



# **First Annual Report of the Ofcom Spectrum Advisory Board**

**15 June 2005**

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# Message from Lord Currie

I am delighted to have the opportunity to congratulate the Ofcom Spectrum Advisory Board on their first year of operation. It was clear from the early days of Ofcom that if we were to successfully fulfil our duty to get the best out of the spectrum and to take account of all those who used the spectrum, we would need to secure high quality independent advice. Under the Chairmanship of Sir David Brown, the members of OSAB provide an invaluable collective expertise representing a wide variety of interests and considerations. In their first year, OSAB have discussed a number of high level strategic topics which are at the heart of Ofcom's thinking and their advice has been invaluable in taking forward major projects such as the Spectrum Framework Review. I was able to attend part of OSAB's first meeting held in June 2004, and to convey the appreciation of the Ofcom Board. The Board looks forward to meeting OSAB later this year.

A handwritten signature in black ink, reading "David Currie", with a long horizontal flourish underneath.

**David Currie**  
Chairman, Ofcom

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## Foreword by the Chairman



When the Ofcom Spectrum Advisory Board (OSAB) was established, its members expected its first year's workload to be substantial, varied and interesting. We have been disappointed on none of those counts. The strategic spectrum issues on which we have advised Ofcom have included:

- The Spectrum Framework Review and Implementation Plan.
- The Strategic Review of Telecommunications.
- The implications of technological developments e.g. Ultrawideband and Software Defined Radio.
- Technological developments (covering a range of issues e.g. dynamic spectrum allocation, R&D).
- The changing relationship between spectrum and capacity as it impacts property rights, spectrum trading, market liquidity and harmonisation.

Ofcom has encouraged us to think widely and critically; has listened intently; and has put much of our advice to good use. We could have asked for no more than that.

As OSAB looks forward to its second year, I wish to thank its members for the time they continue to give unstintingly and freely to OSAB, and for making the Chairman's job so easy.

A handwritten signature in black ink, which appears to read "David Brown". The signature is written in a cursive style with a long horizontal flourish underneath.

Sir David Brown  
Chairman, Ofcom Spectrum Advisory Board

## Section 1

# Introduction

## 1.1 Background

The Ofcom Spectrum Advisory Board (OSAB) was established on 19 May 2004 to provide independent advice to Ofcom on strategic spectrum management issues. The Spectrum Management Advisory Group (SMAG), which had previously provided similar advice to the Radiocommunications Agency and the relevant DTI Minister, was dissolved at the end of 2003 when responsibility for spectrum management was transferred to Ofcom. Ofcom recognised the continuing value of independent advice, particularly given Ofcom's duty under Section 3 of the Communications Act to secure optimal use of the radio spectrum, taking account of the different needs and interests of all users. The provision of independent strategic advice is invaluable in helping Ofcom to carry out its remit in this respect. It provides Ofcom with:

- A rapid way to test new ideas across a wide range of experts;
- A visionary forum in which radical ideas and possibilities beyond Ofcom's regulatory "headlights" can be identified and explored;
- a demonstration of Ofcom's commitment to consult industry in an open and collaborative manner; and;
- a mechanism to help reach an agreed industry view of difficult and contentious issues through the hosting of open fora.

Ofcom faces major spectrum management challenges in the light of rapid technological change and market development. An independent advisory board encompassing a collection of individuals with the experience to be able to provide a broad range of advice, was therefore seen as being of great value to Ofcom and it was agreed that Ofcom would establish its own independent advisory board, building on the work of SMAG. It was also agreed that the remit of OSAB would be broadened to provide a high level steer on spectrum related research. This took over the work formerly carried out by the Radiocommunications Agency's Radio Research Advisory Committee. OSAB's Terms of Reference are at Annex 1.

## 1.2 Membership

Sir David Brown (Chairman of Motorola Ltd, and former member of SMAG) was appointed as the first chairman of OSAB, prior to the appointment of members. In agreeing membership, a number of considerations were taken into account. OSAB provides advice through its collective expertise and members are appointed as individuals who are able to take a long term strategic view and set aside their own sectoral interests. Collectively it is important that OSAB is seen as having the ability to contribute effectively on a wide range of spectrum issues, taking account of technical, economic and social considerations. Membership includes ex-officio representation by the Department of Trade and Industry. Details of membership are at Annex 2.

### 1.3 Work Programme

OSAB is responsible for agreeing its own work programme. Current priorities for OSAB include:

- Broadband Britain and the Digital Divide
- Digital Switchover
- Interoperability e.g. wireless and wireline
- Short range radio technologies
- The balance between licensed and licence-exempt spectrum
- Implication of technological developments e.g. UWB, SDR
- European and global developments

OSAB meets 5-6 times a year and holds an annual brainstorming where a whole day is devoted to a particular issue. Since its establishment OSAB has met on the following occasions (all meetings, except for the annual brainstorming, were held at Riverside House):

21 June 2004  
12 July 2004 (sub-group on trading and liberalisation)  
27 September 2004  
28/29 October (brainstorming)  
6 December 2004  
21 February 2005  
18 April 2005

Further meeting dates for 2005 are:

25 July 2005  
12 September 2005  
27 September 2005 (meeting with Ofcom Board)  
20/21 October 2005 (Brainstorming)  
5 December 2005

### 1.4 The Year Ahead

Looking forward to the year ahead, OSAB has discussed the key issues that should form the core of their work programme. These issues are:

- UK competitiveness (exploring the links between regulatory, industrial and technological policy).
- The future of European spectrum regulation (with particular reference to the forthcoming EU Presidency).
- The Independent Review of Public Spectrum.
- Technological developments (covering a range of issues eg dynamic spectrum allocation, R&D).
- The Digital Dividend (both in terms of spectrum and opportunity gains).

Meeting dates for 2006 are:

20 February  
24 April  
17 July  
18 September  
19/20 October- Brainstorming

4 December

## **1.5 Further Information**

For further information on the work of the Ofcom Spectrum Advisory Board, please contact the OSAB Secretary:

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Or visit the OSAB website at [www.osab.org.uk](http://www.osab.org.uk) .

## Section 2

# Spectrum Framework Review and Implementation Plan

## 2.1 Issues

The Spectrum Framework Review (SFR) was published by Ofcom on 23 November 2004. Given Ofcom's statutory duty to secure optimal use of the radio spectrum, the SFR sets out Ofcom's plans for managing the civil radio spectrum in the medium and long term. The SFR outlines the rationale for regulating spectrum, and the role of the spectrum manager in providing a right to transmit on a particular frequency over a particular geographical area. It notes that as demand starts to exceed supply, this "command & control" type model may no longer be an appropriate way to manage this resource. The SFR then explores the balance between the three different ways in which spectrum might be managed:

- The traditional "command & control" model;
- the market manages the spectrum within the boundaries of licences ("market mechanisms"); and
- there is no control but power constraints or other mechanisms restrict usage to reduce the probability of interference ("licence-exempt use" or "spectrum commons").

