Ofcom Spectrum Advisory Board

Annual Report 2021 - 2022

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Foreword from OSAB Chair

It is with great pleasure that I take over as the Chair of OSAB. I have been a member of the committee for a number of years and truly appreciate the trusted advisor role that Ofcom affords OSAB for insight on long-term technical and market issues related to spectrum.

I would like to acknowledge the work of my predecessor Professor Linda Doyle for her service to OSAB over the past years, both as active contributor and chair. Linda is an expert at thinking outside the box and asking the "what if …" questions that pushed the boundaries and ensured that OSAB never fell into the trap of "group think". We are full of admiration for Linda's historic achievement in being appointed Provost of Trinity College Dublin, the first woman to ever hold this role in the University's 429-year history. The only regret is that as a result of this appointment Linda has had to step down from OSAB. We wish Linda success in her new role.

In this last year, OSAB has offered insight and advice to Ofcom on several issues which have predominantly been related to looking beyond 5G, spectrum demand, strategy, roadmap and compliance

The Covid pandemic and resulting changes in how and where many people work has increased the criticality of communications technology in the public consciousness. Spectrum plays a crucial role in this connectivity, whether it is for work, entertainment or social interaction. Consequently, there continues to be a growing list of key issues for OSAB and Ofcom to explore in terms of implications for the UK communications market. I am grateful to all OSAB members and Ofcom attendees for their active engagement, diverse knowledge and wisdom and look forward to exploring new areas over the coming year.

OSAB meetings are attended by senior members of Ofcom who actively participate in our debates. I am thankful for the presence and support at OSAB meetings of Philip Marnick, who in January 2022 stepped down as Group Director of Ofcom's Spectrum Policy group, and also want to acknowledge the support and continuity provided to OSAB by Helen Hearn in her interim Group Director role. We are looking forward to equally engaging and illuminating debates with new spectrum Group Director, David Willis, upon his arrival.

Gavin Young

Foreword from Spectrum Group Director

The Ofcom Spectrum Advisory Board (OSAB) has, since its establishment, provided invaluable advice to Ofcom on all Spectrum matters. This has predominantly been as part of its role of advising on issues that are currently "beyond Ofcom's headlights", but OSAB has also acted to broaden the understanding and insight of members of Ofcom. OSAB regularly provides insightful and wide-ranging perspectives, influencing Ofcom's work, from informing policy projects to suggesting topics for longer-term study.

A lot has changed since the publication of the 2017-2018 Annual OSAB Report. The Covid-19 pandemic emphasised the importance of reliable, secure connections as the majority of the country became reliant on digital means of communication overnight, consumers now have access to 5G mobile technology, improvements in AI and Machine to Machine learning are clearly visible and could potentially impact spectrum management approaches and we are now seeing millions of devices connected to the Internet of Things. As a result of these developments, an ever-increasing number of consumers and businesses have access to spectrum for a wide variety of needs. We have recently published our Plan of Work 2022/23 setting out Ofcom's areas of focus this coming year to make communications work for people and businesses across the UK, including investment in strong, secure networks and enabling wireless services in the broader economy. The areas of work are often decided with the support of expert advice from committees such as OSAB.

This past year has also been a time of transition internally, following the departure of Philip Marnick, a strong supporter of the work OSAB does in advising and supporting Ofcom's policy work, I have been leading the Spectrum Group on an interim basis prior to the arrival of David Willis as our new group director and throughout this time, I have experienced the integral work OSAB does and truly value the insight and advice that the highly experienced members of OSAB bring to our policy discussions.

Helen Hearn

1. Overview

Background

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

a) A rapid way to test new ideas across a wide range of experts;

b) A means to identifying issues that are beyond Ofcom's regulatory "highlights"; and

c) A demonstration of Ofcom's commitment to consult in an open and collaborative manner

Covid-19 and Organisational Updates

1.2 Since March 2020, Ofcom have been conducting all OSAB meetings virtually due to the Coronavirus pandemic. This change in functioning has evolved the nature of Ofcom Spectrum Advisory Board (OSAB) meetings, with the duration of meetings including the annual 'deep dive' workshop condensed, to reflect the nature of online working. This revised format has translated into two main segments per meeting, covering either an individual topic or providing the board with opportunity for a round-the-table exchange of views.

