



Market Mechanisms
for **Spectrum**
Management



Organized by ITU and FUB under the
Shaping Tomorrow's Networks Initiative

Market Mechanisms for Spectrum Management is one of the themes covered in the 2007 series of the ITU Shaping Tomorrow's Networks Initiative.

This brochure summarizes the results of a workshop on Market Mechanisms for Spectrum Management held in Geneva, Switzerland, from 22 to 23 January 2007. It was prepared by the Strategy and Policy Unit (SPU) on the basis of specially prepared background papers, input documents and contributions to the workshop. The enclosed CD-ROM contains the background materials and documents of the workshop, as well as a wide range of background resources related to spectrum management.

More information about the workshop can be found at www.itu.int/spectrum.

Further information on the Shaping Tomorrow's Networks Initiative is available at www.itu.int/stn. The following title in the series can be ordered from the ITU Sales Service, or ordered and downloaded via the Internet at: www.itu.int/publications/bookshop/. Discounts on printed publications are available for ITU Member States and Sector Members, and for administrations from least developed countries.

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In addition, there are a number of free downloads of country case studies available at www.itu.int/casestudies, as well as other reports, presentations and position papers at www.itu.int/osg/spu/downloads/.

ITU/FUB Workshop on Market Mechanisms for Spectrum Management

22-23 January 2007

ITU Headquarters

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The report was prepared by William Lehr, Research Associate in the Center for Technology, Policy and Industrial Development (CTPID) at the Massachusetts Institute of Technology (MIT), USA; Cristina Bueti, Project Officer (ITU); and Marco Obiso, Programme Manager (ITU). The report has benefited from the inputs and comments of Tim Kelly, Head of the ITU Strategy and Policy Unit and Guido Salerno, Managing Director of the Ugo Bordoni Foundation, to whom we owe our thanks.

The Market Mechanisms for Spectrum Management project is managed by Cristina Bueti and Marco Obiso, under Tim Kelly's overall responsibility. Information on the Market Mechanisms for Spectrum Management project is available on the ITU website at www.itu.int/spectrum.

The views expressed in this brochure and CD-ROM are those of the authors and do not necessarily reflect the opinions of the Italian Ministry of Communications, the Ugo Bordoni Foundation, ITU or its membership.

Introduction

The information and communication technologies (ICT) sector has been experiencing renewed growth recently. Notwithstanding the highly volatile market conditions of the past decade, long-term technology drivers suggest that tomorrow's telecom market demand will not be measured just in terms of increased bandwidth and quality of service, but will also offer truly pervasive access: "anytime, anywhere, by anyone and anything". Tomorrow's networks will have to provide the necessary flexibility, coverage and transparency to immerse users in a total connectivity universe. The deployment of such infrastructures can only be realized by capitalizing on spectrum-based resources in new and innovative ways.

This new environment presents technical, commercial and policy challenges, none more so than in the field of spectrum management and trading. Traditional "command and control" spectrum management techniques are slowly being replaced by market mechanisms and services operating in unplanned spectrum bands are becoming as economically significant as those in planned bands. This raises the question of how centralized spectrum management agencies will need to adapt and whether techniques for rationing spectrum (e.g., licences, auctions) can coexist alongside unlicensed uses.

While the need for change in traditional spectrum management is clear, there is, nevertheless, no single approach that is universally applicable. Some economies are experimenting with secondary spectrum trading, while others are using generic, technology-neutral licensing as a way of embracing change. Reformers are confronting a number of important questions, including: How best to reconcile spectrum efficiency and equity concerns? Can spectrum be regarded as property, to be bought and sold, or as a public resource that can only be leased for particular purposes? Is it possible to have different spectrum management approaches among neighbouring countries and still maintain a harmonized approach at the regional and international levels?

In line with the stated objectives of the **WSIS Tunis Agenda for the Information Society** (November 2005), that "... *ITU and other regional organizations should take steps to ensure rational, efficient and economic use of, and equitable access to, the radio-frequency spectrum by all countries...*," the ITU and the Ugo Bordononi Foundation (FUB), of Italy, jointly organized a workshop on "**Market Mechanisms for Spectrum Management**".

This Chairman's Report highlights the most important issues and concerns raised during the presentations and open discussions which occurred at the workshop which focused on examining future approaches to the management and use of radio spectrum in an increasingly ubiquitous, user-centric and converged telecommunication environment.

Background Papers

A number of discussion papers were prepared for the meeting. The purpose of these papers was to raise some of the most important issues related to spectrum management in a structured way and to provide speakers and participants with background material on the topics covered during the meeting.

These included:

- **ITU Survey on Spectrum Management**, presented by **Cristina Bueti**, Project Officer, and **Marco Obiso**, Programme Manager, ITU. The impressive trend towards wireless communications in recent years has sparked a debate over the optimal spectrum governance regimes. There does not appear to be a single solution that would bring about complete technical and economic efficiency. Because of the multitude of forces influencing frequency management, several countries have been investigating and implementing alternative solutions for managing the radio resources. The challenge for policy-makers is, in fact, to create a regulatory environment, especially in the management of the radio spectrum, that will sustain these amazing trends and create an environment that allows innovation, particularly new wireless technologies, to flourish. The survey aims to gather information on the most important issues related to spectrum management policies around the world, including details of the initiatives undertaken by authorities responsible for the allocation of radio frequencies in each country, and it represents a snapshot synthesis of responses received from ITU Member States (see Fig.1).
- **Regulatory and Policy Implications of Emerging Technologies to Spectrum Management**, presented by **Frédéric Pujol**, Head of the Mobile Services Division, IDATE. This paper provides an overview of the policy implications of emerging radio technologies, especially those that can support an increased level of market competition. It is based on the work currently being carried out in the **SPORT VIEWS** (Spectrum Policies and Radio Technologies Viable in Emerging Wireless Societies) research project for the European Commission (FP6). This paper surveys new and emerging radio technologies and their relevant characteristics with regard to spectrum management and the economics of spectrum. It provides an analysis of the challenges facing existing radio technologies, spectrum usage, management and existing mechanisms for spectrum allocation. Within the survey made in this study, the focus is on technology innovations in fixed, mobile (including nomadic) and broadcasting systems. At certain points, connections and dependencies with other forms of spectrum use may be observed (such as radars, navigations systems, astronomy, etc.). Only the effect on the technological developments in radio communications of these other forms of spectrum use is mentioned.

Figure 1: ITU Background Resources Website on Spectrum Management

Workshop on Market Mechanisms for Spectrum Management

Background Resources on Spectrum Management

Back to Workshop on Market Mechanisms for Spectrum Management Home Page

Location Map

This section provides useful resources on Regional and National Initiatives related to Spectrum Management. By selecting the geographic area it is also possible to access the profile of single countries.

Americas Africa Europe Asia Oceania

Topics

This section provides some background information on spectrum management policy and regulation in general. This list of resources is not exhaustive. If you would like additional related resources to be reflected, please contact Ms. Cristina Bueti or Mr. Marco Obiso at spectrum@itu.int

- ▣ Framing the Debate
- ▣ Trading and License Exempt
- ▣ Approaches to Liberalization
- ▣ Spectrum Management Reform
- ▣ International Entities
- ▣ [ITU Survey on Spectrum Management](#)

Source: The ITU Survey on Spectrum Management and the Background Resources website are available at: www.itu.int/osg/spu/stn/spectrum/resources.html

The focus is on frequencies below 6 GHz, which is considered the prime frequency range for mobile and broadcast services. In this paper, the most important innovations in radio technology are surveyed:

- Spread Spectrum technologies: OFDM, Ultra Wide Band technologies
- Dynamic spectrum access technologies: Software-Defined Radio, Cognitive Radio and Intersystem Control
- Mesh and ad hoc networks
- Low-power devices
- Advanced antenna technologies

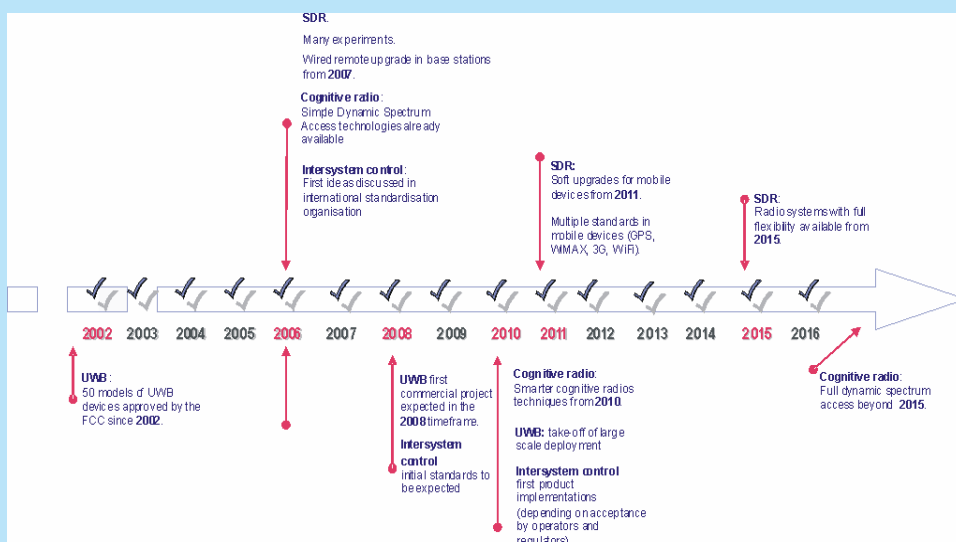
The conclusion is that many new radio technology developments contribute to increased spectrum efficiency and system performance. Also, these innovations form the enabling technology for better frequency utilization or flexible access to the spectrum. There are three innovations in radio technology that are considered as

disruptive, in the sense that the current spectrum management framework requires amendments to enable further development and introduction of these technologies. These innovations in radio technology are:

- Ultra Wide Band
- Cognitive radio (with SDR as important enabling technology)
- Intersystem control

The estimated technology roadmap for these technological innovations is shown in the next figure. It can be seen that UWB is a development currently coming up and resolving the spectrum management issues for this technology is urgent at this time. For cognitive radio and intersystem control the time line is longer and the urgency is not yet so great. Implementing possibilities for these last technological innovations is a process that can be started now, in order to keep up with the developments that are expected.