The SFR states Ofcom's view that when there is sufficient spectrum available for licence-exempt use, market forces should be allowed to prevail where possible through the introduction of appropriate market mechanisms (trading and liberalisation). Ofcom's vision for spectrum management (as set out in the SFR) is that:

- Spectrum should be free of technology and usage constraints as far as possible;
- it should be simple and transparent for licence holders to change the ownership and use of spectrum; and
- rights of spectrum users should be clearly defined and users should feel comfortable that they will not be changed without good cause.

This will be achieved by:

- Providing spectrum for licence-exempt use as needed (but noting current estimates that little additional spectrum will be needed in the foreseeable future – around 7% of spectrum);
- allowing market forces to prevail through the implementation of trading and liberalisation where possible (around 72% of spectrum); and
- continuing to manage the remaining 21% of spectrum using current approaches.

The Implementation Plan was subsequently published on 13 January 2005. The Plan addresses how the vision for spectrum management set out in the SFR can be implemented in two key areas and provides a "roadmap" for these changes. This covers:

- The release of newly available spectrum into the market over the next 2-3 years (covering around twelve different bands); and
- the transition to spectrum trading and liberalisation in relation to mobile services. Particular consideration is given to the removal of restrictions from licences that presently prevent the use of spectrum for the provision of mobile services, including 3G services and mobile services other than 3G, and the potential extension of spectrum trading and liberalisation to the bands currently licensed for 2G and 3G mobile services.

## 2.2 Presentations to OSAB

The Spectrum Framework Review was discussed at the first OSAB meeting on 21 June 2004. William Webb (head of Ofcom's Research and Development) gave a presentation on the proposed review so that OSAB could provide some early thinking. OSAB's initial comments were:

- There were a number of additional areas which could be covered. These included the need to consider the range of licence-exempt WIFI opportunities (given the inherent trend for increased power levels), and Ofcom's view of the industrial market structure in a liberalised trading world.
- It should be recognised that development of cognitive radio could have a huge impact on spectrum management (use of cognitive radio in the US was limited to a fairly niche market).
- In considering UWB, and how this might further the interests of the citizen-consumer, it would be important to develop scenarios of use to enable individuals to envisage the potential opportunities.
- Consideration needed to be given as to how to link the Review with other initiatives such as trading, and the Telecoms and PSB Reviews. Trading in particular was a major underlying issue and the timing of the Spectrum Framework Review might need to be brought forward (or some early thoughts on direction published).
- More fundamental was whether the division of spectrum according to frequency was the right approach to adopt. Such division was somewhat incompatible with UWB and the Review should take a more fundamental look at whether other approaches to dividing access should be used, perhaps for example, a division based on capacity needed.
- It would be helpful to profile market liquidity (taking into account what spectrum is coming onto the market and taking a view as to whether that spectrum is sufficient to generate liquidity). Market liquidity would be vital for the successful implementation of trading and a different approach to the traditional allocation of large chunks of internationally harmonised spectrum (eg for broadcasting) might need to be reviewed.
- OSAB confirmed the trend towards increased market forces and explored the consequences of that trend. The equivalence between spectrum and revenue generating capacity would break down and Ofcom needed to position the UK in order to gain best competitive advantage. The Review should therefore consider the assumptions made by Ofcom as to what drives liquidity and how the breakdown between spectrum and capacity might be anticipated.

A further update was provided by William Webb at the meeting held on 6 December 2004 where Peter Bury (Director of Strategic Resources, Competition and Markets, Ofcom) gave a presentation on the Implementation Plan. In discussing the plan, OSAB made a number of comments:

- The plan affected a wide community and Ofcom needed to ensure wider exposure of issues. A number of events were planned for the New Year involving a wider audience (eg venture capital community and innovators) and it was agreed that there would be benefit in OSAB contributing to these events. Dr Walter Tuttlebee subsequently chaired a joint Ofcom/INTELLECT panel session on behalf of OSAB on 16 March.
- In particular, there was a need to raise the profile of the end-user and to recognise the citizen as an innovator and exploiter of technology, and not just a consumer. It was noted that individual consultations on specific bands would be more citizen-focussed but the overall vision needed to capture these issues at an early stage. Citizens would not be able to engage in discussions unless they were aware of them.
- The Plan also needed to consider social inclusion and to acknowledge social inclusion as a means of benefiting the economy through the enabling of all citizens.
- It was noted that external advice was being sought on liberalisation of the 2G spectrum, but it was felt that there was a need for a number of additional studies to underpin the plan (eg economic studies on the impact of timing of different approaches, updated cost-benefit studies).

Further updates on the Spectrum Framework Review and the Implementation Plan were provided by William Webb at the meeting held on 21 February 2005.

### **2.3 Responses to Consultation**

OSAB formally responded to the Spectrum Framework Review and a copy of its response can be found at:

<http://www.ofcom.org.uk/consult/condocs/sfr/responses/osab.pdf> .

## Section 3

# Strategic Review of Telecommunications

## 3.1 Phase One

Ofcom's Strategic Review of Telecommunications is a wide-ranging analysis of the telecoms sector and will guide Ofcom's approach to the future regulation of the UK telecoms industry. The review considers options for enhancing value and choice, particularly focusing developing effective competition in this market. The Review is split into three phases and it is Ofcom's intention to publish a statement at the end of the Review, setting out Ofcom's approach to future telecommunications regulation.

Phase One of the Review was published on 28 April 2004 and closed on 22 June 2004. Phase One set out Ofcom's view of the current market position and prospects for the telecommunications sector. OSAB discussed Phase One of the Review at their first meeting held on 21 June 2004, when Peter Walker (Ofcom) gave a presentation. In discussing this issue, OSAB made the following comments:

- There was a need to understand whether issues are common to other initiatives (Spectrum Framework Review, digital switchover).
- There were a number of delivery platforms (including satellite) and radio systems should be viewed as a complementary rather than a competing broadband technology.
- Consideration needed to be given to the balance between wholesale and retail requirements, ensuring choice of services (not just provision of access).
- Fixed-mobile convergence would be driven by developments in cognitive radio (eg location awareness).
- When considering regulatory trade-offs, Ofcom needed to take a view on positioning of markets within the innovation cycle (the end of a cycle created a commodity-type market where regulation might be appropriate, whereas the start of a cycle required a more stand-back approach). Care also needed to be taken in order to prevent competition distortions.
- There was a need to broaden the concept of consumer protection/behaviour to cover engagement in technology by informed citizens.
- It would be important to consider preservation of security as networks converged (integrity of data and network trust).
- The development of a super-highway may lead to a utility type model (ie a monopoly network provider over which all services run) but there are potentially other options in the early phase of development.
- Future systems would be driven by sensor-type services and given the inefficiency of IP version 6 over radio based systems, there was a need to develop appropriate protocols for radio.
- It would be important for the Review to clarify the difference between fixed-mobile convergence (which was network-centric) and seamless mobility (which was user-centric) and to consider the progression both in terms of mobility and from user connectivity to object connectivity.

