Department
for Culture
Media & Sport

HM Treasury

Next Generation Mobile Technologies: A 5G Strategy for the UK

March 2017

Contents

1. Ministerial Foreword

Digital connectivity was once a nice to have, perhaps even a luxury. It is now essential. Connectivity creates new business opportunities, opens up markets and supports us in our everyday lives. For an economy that works for everyone, and as part of our modern Industrial Strategy, the UK must be a global leader in the next generation of mobile technologies and digital communications.

We want to enjoy the benefits of new 5G networks early on: faster, more reliable connections; new, valuable services from connected cars to smart factories; and more high-paid, high-skilled jobs. But this can only happen with private sector investment in new networks, engaged customers and innovative service providers.

The Government's job is to create the environment for this to happen. We are acting now to ensure that consumers have excellent connectivity across the UK. Ofcom's latest assessment shows that 99 per cent of UK premises now have indoor mobile voice coverage and 98 per cent have access to mobile data services. And, as a result of our licence agreements with the mobile network operators, £5 billion of private capital investment to boost coverage and connectivity has been locked in, with 4G geographic coverage increasing substantially from 48 per cent to 72 per cent in the past year alone.

To build on this success, we have made it easier to install mobile base stations. We are overhauling the Electronic Communications Code to lower the cost of infrastructure deployment, and we are clearing vital new spectrum for 5G use.

These are the sorts of changes needed to improve connectivity now, but they are also helping to lay the foundations for long-term investment in communications networks. Yet there is still much more to be done – that is why the Government's Digital Strategy sets out

the principles of the Government's approach to digital infrastructure. But such is the opportunity presented by 5G that we are acting now to set out a bespoke 5G Strategy.

This document will serve as the blueprint for how we support the development and deployment of this technology, alongside £1.1 billion of new investment designed to explore and incentivise the next generation of digital infrastructure in the UK.

To deliver our ambitions we will be working as closely as possible with industry, investors, regulators, and researchers to refine the Government's policy as 5G technology emerges and evolves. We will therefore keep our 5G Strategy under review and update it regularly to help maximise benefits for all of the UK.

2. Executive Summary

Introduction

This Government has a clear ambition for the UK to be a global leader in the next generation of mobile technology – 5G. Good digital infrastructure is a building block of the Government's modern Industrial Strategy - it creates new opportunities for growth by allowing business to be done on the move; unleashing dynamic business models; and opening up new opportunities and markets. It also supports us in our everyday lives - connecting us with friends, family and colleagues; helping us to stay safe; and giving us access to information and services that we increasingly take for granted. 5G promises a step-change in mobile connectivity with enormous potential to boost productivity and grow the economy, and we want the whole country to benefit. So we will take a leading role in its development and roll-out, putting the UK at the forefront of the 5G revolution.

Mobile technology is constantly evolving to keep pace with growing demand. One estimate is that by 2020, global mobile data traffic is expected to reach a monthly rate of 30.6 exabytes[1], as compared to 3.7 exabytes in 2015.[2] That is a compound annual growth rate of 53%. Each generation of mobile technology has brought with it new capabilities that have transformed the way we live and work. 5G is an umbrella term used to describe the next generation of mobile communications technologies. 5G is not yet fully developed, with definitive standards only due to be agreed in 2019 and incremental deployment expected over the following decade. Unlike the generations of mobile networks that have preceded it, 5G is not just an extension of existing technologies but a "system of systems" that will bring flexibility to mobile, fixed and broadcast networks and support ever larger data requirements. It will support new consumer experiences based on constant and seamless connectivity.

These new technologies are expected to transform how we interact with the world - providing opportunities for wide-ranging and, as yet, unforeseen new applications, business models, enhanced lifestyles and increased productivity. They will open the door to potentially revolutionary technologies such as automated cars and advanced manufacturing, as well as enabling the many thousands of connected devices, such as smart energy meters, that are predicted to enter our everyday world as part of the Internet of Things (IoT). This sea change will result in huge economic benefits. IHS Economics estimated that 5G will enable USD$12.3 trillion of global economic output in 2035[3].

---

[1] An exabyte is a unit of measurement. One exabyte contains roughly the same amount of data as 250 million DVDs.
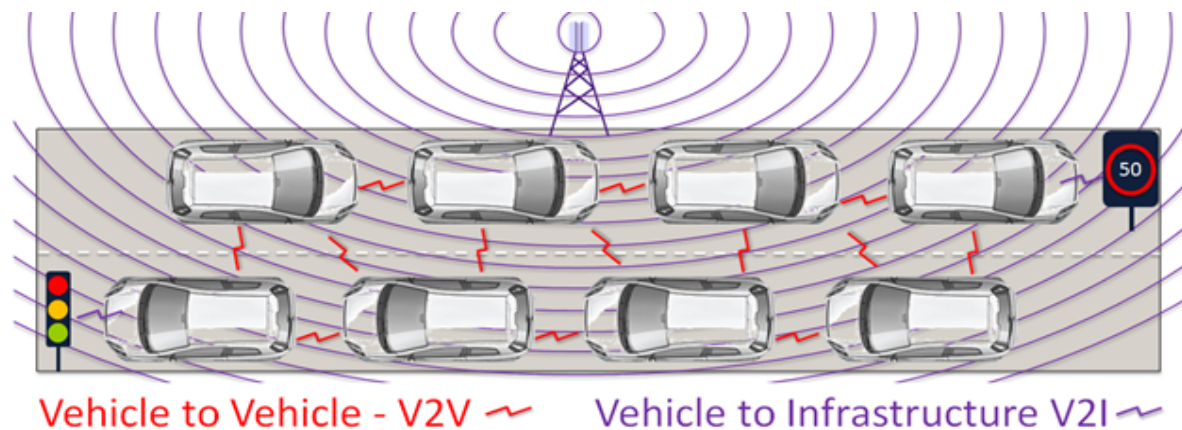[2] Cisco Visual Networking Index (VNI) Global Mobile Data Forecast 2015–2020
[3] IHS Economics / IHS Technology "The 5G economy: How 5G technology will contribute to the global economy" 2017

What are the potential uses of 5G

Whilst it is impossible to predict exactly where 5G will make the biggest impact, sectors across the whole of the economy are expected to make use of new 5G technologies and applications. There is widespread agreement that these could include transport and logistics; financial services; health and social care; retail; digital creativity and information services; and production, manufacturing and robotics. 5G could also enhance everyday consumer experiences - for example, as a result of seamless connectivity and advances in Artificial Intelligence and both virtual and augmented reality applications.

Within each sector, we expect to see a number of different 'use cases' emerge as well as applications and services that will sit alongside them. So, for example, the lower latency (i.e. quicker reaction times) expected to be a feature of 5G networks could make it possible to support the large-scale use of driverless vehicles for the first time. Even within one specific use case - such as a journey from A to B in a driverless car - there are many potential sub-use cases: vehicle to vehicle connections; connections between vehicles and street infrastructure for traffic management; and high speed connectivity to support in-car information and entertainment systems, to name just a few.

Vehicle to Vehicle - V2V ∿   Vehicle to Infrastructure V2I ∿

(5G use cases in a driverless car)

Other possible use cases of 5G are many and varied. They could include:

- industrial predictive maintenance: helping to reduce running costs by warning about imminent equipment malfunctions;

- retail logistics: fleets of connected/driverless lorries and vans transporting goods across the UK;

- smart cities: improving quality of life in urban environments through applications like traffic management, streetlight control, waste management, and smart grids;

- agri-tech: increasingly precise and efficient farming to help meet the challenges of a successful agricultural sector; and

- augmented or virtual reality: offering new 'ultra-realistic' applications in gaming or giving sports fans the opportunity to 'play' alongside their favourite athletes.

5G could also support significant efficiencies in public service delivery. For example, 5G applications in the health sector, such as wearable sensors, could help to monitor people

with health conditions, predicting if someone is likely to suffer a heart attack, or monitoring ill health in elderly people, helping to reduce pressures on primary care and A&E. In education, augmented and virtual reality applications supported by 5G may allow students to learn in completely new ways by making lessons more interactive.

The Government and wider public sector can therefore play a vital role in driving early demand as a major purchaser of 5G services as well as helping to address issues around public perception and safety.

Our ambition

The Government has a clear ambition that the UK should be a global leader in 5G so that we can take early advantage of its potential and help to create a world-leading digital economy that works for everyone.

The Government has had extensive engagement with a wide range of interested parties - including industry and academia - and have received two major reports, commissioned by the Government, that have helped to inform our thinking:

- the National Infrastructure Commission (NIC) set out in December 2016 its recommendations on steps that the UK should take to become a world leader in the deployment of 5G telecommunications networks; and

- the Future Communications Challenge Group (FCCG), established by DCMS, who provided advice in January 2017 on how the UK could become a world leader in the development of 5G telecommunication networks.

The Government's formal response to the NIC report is set out in full as an annex to this document (though it is also referred to throughout this document).

This strategy sets out the steps that we will take to deliver our ambitions and builds on both the recently published Digital Strategy and the Government's modern Industrial Strategy. If we are successful, it will deliver three main outcomes:

- accelerating the deployment of 5G networks;

- maximising the productivity and efficiency benefits to the UK from 5G; and

- creating new opportunities for UK businesses at home and abroad, and encouraging inward investment.

We are focused on creating the best conditions for the market to develop and deploy 5G as rapidly and efficiently as possible. But to do so will not be simple. As a technology, 5G is still not fully developed, and the wide variety of potential future uses of 5G, as well as the level of integration that will be required between them, means that future networks and systems will be considerably more complex than they are now. And even though we are looking at ways to accelerate the deployment of 5G, the ambition for seamless connectivity should not be seen as something that will just happen automatically when 5G arrives - we need to ensure that we continue to improve mobile coverage and capacity for users now.

Being at the forefront of global efforts to develop 5G will give the UK an opportunity to shape its development in a way that maximises the potential benefits to our economy and citizens.

We can ensure this happens by taking a coordinated approach - with the Government playing an active, facilitating role, not least through its own 5G and full-fibre programmes.

The strategy outlines the key themes that will determine our progress towards 5G:

- building the economic case;
- fit for purpose regulations;
- local areas - governance and capability;
- coverage and capacity - convergence and the road to 5G;
- ensuring a safe and secure deployment of 5G;
- spectrum; and
- technology and standards.

Building the economic case

Given the complexity of future 5G systems, it is not yet clear how and where 5G networks will be deployed. It is likely that their development will be part of a much wider ecosystem of wireless connectivity, building on investment in 4G networks and the ongoing development of fixed network infrastructure, with different upgrades required to deliver different use cases in different areas. In connectivity "hot-spots", additional capacity will likely be provided by hundreds of thousands of small cell radios with short-range, high speed connectivity that support the existing network. 5G networks will therefore require a step change in investment in digital communications infrastructure as well as the right skills to deliver its capabilities.

The Government is already taking action to drive the deployment of fibre; notably via the £1.1 billion of a proportion of the new investment announced at the Autumn Statement 2016. A significant portion of this will be used to deliver more extensive full fibre networks. £200 million will fund a programme of local projects to test ways to accelerate market delivery, and £400 million, at least matched by private sector investors, will establish a new Digital Infrastructure Investment Fund, to provide developers with greater access to commercial finance. We have also introduced a 100% business rate relief for new full-fibre infrastructure.

However, the vast majority of the capital investment required for both full-fibre and 5G rollout will need to come from the private sector. Despite the potential for substantial returns, the business case for the investment required for the deployment of 5G is not yet established. 5G is still a technology in development, and the market needs time to understand how to deploy infrastructure at commercial scale and invest in 5G applications and services profitably. Unlike previous generations of mobile telecommunications, it is possible, given the breadth of the potential 5G ecosystem, that the additional investment required in digital infrastructure will not come purely from established network operators.

While industry is best placed to respond to market demand and determine the scope of 5G, the Government has an important role to play - creating a robust framework that helps to underpin and accelerate investment here in the UK; and helping to prove the business case for commercial investment in 5G infrastructure, particularly where increased investment is needed to cover the roll-out of small cells in connectivity 'hot spots'. That is why we are **launching a new national programme of 5G testbeds and trials**. A core objective of the

programme will be to work with industry - through a new national 5G Innovation Network - to coordinate the development of 5G services and applications in the UK within a common framework, and to create the conditions for innovation to emerge in the 5G ecosystem. **We will do this by ensuring that the principles of interoperability, replicability and openness are embedded from the start.**

We will use the 5G testbeds and trials programme to test use cases in both rural and urban areas; and to improve our understanding of the economics of infrastructure deployment in different scenarios and locations and how infrastructure can be deployed in a cost-effective way.

The Government agrees with the NIC that infrastructure sharing, in compliance with competition rules, can be an effective and economically efficient way of delivering telecoms infrastructure, especially in areas where it is uneconomic to deploy competing infrastructure networks. Increasingly, independent infrastructure providers will play an important role in the deployment of 5G infrastructure, alongside both national mobile and fixed operators. **We will work with Ofcom to identify and tackle unnecessary barriers to infrastructure sharing and will explore the potential for a clearer and more robust framework to allow companies to share infrastructure, while preserving investment incentives**.
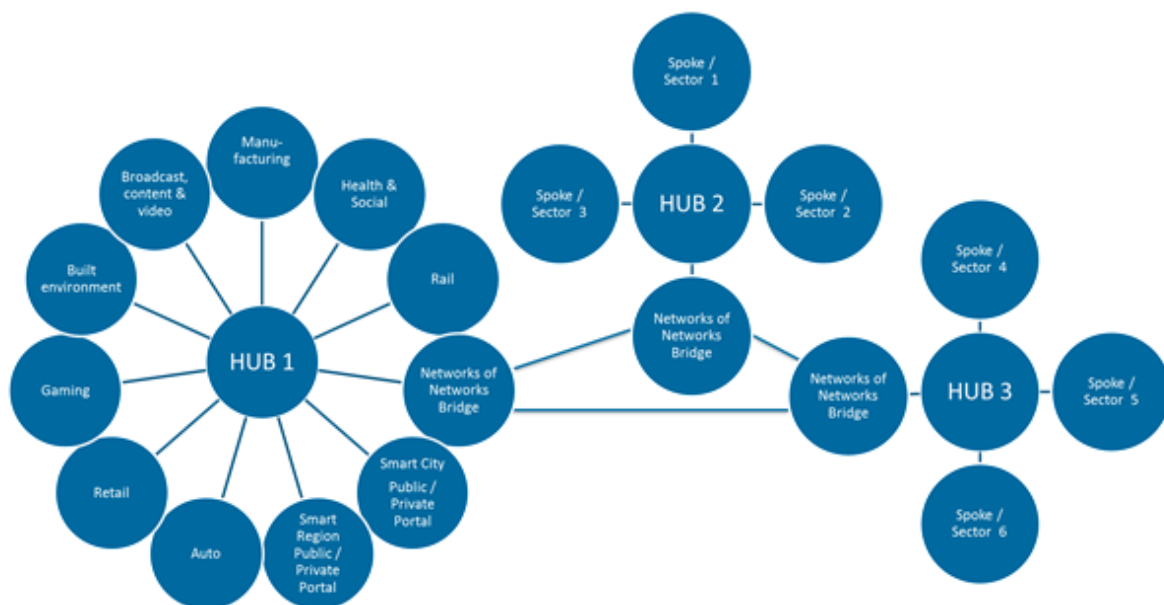
Realising the potential of 5G: The Government's 5G testbeds and trials programme

The Government is committed to ensuring that the UK is a world leader in the development and deployment of 5G, and, as announced at Autumn Statement 2016, **will invest in a nationally coordinated programme of 5G testbed facilities and application trials.**

The programme will deliver significant benefits: accelerating the deployment of 5G networks; maximising productivity gains from applications and services; and enhancing commercial opportunities for UK companies (including SMEs) at home and abroad, as well as encouraging investment into the UK by sending a clear signal of the Government's ambitions.

Our approach has been informed by the FCCG, who recommended a 'hub and spoke' model for the new 5G network. The programme will establish 'hubs' - facilities that will provide the core network infrastructure to support the testing of 5G use cases. Each hub will be connected to a number of 'spokes' - testbeds that provide an environment where new 5G applications and services can be trialled in a controlled way. Testbeds could include partnerships between local areas, public sector bodies, industry and academic institutions. The spokes will test the benefits of a variety of 5G-specific use cases in a range of locations and contexts.

