally given a rebate on their AIP by Ofcom. There does not however seem to be a uniform process for applying the rebate or recovering this from the other users. There may for example be cases where MoD agree directly with the user sharing arrangements in their bands yet do not get recognition for this in terms of a rebate or recovery of costs from the other user. There may be scope for clarifying the sharing rebate system to ensure that it accurately reflects the nature of sharing – benefiting the organisation allowing sharing - and that the cohabiting users pay for the benefit they receive (see also Sharing chapter).

One scenario might be that MoD pay the whole fee for a band (maintaining recognition that a band remains under their management) and then charge out for use by others, retaining the income. However, this would impose a resource burden on MoD which the department is not in favour of (MoD preference being to work with a few discrete bodies rather than individual users at the assignment level). It is possible that this charging role could be taken on by a third party (see below for this as a suggestion for facilitating sharing). The alternative would be a greater role for Ofcom in managing the rebate system, and charging those who share the proportion of rebate they have enabled the MoD to benefit from – but this is less attractive administratively and in applying incentives.

To ensure that sharing, and indeed any other trading activity, directly benefits the MoD, the Department should be able to benefit financially from such activity. As outlined in chapter 2, we will clarify whether income generated from activities such as sharing could be retained under the Wider Markets Initiative.

The Audit team will also discuss with MoD whether spectrum, as an asset, should be incorporated into the MoD's commercialisation strategy under the Wider Markets Initiative, which would give a further boost to this type of activity in terms of momentum and resource.

A further element of developing an incentive structure to encourage sharing could be the application of targets to the MoD for their sharing or other spectrum usage activities. The MoD's target structure is based on their overarching Public Service Agreement with the Treasury, which is then cascaded down. The nature of a target could vary, from quantitative aims for bandwidth to be freed up or shared, to a more qualitative target for strategy setting and implementation of improved spectrum-management systems. The Audit team will consider the feasibility and likely effect of creating spectrum-relevant targets for the MoD, and, if there are benefits to this, the level at which these could be applied and the nature of such a target.

Third party

The Audit team can appreciate the reasons for MoD's primary focus on core operations, to the exclusion of consideration of exploitation opportunities for its spectrum. It may therefore be useful if a third party were to be engaged to facilitate trading and sharing on behalf of the MoD. The parameters for such an arrangement would need to be carefully defined, e.g. to take account of security considerations and policy responsibility. But if these issues could be addressed, as has been the case with JFMG, a third party intermediary could usefully provide the extra resource to enable better value to be obtained from MoD spectrum. This suggestion is covered in more detail in chapter 4 on Sharing, and we are inviting views from potential sharers and those who might facilitate such an arrangement themselves on whether this would be an attractive proposition.

Defining Parameters

For both parties to have confidence in sharing arrangements, it is important that there is an effective means of setting the technical sharing conditions, the financial arrangements and clear mechanisms for arbitration and dispute resolution. The MoD and Ofcom (and previously RA) have a long-standing but largely ad-hoc system of defining and regulating existing sharing arrangements between the military and well-defined civil sharers who can co-ordinate with military needs via Ofcom.

Under Ofcom's trading and liberalisation agenda, which will permit change of use, the MoD has some concerns about their current rights and how these will be protected.

There may also be an issue where defence use has historically been incorporated in civil bands and alongside civil use with minimum constraints on that use but where liberalisation is being introduced for that civil use.

While there are concerns about protecting existing arrangements, MoD are likely to be reluctant to enter into new arrangements, at least until they have gained experience in the practical implementation of liberalised regimes. ***The Audit has some sympathy with these concerns, and considers that action needs to be taken to codify current sharing arrangements***. The most appropriate forum for this to be done in seems to be the National Frequency Planning Group (NFPG), and we are of the view that the NFPG should add this as an item to their agenda, and consider a paper produced by Ofcom and MoD in conjunction with individual sharers, scoping out routes for codifying these arrangements. Annex C of the UK Frequency Allocation Table currently details sharing arrangements in the 410-450 MHz band – one possibility would be for this Annex to be expanded to cover sharing arrangements in other bands. Another possibility would be for the MoD to seek Recognised Spectrum Access which would specify these arrangements (this is explored in more detail in the chapter on public sector spectrum acquisition and trading).

A related issue is where a MoD use is not labelled as primary (and therefore doesn't attract a charge) but constrains other services in that band. This is the case for example at 1.7GHz where there is a longstanding MoD use of the band for transmitting earth stations. Any incoming commercial operations in this band have to accept any interference caused by these earth stations. Action taken to clarify parameters should examine whether these instances should be recognised as primary (therefore automatically attracting a charge) or whether there is another way of pricing the actual use and its effects, to better recognise MoD use of this type. It is recognised that there may be instances where details of use cannot be revealed.

Pre-emption

The ITU and UK national law recognises that in a time of civil emergency defence interests may act outside their agreed parameters. The procedure for dealing with a UK civil emergency in terms of spectrum management is covered in chapter 2. The Audit team is of the view that it is right that there should be a process clearly allowing the MoD to operate in emergency mode, in a timely manner, when this is necessary.

The MoD exercising these sorts of rights might however affect the activities of others who may be sharing those bands. The extent of this limitation and its effect on civil services would depend on factors such as the duration of the pre-emption, under what circumstances these rights would be applied and whether the service provider has access to a fallback provision. The MoD has in the past written pre-emptive rights into sharing agreements with other users, (although these have never been exercised), and may wish to apply similar restrictions to new sharing arrangements.

What impact does the possibility of restrictions to be imposed in a time of civil emergency have on the attractiveness of sharing MoD spectrum?

5.9 MoD spectrum policy

The MoD is currently revising its spectrum policy, setting out plans for managing its spectrum holdings in the future. In summary, the policy is expected to:

- Discuss the impact of spectrum congestion and how effective management of congestion will be needed to ensure NEC;
- Identify that equipment programmes are demanding significantly increased use of MoD spectrum holdings;
- Identify the need for better control of the spectrum implications of the equipment acquisition programme;
- Suggest the creation of an over-arching Spectrum Acquisition Authority;
- Provide a basis for spectrum management processes & tools;
- Suggest that tools are required to model and manage spectrum in collaboration with allies;
- Discuss monitoring;
- Look at enhanced military spectrum management (including awareness, training and manpower

Many of these areas overlap with the Audit's interests, and the Audit team will continue to work with MoD over the coming months as its proposals develop to ensure the two projects are taken forward in a complementary way.

5.10 Band specific

Over the years the MoD has reviewed, with Ofcom (and its predecessor, the Radiocommunications Agency) the use of the bands it manages, when there is a demand for spectrum in those bands. This has led to various bands being made available for alternative use and 'band-shuffling' where necessary and appropriate to accommodate any use migrating between bands (either defence or commercial services sharing with defence). Over the last decade, over 250MHz of defence spectrum in the valuable range below 3GHz has been made available for civil use through this cooperative process. This includes spectrum for 2G at 900MHz. Where RA/Ofcom has identified a demand for spectrum in MoD bands, bandsharing agreements between the MoD and the new user have often been the way of resolving the demand.

The 2002 Cave Review recommended that a comprehensive audit be carried out of all MoD bands. A consultant's report was subsequently carried out which looked in detail at fifteen bands. The report acknowledged caveats – for example that potential future MoD use in these bands had not been taken account of. Acknowledging these limitations, however, the report suggested that in most of the bands examined there should be scope for either reducing the MoD's holdings while maintaining current benefit, or for increased sharing of the band. Since the report was carried out, MoD has released two further bands to Ofcom (2290-2300MHz and 8400-8500MHz) and has identified an expanding requirement for spectrum access to meet the needs of its new equipment programme. There have also been changes to the services operating in these bands, which may affect the original analysis.

The Audit team is revisiting these bands and others with the MoD to ascertain whether there is potential for releasing all or some part of the allocations to Ofcom, or for increasing sharing in the band. These have been chosen because of their potential for civil use. These bands, and a brief description of their current use and the future possibilities being examined, are listed below.

To judge potential demand, we would welcome views on the bands highlighted – listed in Annex C and detailed in this chapter and those on Aeronautical and Fixed Links. Would possibilities for (i) sharing (including time limited or ad hoc

sharing) or (ii) freed up bandwidth in these bands be of interest to other users? Are there other bands the Audit should examine?

In the following list, * indicates that the band is shared with CAA

225-400MHz
This band is NATO harmonised and managed, and houses use of Air-Ground-Air systems, Instrument Landing systems and Radio Relay. More recently military SATCOM has been added to this band. TDAB and emergency services uses have been introduced into this band at the lower and upper ends of the band respectively.

The Military currently utilise 25 kHz channels in this band. International agreement would be needed to change this; although as part of a forthcoming NATO reorganisation of this band, 5MHz has been put aside for countries wishing to use reduced bandwidths, which could free up some of the wider channels (such a move would be progressive, refarming to narrower channels). MoD are of the view that the spectrum released by moving to narrowband (12.5 or 8.33 kHz) will be needed in a later reorganisation to meet growing military requirements both within NATO and with other allies. The Audit team will continue to discuss this band with the MoD.

400-406MHz
This band is used by the Met Office for radiosondes. The Audit team will be discussing in more detail with the Met Office their use here and their future needs for this band.

960-1350MHz *
This band incorporates a variety of uses including radionavigaiton shared with the CAA, radionavigation satellite, earth exploration satellite and radiolocation. This band appears to have a high intensity of use.

1559-1626.5 MHz
MoD use 1559-1610 for GPS (available for civil use).

2310-2450MHz
This band is of prime commercial interest, and we will continue to explore the planning of this band with MoD.

The MoD currently uses this band for a variety of uses, including aeronautical telemetry. Some sharing is already incorporated, e.g. RLANs (2400-2483.5 MHz), Programme Making and Special Events organisations and the Emergency Services. The MoD forsee possible future use of this band for UAVs.

There is a suggestion, due to be discussed at the 2007 World Radio Conference, for there to be an internationally harmonised band for telemetry. If this was to go ahead, possibly using a higher band, then there may be scope for migrating some services out of this band (subject to a suitable band with appropriate propagation characteristics being identified).

2.7-3.4 GHz *
Radars in bands such as this generally use significant bandwidths. This band in particular is in a valuable part of the spectrum and therefore there is a need to ensure both that the band is being used effectively and that the cost of this use is recognised. The potential application of AIP to radar bands is covered elsewhere. In this band, we will be concentrating on examining with the MoD (2700-3400 MHz) and CAA (2700-3100 MHz) the technical justification for the use of such large bandwidths, and whether there is any scope for better planning of the use of these

bands, or reducing the size. 200MHz (2900-3100 MHz) is also used for mobile maritime radars and associated navigation aids. International restrictions will be relevant in both cases.

3.4-3.6 GHz
Part of this band is currently leased out for 15 years to a commercial operator. MoD anticipates a future need for this band at the end of this period.

4.4-5 GHz *
This is a NATO band for fixed infrastructure, mobile and nomadic use. We will continue to work with MoD to examine the detailed use of this band, including looking at the equipment used and whether some services could be provided in an alternative way. Again, this is a band that MoD have identified as possible for future UAV use.

7 & 8 GHz
The military use these bands for SATCOM (NATO-wide satellite allocation). We will be considering further with MoD whether the sharing possibilities are being fully exploited.

8.5-10.5GHz *
This band contains a mixture of services including radiolocation, radionavigation, and some Emergency Services use. Some of these military systems tune across the bands, raising the possibility that sharing with some services might be achievable.

There has been a positive step towards admitting civil use with the agreement for 10.125-10.45 GHz to be used for Fixed Wireless Access.

13.25-13.4 GHz
The Audit team are engaged with MoD and CAA in examining the use in this aeronautical radar band.

13.4-14 GHz
13.75-14 GHz has been agreed internationally for FSS use (where there is UK demand for greater use) and Ofcom and the MoD are discussing implementation of this in the UK.

15.4-17.7GHz *
There is a wide range of uses in this band, which we will be exploring further with MoD.

Further examination will also be carried out of bands covered bythe report following the first Cave Review (excepting one already released to Ofcom):

137-138 MHz
142.5-143 MHz
149-149.9 MHz
153.5-154 MHz
430-450 MHz
1375-1400 MHz
1427-1452 MHz
2310-2390 MHz
2390-2450 MHz
5300-5350 MHz
5650-5850 MHz
7900-7975 MHz
7975-8025 MHz
8025-8400 MHz

Chapter 6

Aeronautical

6.1 Introduction

The civil and military aeronautical sectors are significant users of radio spectrum. For example, aeronautical navigation accounts for around 25 per cent of spectrum – this is divided between civil navigation (14 per cent) and military navigation (11 per cent).[21] This chapter focuses mainly on the civil use. Spectrum is a key input for a variety of systems which provide communications, navigation and surveillance functions key to the safe passage and efficient management of aircraft. They are also used by land-based air traffic control to manage airspace, again for safety and also to accommodate increased density of use of airspace and airports as the aviation industry grows. As such, most of the spectrum usage by the aeronautical community has a significant public safety, and thus a public policy, dimension in addition to its economic value.

Many of the aeronautical uses of spectrum are similar to those in maritime, which is covered in chapter 8. Much of the radio and navigation equipment is in use across the world on internationally mobile aircraft not registered, or originating within the UK, which reduces the opportunity for unilateral action. Other allocations may also be used for purposes such as meteorological radar for detection of windshear in front of an aircraft.

The aeronautical sector has a total spectrum allocation of 2440 MHz in high demand bands, divided between:

Radio Beacon	17.9%
Radar	67.4%
SSR & Radio Altimeters	9.8%
Communications	1.8%
GNSS	3.0%

Many of the aviation spectrum allocations are long-standing; made when there were few competing demands and no scarcity in spectrum above 1 GHz. Aviation has historically been a significant user of spectrum with limited pressure on its incumbent rights. Due to the safety imperative and the seriousness of the consequences if aviation systems fail or overload, the sector has tended to be conservative with regard to its spectrum use.

However, the Aviation industry is also growing rapidly. For example the CAA plan on the basis that air traffic will continue growing by 5 per cent per annum into the future and this growth will have an effect on spectrum requirements. Several aviation systems - including communications and the L and S-Band radars - operate in parts of the spectrum that are increasingly congested and valuable for mass-market communications. There is therefore a tension between a desire for very high safety standards achieved through multiple redundancy and spectrum congestion. The Audit appreciates that aviation is a safety critical service, and that fallback systems are required. We will however be examining operational requirements, and layers of systems in place to deliver these, to ascertain whether the combination of different

[21] See footnote 3 for derivation of statistics

systems in use delivers the optimum balance between ensuring safety and efficient utilisation of spectrum.

Civil aviation spectrum and some military radar bands are not currently subject to incentive pricing (AIP). Ofcom have been exploring the options and feasibility for extending AIP, including by commissioning research into the scope for improved technical efficiency, but outstanding issues remain on whether and how aeronautical pricing should be introduced. Pricing of communications equipment is discussed in more detail later in this chapter. Chapter 7 covers regulatory and pricing issues for radar in detail.

