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TOWARDS MORE FLEXIBLE SPECTRUM REGULATION AND ITS RELEVANCE FOR THE GERMAN MARKET

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The opinions expressed in this document are those of the authors and do not necessarily reflect the views of the International Telecommunication Union or its membership.

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Abbreviations

2G	2nd Generation
3G	3rd Generation
4G	4th Generation
ABA	Australian Broadcasting Authority
ACA	Australian Communications Authority
ACA Act	Australian Communications Authority Act
ACCC	Australian Competition and Consumer Commission
ACMA	Australian Communications and Media Authority
AIP	Administrative Incentive Pricing
AM	Amplitude Modulation
ATA	Australian Telecommunications Authority
AUD	Australian Dollar
AWS	Advanced Wireless Service
BRS	Broadband Radio Service
BTCE	Bureau of Transport and Communications Economics
BWA	Broadband Wireless Access
CB	Citizen Band
CBS	Cell Broadcast Service
CEPT	Conférence Européenne des Administrations des Postes et Télécommunications
CENAC	Centro de Arbitraje y Conciliación
CRTC	Canadian Radio-television and Telecommunications Commission
dBM	decibel mW
dBW	decibel W
DCS	Digital Cellular System
DCITA	Department of Communications, Information and the Arts
DECT	Digital Enhanced Cordless Telecommunications
DFS	Dynamic Frequency Selection
DRCS	Digital Radio Concentrator Systems
DSI	Detailed Spectrum Investigations
DTV	Digital Television
EBS	Educational Broadband Service
EC	European Commission

ECC	European Communications Committee
EHF	Extremely High Frequency
EIRP	Equivalent Isotropically Radiated Power
E-mail	Electronic Mail
ERC	European Radiocommunications Committee
ERMES	European Radio Message System
ESMR	Enhanced Specialized Mobile Radio
ETSI	European Telecommunications Standards Institute
EU	European Union
FAC	Frequency Assignment Certificate
FCC	Federal Communications Commission
FCFS	First-Come, First-Served
FDD	Frequency Division Duplex
FM	Frequency Modulation
FreqBZP	Frequenzbereichszuweisungsplan (Frequency Allocation Plan)
FreqNP	Frequenznutzungsplan (Frequency User Plan)
FSS	Fixed-Satellite Service
FWA	Fixed Wireless Access
GHz	Gigahertz
GPS	Global Positioning System
GSM	Global System for Mobile Communications
GSM-R	Global System for Mobile Communications - Railway
GUL	General User License
GURL	General User Radio License
GUSL	General User Spectrum License
HCRC	High Capacity Radio Concentrator
HDTV	High Definition Television
HF	High Frequency
HHI	Herfindahl-Hirschman-Index
IEEE	Institute of Electrical and Electronic Engineers
IIC	Interference Impact Certificate
ITFS	Instructional Television Fixed Service
ITU	International Telecommunication Union
kbps	kilobit per second

kH	Kilohertz
km	Kilometer
LAN	Local Area Networks
LMDS	Local Multipoint Distribution Service
LPFM	Low-Power FM Broadcasting
LPON	Low Power Open Narrowcasting
m	Meter
Mbits/s	Megabits per second
MCI	Mobile Communications International
MCS	Multichannel Communications Service
MDS	Multipoint-Distribution Service
MED	Ministry of Economic Development
MF	Medium Frequency
MHz	Megahertz
MMDS	Multichannel Multipoint Distribution Services
MoD	Ministry of Defence
MPL	Minimal Path Length
MR	Management Rights
MRR	Management Rights Regime
MSS	Mobile Satellite Services
MWS	Multimedia Wireless Systems
NGSO FSS	Non-Geostationary Fixed-Satellite Service
NGSO MSS	Non-Geostationary Mobile-Satellite Service
NHz	Nanohertz
NOI	Notice of Inquiry
NPRM	Notice of Proposed Rulemaking
NTIA	National Telecommunications and Information Administration
NZD	New Zealand Dollar
Ofcom	Office of Communications
OECD	Organisation for Economic Co-operation and Development
OET	Office of Engineering and Technology
OPP	Office of Plans and Policy
OSP	Office of Strategic Planning & Policy Analysis
P2MP	Point to Multipoint

P2P/ P-P	Point to Point
PAMR	Public Access Mobile Radio
PBR	Private Business Radio
PBRS	Private Business Radio Suppliers
PCS	Personal Communications Service
PFD	Power Flux Density
PIB	Public Information Brochures
PL	Path Length
PLMRS	Private Land Mobile Radio Service
PROBE	Provincial Broadband Extension
RA	Radiocommunications Agency
RC Act	Radio Communications Act
RFID	Radio Frequency Identification
RLR	Radio License Regime
RSM	Radio Spectrum Management
RSMG	Radio Spectrum Management Group
RSPG	Radio Spectrum Policy Group
RSPP	Radio Spectrum Policy and Planning
R&TTE	Radio and Telecommunications Terminal Equipment
SDR	Software Defined Radio
SDTV	Standard Definition Television
SMA	Spectrum Management Agency
SMART	Spectrum Management and Registration Technology
SMO	Spectrum Management Organisation
SMP	Significant Market Power
SMR	Specialized Mobile Radio or Simultaneous Multiple Round
SPTF	Spectrum Policy Task Force
SQBs	Spectrum Quality Benchmarks
SRD	Short Range Devices
SRR	Spectrum Rights Regime
STU	Spectrum Trade Unit
TCNZ	Telecom Corporation of New Zealand
TDD	Time-Division-Duplex
TFAC	Technical Frequency Assignment Criteria

TKG	Telekommunikationsgesetz (Telecommunications Act)
TLMS	Trunked Land Mobile Service
TP Act	Trade Practices Act
TPRC	Telecommunications Policy Research Conference
TUF	Títulos de Uso de Frecuencias
TVOB	Television Outdoor Broadcasting
UHF	Ultra High Frequency
UHF TV	Ultra High Frequency Television
UK	United Kingdom
UKPFA	UK Plan for Frequency Authorisation
UMTS	Universal Mobile Telecommunications Systems
USA	United States of America
USD	US Dollar
UWB	Ultra Wide Band
VHF	Very High Frequency
WAPECS	Wireless Access Platforms for Electronic Communications Services
WCS	Wireless Communication Service
WiFi / Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless Local Area Network
WLL	Wireless Local Loop
WRC	World Radiocommunication Conference
WRS	Wireless Radio Service

1 Introduction

The demand for radio-based applications continues to grow in line with the increasing mobility of the communication society. This demand can only be satisfied, however, if there is sufficient spectrum available. Furthermore, the pace of technological change, with accelerating cycles of innovation, calls for a regulatory regime that makes suitable spectrum available as quickly as possible.

These developments, driven by technological and market forces, present spectrum regulators with major challenges. On the one hand, the regulator must provide spectrum to meet demand, i.e. at the right time, in the right quantity and, if possible, for multiple applications. On the other hand, the regulator must ensure that spectrum use is efficient and interference-free and that there is a level playing field for competitors, as well as working to establish sustainable market competition. In addition, spectrum regulation must also take account of the interests of professional, scientific and military radio users, as well as the emergency services.

The aim of the study is to support the Federal Network Agency in devising possible approaches to a system of spectrum regulation that is both market-based and forward-looking. To this end, the study shall describe and evaluate the different routes by which other countries have reformed their system of spectrum regulation or wish to do so. The countries in question are the United Kingdom, the USA and Canada, Australia and New Zealand, and Guatemala.

The study shall examine the model of spectrum regulation in use in the selected countries, and the extent to which the countries operate – or intend to operate - flexible systems that permit a more efficient use of the spectrum. Efforts to introduce a more flexible approach to spectrum regulation fall into two broad categories: Liberalisation and spectrum trading/transfer, terms that are now widely used in Europe. *Liberalisation* addresses the extent to which spectrum usage rights should still be restricted and indeed whether any such restrictions are needed. *Spectrum trading*, on the other hand, focuses on the options available for transferring spectrum and the detailed institutional arrangements for a spectrum trading regime. In some countries, such as the UK, the topic of *spectrum pricing* is being discussed at the same time as liberalisation and spectrum trading. Indeed, usage charges that reflect the economic value of the spectrum are a further tool that can be used to promote an efficient use of spectrum. Such charges are also a means of preventing the original spectrum users from making windfall profits, in case the economic value of the spectrum increases sharply, for example as a result of technological advances or changes in the conditions of use.

The country studies also reveal the extent to which the regulatory regimes in the various countries respond to new developments in technology, for instance *software-defined radio*, which can access unused spectrum almost automatically. It is also necessary to examine the degree to which a regulatory regime should respond flexibly in the context of securing the availability of spectrum and usage rights for new system technologies such as systems that comply with the IEEE 802.16 family of standards (e.g. WiMAX).

The literature on the topic reveals a wide variety of institutional arrangements for allocating spectrum, including band managers, spectrum exchanges, trading platforms and leasing. The study examines the extent to which these concepts are already in use or are in the pipeline.

The following text highlights some key factors that are of particular significance in the context of liberalisation and spectrum transfers/trading.

Liberalisation

- What key changes have there been in the conditions of use?
- To what extent is it possible to partition assigned spectrum?
- What kind of interference management regime is in place and how has this evolved over time? Are there still guard bands/maximum power flows? Is it possible for the parties involved to reach agreements that deviate from the prescribed thresholds? Are there different interference management regimes depending on the type of spectrum and blocks of frequency in question?
- What changes have there been with regard to obligations on use? (e.g. has there been a move away from coverage requirements? To what extent are quality standards specified for the intended service?)
- Is there a trade-off between (international) moves towards a harmonisation of spectrum use (e.g. GSM harmonisation) and liberal, less restrictive frequency usage plans?
- Do conditions of use apply in perpetuity or only for a certain period? How has this changed over time?
- How is it ensured that sufficient spectrum is available for applications that serve the public interest?
- Which frequency bands are assigned using the commons model, a command-and-control approach and market-based mechanisms respectively? The difference between a command-and-control and a market-based approach is that under the latter it is possible to trade spectrum usage rights, whereas a command-and-control approach requires redistribution by the regulatory authority.

Spectrum trading

- In which frequency bands is it possible to trade spectrum?
- Is it permitted to lease usage rights for a defined period? If so, under what conditions?
- What are the institutional arrangements for spectrum trading? Are there band managers for certain bands?
- To what extent does a functioning trading regime depend on the conditions of use and the degree of liberalisation?
- How are the trading mechanisms designed? Does the regulatory authority decide on the type of assignment mechanism?
- Are the original obligations of the spectrum user also transferred when spectrum is traded?
- To what extent are competition issues taken into account? Is the ex post application of competition law deemed sufficient or are there ex ante provisions governing spectrum trading, such as spectrum caps?

- How is the approved trading mechanism designed? Are there bilateral negotiations, auctions, trading platforms etc.?
- What information has to be provided to the regulatory authority when a trade takes place?
- Is spectrum trading only possible in certain frequency bands? Is there a timetable for its introduction etc.?
- Is trading permitted even if spectrum was not originally assigned in an auction?

Efforts to introduce a more flexible regulatory regime with regard to conditions of use and spectrum trading are sometimes accompanied by changes in the policy towards spectrum pricing, for instance with the aim of preventing windfall profits. Such changes will also be examined as part of this study.

Spectrum pricing

- How is the spectrum pricing regime designed?
- How has this evolved over time?
- Has administrative incentive pricing been employed, or are prices merely set at a level that recovers administrative costs?

The study shall examine the United Kingdom, the USA and Canada, Australia and New Zealand, and Guatemala, focusing in particular on the following points:

- What were the key reasons underlying the changes that have taken place?
- What specific changes have been made compared to the previous regulatory regime?
- Why were these measures chosen in particular?

This shall provide a framework for devising concrete proposals regarding the future of spectrum regulation in Germany. The proposals shall take particular account of the specific conditions that prevail in Germany (e.g. nine neighbouring countries, population density).

Structure of the study

The study is structured as follows: *Chapter 2* starts by outlining the fundamental economic considerations underpinning a more flexible approach to spectrum regulation. *Chapter 3* examines the current legal framework in Germany, pursuant to the new *Telekommunikationsgesetz* (TKG - German Telecommunications Act). This is followed by the country studies in *Chapter 4*, which focus on the United Kingdom, the USA and Canada, Australia and New Zealand, and Guatemala. At the end of each country study, there is a summary of the situation in that country as well as lessons that can be learned for Germany. Finally, *Chapter 5* draws on the knowledge gained from the country studies to present guiding principles for a flexible system of spectrum regulation in Germany.

2 Economic considerations underpinning a more flexible approach to spectrum regulation

2.1 Guiding principles of effective and flexible spectrum regulation

In the following section we examine the most important factors that need to be taken into account in any effort to establish an efficient system of spectrum regulation. The goal of a more flexible regulatory regime, in whatever form, should be a more efficient use of spectrum, which is a scarce resource. This goal should be reflected in the licence conditions (governing spectrum use), the rules for assigning frequencies and the options available for transferring rights of use, as well as in the relevant institutional arrangements. The conditions of use, for example, should impose only the minimum of restrictions, while it should also be possible to transfer or re-assign spectrum if, in the light of technological developments, it can be used more efficiently elsewhere.

It is also important to ensure that the transaction or administrative costs for spectrum users are as low as possible. This implies, for example, that there should be few bureaucratic obstacles to the transfer of spectrum. At the same time, there should be a source of clear information that allows prospective spectrum users to find out which frequencies are available, what they can be used for, who is currently using them and what needs to be done in order to obtain rights of use. This in turn implies the clear definition of spectrum usage rights.

The goal of ensuring that at any point in time, spectrum usage rights should be held by the person "best" able to use that spectrum, is not the only factor to consider when regulating frequencies. For instance, spectrum usage can be impaired by interference, which is caused by two users operating at a similar frequency. Any model used to distribute spectrum must take this factor into account. The public interest, something ignored in purely commercial transactions, also plays a part; there must be sufficient spectrum available for public broadcasting and military usage, for example. Competition policy is a further factor to be taken into consideration, whereby the relative transaction costs of *ex ante* and *ex post* regulation should also form part of the equation. International rules and agreements, emanating for example from the ITU and CEPT or deriving from European directives, must also be observed. Decisions to harmonise spectrum usage (e.g. in the case of GSM) impose limits on the services that can be offered, yet may well result in more efficient usage because they lower the costs of coordination and open up the possibility of international applications (e.g. international mobile roaming). This highlights the factors that need to be taken into account in any effort to establish an efficient system of spectrum regulation, and shows just how complex the subject is.

The following points revisit the most important principles in any discussion about how to improve the flexibility of the current system.

- *Ensuring the efficient use of the radio spectrum*: In view of the fact that spectrum is a scarce resource, the goal of spectrum regulation should be to ensure that frequencies are assigned to those who, in economic terms, can use them most efficiently. This calls for a selection process that assigns the right to use spectrum to the person who is willing to pay the most for that right. The amount users are willing to pay corresponds to the economic benefit they expect to derive from using the frequencies. This approach implies that users must not benefit from

hoarding spectrum, while it should also prevent users withholding spectrum from trading for speculative reasons or other strategic motives. Furthermore, there should be no barriers to market entry that prevent sound economic use of the spectrum. This means, for instance, that the charge for using the spectrum should never be higher than the corresponding opportunity cost, which is equal to the market price.