1.3 A new OSAB chair, Gavin Young, was appointed at the end of 2021. Gavin follows on from Linda Doyle, who held the post from 2018-2021. OSAB wish to thank Linda Doyle for her stewardship of the group during this period. A listing of the current OSAB members is included in Appendix 2 of the Annex for reference.

Annual Report

1.4 This document reports on OSAB 2021-2022 activity. It is intended to provide high-level highlights of discussions throughout the year and its content is based on minutes taken during the quarterly OSAB meetings.

1.5 In this document, we will also provide an updated view of recent, related Ofcom publications. These will be clearly signposted.

Work Programme for 2021-2022

1.6 OSAB is responsible for agreeing its own work programme. During 2021-2022, the discussions were primarily focused on the following topics:

a) Beyond 5G evolution

b) Future Mobile Spectrum Demand

c) Spectrum Management Strategy and Roadmap

d) Spectrum Compliance

1.7 Other relevant topics were also considered in 2021, such as Software Defined Radio Receivers

1.8 OSAB's membership spans a wide range of sectors and members' observations form an important part of the session. Round-the-table exchanges around developments in their sectors provide for a useful interplay of ideas and insights, including perspectives from manufacturing, operational, academic, and economic sectors.

Future Meetings

1.9 OSAB sets its agenda from meeting to meeting depending on progress made in particular areas, time available and prominent topics arising. It deliberately does not plan a year ahead to allow for flexibility and responsiveness to development(s) in the telecommunications sector.

1.10 Recognising the flexibility that remote meetings have provided, whilst also understanding the significant benefits of in-person discussions, going forward Ofcom and OSAB are considering a mixture of hosting arrangements.

2. Highlights from OSAB Discussions

Beyond 5G Evolution

2.1 OSAB held a number of discussions around the future of mobile and its implications for spectrum:

a) The annual "deep dive" workshop in 2021 was used to explore the potential spectrum implications of emerging 6G technologies;

b) Future mobile spectrum demand

c) Beyond 100 GHz

6G Workshop

2.2 The workshop was intended to provide OSAB members with an opportunity to consider the potential implications of 6G for future spectrum demand and management. To provide context and stimulate debate, Ofcom invited three speakers to give presentations on themes encompassing the 6G vision and what the UK needs to do to be considered a leader in innovation, emerging technologies, spectrum access and sustainability.

The 6G Vision and Spectrum

2.3 Regius Professor Rahim Tafazolli (University of Surrey, 5GIC, 6GIC) gave a presentation on the emerging vision from industry and academia for 6G. In the presentation, Prof. Tafazolli outlined state of the art thinking on how 6G was expected to move beyond communication to enable integrated communication and sensing, a fusion of the virtual and physical worlds and high accuracy time and geolocation. In spectrum terms, higher frequency bands (such as higher mmWave and sub-Terahertz bands) and mid-band spectrum should be considered; reconfigurable reflecting surfaces could support coverage. Prof. Tafazolli concluded by summarising views on how the UK could take a leading role in 6G innovation, including identification of 6G frequency bands and a combined approach to standardising cellular, short-range, wide-area and satellite systems for an integrated 6G 3D network.

Emerging Technologies

2.4 Following the recent publication of its Technology Futures report, Ofcom gave a presentation on future networks and potential disruptive technologies for enabling 6G that would require a change at the architecture and component level. He focused on four technology developments: (i) new enablers at the component level, such as reflective surfaces and new types of MIMO; (ii) AI-Native wireless applications; (iii) joint communication, positioning, and sensing and joint communication and radar; and (iv) changing network topologies.

An International Perspective on Spectrum Access and Sustainability in the Context of 6G

2.5 Dr Maria Matinmikko-Blue (6G Flagship, University of Oulu) provided an international perspective on 6G, including consideration of what role spectrum access and sustainability might play in future service provision. In this she outlined how 6G will merge communication and other applications and could contribute to achieving the UN Sustainable Development Goals (SDGs). Dr Matinmikko-Blue noted there was fierce competition for spectrum, but also international fragmentation in spectrum management approaches adopted for 5G spectrum, which might continue and hinder full realisation of the benefits of 6G. Finally, Dr Matinmikko-Blue noted the emergence of some local mobile communication networks and the importance of spectrum sharing for making spectrum available locally.

