

# New spectrum-using technologies and the future of spectrum management: a European policy perspective.<sup>1</sup>

**Martin Cave**

Professor and Director of the Centre for Management Under Regulation,  
Warwick Business School

This chapter is concerned with the two-way relationship between new spectrum-using technologies, such as ultra-wideband or software-defined radio, and the future of spectrum management, especially in Europe.

After a brief discussion in Section 1 of how spectrum fits into the value chain and of the benefits of promoting spectrum access, Section 2 sets out the case for a market-based spectrum management regime building on the argument that spectrum should be treated like any other input. It also sets out the need for smooth implementation of flexibility in the currently prevalent management regime for spectrum, which is based on discrete (unshared) assignments of spectrum to particular licensees. I call this 'first generation flexibility'.

Section 3 discusses how licence-exempt spectrum or commons can be fitted into this market-based framework. Section 4 discusses new spectrum-using technologies, many of which can operate on disaggregated components of frequencies, and Section 5 considers how spectrum management can be adapted to achieve flexibility in spectrum use in this richer context. I call this 'second generation flexibility'. Section 6 suggests spectrum reforms

for the EU for the period following 2010, implied by the previous analysis, for which new legislation is now being considered.

## 1. Spectrum in the value chain

The goal of spectrum regulation and economic regulation should be the same: to pursue the long-term interests of end-users. Most observers agree that competition is the most effective instrument, although the nature of competition in the value chain can be very varied. Figure 1 shows a typical vertical structure of production of wireless broadcasting and communications (to the extent that a distinction between them can be maintained).

Different degrees of vertical integration or separation can allow a number of sharing opportunities, for example:

- the same physical assets and transmission capabilities can allow a range of programming to be sold or shared; equally, content can reach end-users via many platforms;
- access to spectrum can be achieved in numerous ways via commons, direct licensing, underlays or overlays (see below),

1. This is a shorter version of a paper prepared for Thinktel, an international think tank for telecommunications.

Value Chain		Examples
Content		Programmes, file-sharing
Physical assets		Towers and masts
Spectrum	Wholesale	Licensees, intermediaries, commons
	Retail	
Transmission		MVNOs, broadcasting transmission
Reselling		Airtime
Retail (end users)		Mobile telephony, broadcasting services

Figure 1: Spectrum in the wireless service value chain

via intermediaries such as band managers or operators of real time access regimes;

- physical assets, spectrum and other resources can be used to provide entry or access points nearer the end-user – for example via MVNOs or resellers; and
- end-users themselves – 2.4bn mobile subscribers – are skilfully brigaded by their operators into a pattern of shared spectrum use.

But should regulators have a preference among the points of entry? This depends to a considerable degree on the availability of competing platforms (for example, competing end-to-end mobile operators, cable, satellite, ADSL and so forth).

If this end-to-end competition is lacking (as it is for broadband in un-cabled areas),

regulators, including spectrum regulators, should be interested in inserting competition in infrastructure as deeply into the value chain as possible, in order to sharpen commercial rivalries and promote service differentiation. Given the relatively low level of fixed sunk investment required of wireless access networks, replication of assets, including spectrum access, is fairly easy to achieve and spectrum policy should encourage it as far as possible.

## 2. Spectrum markets based on current technologies

Rather than set out the pros and cons of alternative spectrum management regimes in this section, I prefer instead to set out the case for a major extension of market forces. (For extensive reviews of markets vs. administrative methods, see Cave 2002, FCC 2002, Cave and

Webb 2003a, Ofcom 2004 and European Commission 2005).

The context of the discussion in this section is a management regime in which licences are assigned for the exclusive use of one firm or organisation. Under a market system, this is subject to change of ownership and/or change of use. The goal is thus 'first generation flexibility', based on an unrivalled access by each licensee to its full frequency.

The key underlying insight is that spectrum, like other natural resources such as capital and labour, is an input. The starting proposition in a market economy is that these inputs are best allocated to produce particular outputs by a market process, which co-ordinates the interests and information of millions of agents, in a way best calculated to encourage efficiency and innovation.

This approach is quite consistent with decisions about final demand being taken by the private sector (such as households buying goods, or firms buying investment goods); or by governments (such as a local government organising emergency services, or a national government pursuing the defence of the realm).