- *Creating incentives for investment and innovation*: One goal of spectrum regulation should be to encourage investment and innovation. This means that users must be able to use the spectrum for long enough to amortise their investments; a company must have adequate opportunity to make a profit. Care also needs to be taken to ensure that spectrum regulation does not have a negative impact on the returns that can be achieved in certain sectors.

- *Addressing issues of competition policy:* Regulatory policy seeks to create a market in which prices are as close to costs as possible and where consumers can choose from a wide range of services. Sustainable competition is usually only possible where there are competing infrastructures, yet the scarcity of radio spectrum creates restrictions which often mean that an oligopoly is the only possible outcome. Frequencies should therefore be distributed in such a way as to create a market structure that ensures the maximum possible degree of competition for the available spectrum.

- *Non-discrimination*: Spectrum regulation should be non-discriminatory and should not favour one group of users over another, unless there is an objective and relevant reason for doing so.

- *Transparency*: Every single action relating to spectrum regulation should be transparent.

- *Workability*: The system of spectrum regulation should be workable, administrative outlay should remain within reasonable bounds, and transaction costs should be kept as low as possible. The last point means in particular that institutional barriers to spectrum trading should be kept as low as possible.

- *Providing planning certainty*: The regulatory regime should enable companies to plan for the future with a high degree of confidence. Licence periods should be clearly defined, as should the type of usage for the spectrum in question. In terms of spectrum trading, this calls for the authority to clearly define spectrum usage rights/rights of use at the time the spectrum is initially assigned to the user. The authority should also clarify, as far as possible, the extent to which the spectrum can be traded.

- *Minimising interference:* The use of similar frequencies for different services may lead to interference for both. This can occur within a country as well as in border regions. Interference limits the use of the spectrum, a negative external effect that results in economic inefficiencies (users of the GSM spectrum, for example, require a guard band separating them from their spectrum neighbours). Spectrum regulation should seek to avoid or at least minimise such interference.

- *Ensuring compatibility with the original frequency assignment:* The rules of spectrum trading should conform to the original assignment procedure. For instance, it would be extremely

counter-productive if, when spectrum was initially assigned, care was taken to ensure that all prospective users had an equal (non-discriminatory) opportunity to acquire that spectrum, yet these concerns were then ignored in a subsequent trade.

- *Satisfying public interest requirements:* It is important to ensure that sufficient radio spectrum is available for emergency services, distress calls, military users and other institutions that serve the public interest. And insofar as certain types of private use are deemed to constitute merit goods, then these, too, should not be put at risk by the system of spectrum regulation. In Germany, for example, one of the goals is to ensure a diverse offering of television channels.

- *Observing international agreements on spectrum use:* International agreements on spectrum use have been drawn up by the ITU, the World Radio Conference and other bodies. These are legally binding and impose restrictions on the type of spectrum use.

- *Recovering administrative costs*: In line with the economic principle of benefit received, the administrative costs incurred by the regulatory authority should be recouped. Such costs are incurred during the assignment process, for instance, but also as a result of the administrative expense of central regulation (e.g. preparing the frequency usage plan, maintaining a central register of current spectrum use etc.)

2.2 Regulatory models

There are currently three basic models for regulating spectrum: Command and control, market mechanism and commons model.

Command and control: Under this model, the national regulatory authority (NRA) determines exactly how the spectrum may be used, notably in terms of technologies and services. The NRA also decides who may use the spectrum, for how long and under what further conditions (e.g. roll-out obligations). This is a restrictive approach, in which the NRA specifies all the important parameters. And in this case it will typically use a beauty contest to decide who initially receives the spectrum. Command and control has traditionally been the most common approach adopted by NRAs.

Market mechanism: This approach first requires the clear definition of exclusive spectrum usage rights. Once this stage is complete, market forces take over. This implies that the primary assignment of spectrum will take the form of an auction, after which usage rights can be transferred by the mechanism of spectrum trading. It is up to the users, who should be given as much freedom as possible in making this decision, to determine what services they will offer, and on the basis of which technology. This will be a commercial decision based on market factors.

Commons model: Under this model there are no exclusive usage rights and, where possible, multiple users share access to a single frequency band. Apart from the licence conditions, which stipulate the type of services and technologies permitted in this frequency band, there are therefore no restrictions on individuals and companies. However, this form of institutional arrangement is only suitable for short-range, low-power applications such as Bluetooth links, wireless TV remote controls and private or public LANs (Local Area Networks). It is not yet clear whether or not such a model is also suited to long-range, high-power radio applications. In the case of business models that require major

investment and therefore have a lengthy payback period, an exclusive usage right would be essential. Otherwise there would be significant capacity risks as well as a major risk of interference. Consequently, frequency bands should only be shared in this fashion if the issue of interference can be well managed and if users do not require an exclusive right of use. Although open access would be desirable as a means of liberalising the market, there are technical and economic limits on how far it can be implemented in practice. The regulatory authority should therefore think very carefully before deciding to open a frequency band for general usage. Once a band has been released for all users, it is difficult to reverse this decision.

2.3 Mechanisms for the primary assignment of spectrum usage rights

Even under a flexible system of spectrum regulation that allows considerable scope for secondary trading, there will always be situations when the regulatory authority has to either assign frequencies for the first time or re-assign them. This would even be the case under a big-bang auction[1], for example. Any mechanism used by the regulator to assign spectrum should always conform to the aforementioned principles of efficient spectrum regulation. The following section offers an overview of the different mechanisms that can be used and the main features of each. Radio spectrum is initially assigned by a government body using one of the many different mechanisms available. These fall into four main categories:

- First-come, first-served
- Lotteries
- Beauty contests
- Auctions

With the exception of lotteries, all these mechanisms have been used to assign spectrum in Germany. To date, there have been three auctions: The ERMES auction in 1996, the auction of additional GSM-1800 frequencies (complementary spectrum) in 1999 and the UMTS auction in 2000. The GSM-900 and original GSM-1800 licences were assigned by means of a beauty contest, as were the WLL frequencies. The following pages briefly describe the main features of each mechanism.[2]

2.3.1 First-come, first-served

The central principle of this mechanism is that the right to use the spectrum is assigned to whichever candidate is first to apply. It relies on the ability to establish beyond doubt the time at which applications are received. If this is possible, then the "first-come, first-served" mechanisms offer a clear, transparent and non-discriminatory means of distributing spectrum. It is recommended that applications be submitted by fax or e-mail in order to discern the precise sequence in which they arrive. The log of incoming messages will reveal the exact time each application was received and virtually rules out the possibility of two applications arriving simultaneously.

The first-come, first-served mechanism rewards a candidate's speed. Prospective users with a strong interest in the frequency block will therefore make every effort to submit an application as quickly as

possible. At the same time, candidates with good information sources that give them adequate warning of the application process are also at an advantage.

The first-come, first-served principle is popular owing to its simplicity, while the associated administrative costs are low. Nevertheless, the mechanism also has disadvantages. For one, this method of distribution does not necessarily lead to an economically efficient assignment of spectrum. This is because selection is not determined by the price the prospective user is willing to pay. Instead, the first-come, first-served approach assigns spectrum usage rights to a few quick, well-informed applicants. Furthermore, spectrum trading then offers the successful applicants the chance of making windfall profits, especially if they are not in fact end users and intend to resell the spectrum usage rights. Such trading, however, would nevertheless tend to ensure that the spectrum ends up in the "right" hands. Alongside secondary trading, the spectrum usage charge levied by the regulatory authority also plays a crucial role. If the charge is low and its impact on the applicant negligible, there may be an incentive to hoard spectrum. However, the regulator has other tools at its disposal to prevent such behaviour, for example it can limit the number of frequencies that any one candidate can acquire. Beyond this, it is difficult to set clear criteria for determining whether demand is genuine, while verifying the usage criteria in practice presents a further difficulty.

2.3.2 Lotteries

If the distribution of spectrum entails a conflict of opposing interests, this can be resolved by opting for a lottery, whereby spectrum is assigned to applicants at random. This is intrinsically non-discriminatory and eliminates any competitive distortion. There are, however, different ways of designing a lottery and this means that the procedure must be defined precisely and unambiguously (for example, the lottery may assign packages of spectrum directly to users or it may give them the right to choose from the remaining packages available). Just how non-discriminatory the mechanism is ultimately depends on the exact form it takes.

Lotteries do not generally result in an efficient assignment of radio spectrum. If the assignment fee is relatively low, there is no restriction on who may apply and spectrum trading is legally permissible, this will create an incentive to acquire spectrum in order to resell it at a profit (windfall profits). In the USA, this led to the submission of thousands of applications, resulting in extremely high transaction costs. This was one of the reasons why the FCC chose to use auctions instead of lotteries to distribute spectrum.

2.3.3 Beauty contests

The most common mechanism for assigning spectrum is the beauty contest. The applicant is required to provide certain information that is then evaluated on the basis of a set of criteria. The experience of various other countries has shown that these criteria can be very extensive. It should also be mentioned at this point that this mechanism may be used in combination with – and not instead of – the first-come, first-served approach. In this case, the set of criteria would only be used if two applications for spectrum were, according to the rules of assignment, received simultaneously.

In order to employ this mechanism it is essential to first draw up a list of the criteria deemed to be important. These are usually the applicants' specialist knowledge and efficiency, the suitability of their plans for providing the telecommunications service in question, and the promotion of effective competition. It is then necessary to determine how each criteria is to be measured and to devise a system of weighting. This will ultimately allow a decision to be reached as to the best candidate. In practice, however, this process often proves difficult. The fact that it is impossible to completely exclude subjective judgements means that rejected applicants almost always accuse the regulator of partiality. This is exacerbated by the regulator's inability to publish and document information provided by companies in the course of the contest (e.g. business plans and strategies). Such information may have played a part in the decision yet must remain confidential. The result is that a mechanism of this type may no longer satisfy the criteria of transparency and therefore non-discrimination. This approach is consequently vulnerable to lobbying at the time the criteria are drawn up and during the contest itself, which in turn means that rejected applicants believe a legal challenge will have a good chance of success. Depending on the significance of the spectrum in question, legal battles are therefore likely to be less the exception than the norm.

A beauty contest does not necessarily result in an efficient assignment of spectrum. It is therefore possible that this system could also present successful applicants with an immediate incentive to resell spectrum. This incentive is likely to be lower than would be the case under a lottery model owing to the evaluation of the applicants' specialist knowledge and efficiency carried out by the regulator. Nevertheless, changes in the economic environment may in future create an incentive to resell spectrum usage rights and, depending on the size of the spectrum usage charge, this again offers the prospect of considerable windfall profits.

2.3.4 Auctions

According to McAfee and McMillan (1987, p.700)[3], an auction is a market transaction, conducted on the basis of explicit rules, that allocates resources and determines a price by comparing the bids submitted by market participants. The word "auction" is derived from the Latin word "augere", which literally means "to increase". The size of the bids generally corresponds to the amount prospective users are willing to pay, which in turn reflects the economic value they place on the resource in question. The bids that are submitted determine the price to be paid. This need not necessarily be the highest bid (see McAfee and McMillan (1987)). There are many different types of auction, some of which allow several rounds of bidding whereas others permit only one bid. It is also possible to auction multiple objects simultaneously or in sequence, depending on the chosen design. The following paragraphs describe the characteristics of each of the different types.[4]

The types of auction outlined in Table 1 are employed when there is only a single lot to be auctioned. The English auction involves repeated bidding which ends when no higher bids are forthcoming. The highest bidder then pays the price that she or he bid. In a Dutch auction, on the other hand, the auctioneer lowers the price until someone accepts. She or he then pays that price. The first-price, sealed-bid auction and the Vickrey auction are both single-round auctions. Each bidder submits just one bid (in a sealed envelope) and the person with the highest bid is successful. In a first-price auction, the winner then has to pay the highest bid, whereas in a Vickrey auction the price paid corresponds to the second-highest bid.

Table 2 outlines the different types of multiple-lot auctions. In a sequential English auction, each lot is sold individually in a series of separate English auctions. A simultaneous sealed, first-price auction comprises one round of bidding in which a single bid is submitted for each lot. The highest bidder in each case is successful and has to pay the bid price. A one-price auction is used where there are several homogenous lots. The auctioneer continues to raise the price until the market-clearing price is reached. Finally, simultaneous multiple (English) auctions are designed so that bidders can bid simultaneously for individual lots. The auction is conducted over an unlimited number of rounds and ends when no higher bids are forthcoming. The highest bidder then pays the price that she or he bid. Table 1 and 2 provide a summary of these two different forms of auction:

Table 1: Features of single-lot auctions

	English Auction	**Sealed-bid auction**	**Vickrey Auction**	**Dutch Auction**
Meets the market price	yes	only approximately	yes	only approximately
Identifies the bidder with highest esteem?	yes	not completely safe	yes	not completely safe
Possibility for pooling?	afflicted with risk	low risk	low risk	afflicted with risk
Winner's Curse?	provides some protection	afflicted with risk	afflicted with risk	afflicted with risk
Procedure comprehensible to the open public?	yes	yes, appropriate to complex situations	no, afflicted with political risks	no

Source: Nera/Smith (1996), p. 64.

It may be noted that, assuming the participants in the auction behave rationally, the outcome will generally be an assignment of spectrum that is economically efficient at the time the auction takes place. If this is the case, there will be no incentive to trade spectrum immediately after the auction has ended; any incentive for secondary trading will depend on future developments. If the auction succeeded in finding the market-clearing price, it will only be possible to make a profit if the market outperforms expectations.

Spectrum trading offers bidders a safety net in case their business model proves unsuccessful. This in turn tends to raise the amount they are willing to pay. On the other hand, it also gives companies the opportunity of dropping out of an auction if they believe they can acquire the licences/spectrum for less money at a later date. For instance, in the first PCS auction in the USA, MCI withdrew immediately because it believed that it could acquire second-hand licences more cheaply after the auction.

Table 2: Features of multiple-lot auctions

	Sequential English Auctions (or similar)	Simultaneous Sealed First Price Auction	One Price Auction	Simultane multiple Auction
Meets the market price	only approximately	only approximately	yes	yes
Identifies the bidder with highest esteem?	not completely safe	not completely safe	yes	yes
Possibility for pooling?	no	no	yes	yes
Winner's Curse?	provides some protection	afflicted with risk	afflicted with risk	provides some protection
Procedure comprehensible to the open public?	comprehensible procedure	comprehensible procedure, appropriate to complex situations	difficult to understand, afflicted with political risks, only at identical objects of auction	new, but easily to understand

Source: Nera/Smith (1996), p. 64.

2.4 Liberalisation of spectrum usage

2.4.1 Elements of a system governing spectrum usage rights

Spectrum usage rights are subject to certain conditions. In the past, these have tended to impose fairly tight restrictions, for example on the services that could be offered in a particular frequency band, and even on the technologies that could be used. Liberalisation, however, seeks to lift such restrictions wherever possible. In a fully liberalised environment, there would be no restrictions on spectrum usage whatsoever. Extensive liberalisation tends to offer the advantage that each frequency band is used for the most attractive service. In other words, there are no stipulations that would create an artificial scarcity of certain applications. This would also tend to ease the scarcity of spectrum for economically attractive applications such as mobile communications or broadcasting, thereby providing a possible boost to competition in these markets. On the other hand, flexible usage has the potential to cause considerable interference, while in certain areas it can actually make very good sense to internationally harmonise conditions of use. Although carefully defined rights of use should impose as few restrictions as possible, it is nevertheless important to establish a series of conventions.

