



# Reforming Spectrum Policy

# Foreword

I hope you enjoy our fifth Vodafone Policy Paper. Our aim in these papers is to provide a platform for leading experts to write on issues in public policy that are important to us at Vodafone. These are the people that we listen to, even if we do not always agree with them. These are their views, not ours. We think that they have important things to say that should be of interest to anybody concerned with good public policy.

**Arun Sarin**, Chief Executive, Vodafone Group

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**Richard Feasey**

Public Policy Director, Vodafone Group

Richard Feasey is the Public Policy Director for the Vodafone Group, coordinating public policy and regulatory affairs throughout Vodafone's operating companies. Richard has over 15 years experience in international telecommunications in fixed, internet and wireless sectors.

## Introduction

The similarities between spectrum policy and energy policy have never seemed stronger. Both involve trying to manage scarce resources in the face of surging demand driven by technological innovation and the economic growth that produces. Spectrum and energy are both key strategic assets for modern industrial economies. Both are rightly at the forefront of public policy debates today.

Users of energy and spectrum are both trying to exploit their existing assets more efficiently whilst at the same time constantly seeking new reserves. In both areas policymakers have to rely on uncertain forecasts about future demand. Both are also susceptible to claims that technology can replace the need to 'solve' the problems of scarcity although, regrettably, in neither case does this appear likely in the foreseeable future.

Finally, both spectrum and energy involve complex relationships between industry and Governments, and between Governments, to ensure that private capital can be applied to exploit what many regard as public assets which need to be used for the common good.

This collection of papers is intended to be a contribution to current debates about spectrum policy, particularly as the European Commission contemplates some important and far reaching reforms of spectrum policy as part of its 2007 review of the EU Telecoms Framework. Vodafone believes these are urgently needed if the European wireless sector is to remain globally competitive.

Tom Hazlett reminds us in his paper that attempts to reform spectrum policy around the world have been partial at best. Hazlett explains that many of the costs of Europe's failure to reform spectrum have been disguised by decisions to allocate a relatively large amount of spectrum to the most valuable use of spectrum yet invented – mobile telephony. At the same time, failure to allocate enough spectrum to mobile telephony in the US has been partially overcome by the much greater flexibility which the FCC has allowed operators.

Hazlett argues that neither Europe nor the US will be able to disguise the costs of getting spectrum policy wrong in the future. The transition from analogue to digital television and the 'digital dividend' of spectrum which this will release over the next decade provides an historic opportunity to release – or destroy – an enormous amount of economic value. Policymakers need to be bolder than they have been in the past.

Gerry Faulhaber explains how the US debate on spectrum reform has become distracted in recent years by arguments between 'private property' and 'commons' advocates. This is a diversion which Europe would do well to avoid. He shows that there are fewer differences between the two camps than many suppose. 'Exclusive' spectrum licences, such as those used by mobile telephony providers, allow multiple users to enjoy the same spectrum – just as they would under a 'non-exclusive' commons regime. Private firms manage the co-ordination issues and pay for the

licence in the former case, whilst regulators manage them in the latter. Faulhaber's point is that in either case somebody has to manage the spectrum and in neither case is it free. He reminds us of Ronald Coase's famous conclusion that if scarce resources are generally better managed under a private property regime, spectrum should be too. Both Hazlett and Faulhaber are sceptical of claims that spectrum is fundamentally different and Hazlett shows in his paper that the (few) cases where Coase's principles have been applied - in specific countries such as New Zealand or in specific sectors such as cellular in the US - Coase seems to have been proved right.

When the EU Telecoms Framework was first under development in the late 1990s, there were enough controversial questions to resolve between the Commission and the Member States without adding spectrum reform to the list. Instead the Framework created a set of committees which were designed to build consensus on spectrum issues and from which, it was hoped, more concrete proposals could later emerge. Europe has made some progress over the last five years in developing concepts such as WAPECS, but we are still a long way from implementing substantive reform. Europe has been less distracted by the 'private property' versus 'commons' debate, but perhaps more confused about the respective merits of trading spectrum to new users and allowing more flexibility for existing users.

At Vodafone we believe that a very large proportion of the potential gains from spectrum reform are associated with flexibility rather than trading. There have been some efforts to examine the potential benefits for Europe from spectrum reform, but we asked Neil Pratt and James Bellis of Frontier Economics to look specifically at the potential gains from allowing mobile operators to reuse their GSM spectrum for '3G' UMTS technologies in Europe. This is an area of spectrum reform which has proven difficult and controversial, but Neil shows that it could generate consumer benefits of over €3 billion each year if policymakers are prepared to grasp the opportunity. With UMTS900 handsets that can be used in GSM bands becoming available next year, the costs of failure are becoming very real.

We believe that the time has come in Europe to move from building consensus around ideas to concrete action. Doing this in Europe requires a set of institutional and legal instruments to effect practical change, although Martin Cave and Peter Crowther find that since 'efficiency' is already a primary objective for regulators under the existing legal framework, pursuing these actions need not await further legislative change.

Cave and Crowther argue that legislative changes are likely to be needed in the review of the EU Telecoms Framework, but that Europe can get a long way using existing instruments if there is the political will to do so.

Finally, the quest for new spectrum will remain unabated even if reforms in Europe, the US and elsewhere improve the efficiency with which we exploit the spectrum already allocated. The ITU's World Radio Conferences seek to match future spectrum availability to future demand at a global level. Jonathan Sandbach suggests that the forecasting tools employed today are unlikely to capture the real economic trade offs. If initial allocations at the global level are unable to match supply to demand, then it is even more important that national and regional spectrum markets work well enough to correct for mistakes afterwards. We have a lot of work to do before we can be confident of this.

I hope you enjoy this collection of papers and welcome comments. As usual, the views presented are those of the authors, not Vodafone. Comments should be sent to me at: [richard.feasey@vodafone.com](mailto:richard.feasey@vodafone.com)

**Prof. Thomas W. Hazlett**

Professor of Law & Economics  
Director, Information Economy Project  
George Mason University  
Arlington, Virginia

Thomas W. Hazlett is Professor of Law & Economics and Director of the Information Economy Project at George Mason University. He was formerly a faculty member at the University of California, Davis, Columbia University, and the Wharton School, and served as Chief Economist of the Federal Communications Commission. He has published widely on government regulation and the economics of information technology, both in the academic literature and the popular press. He is currently a columnist for the Financial Times' New Economy Policy Forum.

## Spectrum allocation & economic efficiency: An international perspective<sup>1</sup>

### Foreword

Traditionally, regulators have allocated radio spectrum via central planning, failing – as Ronald Coase noted in 1959 – to capture efficiencies of competitive resource ownership. As broadcasting has become eclipsed by mobile telephony, some Governments have extended greater flexibility to licensees, allowing market forces to assume broader scope. The result, where this has occurred, has been a dramatic increase in the productive use of radio waves. Yet constraints remain, and these rigidities continue to substantially hinder economic growth. Some countries, such as the United States and many developing nations,

have been extremely parsimonious in allocating bandwidth to wireless markets. Others, including many in Europe and Asia, still impose inefficient constraints on licensees. More allocated bandwidth, and more liberal use of that bandwidth, is needed to deliver additional market rivalry, technological innovation, and consumer welfare gains. In particular, the “digital dividend” arising from the release of extremely productive VHF and UHF broadcast TV spectrum provides an opportunity to generate enormous social benefits.

## Introduction

In 1959, Ronald Coase presented the idea of spectrum liberalization. By shifting from a centrally directed system for allocating airwaves, assigning property rights to the use of frequencies to rival firms, competitive markets could achieve efficiencies in wireless just as in other sectors. The reforms were controversial, to say the least. Asked to testify at the U.S. regulatory agency, the commissioners began the questioning with, “Is this all a big joke?”

The intervening decades have proven Prof. Coase’s view entirely serious. The contrast between central planning and market allocation has played out most widely in the parallel paths of development for the broadcasting sector and wireless telephony. The former has been, and continues very largely to be, regulated under traditional methods, with regulators determining what services are offered, what technologies are used, and what business models deployed. Private licensees are severely constrained in their use of the assigned frequencies. In wireless telephony, however, much wider scope is generally afforded licensees to configure their own networks, to introduce innovative applications, and to experiment with various pricing structures.

The results were anticipated by Coase. Spectrum allocated to broadcasting is routinely squandered, with little regard for the opportunities available from alternative approaches. Licensees, lacking permission to supply services in place of specified TV or radio broadcasts, ignore socially valuable innovations. With wider property rights to use frequencies, however, cellular operators embrace change. Service quality improves through time as networks expand and as technological upgrades are deployed. Handsets become smaller and batteries last longer. And new applications piggyback on existing services, with data networks sharing spectrum space and communications infrastructure with voice. Often such services are supplied by third party vendors who effectively “buy spectrum” by contracting with a wireless phone network.

Yet, overly conservative regulatory limits remain. Not only in the *ancien regime* governing broadcasting, but elsewhere, valuable opportunities are needlessly blocked. Too little spectrum is allocated for consumers to use, while that spectrum that is made available continues to be subject to counter-productive regulation. Excepting a handful of countries that have instituted sweeping liberal spectrum reforms, regulatory agencies continue to micro-manage frequency allocations. Driven by various political concerns, including bureaucratic inertia, a temptation to increase license auction receipts at the expense of efficiency, and a tendency to see spectrum set-asides for license-exempt use as effective substitutes for exclusive

rights allocations, most regulators have pursued Coase’s liberal agenda half-heartedly if at all. Such diversions undermine competitive markets, pre-empt dynamic innovations, and ultimately punish consumers.

## Wireless: A brief regulatory history

Modern regulation of the electro magnetic spectrum was crafted to deal with radio broadcasting, a wireless application now a century old. Broadcast stations were seen to possess the potential for enormous political and cultural influence. Keen interest was taken by policy makers, who desired to control content by controlling airwaves.

State jurisdiction rested on the public interest in establishing rules over spectrum use. The premise was that without government regulation there could be no communications, but simply a “cacophony of competing voices,”<sup>2</sup> as the U.S. Supreme Court once characterized the radio market prior to the advent of licensing in 1927.

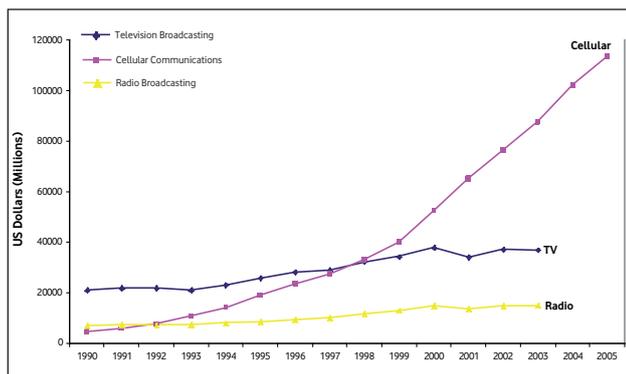
Society does benefit from rules helping coordinate radio wave access. The well-known “tragedy of the commons” often obtains where the spectrum pool is open without limit. But as Ronald Coase noted in a semi-famous 1959 article,<sup>3</sup> the standard path in a market economy is to define private property rights, allowing owners to determine how resources will be conserved, shared, and productively employed. This was the road not taken. Instead, administrative allocation – government planning – controlled spectrum use.

Regulators in most countries held that airwaves were not subject to ownership, and that governments alone could determine how radio waves would be used. Private broadcasting licenses did not cede control over bandwidth; licensees had no discretion to do anything other than that specified in the license. A radio station could not go silent and use its assigned channel to transmit paging services or fire alarms.<sup>4</sup>

It is a regulation-intensive choice for dealing with potential “tragedy of the commons.” In fact, the numerous restrictions result in “tragedies” of their own, as they block countless wireless services from being offered to the consumer. As new technologies are developed, they may not be deployed until new spectrum allocations are made by regulators. This constitutes a bottleneck of severe proportions, given the lengthy delays and pronounced uncertainties yielded by the administrative process. As existing licenses do not authorize new uses, and new licenses are available only in the very long run if at all,<sup>5</sup> innovators attempting to deploy advanced wireless

systems are deterred from competing – or investing in research and development in the first place. FM radio, invented in the early 1930s, fought U.S. regulatory restrictions until the 1960s when – despite having been initially dismissed as inferior to AM by the Federal Communications Commission – it astonished listeners with “high fidelity,” and overtook established radio stations in listening audience within a few short years.<sup>6</sup>

**FIG. 1. CELLULAR AND BROADCASTING SERVICE REVENUES, 1990-2005 (USA)**



The traditional era in spectrum regulation is now being eclipsed. The simple explanation is that radio and television broadcasting, once the overwhelmingly dominant wireless sector industries, dominate no more. Broadcasters are losing ground to alternative media delivery platforms, including cable, satellite, and Internet-based content distribution, and being overtaken in the “wireless spectrum” world by mobile telephone networks. This is seen for the U.S. market (where data are more readily available than in the international market) in FIGURE 1, and mimics worldwide trends. The emergence of mobile telephony as the “killer app” of wireless changes essential aspects of the regulatory structure.

Most pointedly, political concerns giving policy makers inordinate interest in controlling airwave use are fading in importance. Wireless phone operators are common carriers, having no direct influence over what is communicated. Hence, *the demand to regulate cellular* has never been so intense as *the demand to regulate broadcasting*, where content creation has long been tied to program distribution.<sup>7</sup> Conversely, the cost of micro-managing cellular communications networks is orders of magnitude more difficult than micro-managing broadcast facilities. Modern cell phone systems are complex to design and operate, with waves of new technology continually swamping older designs. Each TV station, on the other hand, is well defined by a transmitter blasting emissions from a single point, and analog TV sets in the U.S. today use a technical standard crafted in 1941.

The net result is that regulators – particularly in countries such as the United States or Australia – have been

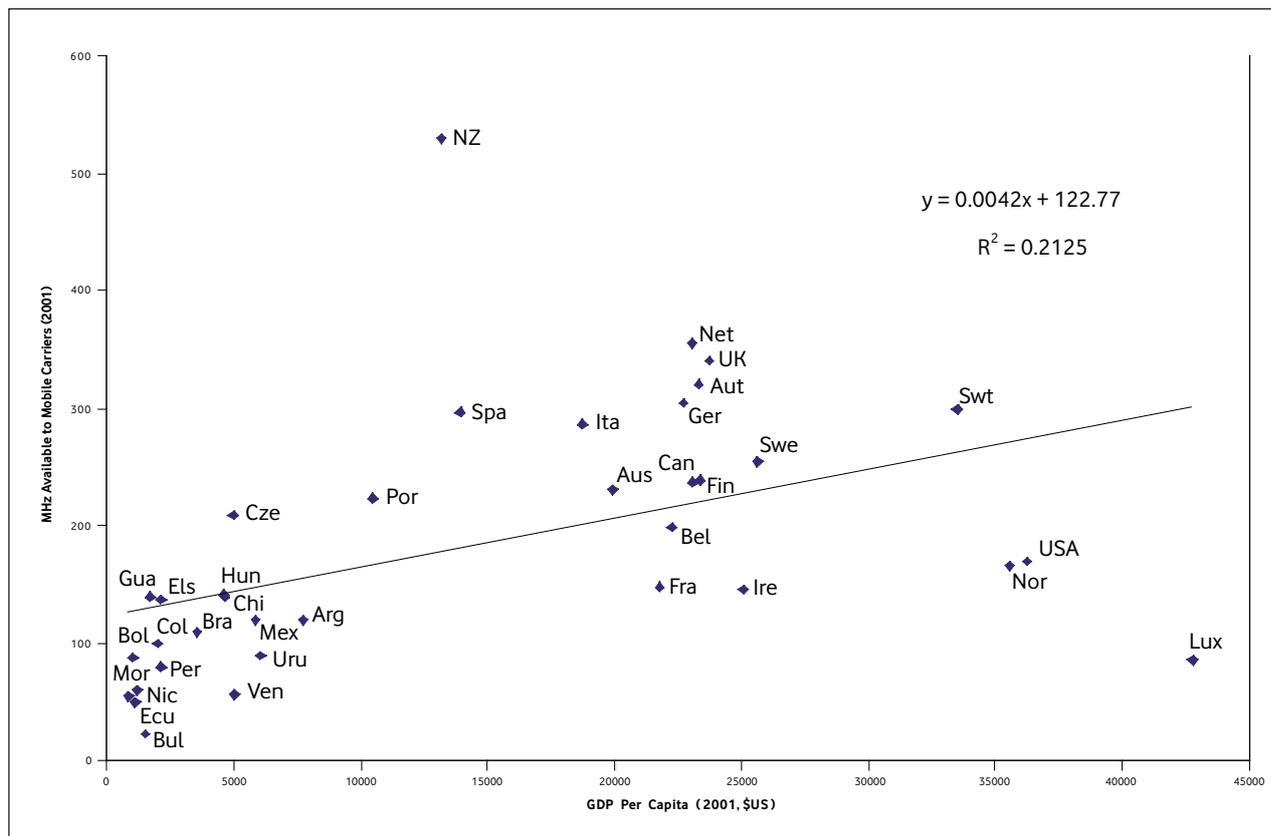
amenable to delegating far more authority to cellular operators than to radio or TV broadcasters. A cellular network, given wide discretion over how to optimize the use of spectrum, can seamlessly transition from last year’s technical standard to next year’s. Mobile phone networks pile function upon application upon network overlay, constructing a complex mosaic of economic relationships for customer enjoyment – within a prescribed radio space permitting far more flexibility for the licensee than the traditional spectrum allocation rules associated with broadcasting.

Those regimes pursuing a more cautious approach, such as many in Europe, have often sought to confine each license to a particular mobile technology on the basis that regulation is needed to achieve economies of scale in developing and manufacturing wireless equipment. In effect, the basis for micro-management flipped from traditional concerns about the influence of broadcasters to an industrial policy supporting preferred technologies. This approach is now being challenged. What was once thought necessary to promote new cellular technologies is proving to be an obstacle to the adoption of emerging efficiencies.

### Bandwidth availabilities across countries

Despite relatively flexible use of radio spectrum allotted mobile phone licenses in some markets, the bandwidth allocated to such liberal licenses can be severely limited by regulators. Consumers would handsomely benefit from the additional services, and product innovation, that would flow were additional frequency space accessible to competitors.

Figure 2 displays the bandwidth (MHz) allocated by 36 countries (mostly in Europe and the Americas) for the wireless telephone market. The data are for year-end 2001,<sup>8</sup> and average 194 MHz per market (equally weighted). The range extends from 50 MHz for Ecuador to 530 MHz for New Zealand (where liberal rules on spectrum use obtain, as discussed below). There is a positive correlation between per-capita income and the amount of spectrum, yet only about 21% of total (MHz) variance is explained by income differences. Given that the airwaves not utilized in mobile telephony generally lay fallow, they could be deployed for mobile services at little or no opportunity cost. Hence, it is clear that many countries featuring relatively low spectrum allocations could improve performance in their mobile markets by simply allowing more radio spectrum to be utilized. Consumers could benefit substantially were regulators to allow greater quantities of bandwidth to be made available to mobile carriers.<sup>9</sup>

**FIGURE 2. MOBILE SPECTRUM ALLOCATIONS AND GDP PER CAPITA**

The value of spectrum is overwhelmingly in the consumers' surplus it generates, not in license prices (which reflect producers' surplus). Take the 140 MHz allocated to the United Kingdom's 3G licenses, famously assigned by auction in 2000. While the headlines were all about the heated bidding – \$34 billion in aggregate<sup>10</sup> – the social value of the additional spectrum is of far greater importance to consumers and the economy.<sup>11</sup> As incremental bandwidth becomes available, wireless services increase in quality and decrease in price, and new systems – such as broadband data networks – are created.

As we have already seen, the paucity of spectrum in the USA versus other peer countries has been offset, to some degree, by liberal policies with respect to network operations.<sup>12</sup> By granting mobile operators enhanced spectrum flexibility, networks have efficiently coped with the artificial spectrum scarcity imposed by regulation. So, for instance, the U.S. has been able to deploy 3G technologies – including high-speed Internet access – using 1G and 2G licenses. The result is that three carriers (Cingular, Sprint, and Verizon) offer “coast to coast” broadband access.

Conversely, many European mobile operators may have been able to partially compensate for the inflexibility of their licensing regimes by securing access to relatively generous allocations of spectrum, such that the true costs of regulatory inflexibility are disguised (although no less

real). At some point however, these offsets, and those emanating from the relative flexibility of U.S. license terms, will be exhausted. Both the European and the U.S. wireless industries are disadvantaged relative to operators in other markets who enjoy both access to more bandwidth and the opportunity for more productive spectrum use.

## Liberal Transition

### The Possibility of Regulatory Improvements

One way to think about reform is to consider notable instances where it has successfully been implemented, as in the case of license assignments. For decades, critics of traditional licensing argued that competitive bidding would be an efficient substitute for “comparative hearings” or “beauty contests.”<sup>13</sup> The argument was not ultimately successful, however, until applied to mobile telephone licenses.

Competitive bidding for wireless rights was instituted in New Zealand (1989)<sup>14</sup> and India (1991)<sup>15</sup> before being adopted in the U.S. in 1993. The enabling legislation made clear that the distribution of PCS licenses were the main purpose of the reform, which excluded broadcast licenses from assignment via auction.<sup>16</sup> The demonstration effect was powerful. By 2001, auctions had become standard in at least 27 countries.<sup>17</sup>

It is useful to recall that auctions were long ridiculed as impractical, academic formulations of little use to real-world regulators. In the late 1970s, when a bold member of the U.S. FCC dared to advance the idea, he was ridiculed by two fellow Commissioners who noted that the odds that this radical proposal would be adopted were “about the same as those on the Easter Bunny in the Preakness.”<sup>18</sup>

In the event, the winning bet was on the Bunny. Over time, not only are efficiency-creating reforms possible, interests favoring greater economic opportunity for spectrum-based technologies discover and embrace alternatives to traditional spectrum allocation.