6.2 Regulation

The Civil Aviation Authority (CAA) is the independent specialist aviation regulator and is a public corporation. The CAA covers all civil aviation regulatory functions (economic regulation, airspace policy, safety regulation and consumer protection) and also plays a role in the regulation of military aviation.

Air Traffic Control (ATC) Provision: National Air Traffic Services (NATS) provides national 'en route' air traffic control services to aircraft flying in UK airspace, and over the eastern part of the North Atlantic. The feeds from NATS radar facilities are sent to both NATS air traffic control centres and the MoD for common use, thereby reducing the number of radars needed. Air traffic control at individual airports is provided by a number of commercial companies. The role of CAA in ATC functions is to co-ordinate frequency assignment and co-ordination and the setting of regulatory policy.

General Aviation (GA) is the term for other aviation activity including executive jet aircraft, helicopters, balloons and microlights. GA is regulated by the CAA.

6.3 Licensing

Licensing of aeronautical spectrum is currently administered by the CAA on a contract from Ofcom. The current licensing process and fees are:

- Ground stations: Frequency based, with emission criteria. The licence application, fees, and frequency allocation are handled through a one-stop-shop. Licences must be renewed annually and if not re-licensed the frequency is reallocated. The charge rate is set by Ofcom and ranges from £50- £250 based on a frequency assignment to a specific location.
- Aircraft stations: Licences costs range from £15-350 for aircraft, banded on aircraft weight. The licensing process is linked to equipment approval. All equipment covered by the licence must be approved and for registered aircraft the installation should also be approved.

CAA collect licence fees on behalf of Ofcom and remit them to Ofcom monthly. Aeronautical radar and communications licences are currently issued on a cost-recovery basis with no economic incentive element. CAA charge Ofcom for its costs in providing the licensing service and Ofcom also contribute to some of CAA's equipment approval work.

Ofcom is considering a proposal to issue free lifetime licences to all ship radio users, including ship portable users and all classes of aircraft radio and aircraft transportable radio users. Ofcom are still considering the possibilities for deregulating the aeronautical licensing process and are minded to make changes to the current regime. However it is likely that a form of aircraft licence would need to be

maintained to meet the requirements of ITU and ICAO. As outlined in Chapter 8 the Audit is concerned to ensure that this process does not have any negative unintended consequences such as making it much more difficult to impose economic incentives through AIP in future.

6.4 International regulation

Spectrum for aeronautical use is allocated by the ITU. However, in order to achieve global inter-operability, equipment standards and frequency planning criteria are further harmonised through the International Civil Aviation Organisation (ICAO), which requires compliance with published Standards and Recommended Practices (SARPs). In addition, in Europe, the European Organisation for the Safety of Air Navigation, Eurocontrol, provides the institutional and support framework within which the spectrum and frequency management processes are coordinated in conjunction with ICAO. The European Aviation Safety Agency (EASA) brings national civil aviation regulators together and sets much of EU harmonised policy.

However, the overall responsibility for spectrum and frequency management remains a matter for national Governments. In general there is significantly more scope for national decisions and variance from international norms in ground-based primary functions than those involving communication with aircraft flying internationally.

The pressure to invest in more efficient technologies or develop sharing standards may be more pressing for the UK and neighbouring European countries than the rest of the world due to the density of air traffic and intensity of other economic activity including wireless communications.

As a result, the UK is often at the forefront of attempts to modernise aviation standards and practices. In determining the UK's position in international fora, the CAA and Ofcom are obliged to consider the overall balance of interests between different users of the spectrum through the International Frequency Planning Group (IFPG), part of the UK Spectrum Strategy Committee (UKSSC) structure, where the CAA, Ministry of Defence, NATS and Ofcom are fully involved.

Although the UK may have scope for unilateral action in some areas, the benefits of standardisation and common markets mean that economic benefits for the UK are likely to be greater if the change can made internationally. This is done through the development of common standards and agreement to international implementation. The lead times are long as new equipment can take around 15 years to develop and 7 years notice is needed to ICAO for new requirements. This international context will need to be taken into account in any final recommendations.

6.5 Future Demand

We understand that aviation may identify requirements for additional frequencies in future. Given the likely pressure on spectrum, the aeronautical community will firstly need to demonstrate that it has done all that is reasonably possible to maximise efficiency in its existing bands. A distinction can also be drawn between the requirements for Safety of Life air traffic control and the telemetry requirements for aircraft testing and combat simulations.

In the next World Radio Conference (WRC 2007), there are two agenda items covering possible additional spectrum requirements for aviation.

- 1.5: “To consider spectrum requirements and possible additional spectrum allocations for aeronautical telecommand and high bit-rate aeronautical telemetry…”. This item will cover aircraft telemetry for aircraft testing and may be extended to consider UAVs for telecommand and possibly communications.
- 1.6: “To consider additional allocations for the aeronautical mobile (R) service in parts of the bands between 108 MHz and 6 GHz…and, to study current satellite frequency allocations, that will support the modernization of civil aviation telecommunication systems”. This is again potentially to support UAVs but also related to a desire for a digital upgrade of VHF communications.

These items may not produce a comprehensive review of aeronautical spectrum use but CAA agree that there is a need to better to define what spectrum is used, how it is used and what safety protection criteria are, and would consider pushing to secure this through international fora. **The Audit is strongly in favour of such a piece of work and would encourage the UK to pursue this in advance of WRC 2007.**

A current growth sector in aviation is UAVs (Unmanned Aerial Vehicles), where CAA consider that the development of standards and products has been a good example of regulators working with industry, leading to discussion at the WRC (World Radio Conference). MoD have also flagged up UAVs as a service requiring more spectrum in the future – we have suggested to MoD and CAA that they should work together to identify potential bands for the operation of UAVs.

The CAA view is that there may be new requirements outside current bands due to new technology in the future. Migrating through bands may release spectrum over time but not immediately due to transitional requirements. We will continue to discuss potential future needs with the CAA.

6.6 Communications

Aeronautical communication is a safety critical service providing a constant link between pilots and controllers. Outside these safety-critical requirements communication is also needed for commercial data related to airline operations and, increasingly, to the provision of services for passengers. Aeronautical communications are sometimes differentiated between Route (R) or Off-Route (OR). Route is typically associated with civil air traffic following designated air corridors, while Off-Route typically addresses military aviation and private aircraft.

Civil Air-Ground communications are primarily met by VHF (118 – 137 MHz). For air traffic services, the existing technology is simple, based in terrestrial regions on voice communication over VHF DSB-AM radios. In addition, UHF and HF continue to be used to support certain voice communication applications. This spectrum is intensively used and considered by the CAA as close to saturation. Channel size has been progressively reduced to accommodate increased traffic within constrained bandwidth, most recently with implementation of 8.33 kHz channel spacing in place of the old 25 kHz channels, although this has not yet been adopted across the board.

The implementation of closer channel spacing requires on-board re-equipment, and in time the increased use of datalinks. This is an example of how mandating new equipment on aircraft is possible but the costs to the industry and hence barriers can be significant, and there is often a need to coordinate the changes internationally.

In the longer-term, many in the aviation industry would like to implement a replacement digital system for VHF communications which would provide additional

capacity and functionality. This is likely to take some time to agree through the international process and there are tensions, including between globalisation and regional variation, between maintaining multiplex functionality for safety which might be considered inefficient over-use of spectrum, and between the needs and preferences of civil, recreational and military users who all need interoperability but typically wish to operate differently.

6.7 Aeronautical Communications Pricing

The 2002 Cave Review concluded that the opportunity cost to individual users of on-board systems is often effectively zero where bands are internationally harmonised, which argues against imposes incentive pricing. However where UK-based users face some technology choice differential licence fees should be imposed to encourage moves to more spectrally efficient equipment, thus easing congestion over time.

Progress in reducing the width of aeronautical communications channels has demonstrated that improvements in spectrum efficiency are possible where there is a will and incentive. This has probably been driven by the need to meet growing demands from aeronautical users within current bands.

Indepen's 2004 study to review spectrum pricing concluded that incentives for the aviation community to adopt narrowband technology could result in a reduction of up to 50 per cent in the spectrum used by each ground station and suggested there should be a premium on licence cost for users who had not yet adopted narrowband equipment. Our initial view is that there does look to be a good case for introducing differentiated pricing in areas like VHF communications where it could promote better use of congested capacity. However as in the maritime sector it is not clear that there is a case for imposing AIP across all aeronautical communications uses. As previously noted Ofcom are considering deregulating aeronautical spectrum licensing and it is important that this does not preclude incentive pricing before a firm decision has been reached on the case for AIP.

Where airlines want to make increasing use of spectrum to provide commercial services, which do not have a safety of life aspect, to passengers - for instance telephony or broadband - this raises questions of how requests for new spectrum or an application to make use of existing harmonised aeronautical bands should be treated. We will be exploring these issues further.

6.8 Sharing

There is already extensive sharing between civil and military users in the aviation bands, including common use of the air traffic control system. There are also some inland radars operating in the 2.9 – 3.1 GHz maritime radar band. This has benefits both for spectrum efficiency and operational coordination between civil and military aircraft. CAA manage sharing, e.g. with military operations, with robust procedures, which include a process through which the technology is examined and modelled, and scenarios are constructed, leading to the production and agreement of safety cases. Sometimes sharing is agreed with caveats. On the whole this arrangement works well as far as it goes – there is for example little proactive encouragement of increased sharing - but sharing does create complexities for the allocation of costs and targeting incentives if pricing is introduced.

Chapter 4 on sharing gives further detail, including investigation of the possibilities for sharing between radar and communications in the same band and the suggestion of a third party intermediary for facilitating sharing. We have commissioned a band-sharing study to provide further evidence on the technical feasibility of sharing. This will focus especially on the possibilities of different technologies sharing the existing aeronautical radar bands and will be used to inform the final report.

If novel forms of sharing are highlighted by this work, the Audit will aim to recommend a regulatory structure and financial incentives that will encourage the aviation industry and other key parties to take this forward if it is technologically feasible, safe, and will be of overall benefit to the UK economy. We fully appreciate the primacy of the need to preserve safety. This should be ensured within the existing international standards and approvals procedures which require a comprehensive safety case and testing.

The CAA have indicated a willingness to work with Ofcom on further technical research into sharing and the possibility of developing standards for international use. We would encourage this, and will work with CAA and Ofcom to discuss what further work would be productive.

6.9 Band-Specific

We are exploring with CAA a number of specific bands where there may be scope to reduce the size of bands that are either under-utilised or occupied by equipment which appears to use spectrum inefficiently given the technological possibilities. Our assessment of a 2004 study into aeronautical and maritime spectrum efficiency (see Chapter 7.3) will also include further analysis of these bands.

Microwave Landing Systems (MLS)
MLS is a precision instrument approach and landing system which has been internationally mandated for implementation in the 5030-5150 MHz band. Many lower frequency systems, especially ILS, may eventually be replaced by MLS (which is in place at Heathrow), but widespread deployment of MLS has been slow, in part due to a lack of commitment to the necessary investment, and it is not clear that all of the allocated band will be needed by the UK. Currently only 5030-5090MHz is partially used, with the upper part of the band reserved for expansion.

There appears to be a case for pricing the aeronautical community for this spectrum to reflect to opportunity of keeping it empty or under-utilised. This could help stimulate a clear decision from the industry as to whether the whole band or only a part will be needed for MLS going forward. If pricing exposed the fact that not all of the band was needed for MLS, the spectrum could be re-used. As the system is ground-based the UK should therefore have reasonable autonomy over which channels within the international MLS allocations are used for this or other purposes within the UK.

There is also a question of whether it is time the aviation industry made a definitive choice between MLS, ILS (the legacy approach system) and GBAS (Ground Based Augmentation System). This would then enable a firm plan for transition to be worked out if required, including the potential release of spectrum for alternative use.

UHF radar (channel 36)
There is diminished and currently very low usage of a radar allocation in this broadcasting channel in the middle of a band that has been predominantly used for

broadcasting for many decades. The functionality could be achieved by new equipment operating in either the L or S bands. This issue was noted in recommendation 3.1 of the 2004 study for Ofcom into options for improving aeronautical and maritime spectrum efficiency. It appears that there may be a case for clearance of this radar use to release valuable spectrum for other services.

Radio Altimeter Band (4.2-4.4 GHz)
Aircraft use the radio altimeter band to measure their height above ground. This is an essential and ongoing safety function. However we are interested in exploring whether it is technically possible to keep full functionality and reliability with significantly less bandwidth than is currently allocated. Each aircraft may need less than 200 MHz and the nature of the use means that different aircraft can re-use the same frequency.

If it is technically possible to use less spectrum for this function there could be significant international and cost barriers to implementation as new equipment might need to be fitted to aircraft where current equipment operates towards the margins of the band. This would require a cost-benefit analysis to evaluate the economic feasibility. However if the band could be narrowed it has the potential to release a significant block of spectrum in a band that could be valuable for broadband wireless access and potentially '4G' into the future.

DME/TACAN (960 - 1215 MHz)
Main en-route ground based navigation aid - expected to remain so for the foreseeable future. The band is quite intensively used and internationally co-ordinated but is very wide and in a valuable part of the spectrum. We will be exploring whether it would be technically possible to free up for example 30-40 MHz at the edge of the band.

L-band (1215-1350 MHz) and S-Band (2.7 – 2.9 GHz) Radar
We will consider these bands further in the light of the results of the sharing study that we have commissioned. There may be scope for a degree of national autonomy and improved efficiency or sharing in these bands could be key potential benefits of the radar pricing system proposed in chapter 7.

To judge potential demand, we would welcome views on the bands highlighted – listed in Annex C and detailed in this chapter and those on Defence and Fixed Links. Would possibilities for (i) sharing (including time limited or ad hoc sharing) or (ii) freed up bandwidth in these bands be of interest to other users? Are there other bands the Audit should examine?

Chapter 7

Radar and navigation aids

7.1 Introduction

Radars play an essential role in the civil and military aviation and maritime sectors, and are the most significant consumer of spectrum in both sectors. Marine and aeronautical radars occupy a major part of the prime mobile spectrum between 1-3 GHz. Between 0.174-15.23GHz, radars plus navigation systems in total account for around a third of spectrum use.[22]

The term radar originates from ra(dio) d(etection) a(nd) r(anging). Radar transmitters typically send out high power bursts (pulses) of microwave frequency signals, usually via a rotating antenna. These signals will be reflected by any objects upon which they are incident, and a fraction of the reflected signals will be detected by the radar receiver. Information about the target such as its speed and direction of travel, or even its size, can also be measured.

There are two main types of radar, primary and secondary. Annex E details the main radar bands and their use.