OSAB Discussion

2.6 OSAB members held a wide-ranging debate on the potential impacts of different aspects of 6G, noting that there was not yet a settled vision. In particular, it was not yet clear whether 6G would be a new mobile generation or a broader change in the wireless environment. The Board noted the importance of facilitating innovation and the scope for out of the box thinking about spectrum allocation and management approaches, particularly in view of the rapid pace of technological change and mobile spectrum becoming a tool for delivering a wider range of services.

2.7 The Board considered that early thought should be given to the potential spectrum management implications of new technologies and the operational requirements of 6G networks, such as intelligent reflective surfaces. New technologies and hybrid architectures offered new opportunities and challenges and raised questions over the terms of spectrum authorisations. For example, networks were looking beyond traditional, terrestrial means of obtaining coverage. OSAB members discussed the potential of mega-constellation satellites to move beyond backhaul links to terrestrial networks and expect direct satellite-to-phone links. Further, AI-native technologies, such as autoencoders and neural networks were good at adapting to specific cases of local propagation, jamming, and at sharing spectrum, however it was highlighted that the emergence of new network architectures could lead to different trade-offs between edge-intelligent and cloud-based networks.

2.8 Members noted the importance of re-farming existing mobile spectrum to support 6G. In their view any 6G new spectrum requirements should be derived from specific use cases, for example resolution or latency requirements. Facilitating spectrum sharing would be important, with scope for technology standards bodies to play an important role.

2.9 Members discussed the idea of formally incorporating issues such as the UN SDGs and climate change into how spectrum decisions are made in the future, noting that this was not currently include in Ofcom's duties, recognising the need for 6G to play a key role in reaching these goals. Potential 6G applications could help to meet the basic needs that remain around coverage and reliability in the developing world, however possible

applications went beyond communication and could provide services that monitor environmental changes, ensure coverage of Internet of Things (IoT) services, and increase the availability of public mobile services.

Future Mobile Spectrum Demand

2.10 Ofcom gave a presentation which set out its approach to assessing the potential for demand for additional mobile spectrum to arise in the period to 2035. The presentation outlined key trends which might drive growth in demand for mobile services, and potential spectrum implications, taking account of consumer and business demand, potential technological evolution of networks and other wireless technologies.

2.11 The Board noted that there was a broad range of potential future sources of demand for mobile connectivity, across consumers, industry and the public sector. New applications and devices and other requirements such as edge computing could require very high bandwidths for mobile connectivity, which would be likely to require higher frequency spectrum.

2.12 At the same time, there was not always a clear demarcation between mobile and other wireless technologies, for example many consumers currently shifted between mobile and Wi-Fi technology when using their mobile phone, depending on their location and the available quality of service. Fixed broadband-based connectivity solutions such as Wi-Fi were often useful in indoor settings. Board members noted that technologies using spectrum under licence-exemption, such as Bluetooth and Wi-Fi, had proved very effective. An important question going forward would be the relative growth in demand for licensed and licence-exempt spectrum, and the optimal balance between the two.

2.13 Looking ahead, Board members noted the expected increase in data traffic drive by machines, and that these might be reliant on public networks, private networks or a combination of the two.

Ofcom Discussion Paper: Meeting Future Demand for Mobile Data

In February 2022, Ofcom published a discussion paper setting out our initial thinking on future demand for mobile services and how mobile networks may need to evolve to meet that demand. There are number of ways in which they might do this including:

- More extensive deployment of existing spectrum holdings and planned future spectrum for mobile, e.g., in the millimetre wave (mmWave) bands;
- Using technology upgrades to increase efficiency of the spectrum they use; and
- Network densification – deploying more cell sites – in particular, using small cells to leverage the capacity offered by the large bandwidths available from mmWave spectrum.

The discussion paper can be found here.

We will take stakeholder inputs into account as we develop our future strategy for mobile spectrum. We plan to set out our conclusions later in 2022.