Figure 2: Estimated Technology Roadmap



Source: Frédéric Pujol, presented to the ITU/FUB workshop, **Market Mechanisms for Spectrum Management**.

Market Allocation of Radio Spectrum presented by **Coleman Bazelon**, Vice-President, Analysis Group. The standard spectrum allocation approach posits three alternative models: “exclusive use”, “commons”, and “command-and-control”. The regulator’s role is specified as selecting from among these models on a case-by-case basis. However, this framework yields the anti-consumer outcomes widely associated

with traditional regulation. The analysis of property rights found in the legal and economic literature offers clarification. It demonstrates that the conventional approach mistakenly conflates *access regimes*, i.e. rules coordinating wireless usage, with *property regimes*, i.e. rules determining who is authorized to make such choices. The debate over spectrum allocation policy gains coherency when, rather than seeking to impose preferred spectrum access regimes, public policy enables a competitive market process to discover them. This requires moving away from case-by-case administrative allocations to a general regime of exclusive property rights.

Failure to do so incurs significant social costs. For example, significant amounts of spectrum in the TV band – the so-called “white space” – will be available for non-broadcast uses in the U.S. even after the scheduled conclusion of the digital TV transition. Regulators are now in the process of deciding how to use the TV band white space for unlicensed use, mandating sharing rules, including power limits and protocols. This is an administrative choice that positions government policy-makers – not parties internalizing costs and benefits under competitive economic constraints – to select the access regime they prefer.

Alternatively, the regulatory agency could enhance social efficiency by exhaustively allocating TV band spectrum via liberal, exclusive property rights. With frequencies assigned to responsible economic agents possessing incentives to discover and implement efficient wireless solutions, rival opportunities for coordinating spectrum access are revealed. Companies, non-profit organizations and public agencies are then able to assess, and to remedy in an economical way, those situations in which any particular access regime is under-supplied. Thus, a spectrum market accommodates and rationalizes the deployment of alternative frequency coordination methods, including those associated with the “commons” and “exclusive use”.

Workshop on “Market Mechanisms for Spectrum Management” – Introduction and Meeting Themes Summary

An ITU/FUB Workshop on **Market Mechanisms for Spectrum Management**¹ was held at the headquarters of ITU² in Geneva, Switzerland, from 22 to 23 January 2007. The event was organized within the framework of the **Shaping Tomorrow’s Networks Initiative** and was chaired by **William Lehr**, Research Associate in the **Center for Technology, Policy and Industrial Development (CTPID)** at the Massachusetts Institute of Technology (MIT), USA.

The two-day meeting was structured to consider and debate five broad themes in promoting international and national dialogue among governments, the private sector and other stakeholders to identify global trends and good practices in radio spectrum management. These themes were:

- **What is the spectrum debate all about?** – In response to the difficulty government administrations have in coping with increasing demands on spectrum, a growing number of countries are shifting towards alternative models. This initial session aimed to provide background information on the two major trends, one of which is driven by the market and the other by technological innovation. In fact, practical solutions are now emerging that combine some of the features of both. This high-level vision was used as a preparatory activity and baseline discussion for all the sessions of the workshop.
- **How will spectrum markets improve efficiency?** – Modern society’s dependence on electronic communications is increasing the market requirement for a broad range of radio frequencies. From mobile telephony to wireless internet access to TV broadcasting, technologies need to coexist harmoniously within our radiocommunications spectrum. The traditional approach to solving competing demands for frequencies has been based upon planning who has the right to use the spectrum. With the sharp acceleration in demand in recent years, change in the marketplace is outpacing the ability of these national and international regulatory regimes to respond. This section examined some of the regulatory models currently in use and the extent to which these countries operate, or intend to operate, flexible systems, and, in particular, analyzed how they will permit the more efficient use of spectrum.

¹ www.itu.int/spectrum

² www.itu.int

- **New technology, markets and changing spectrum requirements** – Developments in technology over the last century have opened up the range of previously unusable radio spectrum, so affording ever-greater access to new allocations and assignments. There is, however, an increasing tension between services offered in licence-exempt spectrum (e.g. Wi-Fi) and those operating in bands where high prices have been obtained at auctions (e.g. IMT-2000/3G). This session looked at the future needs for spectrum at a time of rapid technological change and convergence, providing an overview of the policy implications of technological developments, and how these technologies can accommodate an increased level of market competition.
- **New approach to spectrum management worldwide: country experiences** – The session provided an invaluable opportunity to hear international speakers present their analysis of strategy implementation in several countries. Not only did this enable guests to observe the complications involved in deploying avant-garde policies on a national scale, but it also provided important information about the differing issues experienced by countries at varying stages of technological and economic development. This collection of case studies offered an outline of several policies geared toward the liberalization of spectrum markets, providing a definitive indication as to the true value of governmental deregulation.
- **Mapping the future of convergence and spectrum management** – Today's converging markets have seen an unprecedented level of demand for integrated services through different communication technologies, and have driven developments in radio technology toward more efficient methods of sharing spectrum amongst a wider range of users. Rapid innovation has created a need for speedier access to spectrum, both for individuals and for service providers, than is possible under traditional methods. At the same time, networks and services convergence is changing the approach to spectrum allocation and management; procedures originally intended for distinct, separated services are now being applied to services that will share access and transport infrastructures. All these developments point to the need for greater flexibility in the management of spectrum resources (e.g. for wireless electronic communications), while maintaining harmonization where necessary. This session presented a series of new initiatives designed to meet the needs of a convergent environment.

An **Executive Round Table** was held as part of the workshop. The Round Table provided top-level representatives of governments, international organizations and the ICT industry with the opportunity to engage in an interactive discussion and to share their visions on the overarching theme: "Challenges and Opportunities: What lies ahead for radio spectrum management?"

A final session presented some concluding views and contributions from participants.

The resources [website](#)³ prepared for the event provides links to the [final agenda](#), all of the commissioned [background papers](#), [voluntary contributions](#), [presentations](#), [webcast archives](#), [background resources](#) and the Chairman's Report. The website also provides links to a wealth of other resources and related materials and it represents a valuable source of fresh thinking on this subject.

Approximately 200 participants took part in the meeting, including renowned experts from industry and academia, government policy-makers and regulators, international organizations, telecom operators, communication service providers, ICT companies and other stakeholders.

This Chairman's Report summarizes the debate and proceedings of the Workshop and complements the presentations, background papers and the webcast, which are available from the [event website](#)⁴.

³ www.itu.int/spectrum

⁴ www.itu.int/spectrum

Mr Valery Timofeev, Radiocommunication Bureau Director, welcomed participants to the meeting, outlining that ITU was proud to host this important workshop, which was the result of a successful partnership with the **Ugo Bordoni Foundation** of Italy, within the framework of **ITU's Shaping Tomorrow's Networks**, in close collaboration with the **Radiocommunication Bureau**.

In his **speech**, Mr Timofeev noted that a new century for the international **Radio Regulations**, the centenary of which was celebrated last year, is starting, and that, so far, it has been a successful story of international cooperation among States, with the invaluable support of telecommunication industry partners. He emphasized that the challenge before us is to prove the continuing adequacy of the current arrangements or to search for new paradigms for the international regulatory regime.

Moreover, he informed the participants that 2007 is the year of another **World Radiocommunication Conference (WRC-07)** that will consider, among other topics of high interest to the wireless community, the results of studies on options to improve the international spectrum regulatory framework based on the examination of the effectiveness, appropriateness and impact of the **Radio Regulations** with respect to the evolution of existing, emerging and future applications, systems and technologies.

Mr Timofeev emphasized the interest of ITU in providing a forum for dialogue to exchange views and experiences, in order to discuss possible future approaches for radio spectrum management that will enable all countries, irrespective of their level of development, to implement and use the latest radio technologies in all possible spheres, from mobile communications and broadcasting to radio navigation, multi-media applications, and so on.

He also said that the daring title of the workshop, implying that market mechanisms could address the main issues in spectrum management today, should not make us forget the need to safeguard the crucial interests of non-commercial uses of the spectrum, including some essential safety services, critical defense applications and scientific research.

He introduced Mr Guido Salerno, General Manager of the Ugo Bordoni Foundation and Dr William Lehr, Research Associate in the Center for Technology, Policy and Industrial Development at the Massachusetts Institute of Technology (MIT), as Chairmen and expressed his hope for an open debate and a fruitful workshop.

Mr Guido Salerno, General Manager of the Ugo Bordoni Foundation, opened the meeting by welcoming the participants to the workshop. He highlighted that telecommunication growth is one of the most economically and socially relevant aspects over recent years. As the last century was defined the transportation era, everything is now linked to the communications environment and a pervasive revolution, like the ones based on coal, oil and electricity, is happening.

Mr Salerno argued that a combination of two milestones, transportation and communications, is the perspective of this new century, the goal of which is a "Ubiquitous Society".

In this regard, an innovative approach to spectrum management becomes crucial to cope with the foreseen growth of the telecommunication sector.

He noted that three main families of services and related manufacturers and operators, are competing in the spectrum arena. These are access, broadcasting and mobile.

