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UK Broadband Infrastructure

The growing use of smart phones and data intensive services (such as video streaming), has increased demand for both fixed and mobile internet. This brief looks at patterns in broadband access and use, and the technical and policy challenges of enhancing UK broadband infrastructure to meet future needs.

Overview

- Improved internet access could create social, financial and environmental benefits.
- New fixed line broadband infrastructure is being installed in the UK, with a target of providing at least 24 megabits per second speeds to 95% of people by 2017.
- Wireless infrastructure is also being deployed with the aim of speeding up mobile broadband at 98% of UK premises by 2017.
- There is debate over how best to meet such targets and how this affects innovation, consumer choice and geographical variation in services.
- There are technical and economic barriers to deploying and sharing new infrastructure.

Background

Broadband refers to high speed, always-on, access to data (Box 1). The UK Government considers broadband internet access as essential for individuals and businesses, a key infrastructure for economic growth, and a means for delivering public services.[1,2,3,4] Reliable internet access is identified as critical by 94% of small businesses.[5]

Broadband services in the UK are delivered via two infrastructure types:

- fixed line infrastructure, which provides static broadband connections via networks of copper, fibre-optic or cable, carried by ducts in the ground or held on poles (Box 2)
- wireless infrastructure, which provides internet connectivity through mobile (3G and 4G), WiFi or satellite technology (Box 3). Mobile phone masts and WiFi hubs typically rely on fixed networks to connect to the internet (although mobile networks can be used). Satellite services are provided via either fixed or mobile receivers.

This POSTnote focuses on broadband provision for households and small businesses. It discusses:

- variation in broadband accessibility across the UK
- trends in broadband use
- approaches to expanding infrastructure to meet growing demand for broadband access and greater speeds.

Access to Broadband

There is widespread variation in access to broadband infrastructure across the UK. According to a 2014 Ofcom report:

- 97% of UK premises could (with a subscription) receive a fixed line broadband connection with download speeds greater than 2 megabits per second (Mbps)
- 85% of premises could access download speeds of at least 10 Mbps through fixed line infrastructure
- superfast broadband (over 30 Mbps, Box 1) could be accessed via fixed line infrastructure in 75% of premises (actual take-up is 22%), but drops to 22% in rural areas
- depending on provider, 3G mobile broadband could be accessed in 76-93% of premises (33-74% of UK landmass), and 4G in 32-59% (7-19% of landmass).[6]

Speeds are generally lower in rural areas than urban ones. Reasons for this include less investment in broadband infrastructure in rural areas, and the longer lengths of copper cable often used to connect properties to the network, which reduce broadband speeds.[7,8] Consumer group Which? has raised concerns that broadband speeds advertised by suppliers are available to only a minority of customers.[9] However, Internet service providers (ISPs) note that they produce tailored estimates of speed before purchase, and customers have the right to cancel their contract if these are not achieved. The Government has set a number of targets for broadband provision (Box 4).

Box 1. Broadband Characteristics

Broadband connection quality depends on a number of factors.

- **Download speed** is the amount of data transferred per second to a user, a key factor in determining the time taken to load a website or download files such as video or music. It is measured in millions or billions of bits per second (Mbps or Gbps), and averages 23 Mbps for fixed connections in the UK.[6] A typical HD film would take at least 3 minutes to download on such a connection. **Superfast broadband** is defined by the UK Government as more than 24 Mbps, but by Ofcom and the EU as over 30 Mbps.[10] **Ultrafast broadband** has been used to describe speeds over 100 Mbps.[11]
- **Upload speed** is the speed of data transferred from the user. It is important for cloud computing (remote access to shared computing resources), video conferencing and online gaming. UK upload speeds average 3 Mbps for fixed connections.[6]
- **Latency** is the time-delay between sending a command to a website and receiving a response. Low latency is required for some applications such as video conferencing and online gaming.[12]

