Infrastructure Report

The first Communications Infrastructure Report

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Contents

Section 1

Summary

1.1 The Digital Economy Act 2010 gave Ofcom a new duty to report to the Secretary of State for Culture, Media and Sport every three years on the state of the UK's communications infrastructure. In July, we published an initial report relating to broadband services delivered over fixed networks. This report and associated material published on Ofcom's website constitutes the remainder of the first report.

1.2 The report considers the coverage, capacity and resilience of the main public networks and services available in the UK, which includes fixed line and mobile telephony and broadband, digital radio and digital terrestrial TV. We have considered these from both a UK wide perspective and at the level of county / unitary authority.

1.3 The data we have collected from communications providers have highlighted a number of interesting findings.

Network coverage

1.4 Broadband is now available on nearly every copper telephone line in the UK, however 14% of residential broadband connections are currently operating below the 2Mbit/s speed that government wishes to make available to virtually all homes by 2015. We expect the number of sub-2Mbit/s connections to fall over the coming year as customers upgrade to new technologies and resolve in-home wiring issues that are affecting the speed of their connection. Superfast broadband networks (offering speed of over 24Mbit/s) now pass 58%[1] of UK premises and BT plans to reach two-thirds of UK premises by the end of 2015.

1.5 It is difficult to define a simple, single measure of mobile coverage that fully reflects consumer experience due to the varied ways in which consumers use their phones, particularly when on the move. For the purposes of this report, we have therefore defined two metrics to assess coverage levels – the first represents outdoor coverage of premises (i.e. postal addresses) and the second the overall coverage of land mass. These metrics have allowed us to compare coverage in different parts of the UK and will allow us to track changes in coverage over time. The metrics also provide an insight into the likely upper and lower bounds of consumer experience in different parts of the UK (whilst recognising that in-building experience is highly dependent on the location and construction of individual buildings).

1.6 For mobile networks, the data show that over 97% of premises should have a strong enough mobile signal from all four 2G network operators to make a call when outside (72% for the five 3G networks). While coverage of premises is high, overall geographic coverage by all four 2G operators is 66% (just 13% for 3G). Coverage in rural areas tends to be worse than in urban areas, but our analysis indicates that operators are often deploying more infrastructure per capita to serve rural users – highlighting the challenges of extending network coverage. We are undertaking further research to establish the level of coverage on roads given the importance of coverage on the move to both consumers and citizens. We recognise that there

[1] See http://maps.ofcom.org.uk/broadband/downloads/ofcom-uk-broadband-speed-report-2011.pdf on this metric.

may be economic challenges of deploying networks in some rural areas, and we are exploring whether there is more Ofcom can do to help industry address the remaining mobile 'not-spots'.

1.7 We have published interactive maps on our website that provide more detailed information on the coverage of mobile, digital TV and digital radio networks to add to the maps on fixed broadband networks that we published in July:

http://maps.ofcom.org.uk

Network capacity

1.8 On average, residential fixed broadband customers are using 17GB of data per month. This figure ranges from 10GB to 40GB between operators. Data from the London Internet Exchange shows that traffic over its network routers, which interconnect the UK's Internet Service Providers (ISPs), has increased seven fold in the past five years. While future demand for capacity is uncertain, if demand continues to increase at current rates ISPs will need to make further investment in their networks.

1.9 Virgin Media, BT and others are already investing in new technologies to increase the capacity of broadband access networks; BT plans to introduce technology in 2012 that will deliver up to 80Mbit/s over copper lines and 300Mbit/s over fibre, Virgin has demonstrated 1Gbit/s speeds on its cable network. In mobile, Ofcom plans to auction radio spectrum in 2012 that will enable the deployment of 'Long Term Evolution' (LTE) next-generation wireless technologies which will help meet growing capacity demands. In section 8, we highlight a number of technology options for increasing the capacity of access networks.

1.10 In addition to the upgrades to access networks, increases in network traffic will also drive the need to upgrade backhaul capacity, the data circuits that connect mobile base stations and local telephone exchanges to the core networks. Ofcom has recently published a Call for Inputs as the first stage of our Business Market Connectivity Review, which will review the competitive conditions in the market for leased lines used in backhaul circuits.

1.11 Mobile broadband data volumes are now significant, at an average of 240MB/month for each 3G connection. However, the data suggests that consumers continue to rely on fixed networks for the bulk of their data consumption and a number of operators are turning to fixed networks to off-load traffic from mobile devices on to fixed networks using Wi-Fi and similar technologies.

Resilience

1.12 As a result of the Infrastructure Report and new European legislation, processes are now in place for providers to report to us on the availability and security performance of key networks and services. This report summarises the initial results of this reporting, although the data so far is too limited to draw firm conclusions. We suspect much of the value will come later as we will be able to spot trends in the data.

1.13 While too early to see trends in the reported data, some more qualitative security and resilience trends are apparent from our work in these areas. Reductions in the number of diverse infrastructure platforms, due both to technology developments and company mergers may change, although not necessarily worsen, overall UK

telecommunications resilience. The most common reported cause of incidents was power failures, reinforcing the importance of cross-sector interactions. Some operators are also concerned about a rise in theft of metallic cables from the network, which can often result in damage to other infrastructure and significant service degradation over wide areas.

Subsequent reports

1.14 While we publish various other data related to communications networks and services, this is the first infrastructure report prepared in response to our new duty in the Act. The legislation requires us to continue producing this report every three years, and also interim ad-hoc reports as required. We intend to provide annual updates on mobile and fixed line broadband services as these are changing rapidly. We are keen to ensure that these reports are as useful as possible to a wide range of stakeholders and would therefore welcome feedback. Please send any comments and suggestions for improvements or ad-hoc reports to infrastructurereporting@ofcom.org.uk

1.15 Given that this is the first infrastructure report, and the first time we have gathered some of the reported data, we are unable to draw a firm conclusion on the extent to which infrastructure and services are evolving to meet changing consumer demand. We expect subsequent reports to cast more light on this.

Update to original report

1.16 This is an update to the original report published on 1 November 2011. It includes correction to errors which were identified during the course of producing the 2012 report relating to 3G geographic and premises coverage. These errors primarily affected Northern Ireland, but some other local authorities were also affected. Data on 2G data has also been updated to align with premises data used in the 2012 report. This has resulted in very minor changes to some of the 2G coverage figures.

1.17 To simplify version management the mobile coverage maps and data tables have been removed from the annex to this report. They continue to be available from the Ofcom website:

http://maps.ofcom.org.uk/mobile-services/mobile-services-map-2011/

UK infrastructure dashboard

1.18 We have defined a number of key metrics that we intend to track across future reports to build up a set of data reporting on the evolution of UK communications networks and services. These metrics are designed to provide simple proxies of the state of the underlying infrastructure and services. Figure 1 details the dashboard for 2011. Details of what each metric represents are included in Annex 1.

1.19 This report can be considered as a baseline against which future developments in networks and services can be measured in subsequent reports.

Figure 1 – UK infrastructure dashboard 2011

UK network coverage	
Fixed telephony (PSTN)	
Coverage of fixed line telephony	100% of premises
Fixed broadband	
Coverage of broadband at 2Mbit/s or more	86% of existing connections
Coverage of Superfast broadband	58% of premises
Mobile 2G (outdoor)	
Premises served by all operators	97% of premises
Premises not served by any operator	<0.1% of premises
Geographic area coverage by all operators	66% of land area
Geographic area not served by any operator	6% of land area
Mobile 3G (outdoor)	
Premises served by all operators	72% of premises
Premises not served by any operator	1% of premises
Geographic area coverage by all operators	13% of land area
Geographic area not served by any operator	24% of land area
Digital terrestrial television	
Households served by three multiplexes (public service broadcasting channels)	89% (rising to 99% by Nov 2012)
Households served by six multiplexes (all digital terrestrial television channels)	73% (rising to 92% by Nov 2012)
Digital radio	
Households served by BBC national multiplex	91% of households
Roads served by BBC national multiplex	74% of roads
Households served by the national commercial multiplex	85% of households
Roads served by the national commercial multiplex	64% of roads

Capacity[2] (for March 2011)	
Fixed telephony (PSTN)	
Number of active residential telephone lines	23.7 million
Total number of residential fixed voice calls	1,717 million
Fixed broadband	
Average fixed broadband modem sync speed	7.5Mbit/s
Total data throughput on residential fixed lines	311,000,000 GB
Average data throughput per residential connection	17 GB
Mobile	
Total number of active mobile connections[3]	76.4 million
Total number of mobile calls	10,406 million
Total mobile data throughput	9,000,000 GB
Average mobile data throughput per 3G connection	0.24 GB
Digital terrestrial television	
Total capacity of six multiplexes	121 Mbit/s (rising to 161Mbit/s by Nov 2012)
Digital radio	
Total capacity of the two national DAB multiplexes	2.5 Mbit/s

See Annex 1 for details of how each metric is calculated and what it represents.

[2] The metrics for telephony and broadband measure the capacity demand on the network, while the metrics for digital television and digital radio measure the actual capacity of the network.
[3] In Ofcom's annual *Communications Market Report* (http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr11/), we reported that 93% of the UK adult population use or own a mobile phone. Therefore around a third of the mobile connections are used by adults with more than one active mobile device.

Section 2

Introduction and background to the report

2.1 Under legislation introduced to the Communications Act 2003[4] ('the Act'), Ofcom is required to submit a report to the Secretary of State every three years, describing the state of the electronic communications networks and services in the UK. This first report relates to the state of the UK communications infrastructure in June 2011.

2.2 This report relates to the networks and services used for communications in the UK: the fixed and mobile telephone networks and broadcasting networks. As we set out in our Statement, published in March 2011[5], in this first report we have focused on the networks and services which are most commonly and widely used by consumers. These are the publicly available electronic communications networks and services. In particular, we have chosen to report on only the largest providers of residential services in each sector. Therefore this report does not provide a complete picture of the state of the UK's communications infrastructure, but gives an indication of the vast majority of the residential market.

2.3 The Act specifies the matters upon which Ofcom must report. These are the geographic and population coverage of the networks and services, the degree of infrastructure sharing and wholesale access on the networks, the capacity of the networks, availability and plans for resilience. We are also required to report on the use of spectrum for wireless telegraphy in the UK, and to include a comparison of the standard of UK networks and services with those in other countries.

2.4 The focus on the largest and most commonly used networks means that some parts of the wider communications market are out of scope of this first report. For example, we are not reporting on the state of bespoke and private networks for businesses. The capacity and coverage of the majority of these networks are negotiated on a commercial basis to serve a particular customer need, and issues related to these networks are considered elsewhere. We have recently published a Call for Inputs as the first stage of our Business Connectivity Market Review[6], which will review the competitive conditions in the market for the leased lines that are used to build these networks.

2.5 Under the Act, Ofcom may exclude information from the published version of the report if it considers that it is information it could refuse to disclose in response to a request under the Freedom of Information Act 2000. Where we have redacted information from the report this has been indicated with [✂].

Approach and context

2.6 This report consists of data already held by Ofcom and additional data gathered from the largest operators in each sector. Where possible we have re-used data previously submitted to Ofcom by industry in order to minimise the input required from industry for this report.

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[4] http://www.legislation.gov.uk/ukpga/2010/24/section/1
[5] http://stakeholders.ofcom.org.uk/binaries/consultations/uk-comms-infrastructure/statement/Statement.pdf
[6] http://stakeholders.ofcom.org.uk/consultations/bcmr-inputs/summary

2.7 There are a number of synergies between the requirements of s134A and B of the Act (the requirements for Ofcom to provide a report on infrastructure), and work already carried out elsewhere by Ofcom. For example, we already publish the annual *UK Communications Market*[7] report and the *International Communications Market*[8] report. Where relevant, we also collect and publish data as a part of our market reviews. In 2010 we published the *Wholesale Line Rental*[9] and the *Wholesale Broadband*[10] *Market Reviews*. Other relevant Ofcom projects include our work on planning for the digital switchover, digital radio coverage planning[11], understanding mobile not-spots and projects relating to making the most efficient use of spectrum. We continue to provide support and advice to Broadband Delivery UK in relation to the government's objective of ensuring the availability of 2Mbit/s broadband throughout the UK and superfast broadband to 90% of homes by 2015.

2.8 The communications providers (CPs) selected for information gathering for this report were chosen based on their market share. We selected those operators which in total made up over 80% of that market, with the exception of mobile networks and digital terrestrial broadcast networks where we gathered data from all network operators. We collected data from the providers of fixed and mobile telephone networks and services, and broadcast networks listed in Figure 2.

Figure 2 - Providers, networks and services within scope of the Infrastructure Report

Name of provider	Types of network or service
Arqiva	Digital broadcasting infrastructure, digital television and radio
BBC	Digital television and radio services
BT	Fixed telecommunications infrastructure: voice and broadband
D3 and 4	Digital television services
Everything Everywhere	Mobile telecommunications infrastructure: voice and broadband, fixed broadband services
KCOM	Fixed telecommunications infrastructure: voice and broadband (Hull only)
O2	Mobile telecommunications infrastructure: voice and broadband, fixed telecommunications infrastructure: broadband services
SDN	Digital television services
Sky	Fixed telecommunications infrastructure: voice and broadband services, digital satellite services
Talk Talk	Fixed telecommunications infrastructure: voice and broadband services
Three	Mobile telecommunications infrastructure: voice and broadband,
Virgin Media	Fixed telecommunications infrastructure: voice and broadband, digital television services
Vodafone	Mobile telecommunications infrastructure: voice and broadband,

[7] http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/
[8] http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr10/international/
[9] http://stakeholders.ofcom.org.uk/consultations/wla/
[10] http://stakeholders.ofcom.org.uk/consultations/wba/
[11] http://stakeholders.ofcom.org.uk/consultations/dab-coverage-planning/

2.9 The Act requires us to report on the state of the UK communications infrastructure on a specific date. However, as changes to the infrastructure tend to be made gradually over time, some of the data used in this report refers to a date before the reference date. Where we specifically requested data prior to our reference date in June 2011, we also asked providers to explain how the state of their network might be different on the reference date. In all cases providers expected very little to change between their submitted data and the situation on the reference date. The data on customer demand for voice and data services on fixed and mobile network relates to March 2011.

2.10 Because network operators monitor and measure their networks in different ways, it is not possible to make detailed comparisons between different networks. So only a limited set of conclusions can be drawn from this first set of data. We intend to repeat this data-gathering exercise for subsequent reports, in order to build up a series of data over time. This will help us to understand whether the networks are meeting changing customer demands as the networks mature. This report therefore gives a snapshot view of the UK communications infrastructure, and sets the baseline for future comparisons.

Contents of this report

2.11 As we have already reported some of the required information in other publications we have focused the Infrastructure Report on the fixed and mobile telecommunications network and on the broadcast networks in the UK. There is more information about the use of spectrum on our website and the international comparisons are included in our *International Communications Market* Report.

Use of spectrum

2.12 The information we already publish on our website on the use of spectrum includes:

- The UK Frequency Allocation Table

  http://stakeholders.ofcom.org.uk/spectrum/spectrum-management/UK-FAT-Table-2010/

  This document sets out the applications used in specific frequency bands.

- Ofcom Spectrum Information System

  http://spectruminfo.ofcom.org.uk/spectrumInfo/

  This website contains information about the licences issued in the spectrum managed by Ofcom.

2.13 There are a number of other Ofcom initiatives considering the most efficient use of spectrum, such as the work on 800MHz and 2.6GHz[12], understanding the issues for co-existence of mobile services alongside digital terrestrial television services in the 800MHz band[13] and in developing a long-term view on the use of UHF spectrum[14].

[12] http://stakeholders.ofcom.org.uk/consultations/technical-licence-conditions/
[13] http://stakeholders.ofcom.org.uk/consultations/coexistence-with-dtt/
[14] http://stakeholders.ofcom.org.uk/consultations/uhf-spectrum-bands/

A list of the bands in our spectrum awards programme is published on our website[15].

