Assembly

Delivering Gigabit Britain: Broadband for all

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An independent report by Assembly Research, commissioned by Huawei, with input from:

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Executive Summary

The UK Government has set clear, ambitious targets for the availability of full-fibre and 5G – wanting to bring gigabit-capable broadband to every home and business across the country by 2025. The coronavirus pandemic has laid bare the dependency we place on this critical national infrastructure, which has allowed us to work, learn and play from the safety of our homes. Over the past few years, the UK has made significant progress, in both mobile and fixed connectivity. The UK is a world leader in superfast with more than 95% of premises covered, and this continues to rise. But in full-fibre coverage we lag behind world leaders such as Japan and South Korea, and in some cases our neighbours in Europe.

Even before the pandemic, there was widespread consensus on the benefits of ubiquitous broadband – seen as a driver and enabler of economic growth and new economic activity. Various attempts have been made to quantify this with estimates ranging from tens to hundreds of billions of pounds. Even with the usual caveats, and based on the most conservative estimates, a delay to achieving full coverage of gigabit-capable broadband of even just between one or two years, could mean the UK could miss out on between £9.7 and £28.7bn of productivity benefits. In any normal time, this would be significant, however with a degree of social distancing likely to continue and the need for a strong economic bounce-back, the importance of rolling out gigabit connectivity and realising these benefits for the economy cannot be understated.

The industry stands ready to deliver the Government's ambitious plans, so long as the right conditions allow. But there is a risk that this goal will be missed. While the regulatory environment is shifting in a material way to support investment, there are a number of 'enablers' that still need to be secured from the Government and regulator. These include support for switchover from copper to fibre to incentivise roll-out, business rates exemption for full-fibre to help secure investment, and a credible approach to the so called final third (the 10–20% of the country that will not be commercially viable), so that nobody is left behind.

The challenge may appear daunting, but the UK isn't the first to have made this journey. It is already well known that countries in Asia have achieved impressive coverage of gigabit-capable broadband as a result of supportive government policy, but others closer to home – such as France and Spain provide valuable lessons that UK policymakers can learn from. Whether that is ensuring new builds have fibre pre-installed or simplifying planning applications for mobile masts, we need to make the most of this global experience and best practice.

Too often when talking about broadband we get caught up with just supply side issues, but equally important, and often overlooked, is the demand for broadband and the applications and services that make use of it. With countries such as Japan, China and South Korea being early adopters of new applications and services that are supported by gigabit broadband technologies, we have looked at some of the latest use cases. As well as life-saving use of 5G during the coronavirus pandemic, we see coordinated government policy for making the urban environment smarter, connected live events and enhanced media and entertainment. Paying this attention to driving demand and a rapid take-up of full-fibre and 5G services will ease investor concerns and likely see the commercial footprint grow that much sooner.

Policy Recommendations

1 The focus on achieving the 2025 connectivity target should remain given how crucial connectivity is proving to be for UK citizens, and how it will underpin future economic growth and recovery

The 2025 target for 100% coverage of gigabit-capable broadband was always an ambitious one, which the industry shared in supporting given the right regulatory and policy enablers were put in place. Current events have illustrated just how important it is to have reliable digital infrastructure for work, education and play and how even more important it is that this infrastructure meets the needs of future demands. The economic benefit of full-fibre and 5G is widely accepted, with significant contributions to productivity and GDP set to be realised if rollout is completed on time. Increasing investment in key digital infrastructure will provide the bounce-back and economic recovery the UK will desperately need in the months and years ahead.

2 Sufficient government subsidy and funding models must exist for non-commercial areas if the whole country is to be covered and nobody is to be left behind

Access to reliable, future-proof digital infrastructure for all isn't a luxury, but now accepted as a necessity. The £5bn commitment for the hardest to reach 20% and the £510m as part of the shared rural network are both welcome interventions, but remain modest in the sense of the overall £30bn the rollout is expected to cost. The effectiveness of this subsidy also depends on how the money is spent. Similar countries to the UK (such as France), are making available much more whether it's pure subsidy or through extending voucher schemes to 5G fixed wireless access (FWA).

3 A commitment to the technology neutral approach will be needed to reach the hardest parts of the country on time and in a cost effective way

Until recently there has been a fixation on specifying technology when it comes to broadband policy. Given the pace of technological change, and the suitability of some solutions over others when it comes to deployment, any gigabit-capable technology should be considered – whether it's cable, full-fibre or 5G FWA. To ignore this is not only counter to what end users care about, but also means the UK stands little to no chance of meeting the target for the whole country. Any delay to the roll-out of these networks risks not achieving the target and the anticipated benefits.

4 Investment and innovation should be pursued through competition with a regulatory framework that considers how this competition varies by geography

The intense competition between providers has resulted in considerable benefit for end users in terms of faster speeds and lower prices. Encouraged by Ofcom and others, this rivalry has now spilled down to the infrastructure layer, where multiple infrastructure builders are now deploying competing full-fibre networks. It's widely accepted that this has increased the pace and reach of deployment. However this model is unlikely to work for the whole of the country given different risk profiles and economics. Where competitive network build does not make sense, regulation should allow the appropriate recovery of costs.

5 Remaining barriers to deployment must be removed and promised planning reforms must be completed

Encouraging progress has already been made on mandating full-fibre in new build homes, which if legislated this year will help speed up fibre deployment. However there's still more to do – whether it's extending business rates exemption for England and Wales as has been done in Scotland, or help with obtaining wayleaves – small but significant changes in policy will allow commercial deployments to reach more premises, sooner. Persistent barriers have been acutely felt by those rolling out 5G whether it's with permitted development rights, out of date planning guidance or a mismatch between local and central government thinking.

6 The demand side must be given more attention to encourage take-up and help lower investment risk

Much of the attention when it comes to broadband focuses on the supply – the pipes and the plumbing. For investors, demand matters because it's a route to profitable returns on significant investments. The content, applications and services that consume the network matter as much as the fibre and spectrum used to make them possible. Government has an important role to play here – as a demand aggregator (moving more services online), helping those not currently connected understand the benefits of being so, and through more coordinated policymaking. Plans for a UK Industry 4.0, including smart cities need to better anticipate connectivity requirements to ensure the UK can compete with other leading economies.

From superfast to gigabit-capable broadband

Over the past few years, the UK has made significant progress, in both mobile and fixed connectivity. The UK is a world leader in superfast with more than 95% of premises covered, and this continues to rise. In the years ahead, fixed and mobile networks will be the enabling infrastructure that drives economic growth. As the UK transitions towards this future, it faces the challenge to go beyond superfast, and embrace gigabit-capable broadband.

Gigabit broadband is any internet connection capable of reaching download speeds of 1Gbps. Typically, this is possible through fibre to the home/premise (FTTH/P) (or now more commonly 'full-fibre'), and cable. However recent deployments of 5G also provide a viable way to achieve similar levels of performance through mobile networks. In full-fibre, coverage is currently 10%, where the UK lags behind world leaders such as Japan (c.97%), and South Korea (c.99%). However there are considerable investment and network builds underway.

The UK's connectivity roadmap

CityFibre (FibreNation)

CityFibre is a wholesale-only fibre network builder, which started operating in 2014. As of 6 March 2020, the company had gigabit services live in 11 cities, and set a target to deliver full-fibre to 100 UK cities through its Gigabit City Investment Programme[1]. Upon launch in October 2018[2], the programme involved a £2.5bn investment and targeted 5 million premises by 2025. Following the acquisition of FibreNation in January 2020[3], investment was scaled up to £4bn and now aims to cover 8 million premises by 2025. In February 2020, the company partnered with Three in providing backhaul capacity for Three's 5G deployment outside London[4].