Speeds typically vary during the day and tend to fall at peak times (such as 8-10pm on weekdays) when more connections are used.[34]

Trends in Broadband Use

Current Applications

Adoption of broadband (either fixed line or mobile) has risen from 68% of UK households in 2009 to 77% at the start of 2014.[13] This increase is thought to be driven by factors including increasingly affordable and higher quality internet access.[14,15] Total internet traffic is also increasing because of other drivers such as the use of more devices (for example tablets)[16] and increased use of services such as video (which accounts for two thirds of consumer traffic).[17] There has been particularly rapid growth in wireless services, with mobile data expected to generate 11% of UK internet traffic by 2018, up from 3% in 2013.[16]

Emerging Applications

Future broadband applications are difficult to anticipate. UK Internet traffic has been predicted to grow three-fold between 2013 and 2018,[18] driven by: machine-to-machine communication (also known as the 'internet of things', where everything from fridges to farm animals could be connected to the internet); cloud computing (shared access to remote computing resources); online gaming; and the streaming of high-definition TV.[16] These technologies often require higher data download speeds, faster data uploads, lower latency (Box 1) and greater accessibility on the move.[19] Estimates of future demand for mobile data vary. Some Ofcom forecasts suggest a 45-80 fold rise by 2030.[20,21] Increased mobile broadband usage is expected to be met through the closer integration of fixed and mobile networks.[22] WiFi is expected to play an increasingly important role.[23]

Expanding Infrastructure

UK broadband infrastructure is expanding to meet growing demands for access and speed. There is debate about how best to do this, and infrastructure options raise regulatory, economic and technical challenges.

Investment in Fibre

Funding for the UK's fibre infrastructure comes from public sources and private companies such as BT, Virgin Media and smaller businesses. For instance BT and Virgin Media have announced investments of £2.5 billion and £3 billion respectively in their commercial fibre networks.[24,25] £1.7 billion of public funding (including regional, national and EU) and up to an additional £1 billion from BT[26] has been committed for 2009-2016 to improve fixed and wireless broadband.[27] Most of the public funding is managed by Broadband Delivery UK (BDUK), which aims to stimulate private sector investment in areas that would not otherwise have access to superfast broadband.[28] BDUK established a delivery framework in 2012 to help local authorities select broadband service providers. BT was awarded all contracts procured via the framework for the first phase of the rollout (see HoC Library Standard Note SN06643).[29,30]

As part of the contracts, BT is laying fibre from local exchanges to street cabinets (FTTC, Box 2). The decision to implement FTTC, rather than the far faster fibre to the premises (FTTP, Box 2) was based on cost-benefit considerations. For example, it is estimated that FTTC would be less time consuming and five times cheaper[37] to implement than FTTP.[29] Also, evidence from the rollout of FTTP in South Korea suggests that FTTP is primarily used

Box 2. Fixed Broadband Technologies for Homes and SMEs

Copper

Most fixed broadband connections are provided through copper wires originally built for the telephone network. These run from premises to a street cabinet and on to a local exchange that is linked to the rest of the internet via a fibre connection.[31] BT owns and maintains most copper links from local exchanges to premises in this original network.

Fibre-optics

Far higher speeds can be achieved using glass fibres to transmit a broadband signal. There are three main options for deployment.

- **Fibre to the Cabinet (FTTC)**, which uses fibre to connect the local exchange to the street cabinet, and then uses the existing copper network for the final link to the premises. This technology is being used in the UK's publically subsidised deployment of superfast broadband. BT is trialling new technologies that take fibre beyond the cabinet. It has demonstrated speeds of up to 700 Mbps download and 200 Mbps upload (with fibre laid to within 66 m of premises).[32]
- The **cable** TV network can also be used for the final link to the premises (a variation of FTTC). This separate network is owned and operated by Virgin Media and uses fibre to connect the local exchange to the street cabinet, and then a copper cable technology known as coaxial cable for the final link to the premises. Trials have demonstrated 1.5 Gbps download and 150 Mbps upload speeds using the same infrastructure as residential connections.[33]
- **Fibre to the Premises (FTTP)** is being deployed by BT and a number of other companies (Box 5), while Virgin Media plans to roll out FTTP as part of its network expansion. Speeds of hundreds of Gbps are possible using current technology. FTTP could be shared between competing services and suppliers, depending on the network infrastructure. However, domestic customers typically use services that are less expensive and far slower (Table 1).