- Primary Radar: a radiodetermination system based on the comparison of reference signals with radio signals reflected from the position to be determined – may be used by air traffic control, coast guard and ports to monitor and guide aircraft and ships, or by the military for weapons systems
- Secondary Radar: a radiodetermination system based on the comparison of reference signals with radio signals retransmitted from the position to be determined. May be used by air traffic control to help aircraft negotiate their route safely. Requires the 'target' to cooperate with the interrogator
- Other Navigation Aids: including automated landing systems, direction and distance measuring equipment, location beacons.

The radar detection range depends directly on signal power, antenna size and angular coverage of pulses. Because of their application, radars are required to provide a certain level of performance, relating to the probabilities of correct or false detection of targets with given characteristics (size, shape or speed) within the required coverage area to gain accreditation (for example for use in safety of life services). Radar fidelity also tends to be related to the bandwidth used, as wide bandwidths are needed to create the sharp rise and fall of radar pulses, which in turn help the receiver discriminate between targets.

The result is that long-range radars requiring a high probability of target detection have to transmit at very high power, have very sensitive receivers, and may be widely spaced out through the bands they operate in. It is the resulting combination of high peak power output combined with low noise receivers and safety-related performance requirements that makes it difficult for radars to share spectrum with other services. Within these constraints, however, we would like to explore the possibilities for more effective use of the radar bands.

[22] see footnote 3 for derivation of statistics

7.2 Policy Co-Ordination

The CAA takes the lead in managing aeronautical radionavigation radar bands, but there is a significant amount of joint planning and common use of shared bands between the CAA and MoD. One of the issues the Audit will be looking at is the possible formalisation of the arrangements for joint MoD and CAA coordination of radar bands – for example through use of a joint planning tool - and how this would work in the context of spectrum pricing, which is explored in more detail below.

There is significant overlap between civil and military air traffic control in both spectrum and systems, although the military also has many radar bands not shared with civil (or indeed military) navigation that are used for weapons, targeting, and surveillance. There can also be sharing between radars themselves enabling more intensive use of bands.

7.3 Scope for Increased Technical Efficiency

Modern solid-state technology and advanced signal processing have enabled some improvements to be made to the power and bandwidth requirements to produce a given resolution of response, compared to relatively simple and cheap magnetron radars. Modern technologies have been adopted for many larger and more advanced systems in the military and to a limited extent civil sectors. In some cases this has been achieved by mandating changes in the spurious emissions regulations which govern radar outputs. For example the Spurious Emissions Regulations 2003 introduced a mask to which all new build radars had to conform (the intention is that these regulations will also be applied retrospectively).

There seems to be significant scope for furthering the adoption of advanced and more spectrally-efficient radar, especially in the civil sector. However the innate characteristics of radar operation do mean that technical limits will constrain the extent to which radars required to give high range and resolution performance can restrict bandwidth used. Indeed, as the quality of service expected from radars continues to increase, there is if anything a trend towards radars using even more bandwidth to improve target detection range and resolution, especially in the military sphere.

Following the first Cave Review, a study was carried out to assess the possibilities of introducing more spectrally efficient radiocommunications techniques and technology within the aeronautical and maritime communities.[23] The study concluded that: *"Though opportunities for improving the spectral efficiency of the radar and associated technologies used for maritime radiodetermination are limited, there are potential modifications to spectrum use which could make overall more efficient use of spectrum".*

"In the case of the aeronautical and maritime sectors and maximising the spectrum resource available to them, the key issues would seem to be safety, market issues, the European regulatory framework, treaty obligations, standards, the introduction of

[23] Ofcom contract AY4620, 15 June 2004, Assessment of the technical, regulatory and socio-economic constraints and feasibility of the implementation of more spectrally efficient radiocommunications techniques and technology within the aeronautical and maritime communities.

new technology and last but not least the possible use of incentive pricing to realise spectrum efficiency gains within the sectors"[24].

We are conducting an assessment of the key recommendations from this report, which we intend to make available in advance of our final report.

SES Project: Ofcom have commissioned a study under the Spectrum Efficiency Scheme (SES) to look at options for improving spectrum efficiency, including examining providing the current functionality of L and S-band radars in higher bands. We will follow this and other relevant Ofcom studies to look at areas where functions provided by radar could potentially be maintained or improved at net economic benefit by opening up high-value spectrum for other uses.

Radionavigation Satellite Service (RNSS) New satellite based technologies, such as the Global Positioning System (GPS) and Gallileo offer the potential in the future to reduce reliance on navigation beacons and primary radar for cooperating aircraft and ships with fully functional navigation and communications equipment. The information would be used for on-board navigation in addition to being reported, for example, through secondary radar, as the craft's position and velocity. However, there are currently frequency protection, safety and security concerns about increased reliance on position information derived from satellite networks in place of ground-based beacons and primary radars.

The potential of spectrum pricing to encourage more efficient use of the spectrum is discussed below. Where international harmonisation is needed or in place, or pricing is unlikely to effectively address inefficiency problems of legacy systems, we will also consider alternatives to pricing as a means of promoting efficiency, such as the tightening of technical specifications and seeking change internationally.

7.4 Radar Pricing

When most of the major radar allocations above 1 GHz were made, there were few alternative technologies demanding to use the spectrum and consequently the opportunity cost of radar use of the spectrum was close to zero. However due to the development of technology and the growth of the communications industries, radars now occupy large tranches of what has become high-value 'prime' spectrum.

Civil radar users are currently only charged a nominal cost recovery fee, and the 3.1-3.4 GHz and 5.3-5.65 GHz military radar bands currently have a zero price (there are other military uses of radar in bands which are subject to pricing). The 2002 Cave Review recommended that pricing of aeronautical and maritime radar be introduced where there was some technology choice for UK-based users, and the Government agreed with this recommendation.

An Economic Study to Review Spectrum Pricing by Indepen[25], which was commissioned by the RA to form the basis of updated spectrum pricing in the light of 2002 Cave Review recommendations, concluded that applying AIP to radar could be appropriate to both reflect the opportunity cost of radar usage of spectrum and to discourage excessive out of band emissions:

[24] as above, page 11

[25] 'An economic study to review spectrum pricing', Indepen, Aegis Systems and Warwick Business School , February 2004

'In principle there is a case for applying AIP to aeronautical radar services in bands which could potentially be used by other services facing problems of spectrum congestion, or to older systems whose emission characteristics have the potential to significantly constrain the use of adjacent bands by other services.'

"*AIP could be applied to radars – even in exclusively allocated bands – to give incentives to limit the extent of out of band emissions that effectively deny spectrum use in adjacent bands, i.e. reflecting the opportunity cost arising not only from the denial of spectrum in the band the radar operates in, but also in adjacent bands."*

Ofcom's September 2004 Pricing Consultation Document[26] indicated that the possibility of introducing AIP for ground-based radar will be considered as one of a number of options for making better use of the aeronautical spectrum.

The purpose and benefits of incentive pricing could be to:

1. Maximise operational effectiveness of radar in current bands:
    - By moving to more spectrally efficient radars or reducing out of band and spurious emissions (which impose constraints on other bands or restrict the siting of radars in adjacent spectrum)
    - By promoting better and more timely co-ordination of radars and the retention of no more than the required level of frequency diversity at different sites (see also sections on co-ordination and apportioning fees)
2. Incentivise the aviation community to free bands at the margins for other uses. This should produce a net economic benefit if the service level provided by the radar system were maintained
3. Encourage radar users to pursue band sharing if it was technically and operationally feasible and secondary users could realise significant benefits (assuming that pricing and co-ordination system allowed radar users to benefit financially from this sharing).

There may be a case for differential treatment of primary and secondary radars, and for radar against communications, given the greater degree of national autonomy in ground-based primary radar systems. This was recognised in the recommendations of the 2002 Cave Review in the case of aeronautical radar (maritime radar are covered in chapter 8):

- Primary Radar: The 2002 Cave Review and Ofcom have noted the suitability of ground-based aeronautical radar for incentive pricing in principle. The CAA also recognise there is a rationale for this, given spectrum scarcity. Additionally, ground-based aeronautical primary radars tend to operate in lower frequency or at least different bands to those fitted to aircraft due to antenna size and operational requirements, allowing them to be separated for incentive pricing and spectrum release purposes.
- Secondary Radar and navigation aids: Navigation systems on board aircraft give many of the same problems for incentive pricing as aeronautical communications and maritime systems, i.e. users cross international boundaries and use internationally harmonised equipment. However it is worth looking at where there are potential spectrum inefficiencies and if so developing the economic case for change and campaigning for this in international fora.

[26] http://www.ofcom.org.uk/consult/condocs/spec_pricing/spec_pricing/#content

The Audit considers that designing and implementing a system of aeronautical radar pricing could provide an important mechanism for helping to deliver more efficient spectrum use. However there are a number of complexities around which types of radar this could in practice be applied to in the short to medium term, how any system should be designed and how the level of prices should be determined to give an effective and fair incentive to make better use of the radar and navigation aid bands.

We will investigate the rationale for radar pricing further. If the case is proven, we will make recommendations on a potential basis for introducing radar pricing and our view on a realistic timetable for implementation. It will then be for Ofcom to take this forward in consultation with Government and the aviation industry. Given the size of the major radar bands the potential pricing levels could be significant and Ofcom and Government would need to consider whether for instance pricing should be phased in. Decisions on spectrum pricing are also closely linked to the issue of trading of aeronautical bands and frequencies, which was covered in chapter 2 on spectrum trading.

7.5 Potential Basis for Charging Level

As set out in chapter 3, Ofcom has adopted the approach suggested by Indepen in 2004 of setting AIP fees in relation to both the value of spectrum in existing uses and its value in other potential uses for that band. Fees are then levied on a 'per MHz' basis, either for national coverage or on a geographical basis depending on the specific characteristics of the service and licence. We agree with this general approach but below we have set out a number of specific issues that we think need to be considered in relation to designing an AIP system for radar and navigation aids. We would welcome views on these more detailed issues, which could significantly affect the level and effectiveness of pricing, and the nature of the incentives on the aeronautical community. It should be noted that given the scale of radar bands and their occupation of large sections of 'prime' spectrum, the overall total of radar pricing could potentially be large.

Charging on basis of value to radar users

- Cost of reducing bandwidth used: This would reflect the cost of providing equivalent functionality through using less or different spectrum. In our view there is a strong case for introducing clear incentives to deploy more spectrally-efficient radar where possible and eliminating unnecessary frequency diversity, but as noted above there may be technical and security limits to this. There is also limited scope for providing radar services through alternative technologies. In addition we think there is a case for imposing higher charges on radar types that produce higher out of band or spurious emissions.

- Value to a marginal radar user: If there is a scarcity of radar spectrum which might restrict the scope for expansion/establishment of aeronautical services, then it is possible to look at what a potential radar user at the margins would be willing to pay.

Charging on basis of value to alternative technologies

- Likely alternative use: L and S-band spectrum has propagation characteristics suitable for high-value mobile applications. We would like to explore with Ofcom

the process for deciding whether to, for instance, price radar bands at the current 'fixed' or 'mobile' per MHz rate or some different value. This links to our view outlined in Chapter 3 that there is a discrepancy between fixed and mobile pricing

- Immediate or long-term opportunity cost: the immediate value of aeronautical spectrum for alternative technologies might be limited by lack of availability of mass-produced equipment if the aeronautical use was long-standing. But in spectrum with favourable propagation characteristics the longer-term value of released spectrum would probably be much higher. This makes it more difficult to determine the opportunity cost. Options are:
    - what the actual value and use of release spectrum would be now
    - apply the standard AIP for the most likely technology alternative (e.g. apply the 'mobile' price to any spectrum below 3 GHz)
    - what is currently permitted by international treaty or practice (some bands are currently restricted to 'fixed' services). A band which, if release, could only be used nationally, would be less valuable than an internationally coordinated one.

- Encouragement to release spectrum at the margin: It may make economic sense to set pricing structures which would sharply incentivise major holders to rationalise their allocations at the margin by setting differential pricing within bands. An example could be charging a mobile price in the lower part of the 2.7-3.4 GHz radar bands that might be especially attractive to mobile operators, but a fixed price higher up. Per MHz prices could also be increased relevant to the number of MHz used, however, there would be significant complexities in designing such a system. We would be interested in views on whether this is worth exploring further.

7.6 Apportioning Fees

There is a question over whether civil radar pricing could be most effectively applied directly to individual users or through the CAA (who manage the bands), whichever method is used. Individual users should be rewarded for reductions in their spectrum usage through lower charges. However real economic benefits from more intensive use, partial release or sharing of radar bands can probably only be realised through concerted action and planning by the regulator acting on behalf of users and in some cases mandating them, and may require international agreement.

One option is to impose a national 'per MHz' band charge through CAA, who would effectively be a 'band manager', obliged to recover the fees from their licensees. If multilateral action was taken to reduce the net spectrum charge the benefits could be cascaded down to all users equally or to those who had made the key changes required to enable it. This structure might provide a particularly good incentive if the pricing structure was deliberately set to reward changes at the margins, or to provide for reduced payments if valuable secondary sharing was enabled within the band. An example here might be a reduction in MoD charges when military airfields are closed and there is the opportunity to redeploy frequencies for civil use in that or another location.

We will consider this further with the CAA, and in the context of our suggestion that there is potential for better coordination of the radar bands between all users.

Do you agree with the principle that AIP should be introduced for (i) aeronautical and (ii) maritime navigation radar? If so what are your views on the best way to determine and impose AIP charges on radar?

Do you think there is scope through means other than pricing (e.g. technical regulations, better co-ordination) to enhance the utilisation and economic efficiency of radar bands?

Chapter 8

Maritime

8.1 Introduction

Providing safety of life equipment, navigation and search and rescue capabilities for maritime vessels constitutes a significant spectrum demand in this area. Requirements are predominantly for radar (in several bands), communications, surveillance and navigation signals e.g. from satellite. Maritime use of the spectrum amounts to some 580 MHz below 10GHz (roughly five per cent of spectrum in the bands the Audit is examining).[27]

Owing to the nature of use of spectrum in the maritime sector due to requirements for near-global mobility of vessels, the majority of maritime spectrum management is governed internationally, with Ofcom deciding the national frequency allocations, mainly for supporting infrastructure such as the distribution of radar imagery between coastguard and port stations. Mandatory standards are set internationally for communications, as are requirements for carriage and technical parameters of equipment. Communications channels are also mandated internationally.

Harmonised frequency allocations are agreed internationally through the ITU and incorporated in the Radio Regulations. There are few regional variations and the relatively few that there are which seek international recognition would be indicated in the RRs. Where international recognition is not required, use of certain bands would be limited to use generally within territorial waters (e.g.Coastal Station Radio UK licence category) only. International mandatory carriage requirements derive from the International Maritime Organization (IMO) through the International Convention for the Safety of Life (SOLAS) for which the MCA have responsibility.

