Ofcom Spectrum Advisory Board

Annual Report 2015 - 2016

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Section 1

Message from Ofcom's Chairman

Ofcom's Spectrum Advisory Board has been a consistently invaluable source of advice for twelve years. It raises our sights from immediate spectrum issues along with the wider telecommunications landscape and informs Ofcom's long term planning with real salience for the sector and the UK economy. It has consistently met the challenge of its remit of 'looking beyond the horizon'.

The pace of change in the communication sector continues at an unabated rate. Expert advice, of the kind OSAB supplies, helps to ensure Ofcom's planning and regulatory framework responds to the challenge of serving the interests of citizens and consumers. The collective expertise of the Committee's diverse membership helps to anticipate problems across a wide ranging market and ensure sensible outcomes and broadening the understanding and insight of executive and non-executive members of Ofcom

I am hugely appreciative of all the time, commitment and most importantly the enthusiasm that OSAB members bring to their role and look forward to continue to work with them.

Dame Patricia Hodgson

Chairman of Ofcom

Section 2

Foreword by OSAB's Chairman

The Ofcom Spectrum Advisory Board (OSAB) is pleased to present its twelfth annual report and my sixth as its Chairman.

In this last year, OSAB has offered sector-wide insight and advice to Ofcom on a number of issues which have predominantly been related to the future of mobile, sharing of communication systems and the Internet of Things (IoT).

It is our policy to regularly refresh membership of OSAB so that we can continue to give fresh perspectives on issues of interest to Ofcom. This year we have said goodbye to Jean Jacques Sahel, Robert Pepper and Phillipa Marks. I would like to express my thanks to them all for the contribution they have made to OSAB discussions.

OSAB meetings are always characterised by the diverse knowledge and the passion for their subject which members bring to its meetings. The meetings are always attended by senior members of Ofcom who also actively engaged in the debates. Chairing OSAB meetings is a genuine privilege as well as a pleasure. I am most grateful to the members, and to Ofcom staff (especially the secretary) for making the Chairman's job so easy.

OSAB is embarking on its thirteenth year with unabated enthusiasm.

David Meyer

Chairman, Ofcom Spectrum Advisory Board

Section 3

Introduction

Background

2.1 The Ofcom Spectrum Advisory Board (OSAB) was established on 19 May 2004 to provide independent advice to Ofcom on strategic spectrum management issues. OSAB provides Ofcom with:

- A rapid way to test new ideas across a wide range of experts;
- A means of identifying issues that are beyond Ofcom's regulatory "headlights"; and
- A demonstration of Ofcom's commitment to consult in an open and collaborative manner.

Annual report

2.2 This document reports on OSAB's eleventh year. It is intended to summarise selected discussions throughout the year and its content is based on the published minutes of OSAB meetings.

Work Programme for 2015-16

2.3 OSAB is responsible for agreeing its own work programme. During this year, a range of topics was discussed. In this document, we have organised the topics into the following broad categories:

- The future of mobile,
- Sharing communication systems, and
- Internet of Things (IoT).

2.4 The topics draw from the minutes of the OSAB meetings during the period covered by the report[1]. These topics are broadly indicative of the key themes that OSAB, its members and many in the wider sector have been considering over the past 12 months.

The Year Ahead

2.5 OSAB sets its agenda from meeting to meeting depending on progress made in particular areas, time available and topics arising. It deliberately does not plan a year

1 http://www.ofcom.org.uk/about/how-ofcom-is-run/committees/ofcom-spectrum-advisory-board/

ahead to allow for flexibility and responsiveness to development(s) in the telecom sector.

Terms of reference

2.6 In 2008, the terms of reference for OSAB were revisited. Ofcom and OSAB agreed that although OSAB's initial role had been to provide advice to Ofcom on spectrum-related matters; it was increasingly difficult to consider spectrum-related matters in isolation in a converging world.

2.7 Hence, it was decided that OSAB's remit should be broadened to include all future communication architectures, access methods, physical layer technologies, spectrum issues, Internet, services and applications.