In light of this, Mr Salerno said that secondary frequency trading, yet to be admitted in the European Union countries, is not a decisive solution and that spectrum management is a public policy that probably implies a more comprehensive strategy.

He said that a rational use of the spectrum requires policies able to manage different aspects and often conflicting goals, such as:

- a user-driven approach, as the growing number of connections and the larger bandwidth foreseen implies more spectrum;
- guarantee of availability and continuity for specific radio-based services: emergency, security, defence, disaster recovery, science and research, maritime, aeronautical, etc;
- reduction of the digital divide in rural areas and in less developed countries through a worldwide harmonized allotment of spectrum for radio access to the network, as requested by WSIS;
- faster digitalization of all kinds of transmissions, as quality improves and digital dividend results: new operators and new services will then be able to enter the market;
- introduction of new technologies and innovative architecture for radio-based networks. It is necessary to increase the spectrum efficiency: even more bit-rate per second, microcellular architecture also for traditional services, Software-Defined Radio technology, smart antennas, MIMO technology, etc;
- convergence toward IP, with an intranet-based architecture for the specific services as in b), in order to avoid any risk;
- protection of the investments made by operators to obtain the individual right of use of the frequencies and to roll out the networks;
- flexibility in the use of different technologies related to the same service, according to fair competition principles and Consumer Protection Laws;
- interoperability of end-user devices, based on new digital technologies with existing analogical networks;

- quality of service, particularly in planned networks based on individual right-of-use of frequencies. To guarantee the Wireless Quality of Service and a more efficient use of the spectrum, a Dynamic Bandwidth Allocation (DBA) scheme has been proposed. This scheme is based on smart technologies at both radio and MAC layers.


Mr Salerno affirmed the importance of good spectrum management, recognizing the vital role played by ITU in this field.

Dr William Lehr, Research Associate in the Center for Technology, Policy and Industrial Development at the Massachusetts Institute of Technology (MIT), United States, introduced the second panel, noting the diversity of views on how best to introduce market forces to improve spectrum management efficiency and best promote the use of RF resources.

What is the Spectrum Debate all About?

Dr Tim Kelly, Head of the Strategy and Policy Unit (ITU). This **opening presentation** set out the framework for the debate over market mechanisms for spectrum management by explaining the main approaches to spectrum management (command and control, open commons and usage rights) and provided examples for market mechanisms for both primary and secondary allocation. The presentation also briefly reviewed the advantages and disadvantages of market mechanisms. The overall conclusion was that there is no “one-size-fits-all” approach, and that spectrum managers need to mix and match different approaches (see Fig. 3).

Figure 3: “One size does not fit all”

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Arguments for and against market mechanisms

Advantages	Risks
<ul style="list-style-type: none"> ▪ Appropriate where scarcity is high and transaction costs low ▪ Should ensure efficient usage ▪ Encourages competition and innovation ▪ Raises cash for govts. 	<ul style="list-style-type: none"> ▪ “Winners curse” may impose burden on spectrum users ▪ May lead to hoarding or speculation ▪ Long licenses may slow innovation but short licenses deter investment

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Source: Tim Kelly, presented to the ITU/FUB workshop, **Market Mechanisms for Spectrum Management**.

Mr Jeremy Cain, Policy Manager Spectrum Markets, Office of Communications (Ofcom), United Kingdom. He highlighted that access to the radio spectrum leads to major financial benefits for national economies. In order to facilitate rapid access to spectrum, increase flexibility and release value, commercial spectrum in the UK is increasingly subject to market forces. However, many spectrum allocations, for example in defence and radars in the aeronautical and maritime sectors, have remained unchanged for many years, even decades. Following an independent review, the UK is embarking on a policy of extending the application of market forces to public sector spectrum. The **presentation** outlined the UK's approach and the plans for its implementation.

How Will Spectrum Markets Improve Efficiency?

Dr Coleman Bazelon, Vice-President of the Analysis Group, United States, contrasted the commons and property rights (licensed spectrum) regimes, stressing that both represent different perspectives on how best to regulate. He argued that for high-value spectrum in lower frequency bands, commons lacks clear mechanism for reconciling disputes, as evidenced by problems in the U.S. with allocating the 3.6-3.7 GHz band. Dr Bazelon noted that unlicensed lacks a useful mechanism for providing rational feedback on how best to use spectrum, whereas flexible licensing (property rights) offers a better way to cut the Gordian Knot of poor incentives and bureaucratic delays. This is the approach that ought to be used for the spectrum that will be freed up as a consequence of the digital TV conversion.

Mr Eric Fournier, Deputy Director, Spectrum Planning and International Affairs, Agence Nationale des Fréquences (ANFR), France. The **presentation** stressed that the objective of spectrum management is, on the one hand, spectrum efficiency, including access to spectrum for new users and innovative applications and, on the other, the avoidance of harmful interference. Market-based solutions such as spectrum trading provide interesting tools, which are being implemented in France, e.g. in the 3.5 GHz band, but the question is how they help in meeting spectrum management objectives. In particular, harmonization of spectrum is key in Europe for facilitating innovation and meeting consumer needs, and it is a utopian dream to rely on generalized spectrum markets to achieve such harmonization. Also, it is not possible to define rules for avoiding interference and still retain the ability to identify the technology or application which may interfere with it or, itself, be interfered with. Therefore, either flexibility is to be paid by large guard bands and loss of efficiency or the rules for avoiding interference will constrain the technology and the application in a way which will be more rigid and less transparent. Whatever spectrum management models are used, it will remain necessary to conduct negotiations to enable new users to access spectrum, all the while preserving harmonization and avoiding interference.

Mr Michael Whittaker, Director, FuturePace Solutions, Australia, presented "**Space-Centric Management: A General Solution for Equitable Access to Radio Spectrum Space under Conditions of Flexible Use**". Flexible spectrum access rules, which provide investment certainty and a neutral technology and service baseline, are essential for the efficient, market-driven introduction of innovative wireless applications. Clear, legally robust, practical interference benchmarks are necessary, which separately address all the well-known linear and non-linear categories of interference and do not depend on negotiations with licensees or a Regulator. The rules must not only separate device authorization from coordination, providing a general framework for new equipment design rather than performing narrow frequency coordination roles, but must also preserve the utility and economic value of spectrum under conditions of flexible use. All this is a much more complex task than the traditional approach, where management of interference is often simplified through the use of harmonized

equipment standards (also referred to as device-centric management). Simply extending these old and familiar methods of interference management will not provide an acceptable solution for flexible access, which must now deal directly with the utility of a five-dimension spectrum space: spatial volume, frequency and time. There is a solution that has operated successfully for the past nine years. For example, over the last three months, more than 5000 WCDMA850 base stations have been authorized in Australia, using rules developed ten years ago. The solution uses an alternative definition for “harmful interference” based on the other end of the transmit-receive radiocommunication entity: the transmitter and, when necessary, authorization through variable levels of guard space. Under the alternative definition, “harmful interference” is defined separately for each interference category simply as radiating a greater than specified maximum power from an antenna. Receivers must be designed to work around deployed transmitters, but the operational parameters for transmitters are constrained in relation to the size of the spectrum space under which they are authorized to operate. Thus, interference management becomes space-centric. Space-centric management is founded on transmitter spectrum denial (transmitters deny receivers access to spectrum) rather than receiver spectrum denial (receivers deny transmitters access to spectrum), the foundation of device-centric management. Many European attempts at designing spectrum licences, for example, Ofcom’s Spectrum Usage Rights or SURs, are based on receiver spectrum denial and, as a result, exhibit many weaknesses. Alternatively, the European “spectrum mask” approach contains one element of space-centric management, but by no means represents the complete solution. Market management, under conditions of flexible access, can be facilitated to quite a surprising level by employing space-centric management with explicit transmission rights and implicit reception rights. The space-centric method can provide a harmonized approach for flexible use, releasing the full benefits of innovation, with access to any technology or service in a technically and legally certain manner – which is authentic neutrality. Mr Whittaker authored a book in 2006 – “Flexible Radio Spectrum Access” – that for the first time clearly described the space-centric method as a fully scalable general solution for radio interference management in a flexible usage context.

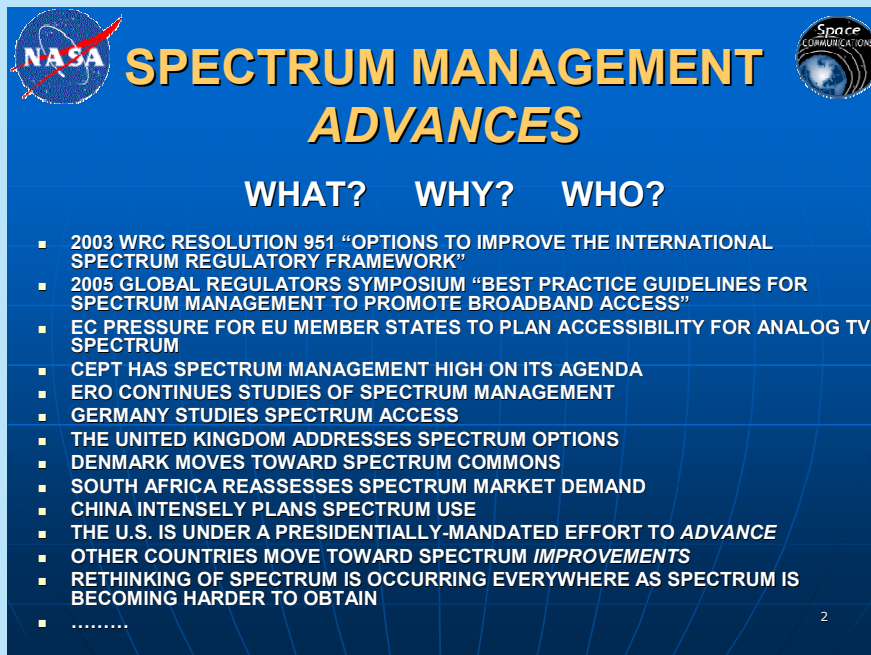
Panel Discussion

The discussions during Session 4 centered on the issue of whether, and to what extent, the flexible and liberal frequency allocations are needed in the modern spectrum management practices, as compared with the traditional school of thought that favoured harmonized allocations. The panelists provided an interested blend of opinions on this subject, representing the views of regulators, industry and academia. The main conclusion, shared at the end of the session by all panelists, was that the flexible frequency allocations should be introduced gradually and carefully, helped by a careful professional analysis of means and implications, and, most notably, by ensuring the robust means of controlling the interference potential of liberal spectrum use.