Every system that governs spectrum usage rights has at least three dimensions:

- The spectrum band which can be used
- The geographical area where the spectrum band can be used

- The period of time during which it can be used

The following table provides a more detailed overview of the main elements that need to be defined in any regime governing rights of use.

Table 3: Elements of spectrum usage requiring definition

Element	Description
Nature of rights	Tradable spectrum access licences defined in terms of frequency, geography, emissions. Change of use within ITU allocation. Right to sign leasing agreements.
Type of licence	Possibility of partitioning assigned spectrum into tradable units, tradability of spectrum assigned to government bodies.
Method for transferring control	The Federal Network Agency decides on mechanism; parties apply for the Federal Network Agency approval of an intended trade; no restrictions on transfer if new licensee agrees to meet all the conditions within the original licence.
Transfer of control	Current spectrum use registered with the regulatory authority in a central database.
Aggregation/partitioning	Is this permitted or not? It may not be permissible if it is exclusively reserved for a specified public use (e.g. military use).
Duration	How long the spectrum may be used for, period during which trading is possible.
Technical parameters	Boundaries set for point at which negotiations between neighbours (for managing interference) are triggered.
Method of changing interference parameters	Framework for negotiations between spectrum users, role of regulatory authorities as referee.
Service/technology constraints	Change of use allowed within ITU allocation and European agreements.
Compliance with licence conditions	Ensuring that licensee and/or lessee complies with conditions and obligations.
Process for enforcing interference conditions	Licensees negotiate with each other. Regulator can take action if privately negotiated solutions breach interference norms and standards.

Source: Department of Trade and Industry, Review of Radio Spectrum Management (2002), p. 116, WIK Consult

The Radio Spectrum Policy Group has identified the following detailed parameters concerning spectrum usage rights:[5]

- Regulatory/administrative obligations
    - Coverage requirements
    - Quality of service requirements
    - Interoperability requirements (e.g. roaming)

- Minimum service offering (e.g. location-based services, high speed data transfer, video telephony, virtual domestic environment)
- Access for third parties to the network
- Public network obligations
- Social aspects and universal service obligations, for instance special services for the disabled
- Protection of health
- Protection of environment (e.g. infrastructure sharing, camouflage of antennas)
- Prevention of handset robbery

- Obligations that are part of a commitment which the undertaking obtaining the usage right has made in the course of the distribution process.
- Technical requirements of use
  - Obligations resulting from the Radio Regulations, applicable CEPT/ECC decisions/ EU directives and National Table of Frequency Allocations (service, system, applications, technical limitations, compatibility criteria, sharing criteria).
  - These obligations result from the need to optimise spectrum use for the benefit of the whole radiocommunication community.
  - These obligations include in particular, technical parameters such as limitations in order to limit interference (e.g. power limitations, spectrum masks, DFS, power control).
- Channelling arrangements (including duplex couplings) and essential requirements, in order to ensure efficient use of spectrum
- Payments for use of spectrum
  - Administrative charges to cover regulation of spectrum by Spectrum Management Authority (SMA)
  - Administrative incentive pricing (AIP)
- Information about use
  - Provision of information to the spectrum management authority (SMA) or to the public
  - Obligations to disclose air interfaces
- Other technical conditions for the use of the frequencies
  - The transmission to adhere to specific technical specifications, such as channel width, modulation technique, duty cycles etc.
  - Limitation of usage rights to certain “time slots”
  - Obligation to coordinate spectrum in case of potential interference

2.4.2 Spectrum regulation in the international and European arenas

The International Telecommunication Union (ITU) is responsible for the international regulation of the radio spectrum. The object of international efforts to coordinate spectrum use is to prevent harmful interference between the radio services of different countries. A further aim is to ensure that the spectrum is used efficiently and to create a level playing field for countries' access to radiocommunication resources.[6]

The Radio Regulations (RR), which divide the world into three zones (Europe and Africa, North, Central and South America, and Asia and Australia), are the primary means by which the ITU manages radio spectrum, and constitute a global framework for allocating frequency bands. The ITU Table of Frequency Allocations sorts individual radio services into categories and allocates these to particular frequency bands, which are then reserved for that purpose. The ITU Table of Frequency Allocations is revised and updated at the World Radio Conference, which is held on a regular basis.

There are also individual international agreements in which the ITU establishes rules governing the use of frequency bands in certain sectors (e.g. broadcasting) or seeks to achieve global harmonisation (e.g. IMT-2000). The Stockholm Agreement of 1961[7], for example, specified how spectrum would be used for broadcasting, while at the WRC in 1995 and 2000 agreement was reached on the frequency bands allocated to third generation mobile communications services.[8]

At a European level, spectrum use is coordinated by the European Conference of Postal and Telecommunications Administrations (CEPT). Within the CEPT, the European Communications Committee (ECC) is responsible for the actual task of coordinating spectrum usage across Europe. CEPT members reach agreements on the use of frequency bands in order to harmonise and coordinate pan-European spectrum usage. These include the agreements reached in Wiesbaden in 1995 and in Chester two years later, which laid the groundwork for digital broadcasting.[9]

Following the WRC in 1992, the CEPT (or rather the ECC) began to draw up a general European frequency plan in order to advance the harmonisation of spectrum use in Europe. At the same time, this frequency plan was also intended to pave the way for the implementation of the WRC agreements. The European frequency plan seeks to harmonise spectrum allocation and usage by 2008. To this end, a series of Detailed Spectrum Investigations (DSI) have been carried out, resulting in the creation of a European Table of Frequency Allocations and Utilisations, the latest version of which dates from January 2002.[10]

As well as the CEPT agreements, the directives and decisions of the European Union must also be taken into account. These include, for example, the Decision of the European Parliament and of the Council on a regulatory framework for radio spectrum policy in the European Community (Radio Spectrum Decision), the R&TTE Directive, and directives and decisions relating to specific services (including the GSM Directive and the UMTS Decision).[11]

2.4.3 Spectrum regulation in Germany

Spectrum usage is determined primarily by the following three mechanisms, which occur in sequence:

- National Table of Frequency Allocations
- Frequency Usage Plan
- Frequency assignment

The *National Table of Frequency Allocations* allocates bands of spectrum to radio services and other applications. These allocations are stipulated by the Federal Government, which enacts ordinances to this effect. The main purpose of the National Table of Frequency Allocations is to implement international agreements concluded by the ITU (WRC), CEPT and EU.

Pursuant to Section 54 of the *Telekommunikationsgesetz* (TKG – German Telecommunications Act), the Federal Network Agency is responsible for drawing up the *Frequency Usage Plan* on the basis of the frequency bands identified in the table of allocations. The plan includes a more detailed allocation of the frequency bands to particular frequency usages, as well as determining the additional parameters required to ensure efficient and interference-free use of frequencies and the further rules needed concerning the use of frequencies in and along conductors. This includes, for example, provisions specifying the maximum permissible equivalent radiated power, channel separation, channel width, and channel subdivisions. Possible frequency usages include amateur radio, business radio, trunked radio, digital cellular mobile communications, aeronautical radionavigation, satellite-to-satellite links and maritime radio. The Frequency Usage Plan is binding, although Section 58 of the Telecommunications Act permits variant frequency assignments in justified particular cases, for example to provide frequencies required at short notice or to test innovative technologies.

As a rule, each frequency usage requires prior *frequency assignment*, in accordance with the Frequency Usage Plan and as part of a transparent and objective process. A general assignment is the first choice for assigning frequencies. However, when the risk of harmful interference cannot be ruled out otherwise or when this is necessary in order to secure efficient use of frequencies, individual assignments will be made. Pursuant to Section 55(9) of the Telecommunications Act, award proceedings are only used to assign frequencies where spectrum is scarce. The frequency assignment specifies, in particular, the type and extent of the frequency usage, insofar as is necessary to secure efficient and interference-free use of frequencies. Secondary conditions may also be attached. Frequencies may be assigned either in perpetuity or for a limited period. Usage rights are also restricted to a particular geographical area. This may be the whole territory of the Federal Republic or one or more of its regions.

2.4.4 Influence of international agreements on spectrum regulation at national level

International and pan-European rules on spectrum usage affect the national regulatory environment, notably in terms of the services and technical constraints for specific frequency bands. There is only limited scope for national regulations to deviate from the international rules on spectrum usage. Frequency assignments that are at variance with the ITU Table of Frequency Allocations are only permissible “on the express condition that such a station, when using such a frequency assignment, shall not cause harmful interference to, and shall not claim protection from harmful interference caused by stations operating in accordance with the provisions of the Constitution, the Convention and these Regulations”[12]. On the other hand, countries can choose whether or not to adhere to CEPT

agreements, although once they have signed up to the agreements they are bound to abide by them when planning spectrum usage.

Table 4 illustrates, by way of example, how frequencies in the 890-960 MHz range are allocated at national and international level. The international rules on spectrum usage limit the trading of spectrum if the intention is to use it for services other than those set forth in the ITU Table of Frequency Allocations. However, the fact that the international allocations are usually formulated in very general terms allows national regulators some flexibility in drawing up their own tables of frequency allocation and frequency usage plans. As mentioned earlier, the CEPT agreements are voluntary, although the countries that sign up to them agree to be bound by their provisions.

Table 4: Allocation of frequencies between 890-960 MHz

Frequency band (MHz)	ITU allocation	EU legislation	Frequency usage according to German Frequency Usage Plan
890 – 915	Fixed radio services, mobile services excluding aeronautical mobile services, broadcasting services, radiolocation services	GSM Directive[13]	GSM (D network)
915 – 921			Currently being surveyed with a view to future mobile applications
921 – 925			Digital rail communication using GSM-R technology
925 – 930			Fixed links (military)
930 – 932			Cordless telephone systems (CT1+)
932 – 935			Fixed links (military)
935 – 960	Fixed radio services, mobile services excluding aeronautical mobile services, broadcasting services	GSM Directive	GSM (D network)
NB: In the European Table of Frequency Allocations and Utilisations (dated January 2002), frequencies between 890 and 960 MHz are allocated to mobile services and aeronautical mobile services.			

Source: WIK Consult

In contrast, the European directives and decisions that allocate individual radio services to particular frequency bands offer less scope for independent action by national regulators. This applies to the following frequency bands:

- 1880–1900 MHz (DECT)[14]
- 169.4-169.8 MHz (ERMES)[15]

- 890–915 and 935–960 MHz (GSM)[16]
- 1900-1980 MHz, 2010-2025 MHz, 2110-2170 MHz for terrestrial applications and 1980-2010 and 2170-2200 for satellite applications (IMT-2000)[17]

If there is very little demand for the radio services on offer, it has proven possible to make the frequency bands available for other radio services. The CEPT is currently discussing how the ERMES spectrum may be used in the future.

2.4.5 Frequency Usage Plan

Rules on spectrum usage are made at both international and national level. These find their ultimate expression in the national frequency usage plan, which imposes legally binding constraints on the assignment and usage of spectrum. For instance, Table 5 lays out the Frequency Usage Plan no. 287 of the Federal Republic of Germany (dated April 2003) and its sub-plan.

Table 5: Excerpt from the Frequency Usage Plan

Frequency Usage Sub-Plan	287	Entry	287002f
Frequency band	2695-2700 MHz		
Condition(-s) of use	D340 30 (specified in the National Table of Frequency Allocations)		
Radio service	RADIOASTRONOMY SERVICE		
Use	Civilian		
Frequency usage	Radioastronomy		
Frequency sub-band	2695-2700 MHz		
Conditions of frequency use	Receiving radio waves and radiated power in space. The protection criteria for this passive radio application are contained in ITU-R Recommendation RA.769.		

Source: German Federal Network Agency - Frequency Usage Plan

Drawing up such a plan is both a necessary and a sensible step. It gives prospective users the information they need in order to devise business models or concepts based on the usage of particular frequencies. However, striking the right balance between restrictive rules and a more *laissez-faire* approach is another matter. Strong protective mechanisms are particularly advisable if there is a possibility of significant harmful interference. Restrictions on spectrum usage become necessary when basic considerations, backed up by field trials or other practical experience, make it clear in advance that, from a regulatory standpoint, certain frequency bands are only suitable for certain applications. In addition, spectrum may be reserved for certain types of use if it is advisable, or even necessary, to harmonise usage at national level. This applies particularly in cases where international applications (e.g. GSM mobile communications) both encourage and require harmonisation and/or if such a step would lead to significant savings in the cost of developing the associated end-user services, thereby boosting technological progress.

2.4.6 Frequency bands particularly suited to liberalisation and flexible transfer arrangements

The study by Analysys et al revealed that the introduction of spectrum trading and liberalisation would bring the greatest economic benefits, in both political and social terms, in the following frequency bands. Their findings were based on a survey of users and an economic analysis.

Analysys also points out that the economic benefits of trading would be maximised if it would be introduced in the same way and under the same rules by all EU member states. The desire to minimise transaction costs again plays an important part in this recommendation. There are consequently many advantages to adopting a coordinated approach. However, the report also emphasises that each specific frequency band should be examined in detail, implying that, before trading and liberalisation are implemented, an extensive consultation process should take place with all those who may be involved.

Table 6: Frequency bands particularly suited to trading and liberalisation

Introduce *trading and liberalisation* throughout Europe in frequency bands currently allocated to the following services	**Introduce *trading (liberalisation optional)* throughout Europe in frequency bands currently allocated to the following services**
Broadcasting – satellite – for space-to-Earth links if and where a recognised spectrum access environment is deemed appropriate *Fixed links* (where usage rights are assigned exclusively to individual users) *Fixed wireless access* *Land mobile – private mobile radio* (where usage rights are assigned exclusively to individual users) *Land mobile* – public mobile networks *Satellite (fixed and mobile)* – for space-to Earth fixed links if and where a recognised spectrum access environment is deemed appropriate; for mobile, subject to assessment of current co-ordination practices *Special user groups* (military, public safety, public transport), subject to ensuring that essential services are not disrupted	Broadcasting – terrestrial (with a review of the case for liberalisation following the 2005 ITU Regional Radiocommunications Conference) Land mobile – private mobile radio (where usage rights are shared between users and the Spectrum Management Agency (SMA) undertakes co-ordination of individual users) Fixed links (where spectrum rights are shared between users and the SMA undertakes coordination of individual users)

Source: Analysys et al (2004): Summary of report no. 78.

2.4.7 WAPECS initiative

Wireless Access Platforms for Electronic Communications Services (WAPECS) are platforms used for radio access to electronic communication networks and services, regardless of the bands in which they operate or the technology they use. WAPECS platforms can provide mobile, portable or fixed

access to a range of electronic communications services. WAPECS applications may be either licensed or unlicensed, which means that the term encompasses all second and third-generation mobile communications services, wireless data transmission services and WLAN/WiFi as well as broadcasting and TV services. Table 7 sets out frequency bands as being suitable for WAPECS, according to a survey of EU member states.

The chosen definition represents a deliberate attempt to move away from restrictive definitions of spectrum allocation. The object is to enable the frequency bands in question to be used by efficient, digital applications, while at the same time taking account of frequency restrictions designed to permit co-existence. One of the first questions to be resolved concerns the restrictions that the spectrum regulator must impose on the frequency bands in order to pursue the intended approach.

