

# **Review of Radio Spectrum Management**

An independent review for  
Department of Trade and Industry  
and HM Treasury

by Professor Martin Cave

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Dear Chancellor of the Exchequer and Secretary of State,

In March 2001 you appointed me to undertake an independent review of radio spectrum management in the UK, and I now take pleasure in sending you my final report. Since March, the review team has published a consultation document to which 80 responses have been received, and also has met or communicated directly with a wide variety of organisations, including firms, public sector organisations, Government departments, consumer groups and overseas regulators. I am grateful to these bodies for the considerable help which they have given the review.

In the June consultation document, I set out a possible approach to spectrum management over the next ten to fifteen years which was designed to ensure that all the spectrum users take into account the costs of the spectrum which they were using. This was likely to encourage efficiency in spectrum use and create opportunities for innovation. Respondents have generally welcomed this approach, but have expanded on it in a number of important ways.

In particular, it is clear that major technological changes are giving the spectrum much greater importance in the prosperity of the British economy and the attainment of the Government's social objectives. In the field of communications, major new services will shortly be provided, in the form, for example, of 3G mobile communications and broadband internet access, delivered by terrestrial wireless or by satellite. Digital broadcasting transmitted terrestrially or by satellite will deliver a much broader range of services to an increasing proportion of the population, and soon to all of us. Other commercial uses of spectrum – for example in the provision of airline services – are also growing in importance.

At the same time, the public services are increasingly reliant upon spectrum. In defence, the importance of gathering and communicating information is growing all the time. Emergency services increasingly require information to be conveyed fully and immediately to the scene of any incident. Technologies to achieve these objectives are currently being deployed. Almost invariably, they place additional demands on spectrum use. I have referred above solely to technologies under commercial exploitation or on the verge of it. But it is clear that over the ten to twenty year period which my proposals are intended to cover, there will be a very large number of further innovations. Some of these, such as software-defined radio and ultra wideband transmission, are under development. Others are not yet known.

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These circumstances place an important premium on flexibility – particularly the ability to make unused spectrum in the higher bands available to users, and to redeploy existing spectrum for new purposes. In the past, such decisions have predominantly been made by international or national regulatory bodies. Particular bands of spectrum have been allocated by international agreement to specified purposes; national governments have then assigned the spectrum through an administrative process to particular firms.

Guided by many of the responses which I have received, particularly from commercial organisations, I have concluded that this system is no longer sufficiently flexible to meet the needs of the twenty-first century. The benefits which it brings in terms of preventing interference from one spectrum user to another, nationally or internationally, and from achieving harmonisation of spectrum use at a European or global level, can generally be achieved by other means – in the case of interference, by a proper specification of the rights of the licensees, and in the case of harmonisation, by intelligent decisions taken by firms, rather than regulators, designed to reduce the cost of service to customers and supported by the vigorous application of competition law to prevent collusive behaviour. Accordingly, I recommend that the Government undertake a policy of selective deregulation of spectrum use where it can within the UK, and argue in international fora for increasing reliance upon the market, rather than administrative systems, for the management of spectrum.

In the case of spectrum utilised by firms for purely commercial purposes, this objective can best be achieved by the introduction of spectrum trading, combined with the auctioning of new spectrum as it becomes available. Trading will give firms an incentive to husband the nation's resources of spectrum and direct it into the most profitable uses. Where demand grows for a service which utilises spectrum, spectrum will increasingly be deployed for that purpose. Firms that do not utilise, or under-utilise, spectrum will have an incentive to lease or sell it. This will require a much clearer specification of the duration and the extent of the rights of users flowing from the licensing process, but these challenges have already been overcome in other countries, and in that relatively small part of the spectrum in the UK which has been subject to auctioning. The Government will also have to resolve questions of capital gains made by firms which were initially assigned spectrum by an administrative process, but which henceforth may have the right to sell that spectrum and my report indicates a number of ways in which this issue might be addressed. In my opinion, the combination of auctioning of new spectrum used for commercial purposes and secondary trading will introduce a much wider

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and better functioning allocation mechanism than exists at present when only the auctioning of new spectrum is permitted. Accordingly, I recommend that spectrum trading be progressively introduced in the case of all spectrum used for commercial purposes, as soon as such trading becomes permissible under EU legislation – probably from the middle of 2003.

In relation to spectrum used for public services, such as defence, the emergency services, science and aeronautical radar, I recommend that the Government adopt a policy of reserving spectrum for such purposes, combined with a system of levying an administrative charge on its use, based upon the value of that spectrum to users. The Radiocommunications Agency has been a pioneer in the development of administrative pricing of spectrum, and I recommend that this process be developed further and utilised more widely, to cover all public service spectrum which has an alternative use. When government departments and other bodies face charges of this kind, they will have an incentive to reduce the amount of spectrum which they use in order to reduce their costs. They may, for example, switch to wire-based rather than wireless technology; they may advance investment to install equipment which uses spectrum more economically. Over time, the effect will be to release public service spectrum for alternative commercial and non-commercial uses as the price mechanism begins to work. In the longer term as spectrum trading develops, the Government should look to expose more public services' spectrum use to this market mechanism.

This process of levying charges for spectrum does not entail any reduction in the level of provision of defence, emergency services, public service broadcasting or other public services within the economy. The Government will still be able to make appropriate budgetary allocations to such services, to permit expenditure on spectrum as well as on other inputs. Care must be taken to ensure that this is done in a way which still gives the suppliers of public services an incentive to economise on costs. My report discusses at some length how this can be achieved. The key point is that public services users of spectrum receive a genuine monetary incentive to use their best efforts to economise. I also recommend that public service spectrum users be given the right to share spectrum with commercial users, by leasing it to them on a time-limited or interruptible basis at commercially agreed rates.

One of my abiding concerns throughout the preparation of the report has been a widespread perception that spectrum charging is simply a device to raise money for the Government from private sector bodies or organisations such as the BBC. Revenue raising has not been an objective which has governed my recommendations. On the contrary,

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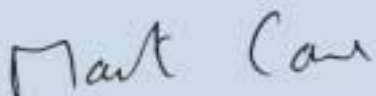
I am concerned that the current régime, in which inflexible allocations of spectrum are made to particular purposes, generates artificial scarcities which limit entry into spectrum-using industries and ultimately lead to higher prices paid by consumers. In the short term, spectrum charges may increase government revenues. In the medium and long term, however, the effect of redeploying spectrum to high value uses will reduce both scarcity and price. In an ideal world, most wave bands would be priced, but the price would be low, as firms respond to the challenge of bringing more of the spectrum into use and economising on it. In my opinion, the gains to the British economy from this process are enormous. For it to be achieved, what is required is that the Government makes a firm commitment to the use of prices for spectrum; the precise date at which they come into effect are a matter of lesser importance provided that a credible commitment is made.

In summary, my recommendations start from the belief that the country needs radically to change the way in which spectrum is allocated, in order to reap the rewards of efficiency and innovation in spectrum use. This can best be achieved in the medium term by a two-pronged approach: the use of markets (spectrum trading and auctions) to allocate spectrum in commercial use, and the continued reservation of spectrum for public service use, coupled with an administrative charge designed to ensure economy and efficiency of its use. For the country to gain full benefit from these changes, the Government should indicate its intentions swiftly and commit itself to a programme of phased implementation.

These proposals will impose new responsibilities on those with the task of managing the UK spectrum – currently the Radiocommunications Agency and, in the future, Ofcom. Fortunately, the RA is among the foremost spectrum management organisations in the world, and I am confident that, within Ofcom, it will rise to the challenge of implementing my proposals, if the Government adopts them.

Finally, I must express my gratitude to the invaluable work of the team which assisted me with the review (named at the front of this report).

Yours faithfully



Professor Martin Cave  
February 2002



# EXECUTIVE SUMMARY

## Remit of review

1. The radio spectrum is a key resource for many new and developing technology-based industries. At the same time, it is a vital input into the delivery of many public services. The management and development of the spectrum will therefore play an important role in creating a knowledge-driven economy and society. To help ensure that the spectrum management framework is at the forefront of change, the Chancellor of the Exchequer and Secretary of State for Trade and Industry commissioned Professor Martin Cave<sup>1</sup> in March 2001 to lead an independent review of radio spectrum management.
2. The review was charged with advising on the principles that should govern spectrum management, and what more needs to be done to ensure that all users, including non-commercial users, are focused on using spectrum in the most efficient way possible. In doing so, it has considered the use of spectrum management tools such as spectrum valuation, pricing and trading.
3. In December 2000, the Government published the Communications White Paper, which set out the future for regulation in the communications sector. The proposed new unified regulator of the sector, the Office of Communications (Ofcom), will encompass a wide range of economic and content regulation, including spectrum management currently conducted by the Radiocommunications Agency. At the time of submitting this report, the Government had introduced the paving legislation to establish Ofcom as a corporate entity, but had yet to publish the substantive Communications Bill which would define in detail the powers of Ofcom. The review was charged with advising on this proposed legislation as it related to spectrum management, but not to revisit the institutional arrangements set out in the Communications White Paper.
4. In line with the remit to consult widely in order to produce a fully informed and authoritative report, the review published a wide-ranging consultation document in June 2001. This set out a preliminary exposition of the potential benefits from, and constraints on, applying economic principles more comprehensively to spectrum management in the UK. Some 80 written responses were received<sup>2</sup>, and the review held meetings with around 60 interested parties.

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<sup>1</sup> Director of Centre for Management under Regulation at Warwick Business School, formerly Vice Principal, Brunel University.

<sup>2</sup> Published on the review's website at [www.spectrumreview.radio.gov.uk](http://www.spectrumreview.radio.gov.uk).

## Purpose of review

5. The use of radio spectrum has become an integral part of society's infrastructure. For decades, viewers have taken for granted the reception of clear TV signals, travellers have relied upon assured communications and radio-location for aircraft, and all citizens have benefited from radio connectivity for the public safety services. More recently, the phenomenal growth in personal mobile communications has turned wireless access via mobile phones from a luxury to a necessity for many people.
6. This value to individuals, businesses and the public sector of access to radio spectrum is becoming increasingly recognised. Radio makes a substantial and increasing contribution to the economy. Recent studies by the Radiocommunications Agency show that even for selected sectors of the economy<sup>3</sup>, the value of radio to the economy as a whole exceeds £20 billion per annum<sup>4</sup>, over two per cent of UK output. Success in managing access to radio spectrum should thus boost the performance of the UK economy.
7. Looking forward, spectrum is an essential raw material for many of the UK's most promising industries of the future. Wherever consumers demand mobile and ubiquitous access to communications, wireless products using radio signals will provide the solution. Radio is a uniquely versatile communications medium, essential to connecting up the information society. New products and services typically complement rather than replace existing ones, so adding to the demands on the radio spectrum. Furthermore, the boundaries between new services are blurring, transcending current business models, reducing the predictability of spectrum use, and challenging current regulatory categorisations.
8. So spectrum management is becoming simultaneously more difficult and more important. But the UK is well placed to respond to this regulatory challenge. The Radiocommunications Agency has a well-deserved reputation as one of the most forward-looking and progressive spectrum managers in the world, having enabled the development of flourishing wireless services in one of the world's most congested radio environments. In recent years, it has garnered valuable experience of the new market-based tools introduced under the Wireless Telegraphy 1998. The Communications Bill and prospective unified regulator provide a further opportunity to refine the regulatory 'toolbox' and make cross-sectoral regulation more effective.
9. The review's purpose at this juncture is to look forward to the principles which should guide the Government and Ofcom in managing access to the radio spectrum in the years ahead, in order to derive most value from this national asset for the UK as a whole. The review aims to build on the UK's experience to date, which reflects a strong central regulatory approach to mandating spectrum use for particular purposes, and co-ordinating users to minimise

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<sup>3</sup> Principally mobile telephony, broadcasting, satellite, fixed links, private mobile radio, but excluding commercial aviation, defence and consumer benefits of some low power devices.