It was agreed that it would be helpful for OSAB to see early feedback on Phase One and that OSAB would formally respond to Phase Two of the Review.

## 3.2 Phase Two

Phase Two of the Review was published by Ofcom on 18 November 2004 and set out a number of options for supporting the growth of greater competition, innovation and investment certainty. Ben Willis and Alex Blowers (Ofcom) gave a presentation on Phase Two on 5 December 2004. OSAB discussed Phase Two in some detail and made the following comments:

- The Telecoms Review needed to be more closely linked with the Spectrum Framework Review (SFR) and any OSAB response to the SFR would need to bear this in mind.
- The Telecoms Review needed to consider the international context (not just restricted to standards).
- It would be important for stakeholders to understand the terminology being used in the review eg “backhaul” failed to convey the 2-way nature of transmissions and the need to consider a number of demand-side variables eg quality of service and convenience, and not just speed.
- The “middle mile” was critical to the emergence of new services and there was a need to address the current disincentive for BT to invest in rural areas. Differential regulation of the wholesale market was needed in rural versus urban environments to facilitate innovative thinking on solving the digital divide.
- Solving the digital divide also required an understanding that while there could be rural coverage, this would entail higher costs to the consumer. Work was already on-going with the RDAs to promote this message and the benefits of business aggregation in rural areas to minimise these costs. The actual costs of rural provision might be lower than predicted provided regulation did not interfere with markets.
- It would not be easy for a regulator to decide where to intervene in the telecoms chain and there was a real risk of slowing down innovation. The liberalisation of the 2.4 GHz band had changed the way in which consumers bought infrastructure and the review needed to recognise and support the move towards a more flexible mix and match (wired/wireless) market.
- Multi-layered access was complicated by the increasing number of different standards and protocols, and consumer advantage would be limited unless there was seamless interoperability. While access might be a current bottleneck, a future bottleneck would be ease of interoperability.

OSAB submitted a formal response to Phase Two (concentrating on those questions most closely related to their terms of reference). A copy of their response can be found at:

[http://www.ofcom.org.uk/consult/condocs/telecoms\\_p2/restsrp2/osab.pdf](http://www.ofcom.org.uk/consult/condocs/telecoms_p2/restsrp2/osab.pdf) .

## Section 4

# Spectrum Trading and Liberalisation

### 4.1 Issues

The concept of trading licences has been under discussion for some time. In November 2003, Ofcom published a Consultation Document on Spectrum Trading which was followed by a Statement in August 2004, explaining that spectrum trading would be introduced in the UK through a phased approach. On 29 September 2004, Ofcom issued a Notice of Proposal to Make Regulations in order to allow the start of phased trading from the end of 2004.

On 17 September 2004, Ofcom published a consultation on liberalisation. The consultation put forward Ofcom's view that reducing or removing the traditional restrictions on changing the use of spectrum specified in the licence, would be of significant benefit to UK citizen-consumers. A report commissioned by the European Commission had estimated the benefits of spectrum trading with liberalisation to be around €9bn per year across the EU, while the benefits of spectrum trading without liberalisation, were estimated to be about one tenth of this. Change of use would either be in response to a specific request from a licensee or more generically, by Ofcom changing existing licences to make them less usage and technology specific. This would allow licensees to make certain types of change to their use of spectrum without needing the prior consent of Ofcom. Ofcom proposed to allow both mechanisms but the more generic approach would be introduced later in 2005, when a new assignment tool was available. The consultation looked at business radio, fixed wireless access, and terrestrial point-to-point fixed links (2G and 3G services were covered separately in the Implementation Plan discussed above). A Statement on Spectrum Liberalisation was issued by Ofcom on 26 January 2005. This set out Ofcom's conclusions on liberalisation, noting that there was general support for moving forward as outlined in the consultation. The Statement confirmed that Ofcom had decided to proceed with the first phase of liberalisation covering Business Radio, Fixed Wireless Access and Fixed Links.

### 4.2 Presentations to OSAB

OSAB discussed trading and liberalisation at their first meeting in June 2004 and agreed that given the timing, a subgroup of members should meet to discuss these issues. A sub-group therefore met on 12 July 2004. Graham Louth (Ofcom) gave an initial presentation on Ofcom's proposals for Spectrum Trading and Liberalisation. In discussing this issue, the following points were made:

- A long-term vision was required for trading both to excite stakeholders and to enable a more focussed discussion of secondary phases of trading. This vision would need to take into account a re-emphasis of international activities (eg the shift from European to global issues and the long term trend towards equipment markets) and anticipate future market structures (eg the need to provide affordable spectrum for SMEs in order to encourage innovation).
- It might be helpful to consider three wireless worlds (licence-exempt, traded and internationally important infrastructure [harmonised]) to provide a context for discussion of a vision. It would be important to ensure sufficient spectrum availability for all three worlds.

- There was a need to ensure that communications services were available for essential emergency services but this did not equate to ensuring that spectrum was reserved. It was noted that there was resistance to the emergency services having to bid for spectrum in an open market but equally there were concerns that the emergency services would benefit from being able to trade spectrum that had been allocated to them by traditional allocation methods.
- There was a tension between the benefit of trading in not having to second-guess future technological developments, and accommodation of technologies such as ultrawideband, which did not fit into a trading regime based on a legacy system where spectrum is divided by frequency.
- One of the aims of trading was to make the UK an attractive market for investment in new wireless technologies but there might be a need for intervention if market mechanisms failed to deliver (eg market domination or fragmentation preventing deployment of 4G).
- Ofcom would need to identify suitable metrics for measuring success. Previous work had centred on the added economic value but alternatives could be considered eg how efficiently spectrum was used (in terms of total amount of data transferred), level of investment in wireless technologies and relative time to market of new products.
- A key requirement for the success of trading would be visibility of spectrum availability and future assumptions, and the public trading register to be set up by Ofcom would need to contain all the information required for a successful trade, while taking account of sensitivities eg transmitter locations. It would also be important to establish suitable trading rules to facilitate the process.
- When considering competition issues, it would be important to properly define markets. The key issue was not the ownership of spectrum but the use that was made of that spectrum, and whether revenue was attached to that use.
- It was noted that Ofcom has a statutory duty to ensure optimal use of spectrum and that there will be a need over time to develop an understanding of spectrum property law. However, there was a concern over Ofcom's proposed detailed involvement in applications for change of use. Early candidates for liberalisation might provide an opportunity for experimenting with a more "hands-off" approach.
- Ofcom had a clear role in resolving interference which occurs as a result of a licence breach, but the situation was less clear where both parties were acting within the terms of their respective licences. Inter-property disputes were bound to occur and might well be a sign of successfully operating markets. Ofcom might also consider licensing dispute resolution practitioners. It would be important for Ofcom to be aware of the wireless landscape and Ofcom's plans to deploy mass unattended monitoring systems were noted.