2.14 The current use of spectrum for mobile telephony, for digital terrestrial television and radio broadcast networks is explained in more detail in sections 4, 5 and 6.

International comparisons

2.15 The Act requires us to compare the standard of UK networks and services with those in other countries. Ofcom already publishes the annual *International Communications Market* Report, most recently in December 2010.This report included comparisons of take up of different types of fixed and mobile telephony and broadcast services and technologies and the different usage volumes between EU countries and elsewhere.

2.16 Broadband Delivery UK (BDUK), the organisation within the Department of Culture, Media and Sports (DCMS) tasked with delivering government broadband policy, has asked Ofcom to publish a set of metrics to allow the UK's broadband infrastructure and services to be compared against other European states. These metrics are intended to help government assess whether it has reached its ambition of leading Europe in terms of broadband services by 2015. We plan to publish the data for the "best in Europe" scorecard during Summer 2012, which is likely to coincide with the first government subsidised local broadband projects commencing construction.

2.17 In anticipation of our *2011 International Communications Market* Report and the Best in Europe scorecard, we have not included comparison of the UK data presented in this report with other EU states.

Outline of this report

2.18 The rest of this document reports on each type of network, on matters relating to coverage, capacity, infrastructure sharing, wholesale services, use of spectrum (where appropriate) and future developments.

- **Section 3** reports on fixed networks
- **Section 4** reports on mobile networks
- **Section 5** reports on digital television
- **Section 6** reports on digital radio
- **Section 7** summarises the plans for resilience and reported availability of the networks and services.
- **Section 8** summarises some of the likely future developments in these networks and services.

Subsequent reports and feedback

2.19 While we publish various other data related to communications networks and services, this is the first infrastructure report prepared in response to our new duty

[15] http://stakeholders.ofcom.org.uk/spectrum/spectrum-awards/

in the Act. The legislation requires us to continue producing this report every three years, and also interim ad-hoc reports as required. We intend to provide annual updates on mobile and fixed line broadband services as these are changing rapidly. We are keen to ensure that these reports are as useful as possible to a wide range of stakeholders and would therefore welcome feedback. Please send any comments and suggestions for improvements or ad-hoc reports to infrastructurereporting@ofcom.org.uk

Section 3

Fixed networks

Overview

3.1 Fixed network connections deliver voice and broadband services to end users. The networks typically have three components. The 'access network' connects the end user premises to a local exchange, while the 'backhaul network' connects the local exchange to the 'core network'. The bulk of the costs associated with building and upgrading a network relate to the access component, due to the need to connect to every end user premises.

3.2 There are two main types of access network technology in the UK, twisted metallic wire (usually copper) telephone lines, known at the 'local loop', and Hybrid Fibre-Coaxial (HFC) cable networks. There is also a limited deployment of fibre to the residential premises in the UK.

3.3 Openreach (part of the BT Group) operates the local loop in most of the UK, with the exception of Hull where Kingston Communications (KCom) is the sole provider. Virgin Media is the largest operator of HFC networks, with Wight Cable providing services on the Isle of Wight and Small World Cable providing services in North West England and South West Scotland.

3.4 The local loop network is used to deliver both the Public Switched Telephone Service (PSTN) and broadband services (and other data services). HFC networks are used to deliver television and broadband services, while PSTN services provided by cable companies are normally delivered over a separate local loop network which they have built in parallel to their HFC network.

Consumer context

3.5 Despite the increasing popularity of mobile voice and broadband services, the majority of UK households still have a fixed line service. In 2010 23m households had a fixed telephone line and 18m of these (equating to 74% of adults) also subscribed to fixed line broadband services[16]. Virtually all homes with a PC now have a broadband connection.

3.6 The average modem sync speeds is 7.5 Mbit/s (see Figure 4), but with the increasing availability and take-up of superfast broadband we expect this figure to increase over the coming years.

3.7 There continues to be strong competition in the provision of retail services over fixed networks. In 2010, BT's share of the fixed broadband market was 28% and their share of the fixed voice market was 37% (by call volumes). Partly due to bundling of services, average household spend on communications services (fixed and mobile) continues to fall, with monthly spend in 2010 12% lower in real terms than it was in 2005.

[16] http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr11/UK_CMR_2011_FINAL.pdf

Coverage

Voice services

3.8 Both BT and KCom are subject to a Universal Service Obligation which requires them to provide a telephone line to any household that requests one, subject to a 'reasonable cost' limit (currently set at £3400[17] by BT). As a result the vast majority of consumers are able to get a fixed telephone line if they wish.

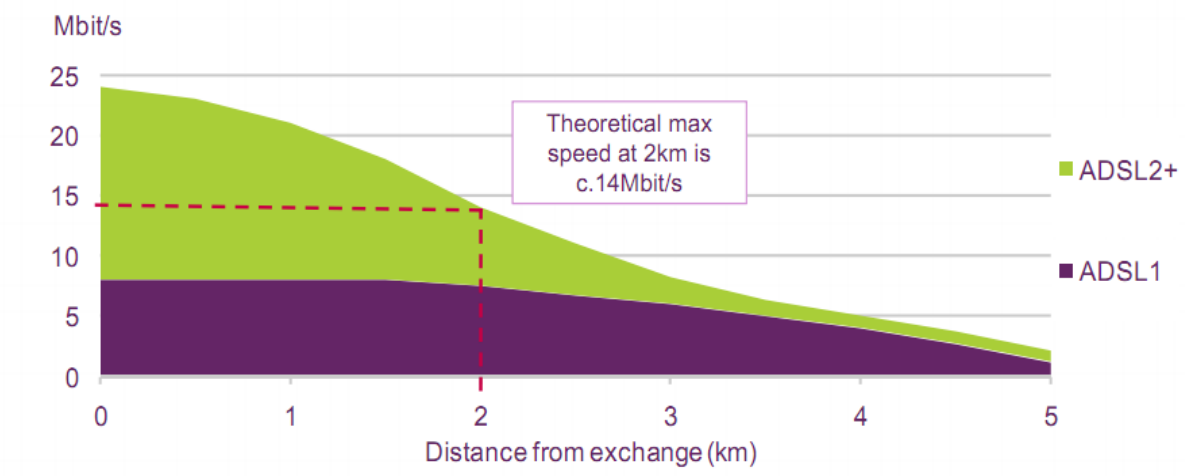
3.9 Data from KCom indicate that no requests for a telephone line have been turned down. BT reported that typically less than 0.25% of requests for new lines exceed the cost limit for USO lines and require excess construction charges. As a result of the excess charges, some customers choose to not proceed with the order. This means less than 0.1% of new line orders are not fulfilled.

Broadband services

3.10 The Universal Service Obligation requires that a telephone line must support "functional internet access". However, the directive was written before broadband was prevalent and, in the UK, the obligations currently only extend to the provision of a line that is capable of supporting dial-up modem connections of 28kbit/s.

3.11 Broadband coverage via fixed networks is currently constrained by the length and quality of individual telephone lines. Lines over 5km are unlikely to support broadband speeds of 2Mbit/s or more, as speeds reduce with increased line length. The variation in theoretical Digital Subscriber Line (DSL) access line speeds, by distance, is illustrated in Figure 3. Further background information on broadband technologies and the factors that affect their performance can be found in section 8 of our most recent UK fixed broadband speeds research published in July 2011[18].

Figure 3 - Variation in theoretical broadband access line speeds by distance



3.12 Cable HFC networks do not suffer reductions in speed with line length, so high-speed broadband is available across the cable network. BT's recent deployment of superfast[19] broadband using Fibre to the Cabinet technology significantly reduces

[17] http://stakeholders.ofcom.org.uk/consultations/uso/main/
[18] See section 8 of http://stakeholders.ofcom.org.uk/binaries/research/telecoms-research/bbspeeds2011/bb-speeds-may2011.pdf
[19] Superfast services are those that provide download speeds of 24Mbit/s or more

(but does not remove) the impact of line length on speed by replacing a section of the copper telephone wire with fibre optic cable.

3.13 Ofcom published information relating to coverage and speeds of broadband services in July 2011[20]. An interactive map displaying the data is available to view at http://maps.ofcom.org.uk/broadband/. The key metrics are summarised in Figure 4 below.

Figure 4 - National broadband measures

	Average modem sync speed (Mbit/s)	Receiving less than 2Mbit/s (of UK households)	Superfast availability (of UK households)	Take-up (of UK households)
England	7.6	14%	61%	69%
Scotland	7.6	13%	41%	65%
Northern Ireland	6.3	23%	97%	60%
Wales	6.5	19%	31%	63%
Total UK	7.5	14%	58%	68%

Source: Ofcom / operators

3.14 In our research on broadband speeds published in July 2011, the actual average broadband speed experienced by consumers in the UK was 6.8Mbit/s; a 10% increase on the average speed measured six months earlier. The increase in speed was a result of consumers moving to faster broadband packages. This actual average speed experienced by consumers is lower than the modem sync speed for a number of reasons, including factors such as traffic congestion, overheads associated with sending data over a network, and the performance of the servers to which the consumer is connecting[21].

3.15 The ongoing investment in superfast broadband services by Virgin Media and BT will not only increase average speeds, but should reduce the proportion of customers getting less than 2Mbit/s. We intend to collect data next summer to quantify the extent to which take up of services on these new networks is leading to higher average speeds and coverage of 2Mbit/s broadband.

3.16 In addition to long lines, broadband may not be available due to incompatible equipment installed on the telephone line. This equipment is typically installed to allow two or more voice services to share the same line. BT has an ongoing programme to remove this equipment, although in a small proportion of cases the costs associated with removal may be excessively high.

[20] http://maps.ofcom.org.uk/broadband/downloads/ofcom-uk-broadband-speed-report-2011.pdf

[21] In 2009 Ofcom commissioned a report into the impact of CP's management techniques on the consumer's Quality of Experience. It found that particular applications, such as downloading files and the standard definition iPlayer continued to function well when the Quality of Service (a range of technologies to manage the network) was affected. However more bandwidth intensive applications such as the high definition iPlayer and multi-player online gaming were unusable when the QoS fell. http://stakeholders.ofcom.org.uk/binaries/research/technology-research/NetworkQoE.pdf

Network sharing and wholesale services

3.17 Due to Ofcom's findings that they have significant market power, BT and KCom have regulatory obligations to provide access to their networks and to provide certain wholesale services to third party CPs. Currently no CPs have chosen to provide residential services across KCom's network. Virgin Media has not been found to have SMP and therefore does not have any obligations to provide access to its network and does not currently provide access to other CPs.

3.18 Beyond the SMP framework, Ofcom is also able to require companies to provide shared access to their infrastructure where this is proportionate and we think it would encourage efficient investment and promote innovation. These new powers came into force in May 2011 as a result of changes to the European Framework Directives. We expect that any company wishing to obtain shared access to existing infrastructure would continue to approach the owners and attempt to reach a commercial wholesale agreement in the first instance. However, where this fails, we will consider whether it is appropriate to intervene using these new powers.

3.19 In line with the Directive, Ofcom's new powers also allow us to collect information about infrastructure that is suitable for shared use from its owners, and to make that information available to others. In their transposition of the Directive into UK law, Government consulted on the idea of producing a national inventory or map of potentially sharable infrastructure. The majority of respondents felt this would be costly and time consuming to produce and therefore disproportionate to the potential benefits, which were generally expected to be limited. We will continue to keep the need for a national map of sharable infrastructure under review. If we see sufficient interest, we will consider whether such an inventory could be cost effectively produced when we next update the coverage maps.

3.20 Different regulation applies to the different parts of BT Group. Openreach operates and maintains the local loop access network, including ducts, poles, cables and exchange buildings. These are network components that are unlikely to be replicated by other CPs due to the high costs involved. Openreach has a regulatory obligation to offer access to these assets (see below). Another part of the BT Group, BT Wholesale, provides a number of services which make use of the network assets controlled by Openreach. BT Wholesale has market power in relation to a number of the products it offers, and as a result is subject to access obligations and charge controls. However, BT Wholesale does face competition in the provision of some products in some parts of the UK.

3.21 Access to BT's network at an infrastructure level (via Openreach) and a wholesale service level (via BT Wholesale) allows other CPs to enter the retail market with varying levels of capital expenditure. Figure 6 below summarises the relationship between Openreach, BT Wholesale and other CPs.

3.22 All operators of PSTN services (over both mobile and fixed networks) are required to provide access to other operators to terminate telephone calls.

Passive infrastructure access

3.23 BT has a regulatory obligation to provide access to its duct and poles[22] to CPs looking to deploy superfast broadband networks. As per this obligation, BT

[22] http://stakeholders.ofcom.org.uk/consultations/wla/statement

published a draft reference offer in January 2011, and since then has been working with CPs to test the product requirements via a series of ongoing trials. BT published updated pricing on 7 October[23]. Passive Infrastructure Access (PIA) is likely to be an important product is supporting super-fast broadband deployments by CPs in the 'final third' (BT has already announced plans to deploy superfast broadband in two thirds of the country).

3.24 Access to BT's passive infrastructure is not the only option available to CPs. In July 2010, Virgin Media began a trial of sharing the electricity infrastructure owned by Surf Telecom[24] in Caerphilly, Wales for rolling out new access infrastructure. This is a commercial arrangement between the two parties and is not the result of a regulatory intervention.

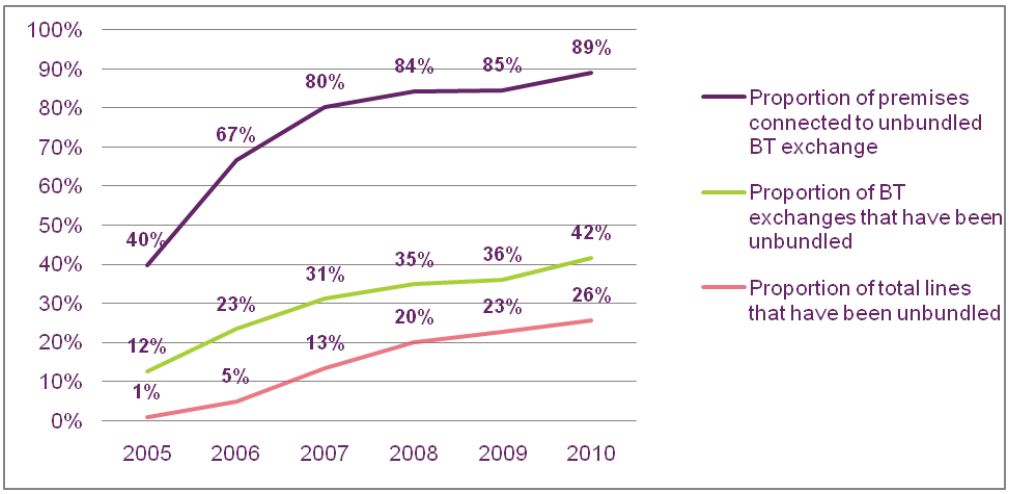
Local Loop Unbundling

3.25 Local Loop Unbundling (LLU) allows CPs to take over control of the telephone line running from the BT exchange to end users' premises and to install their own telephony and broadband equipment in the exchange.

3.26 LLU was introduced in November 1999 and in March 2011, 2344 of BT's 5589 exchanges (41% of all exchanges covering 89% of households) had at least one other CP with its own equipment, taking control of 7.33 million lines.

3.27 Figure 5 shows the increasing number of unbundled exchanges over the past five years.

Figure 5 - Proportion of unbundled exchanges and connected premises



Source: Ofcom / operators

3.28 Those exchanges that have not been unbundled generally serve a relatively small number of homes. This factor reduces the commercial viability of LLU, as there is less opportunity to recover the fixed costs associated with installing equipment in the exchange. It is therefore unlikely that there will be significant expansion of LLU beyond the existing exchanges.