<sup>4</sup> *The Economic Impact of Radio*, A Study by the Radiocommunications Agency, February 2001.

harmful interference. But market mechanisms should play a much broader role in allocating and assigning spectrum to its best use, building on regulatory foundations which are essential for any market to work efficiently.

## Challenges facing spectrum management

10. The fundamental building blocks of regulating access to radio spectrum have remained essentially the same during the hundred-year history of radio. Spectrum blocks are **allocated**, through international agreement, to broadly defined services. National regulatory authorities then **assign** licences for use of specific frequencies within these allocations within their jurisdictions. The current UK primary legislation for spectrum management, the Wireless Telegraphy Act 1949, is largely based on the Wireless Telegraphy Act 1904.
11. This regulatory task involves an inherently complex balancing act in a range of dimensions, in each of which there are conflicting considerations:
  - **Interference.** Transmissions interfere unless sufficiently separated in terms of frequency, geography or time. Regulators must strike a balance between reducing the extent of harmful interference, through careful planning, and enabling new and potentially valuable new services to enter the market.
  - **International co-ordination.** The effective use of radio spectrum in the UK will typically require careful co-ordination with neighbouring countries, to mitigate the extent of harmful interference. The Government must weigh up the benefits of co-ordinated and harmonised use of spectrum across Europe against the constraints which this imposes on spectrum management in the UK.
  - **Investment in equipment.** Most radio equipment can operate over only a limited range of frequencies, and so relies on predictable access over time to defined frequency bands. Stability in spectrum to encourage investment in equipment can slow the pace of spectrum re-use. Increasingly, technical specifications are determined internationally to reap economies of scale in production. National regulators need to balance stability and international harmonisation with responsiveness to new technologies.
12. Developments in technology over the last century have opened up the range of useable radio spectrum, so enabling ever-greater access to new allocations and assignments. While demand from consumers, businesses and public services for wireless communications kept pace with this increased supply over much of the twentieth century, the regulatory regime has proved sufficiently flexible to cope. But with a sharp acceleration in demand in recent years, change in the market place is outpacing the ability of the national and international regulatory regime to respond.

13. Fundamentally, the spectrum manager is called upon to devise procedures to ration current and future demand for radio spectrum between competing commercial and public service users. To do so centrally would require a detailed knowledge of supply and demand trends, technology developments, and the relative value to society of alternative services. This represents a mammoth central planning task, which is now beyond the scope of any regulatory body, no matter how well staffed and managed. The central regulator is becoming less able to accumulate and assimilate sufficient information to make a correct assignment of spectrum to optimise use over time.
14. Instead, spectrum managers will tend, inevitably, to bias decisions in favour of the *status quo* for a variety of reasons:
- **Demand for spectrum.** Incumbent users, facing few if any continuous incentives to economise on spectrum use, will tend to 'over occupy' spectrum, making wasteful use of it and reducing the amount which can be assigned to new users.
  - **Interference management.** New services could potentially create additional interference to the detriment of incumbent operators. Technical studies can clarify the potential extent of interference, but judgements about results will tend to favour incumbents' interests.
  - **Demand for services.** New services will be based upon uncertain projections of future demand, against data on actual usage for current operators. The weight of regulatory evidence is likely to be in favour of the latter, particularly where new services will compete with existing ones.
15. This systemic deficiency of a central planning approach does not detract from the significant steps which the RA has taken in recent years to help meet demands for spectrum from new services. Measures taken include:
- promoting the use of more efficient trunked radio services;
  - making spectrum available for the early licensing of competing cellular mobile telephony services, and the recent licensing of Third Generation mobile services;
  - moving users of fixed radio links to less congested higher frequencies; and
  - enabling the introduction of more spectrally efficient digital technologies in mobile radio and broadcasting.

16. But it does highlight the need to complement the regulatory regime with other approaches to managing access to radio spectrum, in order to enable continued growth of radio-using services in the UK. The DTI itself identified in the mid-1990s the weaknesses and limits of the traditional approach to spectrum management in proposing the addition of market-based tools to the RA's 'toolkit'<sup>5</sup>:
- **Regulatory burden.** Attempting to tackle 'hoarding'<sup>6</sup> by increased regulation alone would be excessively burdensome and intrusive, as well as requiring substantial additional resources.
  - **Inefficiency.** Regulation is inherently inflexible and reduces choice. Users have to meet the regulatory requirements irrespective of whether or not this is economically desirable.
  - **Ineffectiveness.** Given the rapid pace of change, it is likely that relying on regulation alone would not achieve the optimal distribution of spectrum and would discourage innovation.
17. The net result is that a narrow regulatory approach can reduce the ability of spectrum users to respond adequately to changing demands and technologies. The increasing pace of change in both consumer tastes and technologies accentuates the drawbacks of the current regime. The growing role of radio-based services in the UK economy, including the provision of public services, means that undue reliance on regulation is likely to become an increasing brake on economic growth.

## Enabling productive and innovative spectrum use

18. Spectrum is a finite but non-exhaustible resource which is a vital input into an ever widening range of services. The utility of the resource depends crucially on the management of interference from competing users. This has been, and will continue to be, the primary role of the UK's national spectrum management authority. But the value derived from the economy's use of radio spectrum also depends on the ability of the system to accommodate shifting demands for spectrum use driven by market changes in technology and consumer preferences. Finally, UK society derives unquantified value from spectrum use by a wide range of public services, from defence to broadcasting, whose reasonable demands for spectrum have to be accommodated within any spectrum allocation regime.

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<sup>5</sup> *Spectrum Management: into the 21st Century*, DTI White Paper, June 1996.

<sup>6</sup> 'Hoarding' can be defined as demand in excess of current need, a rational response if spectrum access is under-priced, future needs are likely to rise, and incumbents are conferred rights.

19. These competing objectives of spectrum management can be expanded under three headings<sup>7</sup>:

#### **Spectrum management objectives**

##### **Economic efficiency**

- Market allocation of spectrum to users, and to uses, that derive higher value from the resource.
- Provide for responsiveness and flexibility to changes in markets and technologies, accommodating new services as these become technically and commercially feasible.
- Transactions costs, entry barriers and other constraints on a competitive efficient market should be minimised.

##### **Technical efficiency**

- Intensive use of scarce spectrum consistent with adherence to technical interference limits.
- Promote development and introduction of new spectrum-saving technologies where the cost of such technologies is justified by the value of the spectrum saved.

##### **Public policy**

- Consistent with Government policy towards broadcasting, competition in the telecoms market, and consumer choice.
- Safeguard interests of spectrum use for efficient functioning of defence, emergency and other public services.
- Changes to UK spectrum use should remain consistent with the UK's international and European obligations.

20. In some cases, the technically efficient solution may not be the same as the economically efficient solution. For instance, a user of spectrum may place a high value on a particular method of establishing a telecoms link between two sites even though that method happened to use more spectrum than other ways of establishing the same link. If the value it attached to the extra spectrum were higher than any other potential user then the technically less efficient solution would be the most economically efficient, i.e. it would maximise the benefits to the UK economy from spectrum use.

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<sup>7</sup> This table is derived in part from *Deregulation of the Radio Spectrum in the UK*, a report for DTI by CSP International, March 1987. The fact that, 15 years later, Government is reviewing again the balance between these objectives highlights the fundamental challenge of the spectrum management task.

21. The RA has taken significant steps in recent years to shift its emphasis towards enabling greater economic efficiency in spectrum management. Having assessed the challenges facing spectrum management in the coming years, the review considers that there is an opportunity, and an economic imperative, to move significantly further in this direction. The evidence to date, and prospectively from analysis commissioned by the review<sup>8</sup>, suggests that such a move can be made consistently with maintaining standards of technical efficiency in spectrum use, and with the delivery of a range of public policies which depend upon spectrum as an input.
22. The fundamental mechanism by which the spectrum management regime could contribute to economic growth is through ensuring that users face continuing incentives towards more productive use of this resource. The review considers that these incentives should be financial and based on the opportunity cost<sup>9</sup> of spectrum use. In this way, spectrum would be costed as any other input into the production process. Price signals about the cost of using spectrum would be disseminated throughout the economy. This information should enable dispersed economic agents to make their own judgements about their use of spectrum and the alternatives open to them to meet their organisational goals.
23. As with many other input markets, the operation of market mechanisms for spectrum will continue to take place within a framework set by regulation. The intangible nature of radio spectrum and the adverse impacts of unconstrained transmissions on others mean that a considerable degree of regulation will continue to define specific rights to spectrum use. But the review considers that there is considerable scope:
- to increase the range of spectrum users subject to financial incentives;
  - to move such incentives closer to levels at which they reflect the cost to the economy of the spectrum occupied; and
  - to increase the flexibility which spectrum users have to respond to these financial incentives.

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<sup>8</sup> *Implications of international regulation and technical considerations on market mechanisms in spectrum management*, Aegis Systems and Indepen Consulting, November 2001.

<sup>9</sup> Opportunity cost is the value of an asset or resource in the next best alternative that is foregone by virtue of its actual use.

24. The application of incentives towards economically efficient spectrum use will vary sector by sector, but can be encompassed by the review's overarching vision:

Driver	Regulatory response
<b>Rapidly changing environment</b>	<b><i>Maximum flexibility</i></b> Generic allocations, secondary trading of licences, facilitating more rapid 'refarming' from one use to another, within a transparent and predictable regulatory framework.
<b>Maximising economic benefits</b>	<b><i>Market mechanisms</i></b> Auctions and trading of licences where feasible, administratively set spectrum pricing elsewhere.
<b>Protecting social priorities</b>	<b><i>Reserved allocations</i></b> Make sufficient spectrum available by regulatory rationing for delivery of public services, apply spectrum pricing and positive incentives to share and/or release spectrum into the private sector.

25. The net result of the proposed regime should be to place more information in the hands of spectrum users about the costs of the spectrum they occupy, and more freedom to respond to this information in the choices they make about delivery of their organisational objectives. The aim is to move spectrum as far as possible towards a comprehensive competitive input market, where continuing incentives to economise drive spectrum users towards more innovative and productive use over time.
26. The benefits of this approach, building on the progress already made in this direction by the RA, will take time to emerge fully. Spectrum use is intimately tied to investment in specific technologies, and major gains in spectrum productivity and innovation are often only possible at step changes in the re-equipment cycle. Lead times between international policy decisions on allocations for new services and the development of commercially viable businesses and technologies can run to decades. Nevertheless, a consistent and comprehensive programme of reforms by the UK should start to bring tangible economic benefits over the next decade. The review sets out an indicative plan for these actions.