Table 1. Current typical UK speeds and coverage for fixed broadband

	Max speed, Mbps		Average speed, Mbps[34]		Take-up,[6] % of all UK connections
	Down[35]	Up[36]	Down	Up	
Copper	24	1	9	1	66
Fibre					
FTTC	76	17	48	13	12
Cable	152	13	96	8	22
FTTP	1000	1000	128	20	0.1

Box 3. Wireless Broadband Technologies for Homes and SMEs

Wireless communication technologies use the radio spectrum, which is a finite resource needed for services such as radar, TV and mobile phones (POSTnote 292). These technologies can provide a broadband connection to a fixed receiver or mobile device such as a smart phone.

WiFi

WiFi hotspots are the standard way to connect to the internet at home. Around one third of broadband use outside of the home is also via public WiFi hotspots.[38] Speeds of up to 1 Gbps are now possible with new WiFi technologies. However, speeds are limited by the connection supplying the WiFi hub (provided using either fixed or mobile technology), the number of users and the number of hotspots at a location.

Mobile

Broadband is supplied through the mobile phone network by 3G and 4G technology operated by O2, EE, Vodafone and Three. This market is being consolidated, with recent agreements for BT to acquire EE,[39] and for Three to acquire O2.[40] Mobile operators are allocated a number of radio spectrum bands to use for 3G and 4G technologies, which helps them to ensure quality of service (unlike WiFi where quality varies much more with demand).[41] 4G connections in the UK have average speeds of 15.1 Mbps download and 12.4 Mbps upload, but technical upgrades could allow downloads of up to 300 Mbps.[42] 3G provides speeds of 6.1 Mbps download and 1.6 Mbps upload.[43]

Satellite

Three companies offer UK-wide broadband access via satellite, providing download speeds of up to 22 Mbps and uploads of up to 6 Mbps.[44] Trials supported by the Government's Broadband Innovation Fund are developing systems with 25-30 Mbps download speeds.[45]

to download media more quickly and for online gaming,[19] which has been used to question whether FTTP justifies government investment.[46] On the other hand, some suggest that FTTC will be less adaptable to future demands than FTTP, and so more costly in the long term.[47] Others argue that FTTP would be more reliable and lower maintenance,[48] and the Federation of Small Businesses says that ubiquitous FTTP could ensure companies that cannot afford to install their own FTTP are not disadvantaged.[5] Future speed requirements are unclear; one study suggests typical UK household requirements of 20-40 Mbps by 2023.[49]

Sharing FTTC infrastructure

Ofcom requires that multiple ISPs are able to offer services over BT's fibre infrastructure.[50,51] Most ISPs supply superfast broadband by buying a wholesale service from BT and selling this on to consumers. A range of commercial, regulatory and technical factors have been cited as barriers to other companies operating the infrastructure themselves (for example by putting their own equipment into street cabinets).[52,53,54] Some ISPs argue that their inability to operate the infrastructure limits incentives for them to invest in the network, constraining competition and causing consumers to miss out on lower prices and innovation. They say that BT's share of the superfast broadband market is larger than BT's share of the standard broadband market (supplied over copper, where ISPs can install and operate their own equipment in exchanges), suggesting a distortion of competition. BT says that the market reflects the differing strategies of competing ISPs and that they entered it before other major ISPs, not a lack of competition.[58]