Mr Medeisis, Deputy Director of the **European Radiocommunications Office (ERO)**. This **presentation** outlined some general lines for discussion in Session 4. In particular, it highlighted and suggested debating the potential conflict between the harmonization efforts of traditional spectrum management approaches and the recently introduced liberal spectrum management. The presentation briefly mentioned the main principles behind harmonized spectrum allocations as opposed to the liberal assignment of “flexible bands,” outlining the mutual inconsistency of those two principles and seeking to find the balance between the two.

Mr William Luther, Consultant, Office of Spectrum Management, United States. This **presentation** examined the applicability of market mechanisms for national spectrum allocations and assignments for both government and commercial purposes. Recent advances in spectrum management processes were discussed, identifying plans for future changes in these management processes. A comparison was made between the major drivers for spectrum and the significant issues that exist in managing the electromagnetic spectrum. Note was taken of the special requirements by some critical government services that share spectrum with non-governmental services. The needs of both categories of users were explained. Attention was paid to safety, security and disaster relief spectrum needs (see Fig. 4).

Figure 4: Recent Advances in Spectrum Management Processes



SPECTRUM MANAGEMENT ADVANCES

WHAT? WHY? WHO?

- 2003 WRC RESOLUTION 951 “OPTIONS TO IMPROVE THE INTERNATIONAL SPECTRUM REGULATORY FRAMEWORK”
- 2005 GLOBAL REGULATORS SYMPOSIUM “BEST PRACTICE GUIDELINES FOR SPECTRUM MANAGEMENT TO PROMOTE BROADBAND ACCESS”
- EC PRESSURE FOR EU MEMBER STATES TO PLAN ACCESSIBILITY FOR ANALOG TV SPECTRUM
- CEPT HAS SPECTRUM MANAGEMENT HIGH ON ITS AGENDA
- ERO CONTINUES STUDIES OF SPECTRUM MANAGEMENT
- GERMANY STUDIES SPECTRUM ACCESS
- THE UNITED KINGDOM ADDRESSES SPECTRUM OPTIONS
- DENMARK MOVES TOWARD SPECTRUM COMMONS
- SOUTH AFRICA REASSESSES SPECTRUM MARKET DEMAND
- CHINA INTENSELY PLANS SPECTRUM USE
- THE U.S. IS UNDER A PRESIDENTIALLY-MANDATED EFFORT TO *ADVANCE*
- OTHER COUNTRIES MOVE TOWARD SPECTRUM *IMPROVEMENTS*
- RETHINKING OF SPECTRUM IS OCCURRING EVERYWHERE AS SPECTRUM IS BECOMING HARDER TO OBTAIN
-

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Source: William Luther, presented to the ITU/FUB workshop, **Market Mechanisms for Spectrum Management**.

Mr Fabio Leite, Deputy Director, Radiocommunication Bureau (ITU). In his **presentation** Mr Leite highlighted that spectrum management (SM) processes should respond in a timely manner to stakeholders' interests and requirements, provide certainty, and be flexible. All aspects from the international (ITU) to national (general public) point of view must be considered. He argued that the spectrum management goals were:

- international (higher level of harmonization, lower level of certainty): provide international recognition (protection rights). The ITU WRC process is complex and is a matter for experts, but is flexible and has proven to be responsive and effective;
- regional (high level of harmonization, medium level of certainty): foster mass market and radio terminal free circulation – facilitate roaming. They require the existence of appropriate regional structures and arrangements to establish effective supra-national SM frameworks;
- national (lower level of harmonization, higher level of certainty): attract investments and promote technology development, preserving market stability. Flexibility and complexity go together. Goals need to be adaptable to the national reality and fully responsive.

Mr Leite noted that the changing wireless environment is creating more complexity, where market mechanisms and technology cannot provide all the solutions. Therefore, there is a need for expertise and competence for spectrum managers.

He said that the international regulatory framework should adapt, underlining that ITU is carrying out studies (under **WRC Res. 951**) aimed at increasing flexibility and harmonization.

It was emphasized that there is a need to strike a balance between flexibility and stability.

Mr Fred Christmas, Director of Strategic Technology Planning, Hutchison 3, United Kingdom. He made a **presentation** on behalf of the GSM Association and focused on the benefits of frequency harmonization and how this aspect affects the handset costs.

Mr Christmas first illustrated some economical aspects of GSM and WCDMA handset terminals, showing that their more expansive elements are the ones referring to the baseband section, whilst the RF parts affect only a tiny fraction of the overall cost.

He explained that the reason why manufacturers do not produce terminals that cover all the frequency bands is because:

- of the complexity of preventing various air interfaces and bands interfering in the handset;
- they can make the handset less sensitive in various frequency bands and a few dB adds to base stations required;
- extra complexity means more handsets fail testing, increasing wastage;

- extra production line testing time reduces units produced;
- low margins and the above points reduce these small margins further.

A detailed analysis of the impact of vendor costs in the case of adding new frequency band components in mobile terminals was reported.

All the considerations mentioned led to the conclusion that frequency harmonization has a major impact on costs and it is one of the major issues to be addressed when considering liberalization, even if there are other relevant aspects to be considered, for example, interference. Furthermore, limited markets can significantly raise the handset costs.

Mr Phil Laven, Director, Technical Department, **European Broadcasting Union** (EBU). In his **presentation** he highlighted that spectrum pricing is a valuable tool for spectrum management but that not everything can be readily quantified in financial terms. Governments often have important objectives (e.g. coverage obligations for broadcasters) that contradict the objective of spectrum efficiency.

Moreover, auctions do not necessarily reveal the true value of spectrum. In some cases, they merely indicate how much companies are prepared to pay “to stay in business” or “to block access by their competitors”.

He argued that market mechanisms need to be balanced by the need to reflect non-financial factors.

Mr Laven stressed that interference is a key issue, which is often under-played and not understood by economists and lawyers. Interference with a digital service causes failure of the service, irritating the end users, who assume that their equipment has gone wrong (again). Even with sophisticated equipment, it can be difficult to identify the source of the interference (especially if it is intermittent).

Mr Ewan Sutherland, Visiting Professor, Graduate School of Telecommunication and Information (GSTIT), Ethiopia. His **presentation**, “Spectrum Lessons from Europe”, focused on the current situation in Europe, emphasizing the modest role played by the European Commission in spectrum-related matters and stressing that European countries have been reluctant to cede control on spectrum. Different proposals and actions have been tried in recent years, with no great success in the field. He also highlighted that GSM has seen a transnational consolidation by different operators, emphasizing that some very useful and efficient technologies (such as Bi-directional Paging) have been killed by the introduction of mobile services. The same destiny has been reserved for the Trans-European Trunked Radio (TETRA).

To conclude, the success of GSM was a myth, whilst the reality is:

- a set of very deeply flawed markets;
- a bunch of overweening operators.

The success has proved to be unrepeatable and it has been killed or absorbed by other technologies and potential business models.

Mr Sutherland argued that Europe had one success and many failures; it lost its leadership and remains a set of national markets.

Mr Klaus Kohrt, Vice-Chairman, UMTS Forum. In his **presentation**, he illustrated the findings of “Thriving in Harmony – Frequency Harmonization: the Better Choice for Europe,” a study undertaken by Booz Allen on behalf of the UMTS Forum, which considers the impact on mobile consumers and the overall industry ecosystem of two alternative spectrum management scenarios for wide-area communications. Firstly, continuation of the current harmonized approach, which is based on internationally agreed band plans using a designated group of technology standards. Secondly, the liberalized scenario, which advocates flexibility through generalized technology neutrality.

The analysis concludes, through qualitative and quantitative analysis, that consumers and the overall industry ecosystem are best served through the continuation of the current harmonized approach. The qualitative analysis demonstrates that, in a harmonized environment, consumers benefit from the increased penetration of end-user services due to the speed of innovation and network effects (i.e. Metcalfe's Law), while the industry ecosystem benefits from the improved cost structure provided by the large market size and scale effects resulting from a harmonized environment. Finally, the quantitative analysis suggests that spectrum harmonization will benefit end users through the greater use of end-user services, at lower ARPU, with a larger consumer surplus.

New Technology, Markets and Changing Spectrum Requirements

Mr Giovanni Santella, Senior Engineer, **Communications Authority** (AGCOM), Italy, illustrated some approaches adopted in the regulation and spectrum management at regional level, with particular reference to the United Kingdom and Italian cases.

After an overview of the general principles adopted in spectrum regulation, he reported some specific trends in the spectrum management such as the adoption of technology neutral rules, the increased allocation of licence-exempt bands (even if some market players believe that this kind of allocation does not ensure an efficient use of the spectrum), service neutrality, less restrictive individual rights and the adoption of market-driven frameworks (sub-allocation, trading, etc.).