2.8 OSAB would be responsible for high level and longer term vision and not for detailed assessment of different approaches, standard setting or consensus building amongst industry. However, it would not involve itself with content matters.

Membership

2.9 The membership of OSAB is reviewed on an annual basis. This year Philippa Marks. Robert Pepper and Jean-Jacques Sahel stepped down from the Committee. We would like to thank Philippa, Robert and Jean-Jacques for their efforts and their contributions to OSAB. We are in the process of appointing their replacements. We also note that Mike Walker accepted a three-year extension to his current term of office.

Section 4

The future of mobile

3.1 In the last few years, mobile data traffic has grown at a rate of approximately 60% per year[2], enabled by: improving mobile delivery technology, the availability of more mobile spectrum, the availability of new applications and an increasing consumer adoption of smartphones. Today, two thirds of consumers now own a smartphone, making it the most popular way to access Internet.

3.2 This increasing growth in demand for mobile data capacity is set to continue driven by: an increased demand for existing mobile services such as video, the evolution of new mobile applications and new increased capacity mobile delivery technologies, including 5G and "next generation" WiFi.

Summary of OSAB discussions

3.3 In one session, OSAB discussed the mobile data forecast provided by Cisco for 2014 - 2019. In this, Cisco forecasted a nine-fold growth of the UK mobile traffic between 2014 and 2019 and the increased proportion of this traffic being related to mobile video, growing to a predicted 75% of total traffic by 2019. OSAB highlighted that this growth in demand for mobile data could have implications for the future amount and type mobile spectrum that needs to be made available, the evolution in mobile delivery technologies and networks, and the business models adopted by mobile operators. An important factor identified in the discussions was the need for new mechanisms to provide consumers with a flawless connection across different types of mobile connection platforms, including cellular and WiFi.

3.4 In another session, OSAB considered the potential need for new mobile delivery business models to support the growth in demand for mobile data capacity, universal service access and different mobile services. The OSAB discussions highlighted a potential need for new approaches towards maintaining competition in the mobile sector and achieving universal service coverage (e.g. minimum level of mobile coverage / speed delivered to every property in the UK).

3.5 An agile and flexible commercial approach emerged as being essential, otherwise operators would not be able to respond to evolving consumer demand in terms of diversity of services and consequential traffic volumes; and in a cost effective manner. To allow for both agility and flexibility, OSAB members highlighted that future networks

[2] Ofcom, "Update on our strategy for mobile spectrum", June 2016. Available online: http://stakeholders.ofcom.org.uk/consultations/mobile-data-strategy/update-strategy-mobile-spectrum/

and their architectures will need to make an increasing use of Software Defined Networks / Network Function Virtualisation[3] (SDN/NFV) technology.

3.6 OSAB also held a dedicated session on Ofcom's future approach to 5G spectrum. During this it was noted that Ofcom's objective should be to proactively provide the right spectrum enablers to support the timely future rollout of 5G services. The discussions focused on the potential 5G spectrum needed to provide more capacity and higher speed connectivity in towns and cities as well as the need to also support the rollout of 5G services in rural areas. OSAB members noted that it will be very important that the benefits of new technologies (including 5G) can reach everyone in the UK and that Ofcom should provide the right spectrum enablers and encourage innovation to achieve this.

Key points for Ofcom to consider

3.7 OSAB concluded that the current activities Ofcom has in place are well positioned to respond to and support: the increasing demand mobile data capacity, future changes in mobile delivery technology, the evolution of mobile service and new business models in the mobile ecosystem.

3.8 In particular, in relation to 5G, OSAB concluded that Ofcom should continue with its current approach, including:

a) Identifying and prioritising potentially suitable bands for 5G use,

b) Monitoring changes in: consumer demand, market and technology developments,

c) Taking a leading role in in international harmonisation discussions,

d) Taking action resolving coexistence issues, and

e) Awarding new frequency bands.

3.9 Moreover, OSAB highlighted that it is important for Ofcom to continue monitoring IoT and transport-related services in the context of 5G.