### Observable Liberal Rights Regimes in Spectrum

Mobile phone licenses are relatively liberal in a growing number of markets, allowing observation of how spectrum rights delegated to private network operators create efficiencies. Another place to observe the liberal license regime in practice is in those few countries that have come close to explicitly adopting it: New Zealand (1989), Australia (1992, 1997), Guatemala (1996) and El Salvador (1997).<sup>19</sup> These countries have witnessed positive results with reform, having been particularly successful in making abundant spectrum available for wireless operators and other wireless innovations. Excepting Australia, these countries are relatively small, but none appear to have suffered from the loss of economies of scale or critical mass which some regulators fear when considering more liberal regimes.

Guatemala and El Salvador, for instance, have the highest bandwidth allotments available to mobile carriers (140 MHz and 138 MHz, respectively) in Central America – by far. Retail mobile prices, taking a population-weighted average of the two countries, averaged 16.0¢ per minute over the years 2000-2004. This was 59% below the 37.6¢ population-weighted average for its C.A. neighbors, Honduras, Panama, and Nicaragua, each of which permits only about 50 MHz of airwave space to be deployed.<sup>20</sup> Overall, the liberal spectrum regimes appear to be working smoothly, without high administrative costs or excessive uncertainty over spectrum rights.<sup>21</sup>

The countries took different paths to liberalization. Guatemala defined private property rights to the use of radio spectrum – *título de usufructo des frecuencia*, or TUFs.<sup>22</sup> These yield ownership of airwave usage subject only to boundary conditions, which include maximum emitted power within band (thus limiting out-of-band spillovers). TUFs replace licenses, carrying no limitations on how a particular band is used. An important feature of the regime is that parties may request TUFs for unoccupied frequencies, with regulators being constrained by law to issue such rights (by competitive bidding should contesting claims be filed).

El Salvador’s law took a more conservative tack, defining licenses according to international standards (as given by the International Telecommunications Union allocation map), but including a provision making licenses permissive. Licensees are then given the right to provide whatever services, by whatever radio technology, are accommodated within the spectrum space allotted the license.

New Zealand’s approach in 1989 charted new territory. Rights to bandwidth are generally assigned by regulators to band managers, who are then given wide latitude to use frequencies. Managers may reassign rights to actual users or service operators, but are ultimately responsible for band usage.

Australia followed with statutes outlining liberal spectrum policies in 1992 and 1997. The approach was to define spectrum parcels, which would be sold to parties which were then free to use the spaces with wide flexibility. The regime has the added feature that parties petitioning the regulator to make more spectrum rights available are entitled to regulatory action in response to their request. While allowing the spectrum agency some discretion, this requirement appears to have facilitated the flow of new spectrum rights to innovative wireless service providers.

This is seen in the conclusion rendered by the Gartner Group that Sydney, Australia “has become the world’s leading market showcase for wireless data services.”<sup>23</sup> The WALL STREET JOURNAL adds, “[A] reason wireless broadband is taking off here: The government sold off radio spectrum for such services relatively cheaply. Privately held Personal Broadband snapped up its license in 2001 for only about US\$7.5 million.”<sup>24</sup>

Australia’s wireless broadband market now features multiple wireless competitors offering services in competition with carriers’ 3G offerings. These include the 1 Mbps “iBurst” Personal Broadband network, which uses Arraycomm’s adaptive array antenna technology. It provides service utilizing 5 MHz (1910-1915 MHz) of nationwide spectrum,<sup>25</sup> and is marketed through various partners (including Vodafone<sup>26</sup>). The competitive Unwired service offers up to 1 Mbps using Navini Networks “pre-WiMAX” technology delivered via 3.5 GHz spectrum rights purchased in 2000 and 2001. The rivalry has spread from Sydney to markets throughout the country.

Despite New Zealand’s small size, it too has seen entry by innovative wireless broadband service providers. In particular, IP Wireless’ TD-CDMA system is offered by Woosh Wireless, which acquired management rights to a 29 MHz band (2.053 GHz to 2.082 GHz). Woosh offers high-speed Internet access (designed for 500 kbps) within 50 km of downtown Auckland, Wellington, Christchurch, and Invercargill, and now enjoys thirty percent broadband

market share.<sup>27</sup> It launched service in Sept. 2003, becoming the world's first commercial deployment of wireless broadband service.<sup>28</sup> It recently announced a new VoIP venture, an offering aimed squarely at rival Telecom New Zealand, the country's erstwhile telecommunications monopoly.<sup>29</sup>

What many countries are waiting to experience in 2006 – entry by innovative “4G” service providers – has been on display in New Zealand and Australia for some years. The removal of entry barriers via liberalization of spectrum markets helps facilitate this pro-consumer, pro-technology outcome.

### Regulator-led Regulatory Reform

The more radical approaches to spectrum reform may be used either as models to emulate or as laboratory experiments to learn from. In the latter case, regulatory agencies may themselves pursue reform agendas which seek to increase competitiveness in the wireless sector by relaxing traditional spectrum allocation rigidities. This is the way reform is pursued in most countries, including the U.K.

The U.K. began an ambitious re-evaluation of Great Britain's spectrum policies by commissioning a 2002 study. The report, authored by Warwick University economist Martin Cave, elucidated the basic social welfare arguments for liberalization, including greater flexibility of use and more abundant availability of bandwidth.<sup>30</sup> The report's recommendations were largely accepted by the government, and are being implemented. Ofcom, the regulator, has adopted a policy which plans to define exclusive rights to about 69% of the bandwidth below 3 GHz (generally the most valuable bands) by 2010.<sup>31</sup> Licensees will be given wide scope to use these airwaves or assign use rights to others.

The contrast with U.S. regulators is stark. The American FCC also undertook a major report in 2002.<sup>32</sup> The Spectrum Policy Task Force Report, however, pared the FCC's 1999 plan to assign new “flexible use” licenses allocating some 183 MHz of spectrum over five years,<sup>33</sup> delaying it another five years and cutting it roughly in half.<sup>34</sup> What tempered the Commission's enthusiasm for additional flexible-use licenses was its agnosticism between licensed and unlicensed allocations. Once the regulator pursues case-by-case allocations via ever-changing rules, the standard infirmities of “command and control” – including delays and inefficiencies resulting from solutions lacking rational feedback loops – assert themselves.

The result is that U.S. regulatory authorities have spent the past half-decade considering how to balance the various

regulatory approaches, while the U.S. wireless sector suffers from a “spectrum drought.”<sup>35</sup> Ultimately, moreover, choices will reflect political judgments rather than economic trade-offs, as decision-makers have little of the information, and less of the incentives, necessary for efficient outcomes.

The EU now appears to be following, if at considerable distance, a path trod by Ofcom. In a consultation prepared for the European Commission in May 2004, the idea was advanced that Secondary Markets liberalization move forward. The subject was approached in halves, with the more important step being the more controversial:

“There is widespread support amongst spectrum users and other stakeholders for trading, but judgement is more reserved on liberalization.”<sup>36</sup>

Permitting flexible use is commonly opposed because it increases competitive market forces, lessening “preclusionary” values gained by hamstringing rivals with restrictive rules. In truth, flexibility does raise the prospect of interference; relaxing limits on licenses allows new technologies or applications, and these innovations implicate possible conflicts. But efficient dispute resolution mechanisms are the low-cost approach to mitigation. In contrast, traditional regimes seriously err by over-protecting against damage from interference. Again, broadcast regulation – which leaves large numbers of TV channels vacant to protect a relatively small number of stations from interference, ignoring vastly more efficient ways to protect viewers – provides the standard example. The demonstration effect is key. Countries that have instituted far-ranging spectrum flexibility have encountered the potential for widespread interference disputes, yet productive operations have not been impeded.<sup>37</sup> More recent pronouncements from the European Commission suggest that it too is recognizing that liberalization is both possible and necessary if Europe's wireless industry is to remain competitive.<sup>38</sup>

## Opposition To Liberal Reforms

### Harmonization

Those expressing caution vis-à-vis Secondary Markets liberalization in Europe often emphasize the importance of harmonizing spectrum decisions across countries. This is seen to conflict with market allocation of spectrum, in that individual licensees (quasi spectrum owners) will be free to alter usage, upsetting international agreements.

Harmonized spectrum use can yield dramatic economies of scale. When regional or world wide standards are effectively applied, costs tend to fall. The global

acceptance of the 2.4-2.4835 GHz band for low power unlicensed devices, for instance, has helped drive costs down for cordless phones and Wi-Fi chips.

Yet fixed allocations are not without costs. A harmonized spectrum use regime locks in standards selected by regulators. These rules render innovative options off-limits even after original standards become obsolete. This is vividly observed in broadcast TV.

A de facto owner of radio spectrum, conversely, faces strong incentives to capture the gains of harmonization while reducing its costs. Where bandwidth users are confined to particular technologies, the coordination may be helpful but the coercion is superfluous. It only binds when it ought not to. It is disruptive to efficiency, because it blocks wireless providers from shopping in the broadest market for technological inputs.

Not only can harmonization block efficient choices for individual networks, the political process required to achieve consensus may block any productive utilization of allocated airwave space. In its pure form, "harmonization" gives veto power to each group member. This tends to delay decisions for years, wasting valuable spectrum.<sup>39</sup>

Liberalization of license rights permits wireless service providers to reach consensus over standards, but to opt out when benefits from idiosyncratic investments offer greater returns. Governments may assist by permitting explicit coordination (which may require anti-trust immunity and/or international conventions). But delaying liberalization, and the market-based harmonization it affords, is self-defeating.

### Windfalls

Spectrum liberalization is often opposed on the grounds that existing licensees should not profit from more expansive property rights. If more flexibility is granted a licensee, some argue that the new rights should be awarded by auction.

This approach buttresses the worst case outcome for consumers, which is to leave license rigidities in place, sacrificing productivity gains and raising wireless service prices.<sup>40</sup> Imagine a situation where incumbent licensees in a particular market could adopt newer technologies doubling bandwidth, at current costs, for customers. Existing licenses, however, block the upgrade. If new rights are awarded by auction, a competitive bidding mechanism will extract the full profit potential of the new technology *ex ante*.

This tax on innovation will deter support from incumbents. If they cannot benefit from deploying more advanced technology, they are led to support rules that prevent them – and, importantly, their rivals – from doing so. The effort is,

at best, penny-wise, pound-foolish, as the vast proportion of social gains in output markets accrue to consumers. Economists estimate that consumer surplus is at least an order of magnitude above producers' surplus in, for instance, mobile phone markets.<sup>41</sup>

Expanding spectrum use rights held by existing licensees creates two sets of efficiencies. First, the opposition of incumbents is to some degree mitigated. This buys a lot, because incumbent opposition is often, if not typically, determinative.<sup>42</sup> Policies that effectively increase the probability of pro-consumer reform are themselves efficient. Notably, liberal reform is often opposed by incumbent licensees even without auctioning new rights because the prospect of greater competition is expected to lower profits. Broadcasters were so bitterly opposed to Coase's original proposal for property rights in radio spectrum that this factor was explicitly noted by an anonymous reviewer suggesting that the Rand Corporation, which commissioned a follow-up study in 1962, kill the paper – which it did.<sup>43</sup>

Second, defining the "white space" where new wireless entry occurs is not a trivial matter. Incumbents possess proprietary information about the costs of conflicts, such that assigning the new rights to this party is a standard efficiency-creating implication.<sup>44</sup> In contrast, when regulators impose protections on adjacent licensees they often resort to "guard bands" or "taboo channels," leaving potentially productive radio waves fallow largely because they are unable to define rights more finely. Allowing incumbents to enjoy flexible rights and to capture gains from more productive use of airwaves thus provides efficiencies in both the rent-seeking process wherein spectrum rights are allocated as well as in the deployment of the rights themselves.<sup>45</sup>

The ultimate irony of the argument that flexibility should not be granted because it awards unfair windfalls is that it is contradicted by incumbents who oppose liberalization, claiming that windfalls are likely to be *negative*. For example, the EC proposal to relax usage restrictions has been criticized by some mobile carriers who argue that expanded cellular license rights will reduce license values.<sup>46</sup>

I have researched the question of windfalls for those countries – Australia, New Zealand, Guatemala and El Salvador – that have most radically expanded property rights. In evaluating government license auctions for mobile carriers in 24 countries holding 39 auctions, 1995-2001, the licenses sold in the four very liberal spectrum regimes were 37% less expensive, adjusting for other variables.<sup>47</sup> The pro-consumer policy is clear: to eliminate windfalls, make new spectrum rights competitive and plentiful.

### Hoarding

Another note sounded in opposition to liberalization is that, if rights are distributed to private parties, hoarding will deprive society of productive use of radio waves. Anti-competitive warehousing is to be avoided, but that is an argument *for* widespread use of exclusive spectrum rights. It is the existing system of centralized allocation that allows government and private interests to under-deploy assets and yet shift the cost of such inefficiency to others.

Currently, government allocation rules block vast amounts of valuable bandwidth from being productively utilized. This constitutes hoarding by state fiat. Interestingly, many private interests support and encourage such practices. Take the TV broadcasting band in the United States. Since the 1940s TV stations have opposed efforts to peel away unused TV channels for other services, including cellular telephony and public safety radio.<sup>48</sup> The stations do not directly benefit from blocking the alternative services, which do not compete with television broadcasting. The licensees are able, however, to exercise powerful regulatory clout and, in stopping rule changes highly desired by other parties, acquire enhanced ability to procure favorable regulatory treatment for themselves.<sup>49</sup>

The anti-consumer outcome is a product of the *lack* of private property rights. Were the broadcasting band to actually be owned by TV stations, TV band spectrum would not – it is completely safe to say – be allocated as it is. As competing spectrum owners, stations would rationalize use of the band, limiting the space taken up by over-the-air broadcasting, shifting some transmissions to satellite, cable, Internet, or some efficient combination thereof. These spectrum-economizing investments would then allow owners to capture new revenues from additional wireless services. The outcome does not depend on far-sighted management; if a given broadcaster failed to see opportunities for increased efficiencies, then competitive forces (including those governing capital markets) will supply the insight. Hoarding ceases because the opportunity cost of letting perfectly productive airspace be wasted would be internalized by resource owners.

The inefficiency of the present system is that hoarding is costless, both for government and for traditional licensees who veto efficiency-creation without sacrifice. The way out is to shift the economic incentives by introducing something approaching real ownership. The use of standard competition policy is available to police anti-competitive conduct, both with regards to spectrum inputs or otherwise, just as it is now. There is nothing that makes wireless markets more susceptible to output-restricting behavior than other markets save centralized spectrum allocation, which makes it endemic.

### Regulatory Micro-management of Secondary Markets

The idea is popular among both policy makers and academics that the creation of organized markets may facilitate trades of spectrum access rights in standardized parcels (time, distance, bandwidth and, perhaps, power) in relatively high volumes, making markets liquid. The analogy to commodity exchanges is clear.

The development of such institutions, however, is not independent of other supply and demand conditions. Some assets do not “commoditize,” but remain in equilibrium with discrete transactions custom tailored by specialized agents. Real estate, for instance, is traded differently than wheat; the former is not commoditized as is the latter. Both outcomes are rational given the manner in which assets are most productively utilized, and transactions costs of coordinating these productive activities.

In short, financial instruments evolve in response to the goals of market actors. To presume a given structure of exchange is to pre-empt the process by which markets discover optimal trading formats. Yet, proposals to institute commodity trading regimes in radio spectrum sometimes aim to mimic commodity exchanges. While inquiries or experiments about the nature of spectrum trading are usefully pursued in academic research,<sup>50</sup> the idea threatens harm when policies are imposed to achieve specific outcomes. Permissive reforms to allow commodity trading for spectrum rights (illegal under traditional licensing) are efficient; rigging rules to create such trading in a particular format is not.

Wireless market activity sheds light on the manner in which rights are efficiently exchanged under existing rules. Mobile phone networks, for instance, arrange voluminous “spectrum trading,” with users of a network enjoying access to exclusive long-term band rights secured by the carrier. The airwaves used gain value from investments in cellular system infrastructure (base stations, transmission/reception towers, transport links, roaming agreements, applications, handsets, etc.), the coordination of which is supplied, again, by the network operator.

Wireless carriers organize complex spectrum sharing among their subscribers as well as those of other networks,<sup>51</sup> selling access via post-paid or pre-paid subscriptions. Networks offer alternative architectures, technologies and services (to the degree permitted by regulators), and so offer distinct “commodity markets” to customers. Diverse packages sold by rival carriers include bulk sales to mobile virtual network operators who offer still more retail variations.<sup>52</sup> This process resulted in about 4.4 trillion minutes of worldwide traffic in 2004.<sup>53</sup>

To be clear, the conclusion offered is not that commoditization will never be efficient nor that policies

would be wise to preclude it. Rather, it is that competition and survivorship will tend to select efficient transaction models, and that policies should be neutral respecting market structure.

## Conclusion

Mobile phone networks have become the “killer app” of the Wireless Age. Globally, mobile phones now outnumber fixed line connections by nearly two-to-one. New opportunities are unfolding for social growth as even the world’s poorest find themselves linked, at long last, to the international economy.

Yet, regulatory structures erected at the dawn of broadcasting continue in force. The standard regime allocates airwave rights by bureaucratic fiat, characteristically leaving massive portions of potentially useful bandwidth unproductive. Licenses issued to wireless firms, particularly broadcasters, often dictate services and technologies. Entrepreneurs seeking to test innovative applications or business models are deterred.

The economist Ronald Coase critiqued this system of property rights in 1950s research that offered a simple analysis: *Defining ownership rights to valuable assets allows competitive markets to discover efficient ways to organize resources. It works in the rest of the economy, why not in wireless?*

Thanks to the liberalization of licenses issued to wireless telephone carriers, a reasonable facsimile of spectrum ownership can be observed. We find wireless networks rationally evaluating myriad trade-offs, coordinating complex interactions between millions of users and investors, thousands of applications, hundreds of equipment suppliers and scores of technologies. As the usage of one subscriber impacts the opportunities of others, spillovers are carefully evaluated and network access designed – by protocols, pricing, and infrastructure investments – to yield the greatest increment of consumer value.

Today, a great opportunity is at hand. Analog TV stations will go dark as we transition to digital broadcasting. A “digital dividend” is possible. Extremely productive VHF and UHF spectrum will be available for an array of valuable wireless services. Enabling such bandwidth to be efficiently utilized will generate enormous social gains. An opportunity this grand was last seen in spectrum in the 1940s. And squandered.

Coase was right in theory in 1959. Today we have both the evidence to prove it and the chance to extend theory into practice.

## Notes

- 1 This paper was commissioned by Vodafone. All views expressed are attributable solely to the author, who retains all liability for errors or omissions. He would like to thank Roberto Muñoz for many useful insights and inputs. Masha Khazan provided excellent research assistance. Contact: thazlett@gmu.edu.
- 2 Red Lion Broadcasting Co.v. FCC. 395 US 367 (1969).
- 3 Ronald H. Coase, The Federal Communications Commission, 2 JOURNAL OF LAW & ECONOMICS 1 (Oct. 1959). This paper contains Coase’s seminal discovery concerning spillovers and externalities, later dubbed the “Coase Theorem.” But the famous exposition of that proposition came the following year in Ronald H. Coase, The Problem of Social Cost, 3 JOURNAL OF LAW & ECONOMICS 1 (Oct. 1960).
- 4 Nor could the station offer the extra service without going silent were there an economical means for doing both within the same assigned channel.
- 5 Unlicensed, or license-exempt, bands deter entry in a symmetric manner, in that spectrum access is governed via the regulation of equipment. Innovative technologies not approved for use are thereby excluded, pending new frequency allocation rules.
- 6 Thomas W. Hazlett, The Wireless Craze, The Unlimited Bandwidth Myth, The Spectrum Auction Faux Pas, and the Punchline to Ronald Coase’s “Big Joke”: An Essay on Airwave Allocation Policy, 14 HARVARD JOURNAL OF LAW & TECHNOLOGY (Spring 2001) 335.
- 7 Some countries, like Germany, have split the broadcasting function in television, separating the transmission of signals from the production of video programs. Both ends of the business are heavily regulated.
- 8 Spectrum allotted to mobile telephone applications did not change significantly during 2002-2005. In 2006, some countries, including the U.S., plan to make additional license assignments.
- 9 Thomas W. Hazlett and Roberto Muñoz, A Welfare Analysis of Spectrum Policies, Working Paper (April 7, 2006). See also, Thomas W. Hazlett, Jürgen Müller and Roberto Muñoz, The Social Value of TV Band Spectrum in European Countries, 8 INFO 62 (2006).
- 10 Economists estimate that perhaps one-third of auction receipts represent social savings, which are generated if the availability of auction revenue lowers taxes by an identical amount.
- 11 See Hazlett & Muñoz (2006).
- 12 Many developing countries have also been needlessly parsimonious in allocating spectrum rights, as seen in Latin America (see Thomas W. Hazlett & Roberto Muñoz, Spectrum Allocation in Latin America: An Economic Analysis, Working Paper [August 2006]). Since the region is composed entirely of developing economies, it would seem straightforward that regulators would be keen to encourage productive communications infrastructure and enable economic growth. Given the low-to-zero opportunity cost in permitting spectrum to be used for mobile wireless, countries that aspire to prosperity effectively enjoy “free” treasure to spend on this goal.
- 13 The argument goes back to the 1920s, but was first formalized in an article written by a University of Chicago law student in 1951. See Leo Herzel, ‘Public Interest’ and the Market in Color Television Regulation, 18 UNIVERSITY OF CHICAGO LAW REVIEW (1951) 802; Dallas W. Smythe, Facing Facts About The Broadcast Business, 20 UNIVERSITY OF CHICAGO LAW REVIEW 100 (1952); Leo Herzel, Rejoinder, 20 UNIVERSITY OF CHICAGO LAW REVIEW 106 (1952). See also, Ronald H. Coase, Law and Economics at Chicago, 36 JOURNAL OF LAW & ECONOMICS 239 (April 1993); Leo Herzel, My 1951 Color Television Article, 41 JOURNAL OF LAW & ECONOMICS 523 (Oct. 1998).
- 14 Robert W. Crandall, New Zealand Spectrum Policy: A Model for the U.S.?, 41 JOURNAL OF LAW & ECONOMICS 821 (Oct. 1998).
- 15 R.S. Jain, Spectrum Auctions in India: Lessons from Experience, 25 TELECOMMUNICATIONS POLICY 671 (2001).