Table 7: Frequency bands identified for WAPECS

Broadcasting bands	174–230 MHz 470–862 MHz 1452–1479.5 MHz	
Fixed links/point to point (P2P)	5925–6425 MHz, 3600–4200 MHz, 1375–1400 MHz, 1492–1517 MHz, 1427–1452 MHz and 1350–1375 MHz	
Point to multipoint (P2MP)	(without MWS) 3400–3800 MHz, 24.5–26.5 GHz (with MWS) 24.5 GHz–26.5 GHz	
Mobile services	380–400 MHz 410–430 MHz 450–470 MHz 870–876 MHz 880–921 MHz 925–960 MHz	1710–1785 MHz 1805–1880 MHz 1900–1980 MHz 2010–2025 MHz 2110–2170 MHz
Unlicensed bands	1880–1900 MHz (DECT) 2400–2483.5 MHz (RLANs) 5150-5350 MHz (RLANs) 5470-5725 MHz (RLANs)	

Source: RSPG

2.5 Transfer and trading of spectrum usage rights

2.5.1 General considerations

Spectrum trading, or the transfer of spectrum usage rights, denotes a mechanism whereby rights of use are transferred from one user to another for a certain price. In contrast to a system in which spectrum is returned and then re-assigned, the trading approach is characterised by the fact that:

- The transfer of the right to use the spectrum in question is initiated voluntarily by the present user.
- The sum paid by the new owner of the spectrum usage right is retained, either in full or in part, by the previous owner.

Spectrum trading contributes to a more efficient use of frequencies. This is because a trade will only take place if the spectrum is worth more to the new user than it was to the former user, reflecting the greater economic benefit the new user expects to derive from its use. In the absence of misjudgements or irrational behaviour on the part of the buyer or seller, and if the trade does not cause external effects, then it can be assumed that spectrum trading contributes to greater economic efficiency. Furthermore, the option of trading creates an incentive for the voluntary transfer of rights of use. As well as this direct effect, which at the same time boosts transparency by revealing the true opportunity cost of the spectrum, secondary trading also results in a series of indirect positive effects. Spectrum trading makes it possible for companies to expand more quickly. It also makes it easer for prospective new market entrants to acquire spectrum in order to enter the market. And if the introduction of spectrum trading is combined with an extensive liberalisation of spectrum usage rights, there will be a considerable incentive for incumbents to invest in new technology in order to ward off the threat of new entrants in the absence of other barriers to entry (i.e. the unavailability of spectrum). This in turn will boost market competition. These efficiency gains will not be realised, however, if transaction costs are too high or if external effects intervene. Possible external effects include anti-competitive behaviour and interference. In addition, it is important to ensure that the spectrum allocated for merit goods, such as military communications and the emergency services, is available in sufficient quantity and quality.

These criteria constitute the framework for a whole raft of institutional arrangements that determine the precise form of spectrum trading and set forth exactly how rights of use can be transferred. Institutional arrangements stipulate precisely who can make what decisions, when they can do so and under what conditions. They also set forth the implications this will have for the parties involved. Ideally, such a system will include full details pertaining to all aspects of spectrum transfers and trading. At the same time, one of the aims of any spectrum trading regime should be to keep down transaction costs. After all, the goal is to facilitate transfers by establishing a swift and inexpensive mechanism. However, the vast quantity of important details means that both primary legislation and secondary legal texts are limited in terms of how far they can specify actual arrangements.

Any attempt to specify institutional arrangements must answer the following questions (please note that this list is necessarily incomplete):

- Does the national regulatory authority specify the transfer mechanism when an application is submitted by a prospective seller, or does the trade take place in an *ex ante* regulatory environment?
- Does the Federal Network Agency has the authority to completely specify the transfer mechanism, or is it only able to stipulate auxiliary conditions?
- Who has the de facto authority to carry out the trade. Is it the current user, the Federal Network Agency or certain companies or institutions that have been certified to do so?
- Is there one preferred transfer mechanism or is the choice made on a case-by-case basis?
- Does the form of spectrum trading depend on the original assignment mechanism (auction, beauty contest)?
- Who bears the costs of the transfer?
- Who receives the sum paid by the new owner of the spectrum usage right? (If the price exceeds the amount paid by the original owner, is the difference then paid to the state?)
- If the Federal Network Agency specifies the transfer mechanism, how much influence does the person have who initiated the transfer? (Can they set a minimum price? If it is decided to sell the right of use by means of an auction, does the original user have the right to bid at the auction?)
- To what extent must the new user comply with the previous conditions of use/licence conditions? Is alternate use possible (e.g. using spectrum that was initially allocated for point-to-multipoint links for point-to-point links instead)?
- If free trading is allowed, are there spectrum caps that limit the maximum amount of spectrum that can be acquired?
- If the current user puts forward a proposal, can they advocate a transfer to a specific user for a certain price or may they only express their wish to trade and their preferred mechanism for doing so?

The following criteria should be used when assessing whether a specific transfer mechanism is suitable or which of the possible institutional arrangements is most appropriate:

- Care should be taken to ensure that spectrum trading conforms to a great extent with the aforementioned principles of effective spectrum regulation (i.e. it ensures the efficient use of the radio spectrum; it constitutes a transparent, objective and non-discriminatory method of distributing spectrum; it is compatible with the primary assignment mechanism; it recovers administrative costs etc.).
- The institutional arrangements should not be designed so that owners of spectrum usage rights run the risk of obtaining a disproportionately low price. Nor should they give rise to such complexity and inherent uncertainty that it is not worthwhile for the current owner to even contemplate a transfer, even though the transaction itself makes sense. Furthermore, the transfer must be completed within a reasonable period of time. Indeed, time is one of the most important factors, therefore it is important that the transfer can be completed without unreasonable delay.

2.5.2 Forms of spectrum trading

In their report for the European Commission, Analysys et al identify the following methods for transferring rights of use:

- *Sale* – Ownership of the usage right is transferred to another party.
- *Buy-back* – A usage right is sold to another party with an agreement that the seller will buy back the usage right at a fixed point in the future.
- *Leasing* – The right to exploit the usage right is transferred to another party for a defined period of time but ownership, including the obligations this imposes, remains with the original rights holder.
- *Mortgage* – The usage right is used as collateral for a loan, analogous to taking out a mortgage on an apartment or house.

The transfer of usage rights by sale or lease is typical of countries that have introduced spectrum trading. Mortgage-style transactions are possible in Guatemala and New Zealand.

It is also helpful to distinguish between management rights and usage rights. Management rights confer the right to issue individual spectrum usage rights within a given block of spectrum and are used in New Zealand, for example. In practice, management rights create a situation similar to leasing, in which the primary holder of the usage right leases this to users.

In terms of the trade itself, there are a variety of mechanisms that can be used. These include:

- *Bilateral negotiation*: The seller and (prospective) buyer directly negotiate the terms of the sale and are not subject to any particular constraints set by the regulator.
- *Auctions:* Once a type of auction has been chosen and the rules have been decided, prospective buyers have the opportunity to acquire the spectrum usage rights by bidding in the auction.
- *Brokerage:* Buyers and sellers employ a broker to negotiate, with their consent, the contractual terms under which the transfer of usage rights can take place.
- *Exchange:* This refers to the establishment of a trading platform, similar to a stock market, where transfers take place according to specific rules.

It is also possible to combine more than one of these approaches. Ideally, the regulatory authority should, as far as possible, leave the transfer mechanisms in the hands of the market participants. In other words, any regulatory provision should be motivated by the intention to meet the principles of effective spectrum regulation as outlined earlier.

2.5.3 Spectrum trading and the duration of usage rights

The introduction of spectrum trading diminishes the need to set a fixed expiry date for usage rights. Under a system of spectrum trading, rights are transferred to users who have identified an alternate use that promises greater returns. This transfer takes the form of a commercial transaction. Furthermore,

the choice of an expiry date, be it five, ten or twenty years hence, is always somewhat arbitrary. In view of uncertainty about technological developments and changes in demand, it seems doubtful that an expiry date can be set on the basis of rational considerations of economic efficiency. One argument in favour of granting spectrum usage rights in perpetuity is that users make complementary investments in stages. Each investment has a different payback period, with the result that specifying a limited licence period inevitably results in inefficiencies at the end of that period. Economists who place their trust in unfettered market forces therefore advocate that spectrum usage rights be granted in perpetuity. This implies that, after the primary assignment of spectrum, the regulator would only have to intervene if users wished to return spectrum or if their right of use were withdrawn owing to a breach of the conditions of use. This argument carries even greater weight if, in addition, the spectrum charges are set at a level that reflects their economic value.

Nevertheless, if there are significant imperfections in the market it may make sense to give the national regulatory authority the option of withdrawing spectrum usage rights. Alternatively, a certain period of time could be specified at the end of which the regulator decides whether or not the spectrum usage right shall be extended.

2.5.4 Necessity of maintaining a central register for spectrum trading

In order for spectrum trading to be both transparent and efficient, it makes sense to give all interested parties direct access to information on current spectrum usage. To this end, it is advisable to set up a central database, which, for practical purposes, should be the direct responsibility of the institution in charge of assigning spectrum.

The database should contain the following information in particular:

- Current assignment table (name and address of users plus details of their respective blocks of radio spectrum, e.g. size and frequencies).
- Type of usage for the spectrum in question.
- Indication of the relevant legal provisions governing spectrum trading.

If a spectrum usage right has already been transferred on a previous occasion, this should at least be noted, together with information on the date of the transaction, the price that was paid and the identity of the parties involved.

Access to the database should be as simple as possible. Indeed, unless there are any legal obstacles, the information in the database should be made available on the Internet. One possible location would be the homepage of the Federal Network Agency.[18]

In view of efforts to achieve greater pan-European harmonisation it would also seem advisable to aim for the greatest possible degree of standardisation when devising a format for a public register of this type. This would significantly reduce the transaction costs for spectrum users who operate in more than one country.

2.5.5 Spectrum trading and primary assignment

Irrespective of the mechanism used for primary assignment, spectrum trading represents a means of improving economic efficiency in terms of how the radio spectrum is used. Nevertheless, the mechanism used does have implications with regard to the incentives for spectrum trading and the possibility of making windfall profits. If it is assumed that auctions result in an efficient assignment of spectrum, then there shall initially be no incentive for a trade. However, in the case of other assignment mechanisms that do not depend directly on the amount users are willing to pay, there may be an immediate incentive to trade. Furthermore, subsequent external changes may create an incentive to trade, regardless of the primary assignment mechanism employed. Whatever the situation, spectrum trading may lead to more efficient usage. The possibility of making windfall profits depends on the size of the fee charged for frequency assignment and on changes affecting the market value of the spectrum in question. If it is assumed that the winner of an auction pays the current market-clearing price, then it will be impossible to make a profit right away.

2.5.6 Flexible spectrum regulation and windfall profits

Windfall profits accrue to owners of specific property rights without any effort or economic activity on their part. It is not clear just how precisely the term “windfall profits” has been defined in the context of assigning spectrum usage rights. The basic premise holds that a distribution of scarce resources gives the recipients an opportunity to make a profit. If they do so as a result of commercial activity, associated with the roll-out of a network infrastructure, then there are no grounds for censure. On the contrary, there would only be cause for concern if it were possible for the user to make excessive profits without taking on correspondingly higher risks, or if profits could be made simply by trading, without engaging in any productive activity. The latter might be the case if, for example, spectrum usage rights could be acquired for a comparatively low price in a lottery and then, without the owner having put the spectrum to economic use, sold for a much greater sum either shortly afterwards or at a later date. Such cases raise doubts about profits of this kind, which are ultimately an outcome of quasi-monopolistic or -oligopolistic markets (the result of a system that grants exclusive usage rights). These profits may be considerable and the question is: Can they be justified in terms of the distribution of welfare benefits?

As a general rule, windfall profits are less likely to occur where:

- An auction was used as the primary assignment mechanism and the price achieved at auction corresponded to the market-clearing price at the time
- The fee charged for spectrum assignment reflects the economic value of that spectrum
- The value of the spectrum falls over time
- The first user to whom the spectrum was assigned had to satisfy strict requirements as to their suitability
- There is effective market competition

It should be noted that, while trading clearly reveals windfall profits (or profit-making potential), these gains could also accrue to users who choose to retain their usage rights. In this case, however, they

would take the form of company profits and would therefore be less immediately apparent. Users who acquire usage rights for a low price have the opportunity to make profits that are unusually large for the market. From an economist's perspective, such profits can be a cause for concern, especially in the absence of effective competition. They should therefore be countered by appropriate regulation. If existing competition law is deemed inadequate for this purpose, then specific regulations must be enacted for this sector.

Windfall profits that result solely from trading might be viewed as problematic in terms of the equitable distribution of welfare benefits among economic actors. They do not, however, have an immediate impact on economic efficiency. On the contrary, any attempt to block trading may even prevent spectrum from being transferred to the most efficient user.

From a purely economic standpoint, windfall profits do not constitute an argument against spectrum trading. If, however, they are regarded as problematic for other reasons, there are various means of limiting such gains in the context of spectrum trading. First of all, usage rights should initially be assigned in an auction. Other options include a spectrum charge, effective market regulation, a windfall tax or a trading duty whereby the state recoups a proportion of the net gain when a trade takes place. Nor should it be forgotten that even windfall profits which accrue solely to the seller can also boost government finances. This is most immediately apparent if the seller in question is a state-run or state-funded institution. If, for example, the armed forces were to sell off surplus spectrum, the additional funds this would bring would generally mean that less funding was needed from other sources. Furthermore, the more efficient use of spectrum that is expected to result from trading also implies that the new users will make higher profits. This in turn will result in increased tax revenues for the state (from income and capital gains tax and, if revenue also increases, from value-added tax). Once all factors have been taken into account, the issue of windfall profits therefore presents far less of a problem than is often portrayed.

2.6 Interference

Interference occurs when the use of a particular frequency band has an effect on the use of neighbouring bands. From an economic perspective, this constitutes a negative external effect. Interference can be prevented by designating guard bands (frequency bands that nobody is entitled to use), or by specifying maximum power levels or spectrum masks. These regulatory measures should be designed in such a way as to ensure that users can operate with maximum economic efficiency. The technical usability of the frequency bands in question will also have a decisive influence on what steps are taken in each case. Thresholds of acceptable interference are established with reference to a base level. It is generally the responsibility of the regulatory authority to specify these thresholds and then ensure that they are adhered to. Technological developments or changing usage brought about by liberalisation may mean, however, that at some point these limits no longer satisfy the criterion of efficient use. In order to permit the efficient use of spectrum in such situations, it should therefore be possible to adjust the interference thresholds set by the regulator. In other words, if all those affected agree to a modification, the regulator should accept the change. In this scenario, the role of the regulator is reduced to that of a referee.

2.7 Competition issues

2.7.1 General considerations

Market failure can be caused by economies of scale and scope, external demand effects and restrictions on market access (a consequence of the fact that spectrum is a scarce resource). The *ex post* mechanisms of competition law plus regulatory oversight by the competition authority are, on their own, inadequate for policing markets, especially those that exhibit the above features. This means that *ex ante* regulation is required, particularly when it comes to distributing the scarce resource of spectrum. The design of the assignment mechanism, and of the associated licence conditions or conditions of use, is therefore crucial to the establishment of infrastructure-based competition. The assignment mechanism chosen by the regulatory authority shapes the market structure by dividing up the spectrum and limiting the maximum amount of spectrum any one user may acquire. It is generally believed that the greater the number of spectrum users, the more competitive the market and the less need there is for regulating end users.