Nobody finds this proposition particularly challenging in relation to other inputs, such as skilled engineers, land, financial capital, capital goods and so forth. But it's necessary to check whether spectrum has some relevant significant difference which would suggest it should be treated differently. The main candidates for this are:

a) '**Spectrum is a resource which should be available to all.**' This proposition is fine in respect of spectrum used for certain applications where low power and short range allow users to co-exist peacefully; these needs are appropriately met by

limited 'commons'. However, high-powered uses do demand exclusivity of some kind – which entails a mechanism to achieve it.

- b) '**We need command-and-control (or administrative) methods to minimise police interference.**' Liberalising countries have shown that this does not pose a greater problem than other inputs (such as land). We can draw on experience from New Zealand, Australia, the UK, the USA (in relation to certain bands) and Canada, as well as Guatemala and one or two other less-developed countries.
- c) '**Spectrum licence markets will lead to monopolisation, speculation and hoarding.**' In fact, the chief source of this problem is restrictions on *spectrum use* which have the effect of narrowing markets and creating market power. In any case, competition law should be able to deal with such problems. As with other markets, intermediaries ('speculators') and anticipatory purchasers ('hoarders') can smooth demand and supply, and enhance long-run market efficiency.
- d) '**Administrative methods are needed to achieve harmonisation.**' On the basis of the success of GSM, there's an argument that a common allocation of spectrum across the EU (harmonisation) will encourage the adoption of a standardised technology and thus reduce costs, benefit consumers and achieve the aims of European industrial policy. As with command-and-control spectrum policy in other contexts, this argument assumes that the regulators are capable of choosing the correct frequency to adopt in common. This is clearly a gamble, with the risk increasing because of the uncertainties over which technology, and associated frequency, will triumph. For

example, in the case of mobile broadcasting an array of technology and spectrum choices is still under examination, and the risk of regulatory failure is very considerable. In such circumstances, it is better to delegate the decision to a competitive process involving equipment manufacturers and operators, than to rush to judgement. However, a better bet is an alternative form of harmonisation: to harmonise spectrum management procedures across member states in ways that will first be likely to encourage competition, and then to facilitate convergence around the identified winner. As noted below, the European Commission now appears to favour this kind of meta-harmonisation, with occasional signs of support for old-style harmonisation.

While none of the above provides a good basis for rejecting markets as the basic method (which may be subject to minor exceptions) of allocating and assigning spectrum, restrictions created by treaties made under the International Telecommunications Union are a different story.

These establish primary and secondary uses for specific bands, but the uses identified tend to be broad (as well as increasingly obsolete) so that national regulators have considerable freedom of action: for example, the spectrum used for analogue television transmission has 'broadcasting' as its primary use but a Declaration signed by the vast majority of European countries at the Regional Radio Conference in June 2006 (RRC06) has the effect of authorising its use, following analogue switch-off, for other purposes.

The only provision is that they do not impose more interference than a broadcasting application, and require no more protection than broadcasting. Such strategies are less than

ideal, but they show the scope for combining a substantial degree of liberalisation and flexibility while adhering to treaty obligations. This does not, however, make it unnecessary to seek changes in ITU procedures and spectrum management instruments.

To summarise, first generation flexibility in European spectrum management should be directed to an end-state in which (with small exceptions) market mechanisms including *change of ownership* and *change of use* of licences should operate to the fullest possible extent in respect of:

- geographical area (initially the EU, and later globally);
- frequency bands (as many as possible to ensure that spectrum use is optimised by market exchange over as full a range of usable frequencies as possible);
- form of licences (including freehold, leasehold etc);
- identity of licensees (which could be a direct public, or private sector, firm or organisation, a band manager or an intermediary of another type); and
- the nature of the service produced using spectrum (which could be a marketed or non-marketed good, a private or collective good, and so on).

### 3. Marketed licences vs. commons

Traditionally, a small number of frequencies sat alongside spectrum licences assigned by administrative methods to provide unlicensed access to users of particular apparatus. These include frequencies used for television remote controls and Bluetooth short-range communications, as well as spectrum for short-range broadband access using standards such as

802.11 or WiFi. In the UK, unlicensed spectrum of this kind amounts to 4-6 per cent of the total.

While several commentators have proposed a major expansion of the commons (Noam 1998, Benkler 2002, Werbach 2004), others (Hazlett 1998, Faulhaber and Farber 2003, Cave and Webb 2003b, Baumol and Robyn 2006) regard it as best suited to short-range applications where rivalries between operators for spectrum are more limited. (This does not exclude the development of technologies such as mesh networks, especially to exploit short-range transmission using sublicensed spectrum.)