[3] Virtualisation is a technology which enables the use of a single physical 'piece or pieces' of hardware and make it operate as if it were multiple pieces. This improves asset utilisation and efficiency, and decreases costs by reducing the need amount of hardware. SDN-NFV exploits this technology to coalesce the software versions of different network elements and servers within a common hardware environment. SDN-NFV furnishes operators with business agility and operational flexibility, in addition to cost cutting.

Section 5

Sharing communications systems

4.1 Shared access to spectrum is likely to play an increasingly important role to serve the growing demand for radio spectrum access. Greater and more intense spectrum sharing is becoming possible because of more sophisticated technologies and new authorisation approaches.

4.2 In 2016 Ofcom established a framework in which to consider further spectrum sharing. The first band to be considered in this context is the 3.8 – 4.2 GHz band.

Summary of OSAB discussions

4.3 This year, OSAB discussed spectrum sharing in general and sharing in fixed networks at its July and October meetings respectively.

Spectrum sharing

4.4 OSAB is very supportive of new opportunities to make spectrum available for new users and uses through sharing with existing services. For example, OSAB views spectrum sharing by the UK Ministry of Defence and the recent publication of Ofcom's Spectrum Sharing Framework as positive developments.

4.5 A range of different factors will play an important role in supporting these opportunities and this change. For example, market mechanisms and technologies, such as databases controlling access to shared spectrum in real time, that are able to match demand and supply accurately will be key to some applications. The flexibility of those measures, e.g. to align to the geography of demand and supply, will often require very dynamic access frameworks.

4.6 OSAB also considered the importance of reviewing the impacts of new spectrum sharing in a broad sense and on a case-by-case basis. These impacts may vary from country to country and for a similar application. These reviews need to be mindful of widespread concerns amongst existing spectrum users regarding interference risks. These concerns extend to the impact on any new, innovative applications such as IoT. The reviews also need to take into consideration the characteristics of different parts of the radio spectrum; in particular, the extent to which different frequency bands are suited to spectrum sharing, delivering coverage over wide areas and ability to support

broadband services. Furthermore, reviews should also consider how best to provision spectrum, e.g. licensed, licence-exempt, white-space and/or cognitive[4].

4.7 OSAB highlighted that there is inevitably a reliance on devices behaving in accordance with the required standards. Ofcom reported seeing issues with 5GHz WLANs where Dynamic Frequency Selection (DFS) has been disabled, causing interference to weather radars. As increasing numbers of cognitive or adaptive devices try and use the same spectrum their compliance will be essential. Some of the challenges include assuring device compliance which can be difficult, time consuming and expensive to achieve. In addition, there is the potential for users to incorrectly configure devices or download different software that may radically change the devices' behaviour.

Sharing in fixed broadband networks

4.8 OSAB received a presentation on the subject of approaches to sharing in fixed broadband networks. There are three approaches: passive sharing, active sharing and joint venture. OSAB indicated that sharing fibre infrastructure can speed the deployment of Next Generation Access, making new collaboration business models viable.

4.9 A number of techniques for fixed infrastructure were discussed all of which can bring positive outcome for operators and ultimately the consumer. These include:

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[4] Spectrum may be provisioned in a number of ways including:

- **Licensed spectrum** means that to establish and use a wireless telegraphy station or install or use wireless telegraphy apparatus, a person must hold a licence. Licences specify such terms, provisions and limitations as Ofcom think fit but can include the position and nature of the station, the purpose for which, the circumstances in which and the persons by whom the station may be used. The limitations may include the strength or type of signal, the times of use and the sharing of frequencies; prohibitions on transmission or broadcasting.
- **Licence-exempt (LE) spectrum** means that a person does not need to hold a wireless telegraphy licence for equipment or apparatus where their use is not likely to involve any undue interference to other legitimate use of radio spectrum. As the spectrum is available to anyone using compliant equipment, licence exemption does not provide users with any form of protection from other users.
- **White space (WS) spectrum** refers to the range of unused frequencies that exist in certain locations and/or at particular times. WS spectrum can only be accessed by WS devices that respond to up-to-date information about the available WS spectrum. Such information is electronically accessed by WS devices from a common electronically held database.
- **Cognitive-accessible spectrum** refers to a range of frequencies over which self-sufficient / infrastructure-less wireless systems may operate in which either a network or a wireless node changes its transmission or reception parameters to communicate efficiently, thereby avoiding interference with licensed or unlicensed users. It is expected that such systems will make use of intelligent signal processing at the physical layer, to say the least, and are underpinned by software defined radio techniques.