Box 4. Government Targets

The Government made several commitments to expand broadband infrastructure,[30,56] which have evolved over time and include:

- A 'Universal Service Commitment' to provide broadband access (fixed or mobile) of at least 2 Mbps download speed by 2016.[56] Consumer expectations have led some to argue that this should be revised to 10 Mbps.[6]
- Superfast broadband (download speeds over 24 Mbps) for 95% of the UK population by 2017.[4] This is being rolled out in two stages. Phase One (targeting 90% of the UK population by 2016) is underway, and analysis indicates that coverage is likely to reach 90% of UK premises by June 2016.[55] Phase Two (targeting 95% by 2017) is being tendered. A 2015 report by the Environment, Food and Rural Affairs Committee raised concerns that the Government's target for Phase Two may slip to 95% by 2018.[56]
- 4G network coverage supplying broadband speeds of at least 2 Mbps to 98% of the population by 2017.[4]

HoC Library Standard Note SN06643 provides further details of Government policy and of broadband availability by constituency.[30]

The EU Digital Agenda for Europe initiative includes the target of broadband with at least 30 Mbps download speeds for all by 2020.[57]

Ofcom introduced a new pricing rule in April 2015, requiring BT to maintain a sufficient margin between its wholesale and retail charges to allow other ISPs to match its prices profitably.[58] As an alternative to buying wholesale services, ISPs might build their own fibre-connected street cabinets and connect these to BT's copper network for the final link to the premises.[59] However, ISPs argue that building street cabinets is costly and heavily regulated.[37,52] This has led some to invest in other infrastructure,[60] such as BskyB, TalkTalk and Cityfibre's project to lay FTTP in York (Box 5).

Increasing Wireless Capacity and Coverage

Approaches for meeting the increasing demand for mobile data include reviewing radio spectrum allocation and expanding or sharing existing mobile infrastructure. Each of these options present challenges, discussed below.

Radio spectrum for wireless vs other services

Radio spectrum use is regulated by Ofcom. Allowing mobile or WiFi technologies to use more spectrum will increase capacity for wireless broadband.[23,61] However, this may involve removing spectrum from other services such as digital terrestrial TV (DTT) and satellite communications. The introduction of new 5G mobile technology may also require additional spectrum (Box 6). Allocation of spectrum for 5G is being coordinated internationally to ensure new devices can be used across the globe.[62]

The Government is already allocating additional spectrum to mobile technologies,[63] such as the 700 MHz band used by DTT. Ofcom says this will not reduce DTT services.[23] Some mobile operators say that future demands will require further spectrum. They suggest that this could be done by making more spectrum currently used by DTT (470-694 MHz) available to them, because TV provided over broadband may reduce the spectrum needed for DTT in the future.[64]

Some are also calling for more spectrum to be assigned to WiFi,[65] in line with recent changes in the US.[66] However, new technologies could improve the efficiency of spectrum

Box 5. Fibre to the Premises (FTTP) Case Studies

Cityfibre

This company is building city wide fibre networks by connecting large centres of demand (such as public buildings) and then using this core network to reduce the costs of connecting FTTP to homes and small businesses. Cityfibre is planning to deploy networks across 25 UK cities, providing infrastructure through which broadband providers can supply extremely high speed services.

Broadband 4 the Rural North (B4RN)

Community broadband initiatives may offer a solution for regions that broadband operators do not deem commercially viable to serve. For example, B4RN was able to generate local demand in rural Lancashire and has provided more cost effective infrastructure by using local volunteer labour to help build an FTTP network to 300 homes and farms. However, barriers exist in coordinating deployment and finding adequate connections to the rest of the internet.

use, such as using DTT spectrum in areas where certain TV channels are not transmitted (known as white space).[67]

Expanding mobile infrastructure

Increasing the number of mobile phone cells (the electronics on top of mobile phone masts), would help to improve coverage and increase capacity for data. For example by creating a denser network of smaller cells. However, investment in new infrastructure may be limited by:

- restricted access to affordable fibre services for connecting new mobile cells to the internet[38,47,64]
- regulations over access rights for mobile operators to maintain cells[64]
- rates paid to landowners to house mobile cells[64]
- planning permission restrictions for mounting cells.[64]

Sharing mobile infrastructure

Another way of improving coverage in areas served by only some mobile operators is infrastructure sharing.[68] There are a number of options for infrastructure sharing, including:

- customers in an area not covered by their service provider using a mobile phone cell operated by another company, known as national roaming
- mobile service retailers who operate over another company's infrastructure, arranging access to infrastructure owned by multiple operators
- mobile operators installing their own electronics on other operators' masts and sites.

Mobile operators say that some of these options remove incentives to invest in infrastructure and reduce network reliability,[69] and a 2014 Government consultation decided against them for voice and text.[70] However, national data roaming has increased coverage in other EU countries.[71] An alternative approach to infrastructure sharing would be to create 'intelligent' networks (both mobile and fixed) that adapt to share demand across the network, potentially extending the capacity of existing infrastructure.[22]

Rural Access

Broadband infrastructure in rural areas is often more challenging to deliver, but is seen as vital to driving economic and social development in rural communities.[72]

Box 6. 5G Technology

The fifth generation of mobile technology, expected to be implemented from around 2020, is a collection of technologies that aim to provide a perception of infinite broadband capacity. The exact nature of 5G is still being discussed, with the aim of creating international standards for manufacturers and others. Key suggested features include:[73]

- seamless transitions between using WiFi and mobile broadband, with the ability to use multiple mobile masts simultaneously
- faster and more reliable connection at the edges of the network
- more energy efficient electronics, extending device battery life.

Rural fibre

BT is deploying FTTC in rural areas via the Government-funded superfast broadband rollout. However, this relies on premises being clustered and connected to a street cabinet using short lengths of copper. Ofcom estimates that 33% of rural premises connected to fibre-enabled cabinets in the current BT rollout are unable to receive download speeds above 30 Mbps,[6] and it has been suggested this could be higher in some regions.[74] BT is trialling options to increase the speeds available over existing copper lines, which may cost less than laying fibre all the way to the home.[75,76]

Unlike copper, fibre does not reduce the quality of broadband signals over long distances. This makes FTTP particularly suitable for dispersed populations (Box 5). However, the civil engineering required to dig ducts or construct poles when laying fibre over long distances can make costs far higher than in urban areas.[37,77] Rural fibre networks are often far from any other fibre infrastructure, making it expensive to connect to the rest of the network.[47]

Fixed wireless

Broadband could also be provided by 4G or wide-area WiFi networks, which have been shown to deliver superfast connections to rural areas under test conditions. Limitations of such systems include speeds that depend on the number of users, restricted availability of fast links between the local wireless network and the rest of the internet, and the cost and difficulty of installing wireless networks in hilly areas.[78]

Satellite broadband

Satellite broadband equipment can be cheaper than laying fibre in very rural areas.[79,80] However, data transfer is more costly for consumers than fixed connections,[80,81] high latency can be challenging for applications such as on-line gaming, video conferencing and cloud computing, and the capacity of existing UK satellites is limited.[82,83] BDUK has plans to make subsidies available for satellite connections.[80]

Digital Inclusion

Providing broadband infrastructure does not guarantee that people will make use of it. Despite 97% of UK premises having the potential to connect, 18% of households do not subscribe to either fixed or mobile broadband.[6] Research suggests that this is due to factors such as cost, a lack of online skills and unfamiliarity with the benefits.[84] The digital skills charity Go On UK has argued that the full benefits of the internet for the economy, public services and society can only be realised if all households and businesses are brought online.[85] The Government launched the Digital

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Inclusion Strategy in 2014, which aims to bring online everyone who is capable of developing digital skills.[86]

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