[23] http://www.openreach.co.uk/orpg/home/updates/briefings/generalbriefings/generalbriefingsarticles/gen10611.do

[24] http://mediacentre.virginmedia.com/Stories/Virgin-Media-and-Surf-Telecoms-to-Trial-Ultrafast-Broadband-over-Electricity-Poles-1ae.aspx

3.29 In most cases, broadband offered via LLU uses ADSL as the most appropriate technology given the copper line lengths from the exchange to the customers. To offer superfast speeds over the copper connection VDSL rather than ADSL broadband equipment is used and this must be installed closer to the customer – typically at the nearest street cabinet. This is the approach used by BT for the majority of its Superfast Broadband (SFBB) deployment, and it offers Sub Loop Unbundling (SLU), a cabinet-based product analogous to the exchange-based LLU, to allow competitors to do likewise. As the number of customers that can be served from a cabinet is far lower than from an exchange, SLU is likely to be commercially viable in fewer situations. So far, commercial use of the product has been very limited, although some large regional projects, using SLU with public subsides, are operational[25].

Wholesale services

3.30 The range of wholesale services available from BT allows CPs to choose between different levels of management of the services offered to customers. For example, for fixed voice services a CP could control all services over the whole line through Openreach's Wholesale Line Retail product, or simply offer call packages for particular types of calls. Similarly for broadband, a provider could choose a wholly managed product or one which gave it the flexibility to backhaul customer's traffic through its own network.

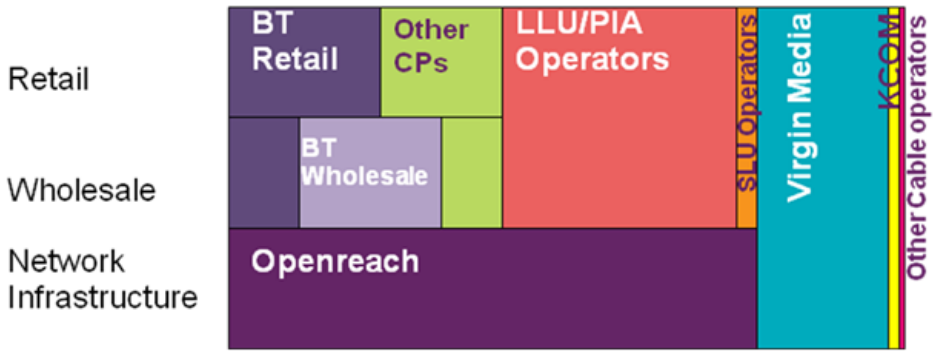
3.31 Where LLU is not cost effective, CPs purchase wholesale services from BT or other wholesale suppliers (such as C&W and Talk Talk), which have unbundled the line at the exchange. This allows CPs to offer services nationally. As of March 2011 BT Wholesale was providing 7.98 million broadband connections to over 500 retail CP customers (including BT Retail).

3.32 Openreach also offers wholesale services for its new superfast Fibre to the Cabinet (FTTC) and Fibre to the Premises (FTTP) broadband network. It offers a wholesale product called Generic Ethernet Access, which provides an active service at a range of defined speeds (depending on the technology of the access network). Nine providers are currently trialling or offering services using this product[26].

3.33 Figure 6 illustrates the structure of the fixed network market in the UK, with Openreach providing the majority of the infrastructure to BT Wholesale and other wholesale customers, which is then resold to retail customers. BT Retail and other retail CPs buy services both from BT Wholesale and from Openreach. Alongside Openreach there are a few vertically integrated infrastructure owners which offer retail services on their own networks.

[25] http://www.digitalregion.co.uk/dr-project
[26] http://www.openreach-communications.co.uk/superfast/

Figure 6 - The structure of the supply chain for fixed telecommunications



Capacity

3.34 The Act requires us to report on the capacity of UK networks. Due to the complex topology of modern telecommunications networks it is very difficult to derive a simple metric of capacity. We have therefore used the volume of data and telephone calls as a proxy of network capacity demand, as networks will be configured to meet demand. As explained below, we expect traffic volumes to increase rapidly over the coming years and, if consumer demand is to be met, network capacity will need to closely track the demand for data.

Voice calls

3.35 Based on data provided by the fixed-line providers that make up over 80% of the fixed line residential market (and KCOM which owns the fixed network in Hull), we have estimated the total voice calls volumes and duration for March 2011 in the UK. This is summarised in Figure 7 below.

Figure 7 - Fixed voice call data

Fixed voice call in March 2011	
Active telephone lines	23.7 million
Number of calls	1,717 million
Total call duration (in minutes)	7,123 million
Average calls per line	72
Average total call duration per line	5 hours

Source: Ofcom / operators

Broadband

3.36 We gathered data on broadband services from the five fixed voice providers and two LLU broadband providers, which together represent over 90% of the broadband market. We have used this to estimate the total broadband demand for March 2011, summarised in Figure 8 below.

Figure 8 - Fixed broadband data

Broadband data traffic in March 2011	
Active broadband connections	18 million
Total data uploaded/downloaded	311,000,000 GB
Data per connection	17 GB
Percentage of data transferred between 6pm and midnight (peak usage hours)	38%

Source: Ofcom / operators

3.37 As this is the first report, we cannot comment on how demand for residential broadband data has changed. However, the London Internet Exchange (Linx) publishes statistics about the volume of data that flows through its switches and sites. This includes both residential and business services, and shows that the average traffic is now seven times greater than five years ago[27].

3.38 The total amount of data downloaded per line (17GB) is the equivalent to downloading just over 11 films per month. The variation in average data per subscriber between operators has some relation to the traffic management policies used by the operator. Those operators offering broadband packages with a monthly download limit generally saw lower average total traffic per customer line, while those operators which did not operate download caps had higher total traffic volumes. This demonstrates that download caps are an effective way for ISPs to manage the amount of data used by each customer. For example, Virgin Media customers downloaded an average of 25GB per month[28]. In comparison, a typical operator with a large proportion of its customers on capped packages had an average throughput per active line of 12GB. This figure ranged from 10GB to 40GB between different operators.

[27] https://www.linx.net/pubtools/trafficstats.html
[28] Virgin Media quarterly earnings presentation for Q2 2011 http://investors.virginmedia.com/imagelibrary/downloadmedia.ashx?MediaDetailsID=1113

How big is a GB?

- **1 Kilobyte (KB) – A single page text document is 10KB**
- **1 Megabyte (MB) – A song download is 4MB**
- **1 Gigabyte (GB) – A two hour film downloaded from iTunes is 1.5GB**
- **1 Terabyte (TB) – 1TB will hold 2000 copies of the Encyclopaedia Britannica**
- **1 Petabyte (PB) – Over 13 years of HD video content**

(These are approximations; as the size of a media file will depend on other factors such as the compression standard used and (for video content) the output frame size.)

3.39 In addition to customer pricing and data caps, some network operators may manage the different types of traffic on the network, especially at peak times, to ensure that time-essential traffic, such as Voice over IP calls, streaming traffic and gaming, can be carried efficiently over the network. In such cases, some other types of traffic such as peer-to-peer downloads and use of newsgroups, may be de-prioritised. Not all operators use these techniques. Ofcom is currently carrying out more work on this topic, through our Net Neutrality project, and we expect to publish the results of this in the near future. Moreover, the amount of data downloaded by a customer on a network could be affected by other factors, such as the access line speed and the way the operator manages the customer's traffic in the backhaul and core networks.

3.40 To help consumers better understand how their ISP manages their broadband traffic, some leading ISPs have signed a voluntary code of practice to provide better and more easily comparable information to consumers about traffic management[29].

3.41 In the longer term, there are a range of approaches which operators could deploy to improve the efficiency of the networks. These could be used to improve the performance of the current network before needing to invest in new infrastructure. For example, with the growing demand for video content from a small number of content providers, operators could store some content locally within their network. This would help to reduce the volume of data which would need to be transmitted from the content provider each time a customer requests to view it. Use of the multicast protocol would also be a more efficient way to distribute the same content to a large number of customers, for instance when a number of end users all wish to view the same live TV channel on line. Multicast is particularly beneficial when the streamed content is in high definition and is watched by a large number of end users, however it is of limited value for video on demand services (unless used to simultaneously 'push' video content to the hard disk of multiple consumers set top boxes, to allow them to subsequently access the content on demand). In May 2011 Openreach published pricing for a pilot of multicast support on its wholesale superfast broadband service[30].

[29] http://www.broadbanduk.org/content/view/479/7/
[30] http://www.openreach.co.uk/orpg/home/updates/briefings/super-fastfibreaccessbriefings/super-fastfibreaccessbriefingsarticles/nga01511.do

3.42 With the focus on broadband performance generally on the improvements to the access connection speed, for example by fibre upgrade, it is important to remember the role of backhaul (the connection from the local exchange to the ISP's core network). While the dynamics of this part of the infrastructure market are different from access, there are still only a limited number of providers, especially with national reach. We are currently performing a review of this market, which will determine whether and where competition is effective. We published a Call for Information in April[31].

3.43 As the roll-out of superfast broadband continues, it is likely that the consumer demand for data will grow. In an Ofcom survey[32], over 80% of SFBB customers reported being satisfied or very satisfied with their service, with the biggest level of increase in satisfaction for download speeds (compared the reported satisfaction with their previous broadband service). A summary of the technologies that could be used to deliver superfast and ultrafast broadband is provided in section 8.

[31] http://stakeholders.ofcom.org.uk/consultations/bcmr-inputs/summary
[32] http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr11/telecoms-networks/5.11

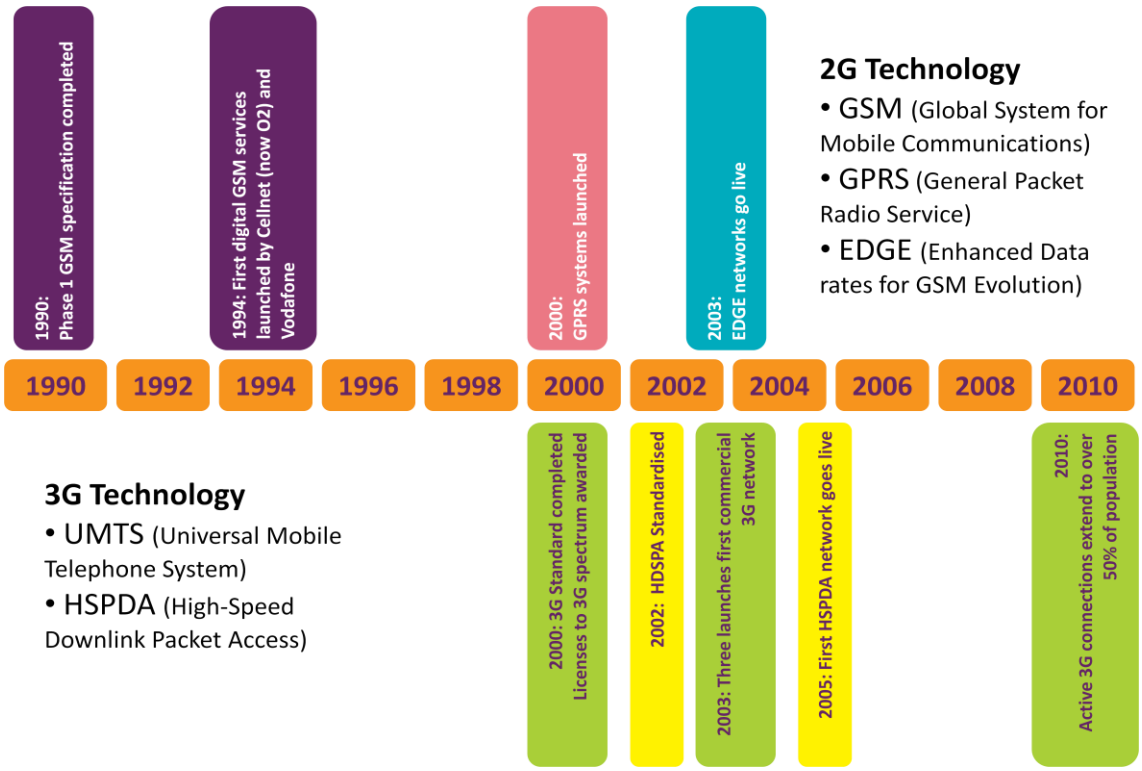
Section 4

Mobile networks

Overview

4.1 Mobile networks deliver wireless voice and data services to end users using radio spectrum. There are two main types of technology in the UK. 'Second generation' (2G) networks based on GSM technology were introduced in 1991[33] replacing the first-generation analogue mobile services (which are no longer in operation) and provide voice calls, messaging and low speed data services. Third generation (3G) services based on UMTS technology were introduced in 2003 and provide higher speed data services. 3G networks work in parallel to 2G networks. Wi-Fi is increasingly used to complement the traditional mobile networks. Next generation technologies, such as LTE, are emerging, which provide increased capacity and speed.

Figure 9 - Timeline of developments in 2G and 3G mobile technology



4.2 Figure 9 above shows the development of 2G and 3G networks, illustrating that after the initial standardisation of the technology and the award of spectrum there is a gap of a number of years before the first commercial services are launched. The take up rate of a new network technology is also determined by other factors, such as consumer demand, pricing and the availability of compatible handsets. Even after the standardisation of 3G, network operators and manufacturers have continued to develop the 2G technology standard, to improve the capabilities of the existing technologies and to improve the ideal download speed to 236.8kbit/s. The same has occurred in 3G networks, where the development in standardisation has

[33] http://licensing.ofcom.org.uk/radiocommunication-licences/mobile-wireless-broadband/cellular/pct/

increased the maximum download speed from 384kbit/s[34] to 42Mbit/s[35]. Mobile operators in the UK are upgrading their networks to this latest version of 3G technology (with up to speeds of 21Mbit/s). However, in reality the actual speed experienced by customers is lower as the mobile transmitter cell is shared between multiple users and also due to other factors, such as network congestion, the distance from the mast and the quality of the signal. The average 3G mobile broadband speed delivered to 'dongles' in areas of good coverage in the UK is currently 2.2Mbit/s[36].

4.3 There are four Mobile Network Operators (MNOs) in the UK (Everything Everywhere, O2, Three and Vodafone). Since the merger of T-mobile and Orange in 2010, Everything Everywhere has continued to operate two retail brands.

Consumer Context

4.4 The large majority of UK adults (93%) use a mobile phone. Mobiles continue to complement rather than replace fixed lines for the majority of households, with just 15% of adults living in mobile only households.

4.5 Use of mobile networks for data is increasing, driven by the take-up of mobile broadband 'dongles' and smartphones. There are now 33m subscriptions to 3G services and 7% of homes rely solely on mobile broadband services (rather than fixed line). Our consumer research shows that 27% of UK adults are now smartphone users (of which over half purchased their device in the last year). More details of our research in to smartphone take up and use can be found in our 2011 Communications Marker Report[37].

Spectrum Use

4.6 All but one of the four operators are licensed to use spectrum for 2G and 3G mobile technology. Three is the only operator to hold a licence for 3G spectrum only. The full allocation of spectrum for mobile telephony is listed in Figure 10.