- The use of a common management system to better interoperate existing networks and hence make more efficient use of existing infrastructure in meeting demand;

- Network slicing where the capacity of one physical network is logically dissected into multiple logical networks, and shared amongst different services (mobile, broadcast, connected-car, health, etc); and

- Leveraging time wavelength division multiplexing passive optical network (TWDM-PON) technology. This technology enables the partitioning of the raw fibre capacity into a number of intendent optical channels.

4.10 OSAB also focused on SDN/NFV: an area which has been receiving a great deal of attention by industry. SDN/NFV has been recognised as the contender for bringing the above points into one common framework. SDN/NFV is capable of enhancing both mobile and fixed infrastructure sharing by implementing and making the use of the data and control plans more flexible.

Key points for Ofcom to consider

4.11 As mentioned in the introduction, Ofcom is already working towards enabling further spectrum sharing.

4.12 In the context of the need to give additional attention to the provisioning of better availability of fixed and wireless mobile broadband services, OSAB invites Ofcom to consider the following when exploring spectrum sharing:

- How it can build on its experience of databased-controlled access to TV White Spaces to increase the extent of new sharing;

- The requirement to take a collaborative approach with government, policy makers in other countries, and market participants;

- The desirability of Ofcom taking a leading role in promoting spectrum sharing opportunities;

- Reconsider whether the risk appetite to allow potential ‘interference’ to some stakeholder groups’ services should be increased if it allows the deployment of important new services to a greater number of people; and

- Continue to monitor developments in the SDN/NFV and optical network technologies; and assess the potential impact on regulation.

Section 6

Internet of Things

5.1 The Internet of Things (IoT) will enable large numbers of previous unconnected devices to collect and share data. This has the potential to deliver significant benefits to citizens, consumers and businesses, including better healthcare management, safer transportation and more efficient use of energy and natural resources. Many organisations around the world are developing the technologies, standards and services that will make up the IoT, including many in the UK.

5.2 The IoT cuts across multiple industry sectors. For example, a smart city application might bring representatives from the building and transportation industries together with service providers, local policy makers and consumer groups. Underpinning these new applications is the need for pervasive, reliable and appropriately secure wireless networks. Given the important role that communications networks play, it is vital that Ofcom takes the necessary steps to ensure that there are no barriers to the emergence of the IoT.

Summary of OSAB discussions

5.3 OSAB periodically discusses IoT, tracking key developments and exploring the likely future size and nature of the market as it emerges. This year's discussion was stimulated by Professor Mischa Dohler's joining of OSAB.

5.4 Professor Dohler's presentation, entitled "Communication in the age of machines", started by noting parallels with personal communications. Spectrum for 3G and 4G services had been made available before the devices to use these technologies had been developed. Demand for mobile data only started to increase significantly after the emergence of a dominant technology design and of market developments which caught the public's imagination.

5.5 Similarly, the IoT has been in existence in some form since the 1990s, but had not been widely adopted as the technology and market were immature. There was a focus on developing technologies and connectivity platform that operated at very low power and short range. However, there was little focus on delivering technologies and connectivity platform solutions able to communicate over longer ranges.

5.6 More recently, technologies are beginning to emerge that have the potential to provide IoT connectivity also over a long range, including open and closed IoT platforms and standardised IoT platforms.

5.7 Moreover, the so-called 'tactile Internet' emerged that involves not just collecting and processing data from remote sensors, but being able to act upon that data in real time. This could facilitate applications such as remote surgery, in which surgeons are able

to operate on patients on the other side of the world while in much the same way as if they were in the same room. This requires new technologies that drastically reduce the time taken for data to travel across networks and new schemes to manage those networks.