Beyond 100 GHz

2.14 A presentation was given by Ofcom which set out early views on Ofcom plans to further develop usage in the range of 100 GHz and above. It was note that in October 2020, Ofcom released specific bands between 100 and 200 GHz, under a light licensing framework, for new and innovative purposes. The presentation highlighted that Ofcom are internationally engaged to champion innovation in the 100-200 GHz frequency range, rather than 'stale claiming', noting the importance of co-existence and harmonisation in this range.

2.15 Discussions centred around Ofcom's plans and what implications they would have for spectrum management. The Board queried whether Ofcom would, or should, require additional powers in this regard; to ensure that existing users are protected from potential interference and to manage the use of spectrum in this range more efficiently.

2.16 Board members highlighted the complexity of analysis in the 100-200 GHz range, consideration of the physical characteristics of deep space, weather, and climate change is necessary.

2.17 Under ITU Radio Regulations, there are certain bands in this range that are allocated to Earth Exploration Satellite Services (EESS), which are protected from potential interference and due to physics, are unalterable. Reflecting on this, the Board noted the importance of continued engagement on coexistence with EESS passive bands as upper frequency ranges are developed.

2.18 Board members discussed channel models in these upper frequency ranges, noting that they are not currently sufficient, or accurate enough for allocations. Board members

emphasised the importance of tracking further developments in this area to evolve efficient mechanism for allocating spectrum for new uses.

2.19 The discussion also touched upon the limits of past, and current, technology and how this has shifted to use of higher frequencies over the years. Board members noted that in the past, previous generations of technology considered that anything above 6 GHz was impossible. Noting how far we have come, the Board agreed that 100 GHz and above opens new opportunities and stated that success will be reliant on coefficient mechanisms that can correlate to the rate of technology development.

Ofcom Discussion Paper: Unlocking the Potential of the Terahertz Spectrum

Advances in the use of wireless services continue at pace – and that means ever growing demand for the invisible electromagnetic spectrum that carries signals and data from place to place.

New technology is now being developed which has the potential to open up spectrum at extremely high frequencies – the Terahertz spectrum. In December 2021, we published a discussion document aiming to start a dialogue on how to ensure this spectrum is managed in the best way possible, to support both existing and innovative new uses.

In the document, we share our current understanding of the potential uses for Terahertz spectrum, the challenges we think need to be overcome to fully unlock its potential, and why we think spectrum sharing is key. This document can be found here.

Spectrum Management Strategy and Roadmap

2.20 Ofcom gave a presentation to the Board on the Spectrum Management Strategy for the next decade. OSAB members had previously contributed to early discussions on this topic in the January 2020 workshop and this presentation was to provide them with an overall view of the strategy, focusing on the practicalities of decisions made. Highlights included spectrum for pioneers, industry engagement and spectrum sharing proposals.

2.21 Whilst supporting innovative uses of spectrum, Ofcom recognises the importance placed on the benefits to the UK of existing services that rely on spectrum. In the Spectrum Management Strategy, Ofcom set out potential ideas to support sharing, including 'good neighbour' behaviour such as improving equipment and limiting transmission emissions to prevent interference for other users. OSAB members asked whether transition bands, instead of the established guard bands, could be used to allow more flexibility and encourage spectrum sharing amongst existing, and new, users.

2.22 In the strategy, receiver parameters are identified as an area for improvement. Traditionally, the focus has been on transmitters and receiver performance has been an area largely underdeveloped. As part of our strategy to increase resilience to interference and ensure better conditions for spectrum sharing, Board members agreed that this was an important area for improvement. Discussions focused on potential tools that could be used

in terms of pricing and incentives, the latter being highlighted as a key factor for widespread adoption and to enact effective change.

2.23 Board members highlighted their interest in Ofcom's "spectrum for pioneers" proposal, which would make more spectrum available for innovative uses before its long-term future use is decided. The Board highlighted that this could potentially foster an environment for innovation and growth in various sectors.

2.24 Considerations around innovation led to a discussion about Ofcom could develop awareness in less spectrum-focused industries, with the aim of soliciting responses from a wider range of stakeholders in order to elicit different and useful perspectives. Board members made several suggestions on how this could be achieved, including liaising with scientific advisors from various government departments and reaching out through several routes. Ofcom highlighted the commitment to this work as more sectors become digitised.