However, drawing the line over time between the universal licensed and unlicensed spectrum is highly problematic, and historically has been done using administrative fiat in two dimensions: in the basic decision to assign a frequency for unlicensed use, and in the choice of restrictions imposed on its use (Hazlett 2006).

Figure 2 illustrates the allocation decision between licensed spectrum, some of which may be used for 'private commons'. This is an arrangement whereby users authorised by a licensee (for example, purchasers of the licensee's apparatus) have direct access to spectrum – and unlicensed spectrum.

In the past, spectrum regulators have made decisions on unlicensed spectrum on administrative grounds. But this is arbitrary and unsatisfactory. In a market environment, it would be better to introduce some form of market competition between the two modes of frequency management.

The difficulty is estimating, and making effective, the derived demand for spectrum from unlicensed spectrum users, in the same way that, say, mobile operators can express their derived demand. The root cause of the problem is establishing the willingness to pay of a large number of non-rival spectrum users – an illustration of the classic problem of establishing demand for a public good.

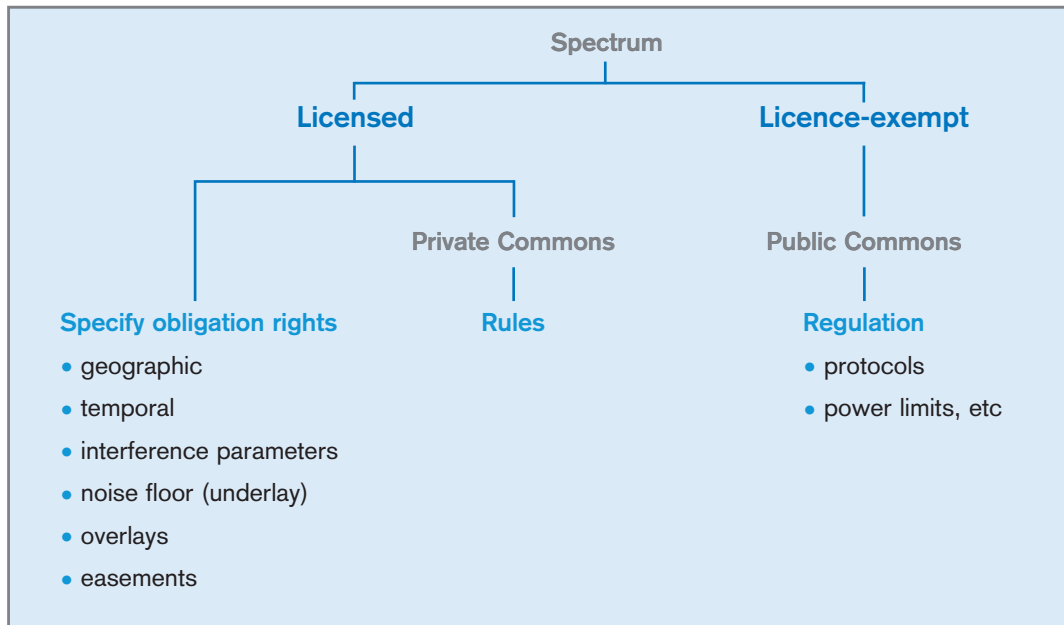


Figure 2: Licensed vs. unlicensed spectrum

In principle, individual levels of willingness to pay should be aggregated (vertically) to derive a social valuation. However, this brings with it the well-known problem that respondents have an incentive to falsify their estimates, in order to increase the supply of a resource for which they will not have to pay, or at least not the full cost.

A number of formal mechanisms have been developed to deal with the problems (for example, the Clarke-Groves mechanism reviewed in Campbell (1995) pp. 283-294). They have the feature that any respondent whose reported evaluation tips the decision to buy into the positive has themselves to pay a surcharge equal to the difference between all other participants' preference for the alternative option. This removes any incentive to report distorted valuations.

These mechanisms do, however, encounter problems associated with the need to make positive payments to some participants as well as to tax others. The budget may not balance, and other techniques such as conjoint analysis may be required to establish the aggregate valuation of unlicensed spectrum from willingness to pay for the services it can offer.

Since a spectrum commons is typically regulated existing services, a range of options may have to be established, in circumstances where consumer understanding of them may not be strong. This will obviously represent a significant challenge.