Ship radio equipment not intended for use on SOLAS vessels is subject to the Radio Equipment and Telecommunications Terminal Equipment Directive (RTTED) (incorporated in the UK by the RTTE Regulations as amended). Such radio equipment is not subject to the same stringent requirements as in the case of SOLAS vessels. In the case of the RTTED equipment, to enable use of the equipment on UK vessels, the equipment must also comply with relevant UK Radio Interface Requirements. These detail “high level” parameters such as frequency and maximum power to ensure interference free operation.

Ofcom leads for the UK in international negotiations on maritime spectrum requirements and is assisted by the Maritime and Coastguard Agency (MCA) of the Department for Transport (DfT). The International Maritime Organization and the ITU are the main international bodies in relation to maritime spectrum use. The MCA also ensures compliance with standards, for example through annual ship surveys and port state control for visiting ships. The MCA issues various certificates for certain categories of ships but Ofcom maintain responsibility for issuing radio licences (both ship and coastal). There are interactions with MoD since naval vessels must share some navigation-related bands and channels with commercial and pleasure users.

[27] see footnote 3 for derivation of statistics

8.2 Nature of use

Maritime use of spectrum can be summarised as follows:

Radar – the largest user of maritime spectrum. Primary radar at 3GHz (S-band) and 9GHz (X-band) are used for radionavigation purposes. There are 300,000 low frequency (S band) radars worldwide and 5 million high frequency (X band) worldwide. IMO mandates carriage of X-band radars, and additionally S-band for larger vessels. Navigation and search and rescue transponders also transmit on radar frequencies in response to a recognised radar pulse.

Navigation – All ships are required to carry an electronic position fixing system which is typically a Global Navigation Satellite System (GNSS) such as Global Positioning system (GPS), in addition to radar as above, and an automated identification system paralleling aeronautical secondary radar operates at VHF.

Communications – in the L band, VHF, MF and HF and higher portion of the LF bands. The system used to comply with the International Convention for the Safety of Life at Sea (SOLAS) is the Global Maritime Distress and Safety System (GMDSS). In the GMDSS ships carry equipment which ensures that they always have two independent radio systems available to them which will permit the transmission of a distress alert to shore.

Life saving appliances – for example VHF handheld radios and search and rescue radar transponders operating at 9GHz. An Emergency Position Indicating Radio Beacon (EPIRB) operating at 406 MHz is a carriage requirement for all Convention ships (passenger and cargo ships over 300 gross tonnage)

Commercial vessel management – often using L-band MSS systems which also provide SOLAS channels. This includes agreeing pilotage and access to waterways, ports and berths, managing cargo and passengers and provision of correspondence for crew and passengers.

8.3 Maritime communications licences: pricing

The 2002 Review of Spectrum Management looked at the issue of pricing for spectrum used for maritime and aeronautical purposes. It concluded that, where there are internationally harmonised channels, the use of which are largely dictated by internationally mandated technology standards and protocols, then the opportunity cost of this spectrum is effectively zero, meaning that there is no case for spectrum pricing. The Audit agrees with this finding.

The first Cave Review did however find that, in the case of some on-board systems, there is an element of choice in equipment and use of the spectrum, meaning that incentives to migrate to more spectrally efficient equipment could be effective. The 2002 Review recommended that pricing should be applied in these cases and the Government response agreed that this should be looked into.

The recent Ofcom Pricing Statement flagged this up as an area for further work. Subsequently, Ofcom issued a consultation document[28] on ship radio licensing, "Consultation on a proposal to reform 'Ships Radio Licensing'" where it proposed a range of options for reducing regulation in this area. The Ships' radio licence covers

[28] The document can be found at http://www.ofcom.org.uk/consult/condocs/src/

the installation and use of all the maritime radio equipment (operating under a maritime designation in the Radio Regulations) carried on board a vessel. Licences are currently issued by Ofcom on application and are renewable annually. The cost is £20 for a ship radio licence and £15 for a ship portable radio licence.

The consultation document set out Ofcom's view that international requirements make a move to full deregulation impractical at this time, hence a range of other options are suggested. Key proposals are:

- To make ship radio licences valid for the life of the vessel (instead of renewable annually); and
- To make electronic licences available free of charge.

On the issue of spectrum pricing, the consultation document says "At this point Adminstrative Incentive Pricing is not considered appropriate for vessels as these bands are allocated exclusively on an international basis and in addition it is not possible to charge foreign vessels for use of the spectrum" Ofcom's view is that here the opportunity cost is effectively zero given the international mandation, requirement to use specific technologies and shared access to spectrum

Ofcom is therefore of the view that there is no scope for incentive pricing to improve spectrum use in the case of maritime on board licences. The Audit team can understand the rationale behind the drive to deregulate licences, and also accepts that there are areas where pricing is not suitable. However, the proposal to issue life time licences does remove the possibility of applying incentive pricing as a tool for encouraging more efficient spectrum use. We are therefore keen to ensure that thorough consideration has been given to whether there could be scope, now or in the future, for using differential pricing for on board licences, and will be following this up with Ofcom in the coming months. Any pricing proposal would need to take account of the international situation, and consider the possibilities of vessels registering in jurisdictions outside the UK.

There may be scope for application of AIP to ground station and coastal stations use of communications or radar equipment as the spectrum, once applied to these users, is not available to others, hence there is an opportunity cost. However this may be limited by adjacent co-channel (internationally) mobile users. We will continue to discuss this with Ofcom.

8.4 Radar

As set out in more detail in chapter 7, the Audit will be considering further the case for introducing pricing for UK-based radionavigation and radiolocation equipment. Maritime radars differ from aeronautical in that UK cannot charge for use on non-UK vessels, there is limited scope for vessels to get inland, maritime radar units may be, and need to be, designed to operate with satisfactory performance much closer than aircraft separation distances, and reaction timescales are longer. Ship and land-based radars also typically use the same equipment, in the same bands, which affects the ability of pricing to differentiate for reasons of spectrum efficiency. However there may be a case for incentive pricing for example if this encouraged the development and adoption of more spectrally-efficient radars. The 2002 Cave Review recommended a phased introduction of new technology over five to seven years to take account of development and replacement timescales. We will consider this in more detail in the update of a study into the options for more spectrally efficient techniques in aeronautical and maritime communications that which, as noted in Chapter 7.3 we intend to produce in advance of our final report.

8.5 Future demand

There were significant developments in the early 1980s such as the establishment of satellite networks which drove demand for spectrum. In the future there is likely to be more demand for remote management, for example with engine telemetry, which may lead to increased pressure for spectrum. In addition there could be developments in satellite systems and use. Digital technology will also play a role in future maritime requirements. It is possible that some future requirements could be met through commercial systems (e.g. automated safety systems). If there is a need for new maritime frequencies these must be agreed internationally through the ITU and probably subsequently allocated specific uses through the IMO. Currently, MCA have no planned new spectrum requirements – we will be working with the MCA to further quantify their likely future spectrum requirements.

Chapter 9

Public Safety Services

9.1 Introduction

There are a wide range of emergency service and other public safety users requiring robust and effective mobile communications and backhaul, including 'direct mode' communication between handsets that the main national public mobile networks cannot provide. In the past emergency services radio systems were highly fragmented, using different systems and bands for different regions and services. More recently there has been a move towards greater consolidation of mobile services onto the Airwave network. This has benefit of economies of scale, spectrum efficiency and better inter-service co-ordination at incidents. Consolidation of emergency service use has enabled Ofcom to consider whether to release some spectrum to the commercial sector, including prospectively the 1790-1798 MHz band as covered in the Fixed Links chapter.

9.2 PSSPG

The public safety services' spectrum needs are coordinated through a dedicated body, the Public Safety Spectrum Policy Group (PSSPG).[29] The PSSPG is a standing interdepartmental committee reporting to the National Frequency Planning Group (NFPG) and ultimately the UK Spectrum Strategy Committee (UKSSC).

The PSSPG is independently chaired and comprises representatives from Ofcom, the Department of Trade & Industry, and the sponsoring departments of the emergency services, which are the Home Office (HO), the Office of the Deputy Prime Minister (ODPM), the Department of Health (DoH), and the Scottish Executive (SE). The Scottish Executive is responsible for planning the emergency services spectrum in Scotland.

In the past the Government has given assurances that the spectrum demands for essential emergency services would be met, and it is clearly important that the emergency services ultimately have access to the resources they need to provide an effective service. The question is how these needs can be met adequately, efficiently and in a way that recognises the competing demands of other spectrum users.

9.3 Coordination

The Home Office used to manage spectrum access for police and fire services in England, Wales and Northern Ireland. The ambulance service was managed by the RA and treated and protected as a public safety service but actually uses Private Mobile Radio (PMR). This has now been consolidated with Ofcom taking over the role of technical spectrum manager for emergency service and public safety users and strategic and policy issues handled by PSSPG. The PSSPG acts as band manager for public safety services and has a strong understanding of their requirements, both technical and operational. It is seen as an effective forum for bringing together the relevant parties to discuss issues of common concern. However, where the forum appears less strong is in providing an overarching policy

[29] Terms of reference can be found at http://www.ofcom.org.uk/static/psspg1/index.htm

direction for the emergency services as a whole, providing a single point of contact for wider public safety service users, and taking into account the competing needs of other potential spectrum users. **We will be discussing how this issue could be addressed with the parent departments for the emergency services.**

9.4 Emergency Services Mobile Requirements

The Airwave O2 Ltd's ('Airwave') TETRA network provides mobile radio services to the police and an extensive list of other 'sharer' organisations with emergency or safety of life functions. The introduction of the Airwave TETRA network has enabled a significant rationalisation of emergency services spectrum holdings by providing a unified network to services that previously had their own separate systems operating in different bands. The network has been built to meet emergency service needs but is operated by Airwave on a commercial basis. Ongoing modernisation and procurement exercises are likely to further this consolidation although there is no compulsion for public safety users to choose Airwave for their mobile requirements.

Airwave currently operates in two sub-bands between 380-400 MHz. The emergency services have requested to be given all or part of the 410-425 MHz band by administrative allocation for emergency service mobile capacity. This spectrum has been vacant since the TETRA network that had previously occupied it closed down in 2004. Section 5.14-5.29 of Ofcom's SFR:IP set out the principal options for this band including auction to the highest bidder and administrative allocation to the Emergency Services. The final outcome will be dependant on the result of procurement exercises for fire and ambulances service radio. This example raises various issues about access to spectrum, including those discussed in Chapter 2. These include:

- **Licence holder:** Currently Airwave hold a licence for their existing spectrum. If a new non-market administrative assignment was made for public policy reasons it might be more appropriate for a public body itself to hold a licence, given that the award could convey potential windfall gains or competitive advantage.

- **Trading:** The fact that Airwave is run on a commercial contracted basis could risk giving a potential windfall to a commercial operator through administrative allocation if the licence was held by Airwave directly with trading rights. It may therefore be necessary to impose limits on tradability here (depending on who holds the licence).

- **Access to network:** Access to Airwave's TETRA network is available only to organisations that have been accepted on to a sharers list[30], having been approved by Ofcom as an eligible emergency service or public safety user. Ofcom makes the decision whether applicants are allowed on the sharers list in close consultation with PSSPG. Once a user is on the sharers list, and has the appropriate security clearance, they can then negotiate a commercial contract with Airwave. The Audit team is interested in whether the sharers list is, going forward, the most appropriate and effective mechanism and will be considering this further in the context of the criteria set out in chapter 2 on the decision making process for public sector access to spectrum.

[30] available at http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/business_radio/emergency/airwave_index/?a=87101

- **Method of Acquisition:** In this case - to address safety-critical requirements - needs may need to be addressed by administrative assignment of spectrum. However, as detailed in chapter 2, the presumption going forward should be for new demands to be met through the market in all but exceptional cases.

- **Procurement:** A situation similar to that of the MoD may apply, where spectrum requirements are not taken account of (in terms of cost, availability or accessibility) during the procurement process. This is not likely to produce the most financially and economically efficient outcome and we will be looking at this issue further.

- **Degree of Outsourcing**: If the emergency services contract out the provision of their mobile radio network then there is an argument for extending this to include a requirement for the provider to acquire and hold the spectrum needed, as it would with other inputs required. This would avoid many of the potential problems above.

9.5 Future Demand

In common with other sectors, the emergency services are making increasing use of broadband applications such as real-time wireless video surveillance or 'heli-telly'. This should be considered as part of the wider exercise in setting future public sector strategy and estimating demand (see chapter 2). It may be possible to accommodate some more sporadic emergency service uses on a secondary basis, which already happens within MoD bands. Ofcom's recent SFR Statement[31] noted as an example of possible development in a liberalised spectrum market that emergency services might gain temporary access to spectrum when they need it to enable immediate video links.

[31] http://www.ofcom.org.uk/consult/condocs/sfr/sfr/sfr_statement, p7

Chapter 10

Science services

10.1 Introduction

Frequency allocations for Science Services include a number of bands from 19kHz to over 100GHz. The main uses are for radio astronomy, meteorological aids, earth exploration satellite, Standard Frequency and Time signals and space research.

10.2 Radio astronomy

Radio astronomy involves observing radio signals for research into the properties of stars, galaxies and the universe. The physical characteristics of the transmissions being monitored usually determine the frequencies needed for observation, meaning that there is a limited choice for radio astronomers in the bands they can use.

Radio astronomy is a passive activity, not involving any manmade radio transmissions but measuring very faint electromagnetic emissions from space. Radio astronomy bands take up two per cent of spectrum below 50 GHz. Annex D of the UK Frequency Allocation Table sets out allocations and the level of protection afforded in each band in the UK, while the main table indicates the wider international provisions. The radioastronomy service is susceptible to even low levels of interference from other radio services and unintentional radiation, an issue which may become more prominent as the use of spectrum for satellite and terrestrial communications grow.

The Particle Physics and Astronomy Research Council is the lead body in this area and pay a charge to Ofcom - currently around £345K a year - on a cost recovery basis for the cost of Ofcom providing international representation and interference protection.

There are six radio astronomy sites in the UK, mainly operated by universities. The levels of protection afforded to these sites can in practice equate to coordination or exclusion zones around the sites. For example the highest protection category – full protection – could effectively mean an exclusive national allocation, with no other user having transmission rights.

This can prove restrictive for other services. For example, in the recent consultation on Ultra Wideband (UWB), potential interference problems between radio astronomy sites and UWB were examined. The consultation document suggested that “The most likely solutions involve ensuring that UWB devices are not close by radio astronomy sites. This could be achieved through using a perimeter fence to physically exclude devices, conducting measurements at night when UWB activity is likely to be lower, or through siting new radio astronomy sites well away from populated areas.”[32]

The consultation was followed by an Ofcom summary and reaction to responses. [33] Having considered the responses, which highlighted the difficulty in relocating sites,

[32] http://www.ofcom.org.uk/consult/condocs/uwb/uwb2/#content

[33] http://www.ofcom.org.uk/consult/condocs/uwb/summary/#content

Ofcom decided that further study was needed to confirm that interference into radio astronomy can be mitigated.