Gigaclear

Gigaclear is a rural fibre optic ISP which currently covers more than 200 rural communities in 22 counties across the South West, the Midlands, and the South East, for a total of 65,000 homes and businesses[5]. Gigaclear's network is built through a mix of commercial funding and local government contributions via the Building Digital UK scheme (BDUK)[6].

At present, Gigaclear is running six expansion projects across the counties of West Oxfordshire, Herefordshire and Gloucestershire, Berkshire, Essex, Northamptonshire, Wiltshire. In total, these will cover more than 182,000 homes and businesses with full-fibre, with most projects scheduled to be completed during 2021[7]. Gigaclear is also investing £20m in Devon and Somerset.

Hyperoptic

Hyperoptic is a full-fibre network provider having started in 2011, when it claimed to be the first to deliver gigabit speeds in the UK[8]. It currently covers more than 500,000 homes and businesses across 40 towns and cities and is on target to reach 2m premises by 2021, and 5m by 2024[9].

Openreach

Openreach runs the largest network in the UK, and has been the main provider involved in the rollout of the superfast broadband network that currently covers 95% of the country. It developed its Fibre First[10] programme in April 2018, with a view to deploy full-fibre to four million homes and businesses by 2021, and to 15 million premises by 2025 – if the right regulatory and policy conditions are in place. As of February 2020, Openreach was on track for the 2021 target, and is currently connecting 26,000 premises each week, having already covered 2.2m homes and businesses[11]. Ultimately Openreach believe they can pass c.3m premises per year and continues to build in both urban and rural commuinities across the UK.

Virgin Media

Virgin Media, owned by Liberty Global, is the UK's largest cable operator, with a total of 14.9m UK homes passed as of Q4 2019[12]. Its cable network delivers standard average speeds of 516Mbps for consumers and businesses (1104Mbps in gigabit broadband areas). It is currently upgrading its cable network, and plans to bring gigabit broadband to about 15m homes across its network by the end of 2021. As of March 2020, Virgin's Gigabit broadband was available in Southampton, Manchester, Reading, Birmingham and Coventry and their surrounding areas, after launching in the West Midlands on 19 March 2020 for 1m homes[13].

EE

EE was the first UK operator to launch a 5G service in May 2019. This was initially in six high-population cities, and is currently available in 71 UK cities and towns[14]. They currently offer a range of home broadband and SIM-only plans. Among the SIM-only plans, the 5G plan offers unlimited data and costs only £5 more than EE's unlimited data plan on 4G.

O2

O2 launched its 5G service in October 2019. It launched in six major towns and cities. As of March 2020, the number has increased to 30, with a view to bring 5G to at least 50 towns and cities in total by summer 2020[15]. O2 does not differentiate between 4G and 5G plans in its SIM-only offering, meaning there is no price premium for 5G.

Three

Three launched 5G as a home broadband service (5G FWA), in August 2019[16]. This is currently available in parts of London, and the operator pledges to expand it to the rest of the UK "very soon". In February 2020, Three launched 5G as a mobile service, available in 66 locations across the country[17]. Three reports that the maximum speeds available on the 5G home broadband service can reach up to 1.6Gbps. All Three's SIM cards are 5G-ready and available at no extra cost[18]. There is a small premium on 5G home broadband, marketed at £29 per month whereas 4G home broadband plans range between £22 and £24 per month.

Vodafone

Vodafone launched its 5G network on 3 July 2019. Vodafone's 5G was available in seven cities at launch. As of March 2020, it was available in parts of 41 UK towns and cities[19]. Vodafone's home 5G broadband service offers speeds of up to 1Gbps. Vodafone offers 5G at no extra cost to 4G. It is offered as the standard technology on any plan with a data allowance of at least 5GB of data per month.

The benefits of gigabit broadband

Economic benefits

There is widespread consensus on the benefits of ubiquitous broadband. While estimates vary, broadband is seen as a driver and enabler of economic growth and new economic activity in both urban and rural areas. The following recent studies show the considerable contributions that are possible.

Future benefits of broadband networks (2017)

Research published by the National Infrastructure Commission in 2017 assessed and quantified the relative benefits of rollout to residential premises of advanced Ultra-Fast Broadband Access (UFBA) under different scenarios[20] (where UFBA is a mix of technologies including FTTH/P and 5G). The combined effect of the use cases considered results in additional benefit to the UK economy of between £28.6bn and £71.1bn over 30 years between 2020 and 2050.

UK strategy and plan for 5G & Digitisation (2017)

The Future Communications Challenge Group produced a report for the DCMS in 2017, which estimated that 5G could benefit the UK economy by a total of £173bn between 2020 and 2030, from direct and indirect benefits[21].

The economic impact of broadband: evidence from OECD countries (2018)

A 2018 study published by Ofcom found that the increase in broadband adoption over a 15-year period (2002–2016) led to an increase in GDP of 0.37% per year, which meant a cumulative increase of 5.3% over the period[22]. The same study showed the strong positive relationship between broadband speed and economic growth. Taken together, the impact on UK GDP of broadband investment and speed improvements was on average 0.47% per year. The cumulative total was an addition of 6.7% to UK GDP.

The Economic Impact of Full Fibre Infrastructure in 100 UK Towns and Cities (2018)

A 2018 study from CityFibre predicted the total economic impact of deploying full-fibre broadband networks across 100 UK towns and cities[23]. It found that the UK's business community (particularly small and medium sized companies), could benefit enormously.

Access to full-fibre could unlock £4.5bn in business productivity, innovation and access to new markets in these locations; a further £2.3bn in growth could be driven from catalysing new business start-ups; while the increased ability for companies to support flexible working could add £1.9bn. The UK's homeowners and wider property market can also expect to reap rewards. With access to reliable, high speed broadband becoming ever-more important to buyers, up to £7bn could be added to the value of homes. In total, the study estimates that full-fibre could have a gross value added (GVA) impact of £62bn over a 15-year period, which translates into £120bn of GDP.

Full fibre broadband: A platform for growth (2019)

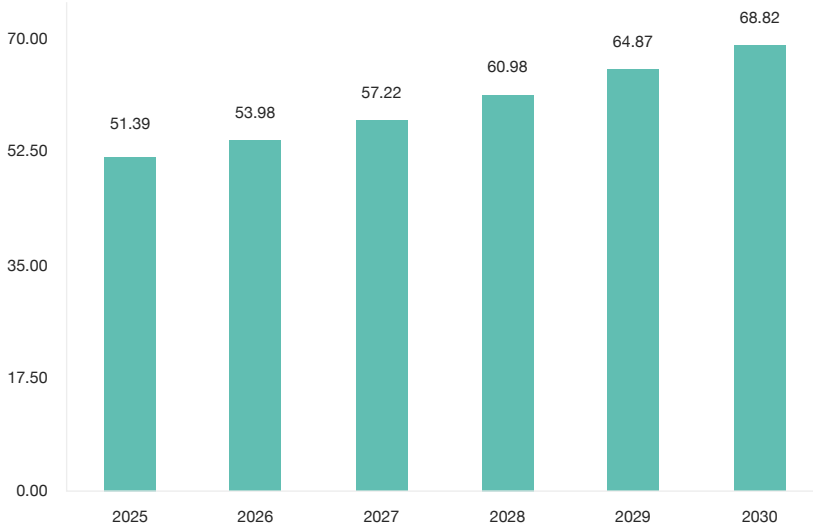
A 2019 report from Openreach[24] made a similar analysis, and concluded that, should the rollout be completed by 2025 (the current Government target), nationwide, full-fibre broadband could unlock a positive GVA impact of £59bn in 2025, which would grow to £63.5bn in 2030, £66.3bn in 2033, and £70.9bn in 2038. This is a conservative estimate based on uptake of fibre continuing at the current pace. Under a more optimistic scenario the benefits in 2038 would increase to between £79.9bn and £131.8bn, should fibre have a more profoundly transformative impact on the UK economy.