But let's imagine such an unbiased estimate were available. In this case, a proxy bidder seeking spectrum to be licence-exempt could compete against bidders for licensed spectrum, including those proposing private commons. This would require public financing, but for limited frequencies this might not be too problematic.

To summarise the argument so far: a case based on existing spectrum-using technologies has been made for the use of market methods, and an (imperfect) way, based on the market choosing between licensed and unlicensed use, has been proposed. It is pertinent to ask, however, if foreseeable technological developments support or undermine the case for the market. This is the task of the next two sections.

#### 4. New technologies round the corner

New technologies show great promise in how to make more effective use of spectrum. Developments in spread spectrum technologies, software-defined radios and smart antennas have raised particular interest.

These technologies have the potential to increase spectrum efficiency in many ways, including a higher level of frequency re-use and sharing by means of both underlay and overlay techniques. Moreover, these technologies might be implemented together in mesh network architectures such as ad-hoc networks, thus offering a wide range of new opportunities for spectrum-based services.

Indeed, new technologies may have a relevant impact at different levels of the value chain of spectrum-based services, by enabling a more efficient use of spectrum either directly or indirectly.

In fact, on one hand, spread spectrum technologies appear to be able to bring about great benefits in increasing spectrum efficiency directly, by using frequencies more intensely. On the other hand, smart antennas promise better performance at both transmitter and receiver levels and generate opportunities for enhanced spectrum efficiency by building on the techniques to receive and send signals over frequencies without suffering harmful interference. Software-defined radio (SDR)

technologies are expected to significantly change the way spectrum is used today, particularly as high-level cognitive radios will enable more frequency reuse and more flexible uses of the same hardware and infrastructure, delivering spectrum efficiency in a variety of ways.

#### Increasing spectrum efficiency directly: developments in spread spectrum technologies

A key feature of spread spectrum technologies is that they allow coexistence of multiple applications in the same spectrum, although the capacity of any one application will be reduced as others are introduced. In fact, these technologies spread power over a wide range of frequencies, so their signals only interfere to a limited extent with narrowband radios. Also, some technologies support spectrum overlay techniques, which offer secondary users the opportunity to access a primary channel when this is not in use on the basis of an 'intrude and avoid' principle.<sup>2</sup> Others, however, support spectrum underlay techniques that enable spectrum sharing between systems of either high or low power density levels.

Spread spectrum technologies include a multitude of legacy and new technologies (such as direct sequence spread spectrum, frequency-hopping spread spectrum and ultra-wideband). Their functionality is based on implementation of a code to send information over a much wider band than the actual bandwidth of the transmitted information.

The code, which might be known by other parties, is only used by any one party at one time. Therefore, the information can be coded and decoded by the intended parties at each end of the radio connection, giving, to a

considerable extent, security, interference avoidance and high-speed connections. In fact, spread spectrum technologies have been used in military communications for several decades and they have more recently been moved into commercial applications.

#### Increasing spectrum efficiency by implementing new technologies along other parts of the value chain of spectrum-based services

The new smart (or advanced) antenna technologies have the potential to enable more efficient use of spectrum both directly and indirectly, according to the type of antenna and deployment in the radio-based system. In fact, smart antennas seek to increase coverage, capacity and reliability of a radio network by improving the ability to send and receive signals (i.e. by limiting interference). Actually, antennas are 'dumb', but can be made 'smart' if a digital signal processor enables an analysis of the spectrum environment, such that it is possible to either precisely determine and combine the sources of an incoming transmission, or to direct energy in a narrow beam towards the user.

Therefore, intelligence and greater (indirect) spectrum efficiency can be obtained in two fundamental ways along the value chain of spectrum-based services: on the receiver side, by improving the ability to listen (even with a high level of interference, sometimes known as the 'cocktail party effect'); and on the transmitter side, by transmitting a response only in the desired direction, whereas traditional omnidirectional antennas transmit in all directions. Hence, smart antennas can save on spectrum requirements and also help reduce harmful interference, including multipath problems.

2. For instance, cognitive radios make use of this principle.

However, there are two main practical problems with advanced antennas: they are expensive (particularly when implemented on users' devices) and they don't work properly if there is not a line of sight (in which case, transmissions are easily reflected or blocked).

### Making spectrum-based systems more flexible with software-defined radios

Software-defined radios (SDRs) are wireless communication devices that use software to implement almost completely their functionality on the physical transmission level. Microcomputers are installed in the transmitter and the receiver to handle a wide variety of waveforms<sup>3</sup> and their associated settings. Software is used to control high-speed signal processors, thereby performing functions that in traditional radios were carried out in the hardware.