Imagine for a moment that all the frequencies available for GSM mobile applications were auctioned in small parcels with no restriction on the maximum amount of spectrum that any one bidder may acquire. It is conceivable that one company might acquire all the parcels of spectrum, resulting in a monopoly of the mobile communications market. Without undertaking an exact analysis as to the likelihood of such an outcome occurring under different types of auction, it is nevertheless true that, according to economic theory, an unregulated monopolist is in a position to make the highest profit and will therefore be willing to pay the most for the spectrum.

Depending on the auction design and the companies' expectations of how the market will be regulated, it is possible that the primary assignment may result in a monopoly situation. However, in order to eliminate the possibility of such an outcome, regulators will rightly devise certain constraints in advance of the assignment process (e.g. creating a certain number of licences with a fixed minimum amount of spectrum).

Efforts to establish a competitive market structure do not stop at spectrum assignment. Unrestricted spectrum trading could be exploited by users acting in concert to create a monopoly or at least a more concentrated oligopoly. Spectrum regulation must therefore be a permanent fixture; the responsibility to counter anti-competitive practices does not end with the assignment process. In an extreme scenario, unregulated spectrum trading might result in all frequencies being transferred to one company, with benefits (and disadvantages) distributed by means of a profit and loss transfer agreement. If competition authorities were then to intervene *ex post*, they would be faced with the difficult task of gathering sufficient information in order to prove wrongdoing.

In the past, it has been assumed that frequency bands are reserved for certain types of use. A liberalisation of spectrum usage rights, however, might also make it feasible to re-designate spectrum for different uses, thereby lowering the barriers to market entry in certain sectors. In the first instance, this would tend to affect those parts of the spectrum that offer the greatest profit potential. If accompanied by a liberalisation of spectrum usage rights, unconstrained spectrum trading can therefore serve to boost competition.

2.7.2 Strategic motives for the acquisition of spectrum, including motives for hoarding

It may be the case that companies who own the right to use spectrum do not actually exercise this right immediately. This typically occurs when companies first enter a market and have yet to acquire a customer base. Nevertheless, it is assumed that the assigned spectrum will be needed at some point in the future.

In contrast, the practice of hoarding spectrum refers to companies that hold unused spectrum which they have no intention of actively using in the future. There are two motives for spectrum hoarding:

- Unused spectrum may held for speculative reasons in order to sell it for a profit at a later date.
- Spectrum may be hoarded in order to prevent others from using it. This may be motivated by anti-competitive considerations.

There are two main determinants that will allow a company to obtain spectrum that it does not actually need and to retain spectrum usage rights. Such a development signals that, firstly, the process of spectrum assignment contains inefficiencies and, secondly, the system of spectrum regulation is ineffective and does not permit the withdrawal of usage rights where spectrum remains unused. If there is perfect information and oversight in the market, an efficient system of spectrum regulation would prevent frequencies from being hoarded in this way. If, however, information and contracts are imperfect, then it is certainly possible that such a situation might arise. Should this be the case, then a company can be in a position where it is holding spectrum but not, in effect, using it. The introduction of spectrum trading creates a particular incentive for the speculative acquisition of frequencies. At the same time, spectrum usage also imposes costs. These are incurred in fulfilling licence conditions and paying one-time and recurring fees.

In a competitive market, companies seek to gain strategic advantages over their competitors. Spectrum owned by one company cannot be used by another and, owing to the fact that spectrum is generally a scarce resource, this means that, in economic terms, a strategic decision to hold spectrum has a negative external effect on the competition. Imagine, for instance, that all the spectrum allocated for GSM was assigned to individual mobile network operators and that, although two of the companies have a combined market share of almost 80%, the spectrum was distributed equally to all operators. This may result in the market leaders experiencing bottlenecks in capacity at certain times and in certain regions. This could be avoided either by investing in additional network infrastructure in order to divide the network into smaller cells, or by using more spectrum. In our scenario, however, the smaller network operators have fewer users and could therefore afford to lease spectrum to the market leaders, at least for a limited period. Although a commercial leasing arrangement along these lines would generate additional revenue for the smaller operators, they may nevertheless reject such a deal. In so doing, their strategic thinking would hold that a deterioration in the quality of the market leaders' networks should prompt some customers to switch providers.

The introduction of spectrum trading might conceivably result in a middleman acquiring all the spectrum that is available at a low price, before engineering artificial scarcity in order to resell the spectrum at a high price and thereby make a profit. This type of behaviour can be prevented by means of carefully drafted licence conditions that include the option of withdrawing usage rights, as well as by other provisions.[19]

2.7.3 Tools to prevent anti-competitive behaviour

Anti-competitive behaviour, in the form of an "excessive" acquisition of spectrum, can be prevented in different ways using the following tools:

- Spectrum caps
- The regulatory authority establishes rules that specify how spectrum trading should take place
- Trades or transfers of spectrum are subject to approval by the regulatory authority

The German Telecommunications Act contains provision for all three of these instruments, which can be employed by the national regulatory authority (NRA) to ensure that competitors, whether already in the market or seeking to enter, are able to gain access to the scarce resource of spectrum. Spectrum caps have already been used in the USA; they place restrictions on how much spectrum a company may acquire in a particular range (e.g. a mobile communications company may acquire at most two 20 MHz bands in the 900 MHz range). If the NRA employs an *ex ante* mechanism, its object will be to restrict the transfer arrangements so that issues of excessive market power never arise. Finally, by making transfers subject to its approval, the NRA is able to examine competition issues before giving the go-ahead. The NRA consequently has sufficient opportunity to take adequate account of issues of market power. The choice as to which of the three tools is most appropriate in any given circumstance will certainly depend on the situation in the market, the available spectrum and the extent to which the conditions of use have been liberalised. Furthermore, and although this would be procedurally more difficult, the NRA also has the ability to withdraw spectrum usage rights that are not being used. This gives it the means to prevent companies from hoarding spectrum. A comparison of how equivalent companies in Germany and abroad use spectrum will doubtless offer a useful indication as to whether usage rights are being employed strategically or are simply being hoarded.

The above remarks clearly show that, even under a more flexible regulatory regime, issues of market power will continue to be important. This, however, is not a reason to reject such a regime. In fact, a more flexible approach to spectrum regulation, which not only allows multiple transfers of spectrum but, moreover, is also accompanied by a far-reaching liberalisation of usage rights, would actually tend to diminish rather than amplify potential problems of market power.

It should be noted in addition that competition law also gives the Federal Cartel Office the ability to ban mergers that, in its view, raise concerns relating to competition policy.

2.8 Economic pricing of spectrum usage rights

2.8.1 Principles of spectrum pricing

In its 1993 recommendations[20], the ITU identifies the following key principles for setting spectrum charges. Although these recommendations were drawn up some time ago, the principles remain valid and address almost all aspects of spectrum pricing.

- All spectrum users should pay a charge.

- The spectrum charge should be calculated fairly, i.e. if two users are using the same amount of spectrum in the same way, both should pay the same charge.
- The spectrum charge should be proportionate to the amount of bandwidth used.
- The charges should reflect the spectrum's value to society, i.e. frequencies used for public services should be subject to lower charges.
- The cost of spectrum regulation should not be borne by the state.
- Spectrum users should be consulted about intended adjustments in spectrum charges.
- The pricing structure should be clear, transparent and comprehensive, without unnecessarily lengthening the licensing process.
- The pricing structure should reflect the scarcity of available spectrum and the level of demand for spectrum in different frequency bands.
- The spectrum charge should be calculated so as to recover the costs of spectrum regulation. Spectrum pricing should not seek to maximise revenue for the government.
- The ability to levy spectrum charges should be anchored in law.

2.8.2 Administrative versus incentive pricing

Administrative (cost-recovery) pricing: Spectrum management incurs administrative costs. These result in particular from the process of spectrum assignment, measurements to prevent interference and planning preparations. In accordance with the principle of causation, these administrative costs should be borne by the spectrum users. Administrative charges should therefore start at the level of cost recovery. Although national regulatory authorities generally operate on the principle that charging should at least cover administrative costs, it is difficult to determine to what extent this is achieved in practice. This is due to the fact that there is either no detailed breakdown of spectrum management costs, or that third parties are not given access to this information. In an effort to establish a common framework, a system of cost accounting should therefore be developed in order to apportion administrative costs to individual usages, as far as this is possible. "Overhead" costs should also be identified and assigned to each type of usage in accordance with an appropriate allocation mechanism. At least in some areas, these costs are likely to represent a considerable portion of all administrative charges and, when dividing them up, the scarcity factor and principles of efficient assignment can also play a part. This constitutes a move towards the concept of administrative incentive pricing, which is described in the next paragraph.

Administrative incentive pricing (AIP): Administrative incentive pricing aims to ensure that spectrum is used efficiently, and addresses both static and dynamic efficiency. If spectrum was initially assigned in an economically efficient auction and if the usage rights can then be traded, there is some doubt as to whether charges of this type are necessary if transaction costs are negligible. Imperfections in the auction design, incomplete information and transaction costs may, however, mean that it is advisable to implement AIP so that spectrum is used more efficiently. In addition to the incentive effect, spectrum charges can also be treated as a source of revenue for the government. As a general rule, AIP should result in a higher charge than would be levied under an administrative pricing model. This way, in addition to shaping market behaviour, it also has an impact on the public finances.

There are a range of methods for determining the economic value of spectrum usage. One such method is to calculate the discounted cash flow (income minus expenses) of an assigned right of use with regard to the business model of which it forms a part. Alternative methods focus on the relative costs of using other services or technologies. Ideally, it would be possible to calculate the precise opportunity cost, which represents the economic value associated with the best alternative use of the spectrum. Whichever method is chosen, it throws up numerous questions of methodology and design, to which there are no simple answers. This is likely to result in workable solutions being employed to meet theoretical standards. Furthermore, owing to missing or incomplete information, the figures that emerge will at best be estimates. This means that care must be taken in order not to overestimate the economic value of spectrum usage. Taken to an extreme, this would result in rights of use being overpriced and not taken up by prospective users.

2.8.3 Factors to take into account when calculating spectrum charges

In a recent study, Yu et al identified the following factors that were taken into account by certain countries (UK, Canada, Australia, Korea, Singapore, France and Israel) when setting spectrum charges:[21]

- *Bandwidth (spectrum endowment)*: The amount of bandwidth is generally a good proxy for the amount of resource being used. In view of the scarcity of the resource, the charge should rise in line with the bandwidth.
- *Field strength:* The strength of the field generated by a base station determines the area within which nobody else can use that spectrum. This is therefore a good measurement of de facto spectrum usage.
- *Geographical area*: The spectrum charge may depend on the region in which the frequency bands can be used. The calculation will take account of regional population density and income levels, whereby the value of the spectrum usage right will rise in line with the region's economic appeal, measured in terms of the people who live there.
- *Frequency band:* It becomes more difficult to transmit signals at the higher end of the radio spectrum. In order to encourage greater use of this part of the spectrum, some countries create an incentive by gradually lowering the usage charge at higher frequencies.
- *Exclusive rights vs. commons model*: The spectrum usage charge reflects whether one user has an exclusive right to use the spectrum or whether there is open access.
- *Duration of access:* The spectrum usage right may be granted on a permanent basis or may only be valid at certain times. The charge generally increases in line with the amount of time during which the spectrum may be used.
- *Transmission/reception:* Stations may be configured to both send and receive radio signals, or they can be used solely for reception. In the latter case, there will typically be no charge.
- *Services:* The economic value of spectrum usage depends on the services that can be provided using that spectrum. This is reflected in administrative incentive pricing.
- *Supply and demand:* There are tremendous variations in supply and demand for particular frequency bands. AIP takes this into consideration.

- *Specific applications:* Spectrum used in the public interest, for instance by security services, emergency services or defence forces, will usually be subject to a far lower charge.

3 Underlying framework of the German Telecommunication Act

The new *Telekommunkationsgesetz* (TKG – German Telecommunications Act) creates the framework in which a more flexible system of spectrum regulation can be structured. The key legal provisions for spectrum policy are set out in sections 52 – 65 of the TKG. According to these sections, the primary objective of spectrum regulation is to ensure efficient, undisrupted spectrum use, with the further objectives detailed in section 2 (2) of the TKG also applying. In view of spectrum policy, these are securing fair competition and promoting telecommunications markets with sustainable competition in services and networks and in associated facilities and services, in rural areas as well.

As a result, spectrum use is primarily determined by the following three stages:

- The National Table of Frequency Allocations
- The Frequency Usage Plan
- Frequency assignment.

We already discussed the main characteristics of these three stages in the previous section on national conditions of use.

Once assigned, spectrum can be assigned to other users at a later date in various manners. There are various possibilities for this:

- Spectrum usage rights are withdrawn or revoked (example: WLL spectrum) if these are not used or not efficiently used.
- Spectrum usage rights are restricted to specific bands and are then extended or re-assigned, not necessarily to the previous user (e.g., UMTS spectrum usage rights have a limited term of 20 years).
- Spectrum usage rights are voluntarily returned to the Federal Network Agency (e.g., C-Network spectrum)
- Spectrum can be transferred (WLL spectrum)
- Spectrum can be traded (no example to date).

Within the meaning of section 55 (7) of the TKG, *spectrum can be transferred*, to the extent that this does not distort competition in the relevant market and if efficient and interference-free use can be secured. This can occur via singular or universal succession to an associated company within the meaning of section 15 of the *Aktiengesetz* (AktG – German Public Companies Act), from an individual to a legal entity in which the individual holds an equity interest, or as inheritance.

Spectrum trading: After hearing the parties concerned, the Federal Network Agency may release frequency bands for trading and stipulate the framework conditions of and the procedure for trading when there is interest in trading usage rights for the spectrum concerned. According to section 62 of

the TKG, the framework conditions of and the procedure for trading must ensure, in particular, that spectrum efficiency is increased or maintained, that the original award proceedings do not preclude frequency assignment after spectrum trading, that no distortion of competition in the relevant product and geographic market is to be feared, that other legal framework conditions, in particular the conditions of use and international agreements on spectrum use are complied with, and that the regulatory aims according to section 2 (2) of the TKG are secured (however, to date no spectrum band has yet been identified in which spectrum trading can take place).

The above comments show that according to the new Act it is possible to flexibly change spectrum usage rights either via transfer or via spectrum trading, however the model for this has still to be determined by the national regulatory authority. The conditions of use can also be structured liberally in the Frequency Usage Plan or also in the assignment rules.

In addition to purely economic issues, however, other criteria must also be taken into account for spectrum use. To ensure that public requirements – relating to social, cultural or meritorious issues or defence policy – are guaranteed, corresponding spectrum must be reserved for these purposes.

4 Country case studies regarding flexibility of spectrum regulation and their relevance to Germany

4.1 Conclusions and Recommendations for Germany based on experiences in the United Kingdom

In line with spectrum regulation policy objectives, the UK aims to make spectrum regulation as flexible as possible. This is to be implemented in such a way as to ensure optimum spectrum use and that the needs of end users are satisfied in an optimum manner.