Economic benefits

The benefit of achieving the 2025 target on time

We have assessed the economic benefit of full coverage of gigabit-capable broadband based on the DCMS estimates of the impact of 5G, and Openreach's most conservative estimates of the impact of FTTH/P rollout by 2025. In doing so, we have assumed (in line with the Government's technology-neutral approach to the target), that 5G FWA will be the main technology used in the hardest-to-reach 20% of premises, leaving full-fibre and cable to account for the remaining 80%. Assuming rollout is completed by 2025, the UK could stand to benefit from £51.4bn GVA, growing to £68.8bn in 2030, should current rollout targets be met.

Figure 1: Impact of gigabit broadband on productivity (£bn)



Source: Assembly, Openreach, DCMS

Missing the target

We have considered what a delay to completing roll-out (by 2025) would do to the economic benefit, based on the gains to the economy by achieving the Government's target of delivering gigabit broadband to the whole of the UK by 2025.

- A 12 month delay to achieving full coverage of gigabit-capable broadband would mean the UK misses out on £9.7bn of productivity benefits;
- An 18 month delay to achieving full coverage of gigabit-capable broadband would mean the UK misses out on £23.6bn of productivity benefits;
- A 24 month delay to achieving full coverage of gigabit-capable broadband would mean the UK misses out on £28.7bn of productivity benefits.

Environmental benefits

The deployment of gigabit broadband is also likely to result in significant benefits for the environment. Firstly, the wider range of online and remote activities it enables reduces the need for travelling and commuting; and secondly because of the reduced carbon footprint of fibre compared to copper networks – something to which regulators and operators are increasingly paying attention to.

Several recent studies have estimated the broader environmental benefits of gigabit broadband. Research commissioned by Ofcom in 2018 predicts that faster broadband will lead to a reduction in the UK's annual commuting distance of about 2.3bn kilometres by 2024, and predominantly car journeys. This is about 2% of the current total annual UK commuting distance. Annual net carbon dioxide equivalent (CO2e) savings from increased remote working (attributable to faster broadband), are estimated to be 0.24 million tonnes by 2024. Adding to that the CO2e savings from the changes in business travel and server emissions, the total net carbon savings from faster broadband could be 1.6m tonnes of CO2e per annum by 2024, which equates to a value of about £100 million[25]. A report for CityFibre estimates that, by expanding the range of physical services that can be accessed digitally such as e-commerce and remote working, the nation's consumers and workers could reduce their carbon emissions by over 2.3m tonnes across 100 UK cities, for a total value of £160m[26]. More recently, Openreach published research which foresees that, based on an additional 1 million home workers in the UK, each year there will be 300m fewer commuting trips (200m of which by car), which results in 3bn kilometres fewer travelled by car, and 360k tonnes fewer of carbon dioxide emitted.

With regard to the energy requirements for different technologies, an Ofcom study refers to data from EU countries plus Norway and Iceland to show that deployment of 'all FTTH/B' infrastructure could lead to environmental benefits resulting in 88% less greenhouse gas emissions per gigabit in Europe, compared to the mix of copper and cable technologies in use in 2008. The emissions estimates were based on electricity consumption and therefore could also have operational cost benefits for operators, which could lead to lower prices for consumers. Regulators in other countries are reaching similar conclusions. The French regulator ARCEP recently noted that fibre consumes on average a little more than 0.5 Watt per line, which is about three times less than ADSL (1.8 W) and four times less than PSTN (2.1 W) on the access network[27]. The energy consumption of these technologies is fairly independent of the uses made of them, which means replacing copper with fibre translates into consumption gains in absolute value.

1

Policy Context

Future Telecommunications Infrastructure Review

The digital ambitions of the current Government are rooted in the process that began with the 2018 Future Telecoms Infrastructure Review (FTIR). At the time, the Government noted that the 95% coverage target for superfast broadband (i.e. 30Mbps connections) was met in December 2017, and that it was time for more ambitious objectives – not only with regard to fibre deployment, but also to make the UK a leader in the race to 5G, and make sure the country takes early advantage of its benefits[28]. This drove the desire to accelerate fibre rollout, by aiming for 15m premises by 2025 and full coverage by 2033.

The FTIR envisaged the need to change the existing regulatory and policy environment, which had worked well to date in stimulating retail competition based on existing networks. The objective was to now incentivise large-scale deployment of new networks in rural and urban areas across the UK. The approach set by the FTIR envisaged the most effective way to deliver nationwide full-fibre connectivity at pace would be to promote competition and commercial investment where possible, and to intervene where necessary.

The Government estimated that:

- At least a third (with the potential to be substantially higher) of UK premises are likely to be able to support three or more competing gigabit-capable networks;
- Up to half (or lower if there are more three-network areas) of premises are likely to be in areas that can support competition between two gigabit-capable networks;
- There are likely to be parts of the country (circa 10% of premises) that, while commercially viable for at least one operator, may not benefit from investment. A ‘competition for the market’ mechanism could be used to secure investment in those areas; and
- In the final 10% of premises, the market alone is unlikely to support network deployment and additional funding of some description will be required to ensure national coverage.

This strategy relied on getting five things right:

1. Making the cost of deploying fibre networks as low as possible by addressing barriers to deployment, which both increase costs and cause delays;
2. Supporting market entry and expansion by alternative network operators through easy access to Openreach’s ducts and poles, complemented by access to other utilities’ infrastructure (for example, sewers);
3. Stable and long-term regulation that incentivises competitive network investment;
4. An ‘outside-in’ approach to deployment that means gigabit-capable connectivity across all areas of the UK is achieved at the same time, and no areas are systematically left behind; and
5. A switchover process to increase demand for full-fibre services.

The Government's plan under Boris Johnson

Gigabit connectivity for all

When Boris Johnson took over the leadership of the Conservative party and became Prime Minister in July 2019, he made a pledge to bring full-fibre connectivity to the whole of the UK by 2025. This meant a renewed and strengthened ambition compared to the objectives set out by the previous Government through the FTIR.

The promise was reiterated in the Conservative Manifesto ahead of the 2019 General Election. The Conservative Party pledged to bring "full-fibre and gigabit-capable broadband to every home and business across the UK by 2025"[29]. While most of the deployment is left to private investment, the Government is allocating £5bn of public funding for the hardest-to-reach premises, estimated to be around 20% of the country[30].

The prominent reference to gigabit broadband in the manifesto suggested that the Government was open to considering a more technology-neutral approach to meeting the target, rather than fulfilling it only through full-fibre deployment across the whole country. This was confirmed by the detail laid out in the Queen's Speech of 19 December 2019[31], in which the Government only refers to a target for "gigabit-capable broadband". All reference to the 2025 deadline was also removed.

Achieving the target

New laws for gigabit broadband

In the Queen's Speech, the Government sets out the broader scope of the legislation it intends to pass to facilitate the realisation of the broadband plan. In particular, the Government aims to address the following problems:

- 40% of operators' requests seeking access from a landlord receive no response;
- In 2019, 22% of new build developments were built without a gigabit-capable connection;
- In the same year, around 40,000 new homes were built without full-fibre.