5.8 One of the key challenges will be in seamlessly integrating different network technologies and improving reliability and availability to ensure that IoT is as robust as it can possibly be. A new way of thinking about network design is required, given significant lead times for technologies to appear on the market and industry needs to consider global deployment.

5.9 While industry and academics have a vital role to play in the development of the IoT, government and regulatory agencies should also be involved. This could involve playing a co-ordinating role in bringing together organisations from different sectors. The regulatory environment should also adapt, moving away from models based on human-to-human communication and exploring how best to approach the needs of the IoT.

5.10 The IoT may also drive the need for a more agile approach to making spectrum available to a wider range of service providers, including to new entrants or to organisations who only need spectrum for a limited period or in particular places.

Key points for Ofcom to consider

5.11 Over the past few yearsk, Ofcom has identified priority areas to help support the growth of the IoT. Ofcom has ongoing activities targeting different types of IoT applications, including short range and long range, transport and low latency applications.

5.12 Given the rapid on-going technology and market progress on IoT, OSAB pointed out that Ofcom should continue to review the IoT space, and investigate the market and technology trends that are emerging and the forecasts available for these trends. Emphasis could be focused on the different business and connectivity models that deliver services and applications such as Smart Cities.

5.13 Ofcom will incorporate in its future thinking some of the emergent points from OSAB discussion, which include:

- The challenges of multi-operator / multi-stakeholder network-of-networks environment and related future network architectures;
- The challenges of consumer privacy in such complex environment; and
- Spectrum provisioning to meet the requirement of diverse IoT applications and potential tactile Internet.

Glossary

3G, 4G, 5G	Third, fourth and fifth generations of mobile communication technology.
CAP	Content and Application Provider, e.g. Google, Facebook, Netflix, etc.
DFS	Dynamic Frequency Selection is a mechanism to allow unlicensed devices to use the 5 GHz frequency bands already allocated to radar systems without causing interference to those radars.
G-Fast	A copper-based digital communication technology, with speeds between 150Mbps and 1Gbps over distance up to 500m.
HVDC	High Voltage Direct Current is electric power transmission system that uses direct current for the bulk transmission of electrical power.
IoT	Internet of Things.
MoD	Ministry of Defence.
QAM	Quadrature Amplitude Modulation is a digital encoding scheme that achieves high bitrates.
RF	Radio Frequency.
SDN/NFV	Software-Defined Networks/Network Function Virtualisation.
VDSL	Very-high-bit-rate Digital Subscriber Line is a copper-based digital communication technology.

Annex 1

Ofcom Spectrum Advisory Board – Terms of Reference

A1.1 The Ofcom Spectrum Advisory Board is to provide independent, strategic advice to Ofcom, and where appropriate to Ministers, on matters that directly or indirectly have a bearing on policy issues to do with future communications architectures, access methods, physical layer technologies, spectrum, services and applications.

A1.2 In formulating its advice, OSAB is to consider the future communications landscape from technological, economic and societal perspectives, consonant with Ofcom's statutory duty to further the interests of citizens in relation to communications matters.

A1.3 In particular, OSAB is to advise on:

- Ofcom's spectrum strategy, major UK national allocation decisions, spectrum management, and the application of spectrum pricing/trading.
- Issues that are currently "beyond Ofcom's headlights" to which Ofcom should start to give attention.
- New communication technologies.
- New means of managing the radio spectrum and their implications for Ofcom.
- Whether Ofcom's current and developing policy stance is appropriate and where new policy might be needed.

A1.4 For example, topics that might be considered by the OSAB include:

- The extent to which future wireless and fixed communications infrastructure and services may be complementary or compete with one another.
- Novel technologies such as cognitive radio
- Ongoing initiatives such as digital TV switchover.
- Emerging uses of spectrum in areas such as transport and healthcare.
- Ways to measure and assess the effectiveness of spectrum management policies.
- The development of market-led initiatives such as SURs.
- The balance between licensed and licence-exempt spectrum.
- The stimulation of innovation through spectrum policy.

- Trends in international relations.

- Ways that spectrum policy could be used to further the interests of the citizen and consumer.

A1.5 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.