- 16 This prohibition was later relaxed, but only after virtually all available TV or radio licenses had been distributed administratively. This included more than 1,600 digital TV licenses awarded to analog TV incumbents in 1997. In other countries, various mechanisms have been used to award broadcast TV or radio licenses including auctions or semi-auctions (where money bids are one criterion used, among several, to award licenses), but the general tendency is for broadcast licenses to be treated in a special, more political, manner than other wireless licenses. See Thomas W. Hazlett, *Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?* 41 *JOURNAL OF LAW & ECONOMICS* 529 (Oct. 1998).
- 17 Thomas W. Hazlett, *Property Rights and Wireless License Values*, AEI-Brookings Joint Center for Regulatory Studies Working Paper No. 04-08 (April 2004).
- 18 Glen O. Robinson, *The Federal Communications Commission: An Essay on Regulatory Watchdogs*, 64 *VIRGINIA LAW REVIEW* (1978) 169. The Preakness is an annual American horse race.
- 19 A review of each of the regimes is offered in Hazlett (2004).
- 20 Costa Rica maintains a state monopoly cellular telephone carrier. It is not clear how much spectrum is utilized by this operator, as there is no independent regulator to report the allocation, nor are retail prices reliable as a guide to economic cost.
- 21 Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton, *Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization*, George Mason University Law & Economics Working Paper No. 06-07 (March 10, 2006).
- 22 Giancarlo Ibarguen, *Liberating the Radio Spectrum in Guatemala*, 27 *TELECOMMUNICATIONS POLICY* 543 (Aug. 2003).
- 23 As quoted in Rebecca Buckman, *Unbound Down Under: Wireless Internet Services are Taking Off In Australia, Will They Fly Elsewhere, Too?* *WALL STREET JOURNAL* (Feb. 18, 2005).
- 24 *Ibid.*
- 25 PBBA iBurst Mobile Wireless Broadband Network, Australia, MobileComs-Technology.com: The Website for Mobile Communications; <http://www.mobilecoms-technology.com/projects/i-burst/> (visited April 16, 2006).
- 26 Ephraim Schwartz, *ArrayComm deploys 3G Wireless Down Under*, *INFOWORLD* (July 2, 2002).
- 27 *World's First: TD-CDMA VoIP 'Woosh'-es Into New Zealand*, *TELECOM WEB* (Sept. 15, 2006); <http://www.telecomweb.com/news/1126811800.htm>.
- 28 "Woosh Wireless launched its new generation wireless broadband service in September 2003. Our network is not only a New Zealand first, but also a world first deployment of wireless broadband technology." Woosh Wireless web site, <http://www.woosh.com/ContentClient/WhyWoosh/WhyWooshCompany.aspx> (visited April 16, 2006).
- 29 Peter Nowak, *Woosh—And Your Phone Bill Is Halved*, *NEW ZEALAND HERALD* (Sept. 15, 2005).
- 30 Martin Cave, *Review of Radio Spectrum Management* (Mar. 2002); [www.spectrumreview.radio.gov.uk](http://www.spectrumreview.radio.gov.uk).
- 31 Ofcom, *SPECTRUM FRAMEWORK REVIEW* (June 28, 2005), 38.
- 32 Federal Communications Commission, *SPECTRUM POLICY TASK FORCE REPORT* (Nov. 15, 2002); [http://hraunfoss.fcc.gov/edocs\\_public/attachmatch/DOC-228542A1.pdf](http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-228542A1.pdf).
- 33 Federal Communications Commission Policy Statement, *In re Principles for Reallocation of Spectrum to Encourage the Dev. of Telecomms. Techs. for the New Millennium*, 14 F.C.C.R. 19,868, 19,869–70 (1999).
- 34 SPTFR, 51.
- 35 As deemed by U.S. FCC Chair William Kennard in 2000 (quoted in Hazlett 2001, 337).
- 36 Analysys & Dotecon, *Trading of Radio Spectrum in the European Community: Final Report for the European Commission* (May 2004), x.
- 37 Thomas W. Hazlett, Giancarlo Ibarguen, and Wayne Leighton, *Property Rights to Radio Spectrum in Guatemala and El Salvador: An Experiment in Liberalization*, George Mason University Working Paper No. 06-07 (March 2006).
- 38 European Commission Communication COM (2006) 334 of 29 June 2006 on the Review of the EU Regulatory Framework for electronic communications networks and services.
- 39 The problem is identified in the law and economics literature as "tragedy of the anti-commons." See Michael Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, 111 *HARVARD LAW REVIEW* 621 (Jan. 1998). See also, Lee Ann Fennell, *Common Interest Tragedies*, 98 *NORTHWESTERN UNIVERSITY LAW REVIEW* 907 (Feb. 2004); and Thomas W. Hazlett, *Spectrum Tragedies*, 22 *YALE JOURNAL ON REGULATION* 260 (Spring 2005).
- 40 Thomas W. Hazlett and Roberto Muñoz, *What Really Matters in Spectrum Allocation Design*, AEI-Brookings Joint Center for Regulatory Studies Working Paper No. 04-16 (Aug. 2004).
- 41 *Ibid.*
- 42 M.J. Marcus, discussing the use of interruptible spectrum rights via cognitive radios, explains the problem thusly: "Both of the techniques discussed in this paper involve cooperative sharing of licensed spectrum between existing licensees and new users who would pay for permission. To some this might appear as 'unjust enrichment' of a spectrum licensee who is not using the spectrum they said they needed. However, in the practical world most licensees view their licenses as a "property right" regardless of whether there is a legal basis for this view. It is, at best very time consuming to try to transfer such licensees involuntarily and in practice nearly impossible... Thus it is probably more pragmatic to reward licensees financially for allowing increased utilization of their spectrum resource..." Michael J. Marcus, *Real Time Spectrum Markets and Interruptible Spectrum: New Concepts of Spectrum Use Enable by Cognitive Radio*, Marcus Spectrum Solutions, 1. Strictly speaking, the problem is that the incumbent licensee does not view their license as granting spectrum ownership, meaning that the "property right" they are asserting is premised on their standing within the regulatory jurisdiction – what might be called "veto power." If the licensee enjoyed a standard private property right, it would rationally consider the opportunity to realize gains by selling access to "its" spectrum, as cellular operators do when assigning their spectrum access rights to subscribers, resellers, or third party vendors.
- 43 R. H. Coase, *Comment on Thomas W. Hazlett, Assigning Property Rights to Radio Spectrum Users: Why Did FCC License Auctions Take 67 Years?* 41 *JOURNAL OF LAW & ECONOMICS* 577 (Oct. 1998).
- 44 Harold Demsetz, *When Does the Rule of Liability Matter?* 1 *JOURNAL OF LEGAL STUDIES* 13 (Jan. 1972).
- 45 Note, too, that "transactions costs" are often cited as a problem in using the market to assign rights. Included in such costs, of course, are the definition and enforcement of property rights. The cost-saving antidote is integration of ownership, such that transactions are internalized rather than negotiated between resource users with conflicting interests. This insight is nicely laid out in Harold Demsetz, *Ownership and the Externality Problem*, Chapter 11 in Anderson and McChesney, eds., *Property Rights: Cooperation, Conflict, and Law* (2003).
- 46 Comments by Telecom Italia Group to the Study on Conditions and Option in Introducing Secondary Trading of Radio Spectrum in the European Community, European Commission (Sept. 15, 2004).
- 47 Hazlett, *Property Rights and Wireless License Values*, op cit.
- 48 After many years, a 1970s reallocation of UHF TV Band frequencies was achieved, yielding bandwidth for cellular licenses awarded 1984-1989.
- 49 See Thomas W. Hazlett and Matthew L. Spitzer, *Digital Television and the Quid Pro Quo*, 2 *BUSINESS & POLITICS* 115 (2000).
- 50 See, e.g., K.E. Nolan, L. Doyle, P. Mackenzie, & D. O'Mahony, *Fluid Wireless - Dynamic Spectrum Allocation and Spectrum-Monitoring Application Using Reconfigurable Radio and OFDM*, Proceedings of the 2005 Software Defined Radio Forum (SDR Forum) Technical Conference, Anaheim, CA, USA (Nov. 14-18, 2005).
- 51 Customers of the U.S. carrier Cingular Wireless, for instance, obtain roaming rights with over 100 other wireless phone networks in the U.S., and over 165 networks outside the country. See Comments of Cingular Wireless LLC, Federal

**Prof. Gerald R. Faulhaber**

University of Pennsylvania

Gerald R. Faulhaber\* is Professor of Business and Public Policy and Management at the Wharton School and Professor of Law, both of the University of Pennsylvania; he served as Chief Economist at the Federal Communications Commission from July 1, 2000 to June 30, 2001. His current research includes spectrum policy, file sharing and music copyright, and network neutrality. Professor Faulhaber has been a Visiting Scholar at INSEAD, Fountainebleau, France, the Institut Analisi Economica in Barcelona, Spain, and at Tsinghua University School of Economics and Management, Beijing, China. Prior to his academic career, Professor Faulhaber was Director of Strategic Planning and Financial Management at AT&T, after holding the position of Head, Economics Research at Bell Laboratories.

## The governing regime of spectrum

### Introduction

The use of the electromagnetic spectrum for telecommunications and other functions has traditionally been closely regulated by government agencies in most countries. In the U.S., television and radio broadcasting, microwave transmission, cellular and cordless phones, CB and family radio, amateur (ham) radio, and more recently WiFi and other home networking technologies all operate under frequency assignments, power constraints and location restrictions established and enforced by the Federal Communications Commission (FCC).<sup>1</sup> Generally, broadcasters of radio energy must apply for and receive a license,<sup>2</sup> which sets forth restrictions on the frequency, power limit, and perhaps direction and time of day that the licensee is permitted, and also sets forth the specific use permitted by the license, such as FM broadcasting, cellular telephony, taxi dispatch, and so forth. These licenses are generally time-limited, but there is a strong presumption of renewal of the license at its expiration.

The problem to which government licensing is a solution is radio interference. If more than one transmitter is emitting

radiation at the same frequency in the same location at the same time, then receivers will receive all waveforms and generally be unable to distinguish between the received signals,<sup>3</sup> resulting in an unintelligible signal and bad reception. The government controlled the airwaves (“in the public interest”) and allocated frequencies to specific uses, such as police and fire department radios, AM radios, marine radiotelephones, and taxi dispatch. Within each allocated band, the government (after 1934, the Federal Communications Commission) would assign specific frequency bands to individual users, who obtained operating licenses for specific frequency/location/power/use bundles.<sup>4</sup> For example, the Yellow Cab Co. of Philadelphia would be granted a license to operate at a specific frequency in the taxi dispatch band, in Philadelphia (generally at a specific tower location), at a certain power level, and only for the purpose of taxi dispatch. Operating outside the license parameters was illegal and could result in a fine or license revocation.

## Spectrum management by bureaucracy: “Command and Control”

Over the years, this bureaucratic and political form of resource allocation worked well enough. New uses, such as broadcast television, garage door openers, cordless phones and microwave ovens arrived in a steady stream, but not so fast that new developments in radio technology allowed expansion of the usable spectrum to accommodate these new uses. Prior to 1968, the usable frequency band was 0-1 gigahertz; today, it has expanded to well beyond 5 gigahertz. Unfortunately, the new demands for wireless services are significantly straining this capacity. More particularly, the huge inefficiencies engendered by 75 years of bureaucratic spectrum management are manifest in large swaths of spectrum licensed but greatly underutilized.<sup>5</sup> Since it is licensed, it cannot be used without the licensee's and the FCC's permission. And even if the licensee would be interested in selling or leasing the spectrum, significant barriers exist to that bandwidth being put to its highest valued use. In particular, almost all spectrum licenses have use restrictions that specify the particular use to which that bandwidth must be put, such as taxi dispatch, broadcast television, police radio, etc. The transfer of licenses, even subject to these restrictions, is subject to FCC approval and scrutiny. The sorry result is that cellular companies are straining within their bandwidth restrictions and are unable to obtain new bandwidth to expand their businesses, while large amounts of bandwidth are tied up by UHF television broadcast licensees (for example) broadcasting into marginal markets in a world increasingly dominated by cable and DBS satellite.<sup>6</sup>

Even in spectrum bands where there is actual commercial use, regulatory restrictions may severely hamper efficient deployment. For example, standard VHF TV broadcasting serves a rather narrow audience, as over 85% of US households receive their TV via cable or satellite. Is this likely to be the highest valued use of this large swath of spectrum? Empirical estimates of net consumer surplus that result from moving 200 MHz of TV spectrum to cellular use in Europe are very substantial (see Hazlett et al. (2006)), suggesting the current use of these bands involves a rather large opportunity cost, relative to its alternative use. Thus, even if current spectrum use is actually somewhat useful, it may not be the most valued use, which of course the market would disclose.

Bureaucratic allocation of spectrum is not the only source of the gross inefficiencies in spectrum use. The FCC is also the locus of dispute resolution, and disputes often take years to resolve and even then are subject to court challenge. A single notorious example makes the point: the NextWave Communications case, in which NextWave bid on a very large swath of spectrum at auction and soon after

declared bankruptcy (see FCC (2003) briefly discussing the history of the case). The FCC reclaimed the spectrum and re-auctioned it, only to have a bankruptcy court claw back the spectrum as a NextWave asset. The FCC challenged this ruling, eventually resulting in the Supreme Court upholding the bankruptcy court. A complex negotiation then followed to sort out what would happen to this spectrum. The dispute lasted over five years, during which time this huge swath of spectrum was unavailable to cell phone firms and customers at a cost of hundreds of millions of dollars. While this case is particularly egregious (and well-known), dozens of similar examples demonstrate the inefficiencies of regulatory dispute resolution.<sup>7</sup>

The root causes of bureaucratic inefficiency were thus (i) *inflexible* use of radio spectrum, and (ii) slow and *costly dispute resolution* of interference problems. Each cause led to static efficiency problems, as spectrum bands could not migrate to their most efficient use as needs and technology changed. Additionally, each cause led to *dynamic* efficiency problems, as incumbents favoring older technologies were favored by the regulatory process so that new entrants with new technology, or even incumbents wishing to try new technology, found the forces of the status quo very difficult to overcome.

It is important to note that these root causes do not arise because the staff of the FCC is incompetent or unaware of these issues. These causes cannot be removed by hiring better staff, reorganizing the FCC, rewriting the laws governing the industry, or transferring its functions to another agency. The root causes are an integral part of the political economy of regulation, at least in the US,<sup>8</sup> and are likely to be replicated in any domain to which pervasive regulation applies.

## Can we do better? The Coasian answer: Markets

Ronald Coase answered this question in his famous paper (Coase (1959)) before anyone really asked it: place all licenses into private hands and let the market allocate licenses for specific frequency bands/location/power to ensure that these licenses are put to their highest valued use. Licensees would hold the license as property, with technical restrictions (power/frequency/location) but not use. He noted that the extant system of bureaucratic allocation was exactly the wrong way to do it, and this was a task for which markets would yield a far superior outcome. As with most visionaries, he was thought a crackpot at the time, even by his colleagues at the University of Chicago: Professor Harry Kalven (1967) called his work “an insight more fundamental than we can use.” FCC Commissioners were blunter and less kind. But the logic of his suggestion

was unassailable:<sup>9</sup> a fundamental tenet of modern economics is the efficiency of market allocations (absent market failure) relative to the gross inefficiency of government allocation mechanisms. After years of tiresome preaching by economists, policymakers in some countries were willing to give markets a try; in 1989, New Zealand auctioned off its spectrum, and in 1993 the US Congress gave permission to the FCC for limited licensing via auctions, including digital cellular telephony. However, the rights granted to licensees at auction are quite limited and do not constitute property. Licensees do not own the spectrum license, nor are they permitted to trade or sell their licenses without FCC permission. While auctions are an interesting first step, there is a long way to go before spectrum licenses can be freely traded in the market for whatever use the licensee wishes within the technical parameters of the license.

The key to Coase's answer is that markets provide *flexibility* in the use of spectrum, exactly what government licensing does not. By permitting licenses to move without restriction from less valued uses to more valued uses based on individual transactions, markets would lead to a more efficient allocation of spectrum while still controlling interference (via technical restrictions in licenses).

As we survey the wreckage of the great government-controlled economies of the 20th century, the logic of markets is even more evident than in Coase's time. The fall of the Soviet Union in 1989 began a somewhat bumpy transition period for the countries of Central and Eastern Europe toward market economies. Some have been so successful that they are now member states of the European Union. The explosion of demand for wireless devices and services could well be the start of a transition in the US (perhaps not as bumpy) for spectrum toward a market economy as well.

## Can we do better? The Techno-utopia of the commons

In the past five years, however, a different model of "fixing" the command and control system has been developed, primarily by technologists and legal scholars. This model depends critically on new technology that enables "smart" radios to control interference themselves. The advocates of this position argue that if the hardware built into the devices (such as handsets) can control interference, then there is no need to establish licensed frequency bands to control interference. Rather, we can permit all (or perhaps most) spectrum to be a "commons" in which anyone can use any device provided it is equipped with the hardware that controls interference. One view is that this takes present-day unlicensed bands to their logical conclusion;

we control interference in the unlicensed bands by limiting power (built into the hardware) and by using protocols such as "listen before talk" (also built into the hardware). With the new technology, we have even better means of controlling interference via hardware, so everything (or nearly so) can be unlicensed: a commons.

There are several stratagems for accomplishing this. The FCC has traditionally created low power spectrum rights which create minimal interference with the primary licensee. Such rights have traditionally been a locus of dispute and regulatory lobbying. A newer version of this is Ultra Wideband (UWB), in which power levels are so low that transmissions throughout a wide swath of spectrum are virtually undetectable by standard receivers. However, encoding of the signal permits UWB receivers to detect and decode the signal; in essence, the communication is interference-free. The FCC has recently permitted UWB to operate in the US, although not without controversy. Advocates of UWB desired to transmit at a higher power, while licensees who might suffer interference insisted on lower power. Establishing the "noise floor" below which UWB can transmit is a disputatious regulatory issue.

Another new approach is cognitive, or agile, radio. With this technology, the transmitter detects which frequency bands are currently unused, and chooses one such band. Should another user (such as the primary licensee for this band) start to use the band, the cognitive radio would immediately vacate the band and switch seamlessly to the next unused band (much as a cellular telephone user is seamlessly switched from one cell tower to another as she moves about during a call). This technology would permit high power transmission but control interference by instantly vacating a band when the primary user demanded use. Cognitive radio promises to improve spectrum utilization through dynamic allocation of frequencies, compared to the static allocation of frequencies implicit in licensing. As the name implies, the new technology permits real-time spectrum allocation in response to demand, rather than *ex ante* static allocation.<sup>10</sup>

As appealing as this viewpoint is to those with a preference for technical solutions to societal problems, it depends crucially on the invention and commercialization of technologies that have not yet come to pass. These technologies exist on paper or in prototype, and have yet to stand the crucial test of market deployment and acceptance. Yet they are not new. The fact that we do not see them in the market might suggest that their highly touted capabilities may not survive the rigors of the real world.

The potential for these new technologies to vastly improve the efficiency of spectrum use is very promising. However,

there are three points to keep in mind in evaluating the role of these technologies. First, none of these technologies are currently deployed in a commercial setting; they exist in theoretical papers, lab results, and early field tests.<sup>11</sup> Second, while these technologies may enable a commons regime (if they completely supplant existing technology), they are perfectly capable of deployment in the context of a licensing/property regime; they are a necessary but not sufficient condition for a commons regime. Third, there are many applications for which the new technologies are simply an unnecessary expense: TV/radio broadcasting, airport radars and a host of other high-powered dedicated uses are much better served via exclusive licensing. This is not to imply that these technologies will not become increasingly important; they certainly will. But it does mean that (i) this won't happen tomorrow; (ii) they can work their efficiency magic in either a commons regime or a property regime; and (iii) they are very unlikely to supplant exclusive licenses for all or even most uses.

The enthusiasm of the early work on commons and the new technologies suggested that all of wireless communications could be managed as a commons regime, doing away with all exclusive use and permitting users to self-manage their own frequency spaces through voluntary limited commons and protocol agreements among manufacturers. The early papers suggested that there may be some limited role for regulation, to ensure the proper functioning of the commons, but that this regulation was to be "light." The commons was to be largely self-regulating, drawing on ideas of communities managing a resource for mutual gain. There were to be no intermediaries, such as cell phone companies or other service providers. Services would be provided by the users and the devices they used, and interference would be controlled using protocols embedded in hardware.