The legislation will have three main elements:

1. Creating a cheaper and faster light-touch tribunal process for telecoms companies to obtain interim code rights (or access rights) for a period of up to 18 months. This will mean that they can install broadband connections where the landlord has failed to respond to repeated requests for access;
2. Amending legislation so that all new build homes are required to have the infrastructure to support gigabit-capable connections; and
3. Requiring developers to work with broadband companies to install gigabit-capable connections in virtually all new build homes, up to a cost cap.

These are reflected in the Telecommunications Infrastructure (Leasehold Property) Bill 2019-21[32], which was tabled on 8 January 2020 and was at its second reading in the House of Lords at the time of writing; and in the pledge the Government made on 17 March 2020[33], when it committed to introducing legislation to make sure that developers prioritise on the installation of high-quality digital infrastructure from the outset in new build homes. This will ensure that gigabit-capable connections will be deployed in 99% of total new build premises.

The DCMS 'Broadband and the road to 5G' inquiry

In parallel with the Government's legislative initiatives, the Digital, Culture, Media and Sport Committee (DCMS Committee) launched an inquiry to examine the Government's pledge to ensure every home and business in the UK has gigabit-capable broadband by 2025. The inquiry is accepting evidence until 19 June 2020 (having been extended to consider the impact of COVID-19 on the roll-out of full-fibre and 5G infrastructure), and will contribute to highlighting deployment challenges as well as possible solutions.

Funding for the hardest to reach areas

The Government has pledged £5bn to support the rollout of Gigabit broadband in the 'final 20%' (sometimes referred to as the 'final third'). In the two years to 2021, the Government has already committed £650m to stimulate deployment in urban and rural areas through:

- The £400m Digital Infrastructure Investment Fund;
- The £200m Local Full Fibre Networks Programme, which funds locally-led full-fibre projects;
- The £200m Rural Gigabit Connectivity Programme, which will deploy gigabit capable broadband to local hubs in rural areas, starting with primary schools; and
- The £67m Gigabit Broadband Voucher Scheme.

Ofcom's regulatory approach

Ofcom's strategic priorities

The right regulatory environment for gigabit broadband is of key importance. The Government showed awareness of this in setting out Ofcom's strategic priorities in 2019[35], through which it directed the regulator to set out a framework of "stable and long-term regulation that encourages network investment"[36]. The framework should ensure that investment comes from a range of providers, and that network competition is promoted as a key driver for network roll-out. At the same time, it should provide regulatory stability and clarity through at least five-year market review periods; regulate only where necessary to address competition concerns; ensure there is clarity regarding the application of the 'fair bet' principle over an extended time scale, to give firms confidence that any regulation will reflect a fair return on investment; and make sure firms can develop new approaches to reduce deployment costs through co-investment arrangements.

The Wholesale Fixed Telecoms Market Review

Following the priorities set out by the Government, at the start of 2020 Ofcom began a review of the Wholesale Fixed Telecoms Market (WFTMR)[37]. For the first time, the review covers a five-year period (2021–26) rather than a three-year one. This should achieve the objective of regulatory stability. The proposals take into account the Government's priorities in several other ways:

- The different approach between competitive, potentially competitive, and non-competitive areas (although Ofcom notes fully competitive areas currently do not exist in practice);
- Greater access for rival companies to Openreach's telegraph poles and underground ducts. This enables network providers to lay their own fibre networks using Openreach's infrastructure, cutting the upfront cost of building these networks by around half. Several firms are already using Openreach's ducts and poles to connect homes and businesses to faster, more reliable broadband without having to dig up streets multiple times;
- Support for Openreach in retiring its copper network. As Openreach lays fibre to replace ageing copper lines, Ofcom aims to avoid it incur unnecessary costs in running two parallel networks.

A consultation on Ofcom's draft review closed on 1 April 2020. Ofcom had signalled that it may consult on specific issues again in Q2 2020 (however at the time of writing this work is largely on hold as a result of the pandemic), and had intended to finalise the rules so that they come into effect in April 2021.

National Infrastructure Strategy

The Government is currently in the process of defining a National Infrastructure Strategy for the next 30 years. The plan was originally scheduled to be unveiled alongside the spring budget of March 2020 (as announced in the Queen's Speech of December 2019), however, it has now been delayed, with the stated intention to announce it by May 2020.

The plan, which will foresee the spending of £100bn during this parliament, is likely to include the Government's approach to fulfilling the gigabit broadband ambition, in response to the National Infrastructure Assessment published by the National Infrastructure Commission (NIC) in July 2018[38]. At the time, the NIC recommended that the Government set out a nationwide full-fibre connectivity plan by spring 2019, including proposals for connecting rural and remote communities, and suggested targets in line with the FTIR (full-fibre connectivity available to 15 million homes and businesses by 2025, 25 million by 2030, and full coverage by 2033). We now expect the Government to come up with a more ambitious deadline, in line with the pre-election pledges, and to consider a mix of technologies to achieve the gigabit target.

Copper switchover and switch-off

As fibre network deployment gathers pace, it is important to get the transition from copper to fibre right. The key aspects to consider here are:

- Protecting consumers from any disruption, ensuring that the transition occurs smoothly and without the interruption of fundamental services on which they may rely.
- Protecting competition, by ensuring that operators currently using Openreach's copper network have access to alternative fibre networks; and
- Supporting Openreach in the retirement of its copper network, avoiding it incur unnecessary costs that may come from running two parallel networks.

In the FTIR, the Government notes that a range of fibre products and pricing will be important to encourage the migration of the existing customer base from copper networks and recover the costs of the new networks[39]. More broadly, the FTIR foresees the need for a fibre switchover strategy to stimulate demand for fibre, to enable new networks to achieve scale quicker, and to ensure a smooth transition process for customers. This should be led by industry, working closely with Ofcom and Government. In the FTIR, the Government committed to set up a mechanism with Ofcom and industry for planning the switchover process, so that it meets a number of policy conditions:

- It happens in a timely manner;
- It is efficient, with minimal consumer disruption;
- It is transparent, so that customers have the information they need to make informed choices and operators have certainty;
- It is consistent with existing regulatory and consumer obligations;
- It is pro-competitive, so processes are in place to support easy switching between networks; and
- A fair deal for consumers, including adequate safeguards for vulnerable customers.

To aid mass migration from copper-based networks, fibre networks will be expected to have suitable 'entry level' products at prices similar to those provided on copper networks, including voice only services for those who want them.

Ofcom will have an important oversight role in ensuring industry readiness for switchover. It will need to protect the interests of consumers and guard against any anti-competitive behaviour. To this end, Ofcom's WFTMR proposes to remove regulation on Openreach's copper products in areas where fibre is built, and transfer regulation (including price protections) from copper to fibre services. Ofcom also plans to require Openreach to provide access to a fibre product that incentivises copper users in the migration[40]. This would be a service ensuring 40Mbps in download.

Shared Rural Network

Beyond its commitment to building gigabit-capable infrastructure across the country, the Government is also determined to extend mobile coverage in rural areas, where 4G connectivity is still patchy and often limited to one operator only. On 9 March 2020, the Government finalised a £1bn deal with the UK's four mobile operators for the creation of a Shared Rural Network[41]. The four operators have committed to legally binding contracts and investing £532m to close almost all partial not-spots, i.e. areas where there is currently only coverage from at least one but not all operators. This investment will then be backed by £510m of government funding to eliminate total not-spots, i.e. hard-to-reach areas where there is currently no coverage from any operator. This will provide new digital infrastructure in total not-spot areas not commercially viable for the operators.