## International regulatory framework

### *Flexibility within international allocations*

27. The international co-ordination of radio spectrum management is an inevitable constraint on the ability of a single country to conduct an autonomous policy for spectrum use within its own jurisdiction. For the UK, as a medium-sized country in a densely populated region, this multilateral approach can bring benefits to consumers and operators. In many areas, the economic value of spectrum in the UK is driven to a great extent by



international agreements on technology development and spectrum allocations. Within this framework, though, the review considers that there remain many opportunities for the UK to take a more flexible and market-driven approach to spectrum management, while continuing to benefit from international harmonisation.

28. To assess whether the international regulatory framework could constrain application of a market-based approach, it is necessary to consider the impact of International Telecommunication Union (ITU), European Community (EC), Electronic Communications Committee (ECC) of the European Conference of Postal and Telecommunications Administrations (CEPT), and bilateral agreements and regulations. Of these, EC regulations and bi-lateral agreements are likely to be the most binding constraints, particularly when considering the scope for enabling market-driven change of use of particular spectrum bands.
29. If the band in question is subject to an EC Directive or is judged to be harmonised under the proposed Spectrum Decision, then the new use must be compliant with these regulations. This is an absolute constraint until the band(s) in question is removed from the list of harmonised bands. This seems most likely if the services in question are a commercial failure (e.g. ERMES), or become obsolete (e.g. analogue technology replaced by digital). ECC Decisions become mandatory once signed by administrations (although signing itself is optional).
30. Bilateral agreements, within the context of ITU regulations which determine which services have primacy in each band, may constrain what actually happens in practice. These are generally framed in terms of the division of frequencies used in border areas and the level of permitted emissions in preferred/non-preferred frequencies across the band and out of band. If the bandwidth of new services differs from that of existing services, then the agreed sharing pattern may not apply and the new use may face harsh emission constraints. This may prevent service deployment in border areas.
31. Studies for the review<sup>10</sup> estimate that, in frequencies around 900 MHz and above, up to 5 per cent of the UK population resides within areas where co-ordination is likely to be required for most services. The extent to which this would impact on the value of the spectrum would depend on the application and whether additional, unconstrained spectrum were available to support the service. For example, a national broadcaster or fixed wireless access operator could achieve a viable service with less than 100 per cent coverage and would be relatively unaffected by such a constraint, as would a mobile operator which used the spectrum to complement its existing GSM or 3G mobile assignment. The effect of bilateral constraints is likely to affect the UK less than some other European countries which have multiple land borders and/or significant proportions of their populations lying within co-ordination zones.

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<sup>10</sup> *Implications of international regulation and technical considerations on market mechanisms in spectrum management*, Aegis Systems and Indepen Consulting, 2001.

32. In summary, the harmonisation of spectrum use under an EC Directive or Decision and bilateral agreements will permit the application of a market-based approach, including secondary trading of spectrum licences, where this does not involve a major change of use. Where the allocated use of a band would change as a result of applying a market approach (e.g. trading, auctions) then the situation is less clear. In some cases, EC Directives could effectively prevent a change of use. Bilateral agreements place a stronger constraint in lower as compared with higher frequency bands. ITU and ECC regulations are a weaker constraint.
33. So within the current framework of international agreements, the review considers that the UK has significant freedom of action to implement a more market-based approach to spectrum management. The review's analysis of particular market mechanisms and their application to particular radio services identifies in more detail the limits of this room for manoeuvre.
34. To take advantage of this latitude within international allocations, the Government should seek to widen the range of technically feasible services which can be deployed within specific bands. This could be achieved through increasing the number of services which are designated co-primary in particular bands, subject to technical studies identifying the extent of service compatibility within and across bands. In the longer term, there may also be scope to widen the definition of these services to encompass a greater range of compatible applications.

### *Harmonisation of spectrum*

35. The review has also considered the UK policy stance towards the multilateral harmonisation of spectrum for specific uses and/or technologies. This process relies on a complex interplay between technology development, industry business planning, and national regulators. The review's general approach here, as elsewhere, is to emphasise the role of firms (operators and manufacturers) in delivering the benefits of timely and effective harmonisation, within a framework set by the regulators.
36. The review recognises that, for many services, there are enduring benefits from global or regional co-ordination of spectrum use for a variety of overlapping reasons:
- Cross-border movement of transmitters (e.g. maritime, aviation and increasingly personal mobile phones) requires that equipment operate in harmonised channels internationally.
  - Significant propagation of signals across regions (e.g. satellite services, broadcasting) and neighbouring countries require some co-ordination of transmissions.
  - Allocation of bands across regions to particular services or technologies enables manufacturers to achieve economies of scale in the production of equipment, enabling more rapid and economical rollout of new services.

Within this generally accepted framework, though, there remain many decisions about the level at which this co-ordination takes place, and how tightly it constrains individual countries.

37. The review's consultation revealed strong support, particularly among telecoms operators and equipment manufacturers, for spectrum to be harmonised to particular technologies. The global open technology standards identified with specific frequency bands enable manufacturers to focus their research and development effort, thus reducing time to market. Economies of scale from producing for multinational markets and competition between manufacturers for standardised equipment can help deliver better quality and value for end users.
38. These arguments are compelling for a wide range of wireless terminal product categories. There remain though two major policy choices:
  - Where do the costs of harmonisation, in terms of reduced innovation, regulatory delay and constraints on alternative uses, start to outweigh the potential consumer benefits of regionally standardised technology and spectrum?
  - Where harmonisation of frequency bands is economically desirable, to what extent do national governments need to mandate this approach through international regulations?
39. Both questions can only be answered definitively in specific cases by an empirical examination of the facts. But the review considers that there are generic steps which the UK Government and regulator could take to help ensure that harmonisation proposals deliver economic benefits.
40. First, where proposals are made for harmonisation at the European Community level, the UK should encourage the Commission and Member States to assess carefully the economic costs and benefits of this approach. Proposals should be tested against the European Commission's criteria for harmonisation:
  - technical spectrum efficiency: e.g. satellite broadcasting with regional footprints, requiring some degree of co-ordination across the EU;
  - single market in services: e.g. to enable international roaming for mobile telephones, it may be necessary to harmonise spectrum and technology; and
  - single market in goods: e.g. to support economies of scale, particularly in markets with high R&D costs and potentially high volume manufacture (although this factor on its own should not be over-emphasised, as it could unduly restrict competition).
41. Second, where EU Member States have agreed to harmonise spectrum to a particular service and/or technology standard, the UK should seek to ensure that harmonisation constrains the minimum number of parameters necessary to achieve the policy goals of economic and technical efficiency. Wireless

technology working in specified harmonised bands may have wide applications across a range of services, so European regulations should enable market operators to decide where and how to deploy such technology.

42. Harmonisation should also be time limited. Once it has achieved its goal of enabling manufacturers and operators to deliver a cost-effective service to the European market, other developing services and technologies should be able to contest for access to the spectrum. If, on the other hand, harmonisation fails to stimulate the development of a commercially viable market, or the market has plateaued without requiring the full anticipated spectrum allocation, then the regulatory constraint on use of the spectrum should be freed.
43. Third, where harmonisation is proposed, the technology standards developed for specified bands should be open and led by industry bodies. This should support innovation and competition in technology throughout the harmonisation process, and enhance competition in production of equipment. Governments have an important role to play in this process through the linkages and interfaces between spectrum harmonisation decisions and the associated technology standards. The UK Government stance towards particular harmonisation proposals should be focussed primarily on achieving consumer benefits through competition on price and quality. This would act as a countervailing weight to pressures from industrial players to use harmonisation processes to restrict competition.
44. Finally, any proposals for harmonisation within Europe of licensing procedures should be subject to a clear demonstration of the benefits this will bring to the single European market. Otherwise, the UK should retain autonomy over the manner in which it assigns spectrum to particular users, which will need to take account of the balance of supply and demand for particular frequencies and the state of competition in the relevant markets.

## Interference management

45. Interference is unavoidable and ever present. The impact of this ranges from simple inconvenience to individual users to, in the very extreme cases, serious commercial or safety consequences. National regulatory authorities throughout the world have, therefore, regarded it as one of their central duties to ensure both an acceptable interference environment as well as maximising the use of the spectrum.
46. In pursuing the objective of achieving a market-led approach to spectrum management, the review has made a series of recommendations which would devolve to operators considerably more freedom and flexibility over the use of licensed spectrum. But increased rights over spectrum use would need to be balanced by greater responsibility on the part of operators to participate actively in interference management. This would entail shifting the balance of responsibility for interference management, from the regulators further towards industry. Thus, decisions would be taken at the appropriate level – by those operators who are directly affected. The RA should therefore explore

fully the scope for, and means of, transferring more responsibility to operators for interference management, in support of wider moves towards using market mechanisms for spectrum management. There would be a continuing need, though, for the central regulator to monitor interference and take enforcement action against breaches of licence terms and illegal spectrum use.

47. The review considers that a key first step in this process would be the creation of a public on-line database of spectrum assignments. This frequency register should contain a core set of technical and location-based information which would form the basis for operators to carry out the necessary interference co-ordinations associated with any proposed change of use and/or trade within a given band. The RA should also, in conjunction with industry, agree a common understanding of the technical criteria for calculating interference levels.

## Legislative framework

### *Ofcom's remit and objectives*

48. The Government announced in the Communications White Paper, December 2000, the creation of Ofcom, as a new statutory, independent and unified regulator for the communications industry. The spectrum management role of the Secretary of State for Trade and Industry, operating through the RA, will become a cornerstone function of the new regulator. This role will sit alongside the other economic and content regulation functions which Ofcom will inherit from the telecoms and broadcast regulators.
49. The creation of Ofcom provides an opportunity for more effective linkages to be made between spectrum management and the other regulatory decisions affecting the provision of telecommunications and broadcasting services. The review takes this as its starting point. But the benefits of unified regulation will only be realised if Ofcom operates under clear statutory objectives, for which it is accountable. This requires the functions and duties of Ofcom, and the division of responsibilities between Ministers and Ofcom, to be spelt out clearly in the legislation.
50. The Communications White Paper proposed that Ofcom's central regulatory objectives should be:
  - protecting the interests of consumers in terms of choice, price, quality of service and value for money, in particular through promoting open and competitive markets;
  - maintaining high quality of content, a wide range of programming, and plurality of public expression; and
  - protecting the interests of citizens by maintaining accepted community standards in content, balancing freedom of speech against the need to protect against potentially offensive or harmful material, and ensuring appropriate protection of fairness and privacy.

It also proposed that in all its activities the regulator give proper weight to, amongst other factors, the promotion of efficiency, including efficient use of spectrum.