A1.6 With the support of Ofcom staff, reporting shall include an Annual Report, publication of key findings on the Ofcom or OSAB website and hosting occasional Open Forums.

A1.7 Members of OSAB 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 matters of strategic significance. Membership will include ex-officio representation by the Department of Culture, Media and Sport (DCMS) who will participate fully in discussions but reserve the right to abstain from agreement on substantive matters. Members will not receive remuneration other than reimbursement of expenses.

Annex 2

Membership of OSAB[5]

David Meyer (Chairman) [May 2018]

David Meyer served in the British Army's Royal Corps of Signals from 1979-2010, leaving as Brigadier and Deputy CIO. During his career he held positions delivering operational information systems and services; leading units responsible for policy, procurement, operations, signals intelligence and computer network defence; and serving overseas in Croatia, Bosnia, Kosovo, the Democratic Republic of Congo, Iraq and Afghanistan. David joined the Foreign and Commonwealth Office as Chief Information Officer in December 2010. He holds a Master's degree in International Studies and is a Fellow of the British Computer Society and a Chartered IT Professional.

Greg Bensberg [May 2017]

Gregory Bensberg is currently the General Manager of Digital UK Ltd, the UK's main commercial public service DTT multiplex carrying ITV and Channel 4 services to over 98% of UK households. He is a leading authority on both the technical and regulatory aspects of digital broadcasting and has over 30 years' experience as a regulator and digital broadcast engineer.

He has previously worked as a policy and technical expert for Ofcom, the UK government and the Independent Television Commission for over 20 years. He acted as a key technical and regulatory adviser to a number of Government Ministers between 2002 and 2003 whilst they were developing the UK government's switchover policy. He was also responsible for leading Ofcom's spectrum clearance programme (800 MHz and 2.6GHz) which enabled the UK's 4G spectrum auction in 2013.

He developed and led the planning and licensing of the UK's digital switchover programme (including its UHF spectrum strategy) and its adoption of the DVB-T2 standard and the launch of terrestrial HD services in 2009. He also led Ofcom's Digital Dividend Review project in 2005/06, which laid out the process and principles for the eventual European digital dividend programme.

Gregory is a chartered engineer and holds an MBA and BSc. He joined the ITC in 1992 after spells working for Marconi, the IBA, Quantel and Thames Television.

He was awarded an MBE in 2014 for services to communications and media.

[5] After each member is given the date that their appointments to OSAB expire.

Professor Linda Doyle [May 2018]

Linda Doyle is the Director of CONNECT and Professor of Engineering and the Arts in Trinity College, University of Dublin. CONNECT is a national research centre focused on future networks and communications and is co-funded by SFI and industry. CONNECT is headquartered in Trinity College and is spread over ten different academic institutions in Ireland. Prof Doyle is also the Director of CTVR – the research centre that was the precursor to CONNECT. Her expertise is in the fields of wireless communications, cognitive radio, reconfigurable networks, spectrum management and creative arts practices. She has raised over 70 million in research funding in the past decade and has published widely in her field. Prof. Doyle has a reputation as an advocate for change in spectrum management practices and has played a role in spectrum policy at the national and international level. Currently she is a member of the National Broadband Steering Committee in Ireland, and is a member of the Ofcom Spectrum Advisory Board in the UK. Prof. Doyle is on the advisory board of Wireless@KTH in Sweden. She is a Fellow of Trinity College Dublin. She is on the Board of the Festival of Curiosity -- a STEM outreach activity for children based on a city-centre yearly science festival. She is a judge in the BT Young Scientist, Ireland's premier science competition for school children. She is on the Boards of the Douglas Hyde Gallery and Pallas Studios. Prof. Doyle is a Director of Xcelerit and SRS, two CTVR/CONNECT spin-outs.

Mischa Dohler [May 2019]

Mischa Dohler is full Professor in Wireless Communications at King's College London, driving cross-disciplinary research and innovation in technology, sciences and arts. He is the Director of the Centre for Telecommunications Research, co-founder and member of the Board of Directors of the smart city pioneer Worldsensing, Fellow of the IEEE, Editor-in-Chief of the Transactions on Emerging Telecommunications Technologies and the EAI Transactions on the Internet of Things, and a Distinguished Member of Harvard Square Leaders Excellence.