The Government will create a new national 5G Innovation Network to trial and demonstrate 5G applications. The Government's initial investment will be up to £16 million for a cutting edge facility with the technology to run the trials, delivered through cooperation between leading 5G research institutions during 2017/18. It will deliver an end-to-end 5G trial in early 2018 and support a number of testbed spokes from 2018/19. Funding for future trials will be awarded on a competitive basis.

(FCCG representation of hub and spoke model)

The 'hub and spoke' model will help to accelerate the development of 5G technologies out of the R&D phase and towards commercial deployment. In the early phases of the programme spokes are likely to be relatively small in scale and could build on existing

projects. As the programme progresses, spokes will increasingly test use cases at greater scale and closer to real life deployment scenarios.

The programme's approach will ensure that the development of 5G in the UK is coordinated, standards based, and can be scaled up and is open to a range of businesses, including SMEs. It will focus on areas of existing UK strength, in particular systems integration (i.e. how different systems and services interact across and within the same networks to give the end user a seamless experience) and cyber security.

The programme is not designed to replace or crowd-out private sector investment, but will help fill in the gaps where there is not yet a clear case for commercial activity. The vast majority of investment in 5G will need to come from the private sector, and we expect the programme to lever in significant investment from industry. Where there is already 5G-related activity happening across the UK, it is our intention that the programme learns from and builds on this work. **To support this, the Government is establishing a new centre of 5G expertise in DCMS to ensure that work across the UK to develop 5G capabilities is joined up in a way that meets the strategic objectives of the programme.**

The new programme team will also:

- ensure that 5G development activity across central government and other public sector bodies is coordinated, best practice is captured, and knowledge is disseminated. The team will work with organisations such as UK Research and Innovation and the Government Digital Service, and ensuring coordination with the Industrial Strategy Challenge Fund;

- work with industry and public sector bodies to identify a pipeline of potential projects to be trialled;

- develop our understanding of how 5G networks could be deployed in a range of locations and contexts and the limits of what the market will deliver commercially;

- monitor the results of trials to build an evidence base to support the case for further investment in 5G services;

- facilitate engagement with local areas and businesses in the UK and, working with the Department for International Trade, overseas to help them understand how they can engage with the testbeds and trials programme;

- facilitate bridges to international work on 5G to ensure that we can learn the lessons from other places and help to shape the global development of 5G in a way that maximises the benefits to the UK;

- work to develop a strong UK 5G brand - the 5G Innovation Network - that supports and promotes the development of the 5G sector in the UK and helps to attract inward investment;

- drive a common set of standards for 5G applications and services so that applications can be more effectively deployed at scale and so that the programme benefits a wide range of businesses, including SMEs; and

- inform the policy and regulatory framework that will be required to provide the right

> incentives for investment both in 5G infrastructure and in the development of 5G applications and services.
>
> The Government will be publishing a more detailed prospectus shortly that will include further details on the programme.

Fit for purpose regulations

The speed of technological progress in the mobile market means that we need a flexible regulatory framework that keeps pace with developments.

We recognise that the planning system is a key factor influencing operators' abilities to expand their network and have already taken steps to make planning regulations more supportive of infrastructure deployment. The Government has also introduced much-needed **reforms to the Electronic Communications Code** that will directly address investment barriers, encouraging long-term capital investment in digital infrastructure, lowering the cost of infrastructure roll-out, and supporting further coverage enhancements.

However, given the volume of infrastructure envisaged within 5G networks, there may still be a case for going further. That is why **we will set out by the end of 2017 whether the Government believes further changes are needed to the planning and regulatory system** to meet the unique challenges of 5G infrastructure deployment. We will review this on a regular basis, as our understanding of these issues improves through the implementation of the 5G testbeds and trials programme.

Many of the potential use cases of 5G will also be subject to their own regulatory regimes (e.g. financial services) that could act as a barrier to their swift deployment. **We will use the 5G testbeds and trials programme to improve our understanding of the different regulatory regimes in which 5G applications and services will operate, working with the UK's regulatory authorities as appropriate, and report back by the end of 2018.**

Local areas - governance and capability

The Government agrees with the NIC that there will be a significant challenge both in finding suitable sites for 5G infrastructure, and ensuring that telecommunications networks meet local needs. Local areas have a critical role to play in facilitating the deployment of mobile telecommunications infrastructure and are already doing so in many areas. Through its Housing White Paper, 'Fixing our broken housing market'[4], **the Government is currently consulting on requiring local authorities in England to have planning policies setting out how high quality digital infrastructure will be delivered in their area.**

Outside of the planning policy framework, **the Government believes that there may also be a case for encouraging and supporting local areas to develop broader plans to deliver local mobile connectivity.** These local connectivity plans would articulate how an

---

[4]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/590463/Fixing_our_broken_housing_market_-_accessible_version.pdf

area will meet its connectivity needs. The Government will also take account of the presence of local connectivity plans and evidence of taking a proactive approach when allocating funds to local projects through the selection process for both local fibre and 5G testbeds and trials programme funding.

The contribution of industry is vital to helping local authorities and other local groups to understand potential costs and benefits of infrastructure roll-out. **The Government will bring together a working group of local areas, government departments, landowners and industry with the aim of providing an accurate picture of local area requirements for the deployment of 5G networks.** This group will also allow government and industry to share knowledge of 5G network planning and will feed into the new centre of 5G expertise in DCMS.

Coverage and capacity - convergence and the road to 5G

Mobile coverage in the UK continues to improve, particularly with the growth of 4G over the past two years. Ofcom's latest coverage statistics indicate that 4G coverage is now available to 96% of UK premises and over 70% of UK landmass.[5]

The evolution from 3G to 4G in the early part of this decade has brought forward applications that were unforeseen just ten years ago. However, the path to a 5G future is unlikely to replicate the linear progression from one mobile standard to the next that we have seen to date. 5G networks will work alongside and build on existing 4G networks, which will form the infrastructure spine for the next generation of mobile networks and support many of the things that we currently think of as 5G use cases. However, the evolution towards 5G is likely to require greater alignment between wireless networks and fixed line networks.

Providing the levels of connectivity and coverage required for 5G means having the best possible networks today. We need to take action now to ensure further improvements in our existing mobile network. **The Government agrees with the NIC that there should be high quality coverage where people live, work and travel.** We are looking at how we can make sure that 4G networks are deployed to a scale and quality that will meet this ambition, while also supporting investments that will enable future 5G networks. This will mean that mobile networks will need to go further than the requirements of the current licence obligations both in terms of coverage and quality. **We will set out by the end of 2017 what the essential elements of high quality coverage where people live, work and travel are, and how we will achieve this as soon as is practical, and no later than 2025.**

The Government agrees with the NIC that the reporting of coverage should provide a genuine and meaningful reflection of the services experienced by customers and **will ask Ofcom to set out by the end of 2017 how this will be achieved for existing services.** However, we note the difficulties of establishing metrics for 5G now, particularly when the technology is in development and individual services or applications may ultimately have different requirements.

---

[5] Ofcom Connected Nations 2016 report
https://www.ofcom.org.uk/__data/assets/pdf_file/0035/95876/CN-Report-2016.pdf

We also agree with the NIC that we need better coverage on our main transport routes to support new ways of travelling and working. The Government already has an ambition to improve mobile connectivity on the rail network in England and Wales and **we will take steps now to understand better how we can achieve this for 5G.** As the NIC notes, the required infrastructure will not come cheaply, and deploying it will present some practical challenges. The Government's preferred approach to improving connectivity on our roads and railways is through a commercial delivery model with private sector funding and involvement. **The Government will work with industry to assess the potential for such models and how new and existing infrastructure can be used in support. We will also consider funding live trials as part of the 5G testbeds and trials programme, particularly where this could build on other planned work.**

Ensuring a safe and secure deployment of 5G

Given the technological advances that 5G will enable, and the wide-ranging impact that new 5G applications and services will have on modern life, it will be important to ensure that networks and services are deployed in a safe and secure manner and in a way that the public understands and accepts. Fit for purpose security architecture needs to be at the centre of 5G development to ensure privacy and customer security.

The 5G testbeds and trials programme will work with organisations such as the National Cyber Security Centre to support the development of new security architectures that meet the expectations of customers and the needs of 5G services and applications.

We will align our work on 5G security with the objectives of the Cyber Security Strategy, and seek to leverage the considerable cyber security knowledge of the UK through the 5G testbeds and trials programme - helping to ensure that the UK remains an international centre of expertise.

Spectrum

Like previous generations of mobile technologies, 5G deployment will rely on the availability of sufficient radio spectrum at the right frequencies. The most recent Spectrum Strategy[6] was published in March 2014 and remains relevant and up to date. However, three years on we can say more about the right policies to support our ambitions on 5G, particularly around making new spectrum available in a timely way; flexibility in how it can be used; and how the UK's spectrum licensing regime can take account of the different geographic scales on which the various 5G bands are likely to be deployed.

The Government has already made spectrum available for 5G at 3.4-3.6 GHz and we are clearing 700MHz for broad 5G coverage. Ofcom's recent update on spectrum for 5G[7] sets out what it is doing to ensure that spectrum is not an inhibitor to mobile data growth and early 5G roll-out. We agree with the NIC that both the Government and Ofcom must keep

---

[6] https://www.gov.uk/government/publications/spectrum-strategy

[7] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf

pace with the rapid evolution of digital communications, and **the Government will ask Ofcom to review and report back to DCMS by the end of 2017, the scope for the spectrum licensing regime to facilitate better 4G and 5G deployment at national, regional and local scales, including in-building usage.**

We expect that 5G will need a mix of low, medium and high frequency spectrum, some of which will be "new" spectrum and some will be "refarmed" spectrum (i.e. previously used by other services or even shared with existing services)**. The indications are that demand for additional spectrum for 5G will be high, and **the Government welcomes Ofcom's commitment "to ensure that 5G spectrum is made available in the most appropriate and timely way"[8].** The Digital Economy Bill contains several measures to allow for increased flexibility within the spectrum regulatory regime, such as new powers to help Ofcom allow secondary use of licensed spectrum when it is unused by the existing user.

The Government will also be taking action to ensure it shares spectrum where possible, either with other government users or with new private sector users. **The Government will therefore prioritise making available public sector spectrum for 5G, subject to an assessment of where there is a clear and demonstrable value for money case.**

And in line with the recommendations from the FCCG's report, **the Government will work with Ofcom to assess the feasibility of accessing the 3.8-4.2 GHz range on a shared basis as an extension to adjacent 3.4-3.8 GHz spectrum and promote this in Europe and agree a timescale and clear milestones for further work.[9]**

Technology and standards

The UK is playing a leading role in developing and finalising international standards for 5G (which are the rules and guidelines for 5G technologies) to help ensure that the technology best meets the needs of the UK.

5G standards will be driven by market needs and, therefore, are being developed in a bottom-up approach through standards bodies. As standards are industry led, government activities in this sphere are about encouragement and persuasion. **The Government will continue to engage with the appropriate Standards Developing Organisations (SDOs) to support the take up of UK needs and ideas in the emerging 5G standards, and monitor developments in security and supplier markets.**

The Government will also consider whether measures such as patent pools and portfolios could assist the market to develop and promote UK interests. This could help companies, especially SMEs, in generating innovative technologies and applications, to promote take up and commercialisation of their ideas.

---

[8] *Update on 5G spectrum in the UK*, Ofcom, 8 February 2017,
https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf
[9]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/582640/FCCG_Interim_Report.pdf

Next steps

This strategy sets out the Government's current thinking on how the UK can reap 5G's benefits and overcome any challenges. It is written in the clear knowledge that 5G is still in an embryonic development stage and that there are many questions that cannot yet be answered. However, we have identified areas where we will take action and outlined areas where further investigation is required.

Where these actions relate to reserved matters they apply to the whole of the UK. Where they relate to devolved matters, the Government will consult with the Territorial Offices, where relevant, and seek to work with the Devolved Administrations.

This strategy is a living document and will be updated regularly as our understanding of the issues and challenges increases.

The National Infrastructure Commission report on 5G

At the 2016 Budget, the Chancellor announced that the National Infrastructure Commission (NIC) would study what the UK needs to do to become a world leader in 5G deployment, and to ensure that the UK can take early advantage of the potential applications of 5G services. The NIC's 'Connected Future' report was published on 14 December 2016.

The NIC's central finding is that mobile connectivity has become a necessity and that securing the mobile networks necessary to put the UK at the forefront of this emerging technology will be critical to the growth of our economy.

The report contains a number of recommendations for government and Ofcom, and the Government's response forms a central part of this strategy. A complete government response to the NIC report is set out as an annex at the end, but key actions include:

- the Government will establish a new Digital Infrastructure Officials Group, comprising senior officials from relevant government departments, to be chaired by a new Telecoms Director and reporting to the DCMS Secretary of State;

- the Government is also establishing a new centre of 5G expertise to ensure that 5G development activity across central government, local government and other public sector bodies is joined up and to engage with industry to ensure a strategic approach and the sharing of best practice;

- the Department for Transport and DCMS will work with industry to assess the potential for the commercial provision of telecommunications services on road and rail networks, and how new and existing infrastructure can be used to support them, and will report back by the end of 2017;

- the Government will take account of local connectivity plans and evidence of taking a proactive approach when allocating funds to local projects through the selection process for both local fibre and 5G testbeds and trials programme funding;

- the Government agrees that the reporting of coverage should provide a genuine and meaningful reflection of the services experienced by customers and will ask Ofcom to set out by the end of 2017 how this will be achieved for existing services;

- the Government will set out by the end of 2017 what the essential elements of high-quality coverage where people live, work and travel are, and how we will achieve this as soon as practical, but by no later than 2025;

- the Government will work with Ofcom to identify and tackle unnecessary barriers to infrastructure sharing, and will report on progress by the end of 2017; and

- the Government will ask Ofcom to review and report back to DCMS by the end of 2017, the scope for the spectrum licensing regime to facilitate better 4G and 5G deployment at national, regional and local scales, including in-building usage.

3. Introduction

How digital communications work

Digital communications is about transporting data from one point to another. It requires networks that are secure, reliable and resilient, and with sufficient speed and capacity.

In order to allow people across the country to make calls, send data (like texts and emails) and access mobile broadband services, each of the four Mobile Network Operators (MNOs) divides the UK into thousands of individual geographic areas known as *cells*. At the heart of each cell is a fixed location base station.

Mobile phones access the mobile network by sending data to and receiving data from a nearby base station. Data is then relayed back to the MNOs core network using physical cabling - often fibre. This is known as *backhaul* - it hauls the signal back from the base station to core fixed networks. The four UK MNOs currently utilise around 40,000 different radio access points to provide mobile coverage under licences that grant them access to specific radio spectrum.[10]

The evolution towards 5G will result in more complex and interconnected networks. Over time, the boundaries between fixed communications technology (such as Wi-Fi) and mobile will become blurred, giving end-users seamless, high quality and rapid connectivity. As technologies develop and mobile networks densify, fibre backhaul will become increasingly important to fully realise the benefits of 5G.

Since the first mobile phone call was made in the UK in 1985, the mobile industry has delivered huge benefits to consumers and the wider UK economy. For example, the roll-out of 4G in the UK has been estimated to deliver £75 billion of additional GDP over ten years[11]. New technologies - or generations - have been introduced roughly every decade, each offering improved services compared with previous generations:

- 1G: the first generation of 'cellular' mobile phones, which used analogue radio transmission and supported voice calls;

- 2G: the second generation of mobiles, which used digital transmission and allowed for digital phone calls and messaging;

- 3G: the third generation of mobile communications enabled faster data services than those available on 2G networks, which led to the first consumer friendly mobile broadband internet experience for users; and

- 4G: the fourth generation of mobile communications is a more data-oriented network than its predecessors and is the first all-Internet Protocols mobile communications system. The main advantage of 4G services compared with previous generations are that they offer faster download speeds and quicker response times (latency).