51. The review considers that spectrum management is a sufficiently distinct and important activity of Ofcom for it to be defined as a distinct objective of Ofcom. Many of the regulator's spectrum management activities will be directed towards the first of the proposed objectives, delivering consumer benefits, particularly as regards the regulation of spectrum used for telecommunications and broadcasting. In these areas, spectrum management will contribute, along with economic regulation of networks and services and content regulation of broadcasting, to Ofcom's central objectives. However, the concern of spectrum management stretches far wider than consumers of communications services, and this should be recognised and protected via a separate regulatory objective.
52. To date, the RA and Ministers have faced few statutory constraints or guides on their regulation of radio spectrum. The primary legislation<sup>11</sup> gives wide discretion to Government to license wireless apparatus as it sees fit, with a particular emphasis on allowing the rationing of licences 'for the purpose of ensuring the efficient use and management of the electro-magnetic spectrum'. The legislation which introduced market-based tools to spectrum management<sup>12</sup> gives more guidance as to the factors of supply, demand, promotion of technical efficiency and economic benefits which Government shall have particular regard to in applying such tools.
53. Ofcom will inherit these spectrum management functions and the limited constraints applying to them. To help guide Ofcom further in the delivery of this remit, the review considers that the Communications Bill should place an explicit duty on Ofcom to manage spectrum with the objective of maximising the value of benefits derived by UK society from spectrum use. This would focus Ofcom on enhancing the economic efficiency of spectrum use, where economic efficiency is broadly defined to encompass both public and private sector outputs, marketed and non-marketed services to consumers and citizens. This would put the onus on Ofcom to quantify, where feasible, these societal benefits. It would not imply reducing all Ofcom spectrum decisions to monetary cost benefit analyses of competing allocations, as it would also recognise the unquantifiable social benefits derived from spectrum use.
54. In addition to clarifying the objectives of Ofcom with regard to spectrum management, the Communications Bill should also establish clearly the dividing line between Ofcom's independence in spectrum matters and the continuing role for Ministers in giving Ofcom political direction.

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<sup>11</sup> Wireless Telegraphy Act 1949.

<sup>12</sup> Wireless Telegraphy Act 1998.

55. Many of the fundamental decisions about the allocation of spectrum across public and private sector uses are best made at the political level. Such decisions affect UK citizens in general as well as consumers of telecommunications and broadcasting services, who are the core constituency of Ofcom. Ministers are better placed than Ofcom to weigh up the competing interests of different sectors to reflect the interests of UK society as a whole. As now, the balance between defence and civil, public and private sector uses should continue to be set by the Government as a whole, operating through and advised by a Cabinet committee of officials, the UK Spectrum Strategy Committee. With the creation of Ofcom, the constitution and resourcing for this central Governmental spectrum policy group should be reviewed to ensure that it remains an effective forum within Government for balancing the competing societal demands on radio spectrum.
56. The review recognises therefore the need for Ministers to retain a strategic power of direction over Ofcom in order to reserve spectrum allocations for identified uses or users to fulfil public policy goals which may fall outside the remit of Ofcom. In practice, this could enable Ministers to protect, for example, civil aviation communications bands on public safety grounds, but not to direct Ofcom to restrict commercial spectrum for a specific service, such as broadband wireless access. The separation of Ofcom from Government would require any directions to be made by secondary legislation under the new Communications Act, providing transparency about the extent to which Ofcom was operating solely towards its statutory objectives or towards a wider Government objective which required a spectrum input.
57. But the review considers that it should not be necessary for Ministers to take further powers to direct Ofcom in the specifics of its spectrum assignment, licensing and charging activities. This could risk undermining the regulatory independence of Ofcom in carrying out its well defined remit, potentially creating uncertainty in the market about the stability and direction of spectrum regulation. It could also undermine the accountability of Ofcom for the delivery of its statutory functions and duties, reducing the incentives on the organisation to perform. As with other spheres of economic activity, the review considers that the Government should aim to bolster the independence of the statutory spectrum regulator and reduce Ministerial involvement in the detail of specific regulatory decisions.

### *Licensing tools*

58. Ofcom will inherit the apparatus licensing tool which is currently deployed by the RA under the WT Act 1949. This has proved to be a robust and flexible means of regulating legitimate access to radio spectrum and taking action against transmissions which infringe these rules. The RA has considerable freedom to specify the terms on which particular frequencies are used, which allows a single licensing regime to be tailored to a vast range of radio applications, from individual amateur radio users right up to national mobile phone operators.



59. Looking forward, there will be growing pressures on Ofcom to provide for greater flexibility in the use of spectrum in response to changing markets. The review's general proposition is that the regulator should foster and enable these developments, rather than stand in their way, and should deploy the necessary regulatory tools to do so. In this context, the review has considered the merits of introducing a new form of licensing, based upon regulating access to spectrum defined by the parameters of frequency, geography and time.
60. Licensing access, rather than apparatus, would lend itself more readily to a regime where greater freedom about the use of spectrum were devolved from the regulator to the licensed user. With the licence defined in terms of neutral parameters, designed to constrain the interference caused outside the area or frequency occupied by the licensee, the regulator (and other spectrum users) could be indifferent to transmissions within these parameters. The parameterisation of spectrum in this way would enable division and amalgamation of originally issued spectrum licences into new access licences, combining frequencies and/or coverage. This changing geometry of spectrum use is one of the anticipated benefits of spectrum trading, to which the Government is already committed.
61. The review's consultation identified strong support for spectrum access licensing, particularly in commercial telecoms bands where operators may wish to reconfigure their use of spectrum and equipment over time in face of changing market pressures. Analysis commissioned by the review<sup>13</sup> suggests that, provided the boundaries of such spectrum access licences are defined not in terms of absolute power limits, but in terms of thresholds which would trigger co-ordination between neighbouring licensees, then service-independent licensing could be introduced. This would be a complement to the current licensing approach. It is envisaged that WT Act licensing would continue where it remains necessary, for interference management or other public policy reasons, to define more closely the equipment and/or service deployed in particular bands.
62. The review therefore recommends that the Communications Bill provide a new power for Ofcom to regulate spectrum use via a complementary form of spectrum access licensing, which could be applied as an alternative to a traditional apparatus licence for certain frequency bands. This new form of licence should grant the licensee some exclusivity and protection from interference for transmission and/or reception of radio signals within specified frequencies and geographical areas.

## Market mechanisms for managing spectrum

63. Creating incentives and opportunities for users to make the most economically productive use of radio spectrum is the primary focus of this review. The review's over-arching principle is to expose all spectrum users to the opportunity cost of the spectrum which they occupy. Market-based spectrum

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<sup>13</sup> *Implications of international regulation and technical considerations on market mechanisms in spectrum management*, Aegis Systems and Indepen Consulting, 2001.



management tools, in conjunction with greater flexibility for spectrum users, are the primary means to this end.

64. In the vast majority of cases, there are realistic alternatives to the current use of particular frequencies. These alternatives may involve the provision of the same service using more spectrum-efficient technology, or the delivery of a different service using the same or different technology. The transition to alternative uses may only be viable over an extended period, and may involve regulatory action to enable such change. Nevertheless, the existence of these alternatives provides the basis for deriving an opportunity cost of spectrum, based on the full value in the best alternative use to which they could be put.

### *Financial incentives*

65. The review recommends that all classes of users should face financial incentives to economise on the spectrum they occupy. For the majority of frequency bands, where demand exceeds supply, this will entail paying a positive price to obtain access to spectrum. Where trading has been implemented, users will face the opportunity of a positive financial gain from selling access to occupied spectrum.
66. For some spectrum uses, though, the opportunity cost will be zero. This will occur where use of a particular band in the UK has been exclusively defined through international agreements and incumbents have no scope to change their spectrum use. It will also occur in licence-exempt spectrum where interference is so localised that different spectrum users impose no material constraints on each other's transmissions.
67. For other commodity inputs, current market prices generally reflect opportunity costs, because households and firms have the best knowledge of their own costs and preferences and a strong incentive to respond to market signals and put resources to their best possible use. The review's general approach is to advocate the expansion of a fully-fledged market in spectrum, through the use of auctions to make primary assignments of spectrum and the introduction of secondary trading. Where this is not feasible, either because spectrum is reserved for delivery of public services or because the frequency assignments are not suitable for trading, then the review advocates the application of administratively set incentive prices, based upon technical studies to estimate the opportunity cost of spectrum.
68. The introduction of market-based spectrum management tools is designed to help guide spectrum to those who value it highly. But for the UK to benefit from the incentives to innovation and efficiency which auctions, trading and pricing of spectrum are designed to bring, spectrum users need some latitude to respond to market signals. The international allocation process imposes some constraints, as discussed above. But the national regime for assigning licences very often imposes additional constraints which further limit flexibility. These restrictions are typically imposed to achieve other policy objectives which fall outside the remit of spectrum management. They also provide a partial substitute for market-based incentives towards spectrum efficiency.

69. The review therefore recommends, as a general approach, the reduction of restrictions on spectrum use to the greatest extent possible. This stance should be consistent with the UK's international harmonisation and co-ordination obligations, and with the maintenance of an effective interference management framework. As market mechanisms are developed further, this should allow the RA to remove licence restrictions (such as requirements for service rollout) which had been designed to mimic the incentives operating in more competitive markets.

### *Trading*

70. Spectrum trading is the most significant step towards a market-based spectrum management regime. It offers great potential benefits to spectrum users, enabling them to enter the wireless market and develop a service by purchasing access to the spectrum they need, when they need it. This in turn should bring benefits to consumers from innovation, greater choice and competition. It should also ease Ofcom's task, by devolving many complex commercial judgements to the market to resolve, and opening up telecommunications and broadcasting networks to greater competition.
71. The review strongly advocates the earliest and widest application of spectrum trading possible. Once the necessary liberalising European legislation<sup>14</sup> has been passed, and implemented in the UK, Ofcom should move purposefully and progressively towards converting those licences currently used for fully commercial purposes to tradable form.
72. For trading to bring consumer benefits, then firms must have some freedoms to combine spectrum with other inputs in innovative ways. Ofcom will therefore need to move further than the RA has in defining a generic set of rights and responsibilities for the holder of a spectrum licence. Boundaries of licences will, as ever, need to be carefully defined to help manage interference. But within such boundaries, and subject to any international harmonisation constraints, licensees should be as free as possible to determine the wireless service they provide and the technology they choose to deploy.
73. Trading should be introduced in a way which minimises transactions costs, consistent with maintaining the integrity of the spectrum management regime. This will entail giving licensees the freedom to divide and partition their licences by frequency and geography for subsequent sale. In these cases, rights and regulatory responsibilities for interference management would be sold together. Spectrum users should also be able to lease access to frequencies to others. In these cases, the original licensee would share access to frequencies while retaining responsibility to the regulator for the conduct of the licence.
74. As with other markets, trading of spectrum could potentially enable one or more operators to gain and abuse dominance in the spectrum market or in a 'downstream' market, which uses spectrum as an input. Government needs

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<sup>14</sup> The proposed Framework Directive (COM/2000/0393) for the regulation of electronic communications.

to be vigilant against such an outcome, but should deploy the same competition policy tools in spectrum trading as it does for other input markets.