SDR technologies can have a great impact on electronic communications, although their potential to improve efficiency along the value chain is mainly indirect with regard to spectrum. In fact, by implementing as many functionalities as possible into the software, SDR systems are able to adapt to a wide range of frequencies, bandwidths and transmission standards, without any hardware changes. It follows, then, that SDR can provide more flexibility. Also, SDR is an important enabler for advanced forms of dynamic spectrum access; i.e. any form of flexible spectrum use obtained by dynamically changing the set of transmission parameters.<sup>4</sup>

However, a key feature of SDR technologies is their novel way to carry out the radio functionalities. Indeed, SDRs represent a

major technological advancement away from traditional radio devices for a number of reasons: with the exception of the antenna, physical layer functions are implemented in software rather than in hardware; there is no built-in waveform predetermined by the manufacturer and radios can be re-programmed on the fly, thus providing a high degree of flexibility by adjusting frequencies, bandwidth and directionality.

In this way, a radio becomes a generic device with its functionality defined by running software in a dynamic manner, allowing multiple uses of the same hardware and infrastructure.<sup>5</sup> These features of SDR technologies have generated some interest in the United States, as SDRs allow carriers to run multiple standards on the same network, and promise to reduce operational costs.

In the US, the FCC has recently approved Vanu's system, which commercially deploys SDR technologies in licensed spectrum. Although its commercial jump-start was with the rural market, the system is expected to gain popularity with large carriers, with WiMax potentially becoming part of the system.

### Taking SDR technologies a step further: cognitive radios

Cognitive radios are a relevant and recent development in dynamic spectrum access technologies, based on SDR capabilities. These are smart devices that can perform a multitude of tasks autonomously, enabling more flexible and efficient use of radio frequencies: indeed, a high-level cognitive radio is able to "observe, orient, plan, learn,

3. Waveform is used to refer to the whole software application determining the behaviour of the system.

4. Early forms of DSA mechanisms can be found in modern car radio sets, DECT cordless communication systems and WLAN devices operating in the 5 GHz frequency band. They are all examples of automatic frequency selection mechanisms.

5. E.g. the same SDR could be used as a mobile or cordless phone, a pager or provide WLAN connectivity. Also, a network operator could offer his customers a set of waveforms including UMTS and IEEE 802.11.

decide, act". (Mitola 1999) Although their cognitive behaviour may take different forms, the focus here is on spectrum usage only.

Cognitive radios can acquire information on their spectrum environment and employ this information to decide on their transmission behaviour. Also, they are able to learn from their own behaviour and experience. Indeed, key features include their ability to learn user preferences, prevailing spectrum rules and operator charges. Particularly, cognitive radios can sense vacant frequencies and transmit over unused frequencies until another radio tries to use the same portion of the spectrum.

Therefore, one important advantage is their ability to transmit over temporarily unused frequencies, so considerably contributing to increase available bandwidth. Moreover, by exploiting their ability to acquire information on their physical environment in relevant dimensions – including time, location and frequency – cognitive radio technologies appear to have great potential since parts of the spectrum are often unused in at least one dimension.

Although a prototype military radio system, scheduled for August 2007, is being developed by the US Defense Advanced Research Projects Agency (DARPA), cognitive radios are still in development and it will probably take several years before they come onto the market. Meantime, a number of technological challenges still remain: they include wideband sensing, opportunity identification, interference prevention and dynamic co-ordination.

These issues come together in the so-called 'hidden terminal' problem: if two devices are out of range of each other (for example, if there's a building between the two), they might not spot any activity on a particular part of the spectrum by making independent measure-

ments, thereby starting transmissions. However, the receiver (for example, a base station located within range of both transmitters) will suffer from interference as the spectrum was actually already in use.

### Implementing ad-hoc mesh networks to introduce more flexibility in mobile spectrum-based applications

In mesh networks, radio nodes receiving information can also pass information along, so providing retransmission capabilities. Mesh networks can be divided in two groups: structured and ad-hoc. In the former, radio nodes are fixed and a relevant planning activity takes place in advance. In ad-hoc networks, mobile radio nodes are equipped with relay functionality, which provides a potential for great flexibility and ability to reroute transmissions along different paths by spotting another node within radio range.