---

[10] National Infrastructure Commission - Connected Future. December 2016
[11] http://www.ibtimes.co.uk/4g-everything-everywhere-75bn-lte-economy-334922
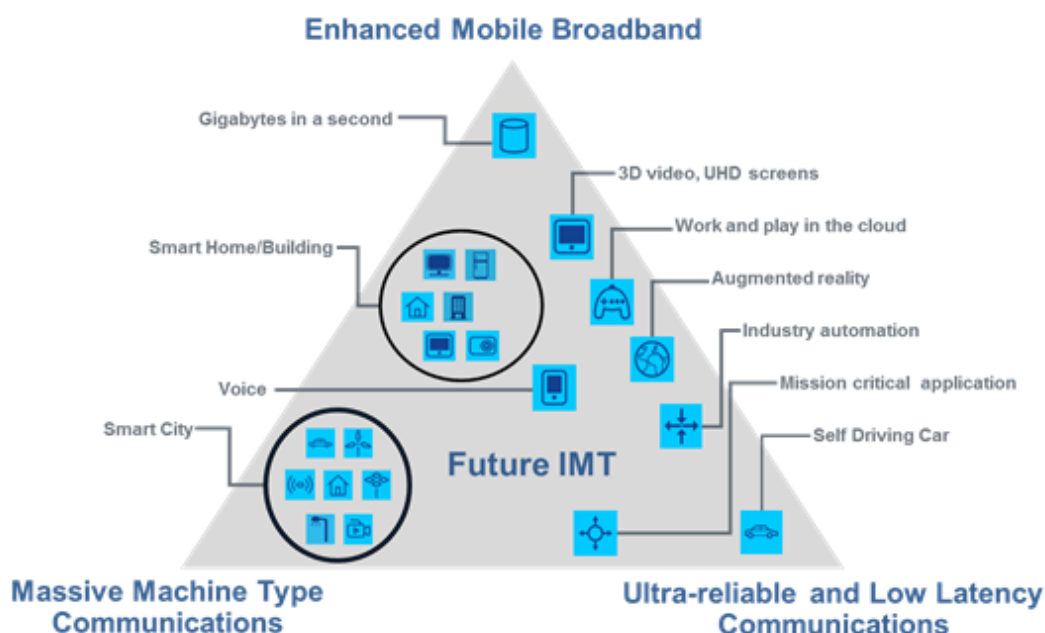
Each new generation of mobile networks has brought disruption to the established business model in place at that time. The first generation of mobile created alternatives to fixed phone lines; 2G saw pagers become largely obsolete; and 3G and 4G smartphones gave users access to significant mobile data for the first time and largely displaced MP3 players and pocket cameras.

What is 5G?

5G is a term used to describe the fifth generation of mobile communications technologies. 5G is not yet fully developed, with definitive standards only due to be agreed in 2019 and incremental deployment expected over the following decade. However, there is an anticipation that it will deliver a step change of ultrafast, low latency (i.e. quicker reaction times), reliable, mobile connectivity, that is able to support ever larger data requirements, as well as wide-ranging new applications. We refer to these as 'use cases'. These use cases might include autonomous vehicles; advanced manufacturing and robotics; augmented reality; smart agriculture; and smart homes and cities.

5G is not simply about faster internet connections. In fact, it is generally agreed that it will deliver the following range of different capabilities:

- enhanced mobile broadband connections;

- massive machine-type communications - between intelligent machines that require no human input (e.g. advanced manufacturing); and

- ultra-reliable and low latency communications (i.e. communication services which are available nearly 100% of the time).

(ITU-R Recommendation M.2083-0 (2015))[12]

---

[12] https://www.itu.int/rec/R-REC-M.2083-0-201509-I/en

As a result, 5G networks will not be one-size fits all - they can be dynamically tailored to meet the needs of the individuals or services that will use them at any moment in time, giving users all the communications capability they need, but actually sharing it with many others. So for example, the capabilities (and infrastructure) required to deliver 5G in rural areas (e.g. smart farming and the IoT) will be different to the capabilities required within a football stadium, where thousands of fans may want to stream HD video and replays. This means that different elements of 5G will be deployed in different places and may be deployed at different rates, with the IoT and other applications being delivered on existing networks.

5G will deliver these flexible networks by making use of multiple bands of spectrum (the means by which mobile signals are transmitted) including:

- lower frequencies (around 700 MHz). These are ideal for providing wide-area coverage such as that which will be needed to support the IoT;

- medium frequencies (around 3.4MHz). These provide higher capacity than 700 MHz; and

- high frequencies (24 GHz and above). These 'millimetre wave' frequencies cover a small area and will in the main be used to support the ultrafast, complex capabilities expected of 5G.

Although high frequency 5G spectrum offers significant potential benefits, it is only able to transmit data across very short distances compared to the frequencies that are currently used to deliver mobile services. So where high capacity and ultrafast capabilities are required - for example, on a busy commuter train - this will need to be supported by the deployment of many so-called 'small cell' radios as well as a dense fibre network to provide backhaul. To give a sense of scale, analysis for the NIC found that as many as 42,000 small cell sites could be needed to deliver the ultra-fast broadband speeds expected of future networks in an area the size of the City of London. By comparison, currently around 40,000 radio access points service the entire UK network. [13]

The successful and early deployment of full 5G networks will therefore require a step change in infrastructure investment. It will also need significant coordination and an evolution of regulatory frameworks.

5G networks

5G will comprise a set of network upgrades that will, in part, build on existing 4G networks. In some cases, what we come to think of as 5G will be rolled-out in a way that uses existing 4G equipment. In other cases it will be a separate set of equipment alongside 4G. Where existing networks remain, 5G will work alongside them.

5G will allow the same network to be optimised so that it can be used at the same time for different purposes with different network requirements. This will enable a single physical network to be split into multiple virtual networks, known as 'network slicing'. This is

---

[13]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577906/CONNECTED_FUTURE_ACCESSIBLE.pdf

analogous to a three-lane motorway (representing the network) where vehicles are assigned to a lane based on their needs. For example, trucks could be assigned to lane one (wide but slow); small/slow cars to lane two (narrow and slow); and larger/faster cars assigned to lane three (fast and medium width). In a similar way, 5G is not necessarily about having ultra-fast speeds everywhere, but about having a network that meets users' needs.

We have had a number of representations suggesting the potential for net neutrality regulation to interact with the technical characteristics of 5G services, including network slicing. We will explore how the regulatory framework can best enable and support 5G networks.

The transition from 4G to 5G is likely to be a complex and nonlinear process with many of the technological innovations that may be classified as 5G being introduced early on through evolution of the current 4G standards. This means that there is unlikely to be a 'big bang' moment when we will be able to say that 5G networks have been 'switched on' - it will be an evolutionary process - and, as the NIC report notes, it means we need to continue to focus on ways of improving connectivity across the UK now.

The role of Ofcom

Ofcom, as the independent communications regulator in the UK, seeks to make sure that people in the UK get the best from their communication services by regulating the TV, radio and video-on-demand sectors, fixed-line telecoms mobiles and postal services, plus the airwaves over which wireless devices operate. [14]

Ofcom has a legal duty to ensure that the radio spectrum (the airwaves used for modern day telecommunications, broadcast TV and radio) is used in the most efficient way. Radio spectrum is a finite resource and so Ofcom allocates bands to users, including the MNOs.

While strategy and policy are a matter for government, Ofcom will have a key role to play in supporting the delivery and roll-out of 5G across the UK. It represents the UK in international radio spectrum matters, including international discussions to agree the future spectrum bands and standards for 5G. Later this year, Ofcom plans to auction spectrum in the 3.4-3.6 GHz band, which has been identified as central to the rollout of 5G across Europe. Ofcom's proposed Annual Plan[15] for 2017/18 includes further work on 5G for 2017/18, and its recent update on spectrum for 5G[16] sets out what Ofcom is doing to ensure that spectrum is not an inhibitor to mobile data growth and early 5G roll-out.

The Government will consider whether a Strategic Policy Statement for the telecommunications sector could be used to promote the development of a regulatory framework that supports the delivery of this strategy.

---

[14] https://www.ofcom.org.uk/about-ofcom/what-is-ofcom
[15] https://www.ofcom.org.uk/consultations-and-statements/category-1/proposed-annual-plan-2017-18
[16] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf

Why do we need a 5G strategy?

Although there is widespread agreement that 4G will not achieve its maximum potential for a number of years, and that there will be further 4G developments over the short to medium term, there is already significant attention on 5G. This is because the search for solutions to some of the 21st Century's biggest technology challenges (connectivity, data capacity and the infrastructure required to realise revolutionary innovations such as driverless cars, for example) will increase the demands on mobile networks exponentially in the coming years, and beyond the capabilities envisaged from 4G.

As an example, in its 2020 forecast[17], Cisco predicted that, globally, mobile data traffic will grow eight-fold from 2015 to 2020, a compound annual growth rate of 53%. As well as supporting ever greater flows of data, the advent of new systems and technologies such as the IoT and smart cities, means that there is a growing need for more flexible and multi-capable networks.

Being at the forefront of the development and deployment of 5G networks will help the UK digital sector compete in global markets for a range of products and services; enhance UK capabilities at home and overseas, and help attract inward investment.

Development of 5G in EU Member States

The Government wants to have a positive and constructive partnership with the EU that works in our mutual interest.

The Government's ambition is for the UK to be one of the world's leading digital nations. The EU has set out an ambitious plan in relation to 5G; while we remain a member of the EU, we will continue to take an active part in Digital Single Market initiatives, including the 5G Action Plan, to ensure that UK interests are protected. The UK is continuing to participate fully in the re-negotiation of the European Electronic Communications Code (formerly the Electronic Communications Framework) to ensure that the revised regulatory framework supports private investment in infrastructure and efficient management of spectrum.

As the UK forges a new partnership with the EU, we want continued close cooperation with other EU countries on 5G at all levels. We will also expand collaboration on communications technologies with other world-leading countries such as China, the US, South Korea and Japan.

The Government will ensure that the UK remains a key collaborator in global 5G developments. A key objective of the 5G testbeds and trials programme will be to facilitate and develop international links ensuring that we maximise the benefits for the UK from collaboration and learning.

---

[17] http://www.cisco.com/c/dam/assets/sol/sp/vni/forecast_highlights_mobile/index.html#~Country

Conversely, a significant lag in the development of new mobile capabilities would harm the UK's prospects in all these areas. Internationally, our competitors are already making significant investments in new mobile technologies. The European Commission has also issued an ambitious strategy for European countries to develop 5G networks. [18]

Development of 5G around the world

A number of other countries around the world are already taking steps to promote the development of 5G. A summary of our understanding of major global trials that are either happening or planned is set out below.

While the Government is committed to ensuring that the UK seizes the opportunity to be a world leader in 5G, we are realistic that other countries may already have an inbuilt advantage in the development of some aspects of 5G (e.g. the development of 5G hardware). That is why the Government is taking a targeted approach that builds on the UK's existing strengths - in particular, enabling the 5G ecosystem by focusing on systems integration and interoperability, and leveraging UK expertise in cyber security.

We will be looking carefully at early trials of deployment around the world, including:

- *Japan* - A trial 5G network will be launched in areas of Tokyo this year to evaluate the performance of prospective 5G technologies in a live environment. Japan is working to launch 5G in time for the summer Olympics in 2020, though probably only in the host city, Tokyo.

- *South Korea* - Samsung and KT CORPORATION have completed early 5G connectivity trials and they are planning to facilitate the world's first mobile 5G trial service at the PyeongChang 2018 Winter Olympic Games. All three Korean mobile operators are expected to commercially launch 5G by 2020.

- *United States* - AT&T is seeking a three-year licence to run 5G tests. Verizon has also announced 5G trials, which are set to begin this year.

- *China* - state-run telecommunications companies China Mobile, China Unicom and China Telecom have announced 5G testing this year together with telecommunications vendors Huawei and ZTE. The 2022 Winter Olympics in Beijing is likely to be a showcase of new 5G technologies.

- *Australia* - Telstra, in partnership with Ericsson, tested one of the world's first 5G radio testbeds in Melbourne. It aims to conduct full trials of 5G at the 2018 Commonwealth Games on the Gold Coast.

- *Sweden* - Telia worked with Ericsson to conduct trials in Kista, Sweden, over a live 5G network. Telia plans to offer service in Tallin (Estonia) and Stockholm in 2018.

---

[18] https://ec.europa.eu/digital-single-market/en/news/communication-5g-europe-action-plan-and-accompanying-staff-working-document

Delivering the next generation of digital connectivity is at the heart of the Government's modern Industrial Strategy - investment in infrastructure is one of the ten identified 'pillars' that the Government believes are of most importance. The Government is therefore determined that the UK is well placed to reap the potential rewards of 5G and is acting now to deliver the networks that the country will need to secure continued economic growth, prosperity and development for everyone.

New 5G networks are likely to be much more complex than current systems. As Analysys Mason recently noted, "5G will take the business case for mobile infrastructure investment significantly beyond the scope of today's consumer-driven mobile broadband services, towards support for a diverse range of use cases"[19] across different sectors. This means that the success of the next generation will need to be underpinned by a vertical industry uptake of the technology as well as direct consumer services. To achieve our ambitions will require concerted action from government, industry, academia and local areas, to develop the technology and deploy the networks to support it.

We will not simply subsidise industry, or undertake activities as government that are best done by experts in research institutions or the private sector. There are already 5G-related activities happening in the UK, many tied to an academic institution and focused on the R&D phase. We do not intend to replace these. Instead, the Government believes that its role at this stage is to coordinate work to ensure that the UK maximises the potential benefits; to provide a supportive policy and regulatory framework; and to help prove not only that the technology works but also that a market exists to monetise that technology. We will be doing this through our programme of 5G testbeds and trials.

This strategy is written in the clear knowledge that 5G is evolving as a technology and that a number of questions cannot yet be answered fully. Despite this, we believe that it is important to set out the key issues at hand, so that we can be on the front foot when 5G is deployed. The strategy therefore focuses on issues that we believe the UK needs to tackle straight away; sets out our thinking on where decisions can be taken now; flags issues for further work; and highlights areas that we know will be important for 5G but where we don't yet have all the answers. It will be refreshed on a regular basis, to take account of new technology innovations and industry developments, in order to remain relevant.

Championing 5G across government

The Government agrees with the NIC that responsibility for digital infrastructure should reside in one place under a single Cabinet Minister. The Secretary of State for Culture, Media and Sport is the lead Minister for digital infrastructure, and has overall responsibility for delivering the Government's commitments in this area. DCMS is in the process of strengthening its telecoms capabilities and expertise in support of this mission. As the Commission notes, the department has created a Director General (DG) with overall responsibility for the digital economy and is also creating a new dedicated Director of Telecoms post.

---

[19] http://www.analysysmason.com/Research/Content/Reports/investment-in-5G-and-IoT-infrastructure-Dec2016/

The Government will establish a new Digital Infrastructure Officials Group reporting to the Secretary of State for Culture, Media and Sport, chaired by the new Telecoms Director and comprising senior officials from relevant government departments, to:

- **coordinate public projects across government that have a significant element of digital infrastructure delivery; and**

- **ensure that when upgrading existing or delivering new infrastructure projects, the long-term capacity needs of telecoms networks are considered and met wherever practical, affordable, and value for money.**

The Government is also establishing a new centre of 5G expertise within DCMS to deliver the 5G testbeds and trials programme, its role will include:

- **ensuring that 5G development activity across central government and other public sector bodies is joined up in a way that meets the strategic objectives of the programme to accelerate deployment, maximise benefits and enhance opportunities for UK businesses and inward investment. This includes ensuring best practice is captured, and knowledge is disseminated;**

- **working with industry and public sector bodies to identify a pipeline of potential projects to be trialled on the new 5G testbed networks; and**

- **providing support and challenge to local government in developing local connectivity plans, including through a new joint working group and in allocating funds through the 5G testbeds and trials programme.**

The Government will work through the Digital Infrastructure and Inclusion Implementation Taskforce, chaired by the Secretary of State for Culture, Media and Sport, to deliver our response to the Commission's recommendations and the actions in this strategy. The Secretary of State will update the Economy and Industrial Strategy Cabinet Committee on progress in delivering the strategy.

The Future Communications Challenge Group

The Government established the FCCG to bring together industry and academia to advise on how the UK can lead on 5G.

The FCCG's interim report was published on 10 January 2017. It suggested that other countries may have an inbuilt advantage in the development of some aspects of 5G (for example, the development of 5G hardware) but that the UK could be a global leader if we focused on our existing strengths - such as systems integration and cyber security.

The centrepiece of the FCCG's recommendations is for a programme of coordinated '5G testbeds and trials that will help to accelerate and de-risk the deployment of 5G infrastructure and services, as well as presenting significant opportunities for UK companies at home and abroad.

The FCCG also recommended:

- the establishment of a 5G implementation advisory board to advise on maximising the significant opportunities for the UK of the 5G ecosystem;

- that the Government should encourage and strengthen links with international partners and bodies who are also working on the development of 5G;

- that the Government should adopt a digital first approach to encourage the trialling of solutions to ensure that the structure of 5G networks will maximise energy efficiency;

- that government departments should assess how 5G adoption can support the delivery of their priorities e.g. creative industries transport, health;

- that we should explore through testbeds and trials, models for improving coverage alongside roads and rail lines;

- that the Government should consider regulatory and planning changes to support 5G infrastructure deployment; and

- that the Government and Ofcom should ensure that spectrum is available to support the early and rapid deployment of 5G.