In principle, the effect of the location of radio astronomy sites on other services creates a significant opportunity cost for the use of spectrum which is currently not recognised. In practice, the Audit recognises that there are major cost and practical issues involved in the location of sites, and will be working to gain a better understanding of the factors considered in determining the location of radio astronomy sites.

10.3 Pricing

The first Cave Review in 2002 identified that there was scope in the various radio astronomy bands for action at a national level to optimise spectrum use. The review identified that around one third of the frequency allocations for radio astronomy were harmonised globally for passive use, but that the remaining two thirds shared bands with active services such as Fixed and mobile. Although sharing in this manner is possible (MoD is the sharer in many of these cases), it needs to be managed carefully to avoid harmful interference, and the protection necessary for radio astronomy sites can put restrictions on deployment of active service.

The Review recommended that UK based radio astronomy sites should be subject to an administratively set spectrum charge for those bands where the UK has scope for deploying other actively transmitting radio services on a co-primary basis in the band. Where other services were admitted into radio astronomy bands, there should be some recognition of this in pricing.

10.4 Recognised Spectrum Access

The Government response to the Cave Review agreed with this recommendation. Ofcom is now taking this forward with a proposal for the introduction of Recognised Spectrum Access (RSA) for radio astronomy (see box below).[34] As a passive service, and so not able to interfere with other users, radio astronomy is exempt from individual licensing. Equipment is however highly susceptible to interference, so some form of protection is necessary (currently as set out in the UKFAT as above).

RSA would give radio astronomers greater certainty about the levels of interference they could expect to receive. Pricing would be applied to incentivise best use of the radio astronomy bands. For example, users do face some choices about the siting of equipment and can obtain data from radio telescopes situated outside the UK. Trading of RSA may also be permitted as a further incentive.

Box 5: Recognised Spectrum Access

Ofcom is currently in the process of introducing Recognised Spectrum Access (RSA) for selected services. An RSA would require Ofcom to take account of receiving equipment on a comparable basis to licensed use. So Ofcom would have to take into account the existence of an RSA “right” when granting a licence in the same way it does with existing licences.

[34] consultation document at http://www.ofcom.org.uk/consult/condocs/astronomy/

RSA enables the holder of the grant to identify and seek Ofcom agreement to frequency bands and geographic areas within which Ofcom will undertake to ensure that agreed levels of interference are not exceeded.

Ofcom is able to charge fees for RSA reflecting the economic value of the spectrum in question. It will not be mandatory to seek RSA approval where it is introduced. RSA may also tradable and convertible into licences where applicable. Ofcom is currently considering other future candidates for RSA, which include receive earth stations operating in satellite services

10.5 Meteorological aids

The UK Meteorological Office (operating with a trading fund within MoD) manages and operates a series of meteorological aids and radiosonde systems. Some of the frequency bands used are in designated MoD bands and there are both national and international commitments to provide environmental measurements for weather prediction and monitoring climate change. The Met Office works directly with MoD to coordinate use in this area. Relevant bands are covered as part of chapter 5 on MoD.

The Met Office and MoD operate a number of radar systems in the 900MHz, 1200 MHz and 5600 MHz bands to measure wind profiles and rainfall in the UK.

The Rutherford Appleton Laboratory (RAL) operates a research facility at Chilbolton, Hampshire, covering a range of research radar systems. The main facility is the 25 meter diameter fully steerable paraboloidal antenna. CAMRa - Chilbolton Advanced Meteorological Radar - operates at 3.075 GHz (Doppler-Polarisation radar) includes a rain radar system which can provide measurements of rain droplet size.

10.6 Earth exploration satellite

Active and passive sensors are used for collecting data on the Earth's environment. The objective of passive remote sensing is to receive and detect the natural thermal radiation from objects and from the spectral lines of atmospheric molecules. Interference can therefore be damaging to passive microwave sensors. Most passive bands are shared by radioastronomy, space research and EESS (Passive) services.

EESS information is used for many purposes – from long term science such as climate change, pollution, topography and vegetation monitoring, through storm and monsoon warning systems, medium-term and daily weather forecasting and to minute by minute weather warnings for shipping and aircraft. Transmitting Earth stations are licensed, but satellites are not, as they are beyond terrestrial rights. Ofcom are considering introducing RSA for receive-only earth stations.

For Active sensors radiation is transmitted or scanned over a target and the backscatter or degree of absorption is measured. Here too the sensitivity of measurements can be affected by interference. There is no single UK satellite, but the UK has significant interest in number of European EESS projects through the European Space Agency (ESA). For example a 5.3 GHz satellite which has seen a £300 million UK contribution to the overall ESA's ENVISAT EESS satellite project.

We understand that the 8025-8400 MHz EESS band is becoming congested due to growth in the number of missions.

10.7 Space research

Space research is also mostly pursued through ESA. For example communication links – which are licensed - with manned or unmanned space craft. UK contributes to number of ESA missions through the British National Space Centre (BNSC). This covers research, operational and facility costs. A proportion of this is fed back to the UK through a “just retour” basis for UK research and industry to provide services and equipment for space missions.

We understand that there is a growing need for additional spectrum for data downlink bands due to the increase in number of space missions in the recent years, and that there is already congestion in some of the downlink bands.

10.8 Time-signals and Frequency standard transmissions

This covers standard frequency and time signal services. The UK interest in this area is largely pursued through National Physical Laboratory (NPL) projects which includes transmission of the national time standard from Rugby.

10.9 International

Many space service frequency bands are subject to international allocation, harmonisation and cooperation, which limit the scope for unilateral action by the UK. The protection requirement of passive service is so stringent that use of the band in one country could have impact on the neighbouring countries.

Ofcom is leading in developing the UK positions for WRC-07 (World Radio Conference) agenda items dealing with science issues. These agenda items deal with protection of science services and additional allocations for Meteorological Satellites and Earth Exploration Satellites Services.

Chapter 11

Fixed Links

11.1 Introduction

Infrastructure and access networks for communications and broadcasting systems are provided through fixed terrestrial services – another significant user of spectrum. Growth in mobile services and fixed wireless access has lead to increased demand for the fixed infrastructure support underlying networks, and this is likely to continue. Ofcom makes individual assignments for fixed links licences.[35] Links are assigned on a first-come, first served basis. In most cases Ofcom have sufficient capacity to make allocations, although sometimes compromise is needed to fulfil requirements in areas of congestion.

BT and Cable and Wireless used to have exclusive use and management responsibility for some of the fixed links bands, but over a period of some ten years, ending in 2004, these were brought back into Ofcom management to ensure that maximum use was being made of the bands and to aid competition. All fixed links bands are now actively managed by Ofcom - for example to ensure valuable low frequency bands are preserved for long- distance links and to get most technically efficient use of the spectrum, e.g. mixing satellite and fixed services.

There are currently twenty discrete fixed links bands available for use within the UK ranging from 1.5 GHz to 65 GHz. These provide access and infrastructure links ranging from over fifty kilometers down to a few hundred metres. In total the fixed links bands make use of over 20GHz of spectrum. Much of this is shared with other services. As mobile technology has developed, mobile services are now able to utilise much higher frequencies than previously - the effect of this has been to push fixed use up to higher frequencies.

Within ITU allocations for fixed links bands there can be some choice of service to be provided in that band e.g. point to point or point to multi-point fixed wireless access. However, there are difficulties in varying standards at an international level. Coordination is sometimes needed internationally or with other services in a band. For example, the fixed links bands can be used by satellite fixed earth stations as well as by Fixed Links and Fixed Wireless Access. In some cases all three services may wish to use the same bands, requiring coordination to avoid interference. This may impose limits on the location and bands possible for new stations.

Ofcom have found demand for fixed links increasing over the years. For example, from around 80 assignments a month in the early nineties to around 500-600 a month now (and often for higher capacity links). Fixed links are therefore using more spectrum – but efficiency of use has increased in parallel. For example a link carrying 155Mbps used to require 135MHz of bandwidth whereas this can now be carried by a link of 28MHz bandwidth. However, the higher order modulation schemes that enable the same data rate to fit into a narrower channel require greater protection from interference so such links must be spaced further apart. This means that, in practice, the overall gain in spectrum efficiency will be lessened. In addition,

[35] Ofcom has also assigned exclusive geographic area licences for Fixed Wireless Access, a developing technology for delivering broadband connectivity to individual users, but we are not intending to focus on this area

innovations in fixed links have led to the use of higher bands (e.g. 65GHz) where spectrum is less congested.

Given the cost and time constraints of bringing new equipment into operation, there are still some fixed links which could be seen as "spectrally inefficient" due to the bandwidth used by dated equipment. Ofcom envisage that the new pricing algorithm (see below) will create a strong incentive on these operators to move to more efficient equipment.

We agree with Ofcom's view that spectrum efficiency should be achieved through the market where possible. However, the Audit's remit was extended to cover fixed links to examine whether the nature of the licences granted means that it may not be possible to deliver the spectrum to a higher value potential user through trading and liberalisation - i.e. whether there are barriers which will impede the market. This becomes more pertinent as some of the fixed links bands have potential to be valuable for high-value mobile applications now or in the future.

11.2 Pricing

Fixed links are licensed on a geographical basis (the defined spectrum volume between the two connected points) rather than giving national or regional rights to a given band of spectrum. The fee structure is now based on the opportunity cost of using spectrum and the amount used. The charge for each link is based on an algorithm that reflects characteristics including the bandwidth used and the path length to arrive at an estimate of the opportunity cost. This algorithm has recently been revisited increasing the average charge by around 15%. The new formula is as follows:[36]

Fixed link licence fee =

Spectrum price
× *Bandwidth factor*
× *Band factor*
× *Path length factor*
x *Availability factor*

Ofcom are confident that the new charges better reflect the efficiency of use of spectrum, as factors included in the calculation reflect for example the value and congestion of bands and whether sharing is allowed. Choice is also incorporated, through the availability factor, to enable users to trade-off reliability (e.g. through high power) and the greater charges that are made to reflect higher sterilisation due to this. It will be interesting as the revised algorithm comes into play to see whether this results in users reducing the bandwidth used, or returning any little-used links to Ofcom.

11.3 Effectiveness of Pricing/trading

Ofcom has previously looked at the extent to which the early phase of AIP implementation incentivised more efficient use of fixed link bands. This study found that pricing was having some effect at the margin but had not yet led to major changes. There is a history of action by the regulator to clear out fixed links from bands to enable a change of use. In the past this has generally been done by giving notice (a standard five years) for the licence holders to vacate a band, often

[36] for more detail see *A summary of Ofcom Spectrum Pricing: A Statement on proposals for setting Wireless Telegraphy Act licence fees*, 23 February 2005

allocating replacement bands further up the spectrum to those being cleared out. However, clearing a band through paying compensation is also possible (see Re-farming section below).

In theory AIP should help to clear a band if the alternative use is much more valuable, but every user needs to vacate to enable an auction of clear spectrum. This problem is exacerbated by the fact that the AIP applied is effectively a lagging indicator of the value of alternative uses. For example, some of the lower fixed links bands are in parts of the spectrum that may become much more valuable in the medium-term for mobile services like 4G.

Equally, a new user wishing to buy out a fixed links band, for example to use it for another service, should be able to do so through offering a high enough price – but again this relies on negotiation with many different users, and all those users being willing to sell. The applicability of trading to individual links is possible, but link specifics would need to be the same to enable a trade. Trading has been possible in most fixed links bands since December 2003 and auctions have taken place - for example, the 3.4 GHz band was auctioned in the regions.

All licences are being reviewed with a view to minimising constraints (as recommended in the first Cave Review). This doesn't however guarantee demand – for example, with the first issue of licences for 28GHz, backhaul was prohibited, prioritising fixed wireless access (specifying mode of use in licence conditions) This prohibition was lifted for the second set of licences, but has yet to be made use of.

A programme of awards in fixed links bands was set out in Ofcom's Spectrum Framework Review: Implementation Plan.

11.4 Band Managers

The 2002 Cave Review recommended that where licensees are currently granted tailored access to shared spectrum which is managed by the regulator, such as in fixed links, the RA should move progressively to converting the spectrum to auctionable geographic licence blocks, with a view to competing commercial licensees then managing access for their own and/or third party access to this spectrum – ie a 'band manager' approach.

In response, the Government indicated its willingness to facilitate such an arrangement in some hitherto unused spectrum. 32GHz was identified as a suitable band for trialling such an arrangement and Ofcom invited proposals to be submitted (two thirds of the band was identified for this). Ofcom did not explicitly run a pilot project, but equally there have, to date, been no expressions of interest from industry in adopting such an approach. Ofcom have therefore decided to auction the remaining two thirds of the band on a technology and service neutral approach.

The Audit team supports this approach, but is keen to ensure that the possibility of band managers holding this band is not ruled out. ***The Audit team would therefore like to hear from any prospective band managers who have considered, or would consider such an arrangement, to hear views on potential barriers.***

11.5 Measuring usage

Historically, there has been limited monitoring of fixed links use. Moving to a trading and liberalisation environment makes knowledge about usage more important in

supporting a well functioning market, and as a result Ofcom plan to establish a capacity for making spot measurements. Different equipment is needed from that measuring other services due to the need not to interfere with the continuous link transmission. The Audit team supports Ofcom's intention to establish a capacity for measuring usage of fixed links services.

Box 6: Spectrum Efficiency Scheme (SES)

The Spectrum Efficiency scheme began in 2002 and has a £5m annual budget (with recourse to the Treasury if bigger projects are proposed). It can fund:

- Research and development work to promote the efficient use or management of the spectrum. The research programme is popular and has funded some interesting and useful research projects (some of the current projects are relevant to this Audit and mentioned elsewhere in the Sharing chapter).

- As mentioned below, grants likely to promote the efficient use or management of the spectrum. An example of a small-scale clearance project is noted below but there have been no major exercises on this basis to date.

The Audit thinks that the SES is a valuable way of providing resources to improve spectrum efficiency, and is keen to ensure that its use is maximised. We will be seeking clarity over the criteria used to access SES funds, considering whether there is scope and justification for widening this, and are also considering whether anything could be done to raise awareness of the scheme. For example, the Government could make it clear that 'Spend on technology to save on spectrum' projects are eligible for funding from the SES. For example, to kick start this Ofcom could invite bids for a one off scheme. Criteria could include:

- open to public sector holders of spectrum (and possibly fixed links)
- result of spend would be spectrum judged as valuable by the regulator to be returned to Ofcom/freed up to be shared by other users

We would welcome views on whether such a scheme would be of benefit, and views on the Spectrum Efficiency scheme generally, including whether its scope could usefully be expanded.