[34] Specified in Release 1999 http://www.3gpp.org/article/release-1999
[35] Using High Speed Packet Access (HSPA) http://www.gsmamobilebroadband.com/about/
[36] This was calculated in our research on the performance of mobile broadband published in May. http://stakeholders.ofcom.org.uk/market-data-research/telecoms-research/broadband-speeds/main/mobile-bb-10 The research measured the performance of mobile broadband for mobile dongles and broadband datacards, but not smartphones and other devices.
[37] http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr11/UK_CMR_2011_FINAL.pdf

Figure 10 - Spectrum bands used for mobile networks

Network Operator	GSM 900		GSM 1800		3G	
	Base Rx	Base Tx	Base Rx	Base Tx	Base Rx	Base Tx
O2	885.1 - 890.1	930.1 - 935.1	1710.1 - 1715.9	1805.1 - 1810.9	1934.9 - 1944.9	2124.9 - 2134.9
	894.7 - 902.3	939.7 - 947.3			1909.9 - 1914.9 (Time Division Duplex)	
	910.1 - 914.9	955.1 - 959.9	*Total GSM*	*2x23.2 MHz*		
Vodafone	880.1 - 885.1	925.1 - 930.1	1715.9 - 1721.7	1810.9 - 1816.7	1944.9 - 1959.7	2134.9 - 2149.7
	890.1 - 894.7	935.1 - 939.7				
	902.3 - 910.1	947.3 - 955.1	*Total GSM*	*2x23.2 MHz*		
Orange (Everything Everywhere)			1751.7 - 1781.7	1846.7 - 1876.7	1969.7 - 1979.7	2159.7 - 2169.7
			Total GSM	*2x30MHz*	1904.9 - 1909.9 (Time Division Duplex)	
T-mobile (Everything Everywhere)			1721.7 - 1751.7	1816.7 - 1846.7	1959.7 - 1969.7	2149.7 - 2159.7
			Total GSM	*2x30MHz*	1899.9 - 1904.9 (Time Division Duplex)	
Hutchinson 3G					1920.0 - 1934.9	2110.3 - 2124.9

Source: Ofcom

Coverage

4.7 We have collected data on predicted mobile signal strength (based on operator planning models) for both 2G and 3G networks in the UK and used this to calculate two measures of coverage[38]. The first considers the proportion of postal addresses that are within coverage of the networks ('premises coverage'), while the second considers the overall geographic coverage i.e. what the percentage of land mass is served ('geographic coverage'). We have based our analysis on a signal strength that should be sufficient to make or receive a call outdoors[39].

4.8 As there are nine licensed mobile networks (four 2G networks - O2, Orange, T-Mobile and Vodafone, and five 3G networks - O2, Orange, T-Mobile, Vodafone and Three) we have chosen two simple metrics to allow coverage between different local authorities to be more easily compared and tracked over time. The first metric represents the percentage of geographic locations and percentage of premises that do not have coverage from any of the operators i.e. they are total mobile 'not-spots'.

[38] There are a number of other mobile coverage projects elsewhere, such as the BBC's mobile coverage research (http://www.bbc.co.uk/news/technology-14582499) and OpenSignalMap (http://www.opensignalmaps.com/), both of which use consumer end devices to measure mobile coverage. The outcomes of this crowd-source approach are limited by the number of test devices and where the phones are used.

[39] See Annex 1 for details on the signal thresholds we have used.

The second metric represents the percentage of premises and geographic locations that are served by all of the operators.

4.9 It should be noted that consumers' experience of mobile services may not be fully reflected in the metrics we have adopted for a number of reasons:

- While we have considered premises coverage, the signal strength threshold we have used is associated with outdoor coverage. Whilst many premises will have sufficient signal to make calls inside, indoor coverage can be affected by building construction and some consumers, particularly those on the edge of coverage areas, may achieve lower coverage indoors than outdoors. As such the metrics will tend to overstate the extent to which consumers can use their mobile phones in their homes in the manner they might wish to.

- The geographic coverage metric considers the entire land mass of the UK, including the large parts of Scotland and central Wales where there are no premises and there is relatively less demand to makes calls. However, the metric does provide an insight into the issues consumers on the move face as they pass through patchy areas of coverage which can lead to dropped calls, such as those travelling by road and rail in rural areas.

- Whilst generally good, the planning models used by mobile operators are not 100% accurate[40], and hence there may be some areas where signal levels are lower than predicted. Signal levels can also be affected by localised effects, such as shadowing of signals by buildings and trees and signal levels will be lower inside vehicles and buildings due to losses from travelling through walls etc.

- Service quality may also be affected by the type of handset used. The ability to make and retain a call may also be reduced if networks are busy, and problems may be experienced when calls are handed over between cell sites when the user is on the move.

4.10 Whilst they do not fully reflect the user experience, and we would not expect consumers to always be able to make calls even where coverage is predicted to be over 99%, we believe the two metrics we have adopted provide useful upper and lower bounds for consumer experience in each local authority area. These will allow us to track improvements in coverage in subsequent reports.

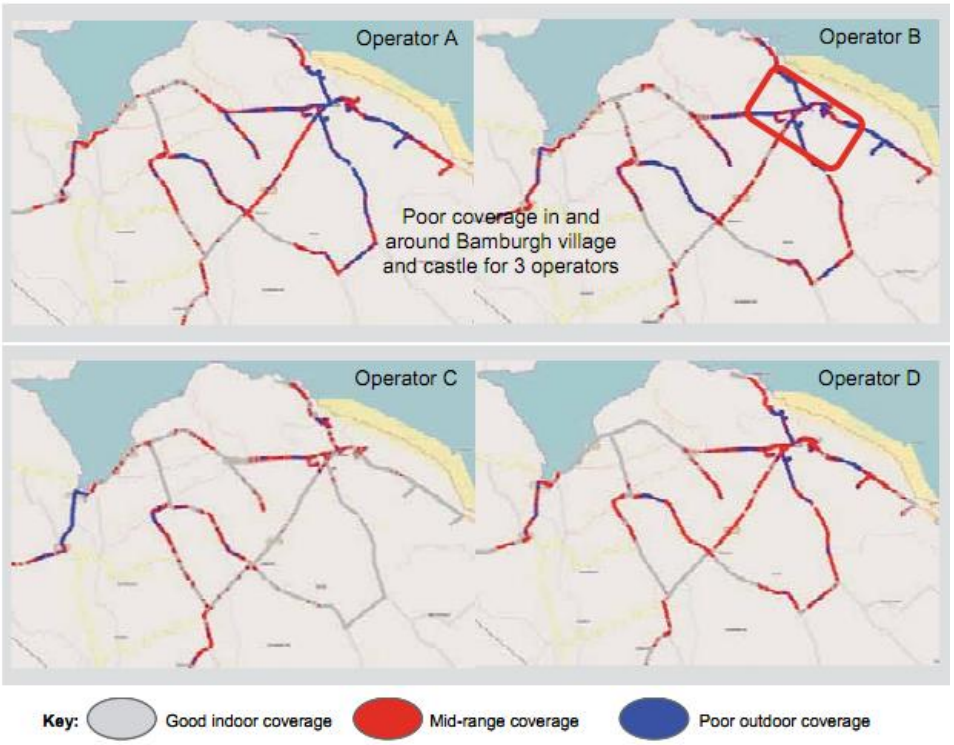
4.11 We have published interactive maps on our website displaying the metrics for 2G and 3G networks for local authorities across the UK. The maps are available at http://maps.ofcom.org.uk/maps/mobile.

4.12 As outlined above, because the maps show the aggregate coverage levels across each local authority they do not provide an insight into how 'patchy' the coverage from each provider is. For example, if geographic coverage in a county is 90%, it's not possible to determine from the data whether there is a contiguous area covering 10% of the land mass without signal, or whether there are a large number of small pockets. The geographic make up of the not-spots has implications for how consumers perceive the available coverage.

[40] Ofcom has commissioned research into accuracy of mobile operator signal predictions. See http://stakeholders.ofcom.org.uk/binaries/research/telecoms-research/not-spots/mobile-coverage/mobile-coverage-information.pdf

4.13 Research we commissioned from PA Consulting[41] in 2010 highlighted these issues. PA investigated mobile coverage in fourteen suspected 'mobile not-spot' areas. The research indicated that, whilst most areas had generally high levels of coverage from providers, consumers would often experience intermittent coverage from their chosen operator which could prevent them from making and receiving calls in some localised areas or calls might sometimes drop as they move over relatively short distances. For example, in the popular tourist destination of Bamburgh, it was found that three of the four 2G operators had patchy coverage around the village centre, but overall coverage was reasonably good. These 'local' not-spots will typically result from very specific circumstances and may be technically and commercially challenging to resolve. Figure 11 provides an example of the coverage of the four 2G operators in Bamburgh and illustrates the problems of patchy coverage.

Figure 11 - Mobile coverage in Bamburgh (measured)



Source: Ofcom / PA Consulting

4.14 Given the potential discrepancy between consumer perception of their mobile service and the absolute, aggregated levels of coverage, the data presented on the interactive maps and set out in this report should therefore be considered in the context of the broader consumer experience. Consumers are generally only concerned about the coverage of their chosen network operator, and gain little comfort from knowing that a signal from another operator is available when they find themselves in a 'local' mobile not-spot (unless there is an arrangement between network operators to allow network roaming, such as the roaming agreement currently being rolled out by Orange and T-Mobile as a result of the Everything Everywhere merger).

4.15 A summary of coverage for each of the UK nations is shown in Figure 12.

[41] See http://stakeholders.ofcom.org.uk/market-data-research/telecoms-research/mobile-not-spots/

Figure 12 - Mobile coverage (based on predicted coverage)

Mobile Coverage								
	2G				3G			
	Geographic coverage		Premises coverage		Geographic coverage		Premises coverage	
	no signal from any operator	signal from all operators	no signal from any operator	signal from all operators	no signal from any operator	signal from all operators	no signal from any operator	signal from all operators
England	1.4%	83.8%	<0.1%	97.7%	6.1%	20.3%	0.3%	76.6%
Scotland	15.5%	38.1%	0.2%	94.8%	50.7%	3.1%	3.0%	63.0%
Northern Ireland	2.2%	73.5%	0.4%	93.5%	51.7%	1.0%	13.1%	16.5%
Wales	5.8%	59.1%	0.2%	91.9%	22.1%	6.8%	3.5%	49.7%
UK	6.4%	66.4%	0.1%	97.0%	24.4%	12.5%	1.2%	72.4%

Source: Ofcom / operators

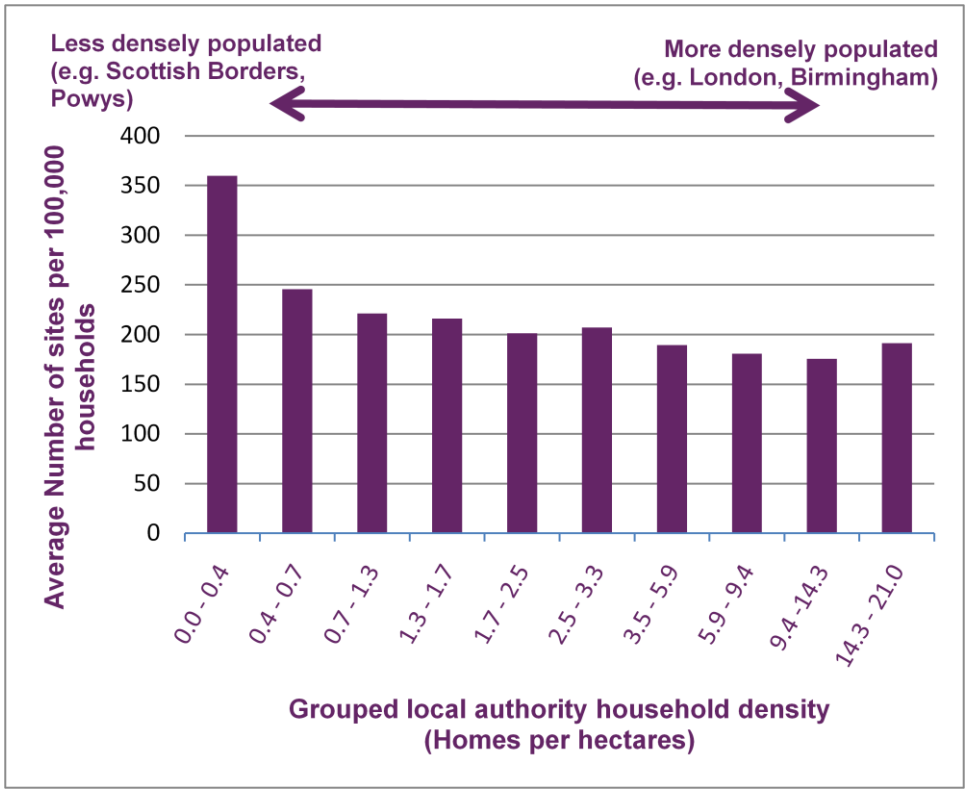
2G Geographic coverage

4.16 The geographic coverage map on the Ofcom website shows a clear distinction between the more urban parts of the UK and the rural areas. Relatively compact, densely populated areas, such as cities typically have full coverage, whereas the larger authority areas, particularly where the population is concentrated in a small number of towns and cities (leaving the rest of the geography sparsely populated) have lower geographic coverage.

4.17 While geographic coverage in rural areas is typically lower than in urban areas, our analysis of the number of base stations which the operators have built in each local authority area indicates that infrastructure investment in rural areas is often greater on a per head of population basis. Figure 13 shows how the number of sites[42] per 100,000 households varies with the population density of regions. The chart shows that areas of very low population density have, on average, a higher number of sites per head than more densely populated areas. (The upturn in the chart for very high density areas is likely to reflect the need to deploy more base stations in these areas to provide network capacity, rather than network coverage.)

[42] A site is the physical location of the mobile transmitter equipment whilst a base station is the active equipment for the cell. There may be multiple base stations at the same site.

Figure 13 - Average number of sites in a local authority (for England, Scotland and Wales[43])



Source: Ofcom / operators

4.18 The data highlight the challenges of providing mobile coverage in rural areas. While infrastructure sharing (see below) can help reduce network deployment costs, as with fixed networks, deployment of mobile networks in sparsely populated areas may not always be commercially viable.

2G Premises coverage

4.19 While the interactive maps show the differences in geographic coverage between rural and urban areas, the distinction is less stark for premises coverage. This is attributed to operators' planning of base station locations which are optimised to serve the areas where consumers wish to use their phones most often. This typically corresponds to the location of premises (as well as roads and other highly 'populated' areas).

4.20 The interactive map shows that the large majority (68%) of local authorities have 2G coverage from all mobile operators for over 95% of premises. This is in contrast to geographic coverage, where only 46% of local authorities achieve over 95% coverage for all operators.

4.21 The areas with lower premises coverage correspond to those areas with poor geographic coverage, and this reflects the fact that the large majority of premises without coverage are located in rural areas.

[43] Household density data was not available for Northern Ireland. Therefore the data from the local authorities in that area was not included in this analysis.

3G coverage

4.22 The geographic coverage of 3G networks is lower than 2G, with deployments concentrated in urban areas. Twenty Four of geographic locations in the UK are currently not served by 3G (compared to 6% for 2G). One contributing factor to the lower coverage relates to the nature of the spectrum used for 3G services. The frequency band used for 3G (2.1GHz) is higher than for 2G GSM (900MHz and 1800MHz) and these higher frequency signals do not propagate as far as lower frequencies. Consequently more base stations are required to cover large geographic areas which can translate to an increased cost of deployment for each 3G MNO.

4.23 Earlier in 2011, following a Direction from government, Ofcom made changes to spectrum licences that allowed mobile operators to use 3G technologies in the lower frequency bands currently used by 2G services[44]. This liberalisation of spectrum use could allow operators to provide greater coverage of 3G services in rural areas and we will continue to monitor the impact of this regulatory change, by updating these interactive coverage maps.

4.24 The interactive map gives the percentage coverage where all five 3G operators are present. It shows that for some local authorities, less than 1% of their area is covered by all five 3G operators. This is typically because one or more of the operators has chosen not to deploy 3G technology in that area. To provide further insight into what level of service is provided we provided data on the percentage of geographic area and premises that are served by zero, one, two, three, four (and five for 3G) operators in each area. The data table is available for download from our website in csv format. This table shows that, 3G coverage by two or three operators is available for many premises.

Ofcom's work on mobile coverage

4.25 Ofcom has a programme of work exploring whether more can be done to improve mobile coverage in rural areas, on the roads and on trains.

4.26 We have been conducting drive testing of a selection of motorways and other arterial roads across the UK and expect to publish the results later in the year. This will help determine the extent to which operators are providing road coverage and how road coverage compares to the overall geographic coverage in different parts of the UK. The testing will also identify the extent to which other factors, other than signal strength, impact on consumers' ability to make and receive calls.

4.27 We are in discussions with mobile operators to better understand how they are developing coverage checkers in the future to ensure that consumers have access to information that will enable them to make informed choices about mobile coverage.