While fixed wireless access systems are often included in the concept of structured mesh networks, ad-hoc mesh networks are in their early stages of development. Implementation of SDR technologies might facilitate deployment by allowing radio nodes in the network to become instantly flexible, according to the physical environment. High-level cognitive radios are candidates to be deployed as radio nodes in ad-hoc networks by creating their own transmission path in every specific situation, involving several hops of other radios in the network (perhaps using spread spectrum technologies such as Ultra-wideband (UWB) for high-speed, short-range communications).

### What requirements do the new technologies impose on spectrum management?

The traditional regime for spectrum management is 'one frequency, one user' (who is

bound to provide a particular service using individually licensed apparatus). Developments in the use of market methods, as recommended earlier in Section 1, have in some jurisdictions already achieved first generation flexibility, allowing change of ownership and use across discrete spectrum-using services and technologies in any given frequency. The next issue we consider is how to achieve the benefits of flexibility in the context of the more sophisticated technologies described above, which are capable of accommodating spectrum sharing, often dynamically – in other words, in ways which vary over time.

I am not suggesting that all these technologies will necessarily be applied on a large scale. Indeed, Ofcom's own analysis of the costs of SDR and cognitive radio casts doubt on their cost effectiveness, compared with the simple historical alternative of boosting efficiency by decreasing cell sizes and reusing spectrum more efficiently on a discrete-user basis. It is important, however, to give thought to their potential impact, if the spectrum management regime is to be made future-proof.

A simple dimension of spectrum use is its efficient scale. A technology such as cognitive radio relies on agility to pile more use into given frequencies. Much of the benefit flows from pooling intermittent demands to achieve a greater utilisation rate. Other things equal, this process occurs more efficiently on a larger scale, subject to the increasing cost and technical complexity of ranging over more spectrum. The least we can expect, therefore, is aggregation of demand under cognitive radio, which will capture the benefits of scale, possibly involving intermediation – for example, a band manager which sells access to a range of possible frequencies.

Mesh networks have the prospects of diminishing the power required of transmissions, by virtue of their use of multiple short hops at low power levels rather than one long hop at a higher power. To that extent, they enhance the scope for commons, provided that increases in equipment costs do not outweigh savings in spectrum use.

The two remaining, and more fundamental, issues concern underlays and overlays. Underlays are exemplified by UWB, which operates under the noise floor of other services.

In principle, UWB could be used in at least three ways. First, one or more separate geographical licences could be carved out beneath any existing noise floor and assigned on an exclusive basis. Or the same space could be carved out, and made licence-exempt. Or an obligation could be imposed on any prospective user of UWB to negotiate an arrangement with all licensees under whose noise floor it proposed to operate.

The last option would almost certainly fail because of the transactions cost incurred in negotiating with countless licensees. Choice between the licensed and licence-exempt modes of permitting UWB should hinge on a calculation of the risks of interference, either between UWB users or from UWB users to other licensees. It is necessary here to conduct a risk management exercise to establish the consequences in the future if the multiplication of UWB users ultimately led to either of the interference problems noted above. The conclusions reached so far by regulatory agencies (notably the FCC and Ofcom) favour creating a traditional commons with very strong power limitations.

Finally, there is the question of overlays, or access by users to spectrum licensed to others.

In principle, this could be made generally available. Indeed, the European Commission's recent proposals on spectrum reform<sup>6</sup> seem to contemplate just this kind of general right of access, when it says that:

"A new system for spectrum management is needed that permits different models of spectrum licensing (the traditional administrative, unlicensed and new market-based approaches) to coexist so as to promote economic and technical efficiency in the use of this valuable resource. Based on common EU rules, greater flexibility in spectrum management could be introduced by strengthening the use of general authorisations whenever possible." (p 7)

This clearly raises fundamental issues of spectrum management and the design of property rights. Within one given frequency, transaction costs would not preclude bargaining between an original licensee and potential secondary users. There is also a concern that unlicensed entrants, lacking security of access, would not be in a position to make collateral investments, or to offer adequate assurances to their customers of continuity of supply, and quality of service. Alternatively, they might establish *de facto* some squatters' rights of a contestable nature, which would prevent the licensee from being able to exploit its asset to the full.

These questions have been widely debated in recent years. Notably, Faulhaber and Farber (2003) have been in favour of unlicensed non-interfering overlays or easements of this kind, arguing – *inter alia* – that absent imposition of such a regime, licensees will not be prepared to supply access to secondary users by entering into appropriate contracts with what might be their rivals in downstream markets.