Further details of the recommendations and the evidence underpinning them can be found in the FCCG's interim report.[20] We will be taking forward these recommendations as part of the Government's 5G testbeds and trials programme and will report back on them when this strategy is next updated.

---

[20]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/582640/FCCG_Interim_Report.pdf

4.   Building the economic case

This section outlines the steps that the Government will take to help to build the case for investment in 5G - accelerating the deployment of 5G networks and maximising the productivity and efficiency benefits to the UK.

The potential economic benefits of 5G

Mobile connectivity allows business to be done on the move, enables access to information and services anywhere, and opens up new opportunities and markets. The mobile sector itself is a major contributor to the UK economy with retail revenues of over £15 billion in 2015[21], but it is also an enabler of economic activity in other sectors. The mobile industry group, the GSMA, estimates that a doubling of mobile data usage is associated with an increase in annual GDP per capita growth of 0.5 per cent.[22]

Simply as an incremental improvement on current mobile broadband networks, 5G could therefore deliver real economic benefit. However, the promised improvements in speed, reliability and latency mean that 5G has the potential to be an even greater transformative technology - enabling new markets to develop and reshaping others, as well as supporting research and development for economic and social benefit. 5G's full economic impact is difficult to predict at this early stage but there is emerging consensus that one of the main benefits will be in enabling new applications in a number of different sectors. For example, the GSMA estimates that the contribution of mobile to the global economy will be worth USD$3.9 trillion in 2020, of which over 75% will be benefits to the wider economy that are enabled by mobile.[23]

Other recent reports have illustrated the potential gains from 5G. In particular:

- the FCCG's report suggests that UK leadership in 5G could result in the opportunity to create £173 billion of incremental UK GDP growth over a ten year period from 2020 to 2030.[24]

- IHS Economics / IHS Technology estimated by modelling industry investment and impacts on total factor productivity from expected use cases that 5G will enable USD$12.3 trillion of global economic output in 2035.[25]

In addition, the public sector could be a key beneficiary of 5G applications through improved services and more productive ways of working.

---

[21] Ofcom Communications Market Report 2016
[22] GSMA "What is the impact of mobile telephony on economic growth?" 2012
[23] GSMA Mobile Economy report source -
  http://gsmamobileeconomy.com/global/GSMA_Global_Mobile_Economy_Report_2015.pdf
[24] Future Communications Challenge Group "UK strategy and plan for 5G & Digitisation - driving economic growth and productivity" 2017
[25] IHS Economics / IHS Technology "The 5G economy: How 5G technology will contribute to the global economy" 2017

These estimates are by their nature speculative but give a sense of the potential growth and productivity benefits and opportunities that 5G can bring to the UK.

Market conditions

As noted previously, where 5G networks are deployed, they will build on the foundations established by previous mobile generations. Existing mobile phone masts and other base station sites will be adaptable for use with 5G, with different upgrades required to deliver use cases in different areas. But to deliver the high speed, high capacity capabilities of 5G will likely require hundreds of thousands of small cells to be deployed, alongside dense fibre networks or another form of backhaul. **To give a sense of scale, analysis for the NIC found that as many as 42,000 small cell sites could be needed to deliver the ultra-fast broadband speeds expected of future networks in an area the size of the City of London**. Therefore, if predictions are correct, small cell 5G deployment will require a step change in infrastructure investment.

The overwhelming majority of this investment will need to come from the private sector. Existing mobile and fixed operators, alternative network and independent infrastructure providers and other communications service providers will have a critical role to play in the successful deployment of 5G networks. As such, the ability of the UK telecommunications market to scale large amounts of capital investment will affect the speed and potentially also the quality of 5G rollout. However, unlike previous generations of mobile telecommunications and, given the likely breadth of the 5G ecosystem, it is possible that the additional investment needed will not come purely from established network operators.

Despite the potential for substantial returns, the business case for the initial investment required for 5G is not yet established. While industry is best placed to determine the scope of 5G, both the Government and Ofcom have an important role to play in creating the conditions for the market to develop and deploy 5G as rapidly and efficiently as possible here in the UK, whilst supporting innovation in the ecosystem. That is why we are launching a new programme of 5G testbeds and trials to help to prove that 5G technology works. **The programme will provide a catalyst for the development of products and services that will use future communications networks, and therefore help to prove that a market exists to monetise that technology.** This is particularly important where increased investment will be needed to cover roll-out of small cells in connectivity hot spots. Through the programme, **the Government will also explore the key public sector challenges that 5G and related technologies could help to solve.**

A core objective of the programme will be to coordinate the development of 5G services and applications in the UK within a common framework. **We will do this by ensuring that interoperability, replicability and openness are embedded from the start.** By providing access to testbeds and working with the developers of applications and services to ensure they are built using common standards, the programme will help to ensure that the benefits are scalable at a national level. In this way the public sector can harness its purchasing power to become a major driver of 5G services. This will not only deliver cost savings for the taxpayer but also provide a revenue stream to support the commercial case for development.

As noted elsewhere, one of the expected benefits of 5G networks is that they can be tailored to give users all the communications capability they need - giving consumers the impression of a seamless experience. The infrastructure needed to deliver users' needs will vary, with the market largely deciding which elements of 5G are needed in different places, based on where demand and potential applications provide added value and cost-effectiveness. It is possible that the more complex and expensive capabilities of 5G may only be cost-effectively deployed in a limited number of locations.

However, the Government will use the 5G testbeds and trials programme to test use cases in both rural and urban areas and to improve our understanding of the economics of infrastructure deployment in different scenarios and locations, and how infrastructure can be deployed in a cost-effective way.

Government action to encourage deployment of new fibre

5G will not purely be a single end-to-end network like earlier generations of mobile technology. It could lead to further convergence of existing mobile infrastructure and technology with fixed networks. It is possible that the evolution towards 5G means that wireless operators will need to be able to work ever more closely with fixed line providers. 5G itself also potentially offers an alternative to fibre over the so-called "final mile".

It is clear that in any scenario, 5G will need large amounts of fibre connections for mobile backhaul. Although in more remote areas it is possible to use fixed wireless links for backhaul, the need to transport the higher rates of data possible over 5G will make access to fibre a vital element of 5G rollout, particularly for smaller, high-capacity cells. This will go hand-in-hand with the growth of full-fibre networks.

The bulk of the investment required for both fibre and 5G roll-out will come from the private sector. The Government is supporting fibre roll-out through a number of initiatives, including:

- the 100% business rate relief for new full-fibre infrastructure for a five year period announced at Autumn Statement 2016; and

- the £400 million Digital Infrastructure Investment Fund which will make available much needed finance to smaller fibre network providers.

Starting in 2017, the Government will invest £200 million to fund a programme of local projects to test ways to accelerate market delivery of new full-fibre broadband networks. This programme will make better connections available to business and residential premises across the UK and help to deliver fibre connections that will support 5G.

The Government's full-fibre and 5G programmes will help to develop our understanding of how these technologies will be brought together and the challenges around the fibre that will be required. **The Government recognises that having access to fibre is a critical limiting factor in the deployment of 5G and will continue to drive the deployment of new fibre networks. We will also work with Ofcom to ensure that operators can get fair access to fibre on reasonable terms and explore the scope for a duct and pole access remedy as part of the next Business Connectivity Market Review, for the purposes of supporting 5G deployment.**

Infrastructure sharing

The Government agrees with the NIC that infrastructure sharing, in compliance with competition rules, can be an effective and economically efficient way of delivering telecommunications infrastructure, especially in areas where it is uneconomic to deploy competing infrastructure networks. However, we are also mindful of the need to protect investment incentives.

Passive vs. Active infrastructure sharing

Broadly speaking, infrastructure sharing can be broken into two categories - passive and active.

Passive sharing is usually defined as the sharing of space or physical supporting infrastructure that does not require active operational coordination between network operators. Site and mast sharing are considered to be forms of passive sharing[26]. Active sharing is where operators share a Radio Access Network (RAN) or other active elements, such as in network roaming.

Within the context of the action outlined below, we will consider issues relating to both passive and active infrastructure sharing.

Mobile networks have already seen consolidation through joint ventures between Vodafone and Telefonica (CTIL) and between EE and Three (MBNL). Independent infrastructure providers that lease capacity on masts to several network operators provide a similar benefit. The Government is also looking to ensure that infrastructure delivered as part of the new Emergency Services Network can be made available for shared use, where possible.

We recognise that regulatory and legal frameworks can impact the extent of infrastructure sharing. **The Government will work with Ofcom to identify and tackle unnecessary barriers to infrastructure sharing and will explore the potential for a clearer and more robust framework for sharing, while preserving investment incentives. We will report on progress by the end of 2017.**

Commercialisation of 5G technologies

As mentioned elsewhere in this document, 5G is an evolving technology and its development and deployment at a commercial scale is still some way off.

It is widely recognised that a typical cycle of activities for the development and deployment of new uses of technologies consists of four phases:

• phase 1 - research and development, where technologies are initially developed;

---

[26] http://www.gsma.com/publicpolicy/wp-content/uploads/2012/09/Mobile-Infrastructure-sharing.pdf

- phase 2 - testbeds and trials, to further develop, test and iterate solutions working with industry sectors for use cases;

- phase 3 - early deployment infrastructure, where following phase 2, early commercial trials can commence to scale and create early deployment infrastructure; and

- phase 4 - full commercialisation.

The Government's programme of 5G testbeds and trials will primarily be focused on 'phase 2' and will be developed in the context of a much larger set of related activities across the UK. These activities, including projects focused on smart cities and IoT, are helping to build the case for 5G networks as well as helping to build expertise and commitment to the digital economy amongst local areas and industry. The Government's approach will be to coordinate with, and build on, such initiatives.

Examples of such projects include:

- *Bristol Is Open*. This is a joint venture between the University of Bristol, Bristol City Council and industry partners Nokia and NEC to explore new forms of 'on-demand' network connectivity using fibre, 3G, 4G and 5G, and an IoT mesh network across the city. This software defined network is used to support research and development initiatives that contribute to the development of smart cities and IoT.

- *Aberdeen City Council* has ensured that new digital infrastructure in the city is available to all network providers in order to maximise connectivity. Over a two-year period, representatives from the Council and the Wireless Infrastructure Group (WIG) have worked together to develop plans to launch a 5G-ready small cell network connected by fibre in the city.

- *City Verve, Manchester*. This is a project funded by DCMS as part of the IoTUK programme to test services using IoT technology in healthcare, transport, energy, and culture. It includes plans for talking bus stops, which let bus operators know when commuters are waiting, and a network of sensors in parks and along commuter routes to encourage people to do more physical activity.

- *Brighton 5G testbed.* A project to support the local digital sector to develop applications for common 5G use cases, run by the Digital Catapult and Digital Catapult Centre Brighton.

- *Keele Campus Smart Energy Demonstrator*. This project has made the campus of Keele University into a giant 'laboratory' where new energy-efficient technologies can be researched, developed and tested in a real world environment.

- *University College London's TRIANGLE project* is building a framework to help application developers and device manufacturers to test and benchmark new mobile applications in Europe, utilising existing and extended testbeds.

- *BT and Nokia* are working together to research potential customer use cases for 5G technologies and are conducting trials focusing on the technology enablers for 5G.

- *Future Cities demonstrator, Glasgow*. This is a project to make Glasgow a smart city by using open data sources in order to create a range of services to make the city safer, smarter and more sustainable.

- *Digial Greenwich*. This is an initiative to implement the borough's 'smart city' strategy, which, amongst other things is transforming the way that their services are managed while also managing an innovation fund to pilot new approaches and ideas for the borough.

- *The Centre for Connected and Autonomous Vehicles*. A joint Department for Transport (DfT) and Department for Business, Energy and Industrial Strategy (BEIS) programme, set up to keep the UK at the forefront of the development of connected and autonomous vehicle technologies.

- *The City of London Corporatio*n has announced that it will be replacing and upgrading its current free Wi-Fi service to support gigabit speeds and to help foster a future 5G network. The new network will be rolled-out in early 2017 and will be accompanied by over 400 small cells to boost the strength and reliability of the current wireless coverage by using street objects like lampposts, street signs, buildings and CCTV columns.

- *Arqiva and Samsung* have recently launched a 5G fixed-wireless access technology in central London designed to deliver mobile broadband to consumers.

- *Ericsson, BT and King's College London* have agreed a multi-year collaboration on 5G testing and development, focused on creating 5G use cases in commercial and consumer markets, with particular focus on mission-critical services such as medical applications.

- *Agricultural Engineering Precision Innovation Centre*. A consortium of key organisations in the field of precision agriculture and engineering to help the UK's agri-food sector develop advanced technologies that will increase productivity and sustainability in UK agriculture.

In 2012, the Government invested £12 million in the 5G Innovation Centre (5GIC) at the University of Surrey, which has in turn leveraged significant co-investment from industry and regional partners. The 5GIC is the UK's largest academic research centre dedicated to the development of the next generation of mobile and wireless communications. It brings together leading academic expertise and key industry partners to help to define and develop 5G infrastructure that will drive the delivery of mobile communications and wireless connectivity capable of meeting the needs of tomorrow's connected society and digital economy.

As far as possible, the Government expects to build on existing projects through the 5G testbeds and trials programme and will work with the private sector as appropriate to help prove where and how 5G can be commercialised.

Skills

Delivering the necessary fibre, masts, small cells and network capabilities to ensure a seamless 5G experience around the UK will also require sufficient civil engineering capacity and technical skills in the supply chain. At present, the UK has a supply of specialist skills. The existing workforce that is delivering communications projects, such as extending 4G coverage or building new fibre networks, may be able to be refocused towards delivery of

5G. However, we are mindful that a lack of available workers to install the necessary infrastructure would delay deployment and full exploitation.

The Government will investigate skills requirements through the 5G testbeds and trials programme and continue to monitor labour market trends to assess availability, and may take action when and where appropriate to support delivery. As we leave the EU, it will be even more important to ensure that we continue to develop our home-grown talent, up-skill our workforce and develop the specialist digital skills needed to maintain our world leading digital sector.

We also want everyone to be able to use the digital services enabled by 5G applications so they can reap the financial, health, social and other benefits they offer. This means ensuring that people and businesses have the digital skills necessary to use them. The Government is already working with industry, businesses, and the voluntary sector to increase digital capability, including through creation of the Digital Training and Support Framework to ensure government can efficiently and effectively procure the necessary support for citizens who have do not have the necessary digital skills, confidence or access. The Government's Digital Strategy has also announced a number of measures that will give businesses and the public the wider digital skills they need.

5. Fit for purpose regulations

5G is still an undefined technology. Industry has produced a very expansive 5G vision, and whilst the limits of that vision are a matter for industry, the speed of technological progress means that a flexible regulatory framework is needed to keep pace with developments and innovations. This section sets out the steps that the Government will take to create a regulatory framework that accelerates investment in infrastructure and helps to create opportunities for UK businesses at home and abroad.

<u>Planning regulations</u>

Planning regulations are a key factor influencing a network infrastructure provider's ability to expand its network, as they govern where sites can be built and the physical appearance of the equipment that can be installed on such sites. As noted elsewhere in this document, the deployment of 5G will require a significant increase in the number of small radio cells - likely to be located on street furniture, the sides of buildings etc. - in order to facilitate the requirements of 5G networks. Therefore, flexible and fit for purpose planning regulations will be required to support the deployment of 5G networks.

The Government has already introduced planning reforms in England which include a significant relaxation of restrictions on the siting and installation of small cells that will support both 4G and future 5G rollout. In particular we have:

- legislated for additional permitted development rights for taller mobile masts;

- removed the threshold for placing small cell antenna on commercial buildings/structures to support mobile rollout. This means MNOs can deliver a greater number of small cells to handle greater mobile capacity on their networks for 4G and, subject to how it will operate, 5G;

- brought into effect new building regulations which require all new buildings and existing buildings undergoing major renovations to have infrastructure capable of delivering superfast broadband greater than 30Mbps; and

- brokered an agreement between Openreach and the Home Builders Federation (HBF) to offer full-fibre To The Premise (FTTP) for all new developments, either free or as part of a co-funded initiative. Agreements are now being reached between other infrastructure providers and the HBF to deliver FTTP to new builds.