4.28 In addition to coverage checkers provided by mobile operators, Ofcom publishes information on the location of operator base stations on the Ofcom website (http://sitefinder.ofcom.org.uk). This information may be useful to consumers who are experiencing coverage problems with their operator to find out whether another

[44] http://stakeholders.ofcom.org.uk/binaries/consultations/900-1800mhz-wireless-telegraphy/statement/Statement.pdf

operator has a mast closer to where they wish to use their phone[45] (although distance from the mast is not the only factor that affect signal quality, it is a good indicator).

4.29 On 3 October HM Treasury announced plans to make £150m available to improve mobile coverage. We welcome the announcement that public funding is being made available to address this important issue and will be working with DCMS on its implementation. Where appropriate, we will draw on lessons learnt from similar projects in other countries (the French government introduced a similar scheme in 2008).

Network sharing and wholesale services

4.30 Within the mobile sector there is extensive sharing of network infrastructure and provision of wholesale services.

Infrastructure sharing

4.31 It is common within the mobile industry for operators to share physical infrastructure, such as base station sites and masts. There are different degrees of mobile infrastructure sharing, ranging from sharing the physical site, mast and antenna (i.e. sharing only passive infrastructure) to sharing the active electronics at the site and the backhaul circuits that carry traffic to and from the core network. Increasingly operators are sharing the active elements of the network. This allows them to reduce the cost of network deployment while continuing to operate separate 'logical' networks and use their own spectrum.

4.32 There are currently two main sharing arrangements in place between the four MNOs, which provide examples of very different models of sharing.

4.33 Three and Everything Everywhere jointly own MBNL[46], a company set up to deliver a combined 3G network for both operators. This is an example of sharing of active equipment between two operators. The sharing arrangement was initially set up to enable sharing of the Three and T-Mobile network infrastructures, including transmitter sites, base station equipment and backhaul for the 3G network. Since the merger of T-Mobile and Orange, it was announced in October 2010 that Orange would join the shared network[47]. This means that the three networks will increasingly share the large majority of their transmitter sites, although each operator also retains a small number of sites for its own use. Under this arrangement operators continue to run separate logical networks using their own spectrum, except where there are roaming agreements.

4.34 Vodafone and O2 have a different sharing arrangement (under the project name Cornerstone) to share transmitter sites[48]. This is currently limited to shared use of physical assets at base stations; the active equipment for each network is maintained separately.

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[45] It should be noted that data on Sitefinder is provided voluntarily by mobile operators and not all operators have provided their most up to date information on base station locations. We recommend consumers also consult mobile operator coverage checkers which are available on their websites.
[46] http://www.mbnl.co.uk/
[47] http://www.mobiletoday.co.uk/News/9930/Orange_hooks_up_with_MBNL.aspx
[48] http://pressoffice.telefonica.com/documentos/nprensa/np090323_en.pdf

4.35 Between the four operators, around 40% of cell sites are shared with other infrastructure owners. Due to the technical difficulties of integrating the 2G networks, it is likely that while network sharing of electronics will increase between operators of 3G networks owned by different providers, 2G sharing is less likely in the short term.

4.36 Information on the number of sites in each local authority, and the extent to which sites are shared is available on the Sitefinder website[49].

4.37 In addition to sharing infrastructure with other mobile operators, mobile network providers also access infrastructure provided by other infrastructure owners. One example of such sharing is the use of Arqiva's passive infrastructure for broadcasting. Access to Arqiva sites include the use of infrastructure it owns or manages, such as pylons, rooftops, street furniture and broadcast towers. Arqiva provides passive access to a large proportion of its sites.

4.38 Over the next few years it is expected that Everything Everywhere will consolidate its T-Mobile and Orange networks to increase coverage and capacity while reducing operational costs. In May 2011 it announced that Huawei would work on the 2G network over the next four years[50]. In anticipation of this network convergence, customers of the two networks can already roam between the two networks for 2G voice calls, where coverage by their home network is poor.

Wholesale Services

4.39 In addition to the services provided to retail customers on their own networks, all four MNOs also provide wholesale services to retail only mobile operators (Mobile Virtual Network Operators – MVNO). The coverage of an MVNO network is assumed to be the same as that of the wholesale provider's network. These networks are providing wholesale services to 35 MVNOs. In total, across the sector, 16% of voice minutes and 14% of mobile data are associated with MVNO traffic.

Capacity

4.40 The Act requires us to report on the capacity of UK networks. We have used the volume of data and telephone calls as a proxy of network capacity demand. Unlike the data submitted by fixed network providers, mobile operators did not distinguish their users between residential and business customers. Therefore the data reported below relates to the demand from all types of customers and also includes customers of MVNO networks

4.41 Every device which registers to a mobile network requires an active SIM[51].However, not all SIMs are used in devices which are capable of using both voice and data services. Some are used only for mobile voice calls (e.g. older handsets), while others are used only for mobile data (e.g. 3G dongles for mobile broadband). The analysis in this report assumes that nearly all data traffic is carried on devices with active 3G connections.

[49] http://stakeholders.ofcom.org.uk/sitefinder/table-of-totals
[50] http://www.huawei.com/en/about-huawei/newsroom/press-release/hw-092728-uk-2g-network.htm
[51] Subscriber Identity Module

Voice

4.42 Figure 14 summarises the mobile voice call traffic across the UK's mobile networks in March 20011.

Figure 14 - Mobile voice call data

Mobile voice call in March 2011	
Active connections[52]	76.4 million
Number of calls	10,406 million
Total call duration (in minutes)	12,722 million
Total duration of calls per connection	166 minutes
Average call duration	1 minute 13 seconds

Source: Ofcom / operators

4.43 Where the network operator manages both 2G and 3G networks, the majority (72%) of calls are carried on the 2G network.

4.44 The number of active connections reported is greater than the population in the UK, as some consumers may use multiple devices with active connections (e.g. multiple mobile phones or a 3G-enabled tablet device alongside a mobile phone). Ninety-three percent of the UK adult population own or use a mobile telephone, implying that a significant minority of UK adults have multiple mobile connections.

Data

4.45 Figure 15 summarises the mobile broadband traffic across the UK's mobile networks in March 20011.

[52] Reported 2G and 3G connections not including those for mobile broadband.

Figure 15 - Mobile broadband data

Mobile broadband data traffic in March 2011	
Active 3G connections[53]	38.0 million
Total data uploaded/downloaded	9,000,000 GB
Data per 3G connection	0.24 GB
Percentage of data transferred between 6pm and midnight (peak usage hours)	32%

Source: Ofcom / operators

4.46 The 3G networks carry most of the data traffic. Where the network operator owns both 2G and 3G networks, around 88% of the data traffic is carried on the 3G network.

4.47 Variations in the volumes of mobile broadband data transferred in different parts of the UK are shown on the interactive map on Ofcom's website. The data is presented on a per premises basis (rather than a per 3G connection) as we do not have accurate data on the distribution of 3G connections by geographic area.

4.48 Based on the figures we collected for March 2011, the volume of data carried by the mobile networks is currently over thirty times lower than for fixed broadband networks, despite there being approximately twice as many active 3G connections as there are residential broadband connections. However, as only 32% of mobile subscribers reported using their mobile phones to access the internet, it is likely that the average amount of data used by mobile customers who actively use data on their handset is two to three times higher.

4.49 We do not have any evidence to suggest that inherent network limitations are a significant contributor to the difference in data volumes across fixed and mobile networks. While some consumers will use a mobile broadband dongle as a substitute for a fixed broadband connection, many consumers use mobile broadband, whether via a dongle or smartphone, for applications which do not require large volumes of data such as web browsing and e-mail. An Ofcom survey found that the most popular uses for a smartphone were for internet surfing, taking photos/videos, email and social networking[54]. Large file downloads and video streaming, which represent a significant proportion of fixed line broadband traffic, are less popular on smartphones and laptops used on the move.

4.50 Many mobile broadband tariffs include data caps, which may have the effect of suppressing how much data users choose to consume on their connections. It is unclear whether, without these caps, mobile operators would experience significant capacity limitations on their networks. At least one mobile operator continues to market 'unlimited' mobile broadband packages.

[53] Most mobile data services will use the 3G network, however 2G networks are also capable of carry data, albeit at a slower rate. This figure includes SIMs issued for mobile broadband dongles.
[54] http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr11/uk/1.44

4.51 Capacity limitations on mobile networks can occur at various stages in the network, but typically upgrades are required in the 'radio access network' (the link from the base station mast to the handset) and, potentially, in the backhaul data circuit connecting the base station to the operator's core network. In addition to reducing demand by off-loading traffic onto Wi-Fi networks (see section 8), operators are able to increase the capacity of the radio access network by using more of their licensed radio channels and, where capacity demand cannot be met even when all available radio channels are in use, by deploying additional, smaller base stations – known as micro cells, which allows spectrum to be reused. We expect demand for mobile data to increase due to the increasing take up of smartphones and the growing use of data on the move and that mobile operators will continue to make significant investments in their networks to respond to the growing demand, including the deployment of next-generation mobile technologies.

Future developments

4.52 Ofcom published its consultation on the proposal to award 800MHz and 2.6 GHz spectrum on 22 March 2011[55], following the government direction in December 2010. We anticipate that the auction for this spectrum will be held next year. The spectrum is suitable for the deployment of the latest mobile technology, known as Long Term Evolution (LTE), which promises higher speeds and greater capacity.

4.53 This spectrum is not likely to be used to offer mass-market retail services for a number of years. In the mean time, network operators continue to invest in maintaining and upgrading their networks. In January 2011, O2 announced that its network in the south of England would be upgraded with capability to support LTE equipment by Nokia Siemens Networks. [56]. Ericsson is doing the same for the O2 network in the north of the UK[57]. In September 2011 Everything Everywhere and Three announced[58] an agreement with Virgin Media's business division under which Virgin Media would provide 1Gbit/s Ethernet backhaul service to help ensure that backhaul capacity does not become a constraining factor as radio access networks are upgraded.

[55] http://stakeholders.ofcom.org.uk/consultations/combined-award/
[56] http://www.nokiasiemensnetworks.com/news-events/press-room/press-releases/nokia-siemens-networks-to-modernize-o2-network-boosting-smartp
[57] http://www.ericsson.com/news/1482512
[58] http://www.virginmediabusiness.co.uk/news__events/news/2011/mbnl.aspx

Section 5

Digital television

Overview

5.1 Consumers in the UK receive their television services via a variety of platforms. Analogue TV is now only available through an aerial from terrestrial transmitters, whilst free-to-air and pay digital TV services are available via satellite, digital terrestrial and cable platforms.

Consumer context

5.2 Digital TV was first introduced in the UK in 1998. Figure 16 shows the break-down of take up of the different television broadcast platforms. Whilst 93% of households have digital TV on their main set, 96% of households have at least one TV set using digital TV.

5.3 Pay-TV is available on all digital TV platforms. Sky retails services on digital satellite, Virgin Media is the largest cable operator and pay services are also available on digital terrestrial TV from both BT (BT Vision) and TopUpTV.

5.4 The main free to air brand is Freeview on digital terrestrial TV. Freesat, a joint venture between the BBC and ITV launched in 2008, provides access to free to air channels on satellite (these channels are also available on Sky receivers without the need for a subscription).

Figure 16 - Percentage of take up of television platforms

Television platform	Percentage take up by households
Digital terrestrial (DTT)	38%
Analogue terrestrial	7%
Pay digital satellite	35%
Cable	12%
Free-to-view satellite	8%

Source: Ofcom & GfK NOP research

Digital terrestrial television

5.5 DTT is the broadcast TV platform which is progressively replacing the UK's historic analogue television networks in the digital switchover (DSO) process. As this process is due to be completed by the end of 2012, we report only on the digital terrestrial networks and not the remaining analogue services. The technical aspects of the switchover process are being coordinated by Digital UK in collaboration with the terrestrial broadcasters, the transmission provider and Ofcom. Digital television is also available via the cable networks and on satellite.

5.6 DTT services are transmitted from the network of land-based transmitter masts which formerly carried analogue TV channels. The network comprises of 1156 transmitters operated by Arqiva. The majority of the UK is served by 80 large transmitters (see below), and over 1000 additional smaller masts are required to achieve near universal coverage The services are based on a 'multiplex' structure, with each multiplex containing a number of concurrent TV services (currently up to ten), as well as radio stations and text services. These services are digitally combined into a single signal to form the transmitted multiplex. Each multiplex occupies the same amount of radio frequency spectrum as one analogue TV channel.

5.7 Currently the national DTT platform consists of six multiplexes. Two multiplexes are operated by the BBC, two by Arqiva, one by Digital 3&4 (a company jointly owned by ITV and Channel 4), and one by SDN (a subsidiary of ITV).

5.8 The two BBC multiplexes and the Digital 3&4 multiplex are designated as the 'public service broadcaster' (PSB) multiplexes. These carry standard definition (SD) digital versions of the historic five analogue TV channels, as well as ten other SD channels. In post-switchover areas, one of the PSB multiplexes carries four high definition (HD) TV channels using advanced transmission standards. Five of the UK's major TV transmitter sites in pre-switchover areas also carry the HD multiplex as a temporary additional multiplex until DSO takes place.

5.9 The remaining three multiplexes (two operated by Arqiva, and one by SDN) are transmitted from 80 of the UK's larger transmitter sites. These are known as the 'commercial multiplexes' and contain approximately 30 concurrent TV channels. As some types of video content are more demanding to encode than others (i.e. they require more bit-rate to provide a given level of picture quality), each multiplex uses statistical multiplexing techniques to dynamically allocate the total available bit-rate to individual services based on the instantaneous demands of each channel. The commercial multiplexes will be available to around 90% of the UK population at the completion of the digital switchover programme. By the end of switchover, the three PSB multiplexes will be available to 98.5% of UK households. Due to the high cost of building out transmission networks on a purely commercial basis and the constraints on the availability of spectrum in some areas, further extensions to commercial multiplex coverage are unlikely.

Use of spectrum

5.10 Each DTT multiplex uses a number of 8MHz radio channels to provide coverage across the UK. Unlike DAB radio, DTT does not make extensive use of "single frequency network" techniques (see section 6 for more details). To avoid interference between adjacent transmitters and to allow regional programming, a single multiplex is transmitted on different frequencies from different transmitters. Details of which frequencies are used in which parts of the UK for DTT transmission are detailed in the multiplex operator's licence and are available on the Ofcom website[59].

5.11 One consequence of using spectrum in this way is that certain radio channels 'lie fallow' to avoid DTT broadcasts from one transmitter causing interference to another. Ofcom has recently issued a statement on how these "white spaces" of

[59] http://licensing.ofcom.org.uk/tv-broadcast-licences/current-licensees/multiplex/

spectrum can be made available for other uses, thereby increasing the efficiency with which spectrum is used (see Section 8 for more details).

Coverage and progress of digital TV switchover (DSO)

5.12 The DSO programme began in 2008 at the Selkirk transmitter group in the Scottish Borders. By June, eight of the UK's fifteen TV regions have completed the switchover. Since early June 2011, 34% of UK households are in areas where DSO had been completed. Since June, two further TV regions (Central and Yorkshire) have completed switchover.

5.13 DTT services are also available to many viewers in pre-switchover regions, albeit with relatively low transmitted signal power, meaning that as of June 2011, over four-fifths of UK households were located in areas where digital terrestrial TV coverage was available. DTT coverage will progressively increase as DSO extends to the remaining TV regions before the programme's completion during late 2012.

5.14 An interactive map of digital television coverage in local authorities as of June 2011 and at the end of switchover is available on the Ofcom website: http://maps.ofcom.org.uk.

5.15 The coverage achieved by DTT services generally increase through the process of switchover. In a small number of areas, coverage increased significantly at the time of switchover but will subsequently reduce slightly in 2012 due to changing levels of interference as transmitters in other areas around the UK and overseas undergo switchover. In most cases the changes in reception quality are slight, but can be exaggerated by the planning model which takes a cautious approach to predicting coverage. For this reason, there are small number of local authorities in the UK for which the predicted coverage in June 2011 is slightly higher than it is predicted to be at the end of DSO (these can be seen on the interactive map).