In terms of liberalisation, this means that the usage conditions are to be as free as possible of technology restrictions or other types of restrictions such as roll-out obligations. Regulatory policy restrictions should only be imposed if this is justified. In view of possible restrictions, three issues are of key importance: Harmonisation, competition problems and interference issues. In terms of harmonisation, Ofcom believes that industry is able – via negotiations – to define standards and harmonised use in a cooperative manner. In the case of far-reaching liberalisation, Ofcom believes that ex post application of competition law is sufficient to prevent anti-competitive behaviour. In Ofcom's opinion, there have to be sufficient protective conditions to prevent interference. These conditions should be designed such that far-reaching, flexible use is possible. The details of how the interference norms are to be designed in practice is, however, still a difficult issue to be defined.

In addition, Ofcom intends to replace the command and control spectrum management model with market mechanisms and general assignments. In so doing, however, it must be considered that general assignments are only possible if joint use does not lead to unacceptable mutual impairment. General assignments are thus primarily suitable for applications with a range of less than 100 m, for example for WiFi, etc. This type of general assignment offers, in particular, the advantage that innovative technology can be tested in these bandwidths and developed to become market-ready. The spectrum

bands for which this spectrum management mechanism is suitable are thus restricted. Ofcom believes that they total less than 10%.

This means that a market mechanism should thus enjoy priority implementation. Private spectrum usage rights for spectrum bands should therefore be clearly defined. A change to *property rights* could occur for the issue of new licenses or for existing licenses at Ofcom's initiative, or for current license holders at their initiative, which then need Ofcom's approval for implementation. This type of license, ownership rights or spectrum usage rights should then be auctioned for new issues, and should then, with Ofcom's permission, mostly be tradable without restriction. If national security interests are affected, or if the parties do not fulfil the admission criteria for use of the spectrum, this type of transfer may be prohibited. The transfer of spectrum usage rights should be as flexible as possible. In this regard leasing, i.e. a temporary transfer of spectrum usage rights, should also be made possible, however a fixed final date for the temporary use must be determined. Band managers should be allowed, although not actively encouraged by Ofcom. In Ofcom's opinion, the more information there is available, the better markets function. As a result, Ofcom intends to publish a register of licenses, which at least includes the names of license holders, contact information, license classes, limits of spectrum usage rights and geographic information. In addition, information on the implemented trade should be published.

Ofcom's policy of increasing flexibility is, however, currently in its infancy. This means that no empirical recommendations can be made for the use of successful spectrum management systems in Germany from observing spectrum policy in the UK. The first individual areas, such as BWA spectrum, where spectrum trading is possible, are only just emerging. The WAPECS concept in view of liberalizing spectrum usage rights is only just starting to be discussed. In particular, it must be noted that Ofcom is currently still hesitant about admitting mobile applications in addition to the spectrum assigned for GSM and UMTS. This is only being considered from 2007. Here too, Ofcom believes that there has to be investment protection. In fact, Ofcom currently still implements ex ante regulation in view of competition issues. If trading is not possible and if a specific auction model is defined for the primary assignment of spectrum, this implies that there will be this type of ex ante regulation. Other discussions also show that Ofcom tends to take a cautious and well-thought-out approach for practical implementation. This is also documented in detailed consultations. In addition, Ofcom points out that it believes that it is bound by international agreements, so that existing harmonisation agreements at a supranational level continue to apply to national spectrum use.

Ofcom's approach clearly shows that – even though they have a liberal vision – one can and should only take a step-by-step approach for spectrum policy due to the issue's complexity. This means that international agreements can only be made more flexible one at a time, and individual spectrum ranges must be investigated in detail in view of adequate interference conditions and conditions of use. An intense consultation is required in this regard.

Irrespective of this, it is Ofcom's intention to continue to welcome AIP as an instrument to promote efficient use when determining spectrum usage charges. This instrument reduces the incentive to hoard spectrum for speculative reasons, and it also means that the national regulatory authority has an instrument to tax potential windfall profits. This thereby increases society's acceptance of the introduction of market instruments such as spectrum trading.

4.2 Conclusions and Recommendations for Germany based on experiences in the United States

The United States has introduced many valuable spectrum management innovations to the world. Some U.S. spectrum management practices that may have seemed *avant garde* at the time of their introduction now are generally accepted globally as representing regulatory best practice. The best example of this is the pioneering use of auctions to achieve market-based spectrum assignments in order to bring spectrum to its best and highest-valued use; moreover, the broad underlying principle that market mechanisms should be relied on where feasible is now widely accepted.

The United States continues to be a hotbed of innovation as regards spectrum management techniques. Some of these innovations will ultimately prove themselves out, just as spectrum auctions did. At all events, however, a note of caution is in order: there is no need to imitate United States innovations here in Germany *before* they have demonstrated their worth. It also bears mentioning that the U.S. is for the most part a large contiguous country, with only two land neighbours (Canada and Mexico), and with a very substantial internal market. In a number of instances, the U.S. was able to undertake novel approaches unilaterally, where a country like Germany would need to coordinate with multiple close neighbours.

With all of that said, we consider the potential applicability to Germany of a number of specific U.S. spectrum innovations. The major elements of our recommended approach, as elaborated in the discussion that follows, are:

- Gradual simplification of license transfer and lease mechanisms;
- Recognition of the benefits that North America has achieved with flexible mobile telephony spectrum, and initiation of a planning process to determine the feasibility of migration to a similar system in Germany;
- Expansion of unlicensed spectrum as circumstances permit;
- Consideration of selective use of receiver performance guidelines if circumstances warrant; and
- Continued observation from afar of North American progress with other innovative interference management tools and approaches.

License transfers and leases

The various regulatory changes that the United States has made in order to simplify license transfers have arguably brought some gain in efficiency, and do not in and of themselves appear to have caused adverse side effects.

License transfers should tend to improve the efficiency of spectrum usage, allowing corrections over time to the initial allocations achieved through auctions. License transfers are permitted in Germany, but they are rarely undertaken. Reducing regulatory barriers to transfers, and thus reducing transaction costs and increasing regulatory certainty, should improve the effectiveness of this process.

U.S. experience in defining a category of transfers suitable for fast-track handling provides valuable guidance to the Federal Network Agency. The FCC defined criteria sufficient to identify certain proposed license transfers as not being problematic, they permitted parties to a proposed transfer to self-certify that the conditions were met, and they committed to approve such transfers in a specified, brief period of time absent some specific reason to do otherwise.22 The Federal Network Agency could take similar steps, while holding in reserve as a potential future enhancement the possibility of defining a category of transactions that are so routine as to require no regulatory approval at all.

Spectrum leases should also improve the efficiency of spectrum usage. At the same time, leases are significantly more complex than outright transfers. There is still some question as to the degree to which the benefits exceed the regulatory costs, all things considered.

With that in mind, we recommend that the Federal Network Agency continues the spectrum leasing arrangements already in place, and consider incremental improvements over time. In general, measures that reduce transaction costs and that increase the confidence of parties to a prospective lease that it will be granted will tend to improve the effectiveness of the system.

The FCC has implemented at least four distinct forms of spectrum leasing, each with its own regulatory challenges: spectrum manager leasing, short-term *de facto* transfers, long-term *de facto* transfers, and the private commons. Several interviewees were of the opinion that the more novel forms of spectrum leasing are still not being used very much in the United States. Rather than duplicating this considerable complexity, we recommend that the Federal Network Agency continue at this time to implement only a single form of leasing, which corresponds the simplest and most basic U.S. form of spectrum leasing: *spectrum manager leasing*.

In the spectrum manager form of leasing, the licensee retains working control of the spectrum, and the FCC looks to the licensee to take responsibility for compliance with spectrum-relevant obligations (e.g. interference) and also for general regulatory compliance.

The FCC requires timely notification by the parties of the intent to enter into a spectrum manager lease, but these leases are automatically granted within the term and the geographic scope of an existing exclusive license in an eligible band.

In sum, we recommend that the Federal Network Agency take steps in the near term (1) to simplify spectrum transfers and leases by establishing an FCC-like fast track mechanism, and (2) continue to explore any options that might reduce transaction costs to the parties and thereby increase use of these mechanisms.

Liberalisation of use

In the United States (and also in Canada), there is widespread agreement that the flexibility that mobile operators have enjoyed has been both effective and appropriate. There is a general consensus among stakeholders that this is the preferred model of spectrum management going forward. Liberalised use is also expected to simplify any 2G-3G transition issues, and to avoid artificial spectrum scarcity.

This form of flexibility can no longer be viewed as radical. It is unquestionably working well in the North American context.

We recommend that the Federal Network Agency initiates a planning process to seriously consider the applicability of such a model to Germany. Given the criticality and the commercial significance of these bands, we believe that any German implementation would need significant and careful prior planning, both in terms of transition planning and in terms of mitigating possible side effects.

Spectrum auctions for mobile telephony in Germany distinguished explicitly between 2G and 3G usage, and companies made large investments based on assumptions about how they and their competitors would be able to use that spectrum. Any change in rights would need to consider the potential impact on those firms, and any explicit and implicit commitments that were made to them.

Unlicensed spectrum

The use of unlicensed spectrum has been a great success in the United States. It has served as a spur to innovation. More spectrum is likely to be allocated to unlicensed use over time.

For Germany (as for Canada) it will typically be inadvisable to allocate uniquely German unharmonised bands to unlicensed use. Manufacturing economies of scale, as well as the ability to take gear across borders, argue for international harmonisation.

As new internationalized bands are agreed, the Federal Network Agency should look for opportunities to expand unlicensed spectrum in Germany.

Interference management

Many aspects of the U.S. program have worked very effectively; at the same time, the example of Nextel shows that it is possible to take flexibility too far.[23]

As with many of the U.S. spectrum management institutions, the rather relaxed approach to interference management seems to work satisfactorily most of the time in the context of the United States. There is much to be said for the U.S. perspective that overly aggressive interference management can needlessly impede market entry. At the same time, the U.S. experience does not directly equate to circumstances in Germany.

In the mobile bands, the FCC has imposed only three simple restrictions: (1) radiated power into adjacent bands; (2) radiated power into adjacent geographies; and (3) total radiated power. This appears to have been a very successful model, and one that Germany could well wish to emulate where appropriate.

A number of emerging U.S. innovations bear continued watching:[24]

- The ultimate emergence of cognitive radio and Software Defined Radio holds great promise – it is important that regulation not get in the way.
- It is clear that the selective imposition of receiver standards has the potential to improve overall welfare. There are many interference problems that could most appropriately and most

cost-effectively be addressed by means of a modest improvement in receiver quality, rather than by the traditional method of imposing restrictions on the transmitter. At the same time, manufacturers in the U.S. and Canada have understandably been uncomfortable with the prospect of new regulatory impositions. Nonetheless, it may be possible to make progress. In the Nextel proceeding, the U.S. FCC did not mandate overall receiver quality standards, but it committed to provide protection from interference only for receivers that met certain quality standards.[25] Experience to date is limited, but this approach seems sensible and could be considered for use where circumstances warrant.

- The U.S. work on interference temperature might in time lead to important advances, but it is not yet clear if this single metric is sufficient for regulatory purposes, nor is it altogether clear exactly how to apply the interference temperature to regulation. It would be appropriate to monitor further developments in the U.S. and elsewhere to see if this concept makes progress.
- An additional observation that flows from the U.S. exploration of the interference temperature is the notion that it would be useful to have a better understanding of the overall interference environment. Two approaches that were considered but not implemented to date in the U.S. are (1) the use of a monitoring network, and (2) the "enlisting" of a group of cognitive radios to function as an *ad hoc* monitoring mesh as an adjunct to their primary function. For the former approach, it has not been clear that the benefits would exceed the costs. The latter approach must be viewed today as being futuristic, but it has the potential to provide a very inexpensive yet rich data source on the overall interference environment. If solutions of this type were to emerge, they might be of interest.

4.3 Conclusions and Recommendations for Germany based on experiences in Canada

The spectrum management system in Canada is strongly influenced by the United States; consequently, the recommendations derived from Canadian experience largely parallel those proposed in connection with the United States.

Those recommendations are elaborated in section 4.2, "Conclusions and Recommendations for Germany based on experience in the United States". They include:

- Gradual simplification of license transfer and lease mechanisms;
- Recognition of the benefits that North America has achieved with flexible mobile telephony spectrum, and initiation of a planning process to determine the feasibility of migration to a similar system in Germany;
- Expansion of unlicensed spectrum as circumstances permit;
- Consideration of selective use of receiver performance guidelines if circumstances warrant; and
- Continued observation from afar of North American progress with innovative interference management tools and approaches.

In the United States, there is a strong tendency for government to withdraw from spectrum management as much as possible, leaving everything up to market mechanisms. Canada chooses instead to retain substantial government power over spectrum management, but then to step back as much as possible in order to allow market mechanisms to do what they do best. Government refrains from inappropriate exercise of its rather expansive powers.

The Canadian model would appear to have advantages in comparison with that of the United States. During this period of rapid transition, the Canadian government has far more ability to intervene if necessary to correct any problems that might emerge.

4.4 Lessons learned from Australia[26,27] that are relevant to the implementation of a flexible frequency management system in Germany

4.4.1 Overview

Australia has been a World leader in spectrum management. Liberalisation of spectrum usage and spectrum trading began in Australia in 1992. Australia has managed to keep at the forefront of spectrum management through self review and occasional independent review at the behest of government. These institutional characteristics appear to be an important factor in explaining Australia's maintenance of it reputation for spectrum management.

4.4.2 Spectrum liberalisation

In Australia, Spectrum Licenses can be used with any technology and for any use so long as emission limits are observed. Licenses are not completely neutral as emission limits are designed with the likely use in mind. Spectrum licensing began in the mid 1990s in Australia

Australia is still struggling with the conversion of the old style Apparatus License to Spectrum Licenses. It is increasing looking to allocate Spectrum Licenses with sitting incumbents. It may also allocate Spectrum Licenses to the military as the sitting wide-area Apparatus License incumbent. This would put some responsibilities onto the licensee and away from the ACMA. The Federal Network Agency may also find scope for a level of spectrum license reform which is able to transfer some of its existing responsibilities for interference onto licensees, freeing it to use its resources in other aspects of spectrum regulation.

4.4.3 Spectrum Trading

Licenses in Australia are specifically designed to be traded. Licenses are comprised of Spectrum Trading Units (STUs) which are defined in terms of 4-dimensional units of spectrum space: the area they occupy (2 dimensions); the bandwidth (or frequency range), and the time during which they exist. STUs come in 3 different sizes, depending on population density: 3 degrees of arc in remote areas; 1 degree of arc in rural areas, and 5 minutes of arc in metropolitan and regional areas. 22,000 STUs are

needed to cover Australia. Auctions typically involve regional bundles of STUs being offered, these having been previously determined by industry consultation.

The spectrum management agency (the ACMA) maintains an online and comprehensive database of licenses which it considers essential for the operation of a secondary market in spectrum.