Another relevant issue considered was the use of spectrum quality benchmark to allow alternative usage of allocated spectrum. A possible parameter is the interference ratio among signals from different operators that could be estimated by power flux density on the boundary regions, or out-of-band emissions according to ECC and CEPT recommendations.

A second aspect considered by Mr Santella was the mode to grant the right-of-use of spectrum. Two possibilities were analyzed: "auction" and "beauty contest". He argued that supporters of auctions affirm that, in this case, spectrum is assigned to operators, who are expected to make an economically efficient use of it. There are three main types of auction:

- Ascending Price, which is more effective when a certain number of licences are to be awarded for many different geographic areas.
- Sealed Bid, which is more attractive for new entrants.
- Anglo-Dutch, which is a mixture of the above two types.

On the other hand, Mr Santella highlighted that beauty-contest licences are assigned to those operators whom the government believes best meet the pre-set requirements.

Hybrid approaches are also sometimes used (for example in the UMTS licence assignment in Italy).

He concluded by stating the **ERG** position on spectrum management. ERG supports neutral approaches, both technological and service, as well as a market driven approach in the re-allocation of issued frequencies.

Mr Ron Resnick, Chairman of **WiMAX Forum** and Director of Marketing, Broadband Wireless Division, Intel Corporation, reported the WiMAX Forum position as far as technical neutrality and spectrum policy are concerned, with particular focus on the WiMax technology market perspective.

Mr Resnick suggested some ideas and challenges to increase competition and to reduce the digital divide, especially in those countries where this problem is particularly serious.

One of the main objectives is to ensure as much spectrum as possible for WiMAX operators (at least 20 MHz, but ideally 30 MHz), in order to be able to provide the necessary quality of service.

He affirmed that the OFDMA technology, on which WiMAX systems are based, appears to be the most interesting one in the development of new generation technologies.

He concluded by stating the WiMAX Forum Regulatory position as follows:

- the WiMAX Forum is working with administrations globally to ensure the availability of flexible spectrum for truly open markets and the delivery of cost-effective wireless broadband to citizens;
- the availability of similar spectrum worldwide is crucial to lowering equipment costs for WiMAX Forum Certified™ systems;
- the WiMAX Forum advocates that administrations remain “technology and service flexible” when assigning spectrum:
 - allowing licence holders to deploy the most appropriate services and technology for their envisaged customer base;
 - facilitating innovation with a fast-track route to the market;
 - encouraging competition to deliver best value to consumers.

Mr Richard Feasey, Public Policy Director, Vodafone Group, presented “**Spectrum Reform – Industry Needs**”. He noted that the cellular service industry generates more value per MHz of spectrum than any other industry in history. For example, in the United Kingdom the cellular industry generates about five times more total surplus from each MHz of spectrum than the terrestrial broadcasting industry.

But cellular is a relatively late entrant into the spectrum game. Each successive allocation of new spectrum for the cellular industry made through the World Radiocommunication Conference and other governmental process has occurred at higher and higher frequencies, so that the resulting economics of the spectrum have become progressively worse. Mr Feasey said that it is essential that the cellular mobile industry reverses this trend, given the enormous value it can generate from spectrum. This will not just happen – it requires spectrum reform.

Spectrum reform has several components for Vodafone as a global cellular operator seeking to develop and deploy technologies across many markets:

- Today, we need more flexibility in the uses to which we put the spectrum that we already hold. This is the first priority – not a new spectrum. Specifically, we must be able to deploy our core technologies – 3G – into our core spectrum at 900 and 1800 MHz. There are no obstacles to doing this today (other than legal and regulatory hurdles). We estimate that this simple step would unlock consumer benefits of 3 billion euros each year in Europe.
- Over the next year, we also need to move spectrum reform forward on an international basis. Some opponents of spectrum reform argue that the benefits of global harmonization would be lost with reform. This concern is misplaced (and the degree to which existing regimes deliver harmonization overstated), but it is true that spectrum reform requires some degree of international coordination to deliver its benefits fully.

Mr Feasey stressed that the benefits of harmonization and costs of spectrum fragmentation are poorly argued and most claims from either side should be approached with scepticism. Nevertheless, there are clearly some cases where a degree of “meta harmonization” – to ensure that bands that can be used for similar purposes in multiple countries are released at broadly the same time – is desirable. The treatment of the digital dividend in Europe is an important example of this (and the European Commission’s WAPECS concept is supported by Vodafone).

Although Vodafone is a strong advocate of significant spectrum reform in most markets, there are two major risks which the company wishes to avoid. Firstly, without some coordination of reform across markets we may find ourselves in a position where bands are inflexible but coordinated by governments in some markets, and flexible but coordinated by firms in others. Put another way, governments may have forfeited their role in coordinating spectrum and technology in some markets by allowing firms to do it instead; but in others, where governments retain that role, the same firms may find themselves excluded. We may be left with no common mechanism to coordinate the two regimes.

Secondly, he underlined that the WRC tends to overstate demands for new spectrum systematically. This does not matter if national markets are sufficiently flexible to reassign spectrum which is unused, but it does matter if this is not the case.

Finally, it was said that the debate of licensed versus unlicensed/non-exclusive spectrum is badly distorted. The overwhelming majority of industrial-scale wireless applications works best in spectrum which has clearly defined exclusive rights. There is a (small) role for unlicensed applications – Ofcom predict they will require around seven per cent of UK spectrum by 2010 – but it is small. He emphasized that technology will not eliminate the need for governments – or markets – to allocate scarce resources between firms.

Mr Chris Doyle, Senior Research Fellow, Centre for Management Under Regulation, Warwick Business School, University of Warwick, United Kingdom, focused in his **presentation** on the problem of price of radio spectrum and the possible implications when emerging technologies are considered, on the basis of the UK policy experience.

Traditional pricing approaches are based on recovering the administration costs and applying market-oriented prices instead of using specific methods, in order to encourage greater efficiency in the use of the spectrum.

A possible solution to improving this approach is AIP (Administrative Incentive Prices), which are methods based on the following points:

- AIP are targeted at economic efficiency.
- Economic efficiency has three dimensions:
 - Allocative efficiency (spectrum is allocated to uses and assigned to users in a way that best meets consumer interests);
 - Productive efficiency (spectrum is held by producers who are able to supply services at the lowest cost);
 - Dynamic efficiency (the holders of spectrum face the right incentives to innovate).
- In the absence of market – determined prices for spectrum, AIP are a surrogate for missing markets.
- AIP strictly aim at productive efficiency.

To give an idea of this approach, a brief analysis of the Smith-Nera method was reported.

In conclusion, Mr Doyle presented some technological implications for AIP, outlining how a higher value of the spectrum, with relation to the actual price, is justified when the increasing value of the spectrum with the introduction of emerging technologies is taken into account.

Mr Wolfgang Kopf, Executive Vice-President, Public and Regulatory Affairs, T-Mobile International AG & Co. KG, Germany. In his **presentation** on “Next Mobile Generation Networks”, he illustrated the possible evolutions of mobile networks towards next generation and their impact on spectrum management. He highlighted that the last ITU Radiocommunication Conference set the possible future scenarios for the next two decades, with a strong emphasis on mobile services. He noted that mobile broadband

(based on IMT-2000) will be the future and the different players are starting to realize the huge potential, strongly investing on this communication means. He then proposed how mobile broadband can be deployed, highlighting that some success factors from the technical side include:

- spectrum and band flexibility to accommodate deployment;
- deliver concrete broadband services;
- backward compatibility with the existing networks.

And from the economic side include:

- maximum re-use of existing assets, such as infrastructure sites;
- minimal hardware changes, implementing, as much as possible, software based changes.

In terms of spectrum demand, he noted that it is fundamental to re-use the existing 3G spectrum and that, at the same time, it is important to look for other available frequencies. In this regard, some possible approaches to be followed have been proposed, including:

- lower bands;
- extension bands;
- re-use of GSM bands (900 and 1800 MHz);
- UHF band, currently used for analogical broadcasting that could, in the future, represent a solid digital dividend.

Finally, Mr Kopf affirmed that the World Radiocommunication Conference is a key moment to clarify the various issues and identify the most appropriate strategy.

Panel Discussion

Mr Guido Salerno Aletta introduced the panelists of Session 6 encouraging them to offer their assessment of the effects of new technology on the mechanics of spectrum allocation.

Dr Ken Umeno, CEO and President of ChaosWare Inc., and Principal Investigator, National Institute of Information and Communications Technology, Japan. Market efficiency of spectrum management was discussed from the point of view of newly developed chaos communications technology for attaining good spectrum efficiency and essential uncertainty of services.

A model for spectrum licensing, with incentives for multiple licensing transfer was proposed.

Mr Vadim Nozdrin, Radiocommunication Engineer (ITU), made a presentation on “**Economic Aspects of Spectrum Management for Space Satellite Systems**”. He emphasized that future satellite communication development requires the improvement of the existing spectrum orbit international regulations. In view of this challenge, economic approaches could complement existing technical approaches of management for satellite services, in order to promote more efficient spectrum use. The report examines the state of, and trends in, satellite service development, analyzes problems of existing regulations and proposes possible economic options to be applied.

Mr Sergio Antocicco, Chairman, International Telecommunications Users Group (INTUG), provided a **presentation** on “Bandwidth Sharing and New Auction Procedure” underlining that in packet-based radio transmission systems each packet, in the header, has a special field dedicated to the operator’s code. This identifies the operator of the customer originating the packet. This means that, in subsequent timeframes, a single frequency can carry information belonging to different operators. The situation is similar to the one occurring in traditional wirelines, in which a mix of packets, originated by customers of different operators, are transmitted on the same wire.