5.16 Figure 17 summarises the household coverage of the PSB multiplexes and the common coverage of the PSB and commercial multiplexes in June 2011 and predicted coverage at the end of DSO.

Figure 17 – DTT coverage

	Household coverage (June 2011)	Planned household coverage after DSO (Nov 2012)
Three PSB multiplexes	89%	99%
All six multiplexes	73%	92%

Source: Ofcom / operators

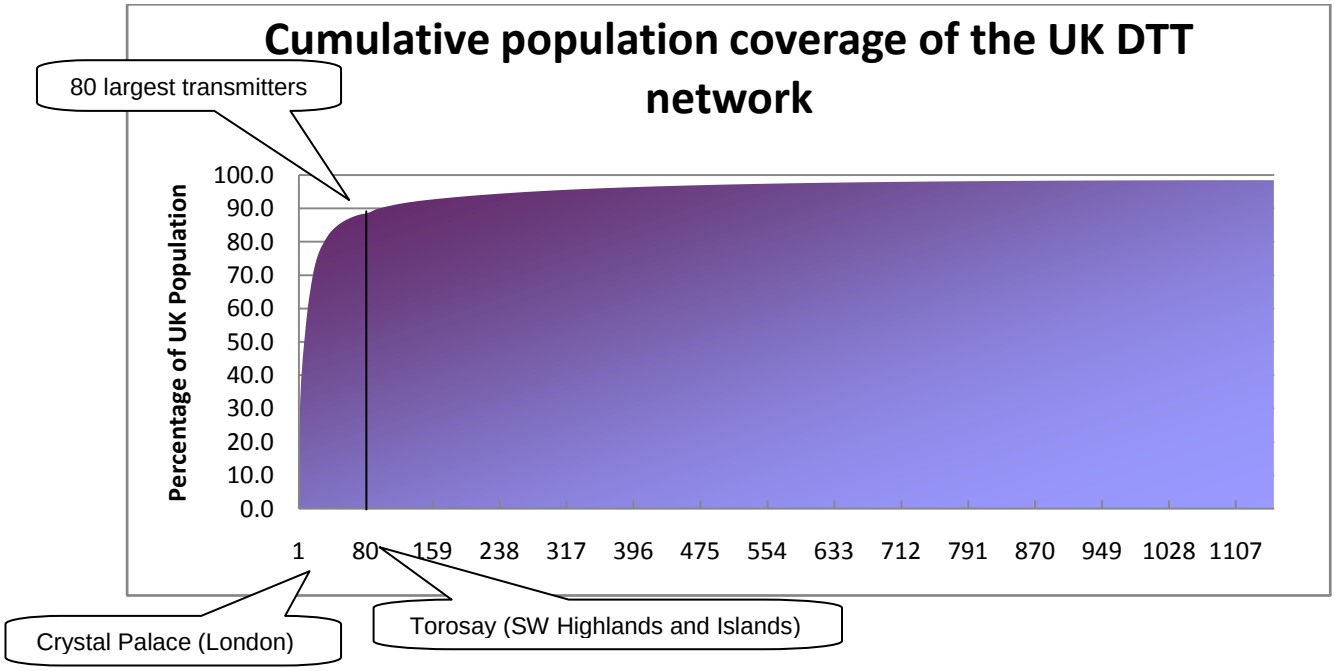
5.17 All of the UK's former analogue TV transmitters[60] are being converted to carry the three PSB multiplexes from their relevant DSO date. By the time DSO is complete, 1156 transmitters will carry these services, providing near-universal access to core DTT services.

[60] 6 former analogue relays are no longer required for technical reasons and will not be converting to DTT.

5.18 At June 2011, 730 of the UK's 1156 TV transmitter sites had converted to digital-only operation, and 38 transmitters in pre-switchover areas carried DTT services.

5.19 Figure 18 illustrates, for the post-switchover situation, the coverage of UK's transmitter network. The transmitters are shown, in descending order of population coverage, on the horizontal axis. The vertical axis shows the cumulative coverage achieved by the network. The chart illustrates that a relatively small number of transmitters provide the bulk of the network's population coverage, with a large number of lower-powered relay transmitters required in order to reach smaller pockets of coverage deficiency. A very large number of transmitters would be required to provide 100% population coverage.

Figure 18 - Cumulative population coverage of the UK DTT network



5.20 Figure 19 below indicates the number of transmitter sites per head of population in each TV region. The relatively high number of transmitters required to serve more rural areas is due to factors including adverse terrain (which presents challenges to TV service coverage) and widely dispersed or relatively small pockets of population. This illustrates the challenge of providing broadcast infrastructure in rural areas, where the cost of infrastructure deployment must be recovered through revenues from smaller numbers of end users.

Figure 19 - Share of transmitters for each ITV region

ITV Region	Transmitters per 100,000 households
London	1.1
Anglia	1.6
Central	2.1
Granada	2.3
Yorkshire	2.4
Tyne Tees	3.2
Meridian	4.1
STV Central	6.3
West	6.8
Ulster	7.1
Border	10.8
Westcountry	14.2
Wales	15.9
Channel	16.0
STV North	17.4

Source: Ofcom/operators

Capacity of the DTT network

5.21 The transmission capacity of the DTT platform is determined by the transmission technology used (which determines the bit-rate of the multiplex) and the video encoding technology (which determines the bit-rate required to encode each TV channel). The five multiplexes carrying standard definition TV channels use the DVB-T transmission technology and MPEG2 video encoding technology. The HD multiplex uses a more recent transmission technology (DVB-T2) and encoding technology (MPEG4). For each transmission technology, different configuration parameters can be set to trade off bit-rate and signal robustness. The choice of signal modulation used is a key parameter, with higher rates of modulation providing higher bit-rates (but lower robustness). On the DTT platform QAM[61] modulation is used (16, 64 & 256).

5.22 In pre-switchover areas, four of the multiplexes use a lower capacity / higher robustness transmission mode (16 QAM). Transmitter power increases that are being adopted at switchover are sufficiently high to allow SD multiplexes to adopt the higher capacity (64 QAM) mode, while still providing a significant increase in coverage and reception robustness.

5.23 The Freeview HD high definition services offered in post-switchover areas use the advanced DVB-T2 transmission standard, which offers a further increase in data

[61] QAM – Quadrature Amplitude Modulation. It is a modulation (signal encoding) technique used in digital television transmissions. 64 QAM carries more data than 16 QAM, but is slightly more prone to noise and errors, meaning for example that a 64 QAM signal requires a higher signal power in order to cover the same geographical area as a 16 QAM signal.

capacity. Figure 20 below summarises the increase in overall DTT platform data capacity enabled by DSO:

Figure 20 - Net bit-rate for each DTT multiplex

Multiplex	net bit-rate (Mbit/s): Pre-DSO	Transmsission technologies Pre-DSO	net bit-rate (Mbit/s) Post-DSO	Transmission technologies Post-DSO
BBC A	18.1	MPEG2 16QAM DVB-T	24.13	MPEG2 64QAM DVB-T
Digital 3&4	24.13	MPEG2 64QAM DVB-T	24.13	MPEG2 64QAM DVB-T
BBC B (HD post-DSO)	18.1	MPEG2 16QAM DVB-T	40.2	MPEG4 256QAM DVB-T2
SDN	24.13	MPEG2 64QAM DVB-T	24.13	MPEG2 64QAM DVB-T
Arqiva A	18.1	MPEG2 16QAM DVB-T	24.13	MPEG2 64QAM DVB-T
Arqiva B	18.1	MPEG2 16QAM DVB-T	24.13	MPEG2 64QAM DVB-T
Total	*120.7*		*160.9*	

Source: Ofcom / operators

5.24 Some DTT channels are 'time exclusive', and are broadcast for a limited number of hours each day (e.g. BBC Three and CBeebies). When such channels are not broadcasting, their capacity within the multiplex is used to transmit programmes from another channel. Each channel is however provided with its own slot (or

Logical Channel Number[62]) on the Freeview programme guide (EPG). Therefore the number of TV channels visible in a viewer's EPG is greater than the number of channels which are actually transmitting at any given time.

Network sharing and wholesale services

5.25 The UK's network of 1156 TV transmitter masts is owned and operated by the transmission and media services company Arqiva, which provides network access (physical access to masts) and managed transmission services (provision of transmission infrastructure services) to the operators of the six multiplexes. Service agreements covering matters such as transmitter reliability are primarily determined by Arqiva's contractual relationships with the broadcasters.

Future developments

5.26 Following completion of DSO during 2012, a further programme of transmission frequency changes will take place at some transmitters in order to complete the '800 MHz clearance' programme. The changes are required in order to clear UHF channels 61 and 62 (790 MHz to 806 MHz) of DTT services to provide capacity for next generation mobile broadband services in the digital dividend[63]. These frequency changes are being implemented in tandem with the DSO programme at many transmitter sites, but will be implemented at the remaining transmitters (e.g. those in early switchover regions) after completion of the national DSO process. We expect most frequency changes to take place during 2013. Most of the existing transmission infrastructure can be reused when changing frequencies, although some components at the transmitter sites (e.g. signal combiners and aerials) may need to be modified or replaced.

5.27 The completion of DSO will also see the completion of the first nationwide DVB-T2 network, providing near-universal coverage of Freeview HD services using advanced transmission standards.

5.28 The government's proposals for local TV envisage new local TV stations being provided by DTT in a number of locations across the UK. These stations are likely to come into service after the completion of DSO[64]. There are maps of potential local TV coverage on Ofcom's website[65].

Digital cable and satellite

5.29 Digital television services on cable are transmitted using dedicated 8MHz channels across the cable networks. On Virgin Media's network, these frequencies are used to carry digital television services in standard and high definition and for video-on-demand services.

5.30 Digital satellite television services have been available in the UK since 1998 from Sky and from 2008 from Freesat, to anywhere within line of site of the satellite transponder. These satellites have been positioned to give coverage to the whole of the UK, although individual premises may not be able to receive the services due to

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[62] A list of the channels carried in each multiplex is available online. The pre-DSO allocation: http://www.dmol.co.uk/mux.php and post-DSO allocation http://www.dmol.co.uk/mux_post.php
[63] http://stakeholders.ofcom.org.uk/spectrum/project-pages/digital-television/clearing_dtt/
[64] DCMS *Framework for Local TV consultation* http://www.culture.gov.uk/consultations/8298.aspx
[65] http://maps.ofcom.org.uk/localTV

line-of-sight issues or because it is not possible to install satellite receiving equipment on the premises. Sky reported that since July 2009, approximately 2% of homes visited could not have the equipment installed. In addition to standard and high-definition television services Sky offers a 3D television channel. Sky's video-on-demand services are provided via the broadband network.

Section 6

Digital radio

Overview

6.1 The digital audio broadcast (DAB) network delivers both local and national digital radio services to end-users via a network of 201 terrestrial transmitter masts.

6.2 Digital radio services are also available via digital TV platforms, such as digital terrestrial TV (outlined in the previous section) and satellite. However, this section focuses on the DAB terrestrial network as it is the primary delivery mechanism for portable and in car radio reception and is expected to be the long term replacement for existing analogue radio networks.

6.3 While the majority of end-users continue to listen to analogue radio services, planning is under way to assess whether analogue services could be withdrawn at some point in the future, as more consumers adopt digital radio. This chapter therefore focuses on the coverage of digital radio services, in particular the two national multiplexes, rather than analogue radio services.

Consumer context

6.4 Across the UK 37% of households now have access to a DAB digital radio and 26.5% of radio listening is via a digital platform (whether DAB, digital TV or on the internet).

6.5 Sales of DAB radios in the year to Q1 2001 were steady year on year at 1.9m. However, sales of analogue radio continue to outstrip digital.

Coverage

6.6 The national digital radio stations are carried on two digital multiplexes. Each multiplex is broadcast on different radio frequencies, one operated by the BBC and the other by Digital One (which is 100% owned by Arqiva).

6.7 Figure 21 shows the current coverage of each multiplex in terms of households served (indoor coverage to a portable receiver) and percentage of roads. A more detailed map of coverage in different parts of the UK is available on the Ofcom website at http://maps.ofcom.org.uk

Figure 21 - Existing DAB coverage

Existing DAB coverage	BBC national	Commercial national (Digital One)
Households	91%	85%
Roads	74%	64%

Source: Ofcom / operators

6.8 Coverage figures are based on planning models which include a number of assumptions about signal propagation (such as the losses incurred when the

signals enter a building) and receiver sensitivity (i.e. the minimum signal strength a radio requires to operate). We have tested the sensitivity of a number of radios available on the market[66] to help determine the correct parameters to use in the planning models. These parameters are being used by the Technology and Equipment Working Group in the Government's Digital Radio Action Plan to establish a minimum receiver performance specification which will be linked to a product kite mark, enabling consumers to identify which DAB radios to buy that will reliably function in the planned coverage areas. We continue to validate other features of the planning model by conducting field measurements and will update and improve the models where necessary.

Capacity

6.9 The capacity of each DAB multiplex is determined by the data capacity of the multiplex and the bit-rate required for each radio station. Lower bit-rates can be used for mono or voice only broadcasts. Each national DAB has a total bit-rate of approximately 2.3 Mbit/s, of which some data is used to correct transmission errors, leaving in the region of 1.5Mbit/s for services. Both national DAB multiplexes are running at near full capacity. The number of channels that can be carried in each multiplex can only be increased, using the current technology, if the bit-rate or error protection is decreased. This could have implications on the coverage of the network.

6.10 The number of channels and the indicative bit-rates for each radio station on the two national DAB multiplexes are shown in Figure 22.

[66] http://stakeholders.ofcom.org.uk/binaries/consultations/dab-coverage-planning/annexes/annex-j.pdf

Figure 22 - Capacity of DAB national multiplexes and peak bit-rates[67]

BBC national 12B 225.648MHz	Digital One 11D 222.064MHz
BBC Radio 1 128kbit/s	Smooth Radio 112kbit/s
BBC Radio 2 128kbit/s	Talk Sport 64kbit/s
BBC Radio 3 160kbit/s	Classic FM 160kbit/s
BBC Radio 4 128kbit/s	Planet Rock 112kbit/s
BBC Radio 5 64kbit/s	BFBS Radio 80kbit/s
BBC Radio 5 Live Extra 64kbit/s	Amazing Radio 64kbit/s
BBC 6 Music 128kbit/s	Premier 64kbit/s
BBC 4 Extra 80kbit/s	UCB UK 64kbit/s
Radio 1Xtra 128kbit/s	Jazz FM 96kbit/s
BBC Asian Network 64kbit/s	Absolute Radio 112kbit/s
BBC World Service 64kbit/s	Absolute Radio 80s 112kbit/s
	Absolute Radio 90s 64kbit/s
	Absolute Radio 00s 128kbit/s
	Absolute Radio extra 112kbit/s

Source: DAB network (Crystal Palace transmitter) as of 18/7/11

Network sharing and wholesale services

6.11 Arqiva operates all the transmitter sites for both the BBC and Digital One multiplexes (Digital One is 100% owned by Arqiva) and the transmission sites are shared. The BBC operates from 201 transmitter sites while Digital One operates from 137. Most of these transmitter locations are shared between the two networks and with DTT transmitters[68].

6.12 As a multiplex operator, Digital One provides wholesale services to individual radio stations, which are owned by 11 different organisations. All radio stations on the BBC multiplex are operated by the BBC.

Use of spectrum

6.13 Unlike digital terrestrial television, DAB transmitters operate in a single frequency network (SFN), in which all of the transmitters forming part of the network operate on the same common frequency. This enables the extension of radio service coverage to be achieved in a spectrally efficient way by adding more same frequency transmitters to the network.