Ofcom Publication: Spectrum Management Strategy

In July 2021, we published our Spectrum Management Strategy for the 2020s, detailing how we can support the UK's Wireless Future.

In the document, we have identified three areas of increased focus to help us achieve our spectrum management vision to enable growth and innovation.

- **Supporting wireless innovation:** Making it even easier for a broad range of users to access spectrum by making more spectrum available for innovation before its long-term future use is certain, working to support innovation in new wireless technologies, including by influencing international standards and technical conditions so they are flexible enough to support new uses, and expanding our work to understand, assist and inform the broad range of organisations who may benefit from wireless technologies in the future.

- **Licensing to fit local and national services:** Supporting the growing diversity of wireless services and providers by considering further options for localised spectrum access when authorising new spectrum use. Local access can suit a range of businesses and specialised services at sites like factories, airports and remote farms, which do not need to use spectrum across the whole UK. Licences for larger areas, including national licences, can support wide coverage for public mobile services.

- **Promoting spectrum sharing:** Encouraging users to share access to spectrum with others. As innovation stimulates greater demand for limited spectrum resource, spectrum sharing becomes even more important. Alongside our flexible authorisation options, technology can help by providing new sharing tools and by creating the opportunity for a fresh approach to sharing in higher frequencies.

Ofcom Publication: Spectrum Roadmap

In the Spectrum Roadmap we outline the work we are planning to deliver on our Spectrum Management Strategy, published in July 2021, both through our current projects (as outlined in the Plan of Work 2022/23) and proposed future areas of work. Our future areas of work it under three broad themes:

- Network evolution and convergence
- Accelerating innovation and sharing with spectrum sandboxes
- Better data for spectrum management

These activities will provide the data, market insight and operational capabilities we will need to prepare us for the coming decade and inform future policy. This document sets out some of the key market and technological trends that Ofcom will need to consider in planning our future work. We also outline the challenges and opportunities these may present for our spectrum management work.

The document can be found here.

Spectrum Compliance

2.25 The annual “deep dive” workshop at the beginning of 2022 focused on Spectrum Compliance activities. As part of this workshop, two presentations were given by Ofcom colleagues on regulating the sale of radio and electrical equipment in the UK and providing a compliance view of spectrum interference.

2.26 Part of Ofcom’s statutory duty is to protect and managed the radio spectrum; regulating the sale of radio and electrical equipment plays a key part of this. Ofcom works alongside the relevant authorities to ensure that equipment in the UK meets technical and compliance standards. The presentation noted that non-compliant equipment presents a risk to the spectrum as it can cause high levels of interference.

2.27 It was highlighted that the biggest challenges in this area are high profile sales platforms, who will cooperate with Ofcom but negate responsibility, and organisations that operate outside of UK jurisdiction.

2.28 OSAB members discussed potential solutions to overcome these challenges, noting the importance of sales platforms taking on more responsibility and ensuring that individuals and companies have access to adequate information and help to obtain conformance declarations. Members posed questions around the use of AI databases to spot counterfeit material, however it was noted that the biggest issue remains non-compliant, rather than counterfeit, equipment.

2.29 The second presentation focused on interference and the work Ofcom does to monitor, and respond to cases of, interference. The presentation noted that some of the main causes of interference include:

a) Faulty and/or sub-standard apparatus or radio equipment;

b) Deliberate interference (jammers); and

c) Unauthorised use of radio equipment

2.30 The presenter talked about jamming devices, noting that unauthorised jamming is a criminal offence in the UK, with the activity only allowed in certain legislated circumstances. Board members discussed possible future activities to prevent unauthorised jamming to protect the radio spectrum, exploring ideas such as audits for jamming and noise floor levels, potential legislation and looking further at receiver performance.

A1. OSAB Terms of Reference

Roles and Responsibilities

A1.1 Section 3 of the Communications Act, 2003 requires Ofcom to secure optimal use of the radio spectrum taking account of the different needs and interests of all users.