Baumol and Robyn (2006) conclude the opposite, basing their argument in part on the analogy of a successful market for licensing intellectual property. They assert that:

"The argument favouring market accommodation of such emissions rests on the now familiar position that spectrum rights holders have an incentive to act in ways that result in (approximately) optimal use of spectrum space. There is reason to question whether a governmental rule without price and profit incentives will be able to match the performance of a market regime." (pp 61-2)

Absent any experience of the non-interfering easements regime, it is hard to discriminate on *a priori* grounds between the two approaches. The one economises on transactions costs, while the other eschews use of the price mechanism to ration access. As usual in economics, it is unlikely that there will be a corner solution, with the same regime optimal in all frequencies. Ideally, the choice of regime would be determined by a procedure akin to that described in Section 3 above, where some kind of quasi-market testing of a secondary commons would be undertaken. But the design of such a mechanism is very challenging.

The best way forward may be to undertake some limited testing of the non-interfering easement approach in likely-looking frequencies. This could provide a better empirical base for the European Commission's careful espousal of the method reported above.

Whatever application easements may have in the future, market methods will almost certainly provide the foundation for achieving flexibility in spectrum use of both the first and the second generation varieties. In the

6. Commission's Communication on the Review of EU Regulatory Framework for electronic communications networks and services (SEC(2006)816-7), on which more details can be found in Section 6.

next section, I turn to how this might be accomplished in the forthcoming revised regulatory regime for e-communications now being prepared in Europe to take effect from 2010.

### What Europe needs to do<sup>7</sup>

There has been fairly widespread recognition that the current regime of spectrum management in most of the European Union is insufficiently flexible to achieve the Union's objectives of promoting industrial competitiveness and innovation. Despite this, the pace of reform so far continues to be slow. In the light of the previous arguments, urgent measures need to be taken to speed it up by extending spectrum reform in the leading countries to other Member States, thus generating the benefit of 'large area liberalisation'.

The European telecommunications market was fully liberalised in 2002 through the Full Competition Directive and, since then, the current regulatory position in respect of spectrum trading has been clear. By virtue of Article 9(3) of the Framework Directive, Member States are currently permitted, but not required, to introduce spectrum trading.

Article 9(4) of the Framework Directive sets out some procedural aspects of spectrum trading and makes it clear that the Spectrum Decision<sup>8</sup> is the principal means by which spectrum use is to be harmonised:

"Member States shall ensure that an undertaking's intention to transfer rights to use radio frequencies is notified to the national regulatory authority responsible for spectrum assignment and that any transfer takes place in accordance with procedures laid down by the national regulatory authority and

is made public. National regulatory authorities shall ensure that competition is not distorted as a result of any such transaction. Where radio frequency use has been harmonised through the application of Decision No 676/2002/EC (Radio Spectrum Decision) or other Community measures, any such transfer shall not result in change of use of that radio frequency."

According to Article 1(1) of the Spectrum Decision, the aim of the Decision is to "establish a policy and legal framework in the Community in order to ensure the co-ordination of policy approaches and, where appropriate, harmonised conditions with regard to availability and efficient use of the radio spectrum..."

Any fresh decisions made under the Spectrum Decision must also be limited to 'technical implementing measures'. Although there is no binding interpretation of the Spectrum Decision that defines the permissible parameters of a technical implementing measure, it is clear from the past practice both of CEPT and the Commission that it can be used to adopt decisions on a band-by-band basis to harmonise the way in which a certain band is exploited – both practically and technologically – across Europe. Article 4 of the Spectrum Decision could be used to achieve freedom of use on stipulated frequency bands.

In September 2005, the Commission published a Communication on a market-based approach to spectrum management in the European Union (Com (2005) 400 final) which noted that a fragmented approach to spectrum reform would make it more difficult to achieve the Union's objectives. Accordingly, it proposed the co-ordinated removal of restrictions on spectrum

7. This section is taken from Cave and Crowther (2006).

8. Decision No. 676/2002/EC of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community.

use in all Member States in order to promote an open and competitive digital economy.

In practice, it was suggested that substantial amounts of spectrum, including roughly one-third of the spectrum below 3 GHz (the spectrum best suited for terrestrial communications) could possibly be made subject to tradable and flexible use by 2010. Clearly the Communication is a key document in which the Commission nailed its colours to the liberalisation mast. If the plan were realised it would represent a significant step towards the desired end-state set out above, even though a lot of non-communication related spectrum, which makes up much of the remaining two-thirds of spectrum below 3 GHz, would not be covered.