[67] The bit-rates for the DAB radio stations are variable and the multiplex operator may change these from time to time so that additional radio stations can be carried within the same multiplex.
[68] Information about the location of transmitters for the Digital One network is available at http://www.ukdigitalradio.com/coverage/. Information about the additional sites used by the BBC is available at http://www.bbc.co.uk/reception/transmitters/radio/digital_radio.shtml

6.14 Each broadcast channel carries a 'multiplex' of several radio and data services. Each multiplex of services is delivered using a 'DAB block', which is an allocation of 1.536 MHz of spectrum centred on the nominal channel frequency. The services on a multiplex normally have identical coverage.

6.15 In the UK, DAB currently operates in part of the VHF Band III spectrum, between 217.8 and 230.0 MHz (DAB blocks 10B to 12D). New services have been licensed on frequencies from 210.8 to 215.8 MHz (DAB Blocks 10B to 10D) although these are not yet implemented. We are also investigating the use of DAB block 5A, which sits between 174.1 and 175.7 MHz, as part of the post switchover local DAB plan. DAB can also operate in a higher frequency band around 1.5 GHz (L-Band), although, in the UK only the VHF Band III frequency blocks listed above have been allocated for use by DAB.

6.16 The national Digital One multiplex uses the block 11D in England and Wales and block 12A in Scotland; Digital One does not currently broadcast in Northern Ireland[69]. The BBC's national services are delivered across the UK using the block 12B. The 11A block frequency is currently unused and could be used to provide an additional national DAB multiplex. To maintain an opportunity to expand the national DAB service offer in the future, this frequency block has not been included in the proposed post switchover DAB plan.

Future developments

6.17 The BBC has announced plans to introduce 34 additional transmitter sites by the end of 2011, which is predicted to increase coverage to 94% of households. Digital One has provided indicative planning to Ofcom for the build-out of its network to levels equivalent to Classic FM[70].

6.18 The government has indicated that it is supportive of digital radio switchover, and the Digital Radio Action Plan[71] details the steps necessary to achieve this, including the criterion that "National DAB coverage is comparable to FM". We therefore anticipate development of both BBC and commercial national DAB multiplexes, if the switchover policy continues to move forward.

6.19 On 22 June 2011[72], Ofcom published a consultation in which we proposed an approach to DAB coverage planning and investigated options to increase DAB coverage to match existing national FM coverage.

6.20 The consultation closed on 14 September 2011, and we propose to provide a final report to government setting out our conclusions, in Q1 2012.

6.21 The exact plans for taking forward the coverage build-out of the national DAB multiplexes beyond current levels are the subject of discussion between the government, the BBC and Digital One.

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[69] A number of the radio stations carried on the Digital One national multiplex are available in Northern Ireland on the local DAB multiplex. Coverage maps for this multiplex can are available in this document: http://stakeholders.ofcom.org.uk/binaries/consultations/dab-coverage-planning/AnnexB/DSO_12D_Northern_Ireland_DA1.pdf

[70] http://stakeholders.ofcom.org.uk/binaries/consultations/dab-coverage-planning/annexes/annex-d.pdf

[71] http://www.culture.gov.uk/images/publications/digitalradioactionplan_vs4_FINAL.pdf

[72] http://stakeholders.ofcom.org.uk/consultations/dab-coverage-planning/

Section 7

Resilience

7.1 Before the introduction of the Digital Economy Act and the later revisions to the EU regulatory framework, Ofcom had few formal duties or powers related to telecommunications resilience. Despite this, its importance has long been recognised and much activity has been undertaken by government, industry and Ofcom. For example, all three parties are involved in the EC-RRG[73], a body which is discussed in more detail later in this section. In terms of government involvement, BIS[74] has overall responsibility for telecommunications resilience as part of its cyber security function, with links to Cabinet Office and GCHQ[75] activity. CPNI[76] focuses on the resilience of telecommunications as it relates to critical national infrastructure, and the Cabinet Office leads on matters associated with civil contingencies.

7.2 In line with the requirements of the Act, we sought figures on the percentage of time that networks were and were not available for use during April and May 2011. In response, some CPs explained that this was not a figure that they typically measured and that deriving a figure would be complex and involve a large degree of estimation. Some of the reasons for this are listed in the next sub-section. Generating accurate and comparable figures for this metric across CPs would involve very detailed service specific specifications and require CPs to put in place new monitoring which was outside the scope of this report. Therefore we have sought information about the most significant incidents on the networks during the reporting period to provide an indication of the outages on these networks. The data the CPs could provide gives a broad indication of the level of performance in this important area.

Availability statistics

7.3 For telecommunications, the lowest availability figures we received for fixed services across voice and broadband were around 99.9%. This equates to a maximum of around nine hours per year during which the service would be unavailable. For mobile, the lowest figure was around 98.5%. It should be noted that this figure includes some planned outages, such as those that occur when changes or upgrades are made to the network. Planned outages are usually scheduled at times when network usage is lowest, so it is likely that the percentage of time when a customer was unable to use the network when they wished to do so would be lower than the 1.5% this figure suggests. These figures relate to the average across the whole network, and the experience of individual customers will vary.

7.4 Instead of reporting the availability of an entire broadcasting network, broadcast operators provided data relating to the availability of each transmitter. The lowest availability for a single transmitter was 98.7%[77]. In the vast majority of cases

[73] The Electronic Communications Resilience and Response Group
[74] The Department of Business, Industry and Skills
[75] UK Government Communications Headquarters
[76] The Centre for the Protection of National Infrastructure
[77] As multiplex operators already submit annual reports on the availability of their DTT networks, data in this section on DTT networks relates to the performance of their network in 2009, the most recent year for which we hold data.

transmitters were available for more than 99.9% of the time. Ofcom's *Television Technical Performance Code*[78] requires the broadcasters to maintain standards of transmitter reliability which are as high as reasonably practicable. Specifically, transmitters should be available for service for at least 99.8% of the time in the case of the 80 larger transmitters, or 99% of the time for other transmitters. Digital transmitter power can be reduced by up to half during engineering works (which has a small effect on reducing coverage).

Major outages – general telecommunications and broadcasting

7.5 We asked CPs to report the two most significant outages during April and May 2011, determined by the number of lost "customer hours". This figure, a product of the duration of the outage and the number of customers affected, gives an indication of overall impact. Not all providers were able to give an accurate figure for lost customer hours, but used this metric as a guide to select which outages to report. We also asked for information on the root causes of these outages.

7.6 Estimates of lost customer hours are not likely to be precise. This makes it difficult to obtain reliable and comparable figures for percentage availability and also to quantify the impact of any given outage. There are a number of reasons for this, for example:

- a network problem may cause varying effects on the services running over it – some may continue to operate while others may not;
- the loss of a network or service may be partial, resulting in limited functionality. The point at which a service may be considered to be unavailable is difficult to define and varies by CP and by service type
- the outage may be intermittent, making an accurate tally of downtime difficult to keep;
- the outage may affect different customers at different times or for varying durations; and
- it may be difficult to accurately gauge the number of customers affected by the outage.

7.7 Additionally, it is not possible to compare the scale of outages between different types of networks and services due to the different network architectures, the way services are delivered and the metrics used by the operators.

7.8 Estimating the number of customers affected by a mobile network outage is particularly difficult because when parts of the network are not operational, the number of customers who were within its normal coverage at that point in time cannot be assessed. The precise number would also vary during the outage as customers moved in and out of the coverage area. This is in contrast to fixed networks, telecommunications or broadcast, where the number of lines or households affected can usually be accurately determined.

[78] http://stakeholders.ofcom.org.uk/binaries/broadcast/guidance/tech-guidance/tv_tech_platform_code.pdf

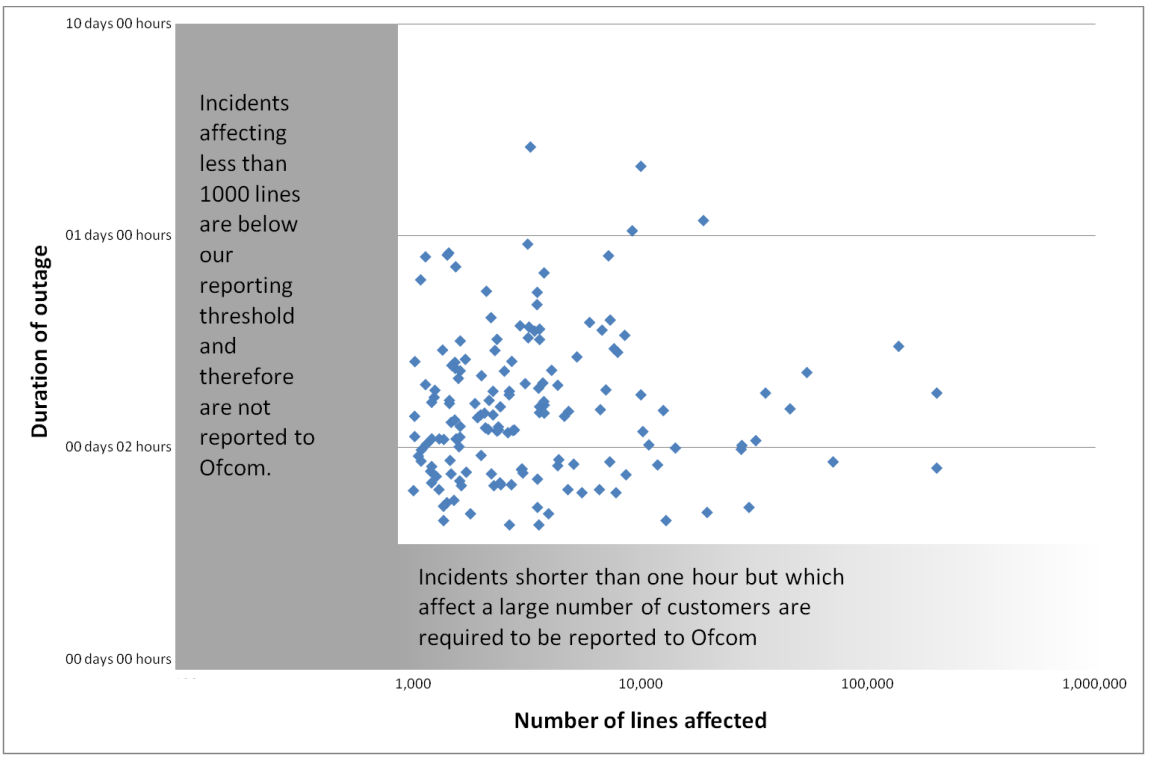
7.9 As a result, the approach to estimating customer impact varied between fixed and mobile operators and between mobile operators. For mobile networks, some simply gave the number of transmitter sites or cells (one site may often host several cells) that were unavailable, while others tried to estimate how many customers would normally have been served by this infrastructure, based on historical usage data.

7.10 The largest amount of infrastructure affected by a mobile outage was around 300 cells and the largest estimate of customers impacted was just over 1 million. At the other end of the scale, the smallest number of customers affected by a reported mobile outage was 4,000. Durations of these outages ranged from three to twenty hours.

7.11 For fixed networks, durations ranged from a few minutes to around one day, with the number of customers affected ranging from 1,000 to 300,000.

7.12 Since the end of May 2011, as a result of the transposition of the European Framework for communications, Ofcom has a new duty to collect reports about security incidents which have had a significant impact on the operation of networks and services. Figure 23 below shows the summary of the reports received so far for telecommunications networks. We have set a number of thresholds for reporting, which means that we do not receive reports for incidents which affect less than 1,000 customers and we are notified of very short incidents only if they affect a large number of customers. The chart shows that, as might be expected, for the three months since the beginning of the reporting process smaller incidents occur more frequently and longer outages which affect a large number of customers occur very rarely.

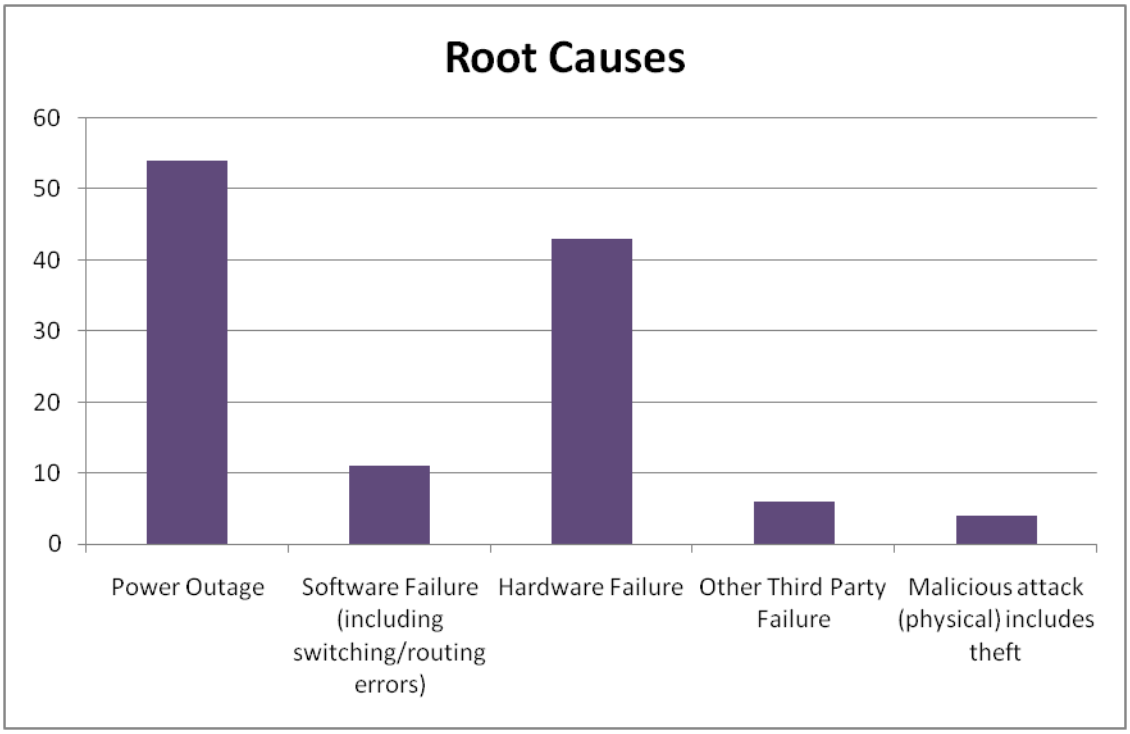
Figure 23 - Summary of impact of network incidents



Source: Ofcom / operators (incidents between 26 May 2011 and 30 September 2011)

7.13 Figure 24 below shows the main causes of these incidents, where a reason was reported. The single most common cause of incidents was a failure of the power supply, for example due to a power cut or a fault with the backup supply. The second highest cause (hardware failure) includes failure of equipment or cables in the network.

Figure 24 - Root causes of reported incidents



Source: Ofcom / operators (incidents between 26 May 2011 and 30 September 2011)

7.14 We believe there is significant overlap between the categories in the chart above. This can lead to the frequency of some causes being under-represented. One example of this is the theft of cables from the network. Many reports received from operators will state only that there was a cable failure and not whether this was, for example, due to vandalism, theft or an accident. At the time of reporting to Ofcom, this information may not yet be available to the operator, and in other cases where the reporting operator is not the owner of the cable it may never become aware of how the damage was caused. All such incidents appear in the diagram above as “hardware failure”, including those which are due to “malicious attack” (unless otherwise specified by the CP).

7.15 Many of the most significant outages reported for broadcast networks during April and May were the result of planned maintenance works to the network in preparation for digital switchover. We have excluded these from further consideration as we were most interested in understanding outages due to unexpected events.

7.16 There are different types of outages on a broadcasting network, from a fault at a transmitter site, which will only affect the population within its coverage area, to playout faults which may bring down a television station and therefore result in a national outage. The DAB outages reported were all at the transmitter level,

affecting between 25,000 and 700,000 customers and lasting between two hours and just over a day.