75. The review recommends that the general competition regime, relying on an *ex post* analysis of the impact of spectrum trading on competition in defined markets, should be the primary safeguard. Where spectrum is an input into a market which is subject to sector-specific regulation, then the objectives of this regulatory regime may be furthered by a more interventionist approach towards spectrum trading, such as *ex ante* approval of specific trades. These arrangements should be consistent with the UK's obligations, under the EU Framework Directive, to ensure that competition is not distorted as a result of spectrum trading.
76. The role of Ofcom in this regime will be to define the initial bundle of rights and interference co-ordination requirements attached to each licence, assign this licence via auction, and then ensure compliance with these requirements, and management of the system as a whole, as the licence trades through the market. In all cases, Ofcom will need to monitor and register trades. Provided Ofcom publishes a comprehensive register of frequency assignments, enabling the market to identify changes in licensee, further reporting requirements, such as publication of transaction prices, may be unnecessary. Evidence from spectrum trading elsewhere suggests that specialist brokers can rapidly fill any information gaps.
77. To reap the benefits of trading, Ofcom should extend this opportunity to as wide a range of licences as possible, and not restrict trading to those which have been assigned initially by auction. This will entail defining more clearly the property rights of non-auctioned licences, which are renewable on an annual basis but provide significantly longer *de facto* tenure. The review recommends that Ofcom consider, band by band, how best to provide some certainty for licensees to engage in trading and some ability for Ofcom to retrieve spectrum where necessary for any future strategic replanning of frequency bands. Options include converting the terms of licences to a rolling five to ten year period, or to perpetual licences with a compulsory purchase provision for Ofcom.
78. Once spectrum trading is enabled, then licensees will face a market-determined opportunity cost of their spectrum use. They will also benefit from 'planning gain' through acquiring a more flexible, tradable licence. There is no reliable means to calculate this benefit and any *ex ante* charge for it could deter trading. So the review considers that trading rights should be granted free rather than sold.
79. Although not directly related to spectrum management, the Government may have wider concerns about windfall gains, particularly in the early years of spectrum trading, where trading rights are granted to licensees which had not purchased their spectrum via auction. One way of addressing these might be to levy a trading duty based on a proportion of the net gain from a particular spectrum trade. This, however, could involve Ofcom in complex

assessments of individual transactions, and may distort the market towards modes of leasing rather than outright trades. A less direct but simpler approach could be to maintain administratively set annual spectrum charges until licences are re-assigned via auction. As administratively set and market prices converge, this should in itself reduce the scope for windfall gains.

### *Auctions*

80. Auctions were first used for the assignment of spectrum licences in the UK in 2000 with the high profile sale for £22.5bn of five licences to use spectrum for Third Generation mobile telephones. They have been used extensively during the 1990s in a number of other countries (notably the USA), for the competitive assignment of commercial wireless licences. Auctions have also been deployed in the UK and elsewhere for the assignment of other scarce resources rationed by regulation (such as commercial broadcasting franchises and mineral extraction rights). The advantages of auctions over comparative selection by regulators are well documented and have been recently validated by the National Audit Office's report on the 3G auction.
81. The review strongly supports the use of auctions to assign spectrum licences to competing users. This should become the default means of assigning licences to exclusive frequency bands. The specific design of individual auctions should be decided on a case by case basis, taking account of competition, marketing and technical analysis.
82. Where licensees are granted tailored access to shared spectrum which is managed by the RA, such as in fixed links and certain private mobile radio bands, the RA should move progressively to converting the spectrum to auctionable form. Regional or national licences for whole bands with exclusive management rights to the relevant frequencies could then be auctioned. This would enable commercial operators to add value by combining market-driven spectrum management with other aspects of communications services.
83. The review rejects claims by opponents of auctions that the competitive bidding process will inevitably lead to a number of negative effects, including the raising of prices to consumers and the delay of deployment of services. The review endorses the NAO assessment of the 3G auction, that there is no strong evidence that consumer benefit would be reduced through higher prices or slower access to services. Rather, the review considers that its proposed combination of auctions, together with secondary trading of licences and fewer restrictions on usage, should bring benefits to companies, which will have more information and choice about spectrum supply than they do at present. Entry barriers would come down and, with a more liquid market in spectrum, the impact of any one particular auction on an operator's business plans should be less critical.

## *Pricing*

84. The RA has been in the vanguard of national regulators in applying pricing to the use of spectrum, with the aim of incentivising more efficient use over time. The review considers that this is a valuable complement to the direct market incentives for those licences which have not been assigned by auction, because they have either been reserved for the delivery of public services or assigned under the traditional 'first come, first served' basis. Given that there will continue to be large swathes of spectrum reserved for public services, the review considers that spectrum pricing would need to be maintained for the foreseeable future. As spectrum trading develops over the coming decade, Ofcom should also incorporate price information from marginal transactions in competitive markets into its own administrative pricing policies.
85. Administratively set spectrum prices are currently based upon technical assessments of the least cost practicable options for enhancing spectrum efficiency. Prices also vary according to factors such as bandwidth, coverage, degree of sharing, and geographical location. The review agrees with the fundamentals of this approach to deriving spectrum prices.
86. But the review has concerns that the price levels are currently too low in areas of high spectrum demand to create the incentives towards efficiency. When the Government originally proposed the introduction of spectrum pricing in 1996<sup>15</sup>, it decided that only half the amount of the increases suggested by the preparatory technical study should be implemented. Spectrum prices have now plateaued at this 50 per cent level. The review recommends that, following a re-evaluation of the technical parameters incorporated in the pricing model, the RA should move to full implementation of the prices thus derived. Abstracting from any changes in technology and costs since the original pricing study was undertaken, this move would lead to a near doubling of prices in the sectors and areas of high demand which are currently subject to spectrum pricing.

## Commercial spectrum use

87. The review has considered the application of market-based mechanisms to a range of commercial spectrum uses. Spectrum is not homogenous, and the propagation of signals varies considerably across the frequency range. This has direct implications for the interference management regime, including the degrees of freedom which can be granted to spectrum users. The markets for wireless services are also widely differing, with consequences for the competition regime applying to the auction and trading of spectrum licences. The review has therefore made specific recommendations sector by sector. Although broadcasting use of spectrum is increasingly commercial, it is considered separately, given the extensive regulation of free-to-air and public service broadcasting which affects spectrum management.

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<sup>15</sup> *Spectrum Management: into the 21st Century*, DTI White Paper, June 1996.

## *Public mobile telecoms*

88. The auction in early 2000 of five licences for Third Generation mobile telecommunications services has set the framework for the future of mobile telephony in the UK. In the meantime, four operators continue to exploit the spectrum licences for Second Generation mobile services, which had been assigned through comparative selection and are which are now subject to spectrum pricing. The majority of spectrum for public mobile telephony is subject to European Union or CEPT decisions harmonising the use of particular frequencies to specific technologies.
89. The review recommends that spectrum trading be introduced as soon as practicable for all public mobile telecoms spectrum. Trading could bring significant benefits, in allowing operators to tailor their spectrum licences to their own needs and enabling new entrants to obtain spectrum for innovative services using compatible technology. Change of use within these bands would initially be constrained somewhat by the European harmonisation decisions. The review recommends that the UK push for the early retirement of the GSM harmonisation directive, which has now served its purpose, to enable operators more flexibility in the range of technologies and services they deploy. Other harmonisation decisions, which have outlived their usefulness (such as the ERMES public paging directive), should also be retired.
90. New licences for commercial services should be assigned by auction, with trading rights and maximum flexibility attached to spectrum use. In the medium term, such auctions may include new licences for spectrum identified for the expansion of 3G mobile, consistent with the Government's regulatory commitments given in the context of the 3G auction. Where licences had previously been assigned by comparative selection and are now subject to spectrum pricing, they should be converted to tradeable form, with greater flexibility on spectrum use. If the Government is concerned about windfall gains accruing to licensees, then Ofcom could levy a duty on a proportion of the net gains from spectrum trades, or continue to impose spectrum prices.

## *Licence-exempt spectrum use*

91. Many users of spectrum are exempt from individual licensing. In the case of user terminals (such as mobile telephones or televisions), this is because spectrum use is controlled by the licence granted to the system operator. The other broad category of licence-exempt spectrum uses are those where the propagation of radio signals (defined by the permitted power levels and technology standards for the band) is so localised that they do not materially interfere with other spectrum users. In other words, the costs of regulating via licensing outweigh the potential benefits. These uses are typically confined to bands which are dedicated to licence-exempt use, often those which had originally been designated for industrial, scientific and medical uses.
92. Use of licence-exempt spectrum is on a 'non-interference, non-protected basis'. Users of such deregulated spectrum must not cause interference to other authorised spectrum users, nor can they claim protection from

interference from such services. With short-range propagation and few devices in any given location, the risk of interference caused by such low power licence-exempt spectrum use has historically been relatively low. At the same time, the absence of regulations covering receivers' standards has meant that in some cases equipment can be very vulnerable to interference from other services. Technology now offers the prospect of increasing the intensity of spectrum use in these unregulated bands through the use of systems which are automatically self-protecting and 'polite'. These avoid interference coming into the band and minimise transmitting over other signals within the band.

93. Licence-exempt spectrum provides an alternative paradigm to regulating for economically efficient spectrum use. Instead of minimising harmful interference through exclusive access to spectrum, the regulator enables multiple re-use of the same spectrum space by limiting the geographical coverage of transmissions. This provides significant flexibility for users, which in turn creates demand for innovative applications of radio technology within these bands. Technology developments are increasingly enabling more valuable broadband applications to be delivered across licence-exempt spectrum.
94. The review recognises the significant consumer benefits which this highly innovative and increasingly ubiquitous use of spectrum can bring. The potential drawbacks of this regulatory approach are that the quality of transmissions cannot be guaranteed, and the utility of the spectrum may ultimately be degraded through excessive use. The review considers, though, that a combination of market forces and regulation is capable of resolving these challenges:
  - Users will decide between licence-exempt and licensed spectrum use, depending on the quality of service they require.
  - Interference from local congestion is often internal to a user's premises and can therefore be regulated by that user.
  - Ultimately, if particular bands show signs of becoming congested, then manufacturers can improve the resilience of radio equipment to interference and regulators can restrict the propagation of signals through power limits.
95. The review therefore considers that further liberalisation of use of licence-exempt bands, by opening up such spectrum to a range of technologies and services, is likely to deliver significant consumer benefits. In particular, the review recommends that the current constraint on the use of licence-exempt bands for the provision of public access communications services (as opposed to private use) be removed.

### *Private mobile radio*

96. Private mobile radio is a complex licence sector, with over 55,000 licensees across the UK including a large number of emergency service and other public safety operators. The RA currently issues a wide variety of licences tailored to



the spectrum use defined under the licence. Frequency planning is primarily managed by the RA, to enable a large number of localised users to share a single national channel. Demand for spectrum in this sector is rationed by the RA, through the application of spectrum prices and the careful assignment of licences. For some bands, spectrum management is devolved to organisations catering for the radio needs of defined groups (such as the utilities).

97. This central planning approach in a changing market environment inevitably gives rise to inefficiencies and rigidities, with the result that spectrum may be trapped in inefficient uses, exacerbating perceived shortages. The review recommends a much greater role for the market in future in helping manage access to spectrum currently reserved for private mobile radio.
98. As a first step towards allowing the market to determine spectrum use, the review recommends that restrictions in licences unrelated to interference management are removed and licences be converted to tradeable form. With the publication of a frequency assignment database, these steps should enable a market to develop in spectrum currently allocated to private mobile radio.
99. In the longer term, the review recommends that a significant amount of the RA's current frequency planning role be devolved to commercial spectrum management organisations. Evidence of increased intensity and flexibility of spectrum use in bands managed by such organisations suggests that there could be significant economic gains from extending this approach. The review recommends that Ofcom assign via auction a number of competing national band managers for a range of private mobile radio bands, in parallel with Ofcom's continued management of the rest of the private mobile radio spectrum. Incumbent licensees within such bands would retain their existing rights to spectrum use, and would become lessees of the commercial band manager. If successful in enabling innovative and intensive use of congested frequencies, this approach could ultimately be extended across the majority of private mobile radio spectrum.