A1.2 The Ofcom Spectrum Advisory Board was established by Ofcom on 19 May 2004 and is a continuation of a group originally established by the Government in the 1990s to advise on wireless and which transferred to Ofcom with the Radiocommunications Agency.

A1.3 The role of OSAB is to provide independent, strategic advice to Ofcom on matters that directly, or indirectly, have a bearing on policy issues to do with future communications architectures; access methods; physical layer technologies; and spectrum services and applications. This provision of independent strategic advice will help Ofcom to carry out its remit.

A1.4 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.

A1.5 In particular, OSAB is to advise on:

a) Ofcom's spectrum strategy, major UK national allocation decisions, spectrum management, and the application of spectrum pricing and trading

b) Issues that are currently "beyond Ofcom's headlights", to which Ofcom should start to give attention

c) New communication technologies

d) New means of managing the radio spectrum and their implications for Ofcom

e) Whether Ofcom's current and developing policy stance is appropriate and where new policy might be needed

A1.6 The OSAB may also be asked to advise on:

a) The extent to which future wireless and fixed communications infrastructure and services may be complementary or compete with one another

b) New and novel technologies

c) Emerging uses of spectrum in various sectors, for example, transport, healthcare and scientific research

d) Ways to measure and assess the effectiveness of spectrum management policies

e) The development of market-led initiatives

f) The balance between licence and licence exempt spectrum

g) The stimulation of innovation through spectrum policy

h) Trends in international relations

i) Ways that spectrum policy could be used to further the interests of the citizen and the consumer

Membership

A1.7 Members of OSAB should be drawn from a mix of commercial, academic and consulting backgrounds, in order to address topics in a multidisciplinary manner, and to advise Ofcom on matters of strategic significance in such areas as future communications architectures, access methods, physical layer technologies, spectrum, services and applications. Membership of OSAB will include ex-officio members from Her Majesty's Government and relevant experts who work for Ofcom; such ex-officio members participate fully in discussions but reserve the right to abstain from agreement on substantive matters. Members will not receive renumeration other than reimbursement of expenses. All members shall be appointed by Ofcom, following the advice of the Group Director of Spectrum. The Group Director of Spectrum also seeks the approval of the Ofcom CEO for the appointments.

A1.8 OSAB shall have a quorum of 6 members, one of whom must be the Group Director, Spectrum Group or their designated Alternate and excluding ex-officio members. Members attendance through telephone or video link is acceptable for the purposes of determining a quorum.

Conduct of Meetings

A1.9 An independent member (not an employee of Ofcom) will be appointed by Ofcom to chair OSAB meetings.

A1.10 OSAB shall meet quarterly. Ad-hoc meetings of OSAB can be arranged if necessary, with the agreement of the Chair.

A1.11 Where the Chair of OSAB considers it appropriate, matters may be considered in between meetings by email.

A1.12 Papers shall be circulated at least 3 working days before each OSAB meeting. Extensions to this will be on an exceptional basis and must be agreed by the Chair.

A1.13 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 by members of potential Ofcom policies.

A1.14 Persons other than Members are permitted to attend meetings for particular items if the Chair of OSAB agrees.

A1.15 OSAB meetings will be supported by a Meeting Secretary and minutes and an action log will be prepared after each meeting.

A1.16 The Terms of Reference shall be reviewed periodically, as and when required by Ofcom. Any amendments shall be approved by the Ofcom Chief Executive, usually via the Ofcom Policy Management Board (PMB).

A2. OSAB Membership

External Members

Gavin Young (Chair)

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 counties where Vodafone currently has fixed access assets.

Gavin was previously Head of Strategy and planning in Cable & 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 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, the Ofcom Spectrum Advisory Board (OSAB) and the Broadband Forum's executive advisory board. Gavin is a member of the IEEE, Fellow of the IET and Distinguished Fellow of the Broadband Forum.

Professor Mischa Dohler

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 a Fellow of the IEE, the Royal Academy of Engineering, the Royal Society of Arts (RSA), the Institution of Engineering and Technology (IET); and a Distinguished Member of Harvard Square Leaders Excellence. He is a serial entrepreneur; composer and pianist with five albums on Spotify/iTunes; and fluent in six languages. He acts as policy advisor on issues related to digital, skills and education. He has had coverage by national and international press and media.