The agreement is expected to provide coverage to 280,000 premises and 16,000km of roads. Some indirect benefits would include a boost to 'in-car' coverage on around 45,000km of road, and better indoor coverage in around 1.2m business premises and homes. Coverage in some areas is expected to improve by more than a third, and especially in rural parts of Scotland, Northern Ireland, and Wales. Overall, MNOs are committing to deliver 95% combined 4G coverage of the UK landmass by the end of 2025. Ofcom will have the power to enforce the commitments by fining up to 10% of an operator's gross revenue if they fail to meet their targets.
Overall, this regulatory and policy environment has worked well. However, changes will be necessary to incentivise the large-scale deployment of new networks in rural and urban areas across the UK if the Government's target is to be met. In the next section we identify how those should be prioritised, and look at what lessons we can learn from countries similar to the UK.

"The COVID-19 crisis has proven beyond doubt that the country needs world class digital infrastructure. As we rebound from the crisis, it will be more important than ever to have a coherent plan to deliver ubiquitous full fibre coverage. The good news is that the basic building blocks required – an increasingly competitive market structure, and the necessary funds for investment – are in place. But our investors still need to see the policy and regulatory measures put in place to support that competitive fibre investment. It is particularly important that Ofcom rapidly resumes its work to put in place a pro-competition, pro-investment regulatory strategy."

Alex Blowers, Director of Regulation at CityFibre

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Overcoming Demployment Challenges

Physical challenges

Geography and population density

The geography of the UK is important to remember when considering network deployment. A country with both very urban but also very rural and remote areas, in which the majority of citizens live in single dwelling units. Both of these taken together makes it challenging to deploy either fixed or mobile infrastructure. France, Spain and Portugal (countries the UK is often compared with when it comes to fibre in particular), possess certain characteristics e.g. higher number of apartment blocks and very high quality ducts that are more favourable than in the UK. However, the policy and regulatory lessons from these countries are relevant and could be adopted as we will go on to see.

Access to suitable sites and planning

In mobile, planning and landlord disputes are slowing down and raising the cost of 5G rollouts and in some instances are incentivising operators to deploy lower spec 5G. Currently, all 5G site upgrades require full planning or constitute a permitted development requiring prior approval. Both of these take between 56 and 86 days for decisions to be made and local planning authorities can refuse planning after a public consultation on a wide range of factors. What is required are automatic planning approval for 5G site upgrades and expedited legal progress to resolve landlord disputes. Government is proposing sweeping reforms of planning laws in England, some of which could be game changing. These need to be adopted as soon as possible and similar reforms need to follow in Scotland, Wales and Northern Ireland.

> Achieving the Government's ambitions for broadband will need a massive effort, significant investment from the private sector, and a faster build rate than virtually any other country has achieved. It's a big ask, and it needs decisive and coordinated action across Government, the regulator and the wider telecoms industry to make it a reality.
>
> There has already been some progress on removing barriers, but action is needed to improve access rights for apartment blocks, make street works simpler and remove business rates on full fibre.
>
> Network builders need the right conditions to invest and the right policies to encourage a fast, efficient build.
>
> **Catherine Colloms, Director of Corporate Affairs & Brand for Openreach**

Wayleaves and mandating full-fibre in new build homes

Wayleaves are the agreements between operators and site occupiers to install infrastructure on or over their land. The Electronic Communications Code was reformed in 2017 to give operators more rights and remove the prospect of so-called 'ransom rents' being charged by landowners. However despite these reforms, operators continue to experience significant challenges gaining access to buildings because of the number of landlords who are not known or not interested. Similarly, for new-build properties, developers can often ignore connectivity requirements, however progress is being made here.

Government will propose legislation to require developers to install high-quality digital infrastructure from the outset, make it a priority as part of the build, and ensure broadband companies are on board before the first brick is laid. Building regulations will be amended to guarantee that all new homes have the right infrastructure to support gigabit broadband. Developers must work with network operators to install gigabit connectivity in new-build homes, up to a cost cap of £2,000 per dwelling. The policy is technology neutral and the Government expects developers to consider fibre and FWA as part of the solutions adopted. If the UK can legislate quickly here, then it can benefit from a quicker roll-out, as has been seen in a number of other countries where policymakers have intervened.

In Germany, for instance, the "DigiNetz Law"[42] ensures that fibre rollout is built into infrastructure planning from the outset. It will be mandatory to make existing infrastructure such as electricity, waterways and wastewater systems, gas and district heating, roads and railways, available for broadband deployment. Municipal governments have to ensure that new residential areas are equipped with passive fibre network infrastructure. The right of way acquisition process must be completed within three months, to avoid lengthy bureaucratic approval procedures. In France, operators benefit from rights-of-way and "easements on private properties", subject to adequate compensation[43]. Operators are allowed to install equipment on public roads, as long as the use of the space is not incompatible with the use of the roads. In Spain, operators have the right to use spaces in the public domain for the deployment of their networks, and local laws have to reflect such a right[44]. Even in some parts of the UK progress has been made. The City of London for instance has a standardised 'wayleave toolkit'[45] to allow operators and property owners to agree on wayleaves in an easier and more efficient way which it is felt would be beneficial to roll-out across the country.

"

To stay in the 5G race, the UK needs to make it easier to deploy 5G technology. We think the Government proposals are a good start, and we encourage them to go further by cutting unnecessary red tape around local planning approvals for 5G equipment. The coronavirus situation has highlighted the importance of mobile services to the country and we would welcome further changes to the Electronic Communications Code to give us quicker site access to support mobile services.

All together, these reforms would speed up the roll out of 5G and allow UK consumers to enjoy the full benefits of 5G sooner.

Stephen Lerner, General Counsel and Director of Regulatory Affairs at Three UK

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Policy challenges

Technology mix

Boris Johnson's Government's adoption of the target to deliver "gigabit-capable broadband" nationwide by 2025 has seen a shift in the reference from "full-fibre" to technology-neutral "gigabit broadband". Until then, and under various previous governments, the focus has very much been on stipulating the use of fixed technologies when it comes to the UK's digital infrastructure because of their "future-proofness". This has been particularly true when public money has been used to fund rollout in those hardest to reach areas.

However the EU's state aid guidelines have been quite clear in stressing that since various technological solutions exist to provide broadband services, policy should not favour or exclude any particular technology or network platform[46]. The provision of the required broadband services should use or combine whatever technology is deemed most suitable, where the most suitable technological solution could be a mix of technologies.

Fixed-wireless access technologies have already been in use to provide home broadband like services using the mobile network. Equipment at the customer's premise, either indoor or outdoor, receives signal from a mobile cell station and provides broadband in the home. This solution has proved popular in places that can't be easily served through fixed broadband. However, current mobile technology has meant that FWA's performance has not been able to rival full-fibre. With 5G, performance of FWA is expected to be more similar to that of full-fibre, thereby allowing operators, consumers, and policymakers to consider it as a viable option to deliver gigabit connectivity to the parts of the country where deploying a fixed solution would be inconvenient or too costly. In particular with FWA:

- It is capable of reaching gigabit speed. In Switzerland, for instance operators have been able to offer speeds close to 2Gbps;
- It can be rolled out quickly. As operators can use their existing mobile sites, at a lower cost of capital compared to fibre. It is estimated that, for suburban areas in countries such as Germany and the UK, 5G FWA can have a cost per line between five and six times lower than FTTH/P;
- Consumers can set it up easily. It requires a plug-and-play device, which can often be delivered on the same day of ordering and they take it with them when they move home.