However, given the sheer scale of infrastructure envisaged within 5G networks, there may still be a case for going further. That is why **we will set out by the end of 2017 whether the Government believes further changes are needed to the planning and regulatory system to meet the unique challenges of 5G infrastructure deployment.** We will review this on a regular basis, as our understanding of these issues improves through the implementation of the 5G testbeds and trials programme.

The Electronic Communications Code

The Government is currently taking forward much needed reforms to the Electronic Communications Code that will directly address investment barriers, lower the cost of infrastructure deployment and encourage long-term investment in digital infrastructure. Specifically, this will provide:

- a new valuation basis which will drive down the cost of infrastructure deployment and incentivise investment in new areas;

- stronger rights for operators to share and upgrade apparatus; and

- a clearer distinction on the role of operators that will protect their investments in infrastructure from additional regulated access or pricing.

We will actively explore further ways to reduce the cost of deployment and operation of network and other related digital infrastructure, working closely with central and local government and industry in order to maximise the commercial case for early, rapid and widespread deployment of 5G.

Other regulatory issues

5G will enable the creation of many new applications and technologies across a range of different industries. Some of these new applications will be created for use in regulated industries (e.g. financial services), and, as they develop, it will be important to ensure that the regulatory frameworks in which they operate do not inhibit their development unnecessarily. Achieving this will require a balance between supporting innovation and providing adequate protections for businesses and consumers.

We will use the 5G testbeds and trials programme to improve our understanding of the different regulatory regimes in which 5G applications and services will operate, working with the UK's regulatory authorities as appropriate, and report back by the end of 2018.

6. Local areas - governance and capability

The Government believes that local authorities have a critical role in ensuring the successful delivery of digital infrastructure: directly through active engagement with the telecoms sector or by allowing access to public sector assets; and indirectly through local planning policies. Devolving powers, budgets and responsibilities to local areas supports local decision making to address productivity barriers and drive local growth.

This section sets out the actions that the Government will take, together with local areas, industry, and landowners, to make sites available for infrastructure development and to deliver mobile telecommunications that reflect the needs of local areas.

Providing suitable sites for infrastructure

As the NIC noted[27], the significant volume of sites required in dense urban areas will require support from local government to ensure networks can expand to meet future requirements.[28] The NIC also identified a need for MNOs to bring together their network expertise with that of local authorities, who best understand their area and can provide an accurate picture of its requirements.[29]

The Government agrees that there will be a significant challenge both in finding suitable sites for 5G infrastructure and ensuring that telecoms networks meet local needs. In recognition of the fact that to deploy a network of small cells, operators will have to undertake more complex network planning than they have done for previous mobile generations, **the Government has commissioned research into a 5G mapping tool to catalyse the development of expertise in network planning for small cells using spectrum at and above 24 GHz.** This will not only accelerate deployment of millimetre wave systems in the UK but also lead to opportunities for the UK to export expertise in network planning. The initial research is expected to be delivered by the end of April 2017.

---

[27]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577906/CONNECTED _FUTURE_ACCESSIBLE.pdf
[28]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577940/5G_Infrastruc ture_requirements_for_the_UK_-_LS_Telcom_report_for_the_NIC.pdf
[29]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577906/CONNECTE D_FUTURE_ACCESSIBLE.pdf

---

Research into a 5G mapping tool

Mobile network planners need to take into account the location of things that are likely to weaken or block the signal from their masts - for example trees, buildings or lamp-posts. This is going to be particularly important for 5G, which uses high-frequency radio waves that do not travel as far as those used for 4G.

In preparation for 5G, the Government has commissioned a consortium of experts from Ordnance Survey, 5GIC and the Met Office to better understand how very high-frequency radio waves travel and the physical factors that would need to be mapped to plan a network of small cells effectively.

The study will consider how radio waves behave in urban, suburban and rural locations. In doing so it will inform thinking on the deployment of infrastructure in the UK.

The public sector will have a critical role to play in providing sites for 5G infrastructure. The Government is already taking steps to address this and will shortly be publishing a Digital Infrastructure Toolkit that sets out the terms for access to central government buildings. This toolkit will be revised as necessary to reflect changes and innovations in the market. **However, a more radical approach to opening up government buildings and land for mobile infrastructure development could be needed in future and we will set out our proposed approach by the end of 2017. We will also work with other parts of the public sector to encourage them to take similar steps to open up their assets for the purposes of supporting 5G infrastructure.**

Local policy frameworks

The Government agrees with the NIC that local areas have a critical role to play in facilitating the deployment of mobile telecommunications infrastructure and are already doing so in many areas. Through its Housing White Paper, 'Fixing our broken housing market',[30] **the Government is consulting on requiring local authorities in England to have planning policies setting out how high quality digital infrastructure will be delivered in their area.**

Industry and local areas working together

Outside of the planning policy framework, the **Government believes that there may also be a case for encouraging and supporting local areas to develop broader plans to deliver local mobile connectivity**. These local connectivity plans would articulate how an area will meet its connectivity needs and ideally should be developed through engagement with key interested parties including Local Enterprise Partnerships and the telecommunications industry. **The Government will consider further what these plans**

---

[30]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/590463/Fixing_our_broken_housing_market_-_accessible_version.pdf

might look like with the intention of producing some guidance on best practice in 2018.

The Government will take account of the presence of local connectivity plans and evidence of taking a proactive approach when allocating funds to local projects through the selection process for both local fibre and 5G testbeds and trials programme funding. Government would expect to see, for example, engagement with relevant Local Enterprise Partnerships, supportive planning policies, Chief Technology Officers and asset registers.

The 5G testbeds and trials programme will seek to evaluate different local models for facilitating the deployment of 5G infrastructure in different types of area such as urban and rural, and both single and two-tier Local Authorities and will consider this as part of any selection process to award funding. Trials will consider how high-quality design can minimise the impact of digital infrastructure on the built environment in order to make deployment more effective.

The contribution of industry is also vital in helping local authorities and other local groups to understand potential costs and benefits of infrastructure roll-out. **The Government will, therefore, establish a working group comprising representatives from local areas, government departments, landowners and industry with the aim of providing an accurate picture of local area requirements for the deployment of 5G networks. This group will also allow government and industry to share knowledge of 5G network planning and will feed into the new centre of 5G expertise in DCMS.** In time this could develop into a number of groups divided into different regions and areas of the UK, taking a more targeted and local approach to connectivity in different areas.

7. Coverage and capacity - convergence and the road to 5G

This section sets out actions that the Government is taking to improve mobile network coverage now, and how it will benefit and accelerate the rollout of 5G networks. It also addresses specifically the NIC's recommendations in respect of coverage on roads and railways.

Current coverage levels

Mobile coverage in the UK continues to increase. Ofcom's latest coverage statistics indicate that 4G coverage is now available to 96% of UK premises and over 70% of UK landmass.[31] This has been driven by the UK's competitive mobile market as well as licence obligations on MNOs which require each operator to deliver voice and text coverage to 90% of the UK by the end of 2017, and requires O2 to deliver indoor 4G coverage to 98% of UK premises, also by the end of 2017. As a result of these obligations, by the end of 2017, 98% of the UK landmass and premises should have 4G coverage from at least one MNO.

The evolution from 3G to 4G in the early part of this decade has brought forward applications that were unforeseen just ten years ago. These innovations have led to significant increases in data use that will only continue to grow and therefore place greater demands on network capacity. However, the path to a 5G future is unlikely to replicate the linear progression from one mobile standard to the next that we have seen to date. Rather, the evolution towards 5G is likely to require wireless networks to align ever more closely with fixed line networks. At the same time, 5G networks will work alongside and build on existing 4G networks, which will form the infrastructure spine for the next generation of mobile networks and support many of the things that we currently think of as 5G use cases. We therefore need to take action now to ensure further improvements in our existing mobile networks.

The Government agrees with the NIC that there should be high quality coverage where people live, work and travel. We are looking at how we can make sure that 4G networks are deployed to a scale and quality that will meet this ambition, while also supporting investments that will enable future 5G networks. This will mean that networks will need to go further than the requirements of the current licence obligations both in terms of coverage and quality. We will set out by the end of 2017 what the essential elements of high quality coverage where people live, work and travel are, and how we will achieve this as soon as is practical, but no later than 2025.

The NIC cites evidence suggesting that there is a gap between consumers' experience of the mobile services that they receive and the coverage reported by operators and government. The Advertising Standards Authority (ASA) is the UK's independent regulator of advertising across all media and is responsible for taking action against advertisements which are misleading in contravention of the UK Advertising Codes. The ASA already has

---

[31] Ofcom Connected Nations 2016 report https://www.ofcom.org.uk/__data/assets/pdf_file/0035/95876/CN-Report-2016.pdf

rules that can be used to address any misleading representations of mobile coverage in UK advertising and, as with all of its rules, keeps these under continual review. If the ASA sees a pattern emerging that coverage is being advertised in a misleading way, it may consider sector compliance activity or provide guidance to industry. In this instance the Government would encourage the ASA to take whatever action it considers appropriate.

The NIC also recommended that the Government and Ofcom should develop a meaningful set of metrics that more accurately represents the coverage people actually receive. The Government believes that we should work to reduce the current multiplicity of metrics being used to a small number shared across government, Ofcom and industry. **The Government agrees that the reporting of coverage should provide a genuine and meaningful reflection of the services experienced by customers and will ask Ofcom to set out how this will be achieved by the end of 2017 for existing services.**

We note the difficulties of establishing metrics for 5G in the future, particularly when the technology is in development and each individual 5G service or application may have different requirements around latency and reliability as well as download speeds. We believe agreements between vertical service providers and 5G network operators may have a role in defining performance standards for services. For voice and data services, better metrics may be more achievable, but this depends not only on MNOs' networks but also on the characteristics of the mobile phone or other device receiving the signal and its location.

Subject to the development of suitable metrics, the Government will consider how it might best use these metrics to inform future policy.

Spectrum

Radio spectrum (often simply referred to as spectrum) is the range of radio frequencies over which wireless services are delivered. That includes broadcast television, radar, mobile phones and mobile broadband, GPS, Wi-Fi and any other wireless service. Spectrum is the lifeblood of digital communications and 5G will require spectrum at several different frequencies.

MNOs currently hold spectrum licences to operate mainly in the 800MHz, 900MHz, 1400 MHz, 1800MHz, 2100MHz and 2600MHz bands; and in the past, obligations to provide a certain level of geographical coverage have been placed in new spectrum licences.

Spectrum is finite - you cannot make more of it - so it has the potential to become congested. It therefore becomes increasingly important to use it as efficiently and effectively as possible.

Like previous generations of mobile technology 5G will rely on having available sufficient radio spectrum of the 'right kind'. With so many modern technologies relying on spectrum it is important to look to maximise the opportunities for sharing spectrum and to consider how we deal with changes of use of spectrum. This is covered in more detail in section 9.

Geographic coverage of 5G

5G will deliver flexible networks by making use of multiple spectrum bands. This will include the highest frequency spectrum, which offers huge potential connectivity benefits, but is only able to transmit data across very short distances compared to the frequencies that are currently used to deliver mobile services. Therefore, its deployment is likely to be restricted to connectivity 'hot spots' and will be supported by the building of many so-called 'small cell' radios as well as a dense fibre network. There will, however, be other aspects of 5G technologies that are suitable to be deployed more widely. As mentioned previously, the Government will use the 5G testbeds and trials programme to improve our understanding of the economics of infrastructure deployment in different scenarios and locations, and how infrastructure can be deployed in a cost-effective way.

If 5G is to live up to the vision of providing users with apparently seamless and limitless capacity then it will require a 'layer' with good geographical coverage but relatively limited capacity. As noted below, different spectrum bands are useful for different purposes, with lower frequency bands such as 700 MHz being suitable for providing coverage over a wide geographical area. 'Capacity' spectrum at 3.4 GHz, for example, has a much shorter range but can support faster data transfers than 700 MHz, while millimetre-wave spectrum 5G cells operating at or above 24 GHz are even shorter-ranged and faster.

In the past, obligations to provide a certain level of geographical coverage have been placed in new spectrum licences. As Ofcom has previously noted, for 'intermediate' bands such as 3.4 GHz spectrum, a simple geographic coverage target is unlikely to be appropriate.[32] Consideration could be given to more targeted coverage, either regional or covering a particular type of area, to improve areas perceived as weaker in overall coverage such as specific roads or rail routes.

For the highest frequencies (24+ GHz) there may be a need to coordinate use to avoid interference, but the Government agrees with the NIC's view that extensive coverage obligations are unlikely to be appropriate. The key factor driving coverage is more likely to be the overall commercial viability of deployment and operation for the network provider and permission from the owner of the building or other infrastructure to install equipment.

Since licences for mobile broadband are valid indefinitely, subject to a five-year notice period, new coverage requirements in practice need to be agreed by mobile operators, as happened in 2015 for example. Extending coverage via spectrum licences could potentially be achieved with other methods not previously employed. For example, a suitable mechanism for adding new coverage obligations to existing licences could be beneficial. One idea for this is that a "reverse auction" could be used to determine an appropriate level of subsidy (perhaps delivered by a reduction in the annual licence fees for an existing MNO spectrum licence). Network operators would bid a lower subsidy level, with the winning bidder receiving the subsidy for a specified period in return for accepting a binding coverage obligation on their licence(s).

---

[32] *Making communications work for everyone: Initial conclusions from the Strategic Review of Digital Communications*, Ofcom, February 2016,
https://www.ofcom.org.uk/__data/assets/pdf_file/0016/50416/dcr-statement.pdf

The review that the Government will ask Ofcom to carry out of the scope for the spectrum licensing regime to facilitate better 5G deployment at national, regional and local scales should include issues of promoting growth of 5G coverage for a range of possible use cases.

Coverage on road and rail

Connectivity on the UK's road and railways has improved over time, but it is clear that there is considerable room for further improvement. As well as being an issue to address now, improving coverage on our main transport routes will also be desirable for 5G. However, the required infrastructure will not come cheaply and deploying it will present some practical challenges.

With regard to the UK's motorways and other major roads, the NIC notes the importance of meeting both the long-term operational needs of connected vehicles and the connectivity needs of passengers, and of ensuring that best use is made of existing infrastructure, such as masts, poles, ducts, power supplies and the roadside fibre network.

Government policy is already helping to improve connectivity across the UK, including on roads. For example, the existing licence obligations on mobile operators will extend geographic mobile coverage in general. Furthermore, as part of the new Emergency Services Network, new masts are being built specifically to provide emergency vehicles with mobile coverage on roads. The Government is also looking to ensure that they can be made available for shared use, where possible. Where such masts are deployed for commercial coverage then this will deliver improved connectivity for consumers.

However, the Government agrees that in the future it will be important to have greater connectivity on the UK's transport networks to support new ways of travelling and working. The Commission's report highlights the potential for commercial provision of telecommunications services on our transport networks. **The Department for Transport (DfT) and DCMS will work with industry to assess the potential for commercial delivery models and how new and existing infrastructure can be used to support them, and will report back by the end of 2017.**

The Government will also consider funding live trials where there is potential for wider UK benefit as part of the 5G testbeds and trials programme, particularly where this could build on other work such as the planned A2/M2 connected corridor or the connected and autonomous vehicle testbeds programme announced at Autumn Statement 2016. In this way, we will look to gain further insights into the challenges and benefits of the deployment of 5G and related technologies on the motorway network ahead of any proposed national rollout.

In respect of the rail network, the Government agrees with the NIC that we need high capacity wireless connectivity for UK rail passengers to help boost productivity and provide a better consumer experience when travelling by train. The Government accepts that there is further to go to have world-class connectivity on the rail network. Some progress is being made, and by the end of 2019, the Government's Wi-Fi on trains policy will mean that almost all train routes will provide free Wi-Fi to passengers. To improve this further, Train Operating Companies will be required to deliver minimum connectivity standards as part of their franchise agreements.

Furthermore, Network Rail is engaging with industry to assess potential trackside solutions, such as Project SWIFT in Scotland, which will provide dedicated Wi-Fi connectivity through trackside infrastructure to trains between Glasgow and Edinburgh. This work will inform our thinking on whether this model could deliver greater improvements at a faster pace.

The NIC report highlights the potential for commercial provision of telecommunications services on our transport networks. As with the road network, **DfT and DCMS will work with industry to assess the potential for commercial delivery models and how new and existing infrastructure can be used to support them, and will report back by the end of 2017.** This will include consideration of models for delivering better 4G connectivity on the rail network to help to pave the way for excellent 5G connectivity.

The Government will also consider funding live trials where there is potential for wider UK benefit as part of the 5G testbeds and trials programme, particularly where this could build on existing or planned projects around railway connectivity. Any trials will also help to deliver benefits to passengers from improved connectivity.