There have been very few trades, however, that have not been transfers between different entities under similar financial control, or that occurred as a result of a sale, merger, or takeover of the company which holds the spectrum license. There are a range of possible reasons for this, knowledge of which may be of relevance to The Federal Network Agency:

- In Australia there is no presumption of renewal of spectrum licenses. This can only be done by the Minister when it is shown to be in the public interest. We believe this may be a significant impediment to spectrum trading in Australia. We commend to the Federal Network Agency the investment benefits of statutory renewal rights to be granted several years prior to expiry, with very specific and limited exceptions. A system of rights in perpetuity can also work under certain conditions, the main ones being those we noted in the next bullet point;

- Existing 15 year licenses are thought to be a significant impediment to secondary trading. Peer review has recommended that spectrum licenses be awarded in perpetuity. WIK notes, that a well functioning secondary market where substitutable spectrum is dispersed among many users, is required before we could recommend this to the Federal Network Agency;

- Where taxes apply to traded spectrum they can prevent trades of spectrum to a marginally higher value users. *Ad valorem* taxes payable on secondary trades fit this description, and may be one factor detracting from the liquidity of spectrum in Australia. We recommend that the Federal Network Agency keep this in mind when reviewing future changes to the secondary trading regime in Germany.

4.4.4 Interference issues

Following initial liberalisation in Australia it was decided that trying to ensure compliance by policing license boundaries was impractical. The ACMA now relies on device registration to ensure that spectrum licensees do not breach the conditions of their licences. The ACMA will only register devices if licensees demonstrate that they would not create unacceptable levels of interference. Assurances on the emission characteristics of licensees' devices are mainly done by private accredited engineers. While we understand that EU law prevents any NRA from checking a firm's equipment, there is a larger issue here that BNetsA may want to consider further; are there technical/interference functions that are able to be equally well performed by private engineers?

In Australia, as occurred in New Zealand, some observers have called the ACMA to look again into whether it can provide more neutral core license conditions as this will increase the degree of usage neutrality. We suggest that the Federal Network Agency look out for any future developments in Australia (and perhaps also New Zealand) concerning core license conditions, as these will have evolved following a lengthy experience and may have practical implications for spectrum liberalisation and spectrum trading.

4.4.5 Class License Bands

The ACMA consults on an ongoing basis with industry in order to have spectrum available for license exempt uses. Australia follows closely low power hardware developments (especially in the USA and Europe) in order that the must useful spectrum is available for unlicensed uses.

4.4.6 Competition issues

The telecoms law in Australia expressly refers to the applicability of competition law (merger and takeover rules) to the acquisition of radio spectrum. In additional to this, however, spectrum caps, and sometimes even auction exclusions, have been imposed by the Minister for certain auctions. The caps do not operated in the secondary market and there is no analysis tabled to support the cap in any particular case. Caps appear to represent a form of government industry policy to encourage new entrants. We can not recommend the Australian approach to the Federal Network Agency. Rather, we would recommend that any cap be included in the auction consultation and then included as an element in the auction rules. This will prevent accusations of arbitrariness and non transparency that can be claimed about the Australia spectrum caps. It will also mean that a cap can be applied to spectrum auctions and also to later spectrum trading.

4.5 Lessons learned from New Zealand[28] that are relevant to the implementation of a flexible frequency management system in Germany

4.5.1 Overview

New Zealand was the first country to implement a market-based system of spectrum allocation and secondary trading and was for several years the World leader in spectrum management.[29] The main feature associated with spectrum management in New Zealand is the licensing of property rights in spectrum to private band managers. Management Right (MR) holders may then allocate Spectrum Licenses in their bands.

While its spectrum resource is more easily manageable than is the case in Germany, due to New Zealand's isolation and low population density, there are several aspects of the New Zealand experience that are of relevance to Germany. We discuss them under the following topics: Spectrum liberalisation; spectrum trading; interference issues, and competition issues.

4.5.2 Spectrum Liberalisation

Spectrum liberalisation in New Zealand has not caused problems, even if it has not yet been completed. Liberalisation is tied up with the design of licenses, including interference rules. The less these rules make licenses liquid, the less able spectrum is to gravitate to its most valuable use. Liberalisation is thus inextricably tied up with factors that influence the tradability of spectrum. With less effective liberalisation there is less tradability, which may be one factor explain the low level of genuine spectrum trading in New Zealand. Spectrum liberalisation is a complex problem that may need to be revisited many times in order to complete a program of spectrum liberalisation.

The implication of this for Germany is that it may be best to approach spectrum liberalisation as an ongoing issue, rather than one that can be completed at some moment. This is also suggested by that fact that a great deal of spectrum in Germany has already been assigned on a use-specific basis. Moving to a situation where spectrum is very largely liberalised will unavoidably take time.30

4.5.3 Spectrum Trading

In new Zealand few trades have been other than transfers between different entities under similar financial control, or that occurred as a result of a sale, merger, or takeover of the company which holds the spectrum license. It is apparent from the New Zealand experience that a system that provides for spectrum to be traded is more difficult to implement than originally anticipated. Not that is has caused problems, but it appears not to have worked well. There are several issues of possible relevance to Germany:

There may be an issue of critical mass regarding the performance of secondary markets:

- The concept of private band managers who allocate spectrum licenses has not worked as intended in New Zealand. It appears to have resulted in too few firms holding the most valuable spectrum, and this may be one reason why he level of genuine secondary trading of spectrum in New Zealand has been low;

- Perhaps also contributing to the low level of trading is that government retains a significant share of the most valuable spectrum which is not available for trading. The reduced pool of tradable spectrum may detract from the level of trading.

- Issues of license 'joinability' and liquidity

    - Management rights and spectrum licenses in New Zealand are not specifically designed to be traded as they are in Australia. They are allocated nationally and moreover may be tailored to specific users on a case-by-case basis. This would appear to detract more than enhance their tradability. It also makes a change of use more difficult;

    - Similarly, allocated spectrum differs in terms of the date of license period termination and the technical parameters relating to interference. This appears to have reduced the combinability of licenses; [31]

    - A 20 year license period without statutory right to renewal will undermine investment incentives as the license gets closer to its expiry date, and reduce the value of the license on the secondary market, and reduce its tradability.

These are relevant issues for the Federal Network Agency as it progresses to an increasingly liberal spectrum management regime. One possible feature that we draw the Federal Network Agency's attention to is that private band management may need to be done on a broad scale, perhaps with band management rights fragmented regionally, if spectrum is to be sufficient liquid for spectrum

allocations to remain efficient. However, the experience in New Zealand is insufficient for us to draw firm conclusions.

We suggest that while we would not rule out the possible efficacy of private band management in Germany, the Federal Network Agency should first observe the outcome of further developments in New Zealand (should these occur) and any other country which adopts the private band manager model.

4.5.4 Interference issues

New Zealand, like Australia, is using accredited engineers to engineer Spectrum Licences and Radio Licences. In both countries it appears to have been a success in reducing the demands on the spectrum management agency so that it can focus on more important aspects of spectrum management. We recommend that the Federal Network Agency explores the scope for adopting a similar scheme in Germany.

Liberalisation of spectrum in New Zealand has not resulted in the interference problems that some industry commentators continue to say it does. We can not be sure that the same would be true in Germany given the more intense use of spectrum in Germany compared to New Zealand or other countries that can claim a similar result, such as Australia and Guatemala. Our suspicion is, however, that a similar system would work relatively well in Germany.

4.5.5 Competition issues

In New Zealand there is a slightly worrying concentration of spectrum in certain bands. To avoid this occurring in some other bands New Zealand has included spectrum caps which extend over a several year period thus preventing circumvention of the cap through secondary market trading. Rather than the cap being decided in an arbitrary way or according to a non-transparent rationale, as may be accused in New Zealand, we suggest that the Federal Network Agency considers the possibility of including any cap in the consultation on the auction, and include the cap as one of the conditions of the auction.

4.6 Conclusions and Recommendations for Germany based on experiences in Guatemala

Except for spectrum allocated to government and amateurs, all spectrum in Guatemala is allocated according to a tradable property right system. In this regard Guatemala has gone further than other countries with liberal spectrum management regimes, and with very successful results. Whether in Germany the more intense demand for the downstream services that spectrum enables organisations to supply, would be achievable by Germany similarly allocating only liberalised and tradable spectrum, is an open question.

The interference management regime which relies heavily on a procedure designed to enable spectrum rights holders to solve their inference problems privately, appears to function effectively. It is unclear whether in Germany the private and public costs of a similar interference regime may be higher than

one that relies on an authority empowered to address interference problems. This option was deliberately avoided in Guatemala due to its meagre institutional endowments.

Radical reform which includes liberalisation of most spectrum, and the licensing of tradable rights involving most spectrum, has not thrown up the range of problems some commentators predicted. There remain problems with capture and political interference, but these are primarily confined to broadcasting, an area where most countries face similar problems.

5 Guiding principles for a flexible system of spectrum regulation

In designing a flexible system of spectrum regulation, the Federal Network Agency should always have the interests of the end user in mind. The goal is to create a framework for assigning spectrum that permits market forces to act for the benefit of the end user. Assignment mechanisms should be selected with the aim of boosting competition; one of the primary tasks of the Federal Network Agency is to create or guarantee effective competition. Greater flexibility is a means to achieving this goal and not an end in itself. In certain cases, it may in fact be necessary to limit flexibility, notably as a means of addressing issues of market power or interference.

In the following section we present our recommendations for implementing a more flexible spectrum policy in Germany. These are based on our analysis of spectrum policy in selected countries and on the fundamental considerations examined at the beginning of this study. The first point to note is that spectrum policy is not only a domestic matter, it also requires corresponding agreements and coordination at international level. A more flexible regulatory regime in Germany will only realise its full potential if the principle of greater flexibility is also applied in the international arena.

On a national level, flexibility means a further liberalisation of spectrum usage rights as defined by the National Table of Frequency Allocations, the Frequency Usage Plan and the mechanisms for assigning spectrum. As far as possible, usage rights should be both technology- and service-neutral. Ideally, spectrum should be assigned using either the commons model or market-based assignment mechanisms. Under the latter approach, comprehensively defined rights of use for scarce spectrum are assigned by means of an auction. After the primary assignment, it should be possible to trade these usage rights or transfer them to third parties at any time. This is different to a command-and-control approach, in which spectrum usage rights may not be sold to third parties and spectrum is initially assigned by means of a beauty contest. External effects, however, mean that spectrum regulation must be accompanied by a suitable system for regulating interference. Care must also be taken of factors that have a distorting effect on competition.

The international context and harmonisation

Frequency Usage Plans should continue to be drawn up and implemented at national level, taking account of international – and in particular European – efforts at harmonisation. Through its participation in international bodies, the Federal Republic of Germany should seek to create an environment that allows each country the greatest possible flexibility in regulating spectrum usage

rights. The goal should be to ensure that the resource of spectrum is utilised as efficiently and effectively as possible, and in the interests of end users (private households and companies).

This further implies that countries should agree to harmonise spectrum usage if this would result in considerable economic benefits. On the one hand, harmonisation restricts the ways in which individual frequencies can be used and thereby excludes certain applications that might be economically attractive. On the other hand, harmonising pan-European usage (including international roaming) makes it easier for services to be marketed and used throughout Europe. Harmonisation allows manufacturers of terminal equipment to plan for the future with greater confidence and makes it possible for them to benefit from economies of scale in production. This is particularly true in the case of equipment and infrastructure components that can only be developed once a critical mass is reached. It is therefore necessary to examine the particular circumstances of each case before proceeding with harmonisation.

Liberalisation of the National Table of Frequency Allocations and the Frequency Usage Plan

The National Table of Frequency Allocations and the Frequency Usage Plan should be designed so as to impose as few restrictions as possible. We recommend in particular a technology- and service-neutral approach. Lifting restrictions on spectrum access for emerging radio technologies will promote innovation and technological progress. In order to ensure that the Frequency Usage Plan can be changed as flexibly and quickly as possible, the formal procedure for drawing up the plan should be streamlined and simplified, whilst retaining the element of public participation. In addition, the provisions governing the range of applications permitted in particular frequency bands should be expanded and gradually liberalised.

The WAPECS initiative from the RSPG is a pioneering example of this approach. The object of the initiative is to open up frequency bands that had previously been reserved for one specific application such as mobile communications, fixed radio services or some other type of wireless access. These frequency bands are now to be opened up for all services. Moreover, WAPECS operates on a technology-neutral basis. Nevertheless, questions of market power and interference also have to be taken into account.

The principle of liberalisation should also guide decisions about the assignment of the UMTS expansion band. It is conceivable, for instance, that these frequencies might also be opened to broadband wireless access (BWA) applications. Any assignment mechanism should therefore include not just the current UMTS licence holders but other qualified operators as well, for example companies that wish to use this spectrum for BWA. If the UMTS licence holders are indeed in a position to use the spectrum more efficiently than the competitors, then they shall also emerge victorious in any auction of usage rights. And if they are not the most efficient of the prospective users, then it makes sound economic sense for the usage rights to go elsewhere. The fact that the UMTS licence holders were promised so-called complementary spectrum does not give them an automatic right to use particular frequency bands. From a regulatory standpoint, this merely means that they have the option of participating in a competitive process in order to acquire this right.

The “digital dividend” spectrum, i.e. those frequencies that will be freed up by the switchover from analogue to digital terrestrial TV, should also be made available for as many applications as possible. Ofcom’s Implementation Plan describes how conditions of use can be gradually liberalised.

Frequency assignment

Frequency assignment mechanisms should be designed with the greatest possible degree of flexibility. When deciding on a system it is important to take a range of factors into consideration: For example, the speed at which applications arrive on the market, the protection needed from interference, the quality of services, the strengthening of the domestic market and the encouragement of innovation. The mechanisms for assigning spectrum should be designed so as to take account of market power issues as well as the goal of avoiding interference.

- The commons model should be employed wherever this promises an efficient use of spectrum, taking into account the issue of interference. This means that multiple users share access to a frequency band reserved for certain types of services. These will mainly be short-range applications such as Bluetooth or WiFi and, providing that certain criteria are met, it will be possible to use devices without the need to obtain a licence (these will typically be low-power devices for end users). Of course, it is still imperative to define clearly the rights of use for such applications.

- In the remaining frequency bands there should be clearly defined spectrum usage rights, which are then distributed to users by means of market mechanisms. Spectrum usage rights should be acquired in a commercial transaction (primary assignment by way of an auction) with the right to resell them at a later date (secondary markets). Market participants are in a far better position to ascertain the economic value of alternative applications in a spectrum market. This is a quicker and more effective way of achieving economically efficient usage.
- The auction of IMT-2000 licences/spectrum in Germany, at which it was to some extent possible for market players to shape the 3G standard, the size of the frequency blocks to be acquired and the market structure are a good example of a more flexible regulatory regime. The mechanism currently under consideration at the Federal Network Agency for assigning 3.5 GHz frequencies is also an example of a more flexible approach to regulating spectrum. Both approaches abide by the principle of keeping restrictions to a minimum.

Characteristics of a market-based model

Where it is appropriate for spectrum usage rights to be distributed by means of a market mechanism, the following elements should be in place:

- If spectrum is scarce, the Federal Network Agency should hold an auction to either assign frequencies for the first time or re-assign them.

- It should be possible to resell spectrum usage rights by transferring them (whereby usage does not change) and by means of spectrum trading (whereby usage does change).

- Spectrum usage rights should be clearly and comprehensively defined.