In the US, one of the reasons that saw the approval of the merger between T-Mobile and Sprint was the commitment from the two operators to build a 5G network that would cover 85% of the rural population within three years, and 90% within six years, including the rollout of a 5G home product as an alternative to fixed broadband[47]. 5G FWA is also becoming common in Austria, where Telekom Austria and T-Mobile[48] have deployed in rural regions where laying cables would be complex, slow, and expensive, and in Switzerland (where only 30% of households can get FTTH/P), and mobile operator Sunrise has reached nationwide 5G coverage by the end of 2019. In Italy, Fastweb has committed to providing 5G FWA to 60% of the country by 2024, with a view to prioritise the small and medium cities – so-called 'grey areas' – and get them served by 2023[49]. In Norway, the regulatory authority Nkom has required Telenor to provide wholesale access to its 5G FWA solution, because it is considered a substitute product where Telenor is switching off its copper network and, as a result, Telenor's competitors need it to replicate similar retail offers[50].

In some countries 5G FWA is already spurring on competition between providers. In Finland, Telia was the first operator to offer 5G FWA, and all other mobile operators soon followed in order to avoid losing ground. As a result of this race, Finnish customers are enjoying 1Gbps speeds with unlimited data from all operators, and one of them (DNA) even offers a speed guarantee of at least 100Mbps. While this is still rare, Optus in Australia is also offering a 50Mbps speed guarantee for its 5G FWA service[51]. As the technology becomes more popular, it is likely other operators will guarantee minimum performance levels.

Business Rates

Business rates (or non-domestic rates) are taxes charged on the occupation of non-domestic property (for example, offices and shops. In the UK, this also includes telecoms networks. The UK Government has had in place a 5-year holiday on business rates for full-fibre broadband infrastructure since 1 April 2017 (due to end 31 March 2022). This is to support and incentivise the roll-out of broadband and 5G services. Relief is only granted in respect of 'new fibre' that has not yet been laid.

Extending the rates relief further has been a key priority for infrastructure builders and their future plans. The Scottish Government is granting a 100% relief, and is doing so for a 10-year period – five years longer than the current UK Government's rate relief. It was announced in the 2020 UK Budget that there would be a fundamental review of business rates and that it would report in the autumn – the timing of which could now be uncertain. Guaranteeing at least the extension of the relief is crucial to match the much longer payback period (often 15 – 20 years) on investments in infrastructure. The impact is significant. For Openreach, the rates on building full fibre create an additional £1bn liability over 20 years which, for them, is equivalent to the cost of building out to three million homes.

"Virgin Media will bring next-generation speeds to our entire network by the end of 2021. By investing private capital to upgrade and expand our network, we will help the Government to achieve half of its broadband ambition four years ahead of its 2025 deadline.

The question now is how we get the other half of the country connected. The Government and Ofcom both need to have long-term focus and commitment to ensure the right environment exists for significant advancements to be made. Virgin Media would like to see the business rates environment change to reflect broadband policy so that gigabit-capable connections are not taxed; new build and MDU legislation strengthened; better collaboration between Government departments on street works guidance and finally a commitment to ensure any future consumer regulation does not negatively impact the expansion of gigabit networks.

Lots of progress has been made but more must be done to turn broadband ambition into reality."

David Rodman, Executive Director of Public Policy and Regulatory Affairs at Virgin Media

Approach to unprofitable areas

In spite of the significant investments and planned coverage of networks, it's widely accepted that competitive, commercial network build will not be possible everywhere. Market competition should deliver full fibre networks across the majority of the UK under the right conditions (c.80%). c.20% of the country is likely to need alternative models to ensure rollout of networks.

An 'Outside-In' approach, where some of the hardest to reach places are tackled first, was initially proposed in the FTIR to ensure that gigabit-capable broadband to premises in the final 10% can be delivered along with the rest of the UK. Since then, the scope of this scheme for the hardest-to-reach premises increased from the final 10% to final 20%. The Johnson Government has allocated £5 billion to tackle this hardest to each 20% of UK premises, but there are no details yet of how that funding will be used. There are several existing funding programmes for full-fibre launched under the May Government, including two voucher schemes to subsidise full-fibre connections to rural premises and small and medium sized business.

In France, FTTH/P deployment has grown at pace, that the Government's objective to achieve full-fibre coverage by 2025[52] looks likely if rollout continues at the current rate. The number of households able to get FTTH/P in a year grew from 1.49m in 2015 to 4m in 2019, and the Government predicts a similar number of households to be covered in 2020[53].

France has achieved these results as a result of its "Plan France Très Haut Débit"[54], which aims to provide every home and business with "very high-speed broadband", i.e. 30Mbps or higher, by 2022, and entails a €20bn investment, both private and public, over 10 years. The Government provides financial support for local authorities with €3.5bn in subsidies, and with long-term loans (up to 40 years) at very low rates. Considering that the 2022 target is on track to be met, and that 80% of the high-speed connections will be fibre by then, the Government now wants to go further and achieve full coverage of FTTH/P by 2025. Within the framework of the existing plan, 75% of the country's departments have already set that target; for the remaining 25%, the Government will make available €280m for local authorities which can now request state aid.

While funding plays an important role, the regulatory and policy framework has also been key to this outcome. Since 2004, local authorities have been given extensive powers for the digital development of their territories, which include the ability to set up public initiative networks ("réseaux d'initiative publique" or RIPs). These are almost entirely limited to rural areas, where there is little incentive for private operators to rollout. RIPs have to be notified to the national regulator ARCEP, and are subject to certain regulatory safeguards, as ARCEP aims to facilitate the use of these networks by commercial operators. Authorities must guarantee the shared use of the network. Full-fibre RIPs covered 7.9% of French households as of Q3 2019, whereas private operators in rural areas covered a total of 8.2m lines, equivalent to 22.4% of all French households.

Legislation has also facilitated infrastructure sharing in the building of fibre networks, and treated urban and rural areas differently. In 2008, France adopted a law ("Loi de Modernisation de l'Economie", LME), which foresaw the obligation to share in-building fibre wiring. The legislation on network sharing was characterised by the organisation of co-investments schemes for rolling out FTTH/P networks in very densely populated areas (where only the in-house wiring is subject to co-financing), and in less densely populated areas (where a larger part of the terminating segment is subject to co-financing). To that end, very detailed symmetric access regulation has been put in place, requesting the operator building the infrastructure to provide wholesale passive access to the operators participating in the co-financing, as well as individual line rental to the access seekers on an ad hoc basis.

France has also acted decisively to provide connectivity to those parts of the country that couldn't get good fixed broadband by 2020, and subsidised up to €150 per household to help operators provide 4G FWA[55].

Stimulating demand and take-up

Whilst the industry appears confident about the long-term demand for higher quality, reliable connectivity, there are substantial demand risks. Uncertainty remains about mass market willingness to pay for higher speeds. This can be expected to impact on the pace at which people migrate to gigabit services and on the price premium that networks can charge. The public sector can play an important role in generating greater demand for fibre networks through targeted funding to local bodies to harness public sector connectivity and aggregate private sector demand to build new and extend existing fibre networks. This includes using hospitals, health centres and GP surgeries as 'anchor tenants'; and upgrading schools, libraries and emergency response buildings to gigabit-capable connections.

In the next section we will look at where the demand is likely to come from by focusing on use cases in Asia who are early adopters of new applications and services that are supported by gigabit broadband technologies.