This vision appears strikingly similar to the early Internet of John Perry Barlow (1996), and the early authors certainly come from this tradition. There are several related policy ideas that commons authors share, such as opposition to copyright and other intellectual property mechanisms, and a general concern over the degradation of the intellectual commons in American life.<sup>12</sup> These writings have a strong tenor that ownership (of spectrum license, of copyrights, of patents...), especially by corporations, leads to exclusion and resource underutilization, while commons ensures full access untrammelled by profit-seeking intermediaries.<sup>13</sup> The commons is asserted to be a superior mechanism for encouraging free speech, although no proof is offered for this highly debatable proposition.<sup>14</sup> Similar arguments are used to illustrate how the Internet, the quintessential commons, is being taken over by corporations.<sup>15</sup>

The model for the commons approach is the FCC's so-called unlicensed spectrum, in which any device may be used by anyone, provided it meets strict FCC technical limitations. A number of services were introduced in the 1970s and 1980s such as cordless telephones, garage door openers, and wireless weather stations (in which an outdoor sensor unit, mounted on the roof or outside wall of a home, communicated wirelessly with an indoor display unit). Most of these services were offered using "Part 15" devices, limited to certain frequency bands.<sup>16</sup> They share a number of properties: (i) no license was necessary for a user to operate the device; (ii) a relatively small number of manufacturers produced the actual radio emitters, each of which was type-certified by the FCC; and (iii) most important, power levels were quite low. This latter property was crucial to the control of interference; users would not want their cordless phone conversations picked up by their neighbor's cordless phone, nor would they want their garage door opener to open their neighbor's garage door.<sup>17</sup>

Perhaps the best-known success in this unlicensed spectrum is WiFi, a high-bandwidth short-range (100-250 ft) wireless technology which has become a standard for wireless home networking. It is also offered in public spaces, such as coffee shops, airports and hotels. Some municipalities have announced plans to deploy WiFi "hotspots" on utility poles and allow residents to access the Internet for free (or at low cost).<sup>18</sup>

The successful deployment of WiFi has been put forward as a strong argument that a commons approach, in which interference is controlled by hardware, can work. However, it is no better an argument than the even stronger deployment (in terms of household use) of cordless phones and garage door openers. All these services use very low power devices, primarily designed for use within a household or establishment, and all have wide distribution. Yes, WiFi interference is controlled by hardware, but then so is garage door opener and cordless phone interference controlled by hardware. Yes, WiFi is rather widely deployed and is a successful product in the market. But then garage door openers and cordless phones are even more broadly deployed and also successful products in their market as well. But the success of these products is quite modest compared to the success of, say, wireless telephony, which has taken off worldwide.

## The property rights vs. commons debate

This debate has been positioned as “property rights vs. commons”; it has also been positioned as new technology (favoring commons) vs. legacy technology (favoring licensing).<sup>19</sup> In this section, the question is parsed with somewhat more nuance; there appears to be a number of questions within the dispute, most of which are not really in dispute. This permits a focus on the core issues truly in dispute; therefore I first discuss the questions upon which we mostly agree.

### New Technology

Much of the power of the commons advocates’ argument is that the latest technology enables, indeed may demand, a commons approach to spectrum. The arguments adduced include agile radio and ultrawideband as requiring a commons, and use of WiFi as a new technology introduced in the unlicensed space as the commons success story. They also suggest that the deployment of mesh networks can lead to increases in bandwidth per user as the number of users increase.

It is noted above that these new technologies have some way to go to demonstrate they are as transformative as their advocates claim, but let us *arguendo* assume the truth of their assertions. Does this imply that new technologies only arise in an unlicensed environment, or that technological innovation is more likely to arise in a commons? Does this imply that these new technologies can only be accommodated by a commons regime? In both cases, the answer is no. Regarding the environment of innovation, there have been extraordinary advances in cellular technology in antenna design and bandwidth utilization, spurred by competition and spectrum scarcity (albeit regulation-induced). There is also very obvious innovation in cellular handsets and data capabilities in this market, suggesting that innovation has many outlets, not merely that of the commons. Regarding the deployment of these new technologies in a licensed regime, each of these technologies is easily deployable within a licensed model. The fact is, *new technology is agnostic* regarding the legal and regulatory framework within which it is deployed. These new technologies neither require a commons regime for their (as yet to develop) deployment, nor do they demonstrate the superiority of unlicensed spectrum as a source of innovation.

### Is one model best (or even feasible) for all spectrum uses?

The current array of wireless applications is simply dizzying, from cellular phones, broadcast TV and radio, WiFi, public safety radio, scientific and medical equipment to GPS systems. These applications are high power, low power, one-way broadcast, two-way interactive, people-to-people

voice and data, machine-to-machine, occasional vs. constant use, and all combinations thereof. Some uses are particularly suited to exclusive use, such as high powered radar in constant use, TV and radio broadcast (again, in constant use). Some uses are particularly suited to commons, such as low powered occasional uses such as garage door openers, cordless phones and home networking. And this is not the end; the uses of wireless are likely to continue their growth, as demands for new services are discovered and developed in the U.S. and abroad. But this expanding set of uses favors neither a commons approach nor a property rights approach. Indeed, it is the realization of this breadth of uses that has led advocates on both sides of this dispute to agree that both a commons and an exclusive use licensing approach somehow need to coexist for the foreseeable future.

It should also be noted that applications currently deployed in unlicensed spectrum could as easily be deployed in licensed spectrum should a market for licenses develop. For example, garage door openers currently operate in Part 15 unlicensed spectrum, a model which is quite successful. However, if licenses were available in regional and national markets, firms that produced garage door openers could purchase small frequency bands (since this is a very narrowband service) throughout the country and design their transmitters for their purchased frequency. Most likely, an industry trade association could purchase the spectrum, which would then be shared among its members (a form of limited commons). Thus, this service (and others like it) can work equally well under either licensed or unlicensed management.

### What rules are needed in commons? In property rights? Who sets the rules?

Whoever controls a band of frequencies in a particular location manages that band, and her management choices are many. For example, is the frequency band licensed or unlicensed? Are there rules governing the use of the spectrum (such as use constraints for licensed bands or power limits for unlicensed bands)? Who sets and administers the rules? Are there social norms among the users that control on-air behavior, such as CB radio and ham radio? Is there a payment for use of the band? If so, to whom? If licensed, does the licensee exclude other users? If unlicensed, do user groups exclude others?

Under the current regime, both licensed and unlicensed frequency bands are subject to rules, beyond the frequency/location/power bundle of rights. In the case of unlicensed bands, these rules may be built into the hardware but they are nevertheless real.

While early advocates of the commons suggested that commons would be self-managing and require no rules imposed by governments or private parties, there is now general acceptance that some rules for unlicensed bands are required, although commons advocates prefer "light regulation" to accomplish this.<sup>20</sup> There is also the suggestion that for some bands, users may well organize themselves, enforcing self-adopted rules through non-legal mechanisms. In fact, this has occurred in the amateur radio band,<sup>21</sup> in which a group of dedicated users follow historically adopted practices and face group sanctions should they not follow these practices. This closely parallels self-policing in other well-defined groups of commons users, such as cattle ranchers in the western U.S. who use public lands to graze their cattle.<sup>22</sup> Far from being rule-free, such arrangements are usually quite complex and even formal.<sup>23</sup>

The point here is that there will be rules; the only question is who establishes and enforces the rules. Will the rules be set by a private licensee, by a government regulator such as the FCC, or a user/producer group such as ham radio operators or garage door opener manufacturers? While one might speculate that rules set by user groups or manufacturers are more beneficial than rules set by private or regulatory controllers, there is no reason to believe this is the case. User groups and manufacturer groups often have motivations that may not coincide with the well-being of the entire group of users or potential users and may be quite inefficient. For example, manufacturers could adopt rules that constitute entry barriers to new competitors, thus preserving oligopolistic market power. This assertion that there will be rules in any spectrum now seems to be accepted by both sides to the dispute.

Another issue is the price at which spectrum will be made available. Early commons advocates took their cue from current unlicensed spectrum, in which there is no charge for spectrum use.<sup>24</sup> Of course, there is a charge for the devices that use the spectrum, such as the cordless phone and the WiFi access point. Further, there is a cost: since the FCC is the current monitor and enforcer of its own standards, it expends resources to make the rules and to enforce the rules. For example, during the CB radio craze of the mid-1970s, the FCC was receiving about 35,000-50,000 complaints per year, usually from owners of TV sets complaining of broadcast interference.<sup>25</sup>

The costs to establish the rules and then enforce them could be substantial, and there is no reason to expect that taxpayers would continue to bear these costs. Moreover, there are opportunity costs of spectrum use: the Part 15 frequency bands have many alternative uses, such as cellular telephony. Thus, users of unlicensed spectrum are imposing an opportunity cost on the economy, even if there is no actual cash flow. User fees (similar to those charged for many other public services, such as National Parks) may be a more

appropriate way to cover these costs. The point here is that the property rights vs. commons debate is not about price. Commons advocates are quick to point out that this is not about "getting free stuff." It appears the "free/not free" is not really part of this debate.

The core of the argument for commons seems to be open access to all. Commons advocates assert that exclusive use licensing will necessarily lead to, well, exclusion. Only licensees will have access to the licensed band, and others will be excluded. In a commons, everyone will have access. Yes, there will be rules, and there may even be a price, but open access to all is the touchstone of the commons argument.

Is it true that commons always implies open access? As a general rule, not all commons are necessarily open to all. For example, cattle grazing on "open" public lands is often quite limited by rules. A non-member will generally not be able to drive up with five head of cattle to let them graze on such lands, as it constitutes a limited commons. But it is certainly the case that Part 15 use of the 2.4 GHz band for WiFi is indeed open to all, and this is what commons advocates have in mind.

Is it true that exclusive use licenses necessarily lead to a closed system? There are cases in which this is true: an airport operating a radar system will not share its spectrum with anyone else, nor will an FM radio station. However, much spectrum held by licensees is actively marketed by those licensees in order to attract as many users as possible. Consider, for example, cellular telephony. Each wireless carrier offers to provide service to anyone; no one is refused (although billing arrangements may vary). Carriers offer flexibility regarding handsets; a check of Verizon Wireless' website revealed the firm offering twenty-seven different handsets from ten different manufacturers, with a wide variety of features and functions.<sup>26</sup> It is hard to imagine access more open.<sup>27</sup>

But the commons advocates rely on the Internet's "end-to-end" principle,<sup>28</sup> in which anyone may launch any application they wish on the Internet.<sup>29</sup> But this is not observed in radio; any device intended for use in the spectrum must either be controlled by a licensed user or be type-certified by the FCC.<sup>30</sup> This is not simply a meddling regulator; devices which do not meet standards may well cause harm to other users. Approval of devices is the norm in unlicensed bands. In the PCS cellular band, the licensee determines what devices it approves. This is a bit more restrictive (and a great deal more efficient) than type-certification, but it is difficult to build a case for open access in unlicensed as compared to licensed based on this small difference.

In fact, current PCS cellular services are quite close to what the FCC has termed "private commons,"<sup>31</sup> privately licensed

spectrum made available to all (under conditions determined by the licensee). The only difference is that the FCC envisions that the licensee would not provide infrastructure, using instead a low-power mesh network architecture. But the openness and availability of diverse technologies appears the same. The only difference appears to be whether the system infrastructure is contained within the user device or not.

Hence, there seems to be general agreement that both licensed and unlicensed spectrum will be subject to rules. In unlicensed bands, the FCC (and possibly device manufacturers) will set the rules; in licensed bands, the licensee will set the rules. The issue is not whether there will be rules or not; the issue will be who sets the rules. Additionally, it is likely that both licensed and unlicensed frequency bands will carry a price, unless explicitly subsidized by the government.<sup>32</sup> The role of open access, strongly emphasized by commons advocates, may actually be well-served in certain licensed bands such as cellular telephony, for the simple reason that licensees find it most profitable to offer services to everyone on similar terms and conditions, although this latter point may be more controversial.

Are there differences in management between property rights/licensed and commons/unlicensed? In fact, the differences are rather profound. In the licensed arena, both private and public agents may hold licenses. For example, police departments, the military, and Federal Aviation Agency air traffic control may hold licenses, as well as TV and radio broadcasters, cellular telephone firms, and cable TV firms. The licensee may use its license exclusively; for example, cable TV network providers use satellite radio channels to transmit TV shows in real time (or on delay) to their various franchisees. Broadcast networks also use satellite channels to distribute material to affiliates. They use these channels continuously and have no interest in sharing. Likewise, air traffic control is not interested in sharing its frequencies. But licensees could also open their spectrum to everyone, such as occurs in cellular, or to some subset of users, such as aeronautical radio (in which only members can use the spectrum). Government licensees<sup>33</sup> can choose to open their spectrum to all, such as Part 15, or to some, such as ham radio operators. Thus, a property rights regime could accommodate both private and public ownership of licenses and could accommodate exclusive use and various forms of open access spectrum, including government-managed commons.

A commons regime, however, has virtually no other management option than . . . commons. Exclusive use is not possible, nor is private licensing. A commons regime is forevermore government controlled and non-exclusive. As a result, spectrum devoted to property rights/licensed has a rich set of management options available, including government-owned and managed commons.<sup>34</sup> Spectrum

devoted to commons has only one management option: commons, subject to regulatory oversight. On the management flexibility dimension, a property rights regime has a decided advantage. This suggests that some form of licensing will be with us for the indefinite future, even in a world dominated by commons.

### Overarching Legal Regime

Since traditional command-and-control regulation is the regime from which all reformers, both academic and practical, flee, it can be removed from further consideration. Today's regime is far enough away from traditional regulation that a reversion to it is not a serious policy option. The commons regime, while attractive to some, is lacking in flexibility that virtually all disputants agree is necessary. If the overarching legal regime is a commons, then there is no management option for exclusive use, either public or private; since many uses are most efficiently deployed using exclusive use, a commons regime must also be removed from consideration. The analysis therefore suggests two possible legal regimes: (i) a property rights regime, in which government control is strictly limited to government-owned licenses; and (ii) a commons regime with some licensed spectrum, all under government regulation. The difference between them is significant; in (i) the government only controls that which it owns, just like any other licensee. In (ii) the government regulates the entire system, including how much spectrum is allocated to unlicensed vs. licensed, terms and conditions of the licenses, power limits, uses, and protocols used in unlicensed, and how to accommodate new technologies in either.

The actual mechanics of how legal regimes work is messy and uncertain. While property rights advocates assume that the costs of a property rights system (dispute resolution, transaction costs, etc.) are low to nil, this need not be the case; cost must be identified and estimated. Likewise, commons advocates assume that if commons are not totally self-regulating then "light" regulation will solve the problem, all at low cost. Again, this is surely not the case; the costs must be identified and estimated.

Neither of these regimes exists today; they are best viewed as possible target regimes toward which public policy could help us move. In the US, today's regime is a mix of command and control, some auctioned (but not owned) licenses and some unlicensed spectrum, and is thus far from either of these target regimes. As we move away from today's unsatisfactory regime, public policy needs a clear target that yields the most net benefits for the economy and society; it is the purpose of this paper to help assess which of these targets best meets this objective.

## Regime change - Finding the answer

In order to assess which regime will lead to greater economic and social value of spectrum use, we examine each of two issues: first, efficiency, including (i) spectrum placed in highest valued use; (ii) transaction costs; and (iii) dispute resolution. Second, robustness and adaptability to innovation, including (i) flexibility to accommodate changing technologies; and (ii) flexibility to accommodate changing demands. This requires that the properties of both regulation and markets be made explicit, so that a comparison on these four dimensions is possible. I first make clear precisely what the differences are between a property rights regime and a regulated mixed regime. I then examine how each of these issues is expressed in the two regimes; I find that the property rights regime outperforms the regulated mixed regime in almost every regard.

A brief statement of the differences between the two candidate regimes is in order prior to a comparison of their characteristics.

### Property rights

Under a property rights regime, specific rights governing transmission of radio energy and freedom from impinging radiation are defined for each frequency band and geographic area, and licenses are owned by either private individuals or firms, or by public agencies. The licensee has the right to operate radio systems within the constraints imposed by the license, which would allow complete flexibility of use within technical interference constraints. The licensee may buy additional licenses, sell the license, subdivide the license, and rent/lease all or part of the license. A licensee may use the licensed spectrum for its exclusive use; it may also use the spectrum to offer services involving other parties (customers) either with or without charge. Such uses include commons-type open access. If a licensee's spectrum is available to others, such as a cellular phone system or a WiFi-type home networking system, the licensee (public or private) may establish whatever rules, regulations, and obligations on users it deems fit, within the overall constraints of its license. In this regime, behavior within the bounds of a license is governed by the licensee, be it private, corporate, or governmental. Behavior among licenses is governed by the market, supported by the courts for dispute resolution.

### Regulated Mixed Regime

In the mixed regime, specific rights governing transmission of radio energy and freedom from impinging radiation are defined for each frequency band and geographic area, and the regulator (say, the FCC) specifies which bands and areas are to be licensed and which bands are held in common as unlicensed. Changes in the allocation between licensed and unlicensed would also be under the control of the FCC. Licenses are owned by licensees and can be bought, sold, subdivided, aggregated, and leased by licensees. However, disputes among licensees would continue to be resolved, as today, by the regulator. The FCC would be able (but not likely) to modify the terms of licenses or even revoke them. Frequency bands held in common would be individually managed by the FCC, and may differ in operating characteristics permitted and may be limited in who may use these bands and/or what uses are permitted in the bands. Disputes among users of the commons would be resolved, as today, by the regulator. Further, selection of protocols and formats to be used to avoid interference would be decided by the FCC, as it does today. The FCC would also control the boundaries among commons uses as well as between commons and licensed uses. The FCC would be able (but not likely) to impose use restrictions for either licensed or unlicensed bands. In this regime, the FCC would have much the same power as today to designate frequency bands as licensed or unlicensed, change these allocations over time, resolve disputes in both licensed and unlicensed, and set the rules and obligations for commons/unlicensed spectrum. The only difference with today's regime is that licensees would have much greater freedom to buy, sell, subdivide, aggregate and lease their licenses. In all other respects, regulatory authority would remain in place.

In brief, the critical difference is the role of regulation. In the property rights regime, regulation is largely replaced by careful construction of property rights to avoid interference, operation of the market, and support of the judiciary for dispute resolution. Regulators are relegated to setting rules and regulations only in frequency bands for which they are the licensees, and their power is no more than that of any other licensee. In the regulated mixed regime, the regulator continues its overarching role of allocator of frequencies, arbiter of protocol and technology choices, and adjudicator of disputes, as it does today. The regime does offer licensees much greater freedom to use the market to buy, sell, and lease their licenses than the current situation, but transactions would still be subject to ultimate regulatory control.

## Property Rights vs. Regulated Mixed Regime: How Do They Compare?

### Efficiency: Does spectrum migrate to its highest valued use?

If both regimes functioned as their proponents envision, then all valued uses would be accommodated and relative efficiency is not an issue. However, this need not be the case. As more applications become available and demand for spectrum increases, then it is likely the demand may exceed supply; this is particularly true for especially desirable spectrum with valuable propagation properties (sometimes referred to as “beachfront” spectrum).<sup>35</sup> The new technologies such as agile radio and mesh networks may keep users from interfering with each other, but crowded spectrum bands still can congest and users be blocked or delayed in their communications. The new technologies allow users to make the maximum use of spectrum bands, but they cannot solve the problem of real shortages. In the short run, it is likely that freeing up the spectrum using either commons or property rights will result in excess capacity (relative to today, with its artificial scarcity). In the medium- to long-run, it is much more likely that there will be multiple bands in which scarcity is the rule and some form of rationing is required. In this world, the property rights regime is the clear winner: prices will adjust upward to reflect scarcity value, and only the more valued uses will be deployed.<sup>36</sup> Within the mixed regime, commons, on the other hand, will result in service degradation for all, a well-known result called the tragedy of the commons. The result is that as long as there is excess capacity in all bands, then both regimes do equally as well. But in the more realistic world of scarcity, the property rights regime assures that spectrum moves to its most valued use, and the mixed regime results in congestion, service degradation and the tragedy of the commons.

A rather more serious form of inefficiency results from the process and actions of regulation itself.<sup>37</sup> If a regulator has jurisdiction over particular markets and technologies, it has the potential to use the coercive power of the government to intervene in markets. This power is highly valued by market participants, and they will lobby the regulator to intervene on their behalf, at the expense of their competitors. Such lobbying is not only targeted at the regulators, it is also targeted at legislators (either state or Federal) that control the regulators budgets and can enact laws overturning regulatory rulings. The regulatory process is designed to listen to all sides, consider carefully the merits as well as the power of the lobbying participants and the likelihood of a successful court challenge, and reach a conclusion, often after years of comment, reply comment, deliberation and reconsideration. Participants use the regulatory/political/judicial process strategically to achieve corporate or group objectives.

There are some frequency bands in which the FCC's hand has been very light; garage door openers and outside home weather stations, for example. But there were very substantial disputes over the introduction of spread spectrum technology in cordless phones, for example; it appears that if the market does not involve a great amount of market value and there are no technological changes involved, then minimal regulation may emerge.

Generally, there is no reason to suspect that regulation under the regulated mixed regime will be much different than it is today, except licenses will be much easier to transact under this regime. But the same forces operating in today's regulated environment will continue to operate in the regulated mixed regime and will be mediated in much the same way. In sum, *as long as there is a regulator to complain to, market participants will complain and the regulator will be forced to respond. The scope and intensity of regulation inevitably expands to meet the demands of market participants.*

The result: not only is a commons inferior to a market for allocating scarce resources (hardly a new observation), but the presence of regulation adds very substantially to the inefficiency of the regulated mixed regime compared to that of the property rights regime.

### Efficiency: Transaction Costs

Commons advocates point out that markets for licenses have costs: buying and selling a license involves costs which would not be incurred in the unlicensed portion of spectrum in a mixed regime. Both Benkler<sup>38</sup> and Werbach<sup>39</sup> note that transaction costs in a property regime are likely to be large and thus suggest the rejection of a market-based property rights regime for that reason (among many others), while neither author offers evidence of large transaction costs nor do they even define “large.”

In the recent past, spectrum transactions have been difficult to execute because of regulatory limitations, and so have been more costly than would be the case in a full property rights market. Even so, a great many transactions occurred; Nextel, for example, purchased over 40,000 SMR licenses to put together its national network, apparently not overwhelmed by transaction costs.<sup>40</sup> A number of large wireless firms bought, sold and swapped spectrum around the country in order to build their national networks, again apparently not overwhelmed by transaction costs,<sup>41</sup> in spite of the difficulty of transacting an FCC license. The empirical evidence suggests that the transaction costs of spectrum in the late 1990s did not prevent a very active market in spectrum licenses, even though these costs are greater than would be expected in a full property rights market.