11.6 Re-farming

Ofcom has the powers to make grants to promote efficient management and use of the spectrum. The Spectrum Efficiency Scheme (SES) gives Ofcom the ability to re-order, or 're-farm' spectrum in a timely manner without impacting on existing Licensee's rights and expectations. Compensation can be paid as an acknowledgement that re-farming has a cost associated with the enforced redundancy of equipment. Generally, enforced redundancy might mean that the licensees will not enjoy the benefit of this existing equipment for the reasonable expected period.

In deciding whether an SES re-farming project is justified, the economic case needs to be considered on the basis of a cost benefit analysis, with accelerated clearance set against clearance after a full notice period or leaving the band in its existing use.

Re-farming projects require substantial planning and notice so need to be done on an at least partly predictive basis to maximise economic gain.

It would be an issue for HM Treasury to determine how much flexibility they might be willing to give to boost the Spectrum Efficiency Scheme (SES) budget to fund any such 'spend to save' recommendations resulting from the Audit.

There has been one example on a modest scale of grants being paid - in compensation for Government action to re-farm spectrum and encourage the early introduction of digital programme-making equipment. Following consideration, RA determined that the correct basis for calculating compensation was the cost of accelerated depreciation of the existing, analogue equipment and as compensation for loss of expectation.

11.7 Other regulatory intervention

There are a number of options for facilitating the clearance of a fixed links band if it was decided that there was a more valuable alternative use. These include:

- No action – left to market. As above this would have some risks given the multiple users in fixed links bands which might act as a barrier to delivering most optimal use. In some cases the regulator has ceased making new assignments in bands which then gradually start to empty, but this is unlikely to make for an economically optimal transition.
- Regulator gives notice to quit. Ofcom can give incumbents notice (since the introduction of spectrum trading, to give licensees security of tenure, fixed links licences include a rolling five year notice to quit clause) to vacate a band. The disadvantage in this is the time lag before any band would become available, reducing the value.
- Regulator facilitates auction – as above but with regulator simultaneously setting a date for an overlay auction – creating a market. Still a time delay, although auction winners could negotiate with current users over earlier move.
- Clearance projects – regulator clears band actively by paying compensation. That band would then be available to auction. More costly, but potential leading to more valuable use, sooner.
- Clearance projects funded/part funded by commercial user with interest in band.
- Leaving links in place and auctioning around them

We would welcome views on the merits of these approaches

11.8 Band specific

Outlined below are the fixed links bands that the Audit team has a particular interest in and will be examining in more detail (including considering the options for intervention outlined above):

To judge potential demand, we would welcome views on the bands highlighted – listed in Annex C and detailed in this chapter and those on Defence and Aeronautical. Would possibilities for (i) sharing (including time limited or ad hoc sharing) or (ii) freed up bandwidth in these bands be of interest to other users? Are there other bands the Audit should examine?

1790-1798 MHz
There are various public sector fixed links in this band which are due to move out in

5-7 years. These users pay by link but the equipment is now quite dated, which probably results in both lower usage and lower revenues than in neighbouring parts of the spectrum. In addition, it is unclear that a specific band is needed for emergency service use as opposed to the utilisation of assignments in commercial fixed links bands. We are also aware that there is MoD use in this band which is permanent, and from which interference will have to be accepted by any incoming user. We will consider whether there would be advantage in early clearance of the band by the emergency services.

3.6-4.2 GHz
Existing fixed services (links) and fixed satellite service (earth stations) are licensed throughout this band. There are also receive-only earth stations using this band. 2x84 MHz of the band is also used for Fixed Wireless Access (FWA) and the band is also a candidate for new Broadband Wireless Access (BWA) technologies (eg WiMax) due to the efficient medium distance radio propagation characteristics. There may be scope for freeing up more spectrum for terrestrial services in addition to the band already in use for FWA.

11GHz
Most civil fixed links share with civil fixed satellite services, as happens in this band, where there is sharing between fixed links and fixed satellite service downlinks. Parts of the bands 10.7-11.7 GHz are also used by broadcasting satellite service systems. Satellite uplinks based in the UK are charged separately (although they operate in other bands). No new fixed links have been assigned for many years to avoid interference to domestic reception of the broadcasting satellite programme use. The existing fixed links are old and could be seen as relatively spectrum inefficient. However, it does seem likely that there would be demand for spectrum in this band if new assignments could be made which did not adversely impact on satellite domestic TV reception. The Audit will be discussing with Ofcom whether the effectiveness of use of this band could be improved.

32GHz
As mentioned above, one third of the band has already been opened up for normal fixed links use. The remaining two-thirds is due to be auctioned as part of the SFR:IP auction programme, and the Audit is keen to ensure that the option of a band manager taking on this band is kept open.

Chapter 12

International

12.1 Introduction

Radio signals do not respect international borders, and this necessitates international cooperation in determining the use of spectrum at different frequencies for different services. In addition, in creating a product for a large scale market, commonality between countries over the use of spectrum provides an important commercial driver for new and innovative services. While the international regulatory structure that has evolved to take account of these issues has strengths in these areas, it also imposes some constraints on national autonomy to make different – perhaps better – local use of the spectrum. Changing the international structure involves significant timescales – usually many years – and therefore can act as a major barrier to new developments.

12.2 International & European Framework

The International Telecommunication Union (ITU) provides the overarching global regulatory framework for radio spectrum. It regulates spectrum by agreeing allocations at World Radiocommunications Conferences (WRCs) for services, on a primary or secondary basis. This indicates the hierarchy of access and reflects the level of protection from interference afforded on an international basis. The international allocations are usually implemented nationally. Stations in a primary service are protected from interference from subsequently implemented stations also using primary allocations, and all stations using secondary allocations. Stations in secondary services must not cause interference to, and must accept interference from, those with primary status even if the latter are introduced later, but are afforded protection from future secondary stations.

Although ITU Regulations are binding, they are not exclusive as they allow for individual administrations to authorise other applications in the band provided they neither cause interference to nor receive protection from stations operated by other countries in accordance with the Radio Regulations. The ITU divides the world into three regions: Region 1 (Europe, Africa and the Middle East); Region 2 (the Americas); and Region 3 (Asia and Australasia).[37]

At a European level, the Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT) provides guidance to national administrations on frequency allocations, harmonisation (see below), regulation and technical criteria e.g. parameters for coexistence between uses or technologies. Adoption of CEPT Decisions is optional for member administrations. The European Commission has the power of mandatory legislation over members of the EU, and increasingly mandates CEPT to develop harmonisation measures, or undertake technical studies in selected areas, which may then be encapsulated into mandatory legislation (EC decisions) following discussions at the EU's Radio Spectrum Policy Committee. The Radio Spectrum Policy Group provides high level strategic advice to the Commission on spectrum issues.

[37] see the Radio Regulations (article 5) for details

An industry-led organisation, the European Telecommunications Standards Institute (ETSI) develops technical standards for services and equipment. Adoption of ETSI standards is voluntary although elements of the standards are sometimes written into harmonisation measures which – depending on which body they have originated from - can become mandatory. The development of standards can also be progressed through routes other than harmonisation. Standards developed by other bodies, either international (such as the ITU) or national (such as the US IEEE) can also have a significant impact on spectrum usage.

Box 7: international measures

- *Standardisation*: The development of an open standard for a particular type of equipment allowing multiple manufacturers to make equipment which can interoperate. Standards are normally developed by bodies such as ETSI and the IEEE
- *Harmonisation*: The identification of common frequency bands throughout a region (eg Europe) for a particular application and in some cases a specific standard
- *Exclusive access*: The exclusive provision of frequency bands for a specific application or standard.

Source: Ofcom's Spectrum Framework Review Statement

12.3 Sector-specific Organisations

There are in addition organisations (for example ICAO, IMO, NATO, Eurocontrol, EASA) which represent and control particular sectors, in particular defence, aeronautical and maritime as has been noted in respective chapters. They can provide useful input and unified positions into the international organisations discussed above, and it would be necessary for the UK to work with and within these bodies to achieve changes at an international level.

12.4 Effective international representation

Ofcom has been directed by the Government to represent the UK in the ITU, CEPT and EU spectrum committees. There is an associated MoU which sets out the working arrangements.

In many of the areas this Audit is looking at, such as aeronautical and maritime, harmonisation is considered to be an operational necessity, although there is scope for national flexibility in some bands.

The first Cave Review made a number of recommendations on enabling effective harmonisation. Ofcom generally takes the view that standardisation and harmonisation can bring a number of benefits (for example, GSM is often quoted as a prime example of a successful application of harmonisation) but that in the longer term it is hoped that the market will lead to the emergence of *de facto* standards and decisions on harmonisation instead of these being driven by regulators.

In the interim, Ofcom's intention is to continue to play an active role in the relevant international fora in order to ensure that harmonisation decisions reflect the best

interests of the UK. In many cases, this will mean arguing for increased flexibility and a more technology neutral approach to spectrum management.

Ofcom do not have a statutory role to provide representation on standards bodies, although are often involved in this process (DTI now sponsor the UK Head of Delegation to ETSI). Although Ofcom (and its predecessor) was involved in several specific standards-making groups, it is now focusing on issues that directly relate to spectrum management and particularly those where there are conflicting interests between different spectrum users. Where issues are confined to a specific industry or user sector, Ofcom considers that it is generally better for that community to be more directly involved in international developments wherever possible.

Whilst the Audit team can see merit in Ofcom's approach, (and supports its attempts to develop more flexibility within the European framework) it is clearly important that Ofcom handles this transition carefully as it is likely to take many years across Europe and in some areas it is likely that mandatory harmonisation will continue to be needed e.g. in the aeronautical sector. It is also important that Ofcom is clear about the process by which it reaches a UK negotiating position for different issues – e.g. to ensure that Government and industry representation is equitable across sectors (something that Ofcom themselves are actively considering) and in balancing competing interests.

The Audit considers it important that Ofcom is clear about its plans for and expectations about the roles and responsibilities of industry/government/the regulator in developing UK negotiating positions and managing international activities.

12.5 Impact on Audit considerations

The international framework will also affect the efficacy of incentives such as pricing. As the first Cave Review recognised:

"the harmonisation of spectrum use under an EC Directive or Decision and bilateral agreements will permit the application of the opportunity cost approach where this does not involve a major change of use. Where the allocated use of a band would change as a result of applying an opportunity cost approach (e.g. trading, auctions) then the situation is less clear"[38]

The first Cave Review also put forward the view that the UK was not making the most of its opportunities for acting autonomously, saying "All of the countries under review must comply with the ITU Radio Regulations. However, these regulations allow a considerable degree of flexibility, allowing NRAs to make their own decisions regarding spectrum use, subject to remaining within the overall framework provided by the Radio Regulations. This flexibility is not currently exploited within the UK as fully as might in theory be possible"

In considering the key areas of the Audit such as defence, aeronautical and maritime services and the feasibility of increasing the efficiency of equipment in those bands or the possibilities for admitting other services, the Audit must do so with an eye to the European and International regulatory framework and established use, and the constraints these impose. It is recognised that achieving change at an international

[38] Review of Radio Spectrum Management, 2002, www.ofcom.org.uk/static/archive/ra/spectrum-review/index.htm

level is likely to be a challenging and potentially lengthy process, and may involve the UK (possibly represented by Ofcom) taking a lead in pushing the process forward.

12.6 International comparisons

In many areas, such as introducing incentive pricing for the public sector, and implementing a market based spectrum management system, the UK has introduced changes ahead of many of its EU and international counterparts. The UK is also often the driving force behind changes on the EU or international stage – for example with the introduction of the three year reviews of ECC harmonisation Decisions to ascertain if they are still warranted.

We will examine the regime for public sector users of spectrum in a selection of other countries through a questionnaire to the regulators and administrations in these countries, asking questions about the public sector spectrum management structure, pricing and incentives. The findings from this will be included in our final report in the autumn.

12.7 UK priorities

There are likely to be a number of issues arising from our Audit which may need to be pursued at an international level to have maximum impact. We would welcome views on whether the issues highlighted below accurately represent those likely to be key at an international level in taking forward the Audit's interests as outlined in this consultation document:

International processes

The timescale for progressing issues at an EU and international level could potentially be a block on implementing changes to enable more efficient use of spectrum e.g. admission of other services into bands, or setting new standards. We understand that there is some consideration of this at a European level. We are also interested in the opportunity created by the WRC-07 agenda item which will look at the ITU's approach to spectrum management at the global level. This could extend the debate to the world-wide level in a forum with the authority to make decisions.

Standards

As an example, if the Audit found that there was scope for new and innovative ways of enabling compatibility between services, then standards might need to be developed to facilitate and formalise this. There might need to be a process for approving this through EU and international procedures e.g. to develop a new sharing standard. The implementation of a new sharing regime might include: proof of technology; adoption of technology by a suitable committee within a standards body; resolution of international and national regulatory issues (e.g. harmonisation). Equally, however, sharing criteria could be developed and subsequent regulatory decisions made, on the basis of non-binding standards.

Sharing

Given the international implications of introducing new services into aeronautical, maritime or defence bands, for example, it might be useful to have a European or international discussion on technology-specific sharing in these bands, possibly linked to existing WRC-07 agenda items. The timescales involved in securing an agenda item appear unhelpful in terms of pushing forward discussions aimed at implementing emerging technologies or innovations.

Future needs

WRC 2007 will look at future needs in the maritime and aeronautical sectors. The Audit team's interest here is in how the case for future needs is assessed (UK and internationally) and the process proposed for implementing this. This has read-across for the national proposals we are making for public sector access to spectrum.

Information

The availability, provision and use of information about spectrum usage is a theme running through our Emerging Issues. This is also an issue gaining attention at a European level. We will watch with interest the development of the European Frequency Information System, which is a search and comparison tool for spectrum allocations and utilisation across Europe. It will be interesting to see how information provision about public sector use of spectrum is handled as part of this overarching agenda.

Annex A

Terms of Reference

1. To identify the major spectrum holdings for consideration.[39]

2. To audit the use of and the operational need for major spectrum holdings, having regard to the potential future demand, with a view to identifying spectrum that could possibly be opened for other use.

3. To recommend a strategic approach for making such spectrum available, taking into account operational, financial, technical and international factors, and to indicate possible timescales. This could include proposals for spectrum clearance projects.

4. To review the effectiveness of ongoing incentives for public sector users to maximise efficient use of the spectrum and whether this could be enhanced, including through the treatment of shared bands and the means of meeting new spectrum requirements of public sector spectrum users.

[39] Investigations will concentrate on, but are not limited to, frequencies below 15GHz

Annex B

Consultation Questions

Responding to the consultation

Responses to this consultation should be sent, **by 5pm on 1st September,** to:
Email: responses@spectrumaudit.org.uk

Post: Desk 05:45, Riverside House, 2a Southwark Bridge Road, London SE1 9HA

Responses will be published unless respondents specify otherwise.

If you would like to contact the Audit team, you can do so at the same address or by calling Helen Watson (020 7783 4942) or Sam Whittaker (020 7783 4937).