He is a frequent keynote, panel and tutorial speaker, and has received numerous awards. He has pioneered several research fields, contributed to numerous wireless broadband, IoT/M2M and cyber security standards, holds a dozen patents, organized and chaired numerous conferences, has more than 200 publications, and authored several books. He has a citation h-index of 43.

He acts as policy, technology and entrepreneurship adviser, examples being Richard Branson's Carbon War Room, David Willetts' 8 Great Technology Fund, Regulator Ofcom, UK House of Parliament, UK Ministries, EPSRC ICT Strategy Advisory Team, European Commission, Tech London Advocate, ISO Smart City working group, and various start-ups

He is also an entrepreneur, composer & pianist, and fluent in 6 languages. He has talked at TEDx. He had coverage by national and international TV & radio, and his contributions have featured on BBC News and the Wall Street Journal.

David Harrison [ex-officio]

David is Director of Technology Strategy in Ofcom. He is responsible for leading Ofcom's technical research programme and supporting Ofcom policy development across a wide range of areas including: white space and cognitive radio, unlicensed Wi-Fi spectrum, radio switchover, network neutrality and next generation broadband access. David led the UHF

Strategy project, which sought to identify the how to best balance the competing demands for UHF spectrum by different services including terrestrial broadcasting and mobile broadband. He has also led work on new approaches to spectrum sharing to increase the future supply of spectrum for mobile broadband and machine to machine applications. More recently he has been working on the technical criteria needed to provide reliable mobile coverage.

Before joining Ofcom, David worked for the Independent Television Commission where he held the position of Deputy Director of Technology, and before that led the high frequency research and development activities in Thomson Multimedia based in Rennes.

David has published numerous technical papers on RF and high frequency engineering and holds 12 patents. David has a first class honours degree and PhD in Electrical and Electronic engineering. He can be contacted at david.mark.harrison@ofcom.org.uk.

David Hendon [ex-officio]

David Hendon is a senior advisor at Ofcom, working on spectrum, international strategy and network resilience issues. He is a member of the Smart Meters Strategic Reference Group and the Smart Meters Steering Group at the Department of Energy & Climate Change and a non-executive director of Multiple Access Communications Ltd and ContinuumBridge Ltd. He is independent Chairman of the 4G/TV Co-existence Oversight Board established by DCMS. He is a Visiting Professor and, Chairman of the Strategy Advisory Board of the 5G Innovation Centre at Surrey University, deputy-chairman of the Radio Communications Foundation and a member of the IET's Communications Sector Panel.

From 2002 to 2011, David was a Director in the Department for Business, Innovation & Skills where he was responsible for BIS's business-facing activities and policy in communications networks, internet, software and computer services, information and cyber security, electronics, digital content, media, publishing and postal sectors and, from 2010, the Office for Life Sciences. .He was previously Chief Executive of the Radiocommunications Agency, which managed UK radio spectrum prior to the establishment of Ofcom. His earlier career included appointments in the Ministry of Defence, the Home Office, Cabinet Office and the Department of Trade & Industry, all involving electronic communications. He was Chairman of the Board of the European Telecommunications Standards Institute from 1996 to 1999 and a council member of the Engineering and Physical Sciences Research Council from 2006 to 2009. He is a CBE and a Fellow of the Royal Academy of Engineering.

Phillipa Marks [May 2016]

Phillipa Marks is a Director of Plum Consulting. She is an international expert in economic, regulatory and policy analysis of spectrum management issues and has advised operators, regulators and governments in Europe, Asia-Pacific, Middle East and North America on a wide range of spectrum management issues. She also advises on public policy and regulatory issues in the media and telecommunications industries. 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. She is a member of the Irish Electronic Communications Expert Advisory Panel.