### *Fixed terrestrial services*

100. The RA currently makes individual assignments for fixed terrestrial point-to-point links, and for uplink transmissions by fixed satellite earth stations within the same bands. It also assigns exclusive geographical area licences for fixed wireless access, such as the recent and ongoing auction for regional 28 GHz licences for broadband services.
101. For those fixed links bands which remain under RA/Ofcom management, the review recommends the continued application of spectrum pricing, on a technology-neutral basis and at the full opportunity cost level. Trading of individual fixed links should also be introduced, to enable operators to reconfigure their networks.
102. To enable commercial operators to make best economic use of the spectrum, the review recommends that fixed wireless access operators should also be



able to deploy fixed links within the geographic and frequency bounds of their licence. This could be for their own use, or they could lease spectrum access to third parties (once spectrum trading has been introduced). Interference management within and at the boundaries of the licence would remain the responsibility of the licensee, subject to co-ordination requirements embedded within the licence.

103. This would remove the exclusive reservation of certain bands for the rollout of broadband wireless access. The review judges that providing operators with extra flexibility in use and trading of the spectrum should enable the deployment of a range complementary broadband access and other fixed wireless technologies. This approach would enable operators to respond directly to the changing market demands for broadband and other telecommunications services.
104. The review recommends that a number of fixed links bands should, over time, be converted from RA management into area licences for firms to use, trade or lease access as they see fit (within the technical parameters of the licence). Commercial operators would have greater scope, information and incentives than any regulator to make intensive economic use of the spectrum. With the introduction of spectrum trading, the licence holder would have the regulatory freedom and commercial incentives to deploy a variety of fixed wireless infrastructure links or broadband access systems, or to trade or lease access to others to do so. This approach has been successfully adopted in US with the auction of spectrum at 39 GHz for microwave services and at 4.7 GHz for so called General Wireless Communications Services. This could best be trialled in the UK by auctioning a number of national licences in spectrum which has yet to be exploited (such as at 32 GHz).

### *Satellite services*

105. Access to spectrum for transmissions to and from satellites is subject to extensive international planning and co-ordination. There may therefore be limited opportunity to improve on the use of spectrum within the UK by satellite systems through the use of market-based spectrum management tools. In particular, given that satellite frequencies are tied to specific satellite systems, often for the delivery of international services, then it is unlikely that trading of such frequencies within the UK's jurisdiction would be feasible. There should, however, be scope to clarify the spectrum access rights and responsibilities of satellite systems for their operation in the UK, and to ensure that they face the opportunity cost of the UK spectrum which they occupy.
106. The RA currently licenses uplink transmissions from UK-based equipment. Traditionally this has been limited to a relatively small number of permanent earth stations. There is now increasing demand for spectrum for mobile transmitters (so called satellite interactive and user terminals). Where fixed satellite uplinks share the same RA-managed bands as terrestrial services, their presence constrains the deployment of these services. The review therefore supports the application of full opportunity cost pricing for these transmissions.

107. Where satellite downlinks operate in their own exclusive bands, there is no spectrum scarcity. The same frequencies can be reused by many satellites in different orbital slots. As such, there is no need or basis for the UK regulator to apply spectrum pricing.
108. Mobile and interactive satellite terminals present a greater spectrum management challenge in sharing bands with terrestrial systems. To date, the RA has restricted, through regulatory means, deployment of fixed links in some bands to protect reception in the UK of satellite signals. The review recommends that Ofcom use new powers to license spectrum access, regardless of the location of the transmitting equipment, to provide greater clarity for operators of satellite systems as to the spectrum they can use for reception in the UK. This would help define the interference protection afforded to satellite and terrestrial systems respectively operating in the same bands. It could be applied to both space to earth and earth to space segments of a satellite system. To the extent that satellite systems constrain the deployment of fixed terrestrial systems, such as communication links and wireless access, operating in the same bands, then Ofcom should impose a spectrum price on satellite system spectrum use, based on the opportunity cost of the spectrum in alternative terrestrial use.

## Public services

109. Public services consume significant swathes of valuable spectrum for the delivery of primarily non-marketed outputs. For example, terrestrial TV broadcasting occupies 40 per cent of the spectrum below 1 GHz, while defence users are allocated nearly 50 per cent of bands in the range 3-10 GHz as well as extensive frequencies elsewhere. It is vital for the productivity of the economy as a whole that such public services face strong and enduring incentives to economise on the spectrum needed to deliver their public service outputs. Without such incentives, there is a growing risk that spectrum hoarding by the public sector will constrain the growth of private enterprise.
110. The review recognises that there will remain a number of public services for which spectrum is a vital input and for which, in the absence of a fully fledged spectrum market, the current regime of reserving sufficient frequency bands for the delivery of these services should continue through the medium term. In the longer term, as spectrum trading develops, the Government should look to expose more public services' spectrum use to this market mechanism. In the interim, therefore, the primary means of encouraging spectrum efficiency should be administratively set spectrum pricing, based on the opportunity cost of spectrum occupied. The review recommends that all public services should be subject to this regime, which should provide durable incentives where necessary to economise on spectrum consumption. As noted above, though, for some spectrum, the opportunity cost may be zero as a result of international agreement on the use of the band which gives the UK negligible scope to make alternative use of the spectrum.
111. The executive summary highlights the application of this approach for a number of major public service spectrum users: defence, broadcasting, and

aeronautical and maritime. The review's report also assesses and makes recommendations covering spectrum use for public safety and science services.

## *Defence*

112. The Ministry of Defence occupies a privileged position as the largest single user of radio spectrum in the UK. It has *de facto* management rights over its bands, and with the RA co-chairs the cross-Government UK Spectrum Strategy Committee which decides on national allocation policy. Historically, the MOD has released a number of valuable bands for civil use (for example, the spectrum used for First Generation mobile telephony). More recently, since 1999 MOD has also faced spectrum prices for those bands which it manages where the comparable civil users are charged. It currently pays some £23m per year for the majority of its mobile radio and fixed links bands.
113. The review welcomes the application of financial incentives to MOD's spectrum use. This is starting to affect decision-making about rationalising defence needs and release of spectrum for civil use. But major improvements in spectrum utilisation will only be realised through consistent impact of spectrum pricing on long term decisions about equipment design, procurement and deployment. It should also be recognised that with military requirements for real-time information in 'battlespace' and training situations rising, then the MOD's internal demand for spectrum, even when priced, will often contend with commercial pressures on the spectrum.
114. The review recommends that the financial incentives on MOD's spectrum use should be strengthened and widened. Following the recommended revalidation of the opportunity cost calculation of spectrum prices, those mobile and fixed links bands which are currently subject to pricing should be charged at the full opportunity cost level. In addition, MOD's use of spectrum for ground-based radar in the UK should also be subject to spectrum pricing, in line with the review's recommendations for the civil aeronautical and maritime sectors.
115. This recommendation could see MOD's annual spectrum charge rise to over £100m (depending crucially on the basis for charging for radar spectrum use). Although this would still be less than one half of one per cent of MOD's total annual budget, the review recommends that the Treasury take account of the proposed additional charge on MOD's programme expenditure in future public spending reviews. It also recommends that the Treasury enable the MOD to respond more flexibly to financial pressure on spectrum use. MOD should have the scope to propose the acceleration of equipment expenditure, within agreed long term totals, where this 'spend to save' can be demonstrated to lead to faster release of spectrum for civil use.
116. Where bands are retained for military use but are not fully utilised, MOD should also face positive financial incentives to sharing access to their spectrum with commercial users. Within an agreed public spending framework, and consistent with the Wider Markets Initiative to encourage

departments to enable commercial use of public assets, MOD should retain revenues from leasing access to spectrum.

117. To encourage more informed assessment within Government and in the wider economy about current and future military spectrum demands, and the scope for spectrum release and/or sharing, the review recommends greater information disclosure by MOD. The review welcomes steps in this direction, such as the publication of the military spectrum strategy. Subject to the protection of national security interests, the review recommends that MOD release more detailed information to RA/Ofcom about its prospective spectrum utilisation, and that it makes sufficient information available to commercial operators to enable them to assess the scope for spectrum sharing in MOD bands.

### *Broadcasting*

118. The review agrees with the Government's commitment in the Communications White Paper<sup>16</sup> that broadcasters, like other major users of spectrum, must use spectrum efficiently, and there should be effective mechanisms to ensure this. Regulation will continue to play a major role in planning the terrestrial transmission of broadcasting services, given the continuing policy interest in the delivery of public service broadcasting objectives (concerning positive content obligations, free-to-air services, and universal service coverage). But the review is concerned that, in the absence of spectrum pricing across the broadcasting sector, major decisions affecting economically significant spectrum would not properly reflect the opportunity cost of the spectrum asset denied to other users. This is particularly relevant in the approach to digital switchover, which presents a strategic opportunity to improve significantly the spectrum efficiency of broadcasting, and release valuable resources to the rest of the economy.
119. The Government's key strategic broadcasting goal is that public service broadcasts should be available to everyone, as now, free at the point of consumption. As alternative delivery platforms (cable and satellite) become more popular, the need for reserved and restricted spectrum for one particular platform (terrestrial transmission) becomes less of a fundamental input for the delivery of public service or commercial broadcasting. Conversely, the convergence of communications services and technologies increases the demand for spectrum which can be used flexibly to deliver a range of wireless broadcast, voice and data services in fixed and mobile environments. So restrictions imposed on spectrum for broadcasting policy reasons become less necessary just as they become more costly in terms of opportunities foregone.
120. In order to ensure such restrictions are no more onerous than is necessary, the review believes the Government should be fully aware of the economic costs, alongside the benefits, of its broadcasting policy as far as it affects the use and availability of spectrum. In the interests of full transparency, the size of these costs should be in the public domain.

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<sup>16</sup> *A New Future for Communications*, DTI/DCMS White Paper, December 2000.

121. In the longer term, the review considers that Government could, and should, aim to separate the delivery of its broadcasting goals from the management of the spectrum inputs to broadcasting. This would entail a less restrictive and exclusive approach to licensing spectrum, with greater application of market incentives on the use to which broadcast spectrum is put. Broadcasting regulation could continue to define positive content requirements, but may over time become more flexible as to delivery platforms.
122. Achieving this structure could take over a decade. It will depend crucially on how the markets for cable, terrestrial and satellite broadcasting evolve over time. It may also require major changes in the way terrestrial TV spectrum is allocated and co-ordinated at an international level. The review's recommendations therefore focus on a number of medium term measures which could be taken, consistent with this long-term goal.
123. Focusing on terrestrial TV transmissions, the review recognises the current particular circumstances of broadcasting, including the substantial payments already made under the Broadcasting Acts by commercial broadcasters, the level of public service obligations undertaken by the broadcasters, and the forthcoming switchover to digital broadcasting. The review's recommendations are designed to take account of the various regulatory agreements between Government, broadcasting regulators and individual broadcasters. They also recognise the particular circumstances of public sector broadcasters (the BBC and Channel 4), and those of private sector and investor-owned broadcasters. They are also aimed at supporting the Government's objective of achieving digital switchover in the coming decade.
124. The review recommends that spectrum pricing should be applied over the coming decade to all spectrum which is used for broadcasting. The level of prices would be determined by the RA/Ofcom using the methodology outlined by the RA's original spectrum pricing study<sup>17</sup> and would be based on the opportunity cost of spectrum use. Broadcasters should have greater flexibility over the type of transmissions made over spectrum licensed to them, and greater scope to lease spectrum to other users where it is not fully utilised for broadcasting services. Ofcom should also have greater oversight of the BBC's spectrum use. The implementation and timing of this approach will vary according to the regulatory regime affecting each broadcaster, recognising that some broadcasters, including Channel 3 licensees and Channel 5, have acquired the use of spectrum through a competitive financial bidding process.
125. Both the BBC and Channel Four have argued strenuously that the universal coverage requirements imposed by the Government mean that they have no discretion on the amount of spectrum which they use; as a consequence, there would be no efficiency gains from imposing a spectrum charge on them. The review has considered this argument carefully, but considers that spectrum charges on these broadcasters are justified. The review believes that,

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<sup>17</sup> *Study into the Use of Spectrum Pricing*, by NERA and Smith System Engineering Ltd, published by the Radiocommunications Agency, June 1996.

notwithstanding current constraints, spectrum pricing can play a role in encouraging more efficient spectrum use by public sector broadcasters. For example, with digital switchover in prospect, the broadcasters can take action which helps create the conditions for switchover. The Government's Digital Television Action Plan highlights a range of spectrum planning and market preparation activities for the broadcasters to help achieve this overall goal. Also, the review recognises that most users of spectrum for public services are constrained to some extent by a combination of their past investment decisions and their obligation to provide services. In the longer term, it is likely that these constraints will either be relaxed or changed. In order to gain efficiency benefits, it is essential that decisions begin to be taken now on the expectation of future spectrum charges.