Laurence Green (Ofcom) then gave a presentation on Spectrum Rights and Quality and this was followed by a wider discussion. The following comments were made:

- When trading spectrum, it would be important for users to understand that they are purchasing an ability to use apparatus to transmit and that this does not imply a guaranteed quality of service, although this is, in practice, implicit. In Australia, interference properties had been viewed as a fundamental input into their model for trading and it would be important for Ofcom to consider this issue carefully.

- To minimise problems, Ofcom could consider establishing zones in certain parts of the spectrum, which would allow similar users to co-exist without the need for Ofcom's intervention. Rather than the traditional service based segmentation, this would be system based (eg power based) and would encourage more market-based resolution of problems. Ofcom could define the zones in the first instance and then provide a mechanism for negotiation between neighbouring users.
- Negotiations might include purchase of neighbouring channels to establish suitable guard bands, or partial transfers eg reductions in power flux densities. Any negotiations would need to take into account the effects on the asset value.
- Trading and liberalisation were likely to provide additional gains eg provision of information on spectrum availability and the removal of artificial wholesale versus end user restrictions.
- It would be important for Ofcom to be aware of developments as trading progressed and trading would need to be backed up with a robust R&D programme.

In summary, discussions could be categorised into Ofcom's aims, the best strategy for achieving those aims and the workability of that strategy.

### **Ofcom's Aims**

OSAB was not convinced that a long term vision had been communicated; a key test of a successful vision would be whether users were excited about the concepts of trading and liberalisation. In considering a vision, it would be helpful to consider the three worlds of licence-exempt, traded and internationally important infrastructures. There were many detailed issues that needed to be considered eg similarities and differences between spectrum use and land use. Ofcom would also need to strike a balance between not trying to second-guess technological developments and not allowing ossification of current technologies.

### **Ofcom's Strategy**

The strategy would need to take into account a number of issues:

- Where to place the UK internationally (European markets versus global markets);
- Potential risks in asymmetric treatment of emergency services (which do not fit easily into the three worlds model) if they were able to trade spectrum but not required to obtain it through market mechanisms;
- A full road map was required beyond Phase 1 and may need to be in place before the commencement of Phase 1.
- The road map should set out system based zones and the market then be left to resolve disputes between neighbouring zones.
- The ability of trading and liberalisation to transform the UK wireless market was dependent on a decisive and speedy introduction. The risks of fast pace needed to be balanced against the risks of proceeding too cautiously but Ofcom needed to ensure that UK markets were not outpaced by other international markets such as the US.

### **Workability of Ofcom's Strategy**

There were too many potential issues for OSAB to comment on separately but key issues were how to properly define zones in property rights terms and the need to properly set out the detailed rules for trading.

## Section 5

# Ultrawideband

## 5.1 Issues

Ofcom issued a consultation on ultrawideband (UWB) on 13 January 2005. This sought views on a proposed way forward for the UK, working to achieve a harmonised approach throughout Europe. The concept of UWB has been about for some time but it is only recently that technology has advanced sufficiently for it to be a practical application. UWB allows a high data rate to be achieved by spreading transmissions across large parts of the spectrum. There are a large number of potential applications including Home Area Networks, through-wall imaging, ground-probing radar and a number of potential other innovative uses. Ofcom's plans are to exempt most UWB devices from licensing (within defined limits) but there are a number of issues that need to be taken into account eg the potential interference to existing users. Initial studies suggest that there could be potential interference to 3G, broadband FWA and radio astronomy.

The consultation considered whether UWB should be allowed and what the most appropriate mask would be. The document also noted the importance of reaching a decision on this issue in order to avoid UWB devices conforming to the US specification being imported illegally. The development of a pan-European specification for UWB is being considered and Ofcom will need to be able to contribute to these discussions.

## 5.2 Presentation to OSAB

OSAB first discussed UWB at its second meeting in September 2004. Janette Dobson (Mason Communications) and Richard Marsden (DotEcon Ltd) gave a presentation on the study commissioned by Ofcom to assess the value of UWB Personal Area Networking Services to the UK. In discussing the project, the following comments were made:

- A number of assumptions had been made when designing the study and these were explored by OSAB. They agreed that users of UWB PC Video and Audio/Video Streaming Applications would only benefit through lower cost of devices, but challenged the statement that there was currently insufficient data rate for such applications to be able to compete with alternative technologies, and considered that 100 Mbps was sufficient. It was noted that although few consumers would currently require data rates in excess of this, the study looked at potential requirements up to 2020.
- The study had deliberately taken a conservative view when estimating potential benefits and had concentrated on hand-held devices as being one of the first benefits to emerge. OSAB were however concerned that the study had excluded the potentially large benefits which would be acquired through the opening up of innovative opportunities by UWB technology.

- The study predicted a long delay in net benefits if UWB were restricted to 6-10 GHz (upper band) due to the unavailability of silicon chips for this band and the poor propagation at these frequencies. OSAB noted however that research on silicon chips for this band was being carried out in Japan and that in consequence, the predicted delay might be over-estimated.
- A key issue, which was difficult to quantify, was the extent to which UWB might constrain future use of the spectrum (eg deployment of 4G services after WRC-07). The study had not been asked to consider this issue but this might mean that there would be longer term benefits in restricting UWB to the upper band.
- OSAB highlighted the need for the study to understand the effects of a non-homogeneous distribution of devices (ie urban versus suburban environments and effects of peak activity eg for UWB devices built into mobile telephones). OSAB suggested that one case scenario might be to model these effects in an urban office where there would be a high density of UWB and mobile devices.

OSAB's comments were fed into the consultation subsequently issued by Ofcom on 13 January 2005.