He argued that the consequence (in the radio transmission case) is that several operators can use the entire bandwidth simultaneously, thus optimizing the frequency usage. In this regard, several additional advantages can be gained, including the need for a smaller numbers of antennas and a lower environmental impact. However, the mechanism for selecting the operators that will be authorized to the bandwidth usage must be changed. Traditional auctions, similar to the recent UMTS ones, seem no more appropriate.

Suggestions and hypotheses on new auction mechanisms were presented.

Dr Jon Peha, Associate Director of the Center for Wireless and Broadband Networking; Full Professor in the Department of Electrical and Computer Engineering and in the Department of Engineering and Public Policy, Carnegie Mellon University, United States. Emerging technology, coupled with effective policy reform, could lead to tremendous gains in spectral efficiency. This would alleviate the spectrum scarcity that many nations have been experiencing. To be effective, reform in spectrum policy must fit the realistic capabilities of emerging technology, as well as applicable economic theory. In his **presentation**, he discussed three general approaches to reform. The first of these is an increased reliance on market-based mechanisms, possibly leading to a spectrum property system. The second approach is the expanded use of commons, or blocks of spectrum that are available to all devices for sharing.

It has been argued that both approaches have significant merit that regulators should exploit. However, each of these approaches is ineffective when taken to its extreme, where unfounded assumptions about technology must be made. The third approach discussed is sharing between a primary spectrum user that is licensed and one or more secondary users, where secondary users may not cause harmful interference to the primary spectrum user. Dr Peha said that many people underestimate the potential importance of this third approach in today's debates over spectrum policy reform. Emerging technology such as cognitive radio, location technology, and secure micropayment schemes will make a variety of primary-secondary sharing schemes, ranging from real-time secondary markets to unlicensed opportunistic access more practical. Each of these schemes could be highly beneficial for a different set of applications and circumstances.

23 January 2007 – Opening Plenary and Executive Round Table

Dr William Lehr opened the meeting and greeted the speakers and participants.

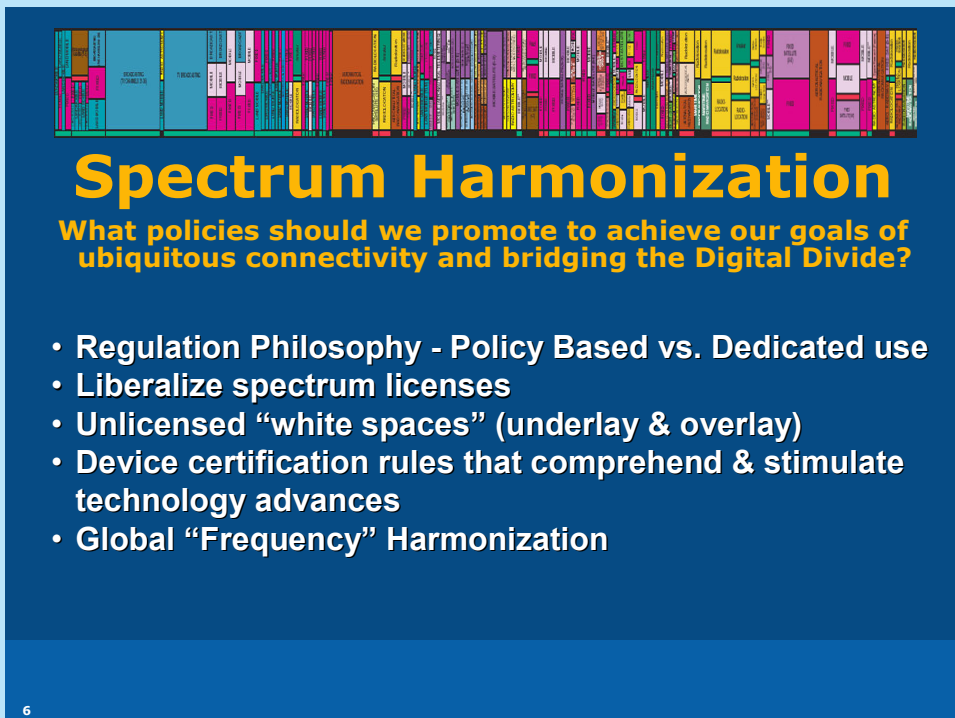
Session 7, the **Executive Round Table**, was chaired by **Martin Sims**, Journalist, **Policy Tracker**. It aimed to gauge views on the contribution that spectrum might make to economic development by asking participants whether they thought it would be as big an engine for growth as oil was in the last century. **Catalin Marinescu**, President of the General Inspectorate for Communications and Information Technology of Romania, agreed, arguing that data were the lifeblood of the information economy and comparable to oil. **Erkki Ormala**, Vice-President, Technology Policy, Nokia Corporation, also agreed, but other responses were more guarded. **Dimitri Ypsilanti**, Head of the Telecommunication and Information Policy Section at the Organization for Economic Cooperation and Development (OECD), pointed out that the creation value of richer countries came mainly from services, a sector in which spectrum played a crucial part. **Dr Hamadoun I. Touré**, the ITU Secretary-General, said that the airwaves were not only an important economic resource, but one that was equally available to all countries, emphasizing the need for international cooperation. He added that ITU is often considered as “guardian” of the world’s radio spectrum and, in this very important capacity, it has to address priorities such as continuing to assist the Membership in developing policies to access radio spectrum using the more appropriate approach; raising awareness worldwide of the social and economic values brought about by an effective spectrum management; and finding ways to accommodate the emerging services, which show much promise in extending the benefits of new telecommunication technologies to all the world’s inhabitants, particularly those in rural and remote areas. **Frank Greco**, of the European Commission, said that it was not comparisons that were important, but extracting the maximum value from available resources, at the same time resolving important issues, such as radio interference, through constructive coordination at the regional and international levels. He added that additional mobility is now the trend, but that radio spectrum is somehow too regulated and could slow down the evolution and usage of new technologies and services. It is important to adapt to the rapid changes happening in the ICT sector and, at the same time, improve the mechanisms and modalities to access the necessary radio spectrum.

The two participating government Ministers, **Paolo Gentiloni** from Italy and **Censu Galea** from Malta, accepted that spectrum policy was important for economic growth, but both emphasized that it also fulfilled important social and cultural functions. Minister Gentiloni also emphasized the importance of an equitable and flexible allocation of the radio spectrum, aiming all the while at the process of harmonization, which is indispensable for guaranteeing interoperability. To achieve flexible harmonization, he continued, it is necessary to establish general rules and coordinate actions at the international level, making use of key players like the ITU.

Minister Galea stressed the importance of identifying actions to ensure that the requirements of all radiocommunication services are met, while also enhancing national competitiveness. He agreed with Minister Gentiloni on the important role played by ITU in terms of international coordination and also in dealing with issues such as spectrum interference.

The discussion moved afterwards to whether or not market mechanisms should be applied to broadcasting. **Brendan Tuohy**, Secretary-General of the Irish Ministry of Communications, was adamant that they should not. He argued that discussions about spectrum had to include a wide range of stakeholders, including the creative communities, since broadcasting was such an important medium for cultural transmission. **Don Whiteside**, Vice-President, Technical Policy and Standards, Intel Corporation, argued that ubiquitous broadband was the key to closing the digital divide and empowering citizens around the world, but added that it was a complement to broadcasting, rather than its replacement (see Fig. 5).

Figure 5: Connecting the Unconnected by 2015



Spectrum Harmonization
What policies should we promote to achieve our goals of ubiquitous connectivity and bridging the Digital Divide?

- Regulation Philosophy - Policy Based vs. Dedicated use
- Liberalize spectrum licenses
- Unlicensed “white spaces” (underlay & overlay)
- Device certification rules that comprehend & stimulate technology advances
- Global “Frequency” Harmonization

6

Source: Don Whiteside, presented to the ITU/FUB workshop, **Market Mechanisms for Spectrum Management**.

New Approach to Spectrum Management Worldwide: Country Experiences

Mr Francesco Troisi, Frequency Management and Planning General Director, Ministry of Communications, Italy. The **presentation** started with a short description of the bodies involved, the legal framework and the aim of spectrum management in Italy, also taking into account the operational activities aimed to grant an efficient utilization of spectrum and the territorial structure involved in the monitoring.

Then the themes of the growing interest in radio spectrum, the reasons for this interest and its consequences on spectrum managers were addressed. With regard to the pressure on the spectrum managers, particular attention was paid to the claim for innovative policies in spectrum management, keeping in mind the potential impact on the efficient use of frequencies, on the need to maintain interoperability and a set of commonality at the international level.

Moreover, the theme of the introduction of flexibility in the frequency allocation was addressed. Finally, he proposed a look into the future, considering the technological innovations that are now predictable and have the potential to change the spectrum management policies.

Mr Denny Setiawan, Director of Radio Frequency Restructuring, Minister for Communications and Information Technology, Republic of Indonesia. He presented "**Auction for Allocating Frequency for IMT-2000: The case of Indonesia**". The auction can be designed and held in a relatively simple way, while still introducing the market-based mechanisms to distribute the spectrum to those who value it most; in this way, the real value of the spectrum can be determined. In the case of Indonesia, the IMT-2000 auction was conducted through a two-round, sealed ascending simultaneous auction, with pre-qualification. The details of auction design, rules, regulations, etc., can be learned from several 3G auction experiences in various countries. Furthermore, Mr Setiawan said that the auction needs a clear regulatory framework and a spectrum policy plan. In the case of Indonesia, DG Postel prepares several regulations and spectrum planning policies, including a migration plan to resolve technically conflicting services at 1.9 GHz, that overlap with the spectrum defined for UMTS 3G at 2.1 GHz, and also decides to apply "price-taker" spectrum licence fee policy and a migration plan to the existing licensees.