126. The review believes that the timing of any pricing regime should take into account the Government's current agreements with the BBC and Channel 4 with regards to financing and delivery of public service broadcasting. Channel Four has such a regulatory contract through a Broadcasting Act licence which expires at the beginning of 2003, whereas the BBC's current Charter and Agreement run until 2006. Spectrum pricing should not be applied before the renewal of these respective regulatory agreements, at the earliest. Spectrum pricing should also take into account the Government's wider commitment to promote and support the take-up of digital TV, for example through some abatement of spectrum prices for digital transmissions.
127. The review considers that commercial independent analogue TV licensees have already paid for their analogue spectrum via their initial bids and ongoing franchise fees for Broadcasting Act licences which allow them to use terrestrial TV spectrum. When these licences are renewed, the review recommends that Ofcom levy a separate administratively set price for the broadcasters' analogue TV spectrum. This would be separate from the mechanism used by Ofcom to assign and charge for broadcasting rights – although the existence of a spectrum charge would clearly influence the value of those rights. In the meantime, Channel 3 licensees will continue to benefit from the so-called 'digital dividend' which provides a partial incentive towards spectrum efficiency by reducing the franchise fees paid in line with the rise in digital take-up.
128. Digital terrestrial TV (DTT) is currently provided through six multiplexes. Each multiplex occupies the frequency of a single analogue channel but can deliver at least six broadcast services. The BBC multiplex operates under its Charter and Agreement, while the five other multiplexes operate under Broadcasting Act licences awarded in 1997 or 1998, for 12 years, with an option to renew for a further 12 years. At the time of the award, the Government committed to a zero-rated levy on the revenues from the commercial multiplexes up to their renewal point, in order to stimulate the development of digital terrestrial TV.

129. The review recognises the benefit of this approach towards DTT in the early years of its development, as a pragmatic means of encouraging investment which could lead to substantial spectrum efficiencies to the benefit of the whole economy. But in the longer term, the review considers that users of spectrum for DTT should face ongoing financial incentives to spectrum efficiency. The review therefore recommends that for the non-BBC DTT multiplexes, Ofcom should levy a spectrum price from the renewal of such licences, scheduled for 2009 or 2010. This cost should be taken into account in setting broadcasting licence fees.
130. This timing is consistent with the plans for digital switchover. Commitment now to future pricing should help broadcasters and their transmission operators to respond in an informed manner to the Government's current consultation on the principles for DTT spectrum planning. In this context, the review recommends that the Government undertake a full cost-benefit analysis of the options for spectrum currently used for analogue TV transmissions. This analysis would take into account estimates of consumer and producer benefits from broadcasting and from alternative uses of the spectrum released by switchover. Subject to this, and in line with the review's general approach towards flexibility in spectrum use, the review also recommends that Government should seek to maximise the amount of spectrum available for re-use following switchover. As a corollary, it should, subject to an assessment of economic and social costs, minimise the spectrum reserved for the delivery of defined public service broadcasting outputs.
131. Spectrum pricing should also be applied to radio broadcasting in order to increase spectrum efficiency. The BBC's digital radio multiplex could thus have a charge, based on the opportunity cost of spectrum use, applied from 2006 onwards. Payment of an opportunity cost price for spectrum should also become a pre-condition for renewal of commercial analogue radio and digital radio multiplex licences. New licensees would also be charged an explicit fee for the opportunity cost of the spectrum used. In areas where demand for spectrum was low in relation to supply, the opportunity cost would be commensurately low.
132. In addition to the major step of digital switchover, there is scope to improve the utilisation of broadcasting spectrum at the margin by providing broadcasters greater freedom to carry a wider range of non-broadcasting services. On both analogue and digital transmissions, there is technically room to transmit data (using broadcast technology standards and within the constraints of international co-ordination). The review recommends that the regulatory and financial constraints on such developments be reduced. The current limits on non-broadcast services carried by digital TV and radio multiplexes should be removed, subject to the condition that licensees continue to meet any public service broadcasting obligations. The review also recommends that the Government clarify the BBC's ability, under its Charter, to develop revenue-generating non-broadcast services for transmission on its spectrum, again subject to fulfilment of its primary public service mission.



133. This package of measures will ensure that all broadcasters face financial incentives and opportunities to economise, over time, on spectrum, notably by moving to more efficient transmission technologies. At the same time, it starts to widen the use to which spectrum allocated to broadcasting can be used, enabling market development of digital information services. It should also enable the gradual separation of broadcasting policy objectives from spectrum management, which should bring wider economic benefits while protecting the economic and social benefits of public service broadcasting.

### *Aeronautical and maritime*

134. The Civil Aviation Authority and the Maritime and Coastguard Agency make extensive use of spectrum reserved for radiolocation, navigation and communications for vessels within UK territory. Marine and aeronautical radars, for example, occupy some 30 per cent of the spectrum in the range 1-3 GHz. Given the global mobility of on-board communications and radar equipment, much spectrum use and associated technology standards in these sectors are subject to extensive and detailed international harmonisation.
135. The review has explored the scope, within these constraints, of incentivising greater spectrum efficiency within the UK through the application of market-mechanisms. It concludes that the application of administratively set spectrum prices would assist in delivering the best utilisation of spectrum reserved for aeronautical and maritime uses. Auctions and secondary trading are unlikely to be feasible in these sectors.
136. In particular, pricing should apply to the use of spectrum by UK ground-based radars, where UK operators subject to pricing have some discretion, over time, to optimise their portfolio of radars and other location devices, in light of the cost of equipment and spectrum. The review recommends that, in light of the current study for RA of the UK's civil radar deployment and the technical scope for reducing spectrum consumption, the RA develop a pricing regime, in conjunction with CAA and MCA, for the spectrum used by UK-based radionavigation and radiolocation equipment. In the aeronautical sector, the spectrum charge (which is unlikely to be significant relative to total aviation costs) would be borne initially by NATS and major airport operators, such as BAA. This may necessitate a phased introduction of spectrum pricing around the middle of the decade, aligned with the CAA's periodic reviews of regulation on BAA and NATS.
137. For spectrum reserved for on-board navigation and communications systems, the review considers that the opportunity cost to individual users is, in most cases, effectively zero, since use of this spectrum is mandated internationally, and users are required to adopt specific technologies. The review recommends, though, that where UK-based users face some technology choice for their on-board systems, that the CAA and MCA consider applying differential licence fees to encourage moves to narrower band, more spectrally efficient equipment, thus easing congestion over time.



## Implementation

138. Reforming the practice of spectrum management based on the principles and recommendations set out by the review will be a long term endeavour, requiring concerted action on a number of fronts. The review's proposals entail a major programme of regulatory reform over the coming decade. Many recommendations build on actions which are already in train by the RA, but which would require a change of emphasis and priority from the Agency. Others would fall within the remit of Ofcom, operating with wider powers and scope, or would be orchestrated by Ofcom in conjunction with other public sector spectrum users. A further set of proposals would require shifts in policy and practice by other Government departments involved in spectrum management.
139. The review has therefore mapped out a potential timetable of steps to be taken by Government and Ofcom over the next decade, to provide an indication of timing of the reforms proposed. The most important new reform, which should be given priority in forthcoming European and national communications legislation and in regulatory effort by RA/Ofcom, is the introduction of spectrum trading. This should be augmented by the application of stronger financial incentives on major public service users to economise on spectrum use. The review anticipates that the combination of these actions should lead to significantly greater innovation and productivity in spectrum use by the latter half of this decade.
140. As the Ofcom Regulators' Steering Group has already identified<sup>18</sup>, in the long run the move to spectrum trading would lead to a reduction in work associated with designing, pricing and monitoring some spectrum licences. Some new work, particularly the introduction of spectrum trading, is likely to lead to an increase in activity in the short to medium term. The implementation of the review's recommended approach to spectrum management would amplify these conclusions.
141. It is difficult at this stage to judge the consequences of the long-term decline in work for the regulator in terms of the reduction in staff employed on spectrum management policy and implementation. Net reductions in staffing might be achieved during the second half of this decade, after the licensing of 3G expansion bands, the realignment of private mobile radio bands, progress towards digital TV switchover, and early experience of spectrum trading.

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<sup>18</sup> OFCOM SCOPING PROJECT, Towers Perrin report to Regulators' Steering Group, October 2001.



# RECOMMENDATIONS

## International regulatory framework

- 4.1 The Government should, wherever technically and operationally feasible, facilitate greater flexibility in the use of a given frequency band. This can be achieved by a broader interpretation of the internationally agreed radio communications service definitions, or by adding additional services to a given frequency band through negotiations at ITU and CEPT level.
- 4.2 Where proposals are made for harmonisation at the European Community level, the UK should encourage the Commission and Member States to assess carefully the economic costs and benefits of this approach. Proposals should be tested against the European Commission's technical and single market criteria for harmonisation.
- 4.3 Where the UK agrees with a collective European decision to harmonise spectrum to a particular service and/or technology standard, it should seek to ensure that harmonisation constrains the minimum number of parameters necessary to achieve the policy goals of economic and technical efficiency. In the medium term, this implies moving towards harmonisation of broad service categories (e.g. mobile, fixed, etc) within defined bands, rather than specific technology descriptions (such as DECT, UMTS etc). This should provide the future spectrum certainty necessary for large-scale research and development investments, while allowing scope for technology competition and innovation.
- 4.4 Harmonisation should be time limited and subject to periodic review. Once it has achieved its goal of enabling manufacturers and operators to deliver a cost-effective service to the European market, other developing services and technologies should be able to contest for access to the spectrum. If, on the other hand, harmonisation fails to stimulate the development of a commercially viable market, or the market has plateaued without requiring the full anticipated spectrum allocation, then the regulatory constraint on use of the spectrum should be freed.
- 4.5 Where harmonisation is proposed, the technology standards developed for specified bands should be open and led by industry bodies. This should support innovation and competition in technology throughout the harmonisation process, and enhance competition in production of equipment.
- 4.6 Any proposals for harmonisation within Europe of licensing procedures should be subject to a clear demonstration of the benefits this would bring to the single European market. Otherwise, the UK should retain autonomy over the manner in which it assigns spectrum to particular users, which will need to take account of the balance of supply and demand for particular frequencies and the state of competition in the relevant markets.