All information about the audit, including a copy of this consultation document, will be posted the Audit's website www.spectrumaudit.org.uk

Consultation questions

Band specific

1. To judge potential demand, we would welcome views on the bands highlighted – listed in Annex C and detailed in the chapters on Ministry of Defence, Aeronautical and Fixed Links. Would possibilities for (i) sharing (including time limited and ad hoc sharing) or (ii) freed up bandwidth in these bands be of interest to other users? Are there other bands the Audit should examine?

Public Sector Spectrum: acquisition and trading

2. Do you agree that public bodies should in general expect to meet future spectrum needs through the market? Are the process and criteria outlined a suitable means of deciding whether an administrative assignment should be made if this is not possible?

3. Public sector demand: We would also welcome input into this consultation on likely future demand in the public sector and fixed links areas we have covered in this document.

4. Commercial market intelligence: In order that we do not overlook important future requirements below the 80% of users that our demand study is examining, we would be interested to hear views on likely future commercial demand, specifically those which may fall below the scope of the commercial study.

5. We would welcome views on what information Ofcom could usefully collect in furthering its role to ensure the efficient use of public sector spectrum

6. Licensing: We would be interested in views on the treatment of the Crown. Do you agree with the idea of using Recognised Spectrum Access (RSA) to define the rights of bodies covered by Crown immunity and enable tradability?

Spectrum Pricing

7. Effectiveness of AIP:

- Do you agree that AIP should remain a primary mechanism for achieving efficient use of public sector spectrum?
- Do you think there is merit in these or other alternative mechanisms to achieve efficient use of public sector spectrum, in addition to or instead of AIP?
- How is this affected by Ofcom's proposals to move to greater market management of the spectrum?

8. Do you agree that there is merit and potential benefit in exploring changes in AIP:

- To ensure the prices are kept up to date and reflect the current alternative use (e.g. bands currently charged as fixed which may be suitable for future mobile use)
- To better reflect the real 'spectrum value curve' in and outside prime bands (c.f. band factor applied to commercial fixed links which is not applied to MoD fixed spectrum)
- To provide a stronger incentive to public bodies to make more efficient use of their holdings (e.g. disposal or sharing; accounting changes that could best tie costs directly to use)

9. The Audit therefore thinks it is worth exploring the possibility of introducing a system of 'freehold rents' or 'retainers' for bands which the MoD is not currently using but continues to hold a right to reclaim and would welcome views on the economic rationale for and possible level of such a charge.

Sharing

10. Would the existence of a third party intermediary to facilitate sharing between public sector organisations and other public/commercial bodies be likely to increase the possibilities afforded by sharing? What roles should such a body have? Would individual users find it useful to be able to negotiate over sharing/trading arrangements either directly with the MoD or organisation acting on their behalf?

11. The Audit team would welcome any views on how existing users can be assured that sharing will not compromise ongoing safety-critical or essential use, including through equipment standards, testing, management of liberalisation and appropriate operational and technical parameters.

12. The Audit would welcome any views on the effectiveness of the current T&D licence regime and how this might be improved. It would also welcome views from existing users on how much flexibility here would be considered reasonable.

13. The Audit team are interested in the potential for more sharing in the bands used by the public sector. Are there techniques or services in which you believe there is particular potential? For example, what are your views on the technological, operational and economic feasibility of sharing between radar and other technologies?

Ministry of Defence

14. What impact does the possibility of restrictions to be imposed in a time of civil emergency have on the attractiveness of sharing MoD spectrum?

Radar

15. Do you agree with the principle that AIP should be introduced for (i) aeronautical and (ii) maritime navigation radar? If so what are your views on the best way to determine and impose AIP charges on radar?

16. Do you think there is scope through means other than pricing (e.g. technical regulations, better co-ordination) to enhance the utilisation and economic efficiency of radar bands

Fixed links

17. The Audit team would like to hear from any prospective band managers who have considered band management in a fixed links band, to hear views on potential barriers

18. We would welcome views on the merits of the listed approaches to regulator intervention

19. We would welcome views on whether a Technology “Spend to Save” scheme would be of benefit, and views on the Spectrum Efficiency scheme generally, including whether its scope could usefully be expanded

International

20. We would welcome views on whether the issues highlighted accurately represent those likely to be key at an international level in taking forward the Audit’s interests as outlined in this consultation document

Annex C

Band specific

This Annex lists the bands that the Audit is currently examining. Some of these are explored in more detail in the chapters on the Ministry of Defence, Aeronautical and Fixed Links. Our final report will contain a comprehensive audit of these bands, detailing current use, future planned use and any scope for releasing either whole bands or some bandwidth at the margins.

To judge potential demand, we would welcome views on the bands highlighted Would possibilities for (i) sharing or (ii) freed up bandwidth in these bands be of interest to other users? Are there other bands the Audit should examine?

Band	Overview of use.
MoD (UK2 bands)	
137-138 MHz	General communication systems (eg military bases). Meteorological Satellite systems (space to Earth) for the Met Office.
142.5-143 MHz	General communication systems, mainly land-based.
149-149.9 MHz	General communication systems, mainly land-based.
153.5-154 MHz	General communication systems, mainly land-based.
225-400 MHz	Main NATO band. Harmonised across NATO and includes a variety of systems including frequency hopping radars, tactical radars and Tactical Radio Relay. Mobile communications for land, sea and air operations. Also used for Instrument Landing Systems which are shared with CAA.
400-406 MHz	Mainly used for Meteorological sondes (weather balloons).
430-450 MHz	Major use is defence early warning radar. Also used for general communication systems (eg military bases), and civil PMR and radio amateurs.
960-1350 MHz *	Radar systems and navigation aids – many of which are shared with CAA

Band	Overview of use.
1375-1400 MHz	Variety of Fixed Links and general communication systems.
1427-1452 MHz	Variety of Fixed Links and general communication systems plus airborne telemetry.
1559-1626.5 MHz	Radionavigation satellite (GPS).
2310-2450 MHz	Heavy use of the band for telemetry, both terrestrial and aeronautical plus a variety of communication systems.
2700-2900 MHz *	Aeronautical Radars planned in cooperation with the CAA.
2900-3100 MHz	As 2700-2900 MHz plus maritime radars
3100-3400 MHz	High power land, airborne (station-keeping) and naval radars.
3400-3600 MHz	Airborne station-keeping radar at bottom of band. Band used extensively used by civil services – programme making, Fixed Wireless Access and Emergency Service helicopter links - for many years.
4400-5000 MHz*	A major NATO harmonised band used for fixed communication systems. Some Troposcatter systems.
5300-5350 MHz	Radars.
5650-5850 MHz	Radars.
7900-8025 MHz	Uplinks for Mobile Satellite system.
8025-8400 MHz	Fixed Links and uplinks for fixed and mobile satellite systems including meteorological satellite systems.
8500-10500 MHz *	Radiolocation and Aeronautical Radionavigation systems. Some sharing of this with CAA. Maritime radar band 9200-9500 MHz
13.25-14 GHz *	Radio altimeters. Land and naval radars.
15.4-17.7 GHz *	Wideband radars.

Band	Overview of use.
CAA	
590-598 MHz	Long-range aeronautical radars.
960-1350 MHz *	Main long-range aeronautical radar band and navigation aids/beacons and secondary radar
1610-1626.5 MHz	Aeronautical Radionavigation including GPS
2700-2900 MHz *	Main medium-range aeronautical radar band.
4200-4400 MHz *	Radio altimeters.
5000-5250 MHz	Limited use for Microwave Landing System.
8500-10500 MHz * (CAA use: 900-9200 and 9300-9500 MHz)	Main short-range aeronautical radar band.
13.25-14 GHz * (CAA use: 13.25-13.4 GHz)	Radio altimeters.
15.4-17.7 GHz *[*]	Radars.
Fixed links	
1790-1798 MHz	Primarily Emergency Service Fixed Links
3.6 GHz – 4.2 GHz	Civil fixed links. Shared with fixed Satellite services.
11 GHz	Limited civil fixed links due to use of the band for domestic satellite television reception.
32 GHz	Civil fixed links. Used for high-density applications.

[*] some shared MoD and CAA use

Annex D

Review of Radio Spectrum Management 2002 (the "Cave Review"): stocktake

Cave Review recommendation	Government response	Update
Recommendation 5.2 The RA should seek to implement an on-line frequency register covering all the civil radio communications bands and the radio systems utilising them	The RA will proceed to consult on detailed plans to publish more assignment information, including on-line, while taking full account of the need for appropriate and effective safeguards	Information on the new frequency authorisation plan and the Wireless Telegraphy Register is now available on the Ofcom website and will be expanded as trading rolls out – see http://www.ofcom.org.uk/radiocomms/isu/
Recommendation 8.4 Current restrictions on the use of any fixed wireless access bands should be removed to allow deployment of any fixed service. Licences should be converted to allow trading. RA should begin to auction area licences in fixed bands which would allow the licensees to deploy any fixed service, or trade the rights to do so	New licences should not generally include restrictions on use. Existing licences will need to be reviewed on a case-by-case basis. Conversion of licences will be considered as part of spectrum trading consultation.	Trading has been possible in most fixed bands since December 2003 (for example the 3.4GHz band was auctioned in the regions). All licences are being reviewed with a view to minimising constraints. In the meantime, requests for changes will be considered by Ofcom. A programme of auctions of unused or under-used spectrum has been announced.
Recommendation 8.5 Opportunity cost pricing should be applied to satellite systems' use of spectrum where such use shares with, and constrains, the deployment of UK-based terrestrial services. Spectrum pricing should continue to apply to	Government accepts this recommended. RSA will enable opportunity cost pricing to be applied where necessary. AIP fees currently charged for permanent earth stations in the UK will continue to be phased in.	Work on implementing RSA is underway. The application of AIP has been reviewed and new arrangements implemented. The pricing of satellite earth stations is being revisited with a view to making changes in April 2006.

permanent earth stations but at full opportunity cost levels. Transmissions from user/interactive terminals should also be licensed with an appropriate spectrum charge. Spectrum access licensing could be used to clarify the rights and responsibilities of satellite transmissions into the UK and where appropriate to apply opportunity cost pricing to such spectrum use		The first application of RSA is likely to be for radio astronomy. A consultation document was published on 6 April 2005 – see Recommendation 14.1 below.
Recommendation 10.1 RA should publish the unclassified UK peacetime FAT	Table will be published by end of 2002	Published in December 2002 as the UK Frequency Allocation Table and re-published in December 2004.
Recommendation 10.2 MoD should conduct a comprehensive audit of all frequency assignments, including patterns of usage by time and location – should be disclosed to RA. MoD should combine this data capture with investment in new frequency management tools, to enable more sophisticated sharing of military frequencies by time and location	A prioritised plan starting immediately for auditing the current and future use of those parts of Ministry of Defence managed spectrum that are most in demand by civil users has been agreed with the RA with the objective of increasing the scope for spectrum sharing, leasing or release for civil use.	A prioritised list of specific bands of likely interest to civil users was drawn up, and audits completed (arranged by RA in cooperation with MoD). The results demonstrated the possibility of re-arranging some MoD use in smaller bands thus enabling some spectrum release for civil use.
Recommendation 10.3 MoD should (without prejudice to security) disclose to industry those bands where spectrum sharing may be feasible as a result of the patterns of military usage. MoD should identify the pre-emption terms and	UK Spectrum Strategy already fulfils this role. Consideration will be given to publicising the availability to civil users of military spectrum by other means. The agreed audit programme will enable this information to be made more comprehensive.	Some sharing exists and is recognised in MOD pricing. The MoD has agreed to further sharing in some limited areas, and released some spectrum completely. However more extensive sharing as envisaged in the Cave

interference management requirements for military systems, to enable commercial operators to judge the viability of sharing such spectrum on a subordinate basis		Review, coupled with spectrum trading and liberalisation, has not taken place. The MoD prefer to share with a limited number of larger users, with known technical parameters.
Recommendation 10.4 Value of NATO managed bands should be more transparent, with disclosure of 'shadow' charge which would apply if the bands were MoD managed	The shadow charge level will be made publicly available, possibly in the next Spectrum Strategy	In reviewing the MoD fees for 2005/6, a shadow charge for the main NATO band at 225-400 MHz was made.
Recommendation 10.5 MoD should bear the full opportunity cost of spectrum currently subject to AIP, with comparable tariffs applying to comparable civil and military uses. MOD should also be subject to a spectrum charge for all of its radar bands, with the tariff unit equal to that applied to civil aeronautical and maritime radar usage.	MoD will be charged on a comparable basis to private sector users, including any alterations to charges to reflect opportunity cost more accurately	MoD is only charged for fixed and mobile bands, not radar bands as AIP has not yet been introduced for civil radars.
Recommendation 10.6 Decisions on MoD's departmental budget should be made consistent with the maintenance of credible and enduring incentives on MoD from spectrum pricing and leasing, to provide positive financial benefits to MoD from efficient spectrum use over time	Agreed	

Recommendation 10.7 MoD should consider proposals to HMT for bringing forward equipment spend which would release spectrum or allow sharing	Where MoD makes equipment procurement decisions within its delegated authority for expenditure, it will, with RA and HMT, develop robust appraisal methods for factoring spectrum efficiency into those procurement decisions. Above delegated authority will be considered by HMT on a case-by-case basis. HMT will also consider expenditure analogous to spectrum efficiency grants or the use of overlay licences to the rationalisation of MoD spectrum where these are considered to be the most effective method of reallocation	The Audit will be looking at MoD procurement processes. The Audit's initial view is that there are not adequate processes for factoring spectrum requirements into procurement processes.
Recommendation 10.8 MoD should retain revenues from leasing access (eg wider markets)	RSA provisions will allow leasing. Government is examining whether this would fall under the Wider Markets initiative, allowing MoD to retain receipts	Clarity is being sought over the wider markets question.
Recommendation 12.1 For on board navigation and communications systems, the opportunity cost is effectively zero. But where UK based users face some technology choice, the RA, working with CAA and MCA should apply differential licence fees to encourage moves to more spectrally efficient equipment	Agreed – RA will work to identify where it would be sensible to apply AIP, and there will be full consultation before introduction	This is an area the Audit will be pursuing with Ofcom.
Recommendation 12.2 RA should develop, with CAA and MCA, a pricing regime for the spectrum used by UK-based radio navigation and radiolocation	Study of UK's civil radar deployment was completed at the end of 2002. RA/Ofcom should then consider, with MCA and CAA, how AIP should be introduced and the timescale for its introduction, following full	Not yet implemented – to be considered further by Audit.

equipment – to be phased in over next five to seven years	consultation.	
Recommendation 13.1 Public Safety users should continue to benefit from guaranteed access to radio spectrum, subject to full spectrum pricing applicable to comparable private mobile radio users	Provision of guaranteed access (subject to pricing) is necessary to secure essential emergency services, where spectrum is shown to be essential for this purpose. RA and Home Office are discussing plans to charge HO users for services not migrating to Airwave	Police and fire and ambulance have been charged on the same basis as Business radio. Charging for Airwave is under discussion.
Recommendation 13.2 RA should rationalise existing disparate assignments and widen the pool of spectrum reserved specifically for the delivery of public safety services, under the management of the PSSMG. Wherever possible, a technology neutral approach should be taken to the systems adopted for use to allow for competition	RA has agreed with Home Office plans for amalgamating the HO bands with spectrum managed by the Agency and making other blocks available to users not going into Airwave, thus widening the pool. Government agrees in principle that a technology-neutral approach would be preferable	All HO frequency planning transferred to RA/Ofcom (Scottish Exec retains for Scotland). Rationalisation of spectrum still longer-term aim. Tenders for fire and ambulance service were technology-neutral.
Recommendation 13.3 The remit of the PSSMG should be broadened. Bands managed by HO providing access for users not migrating to Airwave should be placed under control of PSSMG	Agreed – reconstituted as PSSPG with broader membership. Process agreed to transfer HO management to this group	Done
Recommendation 14.1 UK based radio astronomy sites should be	Government will focus spectrum pricing on bands in which radio astronomy is protected but international rules allow alternative uses.	Consultation document on RSA for radio astronomy was issued on 6 April 2005. Closing date for comments was 13 June

subject to administratively set spectrum charges for those bands where the UK has scope, under ITU regulations, to deploy other actively transmitting radio services on a co-primary basis in the band. Where radio astronomers allow other services to be deployed they should be compensated eg by RA passing on the spectrum fee levied on fixed links which it assigns within the protection zones around observatories	Govt will discuss this with PPARC	2005.