- There should be as few restrictions as possible on how spectrum may be used.
    - As far as possible, usage rights should be technology- and service-neutral.
    - It should be possible to partition frequency bands (particularly with regard to spectrum trading) in terms of both spectrum and geography, in so far as this constitutes an efficient use of spectrum.
    - It should only be possible to specify coverage requirements or quality standards for the intended services in exceptional cases and with good reason. For example, coverage requirements would be justified if the services in question were classified as universal services. In particular situations, however, such obligations are rendered superfluous, notably when the spectrum usage charge reflects the opportunity cost of spectrum use (this is known as administrative incentive pricing and has been partially implemented in the UK). The existence of secondary markets is a further safeguard against the hoarding of unused spectrum, as the price that the spectrum would potentially fetch in the market reflects the corresponding opportunity cost.
    - Spectrum usage rights should include clear rules designed to prevent interference (specifying, for example, spectrum masks).

Spectrum trading regime

Spectrum trading and transfer should be possible in nearly all bands. A trade should only be prohibited if there are overriding reasons of social and economic policy for doing so.

The spectrum trading regime should be designed so that, in principle, the spectrum user is able to change the spectrum usage rights.

It should be possible to transfer usage rights quickly and easily. To this end, the regulatory authority should generally refrain from specifying particular trading mechanisms, such as a specific type of auction for secondary trading.

However, the regulator may justifiably reserve the right to approve or block a transfer of spectrum usage rights in advance. In order to keep down transaction costs for users and prevent the process from becoming a barrier to trading, approval should generally be given as swiftly as possible. In particular, it should only be possible to block a trade if a significant distortion of competition or significant interference might result.

It should be possible to transfer spectrum usage rights for a temporary period (leasing). The parties to the arrangement should sign a contract agreeing a fixed date on which all property rights revert to the lessor.

Central register of spectrum use

There should be a central register of spectrum use that allows existing and prospective spectrum users to find out as quickly as possible what they need to know about the spectrum available, who is using it

at present and the associated rights of use. The register should contain sufficient information to facilitate transactions, and might include additional information consistent with a cost/benefits analysis. It should not contain information that is confidential. Ideally, the information should be made available via an electronic interface. The Federal Network Agency is responsible for the assignment of spectrum and possesses all the relevant information. It would therefore seem logical for the Federal Network Agency to take responsibility for preparing this register.

At a minimum, the register should contain the following information:

- Name of the person or company holding the spectrum usage right
- Postal address, e-mail address, phone number or contact details of the agent
- Band of spectrum and geographic area covered by the spectrum usage right
- Description of all relevant rights of use

Interference management regime

The Federal Network Agency should provide reasonable interference guidelines for each band. It should be possible to deviate from the thresholds specified by the regulator. If all those affected are in agreement, the regulatory authority should allow a departure from the interference threshold. This means that the regulatory authority only intervenes in the event of a dispute

In addition, a number of the innovative interference management approaches that are under study in the United States are promising and bear watching.

It is clear that the selective imposition of receiver standards has the potential to improve overall welfare. There are many interference problems that could most appropriately and most cost-effectively be addressed by means of a modest improvement in receiver quality, rather than by the traditional method of imposing restrictions on the transmitter. At the same time, manufacturers in the U.S. and Canada have understandably been uncomfortable with the prospect of new regulatory impositions. Nonetheless, it may be possible to make progress. In the Nextel proceeding, the U.S. FCC did not mandate overall receiver quality standards, but it committed to provide protection from interference only for receivers that met certain quality standards. Experience to date is limited, but this approach seems sensible and could be considered for use where circumstances warrant.

The U.S. work on interference temperature might in time lead to important advances, but it is not yet clear if this single metric is sufficient for regulatory purposes, nor is it altogether clear exactly how to apply the interference temperature to regulation. It would be appropriate to monitor further developments in the U.S. and elsewhere to see if this concept makes progress.

An additional observation that flows from the U.S. exploration of the interference temperature is the notion that it would be useful to have a better understanding of the overall interference environment. Two approaches that were considered but not implemented to date in the U.S. are (1) the use of a monitoring network, and (2) the “enlisting” of a group of cognitive radios to function as an *ad hoc* monitoring mesh as an adjunct to their primary function. For the former approach, it has not been clear that the benefits would exceed the costs. The latter approach must be viewed today as being futuristic,

but it has the potential to provide a very inexpensive yet rich data source on the overall interference environment. If solutions of this type were to emerge, they might be of interest.

Spectrum pricing

Spectrum charges should cover not only the administrative costs of spectrum use; they should also be levied at regular intervals and reflect the economic value associated with the best alternative use of the spectrum (opportunity cost). This approach is known as administrative incentive pricing (AIP) and has already been used in the UK, for example.

- AIP is effectively an indirect tax that reflects the economic value of spectrum use. It consequently tends to make it more difficult for spectrum users to make windfall profits. AIP can therefore make a flexible approach to spectrum regulation more acceptable from a political standpoint.
- AIP can be used in concert with auctions, spectrum trading and the liberalisation of spectrum usage in order to ensure that spectrum is used efficiently.
- AIP reduces the risk of spectrum usage rights being held for speculative reasons.

Implementing a more flexible regime

A more flexible regulatory regime should be implemented as quickly and extensively as possible, yet also with due care. It is important to ensure that it is still possible to manage issues of interference, that there are no distorting effects on competition and that spectrum is not fragmented or used inefficiently.

A gradual approach, one frequency band at a time, would be appropriate, including consultations with all those affected in order to discuss the specific issues associated with each band. It would also be expedient to set up pilot projects in order to test different approaches, for example with regard to a new interference management regime.

The national regulatory regime is designed against the backdrop of international agreements. Therefore, in order to introduce greater flexibility at national level, a degree of flexibility at international level is required. It is consequently important to prepare for this in advance by paving the way in the international arena for possible approaches to greater flexibility. This will require German representatives to lobby international bodies to this end.

Issues of competition policy

It is expected that the introduction of liberalisation and spectrum trading will be gradual and may therefore differ in detail for each frequency band.

As long as liberalisation is still imperfect, it can be assumed that there will still be a noticeable “artificial” scarcity of available spectrum for certain applications, with the result that tight oligopolies may emerge and competition may be inhibited. Consequently, in such a situation it is imperative that the regulator evaluates the competitive implications of spectrum transfers or trades, either by *ex ante* review or by predefining categories of trades that are permissible.

In the long term, competition law may provide sufficient means of addressing competition concerns. This assumes that spectrum usage rights are almost completely liberalised, spectrum trading is possible and spectrum charges are set according to AIP.

Expanding spectrum usage rights of current users

Expanding the usage rights of current users presents the difficulty of how to introduce a more flexible regulatory regime in a non-discriminatory fashion. This applies both to a broadening of the conditions of use and to liberalisation. It may be the case that, by expanding spectrum usage rights, the regulator is discriminating against those who were unsuccessful at the time the spectrum was originally assigned, regardless of whether this took place via an auction or a beauty contest. It must be emphasised, however, that an expansion of existing spectrum usage rights does not automatically constitute discrimination. Irrespective of these considerations, there are various tools that can be used to counter potential discrimination.

- The user whose existing right of use is being expanded can make a payment to the government that is commensurate with the increase in value.
- The spectrum in question can be distributed in a big-bang auction restricted to that frequency band. This means that all the frequencies within that band are re-distributed by means of an auction, including those that have already been assigned. If the current user is the highest bidder, they will receive the expanded usage right without having to make any further payment. If a different bidder enters a higher bid, they acquire the usage right and pay the bid price to the previous user by way of compensation. This method gives all prospective users another opportunity to acquire the spectrum usage rights in a competitive process.
- Discrimination can also be ruled out if spectrum usage charges are set according to the principle of AIP and already take account of the possibility of expanded use.

If properly designed and appropriately used, such tools can be employed to ensure a non-discriminatory transition. This is especially true if they are combined with spectrum trading. It is therefore indeed possible to expand existing usage rights if this is done by pursuing one of the approaches outlined above.

Implementing liberalisation, spectrum trading and AIP in parallel

In the long term, it will only be possible to reap the full benefits of more flexible spectrum regulation if the restrictions on spectrum usage rights are relaxed as far as possible, if users are able to transfer rights of use (both permanently and temporarily) and if AIP is the guiding principle behind spectrum usage charges.

- Without a liberalisation of the conditions of use, spectrum trading will have little impact, as any new rights holder would have to use the spectrum in the same way. However, in view of the benefits of harmonisation, any steps towards liberalisation must also take careful account of all the relevant regulatory factors.

- Without spectrum trading, a liberalisation of conditions of use would at best allow present rights holders to use the spectrum more effectively. However, there would be no market mechanism for re-distributing spectrum to more efficient users.
- Without AIP, and even if spectrum trading is possible, there still may be an incentive for rights holders to retain spectrum for strategic reasons. AIP can also be used to reduce windfall profits and thereby make spectrum trading more acceptable from a political standpoint.
- *Ex ante* regulation of spectrum markets is only likely to become superfluous when spectrum usage rights are completely liberalised.

Ultimately, the full impact of a more flexible approach will only be felt if all tools are employed together.

Endnotes

1 This refers to a re-assignment of usage rights for a particular frequency band, including the re-auctioning of existing spectrum usage rights.
2 The reader can find a more detailed description in Nett, L. (2001): *Marktorientierte Allokationsverfahren für Nummern*, WIK Discussion Paper No. 213, Bad Honnef, June 2001.
3 McAfee, R.P., McMillan, J. (1987): Auctions and bidding, Journal of Economic Literature Vol. XXV, p. 699-738.
4 See Nett (2001).
5 RSPG04-54 Rev. (final) – The RSPG Opinion on Secondary Trading of Rights to Use Radio Spectrum, 19 November 2004. Attachment to Annex I – Rights and obligations.
6 cf. Withers, D. (1999): Radio Spectrum Management, 2nd edition, Management of the spectrum and regulation of radio services, London, p. 33 ff.
7 cf. Stockholm (1961): Regional Agreement for the European Broadcasting Area Concerning the Use of Frequencies by the Broadcasting Service in the VHF and UHF Bands (Stockholm, 1961).
8 The ITU's 1995 World Radio Conference allocated globally harmonised frequency bands for the IMT-2000 standard, which includes UMTS. The WRC agreements provided a total bandwidth of 230 MHz for IMT-2000, of which 170 MHz is for terrestrial usage and 60 MHz for satellite services. The frequency bands are in the 1885-2025 MHz and the 2110-2200 MHz range. Within these bands, the 1980-2010 MHz (up-link) and 2170-2200 MHz (down-link) sub-bands are reserved for satellite applications. In 2000, the WRC identified three optional frequency bands (806-960 MHz,
1710-1885 MHz and 2500-2690 MHz) in order to make additional spectrum available for the terrestrial component of IMT-2000 applications. It is up to ITU members to decide if, when and to what extent IMT-2000 applications will be introduced in the designated frequency bands. There has therefore been no agreement on global expansion bands for the terrestrial component of IMT-2000. cf. European Commission (2000), p. 6 ff.
9 The 1997 Chester agreement (Chester (1997): The Chester 1997 Multilateral Coordination Agreement relating to Technical Criteria, Coordination Principles and Procedures for the introduction of Terrestrial Digital Video Broadcasting (DVB-T), Chester, 25 July 1997) allocated bands III
(174-230 MHz), IV (470-582 MHz) and V (582-862 MHz) for the introduction of digital terrestrial TV, although the 216-230 MHz band is to be used for digital radio (DAB, Digital Audio Broadcasting). At the Wiesbaden planning conference in 1995, a plan was adopted for distributing spectrum in the
47-68 MHz, 174-230 MHz, 230-240 MHz and 1452-1467.5 MHz ranges. cf. Lehnert (1995) (Lehnert, Joachim (1995): *Bericht über die CEPT-Planungskonferenz zur Einführung von DAB in Europa vom 3.-21./22. Juli 1995 in Wiesbaden*, published as volume 10 in a series by DAB-Plattform e.V., Munich), p. 4 f. and Chester (1997).
10 cf. ERC (2002): The European table of frequency allocations and utilisations covering the frequency range 9 kHz to 275 GHz, Lisboa, January 2002, ERC Report 25.
11 cf. Cave, M. (2002): Review of Radio Spectrum Management, Study for the Department of Trade and Industry and Her Majesty's Treasury, March 2002, p. 64 ff.
12 See Article 4.4 of the ITU Radio Regulations.
13 Council Directive of 25 June 1987 on the frequency bands to be reserved for the coordinated introduction of public pan-European cellular digital land-based mobile communications in the Community (87/372/EEC).
14 Council Directive 91/287/EEC of 3 June 1991 on the frequency band to be designated for the coordinated introduction of digital European cordless telecommunications (DECT) into the Community.
15 Council Directive 90/544/EEC of 9 October 1990 on the frequency bands designated for the coordinated introduction of pan-European land-based public radio paging in the Community.
16 Council Directive of 25 June 1987 on the frequency bands to be reserved for the coordinated introduction of public pan-European cellular digital land-based mobile communications in the Community (87/372/EEC).
17 Decision No. 128/1999/EC of the European Parliament and of the Council of 14 December 1998 on the coordinated introduction of a third-generation mobile and wireless communications system (UMTS) in the Community.
18 Creating a trading market in radio spectrum in the UK, a presentation given by Darrin Mylet, Vice President of Wireless Services, Cantor Fitzgerald Telecom Services, at the Radio Spectrum Liberalisation & Trading in the UK conference held in the BSG Conference Centre in London from
24–25 November 2004.
19 Such conduct may, however, conflict with the Coase theorem, which holds that durable goods monopolists can only achieve a fair market price because they cannot credibly withhold goods for which they

themselves have no need. Everyone knows that these goods will be placed on the market at some point and, as the costs of waiting are identical for all parties, it is better for the monopolist to sell all unused goods right away.

20 ITU (1993): Spectrum Pricing Study, Communication Study Groups, ITU-R SM.2012.

21 Hsiao-Cheng Yu, Zon-Yau Lee, Hung-Yuh Lee (2004): Revising Taiwan's frequency usage fee regulation, Telecommunications Policy 28 (2004), 679–695.

22 See section 4.2.3 of the complete report available at www.bundesnetzagentur.de/media/archive/4745.pdf, „Frequency Trading", and especially section 4.2.3.2.1, „Transfer of Licenses".

23 The *Nextel Order* is discussed in sections 4.2.2.3, 4.2.4.1, and 4.2.6.3 of the complete report.

24 See section 4.2.1.2.3, „The Spectrum Policy Task Force Report", and section 4.2.4, „Interference Issues" in the complete report.

25 See Section 4.2.4.2 of the complete report.

26 WIK-Consult is grateful to the staff of the ACMA, the Department of Communications, Information Technology and the Arts, and the Australian Competition and Consumer Commission, for interviews and for follow up information they provided us.

27 1€=AUS$1.5828 on 1-10-2005

28 1€ = 1.73982 NZD: 1 NZD = 0.574773€ (1 October 2005).

29 These reforms occurred in a period of far reaching reform in New Zealand which included the removal of import tariffs, agricultural subsidies, labour market and tax reform, the adoption of a freely floating currency, the introduction of tradable quotas for the purpose of fisheries management, and a program of privatisation of State own utilities and enterprises. This reform period began with the newly elected government in 1984 and concluded in the early 1990s.

30 Note that in Germany at present it is possible to expand the use through public consultation, although if the expanded use clashes with the Frequency User Plan (FUP) it would require the FUP to also be changed.

31 The more the dimensions along which licenses are defined differ, the less joinable (tradable) are the license. Where licenses are defined according to *n* dimensions, *n*-1 of those dimensions need to be the same in order for spectrum to be purely joinable.