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, organised and chaired numerous conferences, was the Editor-in-Chief of two journals, has more than 200 highly-cited publications, and authored several books.

He was the Director of the Centre for Telecommunications Research at King's from 2014-2018. He is the co-founder of the Smart Cities pioneering company Worldsensing, where he was CTO from 2008-2014. He also worked as a Senior Researcher at Orange/France Telecom from 2005-2008.

Greg Bensberg

Gregory Bensberg is the Managing Director of Digital 3&4 Limited, the UK's main commercial public service DTT multiplex, carry 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 is also the chair of the 5G Media Action Group's regulatory, spectrum and policy group.

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 the UK government during the development of the UK government's switchover policy. He was also responsible for leading Ofcom's spectrum clearance programme (800 MHz and 2.6 GHz) which enabled the UK's 4G spectrum auction in 2013 and the development of the UK's UHF strategy.

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.

Niall Murphy

Niall is CEO and Co-Founder of EVRYTHNG, a pioneer of the Internet of Things managing billions of digital identities on the web for consumer products and organising the world's ecosystem of product lifecycle data. EVRYTHNG is a World Economic Forum Global Innovator. A computer scientist by training, Niall is a technologist, serial-entrepreneur, and angel investor. With 25 years of experience in innovation and future thinking, Niall has built pioneering businesses in internet infrastructure, the mobile internet and web services in Europe, the US and Africa.

Wassim Chourbaji

Wassim Chourbaji is Qualcomm's Senior Vice President and Head of Government Affairs for Europe, the Middle East and Africa. He oversees Qualcomm's public policy, regulatory affairs and senior government relations in the region. Mr Chourbaji leads a senior team dealing with innovation, 5G, intellectual property, digital economy, spectrum, standardisation, data protection and anti-trust policy. Mr Chourbaji studied engineering and mathematics.

Peter Pitsch

Peter Pitsch currently consults for the C-Band Alliance. Peter Pitsch was Associate General Counsel at Intel Corporation, specialising in communications policy matters. Peter was Chief of Staff to the Chairman of the FCC from 1987 to 1989 and Chief of Office of Plans and Policy from 1981 to 1987. From 1980-1981, Peter was a staff member of the Reagan Administration Transition Team.

Peter received a B.A. in Economics from the University of Chicago in 1973 and his J.D. from Georgetown University Law Centre in 1976.

Rosalind Singleton

Rosalind Singleton is a CEO, board chair, NED, advisor and investor with over 30 years of experience in the technology sector. She is the CEO of Spring Fibre, an FTTH start up and the Chair of the UK5G Advisory Board. UK5G is the national innovation network dedicated to the promotion of research, collaboration and the commercial application of 5G in the UK, providing advice to and working closely with the Department for Digital, Cultural, Media and Sport (DCMS).

For the last five years Rosalind has been an active angel investor and mentor and has led several deals, focussing on tech businesses with a female founder. She is a member of the Angel Academe Advisory Board.

Rosalind joined UK Broadband in 2013 and was Managing Director from 2017 until it integrated into its parent company in 2019 following its delivery of the ThreeBroadband 5G launch network. She has previously held senior roles at BT Openreach, Cable and Wireless, Vodafone, various VNOs, and other international operators from start-ups to incumbents.

Rosalind is a member of the UK Government's Telecoms Supply Chain Diversification Advisory Council and Ofcom's Spectrum Advisory Board. She is an Independent NED on the board of Alphawave IP Group PLC, a silicon IP business providing high speed connectivity solutions for global large an hyperscale customers.

Peter Hadinger

Peter Hadinger is the Chief Technology Officer at Inmarsat. Peter and his high calibre engineering team are developing next generation technologies and satellite infrastructure that will enable innovative connectivity services and solutions across land, sea and in the air. These services and solutions sustain operational, safety and mission critical applications for businesses and governments across the world.

After joining Inmarsat in 2011 to help develop the market-leading Global Xpress programme, Peter became President of the business unit responsible for US Government sales and programmes at Inmarsat and subsequently became CTO in late 2017. Prior to joining Inmarsat, Peter spent 30 years as a leader in technology development, engineering and government spacecraft programmes at Northrop Grumman. He holds multiple patents in advanced communications technology and systems.