### Efficiency: Dispute Resolution

Perhaps the most important but most confusing and difficult efficiency issue to address is that of dispute resolution. Disputes take several forms. A classic dispute over a specific interference problem involved Nextel, a wireless cellular provider, and numerous public safety departments around the US in the 800 MHz spectrum. Another form of dispute could be the introduction of a new technology, such as wideband. A third form of dispute could be over standards and protocols, in which one or more parties wish to change an existing standard or protocol and need a means of ensuring that all parties move to the new standard.<sup>42</sup>

It is easy to assess how a regulated mixed regime will handle disputes; it will handle them pretty much as it does today. The Nextel 800 MHz dispute mentioned above involved licensed spectrum. Unless the regulated mixed regime explicitly moves to court-enforced property rights for the spectrum under licensed management, we can expect the FCC to continue to resolve disputes between licensees in much the same way as the Nextel 800 MHz dispute was resolved, typically a long and costly affair with much intervention of outside parties seeking strategic advantage through the regulatory process.<sup>43</sup>

In the case of unlicensed spectrum, the FCC regulatory process has also established a track record relating to new technology introduction. This is particularly important to the commons argument, since the FCC cannot step back from dispute resolution in unlicensed spectrum in the regulated mixed regime. In her excellent article, Ellen Goodman notes: "For example, it took three years and two rulemakings for the FCC to change its ex ante controls for unlicensed operation to allow new, nonconforming technologies into the unlicensed bands." The footnote that follows explicates this long drawn out affair of regulatory cut and thrust involving the introduction of a new technology into a commons regime. It would appear that even in commons-managed spectrum, the regulatory process is not particularly friendly to new technology introduction. But in the future commons, this scenario will no doubt be the norm; again, "light regulation" is an oxymoron.

Commons advocates suggest that in practice industry groups would find it in their interest to cooperate, so that FCC regulation is truly "light": merely approving what far-sighted industry groups agree to. Unfortunately, this is not the case. Goodman continues: "Even when industry groups are responsible for agreeing to protocols that the regulator merely approves, standard setting has often proved to be staggeringly slow and acrimonious."<sup>46</sup> The footnote that follows explicates the lengthy proceedings involved in setting standards for digital television.<sup>47</sup>

Unfortunately, the commons presents a special difficulty in dispute resolution. In a property rights regime, each licensee has only a few neighbors, those that would be most affected by a violation of the license terms and conditions. In a commons regime, there could well be thousands of users of a particular commons. If a particular user decides to "cheat," perhaps using an illegal transmitter with much higher power than permitted in the commons, this will interfere with other users. However, since the interference impinges on many users, there will be a free rider problem with enforcement. Who will bother to file a formal complaint to the FCC, when everyone expects someone else to undertake the costly complaint process? If commons users are given the right to sue the interferer, the problem becomes even worse.<sup>48</sup> Who will bring a costly suit against the interferer when everyone expects someone else to bring the suit? This is the enforcement tragedy of the commons: with lots of commons users affected by the interference, no one user has an incentive to enforce their commons rights.

In a property rights regime, the specification of the property rights becomes critical. Following De Vany,<sup>49</sup> I assume that at a minimum each license has a location, a frequency band, and power levels specified; additionally, a license could also be limited by time of day or direction (relevant for satellite reception, e.g.). It is useful to think of both location and frequency as an allotted space in which the licensee's power across the boundaries of this space are explicitly restricted.<sup>50</sup> For example, power emissions into adjacent frequency bands would be specified,<sup>51</sup> and power emissions across a geographic boundary would also be specified (in watts/m<sup>2</sup>).<sup>52</sup> In both cases, the power limits may be expressed statistically: emissions across a geographic boundary should be no greater than x watts/m<sup>2</sup> no more than y% of the time.<sup>53</sup> These restrictions on transmitting in one frequency band and location become rights for those in adjacent frequency bands and locations. Goodman argues persuasively that the use of nuisance law to resolve spectrum property disputes would be costly and inefficient.<sup>54</sup> Therefore, I propose that license restrictions would have the force of trespass law; should a licensee violate one of its restrictions, its neighbors could obtain injunctive relief without a showing of damages. Could these restrictions be enforced by neighbors? Should a licensee detect interference, either it or a third-party measurement service could objectively measure and record violations. In fact, it may make such measurements routinely, without waiting for allegations of interference violations.

The "bright line" trespass rule together with the ease of measuring violations suggests that courts would find dispute resolution straightforward:<sup>55</sup> technical evidence of violation is presented, no damages need to be proved, no

balancing of interests is required, and an injunction follows.<sup>56</sup> In fact, in such a trespass law regime, few cases would ever reach the court since the outcome would be foreordained. Only the cases with questionable evidence would move forward. Thus, simple dispute resolution should be a relatively low cost. This avoids Goodman's costly nuisance law issues.

But not all interference cases result from license condition violations. Radio waves can do unexpected things and more sophisticated forms of interference may occur, although this should be unusual. In these cases, in which a licensee experiences interference from another licensee who is operating within his property rights, several alternatives are possible. One option is "neighborly" bargaining. As the commons advocates point out, neighbors often figure out means of resolving disputes without recourse to the courts, especially in the presence of long term relationships ("repeated play" in game theoretic language). But neighborly bargaining works in a property rights regime as well as a commons regime, perhaps even better because there are likely to be fewer (and more familiar) neighbors. Such could be the case here, and in cases where such interference occurs, neighborly bargaining is likely to be the first line of dispute resolution. A second option is more formal dispute resolution, including the courts (in the form of nuisance law) or arbitration. In fact, binding arbitration should be considered an option, should this prove to be the most efficient dispute resolution of these spectrum nuisance cases. Since these cases are likely to require specialized knowledge of radio technology, specialist arbitrators are likely to be knowledgeable and effective as against generalist judges and juries.

Dispute resolution costs in a property rights model are thus held low by (i) using trespass law to enforce licensee restrictions; (ii) using neighborly bargaining where possible; (iii) using nuisance law in litigation or arbitration as a backup; and (iv) if all else fails, relocate at low cost.

#### **Innovation: Flexibility to Respond to Changes in Technology**

New technologies meeting new demands occur regularly in wireless without requiring modifications or changes in existing rules. For example, WiFi is a new technology meeting a new demand (for in-home networking) that fits well within the Part 15 rules at 2.4 GHz, and was introduced seamlessly. Similarly, the extraordinary advances in cellular technology were introduced well within the cellular license rules and were integrated seamlessly. However, some technologies may not fit so easily; commons advocates argue that both UWB and agile radio do not fit into the classic licensing model, although introducing the minor change of non-interfering easements into the property rights model appears to solve that problem. But new

technologies, unimaginable today, may also be disruptive of either commons rules or property rights licenses. How robust is either regime to disruptive technology?

There are several ways in which a new technology can impinge on existing arrangements: (i) a new protocol or standard could be introduced into wireless, such as spread spectrum in the 900 MHz band in the 1980s; (ii) a new technology may require more or less power than existing rules permit; (iii) a new technology may require more or less bandwidth than existing bands permit; (iv) receiver technology may become more or less sensitive to interference; or (v) new technologies may require opportunistic or very low power use of existing licensed or unlicensed bands, such as agile radio or UWB.

#### **New Protocols/Standards**

The introduction of spread spectrum for cordless telephones under regulation and the adoption of standards for digital TV, discussed by Goodman,<sup>57</sup> are good models for how well the regulated mixed regime would handle new protocols and standards in both licensed and unlicensed bands. This suggests disruptive protocols or standards are not likely to fare well in the regulated mixed regime.

By contrast, in the property right regime, licensees are free to adopt new standards and protocols without seeking regulatory approval.<sup>58</sup> Market adoption of new standards is never a smooth process and may result in inefficiencies.<sup>59</sup> However, there is little evidence that regulatory standard setting is an improvement, especially given the opportunities for rent-seeking in the regulatory standard setting process.

#### **Flexible Power Limits**

If a new technology reduces the power limit required for a particular use, there is little incentive for individual users in an unlicensed band to adopt this new technology. Manufacturers of devices using unlicensed spectrum have some incentive to introduce power-conserving technologies, as it means they may be able to sell more devices. But this incentive is muted in that its introduction means that all manufacturers can sell more devices, leading to a free rider problem. These problems are not present in a property rights regime; licensees have the incentive to introduce power-conserving technologies as they are the immediate beneficiaries of it. They may even choose to sell off some capacity should this occur.

If the new technology increases required power, then the regulated mixed regime faces difficult negotiations in both licensed and unlicensed bands. Neighboring bands might be required to increase the quality of their receivers to tune out additional out of band power and neighboring locations might be required to do the same. In existing unlicensed

bands, a changeout of all devices may be required to accommodate the new technology. Alternatively, a new unlicensed band could be established for the new technology if one were available. At best, these options are likely to be quite difficult, take a very long time, and may not be successful. In a property rights model, a licensee who wished to use the new power-increasing technology could engage in neighborly bargaining with licensees in adjacent frequencies and locations. This bargaining would include possible payments to neighbors to adjust to higher power levels, or the buyout of the neighbors' licenses. Should this fail, the licensees could buy new spectrum licenses covering enough bandwidth and enough locations to enable it to deploy the new technology, and take advantage of software-defined radio to shift her customer base seamlessly. However, the application could be location-specific, in which case options for deployment are more limited.

In sum, technologies that decrease power requirements are more likely to be deployed and exploited in a property rights regime rather than the regulated mixed regime. Technologies that increase power requirements are in general more difficult to deploy in either regime, but are somewhat more likely to find success in the property rights regime.

### Flexible Bandwidth

If the new technology enables applications to use less bandwidth than previously, the analysis of the previous section on power also applies. The incentive to deploy the technology in unlicensed bands is muted; purchasers of the new technology only benefit if most other users also purchase the bandwidth-conserving technology. Again, a tragedy of the commons. In licensed bands, licensees have incentives to economize on bandwidth, not only to increase the use of their license but also to sell or lease any unneeded bandwidth.

If the technology increases bandwidth needed for applications, then the regulated mixed regime may observe that existing unlicensed bands become more congested, leading to a tragedy of the commons. The regulator can respond to this by purchasing licensed spectrum and converting it to unlicensed spectrum, or it could impose new rules and limitations on users and manufacturers restricting the use of the new technology. Again, we would expect that regulatory resolution of this conflict would be costly and lengthy, and possibly not successful.

In the property rights regime, licensees who wish to expand their bandwidth to take advantage of the new technology can engage in neighborly bargaining with their neighbors to accept higher levels of out of band power, or they may negotiate the purchase of neighboring bands. Failing this,

licensees can choose to sell their current spectrum and move to a new, larger frequency band at relatively low cost, as argued above. In fact, they may purchase several contiguous bands and aggregate them. The same mechanism would apply in the regulated mixed regime, except that a competitor may petition the regulator to intervene on its behalf to halt this market transaction.

Thus, bandwidth-conserving technologies are more likely to be deployed in a property rights regime than in the regulated mixed regime, as licensees can internalize the benefits of the innovation whereas users and manufacturers in unlicensed spectrum are handicapped in this regard. Bandwidth-increasing technologies are likely to lead to a tragedy of the commons in unlicensed spectrum, calling for regulatory intervention with its attendant costs, delays and uncertainty. In contrast, deployment of such a technology in a property rights regime calls for license aggregation: today, this would require buying the licenses of adjacent licensees which could be subject to holdup problems. In the future of software-defined radio, non-adjacent spectrum can be aggregated, completely avoiding any holdup problems.

Even without the deployment of software-defined radio, the evidence suggests that spectrum can be aggregated. The aggregation occurred during the 1990s, when a number of large wireless firms that owned licenses in some metro areas wished to expand their networks to have national scope. This required them to purchase specific frequency bands in specific locations, generally from other cellular companies, to fill out their networks. More dramatically, Nextel purchased over 40,000 SMR licenses nationwide to obtain nationwide coverage. In both situations, the firms managed to solve the holdup problem and put together nationwide networks. This process took time and money, but it did not stop any of the firms involved.<sup>60</sup>

### Innovation: Flexibility to Respond to Changes in Demand

For small changes in demand, we would expect both regimes to perform well, our analysis of efficiency suggests that a property rights regime is superior to a regulated mixed regime at adjusting to such demand changes.

However, there is a more difficult systemic question: suppose that over time the amount of bandwidth devoted to commons/unlicensed proves too little (/too much) and the bandwidth devoted to private property/licensed proves too much (/too little)? If commons-managed spectrum is wildly successful and needs to be expanded at the expense of property rights-managed spectrum, how would either regime accomplish this systemic change? In the regulated mixed regime, the decision becomes regulatory; the regulator would have to decide how to value commons spectrum (as there would be no market price), how much

spectrum to convert to commons, what bands were most appropriate, and then purchase the required licenses at market (and subject to holdup problems). It would then have to decide what commons uses would be permitted to use the newly available spectrum, including power limits and protocols. Each of these decisions could be expected to be costly, delayed and highly uncertain.

In a property rights regime, licensees that held their bands for open access would find their market value increase and seek to purchase new bandwidth licenses to expand their services. Alternatively, current spectrum licensees could also assess the market value of open access spectrum and choose to convert their current spectrum to open access. Included in this group of potential agents would be government (at any level) that could purchase licenses and convert them from exclusive use to commons use, if there were sufficient political demand for this. On the other hand, it could be that spectrum devoted to open access is less valuable than exclusive use spectrum; we would expect that licensees of commons spectrum would convert their frequency bands from commons to exclusive use, much the way an owner of an apartment building may convert the building from rental units to a condominium. This market-driven process would provide much clearer signals regarding the value of moving spectrum to or from open access/unlicensed to exclusive use.

In sum, the property rights regime is likely to adjust rather easily to technology and demand changes necessitating changes in required bandwidth. The regulated mixed regime can rely on market mechanisms to be flexible for licensed bands, but is liable to encounter tragedy of the commons problems in unlicensed bands, which can only be resolved by regulatory interventions that are costly, delayed and uncertain. The overall allocation of bandwidth from commons to property rights and back is likely to be difficult in the regulated mixed regime and relatively automatic in the property rights regime.

## Conclusion

There is general agreement that the traditional command and control regime is an unacceptable option for the future; the question is what regime should replace it? Pure commons is unrealistic, so the choice reduces to either a property rights regime, in which licensees have the freedom to deploy spectrum as they see fit, or a mixed regime in which regulators continue to oversee both licensed and unlicensed spectrum. The paper lays out a legal framework for a property rights regime. It then analyzes each regime on the basis of the four factors above. For one of those factors, the regulated mixed regime has the advantage, at least in commons-managed spectrum:

there are no transaction costs associated with buying, selling or leasing spectrum. In the case of the property rights regime, the evidence suggests that these transaction costs are likely to be rather small, and therefore not a decisive issue. For all other factors, the property rights regime appears to dominate the regulated mixed regime.

The new technologies have been a driving force in this debate, and without exception these technologies hold much promise. However, these technologies do not favor one regime over the other. These technologies enable the commons, in the sense that they help solve the tragedy of the commons (interference) problem, but they support property rights, in the sense that they help solve certain bargaining problems. The technologies cannot tell us the regime to choose, but they do make it easier to implement either regime.

Ultimately, the choice of an overarching legal regime comes down to a choice between regulation and markets. There is much evidence about the economic performance of regulation, not the least from FCC regulation over the past 70 years. Today's markets in spectrum licenses are imperfect; yet the existing spotty evidence suggests they work moderately well. The fears of commons advocates of monopoly, holdup problems and huge transaction costs simply don't withstand careful analysis. The conclusion is clear and inescapable.

While the conclusion in favor of markets is clear, the debate itself between property rights advocates and commons advocates has been costly in that in the US, reform efforts have been diluted and sidetracked by advocates on either side. Vigorous policy choices needed to move rapidly to a market regime have been delayed by techno-utopians arguing strenuously for a spectrum commons that will result in more regulation and more government control, when what is needed is less regulation and more market control. The evidence is compelling, and it is time to end this debate and move on, as the evidence suggests.

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## Notes

- \* The author acknowledges the support of Vodafone Group Plc for this work, which draws upon Faulhaber (2005, 2006). All errors and omissions are the author's.
- 1 The National Telecommunications and Information Agency of the Department of Commerce manages all federally operated spectrum, such as used by the Department of Defense, Federal Aviation Agency, and so forth. The FCC regulates all other spectrum.
  - 2 As we shall see in detail below, the FCC has also set aside important frequency bands for unlicensed use, such as cordless phones, garage door openers and WiFi.
  - 3 Techniques such as code division multiplexing can alleviate (but not eliminate) interference. Such methods allow simultaneous transmissions to be separately identified via coding by smart receivers.
  - 4 Radio spectrum for the use of the Federal government, such as military, FAA, and other government users, is managed by the Department of Commerce's National Telecommunications and Information Agency.
  - 5 For example, in the 1950s, the FCC designed the experiment of UHF television, committing 330 MHz of frequency space in locations around the country, in the hopes of fostering localism in broadcasting. This experiment failed; however, there are hundreds of license holders throughout the U.S. that continue to hold onto these licenses, and so the spectrum cannot be used for any other purpose. See Faulhaber and Farber (2003). The value of this underutilized spectrum can be inferred from the fact that the entire frequency bandwidth devoted to digital wireless cellular service is no more than 180 MHz. Opening up the current UHF band to wireless could almost double the capacity of the U.S. wireless industry. Additionally, studies by Agilent Technology of the power spectrum in Santa Rosa, CA show that aside from the fairly narrow digital wireless bands and the WiFi band, virtually all the spectrum between 1.5 GHz and 3.0 GHz is almost completely unutilized. And a recent study in Brussels, Belgium finds similar vast underutilization of spectrum in a major European city. See Ryan (2004).
  - 6 Paradoxically, licensees still broadcast in this spectrum even though almost no viewers watch the broadcasted signal. They engage in this perverse behavior because FCC rules grant every local broadcaster the right to be carried over all local cable systems at no charge (the "must carry" rule).
  - 7 See Ellen P. Goodman (2004), for a full explication of several dispute resolutions at the FCC.
  - 8 The political economy of US regulation is beyond the scope of this essay, but other countries seem to have somewhat more decisive regulators and the sway of lobbyists, while still substantial, is less decisive.
  - 9 Apparently, many commentators at the time thought it easily assailable, indeed quite mad. Later, Professor Coase provided further detail of the contemporary reaction to his ideas; see Coase (1998).
  - 10 Cognitive radio, however, poses serious interference threats, both in design and in use. As it turns out, the ability of any radio to detect when a primary licensee begins transmission (and thus forces the opportunistic users off the airwaves) is limited by topography and other features that could result in interference fairly often, even if the hardware works perfectly.
  - 11 In fact, each of these technologies as they exist today has technical and operational difficulties that prevent its early deployment. UWB is perhaps closest to deployment, but is a very low power service, and thus only appropriate for services in which transmitters and receivers are quite close. Agile radio (indeed, software defined radio) are still rather costly to produce, and the protocols needed to behave well in an opportunistic setting are still on the drawing board. See Marsh (2005) for a thorough analysis of SDR's problems and prospects). Mesh networks is actually a rather old idea; the Internet itself can be thought of as a mesh network, albeit not a wireless mesh. In order for a mesh network to provide an acceptable quality of service to its customers, there must be a fairly dense deployment of communicating devices and/or NAPs. This is difficult to guarantee with mobile devices, where density (devices/mi<sup>2</sup>) can vary dynamically.