Niall Murphy [May 2017]

A technologist, serial entrepreneur and angel investor, Niall co-founded pan European WiFi network The Cloud in 2003, acquired by Niall is founder and CEO of Internet of Things software company EVRYTHNG. A computer scientist by training, Niall has a background in Internet infrastructure and software services, and was founder of one of the first Internet service providers in Africa in the mid-1990s, acquired by UUnet in 1998. He contributed as a policy adviser on telecoms in South Africa in the early 90s through an African National Congress (ANC) think tank. He has co-authored patents and standards submissions, including a the WiFi roaming framework adopted by the IETF.

Robert Pepper [May 2016]

Robert Pepper leads Cisco's Global Technology Policy team in areas such as broadband, IP enabled services, wireless, security, privacy and ICT development. He joined Cisco in 2005 from the FCC where he served as Chief of the Office of Plans and Policy and Chief of Policy Development beginning in 1989 where he focused on telecommunications regulation, spectrum policy, and policies promoting the development of the Internet. Before joining government, he held faculty appointments at the Universities of Pennsylvania, Iowa and Indiana, and was a research affiliate at Harvard University. He serves on the board of directors of the U.S. Telecommunications Training Institute (USTTI), advisory boards for Columbia University and Michigan State University, and is a Communications Program Fellow at the Aspen Institute. He is a member of the U.S. Department of Commerce's Spectrum Management Advisory Committee and the U.S. Department of State's Advisory Committee on International Communications and Information Policy. Pepper received his BA. and Ph.D. from the University of Wisconsin-Madison.

Jean-Jacques Sahel [May 2016]

Jean-Jacques is currently Vice-President, Europe (Global Stakeholder Engagement), at ICANN. Jean-Jacques is a strong advocate for the open Internet and multi-stakeholder model of Internet governance, in Europe and beyond. For over 15 years in both the private and government sectors, Jean-Jacques has been involved in international government and regulatory affairs. Before joining ICANN in 2014, Jean-Jacques headed government and regulatory affairs for Skype, then digital policy at Microsoft for Europe, Middle-East & Africa regions.

Jean-Jacques was the UK signatory of the 2006 UN ITU Convention and Constitution and has chaired the UK Chapter of the International Institute of Communications since 2009.

Mike Walker [May 2016]

Mike is a telecommunications consultant. Until his retirement in September 2009, Mike was the Group Research and Development Director for the Vodafone Group of companies, with the responsibility for the Group's research activities, intellectual property and technology standards worldwide. He is a Vodafone Fellow and an Executive Technical Advisor to

Vodafone. He is a member of the Board of the European Telecommunications Standards Institute, having been chairman for the 2008-2011 Board period. Mike is a non-executive director of Avanti and is a Trustee of the Alacrity Foundation. He holds the Vodafone Chair in Telecommunications at Royal Holloway, University of London. He is a Fellow of the Wireless World Research Forum. Mike is a Fellow of the Royal Academy of Engineering, and until June 2011 served as a member of Council of the Academy. He was the President of the Institute of Mathematics and its Applications for the Presidential term 2010-2011. He was awarded an Honorary Doctorate of Technology from the University of Plymouth in 2011. He was appointed an OBE in June 2009 for his services to the telecommunications industry.

Gavin Young [May 2018]

Gavin's current role is as Head of the Fixed Access Centre of Excellence within Vodafone. He is responsible within Vodafone Group for the fixed broadband access strategy, architecture and deployment practises across the 17 countries where Vodafone currently has fixed access assets.

Gavin was previously Head of Strategy & Planning in Cable and Wireless Worldwide leading a team of architects responsible for the technology architecture and strategy. He had previously worked at Bulldog Communications (later acquired by C&W Worldwide) where he held a variety of responsibilities from product development through to the network operations and CTO. Prior to that Gavin led the Access Architecture & Design team at BT.

Gavin was a founding director of the Broadband Forum where he was overall Technical Chairman for twelve years. In addition, he has been co-chair of the UK21CN consultation's Broadband Group, chair of the UK NICC's DSL Task Group and also vice-chair of the NICC Ethernet Access Task Group. Gavin also serves on the IET Communications Policy Panel and the Ofcom Spectrum Advisory Board (OSAB).