3

Use Cases for Gigabit Connectivity

Government and education

e-Government

e-Government connects the dots between various use cases of gigabit broadband – from mobility to environmental protection, safety, and emergency response and management. It's essential that administrations are equipped with adequate connectivity, and develop the necessary digital literacy to manage it and use it to its fullest potential. Many governments that have ambitious connectivity targets have gone paperless and intend to fully digitise procedures. These plans not only create strong potential for efficiencies for government, but also benefit citizens more broadly. Monaco has saved 1.4 tonnes of paper through the digitisation of its Official Journal[56], whereas Estonia estimates to have made saving for about 2% of its own GDP by moving administrative procedures entirely online and by using digital signatures[57].

e-Learning

Gigabit connectivity and the classroom

Gigabit broadband has the potential to transform learning both inside and outside the traditional environments of schools and universities. Faster speeds combined with low latency for both fixed and mobile networks unlock new opportunities. Significantly less time to access content, combined with fast network response, will make it possible to add AR and VR tools to the traditional learning tools available at present. This will reinforce student learning and potentially even have an impact on disenfranchised students, which will now be able to access new materials more easily. Some education experts have referred to 5G as a potential social equaliser and a developer of the workforce and economy[58] in rural regions, as it can lower the barrier of access to education and address problems such as a shortage of teachers.

China Mobile's smart campus

With enhanced connectivity, education in schools and universities is becoming more interactive. China is seeing significant growth in ICT-based education, whose market size is now estimated to be worth more than CNY250bn (£28bn)[59]. The Chinese Government is working to promote the informatisation of education, and released an action plan in 2018 to encourage the use of 5G and AI in education, enhance education effectiveness, and optimise the experience of learners.

Against this backdrop, operators such as China Mobile have developed Smart Campus solutions which include 'smart classroom' devices, (writing devices, video interaction devices, e-whiteboards, mood recognition devices, VR/AR devices, among others), as well as platforms for remote interactive lectures, virtual teaching, and campus smart management. These tools enable remote synchronous learning (where teaching is carried out by two or more teachers), remote teaching and research, and holographic projections.

Remote learning during the coronavirus pandemic

With schools and universities closed, educational establishments around the world are making use of solutions for remote learning with the support of tech companies.

Google's "Teach From Home" toolkit[60] includes software for video calls, live streams, and live Q&As, as well as tools to improve accessibility, student engagement, and interaction between teachers. Internet providers are also offering access to e-learning platforms. Vodafone has been doing this globally[61], and operators in several countries (e.g. Italy[62] and UAE[63]) have taken similar initiatives, either by enabling students to access e-learning platforms, or by offering more generous data allowances to those who need to use said resources from their homes. In Poland, the Government has extended a scheme initially designed to provide internet access to schools, so that now it also includes tools for remote learning[64].

In China's Hubei province, where Wuhan is located, demand for remote learning soared during the coronavirus pandemic. This was initially limited to live online classes, and later extended to AI applications to improve safety, detect students' behaviour, and maximise efficiencies. Table 1 outlines the way in which e-learning has been used across three different stages.

Table 1: Remote education solutions in Hubei, China

Phase	Tasks	Detail
1: Live online class (February 2020)	- Online class - Lecture hall	- Utilise existing IPTV network and CDN resources - Hubei IPTV/OTT to introduce online education
2: 5G + AI campus management (March 2020)	- 360° monitoring - Facial recognition - Security management - Epidemic patrol	- Proactive prevention to ensure campus security - 5G + MEC to ensure high speed video transmission - High AI computing power to process and analyse multiple video streams simultaneously
3: 5G + AI smart class (April 2020)	- Teaching report - Classroom behaviour and emotion - Knowledge graph	- Data analysis: personalised classroom analysis academic report generated with one click - Intelligent record of knowledge points and AI health assistant functions to improve student learning efficiency - 5G-enabled high-speed upload and distribution - Classroom teaching behaviour video sharing

Source: Huawei

Live and social events

Gigabit connectivity will also play a key role in enhancing the experience of audiences at live and social events. It is not just about faster speeds, but crucially also a matter of better performance in crowded environments due to higher capacity and lower latency. This means that a gigabit-capable network is less likely to let users down when it matters, and realises the full potential of augmented reality (AR) and virtual reality (VR) applications. For example, mass gatherings like the one that took place in Grant Park in Chicago in 2017, when about 20,000 people attended the Pokemon Go fest[65], will strongly benefit from a more capable and reliable communications infrastructure to avoid the risk of network congestion and to make sure attendees actually live the experience they have been promised.

Some key players in the field of live events and entertainment have already understood the importance of what is coming. The Camp Nou stadium in Barcelona is poised to become soon the first stadium in Europe with internal 5G coverage[66], which will enable a series of enhancements for audiences inside and outside the stadium. In the US, some American Football teams are already doing this: the Dallas Cowboys have been using their newly installed 5G network at the AT&T stadium to offer fans an AR experience[67], whereby they can use a 5G smartphone to choose their five favourite players who duly arrive on screen to have their picture taken with the user. Fans can also look through their smartphone to see AR holograms of players looming over the stadium.

In the UK, EE partnered up with Niantic for the launch of its 5G service, to be the exclusive partner in the UK for the AR game Harry Potter: Wizards Unite. As part of the partnership, EE customers have the chance to experience exclusive content. EE locations appeared in the game as sponsored Inns and Fortresses with higher reward payout and special quests. Video gaming is likely to be an industry which will reap significant benefits from gigabit broadband, as video games producers begin to design experiences that cannot be lived without AR and require the support of low-latency and high-capacity networks[68].

With future technology developments, such as improvements in edge computing, the importance of 5G in these spaces will be even more evident. Sports fans going to an event will be able to benefit from a wealth of real-time information on things such as upgrade their tickets, buy merchandise, and even adjust the underseat heating now being installed in the world's smart stadiums. Public security is also likely to benefit from all this hugely. At the Roland Garros French tennis open in 2018, the French operator Orange provided a glimpse into edge computing and video analytics. Using wireless cameras around the venue, together with AI applications, it demonstrated how it can keep track of individuals around various courts and entertainment areas. Providing intelligence on exactly how populated public spaces are can be invaluable for improving safety and security by avoiding overcrowding and enabling proactive guidance of visitors to a venue.

Media and entertainment

Gigabit capable networks support a whole new set of capabilities for the provision of entertainment and content within the home. In Japan, China and South Korea, where gigabit capable networks are widespread, we have seen the following:

- **Live VR video streaming.** This includes, but is not limited to, sports events. It can include live TV shows as well as VR concerts with tens of thousands of users active at one time. One example was a VR concert with 88,000 concurrent fans who paid an e-ticket to access the experience.

- **Gaming and animation.** Online gaming requires both high speed (especially when it comes to downloading a game) and low latency, to make sure the order given by the gamer results in a timely action on screen. Downloading a game of several gigabytes would require more than one hour with a 10Mbps connection.

- **Enhancement of existing live streaming services**. Some services in Asia, such as V live TV, offer close interaction with local pop stars through chat sessions with fans, performances, reality shows, and award shows. This can draw several million fans to interact with pop stars through these channels (some channels on the V Live up have 16m followers), and in turn drives economic growth. It's estimated that the K-pop band BTS for example accounts for around $4.65bn of the GDP of South Korea.

- **Delivery of on-demand content.** Recent debates about the future of the BBC's funding in the UK have seen suggestions of a move away from the licence fee, to embrace a Netflix-like subscription model after 2027 (when current funding arrangements end)[69]. This, combined with the likelihood that the shift from linear to on-demand content will continue, highlights the importance of infrastructure that supports on-demand high-definition video streaming for both private and public service broadcasters.

Healthcare

Hospitals in Wuhan during the coronavirus pandemic

The city of Wuhan in China was the epicentre of the coronavirus outbreak. On 23 January 2020, the city was subject to a lockdown which lasted more than two months, until the end of March 2020. Similar control measures were extended to the entire province of Hubei by 26 January 2020. As has been the case in the UK and elsewhere, the circumstances increased the demand for connectivity. The new hospitals created for the emergency also needed support for their information systems, and an increase in the activities that could be carried out remotely.