Other recent reports have highlighted similar issues with coverage on road and rail. In particular:

- Analysys Mason highlighted the challenging economics of ensuring coverage on road and rail, and recommended "allowing network sharing and pre-installing 5G (i.e. making cabinet, power and fibre available)" to improve coverage;[33]

- in their work for the NIC, LS Telecom indicated that there was spare fibre capacity and duct space that could be readily used by third party operators to provide better wireless coverage and to deliver high speed connectivity to vehicles enabling numerous transport-related applications;[34]

- LS Telecom also suggested that deployment of a new wireless network on railways would be costly and time consuming, given the access limitations. Any new infrastructure should therefore be pre-equipped with the necessary capabilities to support the new mobile technologies that are being developed; and

- Real Wireless suggested an analysis of the benefits and challenges in deploying cell sites along the rail and road corridors using land owned by the rail and road operators to highlight the opportunities of deploying shared infrastructure where rail and road networks run close to each other.

The Government will consider the range of issues concerning road and rail coverage in its reports on delivery model options. Where telecoms regulation is identified as a potential barrier, it will involve Ofcom in discussions as appropriate to determine how best to deliver the Government's coverage objectives.

---

[33] http://www.analysysmason.com/Research/Content/Reports/investment-in-5G-and-IoT-infrastructure-Dec2016/
[34] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577940/5G_Infrastructure_requirements_for_the_UK_-_LS_Telcom_report_for_the_NIC.pdf

8. Ensuring a safe and secure deployment of 5G

This section outlines how the Government's programme of 5G testbeds and trials will seek to leverage the UK's expertise and strength in cyber security, working with organisations such as the National Cyber Security Centre (NCSC), to help ensure that the UK maximises the benefits of 5G. It also outlines how we will work to improve the public's understanding of 5G, including the potential productivity and efficiency benefits.

Developing fit for purpose 5G security systems

Given the technological advances that 5G will enable, the increased data flow, and the wide-ranging impact that new 5G applications and services will have on modern life, it will be important to ensure that 5G networks and services are deployed in both a safe and secure manner and in a way that the public understands and accepts. For many existing and emerging technologies, security is being addressed through the technical standards work described in section 10 of this strategy.

Robust and fit for purpose security architecture needs to be at the centre of 5G development to ensure privacy and customer security. Customers will not adopt 5G-enabled services if they do not have confidence that their information will be handled securely and if adequate privacy protocols are not in place. At the same time, we must maintain the flexibility and ability to increase the scale of capacity that 5G infrastructure may need to offer in future.

The 5G testbeds and trials programme will work with organisations such as the NCSC to support the development of new security architectures that meet the expectations of customers and the needs of 5G services and applications. The Government will promote solutions that support all parts of the communications and applications chain, to seek cost effective and adequate security for providers and users.

We recognise that the public is, as yet, largely unaware of 5G and the potential benefits that it will bring. **The 5G testbeds and trials programme will also explore, along with other government bodies, how to improve the public's understanding of the opportunities and potential of 5G and the different applications and services that it will offer.**

Building on UK expertise

The Government believes that one of the key strengths the UK brings to 5G development is its expertise in cyber security.

We will align our work on 5G security with the objectives of the Cyber Security Strategy, and seek to leverage the considerable cyber security knowledge of the UK through the 5G testbeds and trials programme. The Government will also look to define implementation guidance with industry to ensure best practice is achieved in network deployment. Where appropriate, regulations (privacy regulations, law enforcement etc.) will also be considered to ensure underpinning security issues are covered adequately.

In addition, we are building on the Government's "Secure by Default" initiative[35] to investigate and support how manufacturers and providers can best provide secure electronic systems and services. This programme of work will ultimately enable the UK to achieve a proactive stance in addressing 5G security issues, so that they can be identified during the shaping of new 5G networks and services. Such a position will ensure a stronger security posture at the outset of any service delivery and reduce the need for more costly re-engineering after deployment.

The Government will monitor and support the development of 5G security technology through the NCSC. The 5G testbeds and trials programme will feed into this work.

---

[35] Work that is happening across government, industry, procurement and the user community to ensure that security products are enablers to more effective and efficient working

9. Spectrum

This section outlines the key spectrum-related issues that will need to be taken into account to support the rollout of 5G networks; which frequency bands might be used; and the actions that the Government will take to accelerate the deployment of 5G networks. It builds on Ofcom's recent update on spectrum for 5G.

The Government's Spectrum Strategy

The most recent Spectrum Strategy[36] was published in March 2014, setting out measures to maximise the benefits from spectrum use to the UK economy, such as spectrum release and sharing. A recent review of the strategy was conducted, with input from industry and Ofcom, following the outcomes of the World Radiocommunications Conference 2015 and the Government believes it remains fit for purpose. In particular, the strategy's increased emphasis on spectrum sharing, including by government, and focus on new technologies (including 5G) remains the right one for the UK. However, three years on we can say more about the right spectrum policies to support our ambitions for 5G: making new spectrum available in a timely way, flexibility in how spectrum can be used (potentially including one or more forms of spectrum sharing, for example) and a licensing regime that takes account of the different geographic scales on which the various 5G bands are likely to be deployed.

These policies are complemented by Ofcom's Spectrum Management Strategy which sets out the measures it plans to take, again with a major focus on 5G mobile.[37] Ofcom's strategy is also expanded into specific strategies for areas such as space and mobile data[38][39]. Ofcom has recently published an update on spectrum for 5G. [40]

5G spectrum needs

Indications are that demand for additional spectrum for 5G, on top of existing allocations to mobile, will be high. Ofcom, as the UK's independent spectrum regulator, has said that it will "ensure that spectrum is made available in the most appropriate and timely way to enable investments, innovation and competition in the development of 5G services to benefit consumers and businesses"; the Government agrees that this is necessary and welcomes Ofcom's commitment. It is not just about releasing new spectrum but also about refarming and repurposing existing spectrum to provide the wide range of frequencies to which 5G will need access. Ofcom's recent update on spectrum for 5G[41] sets out what it is doing to ensure that spectrum is not an inhibitor to mobile data growth and early 5G roll-out.

---

[36] https://www.gov.uk/government/publications/spectrum-strategy
[37] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/71436/statement.pdf
[38] https://www.ofcom.org.uk/consultations-and-statements/category-1/space-spectrum-strategy
[39] https://www.ofcom.org.uk/consultations-and-statements/category-1/mobile-data-strategy
[40] *Update on 5G spectrum in the UK*, Ofcom, 8 February 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf
[41] https://www.ofcom.org.uk/__data/assets/pdf_file/0021/97023/5G-update-08022017.pdf

Modern mobile networks need a variety of spectrum with different frequencies providing different key components. Low frequency spectrum tends to offer better coverage, travelling distances and giving in building coverage, at the expense of data rates (i.e. speed). High frequency spectrum offers shorter coverage distances but substantially higher data rates. We expect that 5G will need a mix of low, medium and high frequency spectrum, some of which will be 'new' spectrum and some will be 'refarmed' spectrum, previously used by other services or even shared with existing services.

We agree with the NIC that the regulatory regime for spectrum needs to be fit for purpose and kept under review. The Digital Economy Bill contains several measures to increase the flexibility within that regime, such as new powers to help Ofcom make best use of dynamic spectrum access techniques to allow secondary use of licensed spectrum when it is unused by the existing user. These, and other spectrum sharing solutions, have the potential to play a greater part in improving the availability and quality of mobile services.

The Government keeps the regulatory regime for spectrum under regular review. It is sympathetic to the wishes of sub-national or regional and local service providers to obtain access to spectrum to enable them to meet the needs of unserved or poorly served areas, where this would lead to a more efficient use of spectrum.

The Government will ask Ofcom to review and report back to DCMS by the end of 2017, the scope for the spectrum licensing regime to facilitate better 4G and 5G deployment at national, regional and local scales, including in-building usage. This would also include issues of promoting growth of 5G coverage for a range of possible use cases. The Government will define coverage objectives and will work with Ofcom to determine how best to deliver these.

5G candidate bands

Spectrum use is international; frequencies available in the UK only would be expensive to use without the economies of scale for network equipment and device manufacturers that come from harmonised bands. So we need to secure outcomes that are advantageous to the UK from international negotiations (within the whole of Europe within CEPT - the European Conference of Postal and Telecommunications Administrations - and across the world at the International Telecommunications Union's World Radio Conferences). Ofcom, operating under a Direction from government, represents the UK at these negotiations and is tasked to secure the best outcomes against UK priorities.

Given this background, and in the light of Ofcom's recent update on spectrum for 5G, we expect the spectrum bands that become available and suitable for 5G will include (but will not be limited to):

- 700 MHz - (spectrum from 694 MHz to 790 MHz that has previously been used for broadcast television and other services which are being relocated). This band is ideal for coverage and for control frequencies for a future 5G network. This band is being

cleared across Europe. The Government is investing up to £600 million in making the band available in the UK, and Ofcom expects to auction it in 2018/19.[42]

- 3.4 GHz - (150 MHz of spectrum within the band from 3.4 GHz to 3.6 GHz, which is a band suitable for higher capacity than 700 MHz). This band is expected to be auctioned by Ofcom during 2017.

- 3.6 GHz - 3.8 GHz - within Europe the whole of 3.4-3.8 GHz is being considered as a 5G band. In the UK, 3605-3689 MHz is assigned to electronic communications services and currently licensed to UK Broadband. Ofcom has consulted on making the remaining 116 MHz available for mobile services, and intends to issue a further publication in the first half of 2017.

- 24.25 GHz - 27.5 GHz - this band is being looked at across Europe for future 5G use as a harmonised band. Using it would require moving or co-existence with other public sector users in 26.5-27.5 GHz. Ofcom intends to consult in the first half of 2017 on proposals to make all or part of the band available for 5G.

- other candidate bands above 30 GHz. Ofcom particularly notes the potential of 32 GHz, 40 GHz and 66 GHz bands, although it sees the first two as longer-term prospects.

Given the strong prospect of harmonisation of the bands in Europe and their potential for global harmonisation, the Government agrees that Ofcom should support 700 MHz, 3.4-3.8 GHz and 24.25-27.5 GHz as 5G pioneer bands. It also welcomes Ofcom's early publication of its 5G roadmap, scheduled for mid-2017.

The FCCG's report[43] into 5G recommends that the Government should "explore potential to access the 3.8-4.2 GHz range on a shared basis as an extension to adjacent 3.4-3.8 GHz Spectrum and promote this in Europe", and that the Government should use the UK Spectrum Policy Forum (SPF)[44] as a sounding board for future spectrum plans for 5G.

The Government already seeks and considers advice from industry through the SPF, including its valuable work to date on 5G, and will continue to work closely with the forum. Spectrum in 3.8-4.2 GHz spectrum is currently used for fixed satellite services. The opportunity for 5G to share spectrum within 3.8-4.2 GHz would need to be considered by both the Public Sector Spectrum Release Programme that manages government spectrum sharing and the current users of that band. **The Government will work with Ofcom to assess the feasibility of 5G sharing in the 3.8-4.2 GHz band, and to agree clear timescales and milestones for further work.**

The FCCG's report also recommended that Ofcom make available frequencies for 5G test beds and trials. This can already be done under Ofcom's Test and Development (T&D) licences, which allow operation on a non-interference and non-protected basis for testing, development, research and demonstration of radio equipment. A full operating licence,

---

[42] Update on 5G spectrum in the UK, section 3.16

[43] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/582640/FCCG_Interim_Report.pdf

[44] The Spectrum Policy Forum is a pro-active industry-led 'sounding board' to UK Government and Ofcom on future policy and approaches on spectrum.

which may have a different owner, may supersede these licences. It is therefore important that test beds and trials make credible arrangements for operation of their networks in the longer term so as to become part of wider 5G roll-out.

Refarming

Another significant opportunity for 5G spectrum will come from so-called 'refarming' of existing spectrum already in the hands of mobile network operators. Licences issued by Ofcom are generally service and technology-neutral. That means that an operator could move one service out of a given band and deploy a different service as long as the overall emissions from the band fall within defined limits. It is likely that some of the spectrum that ultimately gets used for 5G will come from such refarming.

Unlicensed Spectrum

Not all spectrum use is licenced. Unlicensed use is very important to the economy, not least through the value derived from Wi-Fi use in both 2.4 GHz and 5.0 GHz bands. One potential pitfall for unlicensed use is that it comes without any protection from interference. Licensed spectrum will therefore still be needed to deliver reliable, high quality and wide coverage networks, but it is possible that 5G will be able to make use of a combination of licensed and unlicensed spectrum to deliver higher capacity in some circumstances. Therefore it is important that when a band is released or shared the UK considers whether unlicensed use is both possible and practical. Ofcom has been looking at extending Wi-Fi use from the 5.0 GHz band into adjacent bands.
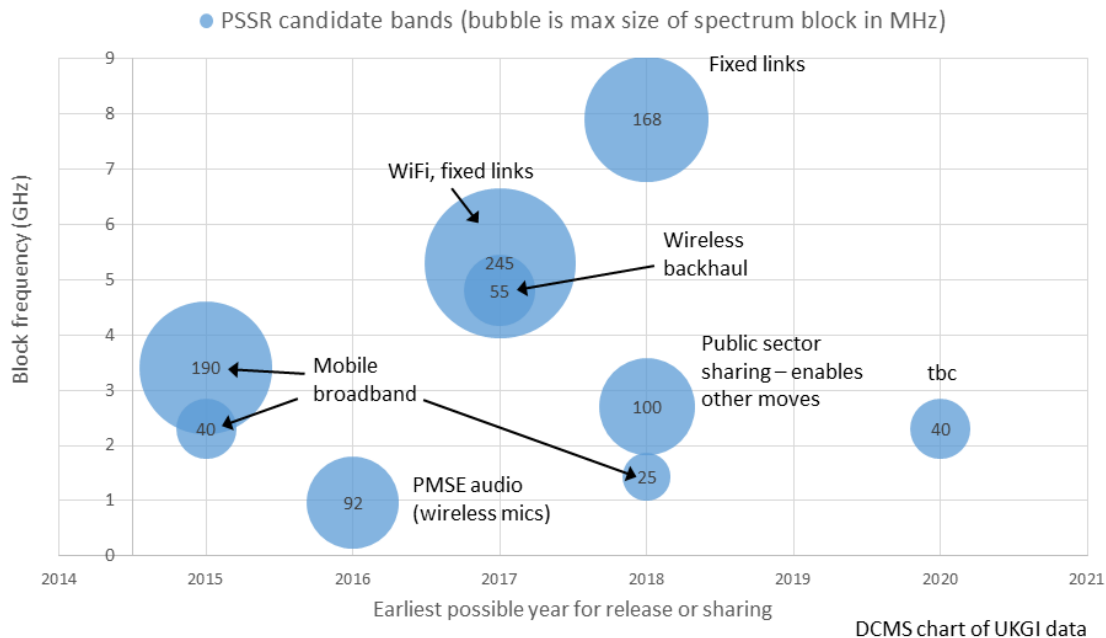
Similar issues apply to the radio networks likely to be used for the IoT. IoT communications can be carried over cellular networks using technologies such as NB-IoT (the NB stands for Narrow Band). But similar low power wide-area (radio) networks (LPWAN) can also operate in licence-exempt spectrum. 5G networks therefore may or may not be used for a particular IoT application - there is a choice of competing technologies.

Spectrum Release

Since 2010, government has been running the Public Sector Spectrum Release (PSSR) Programme to release spectrum from public sector use to private sector use and enable new services and new uses to benefit the UK economy.

PSSR spectrum bands overview

This chart shows up to 955 MHz of spectrum for release or sharing and the earliest year in which some or all of the band may become available.

Overview of public sector spectrum release candidate bands under 10 GHz, as of March 2017. Mobile broadband spectrum is potentially usable for 5G.

The April 2016 update from the UK Government Investments team managing the programme, the Central Management Unit (CMU), highlights that 384 MHz has been released from public sector use since 2010 and sets out from where future releases are likely to come.[45] The initial target was to release 500 MHz of spectrum below 5 GHz by 2020. This target was recently extended to a total of 750 MHz below 10 GHz by 2020, with 500 MHz of that being by 2020. This revision of the target recognised the increasing value of spectrum in the 5-10 GHz range. Spectrum above 10 GHz may well also be valuable for future 5G use.