## Section 6

# Brainstorming

### 6.1 Theme and External Inputs

It was agreed that OSAB should hold an annual brainstorming allowing members to devote an evening and the whole of the next day to a specific topic. The first OSAB brainstorming was held at the Marlborough Hotel, London on 28/29 October 2005. The theme was “The changing relationship between spectrum and capacity as it impacts property rights, spectrum trading, market liquidity and harmonisation”. It was agreed that the discussion would be structured around understanding the key drivers for changing this relationship and that presentations on the economic, technology, international and social drivers would be arranged with a final slot to draw together a roadmap. The presentations were intended as a means of stimulating discussions and were provided by:

Frances Cairncross (Rector of Exeter College, Oxford and previously Management Editor of The Economist) – Economic Drivers

Trevor Gill (Trevor Gill, Head of Radio, Vodafone Group R&D) - Technological Drivers (primarily SDR/mesh)

Björn Thegeby (European Commission) - International Drivers

Professor Leela Damodaran (OSAB) – Social Drivers

### 6.2 Discussions

After the presentations, members split into four groups and were given four different questions to answer. A summary of each group’s discussion appears below:

#### Group 1

*How much spectrum should be allocated to ‘commons’ by 2010 and by 2020?*

- Key considerations are:
  - what type of services will use commons;
  - will there be commons with controls;
  - what are the pros and cons of commons;
  - what will be the impact of change;
  - is there a need for demand analysis in order to justify an increase in commons at 5% and beyond;
  - do we need facilitators for commons;
  - is there a quality of service/innovation quotient; and
  - is there suitability of spectrum ?
- Other considerations are distance, need for quality of service at wholesale level more than at the retail level, need for managed commons (eg airport, mall), and innovation.

- There is a spectrum of degrees of control, from Government licensing (the most controlled), through SMOs, RSA/RSLs, “landlord” controls, and kite marking, to a commons “free for all”. A portfolio of bands and tools would be required to manage these options and any progressive movement between them.
- The group considered that the following allocations to commons might be appropriate:

2002	2%
2004	5%
2010	5%
2020	10% (with controlled demand-led migration)

The relatively low figure for 2020 reflects the current under-utilisation of the 5GHz band.

## Group 2

*What should be the technical basis for capacity allocation (frequency and power or some measure of capacity use over an area?)*

- The key question was how to match local capacity demand to local RF capacity. Was there a technical approach ? And what were the timescales ?
- One answer might be to use a “Capels” definition and a mixture of market and licence-exempt blocks. Within an immediate to 10 year timescale, non-contiguous blocks could be assembled to make 10% blocks and the next stage would be to move to 10% total contiguous.
- This process could be managed by the regulator by assessing spectrum usage and matching societal/economic value to capacity.
- There might be merit in establishing a threshold for regulation (ie below a certain power level/range regulation would not apply). This reflects the problems of policing signals that cannot be detected.

## Group 3

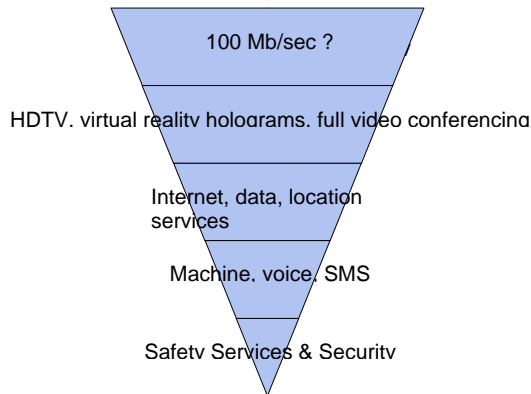
*Will spectrum trading encourage or reduce innovation?*

- The introduction of trading leads to an increased sense of ownership for everybody. This leads to an increase in controllable opportunity and a decrease in uncontrollable risk. Together these lead to increased investment, and in turn, increased innovation and capacity.
- The group therefore considered that trading would encourage innovation.

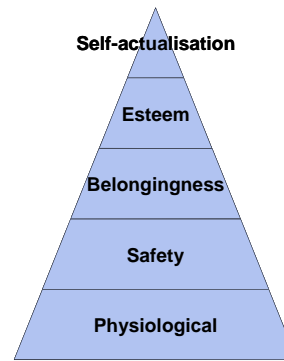
## Group 4

*What kind of connectivity will users want in 2010 and 2020 (technologies, uses and degree of dependency)?*

- In a market driven model of spectrum management, Maslow’s hierarchy of human needs could be inverted to reflect social requirements and spectrum capacity. The higher functioning requirements such as full video conferencing required higher data rates than lower functioning requirements such as safety/security:

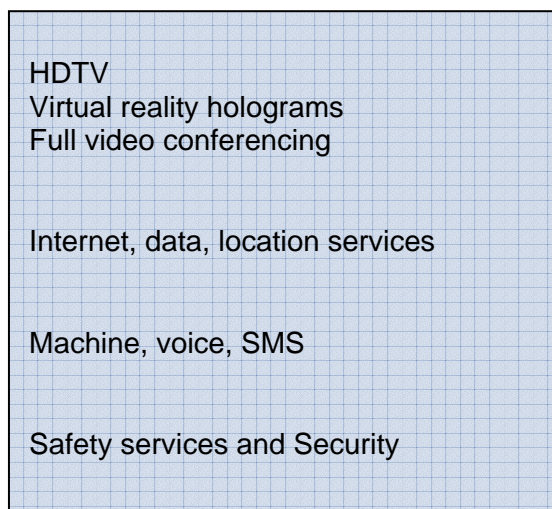


Spectrum capacity



Social needs

- This model perpetuates the digital divide (ie a small proportion of the population benefit from high capacity services).
- However an Interventionist model produces different capacity requirements as the triangle is evened out in order to extend high capacity services to more people:



### 6.3 Outputs

From the four discussions, a series of roadmaps were generated and at the following OSAB meeting in December 2004, Ofcom provided an initial response to these roadmaps, identifying specific prioritised actions and assigning those actions to relevant sectors e.g. Government, Ofcom, industry etc.

## Section 7

# Ofcom's Plans 05/06

### 7.1 Presentation to OSAB

Ofcom's plans for 2005/06 were published for consultation on 20 January 2005. The purpose of the consultation was to seek views on Ofcom's proposed direction and priorities. This had been preceded by a Strategy Day held in October 2004 and attended by a number of advisory bodies; OSAB being represented by Dr David Cleevely and Professor Mike Short. OSAB then discussed the consultation document at their meeting held on 21 February 2005. Robin Foster and Alistair Bridge (Ofcom) presented the annual plans and sought OSAB's views on the following areas:

- Ofcom's view of how the focus of work might change over the next 3 years;
- the proposed priorities for 2005/06; and
- whether there were areas not covered in the outline plan.