Meeting medical needs during the pandemic

Wuhan responded to the coronavirus outbreak with 48 dedicated hospitals, containing 26,911 beds; 13 'cabin hospitals' with 13,348 beds; and two new hospitals built for the purpose, which contained 2,600 beds. Across these facilities, there was the need for a rapid integration of the information systems, and for a communication infrastructure to be built from scratch – in particular, those of the cabin hospitals and the new hospitals required immediate set up and launch. More specifically, the communications infrastructure needed to support the following needs:

- **Highly efficient coordination:** smooth communication anywhere, anytime, to ensure coordination between different systems;
- **Expert resource sharing:** remote diagnosis and consultation;
- **Improvement of testing methods:** AI gene sequencing, AI assisted diagnosis;
- **Protection of medical staff:** reducing the risks of infection by limiting medical staff's time in 'red zones';
- **Automation in isolation wards:** make use of automation to reduce staffing needs, thereby easing the pressure on health workers and hospitals;
- **Protecting hospitals' environment:** assist with thermal temperature testing, disinfection, delivery of goods, etc.

Facilitating patient's medical and social needs

Other than the needs of hospitals and healthcare staff, the communications infrastructure in Wuhan had to serve the needs of others during the emergency, such as the government (needing to support remote coordination and data collection), patients (24/7 care and medical intervention for patients with severe symptoms). Patients also needed to communicate with their relatives, and to have psychological counselling where necessary during isolation), and families (who need to be updated with the progress of their relatives during isolation.

How was gigabit broadband used?

5G and fibre proved to be the answer to many of the demands. Local institutions partnered with operators and with network equipment manufacturers such as Huawei to quickly set up a 5G network to cover the new hospitals, whereas fibre networks played a major role in supporting the communications needs of existing hospitals. 5G networks in Huoshenshan Hospital in Wuhan, and in Xiaotangshan Hospital in Beijing, were built, tested, and launched in three days. In the province of Heilongjiang, the 4G and 5G networks for an emergency response centre were built within 32 hours. This was made possible by the characteristics of easy setup and fast operation of 5G networks. For example, a 5G Active Antenna Unit (AAU) can significantly improve network performance and reduce the number of cable connections required, while innovative "mini post stations" can be set up by street lamp posts with minimum effort. Because of the characteristics of 5G – such as high speed, high reliability and low latency, the healthcare system benefited from improvements in response times, patient monitoring, data collection and analytics, remote collaboration, and resource allocation. In total there were 18 specific ways (across four types of uses), in which gigabit broadband proved invaluable during the pandemic (see Table 2). Among other noteworthy examples, healthcare workers could make use of it to better detect any damage in their protective suits. This was important because the suit poses obstacles to full sight for those who wear it, thereby making it difficult to spot possible damages. Two HD cameras and a smart screen provided a 360° view to assist self-check, and the connection facilitated remote assistance from other members of the team. Through 5G, these hospitals and their teams could also benefit from mobile trolleys for remote diagnostics; remote consultation tools (to avoid close contact with patients); thermal imaging for the measurement of human temperatures; and driverless vehicles and robots (for tasks such as delivery of goods and disinfection of environments).

Table 2: Use cases and value of 5G in responding to the coronavirus pandemic in China

Type	Use case	Value
Live broadcasting	Live broadcast of new hospital construction sites	Live broadcasting of a major public event
Remote coordination	Video conferencing	Coordination between hospitals
	Protection suit self-detection	Reduction of infection rate
	Virtual visit and remote psychological counselling	Useful in isolation wards
	5G mobile trolley	Reduces the need for medical staff
Remote diagnostics	Remote CT and X-ray scanning	Joint consultation, fast decisions on treatment
	Remote ultrasound scanning	Reduces contact with the patient
	Remote ECG transmit	Reduces contact and need for staff
	Remote monitoring of isolation wards	Reduces infection rate, and enables real-time consultation
	Remote medical consultation	Remote consultation on difficult surgeries
	Wireless respiratory monitor	Fast delivery
Remote protection	Thermal imaging temperature detection	Reduces human contact
	Infrared temperature detection + disinfection robot	Reduces human contact and need for medical staff
	Delivery robot	
	Disinfection robot	
	Cleaning robot	
	Medicine delivery robot	

Source: Huawei

Smart cities and smart mobility

Smart cities

Building a smart city is increasingly a goal of local administrations worldwide. In China, this is the case for 89% of cities at the prefecture level, and for 47% of county-level cities[70]. Singapore has been a world leader in its aim to become a "Smart Nation"[71], with initiatives across multiple pillars (strategic national projects, urban living, transport, health, digital government services, and startups/businesses) dating as far back as 2014[72]. Since 2017, the Smart Nation and Digital Government Group is part of the Prime Minister's Office[73], which signals the importance that the Government is attributing to the Smart Nation strategy. The Government of Singapore allocated SGD400m (£224.4m) between 2016 and 2020 to research driving digital innovation in urban mobility, healthcare, services, and to support the building of capabilities in AI, IoT and cybersecurity.

Gigabit connectivity is instrumental to smart city projects, as it's a prerequisite to address problems such as poor sensing capabilities, weak information protection and cybersecurity, and low efficiency in environmental governance. When smart, cities can then become safer, more livable, better governed, and operate more efficiently. This requires low-latency transmission of data, comprehensive sensing capability of public infrastructure, network reliability, and connection and sharing of big data. Public infrastructure is equipped with smart sensors (HD cameras, smart waste facilities, smart lamp posts, etc.) and these devices feed their data into the smart city platform, which monitors, predicts, and analyses it (e.g. data on population and the environment) to facilitate decision making and implementation. The information derived in this way can be used in applications such as law enforcement and emergency response.

Protecting the environment

In China, operators such as China Mobile have developed solutions to integrate IoT, AI, and big data into devices such as HD cameras, air quality sensors, and unmanned aerial vehicles i.e. drones. These can monitor a city's air quality in real time, thereby enhancing pollution prevention and control. This facilitates the efficient location and tracking of pollutant sources and emissions, and helps environmental protection departments to implement effective policies.

Improving emergency response

The combination of gigabit-capable networks with AI algorithms, data analytics and geographical information makes it possible to quickly collect accurate information on the population, and provide population profiles in specific areas. During emergencies, these systems can allow the effective monitoring of populations, and, for example, ensure specific groups of people receive emergency alerts on their smartphones. The predictive capabilities of these systems can also make sure that early warnings are spotted more clearly at the right time and, for example, public events in cities can be managed more easily.

Smart mobility

Smart mobility does not only mean autonomous vehicles, but also traffic planning, which means governments can plan infrastructure upgrades intelligently. The full potential is realised through the development of AI, IoT, cloud computing, big data, and edge computing. In this way, a meaningful interaction is developed between vehicles, roads, and people.

The interaction of all those elements provides additional value to multiple stakeholders. Public administrations can obtain traffic data to optimise the management of urban traffic, and, in the future, the operation of autonomous driving vehicles; drivers and vehicle owners benefit from vehicle diagnosis, entertainment content services, and fleet management services; and car manufacturers obtain in-vehicle running data collection. Use scenarios currently being developed include autonomous driving in public transportation, campuses, and freight logistics. High-precision positioning, combined with 5G's low latency, improves user experience and traffic efficiency, and facilitates smart parking spaces and smart communities. This optimises the sharing and management of parking in a given region. Some applications currently being developed also enhance safety for pedestrians and vehicle passengers, by implementing beyond-line-of-sight perspective, traffic light information push, and pedestrian collision prevention reminders.

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