- Additionally, the use of many relay points in the mesh prior to connecting to the Internet or telephone network can introduce delays that are unacceptable to latency-sensitive applications such as voice. Again, this is not to say that these problems cannot be solved; it is to say that they won't be solved tomorrow and these technologies may well yield less than today's theoretical models promise.
- 12 See Lessig (2001) for a powerful statement of this vision, of which spectrum commons is but a small part.
  - 13 See Lawrence Lessig (2004).
  - 14 Consider, for example, the ability of an individual caller to CNN's "Larry King Live" television show to make her views known to the world and to that evening's high-powered guest, compared to the paltry audience reachable via a cable system's public access channel. The former venue is a private network carried over private cable systems or licensed broadcast TV, to a huge audience. The latter venue is an open access commons, which most viewers avoid like the plague.
  - 15 See Lessig (1999).
  - 16 One of the earliest and best known services of this ilk was CB radio, a personal wireless communication service that did not require owners of CB equipment to be separately licensed in order to broadcast and receive (known as a "Part 95" service). The FCC set aside 40 voice channels in a frequency band that could be shared by anyone with FCC-approved equipment. All conversations were public in that they could be heard by anyone with a CB receiver. Early users of the service, primarily professional drivers, developed social protocols to facilitate effective sharing of the limited channels. The service became wildly popular in the mid-1970s, with sales increasing by a factor of ten, but by the end of the 1970s its popularity had waned.
  - 17 Apparently, even these low power levels were not sufficient to eliminate all interference. The FCC adopted a novel technology, spread spectrum, for use with 900 MHz cordless phones to secure phone calls (though this technology was strongly contested at the FCC). Garage door opener firms adopted a technique called "rolling codes" to eliminate opening neighbors' garage doors. Both these approaches presaged the technologies mentioned above: ultrawideband and agile radios. And both approaches suggest that there may be private means of resolving interference problems using technology rather than licenses, a key point of the commons advocates.
  - 18 See Wireless Philadelphia Executive Committee Briefing, available at <http://www.phila.gov/wireless/briefing.html> (describing Philadelphia's well-publicized WiFi initiative).
  - 19 Another dimension along which battle lines seem to have been drawn is analogy: is spectrum like land, or is it like air? Commons advocates argue the latter is the correct analogy, and conclude that since air is a common resource and is so managed, so must spectrum. They allege that property rights advocates are led to error through the use of the land analogy. In fact, this dimension has more to do with disciplinary differences than with the dispute itself. Legal scholars traditionally argue from analogy, and it is often the case that once the profession settles on the right analogy, the issue is decided. Economists, on the other hand, view analogy essentially as a teaching aid and not a research tool. What spectrum is "like" is largely irrelevant to economists; what matters are its basic underlying physical and economic properties. It is these properties, rather than analogies, which drive the economic logic. The fight over the correct analogy is not a fight that economists understand or care about, and this paper will not engage in this fight.
  - 20 See Werbach (2004); Goodman (2004).
  - 21 Amateur radio is in fact a licensed band; in order to receive a license, a user must pass a test on general radio knowledge including demonstrating proficiency in Morse code. Although Morse code is virtually never used in today's ham radio environment, it acts as a barrier to entry for casual users, resulting in a self-defined elite of radio that helps it observe and monitor the group's adopted rules of behavior.
  - 22 See Robert C. Ellickson (1991) pointing out that in a community in which parties have long-term relationships, norms of cooperation can be enforced by reputation building. If parties are unknown to each other, or otherwise anonymous, then the incentive of each party is to be a selfish short-run profit-maximizer, as reputation sanctions are ineffective.
  - 23 There do exist examples of pure commons in which there are no rules. For example, public domain literature can be published by anyone without payment of royalties or any other restriction. In this case, the use of a book or article in the public domain does no damage to any other party, so untrammelled access is efficient.
  - 24 This is not quite true; some retail establishments that offer WiFi service on their premises often require a fee for usage.
  - 25 Private Conversation with George Dillon, FCC Enforcement Bureau, (January 8, 2004).
  - 26 See Verizon Wireless website, at <http://www.verizonwireless.com/b2c/store/controller?item=phoneFirst&action=viewPhoneOverviewByDevice&deviceType=Phones> (last visited on May 23, 2006).
  - 27 Note that if "open access" is indeed the same as "anyone can use it", then this is simply common carriage, a principle that has been used in telecommunications and utility regulation for over a century, hardly a revolutionary development.
  - 28 See Saltzer (1984).
  - 29 If the application doesn't use the existing protocols of TCP/IP it will not work, and will do no one any harm. If a new wireless application doesn't use the existing rules and protocols, it may work and it is likely to cause others harm, through interference. The Internet is not like wireless in this regard. In fact, the very openness of the Internet has led to its own "tragedy of the commons." The ability of anyone to develop an application and distribute it over the Internet becomes much less wonderful when that application is a virus or worm that can infect computers worldwide in hours or minutes. The anonymity of the Internet becomes less wonderful when that anonymity (plus low cost distribution) fills users' mailboxes daily with hundreds of spam e-mails. The great promise of the Internet is in danger of being undermined by these activities, but they are a product of its openness; it is a tragedy of the commons.
  - 30 Even experimenters must acquire an experimenter's license in order to transmit.
  - 31 See FCC (2004)
  - 32 See Frischmann (2005) stating, "This does not mean, however, that access is free. We pay tolls to access highways, we buy stamps to send letters, we pay telephone companies to route our calls across their lines, and so on. Users must pay for access to some (though not all) of these resources. Nor does it mean that access to the resource is unregulated. Transportation of hazardous substances by highway or mail, for example, is heavily regulated. The key point is that the resource is openly accessible to all within a community regardless of the identity of the end-user or end-use." But as noted above, this is simply common carriage, not a "commons."
  - 33 Under the current regime, the government doesn't actually hold a license to Part 15 spectrum. But if a property rights regime were in place, the government (in fact, state and local governments as well as the Federal government) would hold licenses to any spectrum offered under Part 15 rules. In essence, the government would "own" the commons, much as it owns public lands today.
  - 34 To be perfectly clear, under a property rights/licensed regime, a government (at any level, or any other entity) can own a swath of spectrum and permit others to use it, subject to their rules and regulations. For example, New York City land is governed by a property rights regime, and yet there is a large and important commons in the middle of Manhattan: Central Park. The presence of Central Park in no way compromises the property rights regime governing real estate in New York; the City of New York owns the park and chooses to manage it as a commons available to all, under their rules and regulations. It is in this sense that a property rights regime can accommodate commons usage.
  - 35 Desirable properties include the ability for radio waves of a particular frequency to penetrate building walls, and not be subject to interference from tree leaves or raindrops. Another desirable property, for example, is for propagation properties to be relatively constant over geography, atmospheric and ionospheric conditions.
  - 36 Commons advocates argue that such prices reflect only private values, and thus public or common values are shortchanged in the market. This is not true; if a property (be it a spectrum frequency band or a plot of land) is highly valued for public purposes, then this value will express itself politically and the property can be purchased by a government (local, state or Federal) and committed to this public purpose. We note that Central Park in New York City is located on some of the most valuable property on the face of the earth, and it is owned by the City of New York and devoted to a very worthy public purpose.

- 37 I use the term "regulation" to denote the presence of a permanent governmental body that has been delegated authority to establish and enforce rules concerning core economic decisions of firms in specific markets or market activities, including price, quality, standards, entry and exit, and other such rules and obligations. In this context, I do not consider the courts to be involved in regulation.
- 38 Benkler (1998), p 57.
- 39 Werbach (2004), p. 961.
- 40 See Thomas W. Hazlett (2003).
- 41 Analysts suggested that the broker fee for arranging such sales was approximately 3%.
- 42 Werbach argues that dispute resolution in his "supercommons" will occur via some form of tort which he does not completely specify. Given that a regulator would continue to have overarching authority of all spectrum, both licensed and unlicensed, it is very unlikely that the locus of dispute resolution will change. The FCC will continue to resolve disputes, using rules rather similar to those in place today. Since the regulatory process is very unlikely to change, it is safe to assume that at least in unlicensed bands the FCC will continue to resolve disputes. See Werbach (2004), note 37.
- 43 See FCC (2005) for a short account of this long-running dispute.
- 44 Goodman (2004), p. 376.
- 45 Goodman (2004), note 348.
- 46 Goodman (2004), pp. 376-77.
- 47 Goodman (2004), note 349.
- 48 As suggested by Werbach (2004), note 37, pp. 938-39.
- 49 See De Vany (1969).
- 50 A full discussion of flexible license rights is contained in Kwerel and Williams (2002) pp. 42-44.
- 51 This limitation could be specified to "roll off," so that e.g., 80% of out of band emissions would be within 0.5 kHz of the frequency band border, 95% must be within 1.0 kHz of the border, etc.
- 52 It is more convenient to express power limitations at the transmitter; however, it is actual power impinging across a geographic boundary that is the relevant measure for interference in an adjacent location.
- 53 This specification may also include the height of the measuring antenna: e.g., "...no greater than x watts/m<sup>2</sup> no more than y% of the time measured no higher than z m above ground." Clearly, effective enforcement requires the right to be fully specified, cover (almost) all contingencies, and be measurable.
- 54 Nuisance law cases require a determination of damages as well as a balancing of interests among the parties. This is the basis of Goodman's finding that nuisance law imposes substantial inefficiencies. See Goodman (2004) pp. 326-359.
- 55 No doubt a court would be loath to issue an injunction if a licensee emitted out of band power 1% over its permitted limit for 1 second, without a showing of damages. If the property right were written specifically acknowledging the right of injunctive relief without a showing of damages, it is likely the courts would settle on a threshold level of intrusion that would call forth an injunction.
- 56 The way boundary rights are defined now in flexible licenses does not require measurements nor the existence of "interference" per se. They are enforced either by equipment type acceptance or by calculations using standard propagation models and technical data that licensees must provide. Also, violations of current boundary limits (like trespass on land) are enforceable now even if there is no harm from interference to a licensee's services. Telephone Interview with John Williams, F.C.C. (March 10, 2005).
- 57 Goodman (2004) pp. 376-77.
- 58 The theory of regulation discussed above suggests that regulation provides a mechanism by which competitors can seek to disadvantage innovators from adopting new technologies. The openness of the regulatory process ensures that anyone can object to any proposal to introduce technology that requires regulatory approval. Further, the theory also suggests that the scope of regulation will expand to cover new technologies should these innovations be perceived as a threat to other market participants. These institutional mechanisms are simply not present in the property rights model.
- 59 Besen and Farrell (1994).
- 60 The holdup problem is particularly severe in land, where developers must acquire contiguous land at a particular site for a successful project (indeed, almost all examples of the holdup problem used by commons advocates are based on land). Even here, aggregators have come up with interesting and compelling solutions: an aggregator can make a (generous) "all or nothing" offer to landholders, stipulating that individual offers are contingent upon all offers being accepted. In established neighborhoods, for example, such offers can change the social dynamic among neighbors from common resistance and holdups to common acceptance and social sanctions against holdouts. My thanks to Hon. Stephen F. Williams for this observation.

**Neil Pratt**

Frontier Economics

**James Bellis**

Frontier Economics



Neil Pratt is an economic consultant with Frontier Economics. He specialises in the economics of competition, and provides clients with economic advice on a wide range of regulatory and antitrust issues. Prior to joining Frontier Economics, Neil held a research fellowship at the London School of Economics.

James Bellis is an economic consultant with Frontier Economics. He specialises in the economics of telecommunications and provides clients in the sector with economic advice on a wide range of issues.

## Spectrum liberalisation: the benefits of re-farming spectrum

### Introduction

Under the current EU Framework Directive (Directive 2002/21/EC), all Member States are now able to implement the secondary trading of spectrum rights and also to liberalise spectrum usage.<sup>1</sup> This policy was introduced in recognition of the need to promote the use of market mechanisms in spectrum management in order to improve the efficiency of spectrum usage in the EU.<sup>2</sup>

The potential gains from spectrum trading and liberalisation appear to be very substantial. A recent study for the European Commission estimated that the introduction of spectrum trading and liberalisation across all Member States could give rise to a welfare gain arising from the movement of spectrum from current uses and users to alternative, higher value uses and users amounting to tens of millions of euros per annum.<sup>3</sup> The magnitude of the welfare gain is quantified using a methodology which

takes into account both the increase in value from a reallocation of spectrum from its current use to a superior alternative use (where this exists), and the increase in value from a trade when there is no change of use.<sup>4</sup>

The European Commission's study indicates that a combination of spectrum trading and liberalisation is likely to result in the greatest welfare gain, where this is possible. In practice, however, it may not be possible to liberalise some bands due to interference concerns. Equally, it is possible that spectrum trading may be difficult in some bands, for example due to thin markets. This suggests that spectrum management authorities may need to be flexible in the way that they make use of alternative market mechanisms, and that different approaches may be suitable for different bands.<sup>5</sup>

In this paper we consider the potential benefits from spectrum liberalisation on its own. Spectrum liberalisation could give rise to an efficiency gain without any change of ownership where it would allow current owners of spectrum rights to transfer these rights from their current use to an alternative, higher value use. Because this type of reallocation of spectrum between uses does not involve any change of ownership, the realisation of the associated welfare gain from spectrum liberalisation does not rely on the development of competitive spectrum markets.

We focus in particular on the potential economic benefit to consumers of allowing mobile network operators to 're-farm' the spectrum currently assigned to 2G (GSM) services to provide 3G (UMTS) services.<sup>6</sup> Using data provided by Vodafone, we set out an illustrative calculation that estimates the potential economic benefit from re-farming 2G spectrum.

Our analysis indicates that the re-farming of 2G spectrum to provide 3G services could result in a long-run consumer benefit of around €2.9 billion per annum in the EU. Whilst this estimate is necessarily somewhat uncertain, given the limited availability of data on the likely development of the 3G market, it does nonetheless suggest that re-farming 2G spectrum could result in significant benefits to consumers.

## Re-farming 2G spectrum and 3G coverage

Mobile network operators throughout the EU are currently deploying mobile networks using the 2100 MHz spectrum assigned to the operators for this purpose. These networks will provide consumers with access to a range of new 'third generation' (3G) mobile services that are not currently available, such as video telephony and mobile TV, as well as with improved access to existing services such as internet browsing.

In the absence of 2G spectrum re-farming, the availability of 3G services will depend on the level of investment made by network operators in the new sites and equipment that will be required to provide 3G coverage using 2100 MHz spectrum. Network operators must determine the optimal level of 3G coverage by balancing the significant capital expenditure that is required to provide incremental 3G coverage at 2100 MHz against the expected return from this expenditure. Vodafone has indicated that it is highly unlikely that network operators would provide complete 3G network coverage, given the cost of deploying 3G networks using 2100MHz spectrum, and the prospective demand for 3G services.<sup>7</sup>

If mobile network operators were allowed to re-farm 2G spectrum, then they could use their existing GSM networks of sites and masts to provide 3G coverage by sending signals in the GSM bands at 900 MHz and 1800 MHz with broadly the same propagation characteristics as their existing GSM signals. We understand from Vodafone that re-farming 900 MHz spectrum could result in a substantial reduction in the cost of providing 3G coverage. Re-farming 1800 MHz spectrum could also reduce the cost of providing 3G coverage, although the anticipated cost savings may be less significant than those from the re-farming of 900 MHz spectrum. This is because the 1800MHz mast networks will already provide good coverage in the 1900-2100MHz range, so that the incremental benefit of re-farming will be lower. Nevertheless, re-farming will allow both 900MHz and 1800MHz network operators to achieve comparable levels of 3G coverage, and both would seek to do so in order to remain competitive in the provision of 3G services. Therefore, for the purpose of this analysis we have assumed that any operators that rely on 1800MHz spectrum would, if permitted to re-farm this spectrum, provide the same level of 3G coverage as operators that rely on 900MHz spectrum.

An increased level of 3G coverage resulting from the re-farming of 2G spectrum would give rise to a consumer benefit as a result of the increased availability of 3G services. For example, consumers living in areas where 3G coverage would otherwise not be provided may, with 2G spectrum re-farming, be able to access 3G services from home, whilst consumers visiting these areas may also have greater access to 3G services.<sup>8</sup>

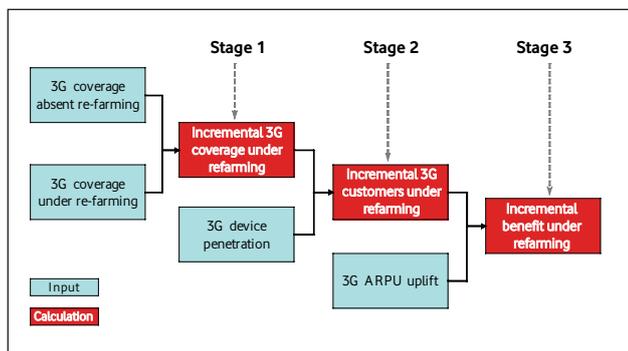
## Methodology for quantifying the consumer benefit from re-farming

We estimate the potential long-run consumer benefit from 2G spectrum re-farming using a three stage process that is illustrated schematically in Figure 1. Under our approach, the consumer benefit from re-farming depends on the following factors:

- the incremental 3G coverage from re-farming;
- the number of additional consumers who can access 3G services as a result of re-farming; and
- the estimated benefit per consumer from 3G services.

We discuss each of these factors below.

**Figure 1: Estimating the consumer benefit of spectrum re-farming**



Stage 1: estimating the incremental 3G coverage under re-farming

In order to estimate the incremental 3G coverage from 2G spectrum re-farming, we assume that:

- if re-farming were not permitted, then mobile network operators would meet, but not exceed any licence commitments in relation to 3G coverage; and
- if re-farming were permitted, then mobile network operators would provide 3G coverage at a level in excess of their licence commitments.

Stage 2: estimating the incremental number of 3G consumers under re-farming

In order to estimate the incremental number of 3G consumers under re-farming we calculate the number of consumers who obtain 3G access as a result of the additional 3G coverage that would be provided if re-farming were permitted (as calculated in stage 1). Since consumers must have a 3G device in order to obtain 3G services, we multiply the number of additional consumers who would have access to 3G services if re-farming were permitted by the estimated penetration of 3G devices.<sup>9</sup>

Stage 3: estimating the incremental consumer benefit under re-farming

In order to estimate the consumer benefit that would result from permitting mobile network operators to re-farm 2G spectrum we multiply the increase in the number of 3G consumers as a result of re-farming (calculated in Stage 2) by an estimate of the 3G expenditure per consumer. This approach is conservative since it ignores the consumer surplus obtained by infra-marginal consumers.<sup>10</sup> Furthermore, we ignore any potential benefit that may accrue to consumers who would have access to 3G services even if 2G spectrum re-farming were not permitted.<sup>11</sup>

## Estimated potential consumer benefit from re-farming 2G spectrum in the EU member states

In this section we provide an indication of the order of magnitude of the potential consumer benefit if mobile network operators throughout the EU were permitted to re-farm 2G spectrum. Ideally, this should be done by estimating the consumer benefit in each Member State. This has not been possible using available data, and we have therefore estimated the potential scale of EU-wide consumer benefit from 2G spectrum with reference to the following assumptions.

- in the absence of spectrum re-farming, 3G networks would cover 80% of the EU population;
- with spectrum re-farming, 3G networks would cover 90% of the EU population;<sup>12</sup>
- 95% of the EU population will ultimately have a 3G device and use this to access 3G services;<sup>13</sup> and
- the incremental expenditure on 3G services is around €66 per annum per consumer in the long-run.<sup>14</sup>

Under these assumptions we estimate that the long run annual consumer benefit from re-farming 2G spectrum in the EU may be around €2.9 billion per annum. This is equivalent to a gain of approximately €6 per annum per capita.<sup>15</sup> Whilst the estimated level of consumer benefit is necessarily dependent upon the assumptions used, the analysis does indicate the potential scale of benefits that re-farming 2G spectrum could bring to EU consumers.

## Notes

- 1 Spectrum liberalisation involves a relaxation of restrictions in relation to the services and technologies associated with spectrum usage rights.
- 2 Radio spectrum management in the EU has traditionally relied upon a centrally-managed 'command and control' approach, rather than decentralised market mechanisms.
- 3 Analysys, Dotecon and Hogan & Hartson (May 2004), Final report for the European Commission: Study on conditions and options introducing secondary trading of radio spectrum in the European Community. The study also identified substantial benefits associated with spectrum trading and liberalisation as a result of increased competition in downstream markets, and increased dynamic efficiency through innovation. Welfare gains are measured relative to a status quo scenario which reflects the likely implementation of spectrum trading and liberalisation in the EU in the absence of any co-ordinated approach across all Member States.
- 4 The study considers the benefit of trading and liberalisation for fixed links, public and private mobile networks and broadcasting-terrestrial bands. These bands are selected on the basis that they are particularly suitable for trading. The study also considers the direct welfare gain from introducing trading alone in all Member States, and shows that these are approximately half the estimated direct welfare gain from trading and liberalisation together.
- 5 The implementation strategy being pursued by the UK national spectrum authority, OFCOM, provides an example of this type of pragmatic approach to the use of market mechanisms in spectrum management.
- 6 This policy option is not considered in the report for the European Commission by Analysys et al.
- 7 In a number of European markets, 3G licensees have an obligation to provide a minimum level of 3G network coverage. For example, mobile operators in the UK must deploy 3G networks to cover 80% of the UK population.
- 8 Consumers may also benefit from a faster roll-out of 3G coverage than would otherwise be the case. In addition, there may be environmental benefits associated with a reduction in the number of additional sites and masts that would be required to provide a given level of 3G coverage. We have not quantified either of these potential benefits.
- 9 We assume that penetration of 3G devices in a local area is independent of the availability of 3G services in that area.
- 10 In the textbook representation of consumer theory, this is represented by the area underneath the demand curve, less the total expenditure on the product or service in question.
- 11 These consumers may benefit from the additional coverage with re-farming spectrum in a number of ways. For example, as the number of 3G customers increases, existing consumers may derive increased value from 3G services such as video calling.
- 12 This does not imply that any Vodafone operating company is committed to providing 3G coverage at these levels. The estimated levels of coverage with and without re-farming are provided only for illustrative purposes to demonstrate the potential scale of benefits from spectrum re-farming. Mobile operators in different Member States have differing 3G coverage obligations. For the purposes of this analysis we assume that 3G networks in each Member State would cover 80% of the population in the absence of re-farming and 90% of the population with re-farming. We do not differentiate between 900 MHz and 1800 MHz operators in our analysis, and the extension in coverage to 90% is therefore intended to capture the overall effect of GSM re-farming across all GSM operators.
- 13 Vodafone estimate.
- 14 This equates to approximately 15% of total ARPU. Vodafone anticipates a 3G ARPU uplift of between 10% and 15%, compared to ARPU for 2.5G customers (Vodafone Interim Results presentation, November 2005).
- 15 The estimated consumer benefit is of course subject to uncertainty, and is sensitive to variations in these assumptions. For example, if only 50% of consumers with a 3G capable device use it to access 3G services, the scale of

potential long run annual gains from re-farming would decrease to around €1.5 billion.

**Professor Martin Cave**

Warwick Business School

**Dr. Peter Crowther, Solicitor**

LeBoeuf, Lamb, Greene &amp; MacRae



Martin Cave is Professor and Director of the Centre for Management under Regulation, Warwick Business School. He holds bachelor's, master's and doctoral degrees from Oxford University. Until 2001 he was Professor of Economics at Brunel University. He specialises in regulatory economics, especially of the communications sector.

He was a member of the UK Competition Commission from 1996 to 2002. He has advised the European Commission, OECD, and assists telecommunications regulatory agencies in the UK, Ireland, Greece, Portugal, Cyprus and Singapore. He is responsible for two studies of spectrum management carried out for the Chancellor of the Exchequer in the UK.

Peter Crowther is a Solicitor in the London office of the law firm LeBoeuf Lamb. A former holder of a Jean Monnet Professorship in EC Law, Peter advises both companies and government institutions on communications and competition law issues. Peter is the author of numerous articles and is the Editor of the Electronic Communications section of the standard competition law looseleaf, Butterworth's Competition Law.