In discussing this issue OSAB noted the following:

- The plan should identify metrics for success so that proposals could be broadly measured against a backdrop of the value of communications to the UK economy. Although Ofcom had looked at some metrics, these were mainly focused on the citizen-consumer.
- Although it was noted that Ofcom was a regulator, there might be merit in having some kind of roadmap (on a contextual basis).
- There was strong support for international engagement and the need for more resolute bilateral engagement with other countries in order to promote UK thinking. It was noted that Ofcom were keen to promote this area of work eg Kip Meek had recently taken on the role of chairman of the European Regulator's Group. It was also important to ensure the visibility of such work.
- When considering future developments, greater emphasis should be given to the impact of digital multimedia broadcasting. There was also a need to expand the reference to second generation broadband as there were a number of complex issues involved (eg ubiquitous access versus restricting provision to dense urban clusters). It was noted that draft terms of reference would be published for work on future developments.
- The plans would also need to consider developing an understanding of the way in which standards and protocols allow networks to be opened up for growth and innovation (eg the success of GSM) so that opportunities could be exploited.
- In addressing citizen-consumer issues, accessibility should be drawn out as a separate priority.

## Section 8

# Other Issues

### 8.1 Research Strategy

OSAB's Terms of Reference include provision of advice on "The high-level strategic direction for Ofcom's research programme, including key areas of market and technical research required for new spectrum allocation and analysis of gaps in industry/academia research programmes." William Webb (Head of Research and Development at Ofcom) gave a presentation on the role of R&D within Ofcom at their meeting held on 27 September 2004. In discussing this issue, the following comments were made:

- When considering a research strategy, it would be helpful to develop a technology roadmap for the next 20 years to identify emerging technologies. It would also be helpful to publish an annual report and to establish a network of stakeholders who Ofcom would be able to call upon for advice.
- Development of unattended monitoring had huge potential benefits for Ofcom and for a number of other parties including defence. There might therefore be merit in establishing a semi-commercial model for funding this research.
- OSAB congratulated Ofcom on the programme to date but highlighted the need to ensure that the research programme was visibly linked to Ofcom's annual planning process.
- There was a need to balance the programme between research needed to support current operation and research into future scenarios. OSAB saw the latter as being more important and more suited to a collaborative approach.
- The scope for collaborative research across a range of organisations (MoD, industry, Ofcom, EPSRC, international) should be explored to ensure sufficient funding. This was a concept already well established in other countries (particularly China and Korea). There was no UK equivalent at present but this was an issue being pursued by DTI.
- There might be merit in establishing an annual competition through the Universities eg concentrating on how the spectrum might be better used for the benefit of society.
- It was noted that Ofcom's website now provided a mechanism for industry to report areas of potential research and it would be important to ensure that this captured industry concerns.

### 8.2 Future Spectrum Sharing Methods

In November 2004, William Webb (Ofcom) met with Dr David Cleevely and Professor Will Stewart (OSAB) and Frank Kelly (Cambridge Maths) to continue discussions initiated after the OSAB meeting in September. The basis of discussion was an acknowledgement that spectrum may well be under-utilised and that whilst unencumbered spectrum is a scarce resource, wireless capacity is not. The discussions therefore concluded that intelligent radio systems may make more efficient capacity sharing possible. This was presented to OSAB by Dr Cleevely and Professor Stewart at the OSAB meeting held on 21 February 2005. The presentation proposed that a framework (analogous to TCP/IP) might be developed, enabling individual radios to obtain access to spectrum, and that its stability should be tested in models and trials as soon as possible. An exploratory workshop was also proposed for the end of 2005. The following comments were made by OSAB in discussing this proposal:

- There was strong support for this issue. There was already a lot of work underway on dynamic spectrum allocation (including two European projects) but there was a need to pull this work together. Some problems had been identified eg the need for a global allocation for the universal control channel. It would also be important to manage expectations as this system was best applied where continuous data flow was not a requirement.
- There was a need to consider the process of how to move to a world of dynamic allocation (eg the process of establishing the Internet required significant early intervention).
- OSAB noted that integrated systems would be available within the next three years and supported the proposed exploratory workshop so that this issue could be progressed further. OSAB did not consider its role to advise Ofcom on who should lead on this issue as there were a number of alternatives eg IEE, academia, and MVCE, but supported the involvement of Ofcom at an early stage.

### 8.3 WIMAX Forum

At the February 2005 meeting, Paul Senior (Board Member, WIMAX Forum) gave a presentation on the work of the Forum and their thoughts on spectrum requirements. The WiMAX Forum is an industry-led, non-profit corporation formed to promote and certify compatibility and interoperability of broadband wireless products. WiMAX is a standards-based technology potentially enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL. It is the Forum's view that WiMAX will provide fixed, nomadic, and eventually, mobile wireless broadband connectivity without the need for direct line-of-sight. OSAB discussed the potential for WIMAX and noted the following:

- The marketing of WIMAX had been extremely successful but WIMAX was unlikely to be "all things for all people" and in practice there were trade-offs eg indoor ranges were likely to be restricted). It would be important for the Forum to closely define WIMAX to avoid unrealistic expectations. However it was noted that WIMAX is likely to create business models even if such models are not immediately obvious.
- There was potential benefit in WIMAX's short technical cycle eg for hotspots or as "add-ons" to existing networks but even with short technical cycles, there would still be a 7-8 year lag in establishing new networks.
- OSAB expressed some concern about the Forum's perceived need for large amounts of spectrum, albeit for broadband provision. It was noted that a separate harmonised allocation would provide a firmer underpinning for the business case, particularly in the US and that there were alternative options eg national allocations or GSM with a WIMAX overlay.
- OSAB also questioned the role of WIMAX in solving digital divide issues.

# Ofcom Spectrum Advisory Board – Terms of Reference

1. The terms of reference for the Ofcom Spectrum Advisory Board are:
  - a. The Ofcom Spectrum Advisory Board are to provide independent, strategic advice on spectrum policy issues to Ofcom.
  - b. While the primary role of the Ofcom Spectrum Advisory Board is to look beyond Ofcom's normal planning period, there will also be a need to take a high level view of near-term issues. In particular, the Ofcom Spectrum Advisory Board are to advise on:
    - The UK Spectrum Strategy, major Ofcom allocation decisions, spectrum management, and the application of spectrum pricing/trading
    - The spectrum policy objectives to be pursued in relevant international fora
    - New technologies or means of managing the radio spectrum and their implications for Ofcom
    - The high-level strategic direction for Ofcom's research programme, including key areas of market and technical research required for new spectrum allocation and analysis of gaps in industry/academia research programmes.
    - The extent to which spectrum policy objectives create a climate for innovation.
    - The need to safeguard the interests of citizen-consumers eg protection of vulnerable users, change management etc
  - c. The Ofcom Spectrum Advisory Board will be responsible for agreeing its own work-programme. Spectrum-related topics that might be considered include:
    - Broadband Fixed Wireless Access
    - Digital TV Switchover
    - Interference Management
    - Interoperability eg wireless and wireline
    - Broadband Public Safety
    - Defence use of Spectrum
    - Short-range Radio Technologies
    - Private Mobile Radio
    - Introduction of Spectrum Trading
    - The balance between licensed and licence-exempt spectrum
    - Development of new technologies eg UWB, SDR
    - Review of spectrum efficiency
    - Trends in international relations
  - d. To avoid any conflict of interest, members of OSAB will not have access to confidential information pertaining to Ofcom decisions affecting specific companies. This does not however preclude the discussion of potential Ofcom policies.
  - e. With the support of Ofcom staff, reporting shall include an Annual Report, publication of key findings on the Ofcom website, and hosting occasional Open

Fora.