Mr Samuel Ritchie, Spectrum Management and Technologies Manager, Comreg, Ireland. He presented "**Spectrum Management at the Edge of Europe**". Having briefly considered Ireland's stage of economic development, the presentation looked at three areas where new approaches to spectrum management have been taken. This included a case study of the local licensing of FWA services that has created a new market, as well as the examination of a unique licencing scheme that permits operation across international borders to enhance markets that may be otherwise economically non-viable.


Using the experience gained in a small country, with a limited population, the presentation ended with five lessons that have been learned and promoted an incremental liberalization policy to expose complications and issues involved in deploying new approaches on a national scale (see Fig. 6).

Figure 6: Spectrum Management at the Edge of Europe

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5 Key Lessons Learned

- 1. Spectrum packaging must suit your market. (e.g. National vs. Local Assignments)**
- 2. There is no shame in being a Technology Follower.**
- 3. Great advantages in having good relationships with neighbours.**
- 4. Mould your allocation practises to follow your strengths (e.g. test and trial licensing.)**
- 5. Incremental Liberalisation rather than big bang:**
 - Technology neutral spectrum allocation – avoid picking technology winners
 - Service Neutral spectrum allocation where possible.
 - An authorisation/licensing process that fits the situation
 - E.g. Relatively low demand = first come, first served
 - Demand exceeds supply = auction
 - Auctions to allocate spectrum – let industry choose the price
 - Start with simple auction formats (sealed bid) and incrementally increase knowledge.



Source: Samuel Ritchie, presented to the ITU/FUB workshop, **Market Mechanisms for Spectrum Management**.

DG Postel, the Indonesian telecommunication regulator, also introduced a new bandwidth licence scheme instead of existing individual radio station licences in cellular services. This provides benefits for regulators and operators, helping them to simplify the problems of collecting and verifying the individual licenses, as well as encouraging the licensee to deploy network and providing services as early as possible.

In order to ensure the deployment of network and services to cover most of the Indonesian population, DG Postel combined market-based mechanisms, such as auction, with policy, regulation and licensing conditions, such as network roll-out obligation. Within less than one year, the number of UMTS 3G users/subscribers in Indonesia reached one million, and the service is now available in more than five provinces of 32 provinces in Indonesia.

Mapping the Future of Convergence and Spectrum Management

Mr Marco Obiso, Programme Manager, and **Ms Cristina Bueti**, Project Officer (ITU), focused their **presentation** on “Convergence and Spectrum Management”. In the first part of the presentation, Marco Obiso drew attention to the implications of the ICT convergence process on spectrum management, illustrating a slightly different perspective, such as how aspects related to convergence of ICT infrastructures and services should be taken in consideration and incorporated into spectrum management. The clear trend towards convergence is one of the critical success factors in implementing policy mechanisms that could improve the management of radio spectrum. In this regard, emerging technologies such as Ultra Wide Broadband (UWB), Broadband Wireless Access (BWA) and WiMAX are examples of “convergence-ready” paradigms that could strongly impact on a better provision of ICT services, only if they are coupled with a consistent and efficient allocation of radio frequencies. In the second part of the presentation, Cristina Bueti presented the “ITU Survey on Spectrum Management”, which gathers information on the most important issues related to spectrum management policies around the world, including details of the initiatives undertaken by authorities responsible for the allocation of radio frequencies in each country. This resource was made available on the ITU website as part of the Background Resources website and will serve as future reference to all entities interested in deepening their knowledge in the field.

Mr Frank Greco, Deputy Head of Unit for “**Radio Spectrum Policy**” Information Society and Media, European Commission, presented “**Rapid Access to Spectrum for Electronic Communication Services through more Flexibility**”. He stressed that, for technologies that use radio spectrum to deliver the new converged services to the consumer, it is important that spectrum regulation also converges and is coherent across all the affected frequency bands. The European Commission is promoting specific actions, which signal a move away from the narrowly defined uses for which specific spectrum is reserved today. The policy objective is to develop the EU internal market and competitiveness by ensuring a common, innovation-friendly regulatory environment, which facilitates rapid access to spectrum for new technologies and leads to the provision of a wide variety of wireless services and applications.

Under a broader definition of “electronic communication services” (ECS), digital technologies shall be stimulated to deliver all usage/services within their capabilities, making use of any frequency band generally identified for this purpose, but subject to technical coexistence rules that are tailored to each specific band. Mr Greco said that in the medium to long term, a coherent and minimum set of technical and authorization conditions will be implemented throughout Europe for most ECS frequency bands.

Mr Mario Frullone, Research Director, **Ugo Bordoni Foundation**, Italy, presented “**A Deeper Insight in Technology and Service Neutrality**”. He argued that the European Commission has recently stressed the need for a coherent spectrum policy approach, driven by social and economic objectives, which deserves of a political response from the highest levels of government.

Such a spectrum policy would also require an innovative regulatory approach. To make it easier to gain access to spectrum, and to similar conditions on its use throughout the whole European market, it is necessary to relax administrative constraints, thus allowing the competitive market environment to “naturally select” those systems, leading to an optimal usage of radio resources. This natural selection can be accomplished by promoting all those administrative and technical procedures that would facilitate the dynamic replacement of services and technologies. Therefore, two basic principles are fostered: service and technology neutrality, which can be roughly synthesized as a full independence between the frequency band in use and both the delivered service and the adopted technology.

In principle, service and technology neutrality pave the way for a more efficient spectrum use and hence should be warmly encouraged. Nevertheless, their inappropriate application can expose customers, operators and governments to new risks, which must be properly foreseen and prevented.

Mr Robert Horvitz, Director of the **Open Spectrum Foundation**, titled his **presentation** “Beyond Licensed vs. Unlicensed: Spectrum Access Rights Continua”. He began by noting that licence exemption implies an approach to spectrum management that is fundamentally different from the one based on licensing. Yet, OSF's recent global survey of Wi-Fi regulations found that the distinction between licensed and unlicensed is often blurred by the use of class licensing to approximate license exemption, and by regulators imposing restrictions on Wi-Fi, regardless of whether the networks are licensed or not. Conditions of use can thus have more impact on the take-up of this technology than the presence or absence of licensing.

Mr Horvitz stressed that licence exemption for short-range devices is envisaged in ITU texts and is considered by regulators as a “best practice” for promoting wireless broadband. So, one wonders why the Radio Regulations still say no private transmitting station may operate without a licence. To resolve this apparent inconsistency, Horvitz presented a draft Question for Study that could lead to recommendations for administrations on the circumstances in which exemptions from radio licensing are deemed appropriate.

OSF's survey found that the differences among national rules for Wi-Fi are mainly due to variables like indoor vs. outdoor deployment; integral antenna vs. separate antenna; commercial vs. non-commercial use; self-use vs. serving others, etc. But a more significant finding is that from a global perspective, diverse national rules form a continuum of spectrum access rights ranging from prohibitively restrictive to completely unregulated, with dozens of degrees of freedom in between. (A summary of OSF's survey, with “thumbnail sketches” of 165 countries' Wi-Fi rules can be found in Horvitz's **background paper** for the Workshop.)

Wi-Fi's access rights continuum emerged spontaneously, as a result of national autonomy in spectrum management interacting with a globalized equipment market. Mr Horvitz wondered if there might be advantages in creating such continua intentionally, at the national level, and he cited several recent proposals along similar lines.

An especially promising proposal involves the use of equipment “scorecards” to evaluate spectrum efficiency and other technical parameters. Devices would enjoy “progressively expanded tiers of spectrum access rights” in proportion to their performance. It would be challenging to reconcile this sliding-scale system with existing methods of awarding spectrum rights (auction, trade, beauty contests, etc.), Horvitz observed. But it could produce a multidimensional scheme that combines bandwidth pricing with incentives for improving equipment performance.

Mr Ryszard Struzak, Full Professor, National Institute of Telecommunications, Poland, and former Vice-Chairman, ITU Radio Regulations Board, addressed flexible-use spectrum rights. These would allow the radio frequency spectrum to be traded, aggregated, divided and freely used for a wide range of user-selected services. His contribution, “**Flexible Spectrum Use and Laws of Physics**”, focused on (1) radio propagation and (2) unintended interactions among radio systems – two physical phenomena that restrict the practicability of these rights.

The physical restrictions do not depend on the spectrum management regime. They are the same when the spectrum resources are treated as private property, or as an open commons, or are regulated administratively, or managed through free-market forces. Depending on the system isolation, a new (or modified) radio station can reduce the efficiency of the neighbouring stations. Questions arise, therefore, about related losses, compensation, market value, etc.

When a number of radio systems coexist close to each other, they are linked together into a common network because of intended and unintended interactions. They must coordinate their operations to avoid mutual interference. This is achieved through the ITU radio regulations, frequency planning, agreements, etc. Once the coordination has been done, little, if any, flexibility exists to modify system operations.

On that basis, Struzak concludes that the flexible-use spectrum rights can be implemented in two cases only, in a congested environment. The first case is that of an isolated system. The second is when a new system does not require any interference protection from, and does not produce any interference threat to, the existing systems, or when it does not disrupt the existing signal equilibrium.

The last condition implies that ‘intelligent’ radio systems that adapt themselves to coexist with their neighbours without interference offer a solution. Only when such systems become popular can the flexible use of radio spectrum resources be implemented in practice.

Panel Discussion

Mr Tomas Lamanauskas, Deputy Director of the Lithuanian Communications Regulatory Authority (RRT), Lithuania, chaired Session 10. He argued that world society is rapidly realizing the benefits and advantages of obtaining services, anytime and anywhere. Great demand on optimal connectivity to this advanced ambience not only leads to fundamental changes in human lifestyles, but also challenges our perception of resources, their employment and effective management.