The Government will be taking further action to ensure it shares spectrum where possible, either with other government users to release bands completely or with new private sector users on a short or long-term basis. The forthcoming new Emergency Services Network is an example of where government is now using private sector networks, operating an additional service within their spectrum, to avoid the need for dedicated spectrum that might not be the most efficient use.

---

[45]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/518303/enabling_uk_growth_pssr_programme_annual_report.pdf

The Government will prioritise making available public sector spectrum for 5G, subject to an assessment of value for money. In particular, we have identified scope for 5G to be deployed in the 26.5-27.5 GHz band, and the Ministry of Defence is leading work with Ofcom and CMU to assess the full extent of what will be possible. We will report back on progress in CMU's annual reports.

10. Technology and Standards

This section outlines how the UK is playing a leading role in work to develop and finalise standards for 5G. This will help ensure that the technology best meets the needs of UK industry both as a producer and beneficiary of 5G services thereby helping to maximise the benefits to the UK from 5G.

Standards for 5G

A technical standard is fundamentally an agreement between parties developing a technology to do things in a particular way. Standards development is a business-led activity, drawing on ideas from academic research and commercial research and development. In Information and Communication Technology (ICT), standards are essential commercial tools, without which there would be a proliferation of incompatible technologies. For 5G a lack of widely agreed standardisation could mean phones that do not work on all networks or in all countries - as was the case 25 years ago - or base stations that do not meet regulators' criteria.

Government and regulators are often involved in standards development, partly to contribute relevant knowledge but mainly to ensure that wider societal needs are addressed by standards. These may, for example, include: security, spectrum protection, safety, interoperability, accessibility, environmental performance, and provision for government needs in products.

Establishing 5G standards will mainly follow the process that set standards for 2G, 3G, and 4G. They are being developed by a group of pan-regional standards bodies through the 3G Partnership Project (3GPP).

The European Telecommunications Standards Institute (ETSI), the regional standards body for Europe, hosts the staff who work for 3GPP. Once developed, the standards will be issued by ETSI and its regional partners across the world. 3GPP will follow two parallel strands of work on 5G: one to allow the use of existing 4G equipment (an evolutionary path), the other (longer-term) building on 4G standards initially but working towards an almost total replacement of them by new 5G standards.

Mobile phone standards sit within a global regulatory regime administered by the International Telecommunications Union (ITU – a United Nations specialised agency). These are supplemented by national and regional requirements as appropriate. The ITU's International Mobile Telecommunications 2020 work (IMT 2020) draws together discussion and study of the developing 5G standards. This will provide increasing clarity around the likely shape of 5G standards until it sets out the final definition for IMT - the formal 5G standard.

3GPP plans for two releases of 5G standards in 2018 (Release 15, largely an evolution of 4G) which will allow early adopters of 5G to have an agreed baseline and in 2020 (Release 16) a more comprehensive set of standards. Standards for 5G will include a concept called New Radio (NR) that will describe a completely different radio system from 4G. NR will be better able to support massive data and low speed data, and be more spectrum efficient.

The initial standards release in mid-2018 will cover an evolution of the 4G core network, which provides interconnection between all the base stations and control of the overall network and users. Further developments for the core network are expected to be based heavily on Software Defined Networks (SDN), where software controls elements of network function that were previously 'baked into' the hardware and could not be changed. SDN will allow core networks to be readily built on general purpose computing systems and use cloud computing. The recently developed Network Function Virtualisation (NFV) standards will be the implementation of SDN used as the starting point for new 5G core network standards.

Greater use of SDN may lead to new combinations of manufacturers and providers in the market. Such standards work also has security implications. **The Government will monitor developments in supplier markets and security issues, and respond as appropriate.**

Key issues to consider

The ongoing 3GPP standards work is likely to be influenced by two issues in particular: the need to work well with both internet standards and the standards set by particular use cases or verticals. The first is perhaps obvious, given the growing significance of mobile phones in internet access, but the second will equally be important in getting the full benefits of 5G. The full significance of these drivers will ultimately depend on the market for 5G services.

People will expect what is delivered over fixed broadband also to be available via 5G connectivity. The growing importance of internet data in mobile communications has to some extent been reflected in current 3GPP standards, but many devices also incorporate features based on non-3GPP standards, such as Wi-Fi in mobile phones. These wider ICT technologies will need to work in an integrated way with the 5G environment – whether or not they are formally part of 5G.

5G devices will incorporate not only internet and web standards from Internet Engineering Task Force and W3C but also others (particularly from verticals) that overlap with 5G or add additional linked features. These complex interoperability requirements will be defined over time by the market, but meeting them will require a new level of sophistication in the relationship between standards. Potential use cases of 5G in sectors such as health or transport have well established standards and ways of working and standards used in these environments will need to integrate with 5G standards. Therefore, a high level of collaboration will be needed between vertical sectors' standards bodies and the ICT standards bodies responsible for the central core of 5G standards.

Timely development of appropriate standards should help to tackle any security or spectrum use problems before 5G devices come to market, and therefore put supported verticals on a firm footing. This will support the early success and long-term value of 5G networks.

We expect a limited range of standards to receive initial focus; providers will roll-out a set of features that are cost effective for them and attractive to users. Enhanced broadband is likely to be the early driver, using lower frequencies for good coverall coverage. Other features such as low latency are more difficult to deliver and so standards work on these aspects will have less priority as well as slower provision of equipment.

To support the take up of UK needs and ideas in emerging 5G standards, government will engage with appropriate Standards Developing Organisations (SDOs), especially

ETSI, ITU and 3GPP. This will include a focus on areas such as spectrum use and security, where it is more difficult to achieve solutions that support wider societal needs.

Intellectual property rights and standards

Intellectual Property Rights (IPR), particularly patents and copyright, are particularly important in the ICT standards community. Standards-essential IPR in telecommunications area tends to be freely licensable for a fixed fee, on terms that are meant to be fair, reasonable and non-discriminatory (FRAND). Standards that are software or IT centric tend to include IPR on a royalty free (RF) basis (i.e. the IPR is made available gratis), or do not allow IPR at all. There is a changing economic model around IPR. As ICT becomes more software based, we see increasing use of the RF model in technologies that were previously considered as telecommunications.

The use of intellectual property in standards can be difficult, not least for the generator of IPR – noticeably for SMEs and academics. Where IPR is licensed on a FRAND basis then using it on equitable terms can be difficult, especially for SME users. Patent pools and patent portfolios, where patent rights are brought together and there is some level of agreement around charging, can be helpful tools in easing the process of using intellectual property. We will thus consider if there is a place for public authorities to actively support patent pools and portfolios in some way.

SMEs have different involvements in standards work. Some are actively involved because their business is generating ideas and getting them used. Many just want standards they can use easily. Others find it a difficult area to access and influence. There is space for the Government to promote the involvement of SMEs in 5G standards development. We will work with standards bodies and industry to stimulate new ways of working such as open source software implementations of standards as "reference models" that can be readily accessed up by SMEs and used to try out ideas on.

The Government recognises that intellectual property rights support technological innovation where managed effectively. RF and payment agreements will both have a part to play in licensing 5G patents (so-called Standards Essential Patents). To support this, **the Government will consider whether measures such as patent pools and portfolios could assist the market.**

11. Summary of actions

This section sets out the actions that the Government has committed to in this 5G strategy, including those taken in response to the National Infrastructure Commission's recommendations published in December 2016. A formal response to the NIC's recommendations, including relevant actions from this strategy, is set out in an additional annex.

Executive Summary

- **The Government will create a new national 5G Innovation Network to trial and demonstrate 5G applications. The Government's initial investment will be up to £16 million for a cutting edge facility with the technology to run the trials, delivered through cooperation between leading 5G research institutions during 2017/18. It will deliver an end-to-end 5G trial in early 2018 and support a number of testbed spokes from 2018/19. Funding for future trials will be awarded on a competitive basis.**

- **The Government is establishing a new centre of 5G expertise in DCMS to ensure that work across the UK to develop 5G capabilities is joined up in a way that meets the strategic objectives of the programme.**

Introduction

- **We have had a number of representations suggesting the potential for net neutrality regulation to interact with the technical characteristics of 5G services, including network slicing. We will explore how the regulatory framework can best enable and support 5G networks.**

- **The Government will consider whether a Strategic Policy Statement for the telecommunications sector could be used to promote the development of a regulatory framework that supports the delivery of this strategy.**

- **The Government will ensure that the UK remains a key collaborator in global 5G developments. A key objective of the 5G testbeds and trials programme will be to facilitate and develop international links ensuring that we maximise the benefits for the UK from collaboration and learning.**

- **The Government will establish a new Digital Infrastructure Officials Group reporting to the Secretary of State for Culture, Media and Sport, chaired by the new Telecoms Director and comprising senior officials from relevant government departments, to:**
  - o **coordinate public projects across government that have a significant element of digital infrastructure delivery; and**
  - o **ensure that when upgrading existing or delivering new infrastructure projects, the long-term capacity needs of telecoms networks are**

> considered and met wherever practical, affordable, and value for money.

- **The Government is also establishing a new centre of 5G expertise within DCMS to deliver the 5G testbeds and trials programme, its role will include:**

  - o **ensuring that 5G development activity across central government and other public sector bodies is joined up in a way that meets the strategic objectives of the programme to accelerate deployment, maximise benefits and enhance opportunities for UK businesses and inward investment. This includes ensuring best practice is captured, and knowledge is disseminated;**

  - o **working with industry and public sector bodies to identify a pipeline of potential projects to be trialled on the new 5G testbed networks; and**

  - o **providing support and challenge to local government in developing local connectivity plans, including through a new joint working group and in allocating funds through the 5G testbeds and trials programme.**

- **The Government will work through the Digital Infrastructure and Inclusion Implementation Taskforce, chaired by the Secretary of State for Culture, Media and Sport, to deliver our response to the Commission's recommendations and the actions in this strategy. The Secretary of State will update the Economy and Industrial Strategy Cabinet Committee on progress in delivering the strategy.**

<u>Building the economic case</u>

- **The 5G testbed and trials programme will provide a catalyst for the development of products and services that will use future communications networks, and therefore help to prove that a market exists to monetise that technology. Through the programme, the Government will also explore the key public sector challenges that 5G and related technologies could help to solve.**

- **The Government will use the 5G testbeds and trials programme to test use cases in both rural and urban areas and to improve our understanding of the economics of infrastructure deployment in different scenarios and locations, and how infrastructure can be deployed in a cost-effective way.**

- **Starting in 2017, the Government will invest £200 million to fund a programme of local projects to test ways to accelerate market delivery of new full-fibre broadband networks.**

- **The Government recognises that having access to fibre is a critical limiting factor in the deployment of 5G and will continue to drive the deployment of new fibre networks. We will also work with Ofcom to ensure that operators can get fair access to fibre on reasonable terms and explore the scope for a duct and pole access remedy as part of the next Business Connectivity Market Review, for the purposes of supporting 5G deployment.**

- **The Government will work with Ofcom to identify and tackle unnecessary barriers to infrastructure sharing and will explore the potential for a clearer and more robust framework for sharing, while preserving investment incentives. We will report on progress by the end of 2017.**

- **As far as possible, the Government expects to build on existing projects through the 5G testbeds and trials programme and will work with the private sector as appropriate to help prove where and how 5G can be commercialised.**

- **The Government will investigate skills requirements through the 5G testbeds and trials programme and continue to monitor labour market trends to assess availability, and may take action when and where appropriate to support delivery**

Fit for purpose regulations

- **We will set out by the end of 2017 whether the Government believes further changes are needed to the planning and regulatory system to meet the unique challenges of 5G infrastructure deployment**

- **We will actively explore further ways to reduce the cost of deployment and operation of network and other related digital infrastructure, working closely with central and local government and industry in order to maximise the commercial case for early, rapid and widespread deployment of 5G.**

- **We will use the 5G testbeds and trials programme to improve our understanding of the different regulatory regimes in which 5G applications and services will operate, working with the UK's regulatory authorities as appropriate, and report back by the end of 2018.**

Local areas – governance and capability

- **The Government has commissioned research into a 5G mapping tool to catalyse the development of expertise in network planning for small cells using spectrum at and above 24 GHz.**

- **However, a more radical approach to opening up government buildings and land for mobile infrastructure development could be needed in future and we will set out our proposed approach by the end of 2017. We will also work with other parts of the public sector to encourage them to take similar steps to open up their assets for the purposes of supporting 5G infrastructure.**

- **Through its Housing White Paper, 'Fixing our broken housing market',[46] the Government is consulting on requiring local authorities in England to have planning policies setting out how high quality digital infrastructure will be delivered in their area.**

---

[46]https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/590463/Fixing_our_broken_housing_market_-_accessible_version.pdf

- The Government believes that there may also be a case for encouraging and supporting local areas to develop broader plans to deliver local mobile connectivity. The Government will consider further what these plans might look like with the intention of producing some guidance on best practice in 2018.

- The Government will take account of the presence of local connectivity plans and evidence of taking a proactive approach when allocating funds to local projects through the selection process for both local fibre and 5G testbeds and trials programme funding.

- The 5G testbeds and trials programme will seek to evaluate different local models for facilitating the deployment of 5G infrastructure in different types of area such as urban and rural, and both single and two-tier Local Authorities and will consider this as part of any selection process to award funding.

- The Government will, establish a working group comprising representatives from local areas, government departments, landowners and industry with the aim of providing an accurate picture of local area requirements for the deployment of 5G networks. This group will also allow government and industry to share knowledge of 5G network planning and will feed into the new centre of 5G expertise in DCMS.

Coverage and capacity – the road to 5G

- The Government agrees with the NIC that there should be high quality coverage where people live, work and travel. We are looking at how we can make sure that 4G networks are deployed to a scale and quality that will meet this ambition, while also supporting investments that will enable future 5G networks. This will mean that networks will need to go further than the requirements of the current licence obligations both in terms of coverage and quality. We will set out by the end of 2017 what the essential elements of high quality coverage where people live, work and travel are, and how we will achieve this as soon as is practical, but no later than 2025.

- The Government agrees that the reporting of coverage should provide a genuine and meaningful reflection of the services experienced by customers and will ask Ofcom to set out how this will be achieved by the end of 2017 for existing services.

- Subject to the development of suitable metrics, the Government will consider how it might best use these metrics to inform future policy.

- The review that the Government will ask Ofcom to carry out of the scope for the spectrum licensing regime to facilitate better 5G deployment at national, regional and local scales should include issues of promoting growth of 5G coverage for a range of possible use cases.

- The Department for Transport (DfT) and DCMS will work with industry to assess the potential for commercial delivery models and how new and existing

infrastructure can be used to support them, and will report back by the end of 2017.

- The Government will also consider funding live trials where there is potential for wider UK benefit as part of the 5G testbeds and trials programme, particularly where this could build on other work such as the planned A2/M2 connected corridor or the connected and autonomous vehicle testbeds programme announced at Autumn Statement 2016.

- DfT and DCMS will work with industry to assess the potential for commercial delivery models and how new and existing infrastructure can be used to support them, and will report back by the end of 2017.

- The Government will also consider funding live trials where there is potential for wider UK benefit as part of the 5G testbeds and trials programme, particularly where this could build on existing or planned projects around railway connectivity. Any trials will also help to deliver benefits to passengers from improved connectivity.

- The Government will consider the range of issues concerning road and rail coverage in its reports on delivery model options. Where telecoms regulation is identified as a potential barrier, it will involve Ofcom in discussions as appropriate to determine how best to deliver the Government's coverage objectives.

Ensuring a safe and secure deployment of 5G

- The 5G testbeds and trials programme will work with organisations such as the NCSC to support the development of new security architectures that meet the expectations of customers and the needs of 5G services and applications.

- The 5G testbeds and trials programme will also explore, along with other government bodies, how to improve the public's understanding of the opportunities and potential of 5G and the different applications and services that it will offer.

- The Government will monitor and support the development of 5G security technology through the NCSC. The 5G testbeds and trials programme will feed into this work.

Spectrum

- The Government keeps the regulatory regime for spectrum under regular review. It is sympathetic to the wishes of sub-national or regional and local service providers to obtain access to spectrum to enable them to meet the needs of unserved or poorly served areas, where this would lead to a more efficient use of spectrum.