## Interference management

- 5.1 The RA should explore fully the scope for, and means of, transferring more responsibility to operators for interference management, in support of wider moves towards using market mechanisms for spectrum management.
- 5.2 The RA should seek to implement an on-line frequency register covering all the civil radiocommunications bands and the radio systems utilising them. The frequency register should contain a core set of technical and location-based information which would form the basis for operators to carry out the necessary interference co-ordinations associated with any proposed change of use and/or trade within a given band. The RA should also, in conjunction with industry, agree a common understanding of the technical criteria for calculating interference levels.

## Legislative framework

- 6.1 Ofcom should operate under a distinct spectrum management duty, which should provide an ongoing requirement on the regulator to maximise the value of benefits derived by UK society from spectrum use. One potential formulation for such a duty would be: 'to maximise, by ensuring the efficient allocation and use of the spectrum, the overall value derived by society from using the radiofrequency spectrum'.
- 6.2 With the transfer of spectrum management functions from the RA to Ofcom, the constitution and resourcing of the Cabinet Office UK Spectrum Strategy Committee should be reviewed to ensure that it can continue to balance the competing requirements of civil and military, public and private sector spectrum users.
- 6.3 The Government should limit its powers to intervene in the details of spectrum licensing. Ministers should retain powers to intervene with Ofcom over the distribution of radio spectrum, in order to make essentially political judgements about: the allocation of spectrum between different classes of use; and the reservation of spectrum for specified uses (such as defence) or for specified users (such as the BBC to enable it to meet its current universal terrestrial coverage requirement). Ministers should also retain a power to specify other public policy objectives and criteria which Ofcom should take into account in regulating spectrum access. Such powers should be clearly defined, transparent and limited in scope, in order not to compromise Ofcom's responsibilities for efficient spectrum management. Ministers should refrain from taking powers to direct Ofcom in the specifics of spectrum management tools, such as assignment methods, auction design, administrative incentive pricing, and exemptions from licensing.

- 6.4 The Government should introduce, in the Communications Bill, a power for Ofcom to regulate spectrum use via a complementary form of *spectrum access licensing*, which could be applied as an alternative to a traditional apparatus licence for certain frequency bands. This new form of licence should grant the licensee some exclusivity and protection from interference for transmission and/or reception of radio signals within specified frequencies and geographical areas. *Spectrum access licences* should be capable of being cast in neutral terms with respect to the type and coverage of the service deployed in the band and the technology used.

## Market mechanisms for managing spectrum

- 7.1 All classes of users should face incentives to economise on the spectrum they occupy. For the majority of frequency bands, where demand exceeds supply, this will entail paying a positive price to obtain access to spectrum, provided there are potential alternative users or uses of a block of spectrum (i.e. the opportunity cost is greater than zero).
- 7.2 The RA should aim to minimise the licence conditions to those necessary for efficient spectrum use. Existing licences should be amended to remove restrictions which are not needed for reasons of international co-ordination or interference management, and new licences should be issued with the minimum number of restrictions possible.
- 7.3 Spectrum trading should be implemented in the UK as soon as possible. The trading regime should be designed to minimise the transactions costs of trading, and it should allow operators to change the use of traded spectrum within international allocations and the national interference management framework.
- 7.4 The general competition regime, relying on an *ex post* analysis of the impact of spectrum trading in defined markets, should be the primary safeguard against any anti-competitive behaviour. Where spectrum is an input into a market which is subject to sector-specific regulation, then the objectives of this regulatory regime may be furthered by a more interventionist approach towards spectrum trading, such as *ex ante* approval of specific trades. In all cases, Ofcom will need to monitor and register trades.
- 7.5 There should be greater legal clarity than at present about the tenure of incumbent licensees. Ofcom should consider, band by band, how best to provide some certainty for licensees to engage in trading, together with some ability for Ofcom to retrieve spectrum where necessary for any future strategic replanning of frequency bands. Options include converting the terms of licences to a rolling five to ten year period, or to perpetual licences with a compulsory purchase provision for Ofcom.

- 7.6 Trading rights should be extended to extant commercial licences regardless of the method of original assignment (auction, comparative selection, or 'first come, first served'). These rights should be granted for free. The Government should assess the case for levying a duty on net gains from spectrum trades and/or continuing with spectrum pricing for tradable licences, against its objectives of encouraging efficient use of spectrum and achieving full economic value for consumers, industry and the taxpayer.
- 7.7 Auctions should become the default means of assigning spectrum licences between competing users, to achieve an efficient market-driven outcome.
- 7.8 Where licensees are currently granted tailored access to shared spectrum which is managed by the RA, such as in fixed links and certain private mobile radio bands, the RA should move progressively to converting the spectrum to auctionable geographic licence blocks. Competing commercial licensees would then manage access for their own and/or third party use of this spectrum.
- 7.9 Spectrum pricing should be applied at more realistic levels and more comprehensively across spectrum uses. Where spectrum pricing has already been implemented, and where there is evidence of continuing shortage of spectrum, then incentive prices should be set at the full opportunity cost level, rather than at the current 50 per cent of the levels derived from pricing models, which should themselves be subject to regular review.

## Commercial spectrum use

- 8.1 **Public telecoms:** Auctions should be used to assign spectrum available for public telecoms use. Where spectrum pricing is currently used, prices should be raised to the full opportunity cost levels. Once spectrum trading is introduced, public telecoms operators should be able to trade spectrum subject to international constraints.
- 8.2 **Licence-exempt spectrum use:** The current constraint on the use of licence-exempt bands for the provision of public access communications services should be removed as soon as possible.
- 8.3 **Private mobile radio:** Current restrictions on the use of PMR bands should be removed, and PMR licences should be made tradable. Area licences should be auctioned in a number of different bands. This approach could, if successful, be extended across the majority of PMR spectrum.
- 8.4 **Fixed terrestrial services:** Current restrictions on the use of fixed wireless access bands should be removed so as to allow the deployment of any fixed service. Licences should also be converted to allow spectrum trading. The 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.

- 8.5 **Satellite systems:** 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 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.

## Public services:

### Defence

- 10.1 The RA should publish the (unclassified) UK Peacetime Frequency Allocation Table, identifying which bands are under MOD management.
- 10.2 MOD should invest in a comprehensive audit of all frequency assignments, including patterns of usage by time and location, in order to inform its own tactical and strategic management of the military spectrum asset. This data should be periodically updated, and should be disclosed to RA to improve RA's own visibility and understanding of military spectrum use. 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.
- 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 interference management requirements for military systems, to enable commercial operators to judge the viability of sharing such spectrum on a subordinate basis.
- 10.4 The value of UK spectrum effectively given over to NATO for management should be more clearly and publicly identified, through disclosure of an annual 'shadow' charge which would apply if the bands were MOD-managed.
- 10.5 MOD should bear the full opportunity cost of spectrum which is currently subject to incentive pricing (fixed and mobile bands subject to MOD management), 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. New spectrum charges should be introduced for MOD as soon as practically possible after the preparatory technical studies to determine the standard tariff units.
- 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.

- 10.7 The MOD should consider making specific proposals to Treasury for bringing forward budgeted equipment spending which would enable re-equipment and thus an earlier opening of identified military spectrum for release to, or sharing with, the civil sector. Where MOD has agreed to vacate spectrum for commercial licensing, RA should enable rapid refarming through assigning overlay licences which provide for new licensees to compensate MOD for early departure from the bands.
- 10.8 MOD should have the ability to retain income generated from arrangements to lease access to spectrum which remains under active MOD management. Such spectrum should continue to bear the full spectrum charge, to be paid by MOD to RA/Ofcom.

## Broadcasting

- 11.1 Market-based spectrum management tools should be applied to the broadcasting sector so that usage of spectrum by all broadcasters is exposed to the full opportunity cost of spectrum use.
- 11.2 Broadcasters should be given the ability to lease spectrum to other uses and/or users, once they have met their public service broadcasting commitments and other obligations. Broadcasters leasing spectrum would be able to keep the resulting revenues.
- 11.3 The spectrum used for broadcasting should be valued and the valuations released into the public domain. From the overall valuation, a value for each national analogue channel and digital multiplex should be derived, based upon relevant factors such as geographical coverage and bandwidth used.
- 11.4 Spectrum pricing should be applied to all broadcasters. The timing of the introduction of spectrum pricing should take account of extant regulatory agreements between broadcasters and the Government (including commercial broadcasters' current franchise fees, which encompass access to spectrum). It should also take into account the Government's commitment to promote and support the take-up of digital TV.
- 11.5 The Government, its agencies and broadcasting regulators should explore options for using variable spectrum pricing and/or spectrum efficiency grants to contribute to the Government's aim of promoting and supporting the take-up of digital TV. The Government should also consider using overlay licences as a mechanism for achieving digital switchover.
- 11.6 Limits on the proportion of digital broadcasting multiplex capacity which can be used for non-programme related data services should be relaxed as soon as possible, and ultimately eliminated. Spectrum released in the future which can potentially be employed for broadcasting should not be confined to broadcasting use alone, but should be made available for other uses through a competitive auction.



- 11.7 Once Ofcom is established, the Government should devolve detailed spectrum planning to the independent regulator, subject to Ministerial direction where necessary in particular circumstances, e.g. to reserve spectrum for BBC services. In order to ensure that the entire volume of spectrum is used in the most efficient way, Ofcom should be given responsibility to plan all the broadcasting spectrum, including that currently used by the BBC.

## Aeronautical and maritime

- 12.1 For spectrum reserved for on-board navigation and communications systems, the opportunity cost to individual users is, in most cases, effectively zero, since use of this spectrum is mandated internationally, and users are required to adopt specific technologies. But where UK-based users face some technology choice for their on-board systems, then the RA, working with the CAA and MCA, should apply differential licence fees to encourage moves to more spectrally efficient equipment, thus easing congestion over time.
- 12.2 In light of the current study for RA of the UK's civil radar deployment and the technical scope for reducing spectrum consumption, the RA should develop a pricing regime, in conjunction with CAA and MCA, for the spectrum used by UK-based radionavigation and radiolocation equipment. This should be phased in over the next five to seven years, consistent with outstanding economic regulation agreements in the aviation sector between companies and the CAA.

## Public safety services

- 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 uses.
- 13.2 The 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 Public Safety Spectrum Management Group. Wherever possible, a technology neutral approach should be taken to the systems adopted for use to allow for competition.
- 13.3 The remit of the Public Safety Spectrum Management Group should be broadened to encompass an expanded group of approved users, including: commercial and local government organisations with a public safety remit; and specialist users whose spectrum needs are currently met from within Home Office-managed bands. Bands currently managed by the Home Office which provide access for users not migrating to Airwave should be placed under the control of PSSMG.

## Science services

- 14.1 UK-based radio astronomy sites should be subject to an administratively set spectrum charge 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. The charge should be directly related, as elsewhere, to the geographic area and bandwidth sterilised, and should be based on the spectrum pricing which would apply to the active use of the band in that region. Where radio astronomers allow other services to deploy within their defined spectrum access, they should be compensated, for example, by the RA passing on the spectrum fee levied on fixed links which it assigns within the protection zones around observatories.