## Driving forward spectrum liberalisation<sup>1</sup>

### Introduction

Despite fairly widespread recognition that the current regime of spectrum management operating in most of the European Union is insufficiently flexible to achieve the Union's objectives in promoting industrial competitiveness and innovation, thus far the pace of reform is slow. This paper argues that 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 argument proceeds in stages. We review the development of spectrum regulation at EU level, against a background in which some member states have already introduced liberalising measures, others are explicitly opposed to them, and others are still in the process of developing a policy. Later sections identify some possible legal mechanisms to achieve a reform of the current system, while the last sections summarise the Commission's proposals and contain our conclusions.

## EU spectrum regulation – current position

The European telecommunications market was fully liberalised in 2002 through the Full Competition Directive<sup>2</sup>. The basic principles are that:

- exclusive or special rights to provide electronic communications networks or services must be abolished;
- except as otherwise permitted, Member States must not impose restrictions on the services that can be provided over networks; and
- conditions attached to any general authorisation to provide networks or services must be based on objective, non-discriminatory, proportionate, and transparent criteria.

### Spectrum trading

The current regulatory position in respect of spectrum trading is clear. By virtue of Article 9(3) of the Framework Directive<sup>3</sup>, Member States are currently permitted, but not required, to introduce spectrum trading. Article 9 (3) provides:

“Member States may make provision for undertakings to transfer rights to use radio frequencies with other undertakings.”

While this permissive regime does not present a *per se* impediment to the development of a properly functioning spectrum market, an obligatory regime that required Member States to allow spectrum to be traded would no doubt contribute to the achievement of the Community's objectives.

### Flexible use of spectrum

The starting point for an evaluation of the current position in respect of flexibility of use is Article 8(2)(d) of the Framework Directive. Article 8(2)(d) provides that NRAs must promote competition by “encouraging efficient use and ensuring the effective management of radio frequencies ...”.

In order for Member States to “encourage” efficient spectrum use, a necessary precondition is arguably that Member States are able to ensure flexibility in its use: it is difficult to see how efficient use of spectrum could be achieved in the absence of such flexibility, as the most efficient use of particular parts of the spectrum may well change over time.

Against this background, we note that the EU regulatory framework does not prevent Member States from allowing flexible use of spectrum.

The principle of effective and efficient spectrum use is echoed in Article 9(2) of the Framework Directive, which provides:

“2. Member States shall promote the harmonisation of use of radio frequencies across the Community, consistent with the need to ensure effective and efficient use thereof and in accordance with the Decision No 676/2002/EC (Radio Spectrum Decision).”

The wording of Article 9(2) indicates that promotion of harmonisation of use of spectrum must be measured against the criteria of its effective and efficient use. Clearly, the presence of national restrictions on use could thwart a particular harmonisation initiative, thereby frustrating the objectives of the EU internal market.

There is some more general support for flexibility of spectrum usage within the current regulatory framework, in the Authorisation Directive<sup>4</sup>. The general rule is that the provision of electronic communications networks or services may only be subject to a general authorisation and not an individual licence. Member States must, where possible, not make the use of frequencies subject to individual authorisations. Where this is necessary (e.g. due to a significant risk of harmful interference), such authorisation may not contain conditions other than those listed in Part B of the Authorisation Directive Annex 2. Moreover, the fact that pursuant to Annex 2 Part B, Member States may (but are not required to) impose conditions regarding spectrum use clearly leaves the door open for a flexible use policy.

It therefore appears to us that while Member States are not explicitly required to enshrine the principle of flexible use in licences, flexible use is not prohibited by the Framework Directive. Furthermore, flexible use appears necessary in practice to achieve the general objectives laid out in the Framework Directive.

As described in more detail below, the Commission recognises the importance of flexibility of use in the Communication on the Review of the EU Regulatory Framework for electronic networks and services:

“Based on common EU rules, greater flexibility in spectrum management could be introduced by strengthening the use of general authorisations whenever possible. When not possible, owners of spectrum usage rights should not be unduly constrained but subject to certain safeguards, have the freedom to provide any type of electronic communications service (‘service neutrality’) using any technology or standard under common conditions (‘technological neutrality’).” (p.7)

The use of general authorisations requires significant further analysis. Assuming however an appropriate and proportionate licensing/authorisation framework is in place, we support the view that flexibility of use should be the guiding principle.

While flexibility in spectrum usage is not at present explicitly mandated, the potential for achieving some degree of flexibility of use does exist within the current framework. Serious consideration should be given to how best to encourage efficient use of spectrum within this framework while preparing the ground for reform that will enable efficient investment decisions to be made and new services to develop.

### Spectrum Decision

Article 9(4) of the Framework Directive makes it clear that the Spectrum Decision is the principal means by which spectrum use is to be harmonised:

“4. 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 harmonized 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<sup>5</sup> the aim of the Decision is to “establish a policy and legal framework in the community in order to ensure the coordination of policy approaches and, where appropriate, harmonised conditions with regard to availability and efficient use of the radio spectrum...”

To achieve this aim the Spectrum Decision establishes procedures in respect of:

- 1) a policy framework for the use of the radio spectrum, taking into account of the economic, cultural, scientific and social aspects of Community policy, as well as considerations of security, public interest and freedom of expression with the aim of optimising the use of radio spectrum and of avoiding interference;
- 2) a methodology to ensure harmonised conditions for the availability and efficient use of radio spectrum;
- 3) the provision of information concerning the allocation, availability and use of radio spectrum in the EU; and

- 4) coordinating the interests of the European Community in international negotiations on the use of spectrum.

The Spectrum Decision establishes a Radio Spectrum Committee (“RSC”) and defines its functions. The RSC is composed of representatives of the Members States and chaired by a representative of the Commission. The RSC’s principal role is to examine and vote upon Commission’s proposals on technical implementing measures for harmonising conditions for availability and use of radio spectrum.

In respect of proposed measures within the remit of the CEPT, the Commission’s role under the Spectrum Decision is to issue mandates to the CEPT and then to decide whether the results of the work carried out pursuant to the mandates will apply in the Community and on the deadline for implementation by Member States. The Commission may also adopt measures to achieve the objectives of a mandate issued to the CEPT if it or any Member State decides that the work being carried out on the basis of a mandate is not progressing satisfactorily or if the results of the mandate are not acceptable.

Pursuant to Article 4(5) of the Spectrum Decision, the Commission may, on the basis of a reasoned request by a Member State, approve transitional periods and/or radio spectrum sharing arrangements in a Member State, provided that such exception would not unduly defer implementation or create undue differences in the competitive or regulatory situations between Member States.

The stated aim of the Spectrum Decision (in Article 1) is to ensure “coordination of policy approaches and, where appropriate, harmonised conditions with regard to the availability and efficient use of the radio spectrum”. The Spectrum Decision provides for two decision-making procedures in respect of certain aspects of spectrum harmonisation and allocation, as follows:

#### *(a) Decisions made through CEPT*

Article 4(2) of the Spectrum Decision provides that, where a technical implementing measure falls within the remit of CEPT, the Commission shall issue mandates to CEPT. This Article gives as an example of a matter falling within CEPT’s remit “the harmonisation of radio frequency allocation”.

#### *(b) Decisions made by the Commission*

There are two ways in which the Commission can itself exercise jurisdiction, rather than going through CEPT. First, if the Commission issues a mandate to CEPT and CEPT is either unable to adhere to the timetable

imposed by the Commission or, in the opinion either of the Commission or of a Member State, the results of the mandate are unsatisfactory, the Commission can itself adopt measures to achieve the objectives of the mandate.

Secondly, if a matter does not fall within CEPT's remit (under Article 4(2) of the Spectrum Decision), the Commission may, under Article 4(6), itself adopt technical implementing measures.

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.

The Spectrum Decision indicates that "technical implementing measures" do not extend to licensing or assignment procedures (Recital 11). It should be noted that freeing up spectrum usage would not necessarily have to have an impact on licensing or assignment procedures – these could still be for Member States to determine. Nor would harmonised mandatory flexibility of use of a certain part of the spectrum be inconsistent with the Framework Directive. Legally at least, the fact that spectrum trading is currently permitted but not mandatory, is not of itself fatal to achieving a harmonised part of the spectrum in which flexibility of use was mandated. This process does however assume that there is a prior harmonisation decision achieving flexible use of part of the spectrum which, as noted above, appears to us to be possible within the existing framework.

It would to some degree be odd to have an arrangement in which spectrum could be used by one entity however it saw fit, but that same entity were not free to dispose of that asset for another entity to use in the same flexible way. This provides strong support for reform of the Framework Directive.

The Spectrum Decision contemplates that the Commission may organise consultations to take account of the views of Member States, and all stakeholders. In view of that, the Radio Spectrum Policy Group (RSPG) was established by a separate decision.<sup>6</sup> The RSPG is constituted of representatives of the Member States and of the Commission, and its function is to adopt opinions on co-ordination of spectrum policy approaches in a wide range

of areas and harmonisation of conditions for the availability and use of radio spectrum.

In 2004, the European Commission published a 'Study on conditions and options for introducing secondary trading of spectrum in the European Community' by Analysys Consulting Ltd, DotEcon Ltd and Hogan and Hartson LLP. The study reached the following broad conclusions:

- secondary trading, maintaining the same use of spectrum, by itself confers net benefits on the EU, but flexibility increases those benefits approximately ten-fold, to EUR 8-9 bn per annum;
- the Commission should therefore promote the introduction of trading without change of use and flexibility through the use of appropriate binding measures on Member States.

Shortly thereafter, the Commission invited the RSPG to deliver an opinion on spectrum trading. After considerable debate among the national spectrum regulators the Opinion trod a careful path between approval of change of ownership (maintaining the same use) and a more sceptical attitude towards change of use.

Further, the RSPG was invited by the Commission to prepare an Opinion on a co-ordinated EU spectrum policy approach for wireless communication radio access platforms, under the acronym WAPECS (Wireless Access Platforms – later changed to 'policies' – for Electronic Communications Services).

The outcome of the process – an Opinion dated November 2005 – adopted the long-term objective of facilitating rapid access to spectrum for new technologies. For WAPECS frequency bands, technological neutrality and flexibility in the future use of the spectrum should be ensured. Equally, service neutrality should be achieved, subject to specific obligations, in the sense that ECS in any WAPECS band should be provided over any type of network, and no frequency band should be reserved for the exclusive use of a particular service. This would clearly require a transition which the RSPG believed would be facilitated by adopting implementation dates as guidelines.

This modest step forward was soon to be overtaken by more radical proposals. The Commission published some policy pronouncements relating to the fulfilment of the Lisbon Agenda, under the title of i2010. Initially these noted the desirability of spectrum reform in fairly general terms, but subsequently 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 Lisbon objectives. Accordingly it proposed the co-ordinated removal of restrictions on spectrum 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 much non-communication related spectrum, which makes up much of the remaining two-thirds of spectrum below 3GHz, would not be covered. The Communication was also a precursor of the more comprehensive proposals contained in the June Communication on reform of the ECS regulatory framework. We summarise this in Section 3 below, but first step back to consider the Commission's options.

## Some options for reform

A key feature of any workable framework for EU-wide spectrum reform must be that it is binding on all EU Member States, allowing no discretion as to whether the policy is implemented at national level. Under current EC law (both spectrum specific and general) a number of short term measures can be taken.

The Commission has identified three reform options which can be summarised as: (i) create a new spectrum agency; (ii) amend the existing framework through wider application of committee mechanisms; or (iii) leave the existing framework unchanged. The first option does not appear to us to be attractive, due to the numerous difficulties (both legal and practical) in creating such an entity. We dismiss the third option on the basis that while some short term steps can be taken under the existing framework (as suggested above, and discussed in some detail below) the framework is insufficiently clear and robust to support an efficient spectrum market.

Clearly, option 2 is to be favoured, but raises an immediate question over the pace at which reform can be achieved, given the current pressing need for flexibility in spectrum usage, to allow the market to grow unhindered. As described above, the Framework Directive currently permits rather than obliges Member States to introduce spectrum trading, without which freedom on spectrum usage has clear limits. New legislation can take substantial time to obtain the approval of the Council and Parliament and be

implemented into national law in each individual Member State.

Consequently, we categorise the options below in terms of short- and long-term options for reform. By necessity, each of the options is described in only summary terms.

### Short term options

#### Use the Spectrum Decision

The limits of the existing regulatory framework have been summarised above. It is possible that, ahead of full reform, certain positive steps towards a more liberal spectrum market could be taken by using the provisions contained in the Spectrum Decision, as illustrated by the Commission in its appraisal of its June 2006 proposals described below. Much could be achieved if the political desire of sufficient Member States was present. Moreover, there is inherent democracy in using the Spectrum Decision as it relies on the principles of comitology, which are accepted principles for efficient decision-making at the Community level with the full involvement of the Member States.

#### Adopt a Liberalisation Directive under Article 86(3)

Article 86(3) has been the real breakthrough tool for achieving liberalisation of the telecommunications sector. Crucially, the Commission can use this legal basis to adopt a liberalising Directive, without the involvement of either the European Parliament or the Council. The argument for using Article 86(3) would essentially be that, by mandating freedom of spectrum usage, the Commission is liberalising (rather than harmonising) a particular area and, therefore, that Article 86(3) is the appropriate legal basis.

On a more long term basis, such a technique could in principle be used in conjunction with Article 7 of the Framework Directive. Article 7 of the Framework Directive provides a mechanism under which the Commission can review (veto) NRA measures. In principle, as a separate initiative, the Article 7 review mechanism could be extended to cover Spectrum policy.

#### Rely on Mutual Recognition under Article 49 EC

The principle of mutual recognition is based on the fundamental freedoms guaranteed by the EC Treaty – namely the freedom of establishment and the freedom to provide services. Mutual recognition has generally been relevant as regards the transferability between Member States of individuals' professional qualifications. This Option may in principle, be available in the event of a delay in the pace of reform and the lack of action by the Commission (or the RSC).

As applied to spectrum, the argument would be that an operator of, for instance, public mobile services in a Member State where spectrum is tradable and not constrained by use, should be able to offer the same

services in any other Member State particularly where the operator hold rights to the same frequency in other Member States. According to the principle of mutual recognition this could occur even where the national laws of that Member State prohibit spectrum trading, or stipulate that a certain frequency must be used for a certain purpose – as to provide otherwise would be to deny that operator its freedom to provide its services on the same basis throughout the European Union.

Article 49 EC has been held to have direct effect (i.e. operators can rely on it to enforce their rights), and has even been used successfully to challenge rules which do not in fact discriminate between the nationals of different Member States, so long as the legislation in question has the effect of impeding access to a national market. Under the *Alpine Investments* case it appears that a national rule which, even if completely non-discriminatory as regards the rights of individuals of different Member States, may be unlawful to the extent that it restricts access to a market of a Member State. This principle was again set out in *Arblade*, in which the ECJ said that "Article [49] of the Treaty requires not only the elimination of all discrimination on grounds of nationality against providers of services who are established in another Member State but also the abolition of any restriction, even if it applies without distinction to national providers of services and to those of other Member States, which is liable to prohibit, impede or render less advantageous the activities of a provider of services established in another Member State where he lawfully provides similar services".

This option suffers from significant uncertainty and, although it could be relied upon in the short term, would, in the event of a challenge, unlikely be resolved much prior to any legislative reform process that was initiated around the same time. Indeed, any claim that a Member State's policy on use of frequencies or tradability of spectrum was contrary to Article 49 would therefore represent a challenge not only to national law, but also to EU law in the form of the Framework Directive.

#### Rely on Member States to take action

This option could take on a number of forms. In principle, Member States could simply agree to remove restrictions either on an ad hoc basis in response to a particular request or more generically. This approach is however unlikely to be practical, not least due to the substantial legislative efforts that might be required, against a background of a future need to amend such legislation as part of wider EU reform.

More creatively, it is possible to envisage the use of the procedure contained in Article 4(5) of the Spectrum Decision. This allows Members States to make a reasoned

request for the Commission to approve spectrum sharing arrangements in a particular Member State. While this provision may have been intended to allow Member States potentially to obtain exceptions to Community-wide policies, the provision could in principle be used to allow Member States to accelerate the pace of reform. Conceivably, this option could also be used in conjunction with the mutual recognition principle described above.

#### Rely on the Commission to take Action

Under this option, the Commission might bring proceedings against one or more Member States on the basis that their national rules were infringing the Treaty (e.g. the competition rules and/or the free movement rules) or the Framework and/or Authorisation Directives (an example of a latter challenge might be that a national policy that did not embrace flexible use did not comply with requirements that frequency allocations must non-discriminatory, and proportionate). While this would no doubt spur the reform process, any benefits would only materialise in the medium term, and, in the current climate, it is not clear to us that this would be an option the Commission would seriously consider.

#### Longer term options

In our view the only longer term option is legislative reform, which should be commenced immediately after the end of the review period. To keep the necessary changes to a minimum, we recommend that Article 9 of the Framework Directive be amended to mandate flexibility of spectrum use as well as its tradability, with a short deadline for its introduction. We emphasise however that given the target of achieving reform by 2010, certain short term steps ought to be taken within the existing framework, to try to accommodate market developments, otherwise valuable opportunities may be lost.

As far as the suggested changes to Article 9 of the Framework Directive are concerned, it is worthwhile reiterating our view, expressed above, that the current requirement on NRAs to achieve efficient and effective use of spectrum, to which flexible use is clearly ancillary, already allows significant steps to be taken towards a properly-functioning market-based spectrum policy. Our proposal is therefore aimed to some degree to clarify and make compulsory what is arguably already embedded within the policy framework.

A revised Article 9 of the Framework Directive might look as follows:

"Article 9

Management of radio frequencies for electronic communications services

1. Member States shall ensure the effective management of radio frequencies for electronic communication services in their territory in accordance with Article 8. They shall ensure that the allocation and assignment of such radio frequencies by national regulatory authorities are based on objective, transparent, non-discriminatory and proportionate criteria.

2. Member States shall ensure that undertakings shall, subject where appropriate to a requirement not to create harmful interference in respect of existing radio frequency users, be free to use spectrum according to the principles of technological and service neutrality, thereby ensuring maximum flexibility of use of radio frequencies.

3. Without prejudice to Article 9(2), Member States shall make provision for undertakings to transfer rights to use radio frequencies with other undertakings.

4. 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."

The accompanying staff working paper illustrates at page 15 possible decisions to be taken under the committee procedure noted above:

"- identification of the bands where the use of spectrum throughout Europe should be made subject to general authorisations only (e.g. unlicensed bands) and co-ordination of the conditions applicable in those bands;

- identification of bands where spectrum rights should be made tradable; ..."

(We assume in the second of these that flexibility is intended as well).

Finally, the Impact Assessment accompanying the Communication favours a second (of three) options for spectrum management, described as 'adapting the regulatory framework and improving co-ordination at EU level through the wider use of committee mechanisms.' (The rejected options are doing nothing and creating a European spectrum regulator.) It states (page 17) that under the chosen option:

"Where general authorisations are not possible, comitology decisions could designate exclusive spectrum usage rights in certain bands as tradable in all Member States, pursuant to a general provision introduced in the Framework and Authorisation directives. In those cases, market mechanisms would replace administrative decision making for the assignment of spectrum. Exceptions to such spectrum trading would have to be limited in time and scope and duly justified.'

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-going reform of the Directives.

## The Commission's June 2006 Proposals

The Commission's Communication on the Review of the EU regulatory Framework for ECS (SEC(2006) 816-7) proposes (at 5.1) that:

"based on common EU rules, greater flexibility in spectrum management could be introduced by strengthening the use of general authorisations whenever possible. When not possible, owners of spectrum usage rights should not be unduly constrained but subject to certain safeguards, have the freedom to provide any type of electronic communications service ('service neutrality') using any technology or standard under common conditions ('technological neutrality')."

"Using criteria based on economic efficiency, 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."

## Conclusion

In an ideal world the Commission would be able to immediately introduce legislation enabling Community-wide flexible spectrum use, and we welcome the fact that, through the concepts of service and technological neutrality, the Commission appears committed to this fundamentally necessary step in the evolution of the EU telecommunications market. Furthermore, there appears to us sufficient flexibility in the current framework to enable the Commission and the Member States to proceed more quickly along the path of reform, if the political will is present.

However, it is clear that only a fully harmonised framework mandating a market-based approach to spectrum ownership and use, will deliver the full benefits of an internal market.

We therefore anticipate that the ad hoc steps in the right direction noted above will have to be supplemented by an amendment to the Framework Directive, which in turn requires immediate political commitment from the Member States.

## Notes

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- 1 This independent paper was commissioned by Vodafone. However, Vodafone does not necessarily support any or all of the views expressed herein, and none of these views should be attributed to Vodafone. We should like to thank Isabelle Claisse of LeBoeuf Lamb for her input.
- 2 Commission Directive 2002/77/EC on competition in the markets for electronic communications networks and services [2002] OJ L249/21
- 3 Directive 2002/21/EC on a common regulatory framework for electronic communications networks and services [2002] OJ L108/33
- 4 Directive of the European Parliament and the Council on the authorisation of electronic communications networks and services [2002] OJ L 108/21
- 5 Decision No. 676/2002/EC of 7 March 2002 on a regulatory framework for radio spectrum policy in the European Community.
- 6 Commission Decision 2002/622/EC of 26 July 2002 establishing a Radio Spectrum Policy Group.

## Jonathan Sandbach



Head of Regulatory Economics, Vodafone Group Services

Jonathan Sandbach is Head of Regulatory Economics, within Vodafone Group Public Policy Department. Prior to this he worked in senior economist roles within Cable & Wireless and British Telecom, and National Economic Research Associates advising clients in telecommunications, postal and other utility industries. Dr Sandbach has a BA 1st class degree in Mathematics and Economics from York University, an MSc in Statistics passed with distinction from the London School of Economics, and a PhD from City University London.