- f. Members of the Ofcom Spectrum Advisory Board should be drawn from a mix of commercial, academic and consulting backgrounds, in order to assess topics in a multidisciplinary manner, and to advise Ofcom on spectrum matters of strategic significance. Membership will include ex-officio representation by the Department of Trade and Industry who will participate fully in discussions but reserve the right to abstain from agreement on substantive matters. The Board should also consider how best to make use of global expertise, particularly from countries with innovative spectrum management policies eg through regular liaison, international representation etc. Members will not receive remuneration other than reimbursement of expenses.
2. A MoU has been established between Ofcom and the Ofcom Spectrum Advisory Board to establish their terms of reference and the basis of the Board's establishment.

## Annex 2

# OSAB Membership

### **Sir David Brown (Chairman)**

Sir David Brown joined Motorola in 1991 and has been Chairman of Motorola Limited since 1997. He is a non-executive director of P&O. He is a Fellow of the Royal Academy of Engineering, a Chartered Engineer and past President of the Institution of Electrical Engineers. He is a member of the President's Committee of the Confederation of British Industry and a Past-President of the Federation of the Electronics Industry. His interests include the promotion of links between engineering and education. He has twice been an Institution of Electrical Engineers Faraday Lecturer and is a Past-President of the Association for Science Education, the professional body for Britain's science teachers. Sir David was Chairman of the University for Industry Design and Implementation Advisory Group and a member of the University for Industry Board. He serves also as Vice Chairman of the Board of UK Trade and Investment and a member of the Industrial Development Advisory Board. He was knighted in January 2001 for services to British Industry.

### **Professor Martin Cave**

Professor Martin Cave is Professor and Director of the Centre for Management under Regulation at Warwick Business School, University of Warwick. He is a leading academic economist who led the Independent Spectrum Management Review, commissioned by the Treasury and DTI. A former member of the Spectrum Management Advisory Group, Professor Cave specialises in regulatory economics and has advised a number of regulatory bodies in the UK and Europe. He is a non-Executive Advisory Director of OFWAT, the economic regulator for the water and sewerage industry in England and Wales, and was a member of the Competition Commission from 1996 to 2002. Professor Cave is currently leading the review of public spectrum, announced by Government in December 2004.

### **Dr David Cleevly**

Dr David Cleevly is a leading authority on telecoms policy and the digital economy, regularly commenting on industry trends and prospects at international conferences and in the media. Founder of Analysys and previous Chairman of Analysys Limited, David has worked with numerous governments at a national and supra-national level to create policy frameworks which encourage innovation and growth. He has made a major contribution to the UK Government's proposals for a unified regulatory body in the convergent world of telecoms, IT and broadcasting (Ofcom). He was also a member of the committee responsible for the Government report [e-commerce@its.best.uk](http://e-commerce@its.best.uk) and chaired the launch of the report by Tony Blair. He continues to advise the Government on policy formation for communications and media, IT and broadcasting.

### **Professor Leela Damodaran**

Leela leads the Information, Technology and Society Research Group at Loughborough University. She is actively engaged in a range of research and consultancy activities with a variety of sponsors including Government departments, UK and European research funding bodies, and blue chip organisations. Her expertise informs policy and the formulation of strategies to promote inclusive design and to manage large scale change. This is based upon Leela's research in the domains of: knowledge management (transition strategies and cultural change) ;

public access to information ; e-government, e-society and the 'Digital Divide' ; stakeholder participation and change management. Leela's team have advised Government on major planned change associated with the proposed switchover to digital television. The outcome was an influential report entitled "Analogue to Digital Switchover: Human Aspects of Adoption", proposing strategies for promoting social inclusion and enhancing public access to information. Leela's external appointments include membership of the EPSRC College of Reviewers, and of the Programme Committee for 'Accessible Design in the Digital World' Conference, Dundee, August 2005. She is also chair of the Digital Technologies and Social Inclusion Consortium and vice-chair of the BCS Sociotechnical Group.

### **Professor Barry Evans**

Professor Barry Evans was appointed to the Alex Harley Reeves Chair of Information Systems Engineering at the University of Surrey in 1983, where he leads the largest UK and European academic research group in Mobile and Satellite Telecommunications. Founder Director of the Centre for Satellite Engineering Research, he became the Director of the Centre for Communication Systems Research (CCSR) in 1996 –a post he still holds. From 1999 to 2001 he was Dean of Engineering and from 2001 to date he holds the Pro-Vice Chancellor (Research & Enterprise) role at Surrey. He has been involved in the UK Foresight programmes in Communications and ITEC, EPSRC Strategic Advisory Committees, MoD-DSAC Committees, adviser to DG of OFTEL, board member of BNSC-TNAB as well as ITU, ETSI and EU Advisory Committees. He is editor of the International Journal of Satellite Communications and has an authorship of over 500 papers in the technical literature and three books. He was elected to a Fellowship of the Royal Academy of Engineering in 1991.

### **Mike Hibberd**

Mike Hibberd is editorial director of Mobile Communications International. He joined MCI, the cellular industry's leading international magazine, as assistant editor in October 1996, becoming editor in Q1 2000. During his time at MCI Mike has chaired conferences, participated in various debates at industry events and provided comment for mainstream media. Prior to joining MCI Mike worked for the British Defence Staff at the British Embassy in Washington DC.

### **Christopher Holmes**

Christopher Holmes was former Director of Wireless and Broadcasting in the Department of Trade and Industry, and attended OSAB in an ex-officio capacity on behalf of the DTI. Christopher had responsibility for the Government aspects of mobile regulatory policy including 3G, spectrum and telecoms technology policy, the development of digital television, the Digital TV Action Plan including digital switchover, and Government relations with the mobile telecommunications and broadcasting industries. He had previously worked at the Ministry of Defence and the Department of Energy and had held a number of senior posts involving communications technology and regulatory policy. Christopher Holmes left the DTI in March 2005 and his replacement on OSAB is Stephen Speed.