Since the radio spectrum is a key resource for many ordinary services in today's society – mobile, wireless communications, TV and radio broadcasting – it gives strong impetus to other economic sectors outside pure communications and therefore plays an important role in bridging the “digital divide”. Effective spectrum management draws more and more attention in the regulatory agendas, both at national and international levels. He also emphasized that the principal goal of spectrum regulation remains the maximization of benefit for end users.

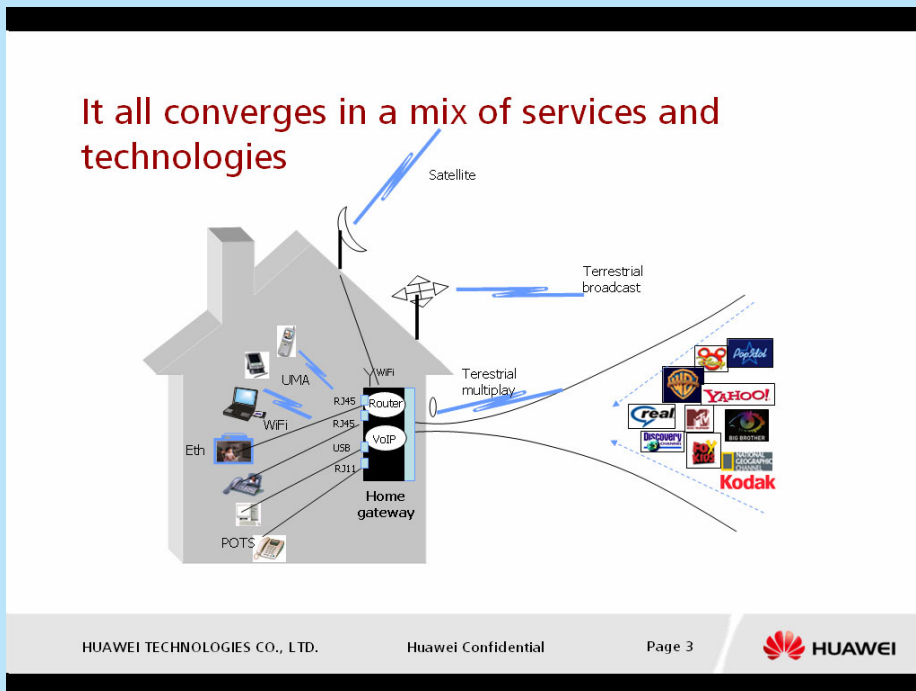
In his **presentation**, Mr Lamanauskas outlined the pre-conditions shaping our attitude towards spectrum management change, different spectrum management approaches and flexible spectrum management trends. He also raised the issues under consideration, such as the presumed challenges of spectrum management liberalization, from both the international and national points of view.

Ms Lamia Delenda, Deputy Director, Spectrum Valuation and Spectrum Strategy Department, France Telecom Orange Group. In her **presentation**, “Spectrum Usage Rights and Impact on Trading”, particular emphasis was placed on the spectrum usage rights and their impact on spectrum trading as a relevant issue to be faced within the debate as a whole. Although the concept of usage rights has been clearly identified, there have been significant changes in the ICT sector that require a new approach, especially taking into consideration the evolving scenarios. In this regard, Ms Delenda stressed that the work being carried out by ITU Working Groups is essential to guarantee the engagement of the different entities involved. The new definition of usage rights should incorporate technical studies, service and technical neutrality and the specificity of the regulatory regimes.

She argued that spectrum trading, within this concept, should be reshaped as well. Trading is certainly possible, but has to be compatible with the rights of use for a specific spectrum band. For greater efficiency, spectrum trading of rights to use radio spectrum should be limited to transactions that do not change the use of the frequency bands under consideration. Once the appropriate monitoring and control mechanisms have been set up, secondary trading of rights to use radio spectrum could be progressively extended to transactions implying a change in use of selected frequency bands. She concluded by saying that, as a general rule, and in accordance with the European regulatory framework, changes in usage rights should not be allowed in harmonized bands.

Mr Lars Bondelind, Vice-President, Huawei Technologies, Sweden AB, presented “**A Manufacturer’s View on Spectrum Management**”. He noted that mobile communications have known an incredible success worldwide, bringing not only voice services but also a host of other services. Regulatory policies are now being challenged by a convergent world, whereby new technologies blur the existing distinctions between fixed/mobile/broadcast services (see Fig. 7).

Figure 7: Spectrum Management for a Converging World



Source: Lars Bondelind, presented to the ITU/FUB workshop, **Market Mechanisms for Spectrum Management**.

Considering spectrum scarcity, Mr Bondelind argued for a continued regulation of spectrum but also remarked that there is a need to define new spectrum management rules that accommodate former and newer technologies and make communications and access to the new information society available to everybody in a fair and non-discriminatory way.

He suggested a set of compromise considerations, including aspects of spectrum characteristics and its constraints by physical laws, implementation cost/complexity, technology advancements and spectrum freedom; considerations that the regulator community has to take into account in order to reach balance in the interest of society.

Mr Enrico Bagnasco, Head of the Department of Research and Trends, Telecom Italia, Italy, presented “**Technology Innovation, Standardization and Spectrum Management as Key Ingredients for Enabling a New Mobile Wave**”. He emphasized that the amazing success of the mobile industry can be related to many factors: the regulatory framework, together with the well-defined technology and standard development, proved to be pivotal. The market is still growing and it values primarily affordable costs and interoperability and roaming of services and terminals. Different new technologies and technology enablers are approaching the industry; research can help the industry by developing new solutions to better exploit the spectrum, but interoperability will be the crucial issue of our innovation path.

He stressed the importance of facing the “spectrum challenge” by building on the solid foundations that enabled the success of the mobile industry and by exploiting the exciting opportunities that new technology enablers are making available, while maintaining full interoperability of services and terminals and large economies of scale.

Dr William Lehr summarized some of the key insights revealed over the two days of the workshop. While a diversity of views were presented regarding the appropriate scope for unlicensed versus flexible licensed use, the pace of liberalization, and the means to be used to evaluate the public interest and the merits of alternative regimes, there was also much agreement. First, there was general consensus that wireless services of all sorts are critical to the future of ICT and the future of wireless is shared spectrum. Multiple drivers are compelling the move to more intensive spectrum sharing, including:

- Technical innovations that enable more intensive sharing of spectrum. These include smart radio technologies that allow lower power operation, enable frequency agile operation, and improved signal-to-noise operation. Generically, the transition to spread spectrum and broadband platform architectures enhances the need for spectrum sharing.
- Customer demand for 24/7, ubiquitous, seamless mobility of applications across heterogeneous platforms (from 3G to Wi-Fi, from wired to wireless, global roaming) is also compelling the drive to shared spectrum. Service providers need to support applications across heterogeneous network infrastructures that arise either as a consequence of mergers or network investments in the face of rapid innovation. This means that applications need to be decoupled from specific frequency bands.
- Network provisioning cost control is also driving towards a more intensive sharing of spectrum. Optimizing the use of scarce spectrum resources necessitates more sharing. This need is accentuated by the rise in bursty, fat-tailed usage profiles and bandwidth-hungry multimedia applications.
- Regulatory reform that recognizes the need to change legacy rules to eliminate the artificial spectrum scarcity arising from restrictive Command-and-Control regulation. Management regimes need to be more responsive to market forces and that will require multiple types of regime, since no one-size-fits-all.

While folks could agree on the need to reform spectrum management regimes to enable the commercialization of more spectrum sharing, they differed with respect to whether reforms ought to be more evolutionary or revolutionary. Generally, incumbent mobile operators and broadcasters appealed for a more evolutionary approach that would ensure protection for legacy interests. Entrants and equipment vendors of new technology such as WiMAX called for a faster transition.

A number of speakers stressed the importance of considering more than just commercial interests and market efficiency when weighing spectrum management reforms, pointing to the needs for public safety and broadcasting as important categories of concerns.

Speakers highlighted the diversity of technologies and issues that arise in different bands, focusing on such issues as whether new technologies were disruptive or complementary, on the appropriate timing of commercialization, and on the implications for regulatory policy. Separate talks focused on 3G GSM/UMTS systems, WiMAX, UWB, cognitive radio, new signal processing techniques, and satellite systems.

There was a tension between harmonization to realize market economies and flexibility to support the entry of innovative technologies. A number of reform options were presented, highlighting again that there is no silver-bullet approach that is best for all situations. There is a role for Command-and-Control, market-based flexible licensing, and unlicensed. With respect to flexible licensing, there seemed to be strong sympathy for the ideal of technical neutrality, but that it needed to be tempered by reality. Service neutrality may present a bigger problem. With respect to auctions, a number of speakers suggested alternative approaches that might be used to limit the drain on industry resources and the upfront risks borne by participants, such as bids that are based on a percentage royalty for future revenues. The possibility of using Administrative Incentive Pricing for spectrum that is not actively traded (and thus, lacks a clear market price) was suggested as a means for improving incentives for sharing spectrum. And, finally, a recurring theme was how to measure spectrum scarcity and assess opportunities for sharing that balance the needs for interference protection and clear regulatory rules with market flexibility.

An important theme of the workshop was the need to improve the multidisciplinary dialog among policy-makers, economists, lawyers and engineers; among industry, government and academia; and among nations. There is much important work left to be done. While the challenges are great, the need for reform is also great and it is important that progress continue to be made toward increased reliance on market forces to manage how spectrum is used.

In closing, Dr Lehr thanked the speakers and participants, the conference organizers, Cristina Buetti and Marco Obiso, the **ITU** and **Ugo Bordoni Foundation**, and the corporate sponsors that provided refreshments during the breaks, including **Alcatel-Lucent**, **Huawei**, **Wireless** and **Pulvermedia**.



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