# Forecasting the need for new spectrum allocation

## Introduction

Spectrum is a scarce resource requiring a process to match demand and supply. Developments in new nomadic and mobile telecommunications services require re-assessment of how the demand for new spectrum is to be met, and allocation and assignment decisions are to be made.<sup>1</sup>

In theory, market mechanisms can assign spectrum to users in a way that should be economically most efficient, requiring trading in a liberalised market in which spectrum can be used for different services (subject to certain safeguards).<sup>2</sup> Full spectrum trading, between different uses, would continually assign and re-assign spectrum through secondary markets – even with administrative allocations at the outset. In practise, there are a number of reasons why spectrum trading solutions may be slow to emerge on a global basis, although important steps are being taken in some individual markets or regions. Amongst the difficulties with trading are the externality costs resulting from interference between contiguous spectrum blocks, dependent on use. In addition, issues of international

co-ordination potentially fall outside the scope of what can be achieved through nationally or regionally instituted trading mechanisms. Consequently, spectrum allocation decisions have long had and are likely to continue to have an important international dimension, with the International Telecommunications Union (ITU) having had a long standing role in co-ordinating supply for new technologies on a global, or at least regional, basis. The World Radio Conference (WRC), hosted by the ITU, meets at intervals of three to four years to discuss and co-ordinate spectrum allocation on a global basis. Although WRC measures are in practice only “permissive”, in the sense allowing spectrum to be used for a particular purpose, without necessarily ruling out other uses, the WRC does set direction for subsequent exclusive allocation and assignment decisions made at national levels.

The thesis of this paper is that the processes used at international (WRC) and national levels are likely to result in allocation of new spectrum that are fundamentally different

from those that would occur in a competitive spectrum market, and risk being an economically inefficient allocation of the scarce spectrum resource:

- On the demand-side: forecasts of spectrum requirements (more than 5 years out) will always be prone to huge forecasting errors. Furthermore, there is a risk that they will be industry or planner aspirations, rather than central estimates against which a market participant would be prepared to commit investment on the basis of a business plan. The recent draft report on spectrum requirements for the future development of IMT-2000 and IMT-Advanced services, produced by the ITU's Radiocommunication Study Group Working Party 8F is an example, in which a spectrum bandwidth "requirement" for 2020 ranging from 1,280 MHz to 1,720 MHz is identified. The difference between this upper and lower bound (of 440 MHz) is more than the entire spectrum allocation for 2G and 3G mobile services in the UK. Furthermore, the lower limit of this range (1,280 MHz by 2020) is higher than a spectrum requirement forecast made by expert consultants (the Analysys/Mason Group) working for the UK government's spectrum review. In this forecast, even in the high demand scenario 1,310 MHz is not required until 2025, whilst the low demand scenario forecasts a requirement that never exceeds 550 MHz even by 2025, and for much of the time until then can be accommodated within existing allocated bands. Premature allocation of spectrum can have a number of negative economic consequences, not least the signaling of new development investment in directions that turn out to be unjustified.
- On the supply side: there is a risk that too little consideration is given to reallocating spectrum in such a way as to release alternative sources of supply that, in many cases, may have more desirable properties. An example would be the re-farming of 900MHz spectrum for 3G use.

Misallocations produce large transactional costs as the market recovers from initial mistakes – and in many countries it may not be able to do so. Governments often assume that 'emptying the cupboard' of spectrum and increasing supply is always the right policy decision and in the presence of a fully functioning market for secondary trading this may be the case. Vendor interests clearly encourage additional supply and governments may also have their own interests in raising revenues from spectrum sales. Making new spectrum available is often critical to realising enormous economic benefits but, as with energy reserves, the strategic significance of the world's spectrum resources means that we need to take a broader view of the consequences when making administrative decisions on spectrum allocation.

## Economic Complexity of Spectrum Allocation

Radio engineers fully appreciate the technical complexity of spectrum allocation. However, the economic complexity may be missed. Work has been done on setting economically efficient prices for spectrum that has been allocated by administrative means,<sup>3</sup> and an individual assignment (e.g. via auctions), but less practical work has been done to understand how economically efficient allocation decisions can be made in the first place.

### Demand Forecasting Approach

In practise, and certainly at the international level, models are constructed that estimate a "bottom-up" spectrum requirement for new and existing services. The Annex to this paper provides a brief synopsis and critique of a spectral demand forecasting methodology prepared in the context of the WRC for 2007.

At first sight this would seem to be a sensible approach. There are, however, problems. Most obvious is the tendency to set forecasts that are industry aspirations, rather than being based on a realistic view of consumer willingness to pay for new services (within a limited budget constraint). In particular, there is always a risk that a pure demand forecasting approach does not give explicit recognition to the link between network build costs (which typically increase for high frequency spectrum), end-user prices required for full cost recovery, and end-user willingness to pay these prices.<sup>4</sup> Thus, the demand-side forecasts risk being over-stated. In a real life business case, where investment funds are to be committed, there is a clear incentive to ensure that this linkage is fully understood, with the aid of market research to understand consumer willingness to pay, and fully costed network studies. However, without this market discipline there is a danger of forecasts being set on secondary information and aspirations that have not been exposed to real market testing.

It is not surprising that different forecasting methodologies can produce very different results. The Annex to this paper compares the forecasts produced in the context of the WRC, by ITU Working Party 8F, with those produced by a different set of experts (Analysys) in the context of a UK spectrum review. The results of the two sets of forecasts are summarised in Table 1.

Table 1 shows that the forecast made by the experts of the ITU Study Group Working Party is consistently higher than those made by Analysys/Mason, even comparing the most pessimistic forecast of the ITU Working Party with the most optimistic of Analysys/Mason. Furthermore, the range of forecasts produced by Analysys/Mason is very large,

**Table 1: Spectrum Demand Forecasts (MHz)**

	2010	2015	2020	2025
<b>ITU Study Group, Working Party 8F</b>				
Low market setting	760	1,300	1,280	n/a
High market setting	840	1,300	1,720	n/a
<b>Analysys/Mason</b>				
"Low traffic" scenario	90	200	430	550
"High traffic" scenario	460	1,270	1,200	1,310

Source: ITU Radiocommunications Study Group, Working Party 8F Analysys/Mason (interpolated where no precise figures given)

reflecting market uncertainty. The ITU Working Party, in addition to being significantly more optimistic, has not reflected the same degree of uncertainty.

The conclusion is that it is very difficult (if not impossible) to produce a definitive spectrum forecast, and even those that are produced are prone to a possible aspiration bias.

**...but there's more than just demand forecasting**

However, there are other more fundamental concerns of spectrum allocations based purely on demand forecasts. The existing international spectrum allocation practices assume implicitly that spectrum is a "free" resource that can be allocated to the first identified potential demand. No explicit account is taken of the lost "option value" that may result from other uses of the spectrum (as yet unknown) further down the road. Although this may have been a factor in the allocation decision, it is difficult to identify any formal analysis.

Finally, on the supply side there is no explicit recognition of the additional supply that could be generated from a more efficient re-allocation of existing spectrum. An example of this is the possibility of permitting re-farming of some 900 MHz spectrum for 3G use.<sup>5</sup> This would allow greater spectral efficiency within the 900 MHz bands, and allow new mobile services to use spectrum more appropriate to wide area coverage (and in the process giving a greater chance that these services will then be provided at a price point consistent with the spectrum forecasts). As before, although this may have been a factor in the allocation decision, it is difficult to identify any formal analysis that took place.

One possible view of the forecasts prepared for WRC is that they are intended to be upper bounds. This view would follow from the fact that "allocation" decisions made by the WRC are usually meant to be "liberalising measures", allowing spectrum to be assigned to a user for the allocated purpose, but also not disallowing assignments within the same band for other uses. Therefore, the WRC allocation decisions could be viewed as simply allowing greater flexibility for spectrum to

be used for certain identified applications, without denying its use for other purposes if locally assigned. The difficulty with this interpretation, however, is that the WRC "allocation" decisions do send out signals to national authorities and companies that the spectrum in question will be used principally (or even exclusively) for the services allocated to it.

**Consequences of Misallocation**

There are a number of adverse consequences of any economic failure in the administrative allocation processes:

- Undersupply - failing to ensure sufficient is made available to meet existing and prospective demand, thus preventing the expansion of existing services or the development of new services;
- Oversupply - allocating spectrum to meet demand for new or existing services which is not realised:
  - signalling investment in particular infrastructures, at the exclusion of others which prove to be more economically desirable; and
  - loss of demand and consumer benefit for other new services (perhaps not yet identified) dependent on spectrum which has now been sterilised through misallocation;
  - high transaction costs associated with 'recovering' misallocated spectrum and reallocating it to other users.
- Non-optimal allocation, i.e. failing to re-allocate spectrum, where re-allocation would allow for greater spectral efficiency resulting in a net increase in the scale and scope of services that could be provided, or result in a net reduction in the costs of utilising the spectrum for specific services.

## An Alternative Approach?

A threshold for allocation of new spectrum should explicitly take account of:

Consumer benefit from services on new spectrum allocation (consistent with the demand that will materialise under user prices)

**Less**

Development, network build and other costs for exploiting the spectrum

**Less**

Opportunity value of alternative known uses of the spectrum (if any)

**Less**

Real option value extinguished by committing the spectrum at this time (including commitment of scarce financial and intellectual resources)

**Should be greater than**

Consumer benefit from same services achieved by liberalising (re-farming) other spectrum

**Less**

Development, network build and other costs for exploiting the re-farmed spectrum

This threshold essentially aims to require policy makers to take explicit account of the major relevant economic factors that should support an allocation decision. Firstly, the policy makers are required to take account of all relevant factors in the consumer benefit forecast (including a realistic view of consumer demand given network deployment costs). Secondly, they are required to net-off the network build costs and, importantly, the opportunities of benefits that will be foregone from other uses of the spectrum, whether they be currently known, or whether they be speculative (and incorporated into the analysis through an option value).

Secondly, the policy makers are required to investigate the benefits of other sources of supply through reallocation (or simply liberalisation) of other spectrum, to test whether this could yield greater consumer value (because, for example, the spectrum made available is more suitable to the new services being considered).

## Option Value

The lost option value of a spectrum allocation is a potentially important element. As with any real or financial option, the value of the option is increased when the uncertainty of future returns (or benefits) on the underlying asset increases.

Thus the greater the degree of uncertainty over the benefits of the spectrum allocation (perhaps due to demand or consumer willingness to pay), the greater the real option value in waiting before committing allocation. Similarly, the greater the uncertainty around the other potential uses of the spectrum, the greater the real option value in withholding allocation. The implication of this for the particular case of spectrum allocation is clear. Uncertainty over the future demand for spectrum around any "central forecast" should increase the threshold requirement for a decision to be made to allocate spectrum.

At first sight, quantifying the value of this real option may appear challenging. However, the crucial parameters can be individually identified:

1. The degree of uncertainty over future demand for the spectrum use in question. This is generally available from the range of low, medium or high demand scenarios, such as those discussed in the Annex case study.
2. The probability that an alternative use may emerge that has greater net value, in terms of consumer surplus, less infrastructure development and build costs. This also may best be treated as a scenario analysis.

## Policy Implications

The conclusion is that in the absence of full spectrum trading caution needs to be taken not to be overly hasty in allocating new spectrum ahead of proven consumer value, and before full consideration has been given to the liberalisation of existing spectrum.

We have proposed a simple threshold test that includes not only the potential consumer benefits of the proposed allocation, but also fully and consistently takes account of the costs and, importantly, the lost real option value of waiting; and compares this with the benefits of alternative schemes involving spectrum reallocation or liberalisation. Such a methodology or procedure could be developed for incorporation into international decision making in order to fully recognise the economic consequences of the decisions made.

## Annex : Case Study on Demand for New Nomadic and Mobile Services

A number of parties within the telecommunications industry are seeking justification for allocation of additional spectrum for nomadic and mobile services. These efforts are focusing on WRC 2007, where a decision could potentially be made to allocate new spectrum ranges, or re-allocate existing spectrum ranges.

Any WRC 2007 decision would require a demand study. To date, the ITU Radiocommunications Study Group, Working Party 8F, has produced a "Draft new Report [IMT.ESTIMATE] on Spectrum requirements for the future development of IMT-2000 and IMT-Advanced".

## Synopsis of Methodology

*Demand Forecasts:* The demand forecast consists of forecasts of 5 "market attributes":

1. Market scale, forecast using traditional "S" shaped curve;
2. Session attempts per user;
3. Mean service bite rate;
4. Average session duration;
5. Mobility ratio (i.e. percentage of usage that is stationary, low, high, super-high).

Forecasts on each of these attributes are made for:

- 5 "Service Environments" (e.g. SE1 = "Dense urban home", SE2 = "Dense urban office", SE3 = "Dense urban public area"); and, in each service environment

- 20 "Service Categories" (e.g. SC1 = "Super high bit rate conversational", ..., SC20 = "Very low bit rate background"), to produce output matrices of Uplink and Downlink service forecasts.

*Spectrum Requirement Forecasts:* Using the demand forecasts for each of the 5 market attributes, the following steps are performed:

- a) Aggregate demand forecasts into traffic requirements for two ITU-R defined RAT (Radio Access Technology) Groups;
- b) Determine system capacity within each RAT Group;
- c) Determine spectrum requirements within each RAT Group;
- d) Apply necessary adjustments to spectrum requirements in practical network deployment to allow for, inter alia:
  - Guard bands;
  - Multi-operator environment;
  - Minimum deployment amounts of spectrum;
- e) Calculate overall aggregate spectrum requirements.

Application of the methodology is said to give the spectrum requirements shown in Tables A1 and A2.

**Table A1: Predicted "average market" spectrum requirements for both RATG1 and RATG2 (MHz)**

	Requirement Spectrum for RATG 1			Requirement Spectrum for RATG 2			Total spectrum requirement		
	2010	2015	2020	2010	2015	2020	2010	2015	2020
Low market setting	760	800	800	0	500	480	<b>760</b>	<b>1,300</b>	<b>1,280</b>
High market setting	840	880	880	0	420	840	<b>840</b>	<b>1,300</b>	<b>1,720</b>

Source: ITU Radiocommunications Study Group, Working Party 8F

**Table A2: Ranges of predicted spectrum requirements (in MHz) in 2020**

	Low Market Setting				
	1 Network	2 Networks	3 Networks	4 Networks	5 Networks
RAT1	800	880	840	1120	1000
RATG2	480	560	720	800	1000
RATG1+ RATG 2	1280	1440	1560	1920	2000

	High Market Setting				
	1 Network	2 Networks	3 Networks	4 Networks	5 Networks
RAT1	880	880	960	1120	1200
RATG2	840	880	1020	1120	1300
RATG1+ RATG 2	1720	1760	1980	2240	2500

Source: ITU Radiocommunications Study Group, Working Party 8F

## Critique

There are concerns about the robustness of these forecasts. These concerns can be grouped together as follows:

*Un-validated assumptions:* the methodology for both the demand forecasts and the spectrum requirement forecasts depend on a vast number of assumptions that, to our knowledge, are un-validated. A systematic review of the entire assumption set would be a very significant task.

*Consumer budget constraints:* there is no robust attempt to estimate the costs of building the networks to support the demand forecasts, and whether these costs are consistent with consumer budget constraints or willingness-to-pay. Thus, the methodology omits the crucial steps of:

- Estimate the network build costs to meet the forecast demand;
- Determine indicative service price levels at which services could be made available;
- Verify the level of consumer demand that would actually exist at the estimated price level (willingness-to-pay);
- Adjusting the service demand forecasts accordingly;
- Adjusting the spectrum requirements accordingly;
- Repeating the above steps until a converged state is achieved in which actual consumer demand equates with supply at the indicative service prices.

As the methodology stands, we suspect that demand would never materialise at the service price levels required to fund the network builds. This is especially true if spectrum supply involves higher frequencies requiring a far denser cell site build.

*Consumer time constraints:* In addition to (economic) budget constraint or willingness-to-pay validation, the service demand forecast methodology should also include a validation against consumer time constraints: i.e. would consumers be prepared to devote sufficient of their work or leisure time to consume the predicted services? We are not aware that this validation has been attempted.

## Alternative Forecasts

Follow-up work for the UK government's "Review of Radio Spectrum Management" (the "Cave Report") resulted in the publication of a study by the Analysys Group<sup>6</sup> consultancies "Final Report for the Independent Audit of Spectrum Holdings: Spectrum demand for non-government services 2005-2025", published on 1 September 2005.

Both the Analysys and the Working Party 8F approach are based on a forecast of service demand. The Working Party 8F forecasts are far more detailed in specifying the individual service categories and applications (as described above).

Hereafter the approaches are totally different. Working Party 8F proceeds directly to a spectrum demand forecast. The Analysys approach acknowledges that the relationship between service demand and spectrum requirement is dependent on the network build investment. For example, a greater investment in network build will mean that the service demand can be met with a lower supply of spectrum. This approach is then able to determine the spectrum demand that will optimise the cost of network build.

In more detail the Analysys model has the following components:

- Traffic model: based on two scenarios ("high traffic" and "low traffic"), projections are developed for:
  - IMT-2000 subscribers, by geo-type and technology;
  - ARPU for voice and data services;
  - Unit price evolution (price per MB);
  - Implied busy hour traffic requirements (in Mbit/s) by geo-type and technology;
- Cost model: estimating the cost of the network build to provide both the coverage and traffic capacity to meet demand, under a given assumption of spectrum availability (supply).
- Essentially, the model then determines the level of spectrum supply that will minimise the network costs for the predicted level of end user demand. This calculation takes account of technological developments, such as HSDPA/HSUPA and systems beyond IMT-2000 (assumed to be available from 2015 in urban areas, and 2018 in rural areas). It is assumed that HSDPA/HSUPA achieves a spectral efficiency of 1.5 compared to original 3G, whilst "systems beyond" IMT-2000 achieve a spectral efficiency of 1.8.

This methodology predicts:

- "Low traffic" scenario: Urban spectrum demand will stay below 550MHz until 2025.
- "High traffic" scenario: Urban spectrum demand will rise to 1270MHz by 2015, and 1310MHz by 2025 (essentially as a result of services provided by "systems beyond" IMT-2000).

Thus, the Analysys model “low traffic” scenario gives a substantially lower spectrum requirement forecast than the Working Party 8F approach. The “high traffic” scenario reaches a level consistent with Working Party 8F for the low market setting scenario, and takes until 2025 to reach this level, rather than the date of 2020 anticipated by Working Party 8F. For the high market setting, the Working Party 8F is well in excess of the Analysys “High traffic” scenario for 2025, even by 2020. Thus we can conclude that, compared to the Analysys model, the Working Party 8F appear extremely optimistic, particularly in respect of the time taken to achieve the forecasts.

**Implications for the allocation of new spectrum for “IMT2000 and systems beyond”**

The existing cellular spectrum supply for the UK is shown in Table A3.

**Table A3:**

UK Currently Available Cellular Spectrum Supply	
2G (900MHz and 1800MHz)	210 MHz
3G (2000MHz)	140 MHz
3G expansion (2500MHz)	190 MHz
Total	540 MHz

Table A4 shows the spectrum bands required to meet each of the forecasts discussed in this note:

- Under the Analysys “low traffic” scenario, the existing allocated 2G and 3G bands are sufficient until around 2016, at which point the 3G expansion bands should provide sufficient capacity until 2020;
- Under both the Analysys “high traffic” scenario, and the Working Party 8F projections, the 3G expansion bands are required by 2010, and further spectrum (over and above the expansion bands) is required by 2012 (and even earlier for Working Party 8F).

Table A4 illustrates the differing implications of spectrum demand forecasts made by different groups of experts. Taking the view of the ITU Working Group, new spectrum needs to be allocated to mobile and nomadic services by around 2010, whilst forecasts by Analysys for the UK imply that additional spectrum will not be required by 2012 at the earliest, and potentially not at all until 2020.

**Table A4:**

Predicted Spectrum Band Requirements for UK/Europe (Urban)									
	2006	2008	2010	2012	2014	2016	2018	2020	
<b>ITU Radiocommunications Study Group</b>									
Further bands									
3G expansion bands									
Existing 2G & 3G bands									
<b>Analysys: “low traffic” scenario</b>									
Further bands									
3G expansion bands									
Existing 2G & 3G bands									
<b>Analysys: “high traffic” scenario</b>									
Further bands									
3G expansion bands									
Existing 2G & 3G bands									

Source: Analysis based on results of ITU Radiocommunications Study Group, Working Party 8F and Analysys/Mason

- 1 Unless otherwise stated, for the purposes of this paper we use the terms "allocate" and "allocation" to refer to the administrative decisions to make a specified part of the radio spectrum, within defined geographical limits, available for specified services, to the total or partial exclusion of other services. Similarly, we use the terms "assign" and "assignment" to refer to the administrative decision or market transaction that gives exclusive rights of use of a specified part of the radio spectrum, within defined geographical limits, to a particular user.

We recognise that these definitions may not correspond to more formal definitions used in ITU (International Telecommunications Union) and other documents. In particular, the ITU treats spectrum allocations to particular services as non-exclusive, leaving to subsequent measures by other (local) bodies to decide which services allocated to a particular band of spectrum are given preference, and which are excluded.

- 2 Subject to assumptions of zero transaction costs and transparency of market information.
- 3 For example, "Study into the use of Spectrum Pricing", National Economic Research Associates, April 1996; "Review and Update of Spectrum Pricing Models", Smith System Engineering and National Economic Research Associates, July 1998; and "An economic study to review spectrum pricing", Indepen, Aegis Systems and Warwick Business School, February 2004.
- 4 Although it is possible that these factors were considered during the analytical process, it is difficult to see how they explicitly dealt with.
- 5 In fact, the ITU Study Group analysis may implicitly assume re-farming by setting a single set of parameters (for spectrum efficiency and channel width) which are closer to 3G characteristics.
- 6 Analysys and Mason.



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