### **Stephen Lowe**

Stephen Lowe is a Consultant for Telewest Broadband, a leading UK cable operator. Previously, he was Director of Eurobell Holding plc. He is Chairman of the Broadband Wireless Association and a leading player in the development of broadband fixed wireless access. Stephen holds an MBA from the University of Liverpool.

### **Phillipa Marks**

Phillipa Marks is a Director of Indepen Consulting. She specialises in the analysis of economic, public policy and regulatory issues in the media and telecommunications industries. She is an expert in the application of market mechanisms to spectrum management. She was educated in New Zealand and at Oxford University. After a period as a research officer with the New Zealand Institute of Economic Research, she moved to the UK working for the Institute of Transport Studies. She then joined the National Economic Research Associates (NERA) where she became a director, leading assignments in media, telecommunications and utility sectors. In 2000, she was appointed by the Home Office as a member of the Gambling Review Body.

### **Professor Mike Short**

Mike's career spans 29 years in Electronics and Telecommunications, with the last 17 years in Mobile communications. He was appointed Contracts Director of Cellnet in 1989 dealing with major infra-structure investments and UK interconnect agreements. In 1993 the focus moved to establishing Cellnet's GSM service. He was elected Chairman of the GSM Association for 1995/96 and served on their Executive Board for 3 years, was the 1<sup>st</sup> Chairman of GSM Europe in 1996 and the GSM Association Data Task Force 1999/2001. He was elected to the WAP Forum Board 2000/2 and was a founder Board Member of Open Mobile Alliance (OMA). He was also elected Chairman UK Mobile Data Association in 1998 (renewed for 2002/4). Mike has served as Vice President UK FEI 1998/2001, and led FEI (now Intellect) mobile / environmental committees. He has also been a member of Ministerial Advisory Groups on Spectrum (SMAG) and Security (Home Office TAB) since 1998, and was appointed a Visiting Professor at Surrey University in October 2003. Mike's focus today is on Third Generation cellular and steering O2's Group Research and Development in mobile.

### **Andrew Sleigh**

Andrew Sleigh is Managing Director, Knowledge and Information Systems Division for QinetiQ. His career has included research in sensors and machine intelligence, operational analysis and strategic planning, and has undertaken a number of senior management positions. Previously, he was Managing Director, Defence Solutions for QinetiQ and prior to that he was responsible for the MoD's ICT strategy and programmes and was Co-Chair of the Cabinet Office Official Committee on Spectrum Strategy.

### **Stephen Speed**

Stephen Speed is currently Director, Communications Networks at the Department of Trade and Industry. His responsibilities cover: the regulatory framework for telecoms; the Government's relations with Ofcom and with BT and other major fixed and mobile network companies and equipment manufacturers; information security, Internet policy and relations with the ISP industry; spectrum policy; communications technology. Prior to this role Stephen worked in the Office of Science and Technology where he oversaw the day to day running of the UK's £2.5 billion science budget and the development of science research policy. He was instrumental in pulling together the Government's cross-cutting review of science and research in preparation for the 2002 spending review. Previous roles in DTI include work on the development and passage of the Utilities Act 2000, planning, management and control of DTI's programme expenditure and spells as private secretary to the Secretary of State and to the Minister for Small Firms and Consumer Affairs. Stephen has a physics degree from the University of Sheffield and more recently obtained an MBA from Imperial College, London.

### **Professor Will Stewart**

Previously the Chief Scientist at Marconi with wide interests in technologies from communications to biosensing, he was educated at Imperial College (Physics). His personal interests have been in optical fibre communications and optoelectronics. Recent interests include microstructured photonic materials (photonic crystals), optical slow-wave structures, nanomechanical systems and the application of various optical, semiconductor and acoustic technologies to medicine, particle physics and industrial processes. He is a visiting Professor at UCL and at the ORC at Southampton. He is author on some 64 conference and journal papers, including many invited papers, and on 48 patents. He is a member of the editorial advisory board for the journal 'Science', chairman of Innos, resident expert on the Foresight 'EEMS' project, on the advisory board of Antenova and many other committees.

### **Stephen Temple CBE**

Stephen Temple joined Vodafone's Corporate Strategy Group as Director of Strategic Projects in July 2003. He spent 7 years with the UK's largest Cable TV Operator NTL, for the most part, leading their technology innovation programme in the Networks Division and finished up as Managing Director of the Networks Division. Prior to that he was a senior official in the Department of Trade and Industry leading for the UK in a number of European telecommunications developments including the GSM mobile project, digital video broadcasting, collaborative R&D and telecommunications standardisation. On the latter he was Chairman of the ETSI Technical Assembly for 4 years. In an earlier part of his Civil Service career he spent 7 years in frequency spectrum management in the Ministry of Posts and Telecommunications and Home Office. He was awarded the IEEE prize for International Communications in 1994, the GSMA chairman's award in 1996 and the CBE for services to Trade and Industry in 1996. He is a Fellow of the Institution of Electrical Engineers.

### **Dr Gary Tonge**

Dr Gary Tonge was until the end of 2003, the Director of Technology of the Independent Television Commission, a position he had held since the ITC's beginning in 1990. During his time at the ITC, he facilitated the development both of Channel 5 and of digital terrestrial television. He is currently doing some consultancy work in the field of electronic communications technology and policy. Gary is a Fellow of the Royal Academy of Engineering, the Royal Television Society and of the Institution of Electrical Engineers.

### **Dr Walter Tuttlebee**

As Chief Executive of the Virtual Centre of Excellence in Mobile & Personal Communications - Mobile VCE - Walter Tuttlebee heads up a unique not-for-profit company established 9 years ago by the mobile telecoms industry and academia as an outcome of the Government's Foresight exercise. Its mission is to undertake long-term, industry-steered, collaborative research, to the benefit of industry and academia. Mobile VCE today has 18 industrial members, operators and manufacturers, including major companies from Europe, Asia and America. Its research results 'seed & feed' its industrial members' internal R&D programmes as well as influencing international bodies such as WWRF, the Software Defined Radio Forum and IETF. Its research addresses core technology evolution to support the long term development of the wireless communications industry. In the 1980s and '90s, Dr Tuttlebee led industry R&D teams in 2<sup>nd</sup> and 3<sup>rd</sup> generation mobile communications, conceiving and playing a key role in key European research programmes which contributed to the 3G standards. He is acknowledged as a pioneer of software radio in Europe and has operated in Business Development in personal communications, digital broadcasting and satcoms. He has edited five

books, has published widely, has several patent filings and holds BSc, PhD and MBA Degrees. In recent years he has led the UK industry missions to Japan, Korea and China within the context of the evolution of future mobile communications.