Annex E

Details of Aeronautical Radar and Navigation Aid Bands and uses

As noted in the aeronautical chapter, there are two main types of radar, primary and secondary (explained below), in addition to differentiation between use for navigation (including obstruction-warning) and location (often military use, but also scientific sensing).

Primary Radar: based on the comparison of reference signals with radio signals reflected from the position to be determined, and used to sense the presence and properties of remote objects. It is used in civil and military air traffic control to monitor the location and velocity of aircraft without relying on the aircraft (or other object such as a balloon) cooperating with the interrogation, which might be due to lack or failure of equipment or malicious intent. The main bands are:

Ground-Based:

- **L-Band (1215-1350 MHz)**: There are 46 ATC L-band assigned civil radar frequencies, 4 of which are reused (12%). Note that most radars require more than one frequency assignment, for example, due to multipulse working or frequency diversity operation. The band is also heavily used by the military (for off-route aircraft management and protection of airspace and GPS-L2), earth exploration satellites (space-to-earth) and the amateur radio service on a secondary basis. Typically providing long-range coverage of approaches to UK with operating ranges in excess of 200 nautical miles, and fall-back coverage over UK territory;

- **S-Band (2700-3100 MHz)**: Civil and military use. Sharing with maritime users takes place above 2900 MHz. There are 82 S-Band civil ATC radar frequency assignments in the U.K. 12 of these frequencies (22%) are reused. Typically supporting aircraft management over and around UK territory, with typical operating ranges from 10 to 120 nautical miles, otherwise similar to L-band radar use;

- **X-band (9.0-9.2 GHz and 9.3-9.5 GHz):** Used for both civil and military primary radar with shorter operating ranges – typically local coverage around an airfield, surface movement or obstruction detection. There are 12 civil X-Band ATC radars operating in the U.K and 5 of the 9 frequencies are re-used;

- **Ku-band (15.63-16.60 GHz)**: Civil and military use. There are three frequencies, all operating at each of three locations. Radars in this band have a very short range such that ground-based frequency reuse should be always possible, and typically perform the same roles as X-band systems. Also used for radio altimeters on military aircraft.

Airborne:

- **C-Band (4.2-4.4 GHz)**: Radio altimeters operate at 4300 MHz (+/- 100 MHz) worldwide;

- **5.35–5.47 GHz**: Airborne Weather Radar – particularly important for detection of windshear during final approach and landing;

- **8.75–8.85 GHz & 13.25-13.4 GHz** Airborne Doppler Radar – terrain following and ground-speed determination;

- **15.63-16.60 GHz.** Radio altimeters on military aircraft.

Secondary Radar: based on signals retransmitted from the position or object to be determined, and **navigation aids:** providing location and direction information to help aircraft negotiate their route safely. As aircraft carrying receivers or transponders operate across international boundaries, these bands need full international co-ordination. Many systems are shared between civil and military users, or have civil and military variants Secondary radar enables more sophisticated air traffic control, e.g. the response from the aircraft includes identity and altitude, and consequently is an important enabler of higher air traffic densities in a growing market.. Secondary radar also forms the basis for Airborne Collision Avoidance Systems (ACAS). The main forms of secondary radar and other non-voice aeronautical radionavigation systems are:

- **L-Band (960-1215 MHz)**: This is the key radionavigation band reserved on a world-wide basis for radionavigation and any directly associated ground-based facilities. Applications include:
    - **SSR** (Secondary Surveillance Radar) encodes information on aircraft identity and altitude in the response transmitted following reception of an interrogation pulse. SSR airborne equipment also supports the Airborne Collision Avoidance System (ACAS) where aircraft receive others' responses or interrogate each other, potentially initiating proximity warnings or automatic evasive action. Interrogation pulses are transmitted on a single, worldwide frequency (1030 MHz), and aircraft reply on another (1090 MHz, both ±5 MHz). Important enhancement to air traffic control to increase safety and enabling higher air traffic densities in a growing market;
    - **IFF** (identification friend or foe) is similar to SSR but with a military application;
    - **DME** (Distance Measuring Equipment), in which the aircraft transmits interrogator pulses on one of 126, 1 MHz channels between 1025-1150 MHz, and calculates distance from the beacon from the delay in receiving a response on the paired channel in 962-1024 or 1151-1213 MHz. The channel plan is linked to VOR, ILS and MLS;
    - **TACAN** (tactical air navigation) – the military version of DME which also includes bearing information;
    - **JTIDS**. A frequency-hopping military information system which also operates in the band but avoids SSR channels.

- **VHF (108-118 MHz)**
    - **VOR** (VHF omnidirectional ranging) operates at VHF and uses the phase difference between a continuous omnidirectional signal and a rotating narrow beam signal to give the direction from the beacon to the receiver. When the aircraft is due north of the VOR beacon, the two signals are in phase; when the aircraft is due south, the two signals are in anti- phase; with the phase difference varying between those two extremes. A VOR beacon also transmits a three-letter identification code in Morse.

Landing systems:

- **ILS (instrument landing system)** - ILS consists of three elements: A set of radio "marker beacons" operating around 75 MHz to identify the runway and provide cues to its proximity, a directional "glide slope" transmitter (328-335 MHz) to indicate whether the aircraft is too high or too low (90 Hz modulation above, 150 Hz modulation below ideal glide slope), and a "localizer" transmitter (108-112 MHz) to similarly define the approach azimuth for the runway (90 Hz to the left, 150 Hz to the right of runway centreline). The localizer signal also includes a Morse ID code, and often a voice channel for communications with ground control;
- **MLS (microwave landing system)**. A more recent and potentially capable landing system operating in 5030-5150 MHz. Approach trajectories need not be straight or universal between aircraft types with MLS, and while channels are intended to be linked to the ILS / VOR plan, deployment has been slow;
- **GBAS (Ground-based augmentation system)** – uses navigation signals from satellites (RNSS – e.g. GPS, Galileo) in conjunction with local, ground-based transmissions at VHF (108-118 MHz) which provide enhanced accuracy and corrections against known local datums, to control aircraft approach and landing. Aircraft need not approach on fixed or straight trajectories. Would require fall-back provision of another instrument landing system, but may be preferred over MLS to enhance ILS provision.

Annex F

Ministry of Defence spectrum fees – indicative breakdown for 2005-06

Band Edges		Width	Apply Pricing (y/n) ?	National, Region 1 or Region 2?	Potential Civil Use	Rate (/MHz)	Total Cost (thousands)	Comments (e.g. reasoning for pricing decision)
70 MHz	70.5 MHz	0.5 MHz	y	nat	Mob	£240. k/MHz	£120	
72.8 MHz	74.8 MHz	1.96 MHz	y	nat	Mob	£240. k/MHz	£470	74.68125-74.71875 MHz - Ofcom.
75.2 MHz	76.7 MHz	1.5 MHz	y	nat	Mob	£240. k/MHz	£360	
78 MHz	80 MHz	2 MHz	y	nat	Mob	£240. k/MHz	£480	
83.5 MHz	85 MHz	1.5 MHz	y	nat	Mob	£240. k/MHz	£360	
137 MHz	138 MHz	0.96 MHz	y	nat	Mob	£240. k/MHz	£230	137.9625-138.0 MHz - Ofcom.
141.9 MHz	143 MHz	0.5 MHz	y	nat	Mob	£240. k/MHz	£120	Anglo French Agreement portion zero rated
149 MHz	149.9 MHz	0.9 MHz	y	nat	Mob	£240. k/MHz	£216	
153.5 MHz	154 MHz	0.5 MHz	y	nat	Mob	£240. k/MHz	£120	
225 MHz	380 MHz	155 MHz	n	-	Mob	£240. k/MHz	Zero.	NATO managed band (5 MHz for TDAB).

380 MHz	400 MHz	10 MHz	y	-	Mob	£240. k/MHz	Zero.	NATO managed band (2x5MHz for PSSPG)
401 MHz	406 MHz	5 MHz	y	nat	Mob	£240. k/MHz	£1,200	
406.1 MHz	410 MHz	3.9 MHz	y	nat	Mob	£240. k/MHz	£936	
410 MHz	430 MHz	15 MHz	y	nat	Mob	£396. k/MHz	£5,940	Minus 5 MHz (2x2.5 MHz).
430 MHz	450 MHz	20 MHz	y	nat	Mob	£396. k/MHz	£7,920	431-432 MHz; 440-443.5 MHz; 445.5-449.5 MHz.
870 MHz	872 MHz	2 MHz	y	-	Mob	£240. k/MHz	£480	
876 MHz	880 MHz	3 MHz	y	-	Mob	£240. k/MHz	£720	MoD 75% in view of UIC estimated use of 25%.
915 MHz	917 MHz	2 MHz	y	-	Mob	£240. k/MHz	£480	
921 MHz	925 MHz	3 MHz	y	-	Mob	£240. k/MHz	£720	MoD 75% in view of UIC estimated use of 25%.
1375 MHz	1400 MHz	25 MHz	y	-	Fixed	£3. k/MHz	£75	
1427 MHz	1452 MHz	25 MHz	y	-	Fixed	£3. k/MHz	£75	
2025 MHz	2070 MHz	45 MHz	y	-	Fixed	£3. k/MHz	£135	Sharing with PMSE under consideration.
2200 MHz	2245 MHz	45 MHz	y	-	Fixed	£3. k/MHz	£135	Sharing with PMSE under consideration.
2310 MHz	2390 MHz	80 MHz	y	-	Mob	£240. k/MHz	£19,200	
2390 MHz	2450 MHz	5 MHz	y	-	Mob	£240. k/MHz	£1,200	Minus 2400-2450 - ISM & 50% 2390-2400 - PMSE

3100 MHz	3400 MHz	300 MHz	n	-	Fixed	£2. k/MHz	Zero.	Zero-rated - radar-only band.
3400 MHz	3600 MHz	80 MHz	y	-	Fixed	£3. k/MHz	£240	Minus 2x20 MHz for FWA & 50% for rest.
4400 MHz	5000 MHz	600 MHz	y	nat	Fixed	£3.9 k/MHz	£2,340	
5300 MHz	5650 MHz	350 MHz	n	-	Fixed	£2.6 k/MHz	Zero.	Zero-rated - radar band.
5650 MHz	5850 MHz	100 MHz	y	-	Fixed	£3.9 k/MHz	£390	Minus 50% for FWA.
7250 MHz	7300 MHz	50 MHz	y	nat	Fixed			Zero rated - international regs. No RSA.
7350 MHz	7750 MHz	400 MHz	y	nat	Fixed			Zero rated - international regs. No RSA.
7900 MHz	7975 MHz	75 MHz	y	nat	Fixed	£3.9 k/MHz	£293	
7975 MHz	8025 MHz	50 MHz	n		Fixed.		Zero.	Zero-rated - no fixed allocation.
8025 MHz	8400 MHz	375 MHz	y	nat	Fixed	£3.9 k/MHz	£1,463	
8400 MHz	8500 MHz	100 MHz	n		Fixed	£3.9 k/MHz	Zero.	Minus HO/SO & PMSE use.
8500 MHz	8750 MHz	250 MHz	y	-	Fixed	£3.9 k/MHz	£975	
8850 MHz	9000 MHz	150 MHz	y	-	Fixed	£3.9 k/MHz	£585	
9500 MHz	10125 MHz	625 MHz	y	-	Fixed	£3.9 k/MHz	£2,438	
10125 MHz	10225 MHz	100 MHz	y	-	Fixed	£3.9 k/MHz	£195	Civil FWA.
10225 MHz	10475 MHz	130 MHz	y	-	Fixed	£3.9 k/MHz	£507	Minus HO/SO (60 MHz) & PMSE (60 MHz).
10475 MHz	10500 MHz	25 MHz	y	-	Fixed	£3.9 k/MHz	£49	Civil FWA = 50%.
13400 MHz	14000 MHz	600 MHz	y	-	Fixed	£3.9 k/MHz	£2,340	
14620 MHz	15230 MHz	610 MHz	y	nat	Fixed	£3.9 k/MHz	£2,379	
								TOTAL: £55,885

Annex G

Glossary

AIP	Administered Incentive Pricing
CAA	Civil Aviation Authority
CEPT	The European Conference of Postal and Telecommunications administrations
ETSI	European Telecommunications Standards Institute
DTI	Department of Trade and Industry
GHz	GigaHertz (frequency of one thousand million Hertz)
GSM	The Global System for Mobile Communications
ICAO	International Civil Aviation Organisation
ITU	The International Telecommunication Union
JFMG	Joint Frequency Management Group
kHz	kiloHertz (frequency of one thousand Hertz)
MCA	Maritime and Coastguard Agency
MHz	MegaHertz (frequency of one million Hertz)
MoD	Ministry of Defence
MoU	Memorandum of Understanding
NATS	National Air Traffic Services Ltd
NFPG	National Frequency Planning Group
Ofcom	The Office of Communications
PMSE	Programme making and special events
RSA	Recognised Spectrum Access
PSSPG	Public Safety Spectrum Policy Group
RA	Radiocommunications Agency
SES	Spectrum Efficiency Scheme
UAV	Unmanned Aerial Vehicle
UKSSC	UK Spectrum Strategy Committee
UWB	Ultra-wideband
WRC	World Radio Conference