- The Government will ask Ofcom to review and report back to DCMS by the end of 2017, the scope for the spectrum licensing regime to facilitate better 4G and

> **5G deployment at national, regional and local scales, including in-building usage. This would also include issues of promoting growth of 5G coverage for a range of possible use cases. The Government will define coverage objectives and will work with Ofcom to determine how best to deliver these.**
>
> • **The Government will work with Ofcom to assess the feasibility of 5G sharing in the 3.8-4.2 GHz band, and to agree clear timescales and milestones for further work.**
>
> • **The Government will prioritise making available public sector spectrum for 5G, subject to an assessment of value for money.**

Technology and standards

> • **The Government will monitor developments in supplier markets and security issues, and respond as appropriate.**
>
> • **To support the take up of UK needs and ideas in emerging 5G standards, government will engage with appropriate Standards Developing Organisations (SDOs), especially ETSI, ITU and 3GPP.**
>
> • **The Government will consider whether measures such as patent pools and portfolios could assist the market.**

Annex: Government response to Connected Future

Introduction

In October 2015, the Chancellor of the Exchequer announced the creation of a National Infrastructure Commission (NIC), to produce a clear picture of the future infrastructure the country needs and provide expert, impartial advice on infrastructure priorities. The NIC was permanently established as an executive agency in January 2017.

At the 2016 Budget, the Chancellor announced that the NIC would study what the UK needs to do to become a world leader in 5G deployment, and to ensure that the UK can take early advantage of the potential applications of 5G services. The NIC's 'Connected Future' report was published on 14 December 2016.

At Budget 2017, the Chancellor confirmed that the Government would respond to the NIC in its 5G Strategy. This annex sets out in detail the Government's response to the NIC's recommendations.

Connected Future

Recommendation 1: Digital infrastructure lies at the heart of the UK's industrial strategy and affects every sector of the economy. To reflect its importance, ultimate government responsibility for digital infrastructure should reside in one place under a single cabinet minister with the authority to shape policy and delivery across government, ensuring that it delivers the Government's overarching digital strategy. This work should report to the Economy and Industrial Strategy Cabinet Committee. It should:

- **Identify the public projects that contain a significant element of digital infrastructure and establish and maintain a plan which sets out how they can help deliver the Government's overarching digital strategy and maximise the benefit of better mobile telecommunications for UK citizens and businesses.**

- **Hold the various parts of government that are delivering digital infrastructure to account, in order to ensure adequate telecoms network provision in the delivery of its infrastructure programmes.**

- **Ensure that when upgrading existing or delivering new infrastructure, such as that alongside our roads and railways, the long-term capacity needs of telecoms networks are considered and met. This could include installing more fibre and additional infrastructure to make sure that networks are future-proof. It will also mean ensuring that the networks are readily accessible to communications providers.**

- **Be a centre of telecoms expertise within government that supports departments in determining their needs and procuring telecoms infrastructure,**

and support departments in demonstrating and testing of new, digitally-enabled ways of delivering public services such as education and healthcare.

- **Support and challenge local government in their plans to enable the delivery of digital infrastructure; both in terms of ensuring that these plans help the UK to meet its national objectives, and that local authorities develop consistent approaches to support the deployment of mobile infrastructure across the country.**

The Government agrees that responsibility for digital infrastructure should reside in one place under a single cabinet minister. The Secretary of State for Culture, Media and Sport is the lead Minister for digital infrastructure, and has overall responsibility for delivering the Government's commitments in this area. DCMS is in the process of strengthening its telecoms capabilities and expertise in support of this mission. As the Commission notes, the department has created a Director General (DG) with overall responsibility for the digital economy and is also creating a new dedicated Director of Telecoms post.

The Government will establish a new Digital Infrastructure Officials Group, reporting to the Secretary of State for Culture, Media and Sport, chaired by the new Telecoms Director and comprising senior officials from relevant government departments, to:

- coordinate public projects across government that have a significant element of digital infrastructure delivery; and

- ensure that when upgrading existing or delivering new infrastructure projects, the long-term capacity needs of telecoms networks are considered and met wherever practical, affordable and value for money.

The Government is also establishing a new centre of 5G expertise within DCMS to deliver the testbeds and trials programme. Its role will include:

- ensuring that 5G development activity across central government and other public sector bodies is joined up in a way that meets the strategic objectives of the programme to accelerate deployment, maximise benefits and enhance opportunities for UK businesses and inward investment. This includes ensuring best practice is captured, and knowledge is disseminated;

- working with industry and public sector bodies to identify a pipeline of potential projects to be trialled on the new 5G testbed networks; and

- providing support and challenge to local government in developing local connectivity plans, including through a new joint working group and in allocating funds through the 5G testbeds and trials programme.

The Government will work through the Digital Infrastructure and Inclusion Implementation Taskforce, chaired by the Secretary of State for Culture, Media and Sport, to deliver our response to the Commission's recommendations and the actions in this strategy. The Secretary of State will update the Economy and Industrial Strategy Cabinet Committee on progress in delivering the strategy.

Recommendation 2: Our motorways must have mobile telecommunication networks fit for the future. It is vital that our motorways are able to meet both the long-term operational needs of connected vehicles and the connectivity needs of the passengers. This will necessitate the timely installation of an open and accessible mobile telecommunication and backhaul network that is fit for the future.

The Government should set out its plans for how to deliver this by the end of 2017. As part of this work consideration should be given to who is best placed to install, manage, fund and own the network, noting the potential for private sector funding.

Ensuring that best use is made of the existing infrastructure, such as masts, poles, ducts power supplies and the fibre network alongside our motorways, so that it can be used to support the backhaul of mobile data will be essential.

Ultimately, the Government should ensure that the necessary infrastructure is in place on motorways by 2025 at the latest if it wants to offer a reasonable level of connectivity on a timescale consistent with the deployment of 5G networks.

Ofcom should set out how a regulatory regime would support these different operating models.

The Government agrees that in the future it will be important to have greater connectivity on the UK's transport networks to support new ways of travelling and working. The Commission's report highlights the potential for commercial provision of telecommunications services on our transport networks. The Department for Transport (DfT) and DCMS will work with industry to assess the potential for commercial delivery models and how new and existing infrastructure can be used to support them and will report back by the end of 2017.

The Government will consider the range of issues concerning road and rail coverage in its report on delivery model options. Where telecoms regulation is identified as a potential barrier, it will involve Ofcom in discussions as appropriate to determine how best to deliver the Government's coverage objectives.

The Government will also consider funding live trials where there is potential for wider UK benefit as part of the coordinated 5G testbeds and trials programme, particularly where this could build on other work such as the planned A2/M2 connected corridor or the connected and autonomous vehicles testbeds programme announced at Autumn Statement 2016. In this way we will look to gain further insights into the challenges and benefits of the deployment of 5G and related technologies on the motorway network.

Recommendation 3: Rail passengers should have high capacity wireless connectivity. This should be achieved through a delivery model that utilises trackside infrastructure to provide an open and accessible mobile telecommunication and backhaul network that is fit for the future.

The Government should set out its plans for how to deliver this by the end of 2017. As part of this work consideration should be given to who is best placed to install, manage, fund and own the network, noting the potential for private sector funding.

Ensuring that best use is made of the existing infrastructure, such as masts, poles, ducts power supplies and the fibre network alongside our railways so that it can be used to support the backhaul of mobile data will be essential.

Ultimately, the Government should ensure that the necessary infrastructure is in place on the main rail and key commuter routes by 2025 at the latest if it wants to offer a reasonable level of connectivity on a timescale consistent with the deployment of 5G networks.

Ofcom should set out how a regulatory regime would support these different operating models.

The Government agrees that in the future it will be important to have greater connectivity on the UK's transport networks to support new ways of travelling and working. The Commission's report highlights the potential for commercial provision of telecommunications services on our transport networks. DfT and DCMS will work with industry to assess the potential for commercial delivery models and how new and existing infrastructure can be used to support them and will report back by the end of 2017. This will include consideration of models for delivering better 4G connectivity on the rail network to help to pave the way for excellent 5G connectivity.

The Government will consider the range of issues concerning road and rail coverage in its report on delivery model options. Where telecoms regulation is identified as a potential barrier, it will involve Ofcom in discussions as appropriate to determine how best to deliver the Government's coverage objectives.

The Government will also consider funding live trials where there is potential for wider UK benefit as part of the 5G testbeds and trials programme, particularly where this could build on existing or planned projects around railway connectivity. Any trials will also help to deliver benefits to passengers from improved connectivity.

Recommendation 4: Local government should actively facilitate the deployment of mobile telecoms infrastructure:

> **a) Local authorities should work together and with Local Enterprise Partnerships (LEPs) to develop coordinated local mobile connectivity delivery plans. These plans should:**
>
> > • **set out how local authorities and LEPs will enable the deployment of mobile networks and maximise the opportunities and benefits to residents and businesses;**
> >
> > • **be developed in discussion with mobile network operators and infrastructure owners;**
> >
> > • **identify a designated individual with lead responsibility for engaging with mobile telecoms infrastructure providers;**
> >
> > • **consider the role of local government assets and infrastructure, (e.g. land, buildings, roads, street furniture) and help coordinate the role that other**

> public buildings in an area (e.g. hospitals and universities) can play to facilitate the deployment of mobile telecoms infrastructure; and
>
> • consider how the deployment of digital infrastructure can be established as a priority in local planning policy.

Local authorities and LEPs should report annually to the Government department with responsibility for digital infrastructure on their progress delivering against these plans.

> **b) Local models for facilitating the deployment of these networks should be piloted and evaluated to inform national roll-out. Any pilot programme should allow for the evaluation of deployment models in different types of area (e.g. urban, rural, coastal) and in both single-tier and two-tier local government areas. It should also seek to establish how high quality design can minimise the impact of hosted infrastructure on the built environment. Such pilots would be a good use of a proportion of the funding recently announced in the Autumn Statement to support mobile telecoms infrastructure.**

The Government agrees with the NIC that local areas have a critical role to play in facilitating the deployment of mobile telecommunications infrastructure and are already doing so in many areas. Through its Housing White Paper, 'Fixing our broken housing market', the Government is currently consulting on requiring local authorities in England to have planning policies setting out how high quality digital infrastructure will be delivered in their area.

Outside of the planning policy framework, the Government believes that there may also be a case for encouraging and supporting local areas to develop broader plans to deliver local mobile connectivity. These local connectivity plans would articulate how an area will meet its connectivity needs and ideally should be developed through engagement with key interested bodies including Local Enterprise Partnerships and the telecommunications industry. The Government will consider further what these plans might look like with the intention of producing some guidance on best practice in 2018.

The Government will take account of the presence of local connectivity plans and evidence of taking a proactive approach when allocating funds to local projects through the selection process for both local fibre and 5G trials programme funding. Government would expect to see, for example, engagement with relevant Local Enterprise Partnerships, supportive planning policies, Chief Technology Officers and asset registers.

The 5G testbeds and trials programme will seek to evaluate different local models for facilitating the deployment of 5G infrastructure in different types of area such as urban or rural, and both single and two-tier Local Authorities and will consider this as part of any selection process to award funding. Trials will consider how high-quality design can minimise the impact of digital infrastructure on the built environment in order to make deployment more effective.

The contribution of industry is vital to helping local authorities and other local groups to understand potential costs and benefits of infrastructure roll-out. The Government will bring together a working group of local areas and industry with the aim of providing an accurate picture of local area requirements for the deployment of 5G networks. This group will also

allow government and industry to share knowledge of 5G network planning and will feed into the new centre of 5G expertise in DCMS.

<u>Recommendation 5:</u> Government and Ofcom should develop a meaningful set of metrics that represent the coverage people actually receive and use these to determine a mobile universal service obligation setting out the minimum service level people should expect to receive.

> **a) Ofcom, government and mobile operators should report their coverage so that they are genuine and meaningful reflections of the services enjoyed by customers. Metrics should be measurable and based on the reality of service and coverage provided to customers, not based on simulated or predicted performance. Ofcom should set out how this is best achieved by the end of 2017.**

Ofcom and government should use these metrics as the basis of future interventions such as spectrum licence obligations or voluntary agreements with operators.

Government, Ofcom or the Advertising Standards Authority should take action if operators advertise or report coverage in a way that does not reflect services being delivered to consumers on an everyday basis.

> **b) Mobile services are increasingly viewed as essential, underpinning our daily lives and the digital economy. Government must deliver a view by the end of 2017 on what aspects of mobile services are considered "essential". It should then establish how this "essential" level of service provision can be made available through a mobile universal service obligation regardless of the network to which a customer is subscribed. Government should engage with Ofcom and industry to establish the best delivery mechanism, whether through spectrum licence obligations, enabling roaming, enabling cross operator Mobile Virtual Network Operators (MVNOs), through government procurement or a mix thereof.**

Government with the assistance of Ofcom should deliver this as soon as is practical but no later than 2025.

The Government agrees with the NIC that the reporting of coverage should provide a genuine and meaningful reflection of the services experienced by customers and the Government will ask Ofcom by the end of 2017 to set out how this will be achieved for existing services.

Subject to the development of suitable metrics for mobile coverage, the Government will consider how it might best use these metrics to inform future policy.

The Advertising Standards Authority (ASA) is the UK's independent regulator of advertising across all media and is responsible for taking action against advertisements which are misleading in contravention of the UK Advertising Codes. The ASA already has rules that can be used to address any misleading representations of mobile coverage in UK advertising and, as with all of its rules, keeps these under continual review. If the ASA sees

a pattern emerging that coverage is being advertised in a misleading way, it may consider sector compliance activity or provide guidance to industry and in this instance the Government would encourage the ASA to take whatever action it considers appropriate.

The Government also agrees with the Commission that there should be high quality coverage where people live, work, and travel. We are looking at how we can make sure that 4G networks are deployed to a scale and quality that will meet this ambition, while also supporting investments that will enable future 5G networks. We will set out by the end of 2017 what the essential elements of high-quality coverage where people live, work and travel are, and how we will achieve this as soon as is practical, but by no later than 2025.

Recommendation 6: By the end of 2017 Ofcom and government must review the existing regulatory regime to ensure that it supports the sharing of telecoms infrastructure. This will be particularly important for areas of the country where competition driven markets have struggled to provide the necessary mobile infrastructure.

The Government agrees with the NIC that infrastructure sharing, in compliance with competition rules, can be an effective and economically efficient way of delivering telecommunications infrastructure, especially in areas where it is uneconomic to deploy competing infrastructure networks. However, we are also mindful of the need to protect investment incentives.

Mobile networks have already seen consolidation through joint ventures between Vodafone and Telefonica (CTIL) and between EE and Three (MBNL). Independent infrastructure providers that lease capacity on masts to several network operators provide a similar benefit. The Government is also looking to ensure that infrastructure delivered as part of the new Emergency Services Network can be made available for shared use, where possible.

We recognise that regulatory and legal frameworks can impact the extent of infrastructure sharing. The Government will work with Ofcom to identify and tackle unnecessary barriers to infrastructure sharing and will explore the potential for a clearer and more robust framework for sharing, while preserving investment incentives. We will report on progress by the end of 2017.

Recommendation 7: Ofcom and government must ensure they keep pace with the rapid evolution of the mobile communications market, and that the regulatory regime is fit for purpose. By the end of 2017 Ofcom and government must review the regulatory regime to ensure that spectrum allocation and regulatory decisions support a growth model in a world where technology developments enable greater shared access and interoperability. Government and Ofcom should review how unlicensed, lightly licensed spectrum, spectrum sharing and similar approaches can be utilised for higher frequencies to maximise access to the radio spectrum. Spectrum decisions should where possible enable:

- **Community or small provider solutions to meet the needs of local areas if they remain unserved or poorly served.**

- **Niche entrants or sub-national players to access the higher frequency spectrum anticipated for 5G. Allocation of nationwide spectrum licences to a small number of operators could leave large areas of the UK fallow.**

- **Businesses, universities and others to access spectrum where they need to within their factories or buildings, including already licensed spectrum if there are no interference risks. This will unlock multiple wireless service provider options, including self-provision, spurring the innovation in industrial internet of things, wireless automation and robotics.**

The Government agrees with the NIC that regulation should be fit for purpose and keeps the regulatory regime for spectrum under regular review. It is sympathetic to the wishes of sub-national or regional and local service providers to obtain access to spectrum to enable them to meet the needs of unserved or poorly served areas, where this would lead to a more efficient use of spectrum.

The Government will ask Ofcom to review and report back to DCMS by the end 2017, the scope for the spectrum licensing regime to facilitate better 4G and 5G deployment at national, regional and local scales, including in-building usage. This would also include issues of promoting growth of 5G coverage for a range of possible use cases. The Government will define coverage objectives and will work with Ofcom to determine how best to deliver these.

Department
for Culture
Media & Sport

HM Treasury

4th Floor, 100 Parliament Street
London, SW1A 2BQ
GOV.UK/DCMS