He also has a diverse regulatory and policy background, having successfully led industry efforts in the World Trade Organisation (WTO) Telecom Services Agreement, the Federal Communications Commission (FCC) World Radio Conference Advisory Committee, the President's National Security Telecommunications Advisory Committee, plus a one-year fellowship in the United States Senate.

Peter received his Bachelor of Science in Electrical and Electronic Engineering from California State Polytechnic University, an MBA with emphasis in finance strategic planning from George Mason

University and serves on engineering advisory boards at Virginia Tech. He was inducted into the Cal Poly Pomona Engineering Hall of Fame in 2014.

Alastair Macpherson

Alastair Macpherson was the partner leading PWC's economic practice and specialising in the communication and other regulated sectors. He has advised numerous operators, regulators, and governments around the globe. A major part of his interest and work has focused on the debate defining the appropriate form of regulatory intervention in the case of market failure in the communications and technology sectors in the face for technology change. He also advises clients in other regulated sectors including posts, health, and water. Alastair has acted as an expert in regulatory, competition and arbitration proceedings including the UK Competition Commission, Competition Appeals Tribunal, European Commission DG Competition and the London Court of International Arbitration.

Prior to joining PWC, Alastair worked at BT PLC where he held various roles in corporate finance, new businesses and regulatory affairs.

David Meyer

David is a former central government Chief Information Officer and was previously a senior army officer in the Royal Corps of Signals. In the course of his career he has worked in the UK Government digital and cyber risk fields, and on electromagnetic spectrum policy issues with Ofcom, industry and the Government.

David chairs a private limited company, DMSL, trading as 'at800', and has been a member of the Ofcom Spectrum Advisory Board since 2009, acting as chair prior to Linda Doyle. He has also chaired an industrial technical body, the Spectrum Policy Forum, since 2016.

Dr Robert Pepper

Robert Pepper is Head of Global Connectivity Policy and Planning at Facebook focusing on global, regional and national infrastructure and connectivity including new technology development, deployment, adoption and policy/regulation. Robert was previously Cisco's Vice President for Global Technology Policy, helping governments develop national digital strategies, address wireless and spectrum policy, security, privacy and internet governance.

Pepper was Chief of the Office of Plans and Policy and Chief of Policy Development at the United States FCC for fifteen years, where he led teams designing and implementing the first U.S. spectrum auctions, developing policies promoting the development of the Internet, implementing telecommunications legislation, and planning for the transition to digital television. He also led the Office of Policy and Development at United States' National Telecommunications and Information Administration.

His academic appointments included faculty positions at the Universities of Iowa, Indiana and Pennsylvania, and as a research affiliate at Harvard University. He is a member of the Board of Trustees of the Internet Society and the board of the US Telecommunications Training Institute and is a member of advisory boards at Columbia University and Michigan State University. He has chaired the US Department of State's Advisory Committee on International Communications and Information Policy and served on the US Department of Commerce's Spectrum Management Advisory.

Pepper received his BA and PhD from the University of Wisconsin-Madison.

Ex-Officio Members

Cristina Data

Cristina is the Director of Spectrum policy and analysis, Spectrum Group at Ofcom and is also a NED of the Energy System Catapult and sits on the UK5G advisory board. Cristina is leading work to understand the long- term impact of technology, market, and international changes on our spectrum management activities. Prior to joining Ofcom Cristina held various market and business intelligence roles within strategy at Telefonica O2 setting up a framework to benchmark data growth across different countries, financial planning and analysis at Orange UK, looking at the profitability of different marketing initiatives and market research and intelligence at Red Bee Media where Cristina had the responsibility to set up the entire unit. Cristina holds a master's degree in Industrial Engineering from the Politecnico di Torino university in Italy.

Holly Creek

Holly Creek is Deputy Director for Wireless Infrastructure, Spectrum and Consumer Policy in DCMS. She has over 20 years' experience working in a variety of roles in central Government and at regional level, managing high profile and complex policy and legislation across numerous sectors including digital infrastructure, media and the creative industries.