The Commission's Communication on the Review of the EU regulatory Framework for ECS (SEC(2006) 816-7), which proposes greater flexibility in spectrum management, could be introduced by strengthening the use of general authorisations whenever possible. Also, selected bands agreed at EU level via a committee procedure would become available for use under general authorisations, or subject to secondary trading across the EU. Common authorisation conditions for the use of the radio spectrum

would also be enacted with this procedure in appropriate cases.

The proposals thus embody a strong attachment to the key concepts of technology neutrality and service neutrality (flexibility in use). They entail extensive use of the Spectrum Decision but little by way of thorough on-going reform of the Directives. Is this adequate for the task?

It probably isn't, so what's needed is a legislated change to the relevant Article of the so-called Framework Directive, the linchpin of the whole regulatory regime in Europe, which would mandate trading and flexibility of spectrum in the bulk of the key band, maintaining the option of exceptions for certain specified public sector uses (Cave 2005). A proposal along these lines is set out in Cave and Crowther (2006).

Actions by the Commission and the European Institutions are therefore required on two levels: use of the 2002 Spectrum Decision ad interim, and a more radical rewriting of the framework directive to allow significant harmonised spectrum trading and liberalisation in the EU. This would respond both to current and to future needs.

## References

- Baumol, W.J. & Robyn, D. (2006), *Toward an evolutionary regime for spectrum governance: licensing or unrestricted policy?* AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C.
- Benkler, Y. (2002), *Some economics of wireless communications*, Harvard journal of law & technology, vol. 16, no. 1, pp. 25-83
- Campbell, D.E. (1995), *Incentives: motivation and the economics of information*, Cambridge University Press, Cambridge
- Cave, M. (2002), *Review of radio spectrum management. An independent review for Department of Trade and Industry and HM Treasury*, London
- Cave, M. (2005), *Independent audit of spectrum holdings*, London
- Cave, M. & Webb, W. (2003a), *Designing property rights for the operation of spectrum markets*, Warwick Business School, papers in spectrum trading no. 1
- Cave, M. & Webb, W. (2003b), *Spectrum licensing and spectrum commons – where to draw the line*, Warwick Business School, papers in spectrum trading no. 2
- Cave, M. and Crowther, P. (2006), *Driving forward spectrum liberalization*, Vodafone policy paper series no. 5
- European Commission (2002), *Directive 2002/21/EC of 7 March 2002 on a common regulatory framework for electronic communications networks and services*, European Commission, Bruxelles
- European Commission (2002), *Decision No. 676/2002/EC of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community*, European Commission, Bruxelles
- European Commission (2002), *Commission Directive 2002/77/EC of 16 September 2002 on competition in the markets for electronic communications networks and services*, European Commission, Bruxelles
- European Commission (2005), *A market-based approach to spectrum management in the European Union*, European Commission, Bruxelles
- European Commission (2006), *Communication on the Review of EU Regulatory Framework for electronic communications networks and services*, SEC(2006)816-7, European Commission, Bruxelles
- Faulhaber, G. & Farber, D. (2003), *Spectrum management: property rights, markets, and the commons*, in *Rethinking rights and regulations: institutional responses to new communications technologies*, eds. F.L. Cranor & S.S. Wildman, MIT Press, Cambridge, MA
- FCC – Federal Communications Commission (2002), *Report by the Spectrum Policy Task Force, ET docket no. 02-135*
- Hazlett T.W. (1998), *Spectrum flash dance: Eli Noam's proposal for 'Open Access' to radio waves*, *Journal of law & economics*, vol. XLI, pp. 805-820
- Hazlett (2006), *'Barbed wireless' & the vertical structure of property rights*, forthcoming.

Mitola J. (1999), *Cognitive radio for flexible mobile multimedia communications*, IEEE International Workshop on Mobile Multimedia Communications, pp. 3-10

Noam E. (1998), *Spectrum auctions: yesterday's heresy, today's orthodoxy, tomorrow's anachronism. Taking the next step to open spectrum access*, Journal of law & economics, vol. XLI, pp. 765-790

Ofcom (2004), *Spectrum framework review. A consultation on Ofcom's views as to how radio spectrum should be managed*

Werbach, K. (2004), *Supercommons: toward a unified theory of wireless communication*, Texas law review, vol. 82, pp. 863-973