7.17 Most DTT outages were due to the loss of power at transmitter sites. These affected between 70,000 to 815,000 households and the duration ranged between 2.5 minutes to 1 hour. There was also the loss of a single TV station to the whole of the UK on two occasions, due to a power failure at the TV studio. These two outages lasted for nearly 4 hours and 5.5 hours. Most of the remaining incidents were split fairly evenly between three broad categories; network equipment failure, data transmission problems (including transmission equipment and fibre problems), and general technical problems (including human error). There was one outage reported during this period caused by suspected equipment theft and vandalism.

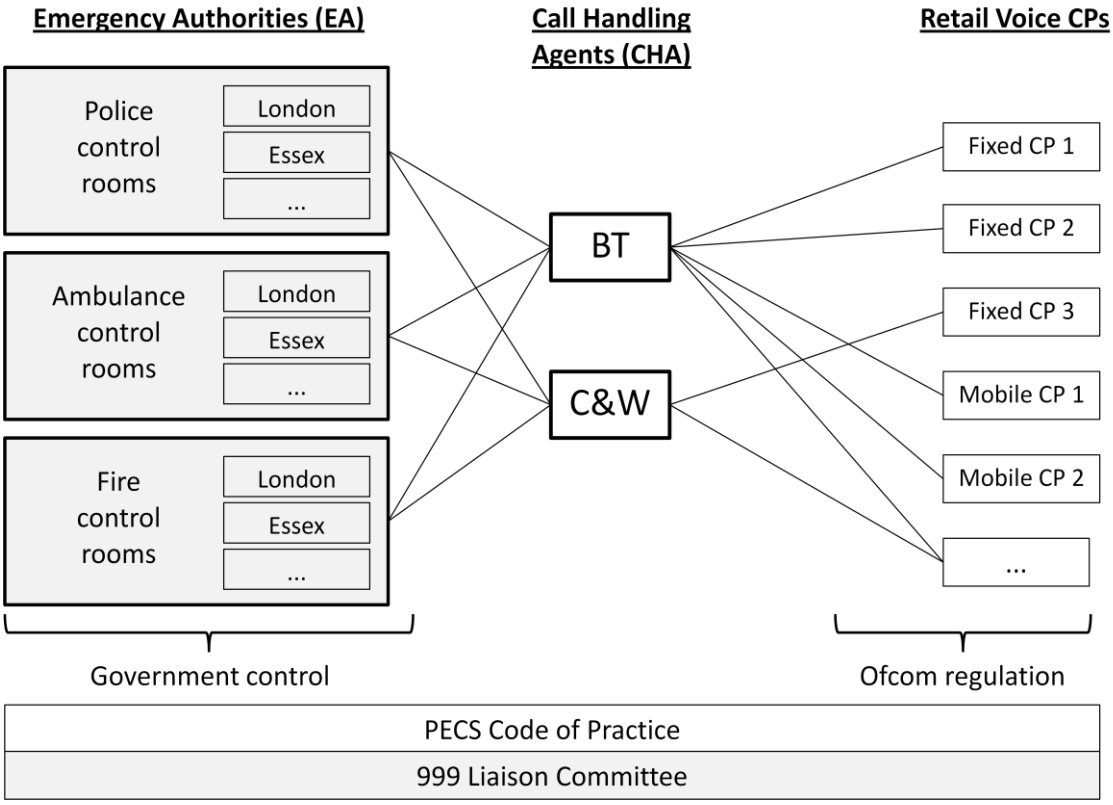
7.18 The range of affected customer numbers and the durations of the reported outages were notably similar across the very different infrastructures we considered. With the exception of the national loss of a single TV station when their play out was interrupted, the extent of outages during the period was limited to a maximum of 5% of total customers, with most affecting less than 3%. Most incidents were resolved well within 24 hours. Assuming the reporting period was typical, these figures suggest that the impact of major outages is quite contained and can be rectified fairly quickly.

Access to emergency services (999)

7.19 Several obligations are placed on providers of telephone services in relation to providing access to the emergency services via voice calls to 999 or 112 and more recently, via mobile text messaging for disabled users. In the course of enforcing these obligations we receive information about a range of outages affecting the service. Most of these incidents result from relatively minor operational problems and typically the scale of their impact are limited, but due to the nature of the service even small incidents can lead to harm or loss of life.

7.20 Many parties are involved in delivering and overseeing access to the emergency services. The main elements are illustrated in Figure 25 below. Providers of retail voice services have regulatory obligations to provide free access to the emergency services for their customers. Due to the historical evolution of the service, a multi-stage process is used for processing incoming 999 calls. First, the call is routed by the customer's retail provider to the wholesale provider (BT or C&W) with which they have a call handling contract. This CHA's call centre then answers the call and establishes basic facts (which service and the caller's location) before routing the call to the appropriate regional call centre for the emergency authority (EA) required. The EA's call centre then takes over the call and determines the appropriate action, such as dispatching an ambulance or police car.

Figure 25 - Overview of the emergency calls service



7.21 [✂]

7.22 The interactions between retail providers, CHAs and the emergency authorities are detailed in the Code of Practice for the Public Emergency Call Service (PECS). This document is produced and maintained by the 999 Liaison Committee, responsibility for which has recently transferred from DCLG[79] to DCMS. This body brings together representatives from the Emergency Authorities, CHAs and the communications providers to discuss matters of shared interest, primarily related to the day-to-day operation of the service.

7.23 [✂]

Preparing for emergencies and restoring service - Telecommunications

7.24 Alongside the new requirements to report significant network incidents to Ofcom, recent changes to the Communications Act 2003 have introduced new obligations on providers of public electronic networks to take appropriate measures to protect the availability of their networks.

7.25 We have published guidance on the necessary steps to meet these obligations[80], and we have recently written to a number of major CPs seeking information on the steps they are taking to comply with these new requirements. The CPs are now submitting the first incident reports to us, and these have been presented in the charts above. We hope the information and data resulting from these new regulations will provide increasingly useful input for future Infrastructure Reports,

[79] The Department for Communities and Local Government
[80] http://stakeholders.ofcom.org.uk/telecoms/policy/security-resilience/implementation-eu-framework/

allowing us to build up a more detailed resilience picture and track how it is changing over time.

7.26 While the changes to the Act represent new formal regulation, the requirements relate directly to activities that most CPs have been undertaking for many years. Clear examples of this come from the EC-RRG[81] – an industry group which exists to improve planning for, and dealing with, emergencies affecting communications networks. Most large infrastructure owning CPs are active members of the group, which works closely with relevant government departments to share information and coordinate responses.

7.27 The EC-RRG owns a process called NEAT, which is used by the member CPs, government and Ofcom during emergencies to share information in a structured way. The group regularly reviews and tests the process, which has been used during emergencies such as the 7/7 London bombings and more recently the high winds and resultant wide spread power outages in Scotland in May. The arrangements of the EC-RRG and NEAT are often used as a reference for crisis management in other countries or other sectors.

7.28 The CPs participate in the EC-RRG and contribute the necessary resources voluntarily. This stems partly from recognition of the vitally important role the proper functioning of the sector's infrastructure plays in the overall health of the UK. However, there is also a strong commercial incentive to participate in activities which improve the resilience of networks or services.

7.29 Telecommunications resilience often focuses on traditional services such as voice, but as internet access becomes increasing important, its performance under stress has received considerable scrutiny. By its open and global nature, the internet faces different threats to its resilience than do traditional services. One area of particular importance is the "internet exchange point"- facilities where internet providers interconnect their networks. The main UK facility, London Internet Exchange (LINX), operates across 10 locations. LINX and Telehouse Europe, which hosts most of the LINX locations, are both members of the EC-RRG and are therefore involved in the planning of the UK's telecommunications resilience.

7.30 When basic arrangements are in place, further improvements in the levels of availability or preparedness for emergencies can become very expensive. Ultimately there will always be a balance between improving performance and increasing cost. From a UK perspective, the optimum point for this balance is likely to shift over time, for example as the economic value of communications service increases.

7.31 It is difficult to determine from the limited data currently available whether the balance is correct at the moment. For example, it is impossible to judge whether an average availability of 99.9% for a given provider's fixed telecommunications services is desirable without a detailed understanding of the costs and benefits of improving this level of performance. However, while a single set of figures is somewhat arbitrary, we believe there will be considerable benefit from tracking these results over subsequent reports. This should allow any trends in increased or decreased performance to be identified and appropriate questions considered as a result.

[81] More information about EC-RRG is available at: http://www.cabinetoffice.gov.uk/content/electronic-communications-%E2%80%93-resilience-and-response-group-ec-rrg

Preparing for emergencies and restoring service - broadcasting

7.32 Redundant equipment chains are in place at most large main transmitter sites in the terrestrial broadcasting network. This means that all infrastructure in the signal path including signal input equipment, transmitter power amplifiers, RF combiners, antenna feeders, as well as the antennas themselves are duplicated. In the event of an equipment fault the secondary equipment path (or part of it) can be switched into service. This process generally happens automatically, and remote control and telemetry systems also allow manual equipment changeovers to be initiated remotely.

7.33 Dual diverse mains electricity feeds, and/or backup diesel generators are in place at many main transmitters.

7.34 [✂]

Trends

7.35 While the single data set derived for this report does not directly allow the identification of trends, it is possible to offer some observations based on previous work in this area.

7.36 Historically, communications services have been delivered over vast range of separate network infrastructures. Although many of these networks are connected or share some common elements (such as masts, ducts or buildings), these multiple networks provide the UK with an inherent level of resilience. This diversity of networks now appears to be decreasing, for both commercial and technical reasons. We see increased sharing of network elements or even complete consolidation of previously separate networks. Even where physical network elements remain duplicated, their management and operation may be outsourced to the same company, removing a layer of diversity. It is also common for multiple end user services to be carried over a common data network, typically powered by IP.

7.37 These trends reduce this form of resilience in depth and increase the possibility of single points of failure. However, whether this will actually result in worse overall availability for consumer services is less clear. The remaining networks may be expected to be built with greater scale and greater investment in resilience. Some of the technologies used, such as IP, have greater inherent resilience than many of the technologies they replace. Also, other trends, such as the ability to undertake a given activity over a growing number of platforms (e.g. voice communications over PSTN, fixed broadband, cellular mobile or Wi-Fi hotspot) offers new choices to users which may further offset the effects of this consolidation.

7.38 Although not appearing as a common root cause of major outages during the reporting period, equipment theft is often cited by the industry as a large and growing problem. This can include organised targeting of high value IP routing equipment in exchanges and data centres and theft of overhead or underground copper cabling for its scrap metal value.

7.39 [✂] For example, up to 30,000 homes and businesses in north Lincolnshire were reported[82] as having lost telephone and broadband services as a result of 73 cable

[82] http://www.thisisscunthorpe.co.uk/30-000-homes-businesses-affected-cable-theft/story-12854507-detail/story.html

theft incidents in the first half of 2011. In terms of availability, consequential damage to high capacity fibre cables that often lay alongside the targeted copper cables can often have by far the largest impact. We note that cable theft is also of concern in other sectors, such as rail and electricity, so efforts to make the disposal of stolen metals more difficult would have benefits beyond improved telecommunications availability.

7.40 As noted, the most common cause of outages in the reported cases was related to loss of electrical power. Power forms an essential input to communications. Likewise, communications is an essential input to many other utility sectors, not least power generation and distribution. This interdependence between the critical national infrastructures is a common theme in existing work to improve resilience.

Section 8

Future developments

Introduction

8.1 While there is relative stability in the passive network infrastructure, such as ducts, poles, masts and cables, there is ongoing innovation in transmission equipment. New technologies, which exploit the cost reduction in computer processing power, implement advanced signal processing techniques that allow data to be sent more efficiently over cables and radio spectrum. Deployment of these new technologies often allows communication providers to extend the life of their network assets while improving the quality of services delivered to consumers.

8.2 This section considers some of the technologies that may be deployed in the next three years. An understanding of the potential evolution of networks provides an insight into the level of investment that may be required to deliver better services to consumers.

Superfast fixed line broadband

8.3 Fixed line deployments to deliver superfast (SFBB - above 24Mbit/s) and ultrafast (100Mit/s and beyond) broadband speeds are expected to continue over the coming years, not only from BT and Virgin Media but also from a variety of smaller, local and regional access providers. It is likely that deployments outside the competitive areas for broadband, particularly in rural areas, will be supported at least in part by public sector funding (for example the Broadband Delivery UK[83] programme).

8.4 Specific future investment plans from access providers will depend on a number of external factors, particularly the current economic climate. Nevertheless, Virgin Media has recently announced an expansion to its network to cover 100,000 additional homes[84] and BT has existing plans to cover 66% of the UK population by 2015 with its SFBB programme.

8.5 In terms of technology use and capability, there are four types of access technology which account for most of the anticipated UK fixed deployments: DOCSIS 3.0, Point-to-Point Fibre, Gigabit Passive Optical Network (GPON) and Digital Subscriber Lines (DSL).

8.6 **DOCSIS 3.0.** Virgin Media has announced plans to continue to deploy and enhance the capabilities of its Hybrid Fibre-Coaxial (HFC) cable network infrastructure. As well as its network roll-out plans, Virgin Media is also trialling 1Gbit/s services to business customers[85]. These higher-speed services would go well beyond the 100Mbit/s that Virgin already offers on a commercial basis over most of its footprint. They are also supported by the existing network infrastructure, thereby avoiding street works, but would require upgrades to customer premises and head-end equipment. DOCSIS utilises the broadcast capability of HFC networks to deliver

[83] http://www.culture.gov.uk/news/news_stories/8389.aspx
[84] http://mediacentre.virginmedia.com/Stories/100-000-more-homes-able-to-get-Virgin-Media-fibre-optic-services-2174.aspx
[85] http://mediacentre.virginmedia.com/Stories/Virgin-Media-to-trial-world-s-fastest-cable-broadband-2119.aspx

data to end users sharing the same fibre 'node'. HFC networks are typically built with a node size of 500 homes passed, but can be combined or split to meet local capacity demands.

8.7 **Point-to-Point Fibre.** A number of smaller access providers are deploying Point-to-Point fibre in a number of schemes across the UK[86]. In general these are in concentrated areas such as apartment complexes or student campuses. The broadband speeds that such technology can offer are essentially limited only by the active electronics provided at each end of the fibre, with 1Gbit/s already available in deployments overseas and expected in the UK soon. Given the relatively high costs associated with this technology, deployment is expected to be targeted at specific areas where such solutions are commercially justified.

8.8 **Gigabit Passive Optical Network (GPON).** BT is currently piloting the use of GPON technology in two locations in the UK and intends to use this technology in a number of locations in the near future[87]. Being a Fibre to the Premises (FTTP) technology, GPON deployments require substantial investment in infrastructure as well as associated street work and installation work at the customer premises. As a result GPON will be more expensive to deploy than upgrades of DOCSIS and DSL.

8.9 Current GPON systems can offer customers peak (headline) rates of up to 2.5Gbit/s downstream and 1.25Gbit/s upstream, but like DOCSIS (and unlike point-to-point fibre), this bandwidth is shared between a number of customers (typically 32 or 64). DOCSIS downstream bandwidth tends to be shared between a far larger number of end users and bandwidth allocation is usually more asymmetric than GPON. For example, BT's 100Mbit/s GPON product offers up to 30Mbit/s upstream, whereas Virgin's DOCSIS product is currently limited to 10Mbit/s upstream.

8.10 The capacity of GPON networks can be increased by reducing node sizes (i.e. the number of end users served by a single fibre) or by utilising more of the bandwidth of the fibre – typically using multiple frequencies of light, a technique known as "wavelength division multiplexing" (WDM).

8.11 Standards already exist for using two frequencies of light over the same fibre and Openreach's FTTP GPON deployments include the necessary optical splitters and filters to allow a second frequency to be utilised[88].

8.12 Work is ongoing to further increase the utilisation of the fibre bandwidth. For example, there are already trials demonstrating 32 different frequencies of light in a single fibre[89]. Over time these WDM technologies could allow even greater bandwidth utilisation and form the basis of international standards.

8.13 Due to the passive nature of GPON architectures, competition between CPs normally exists at the exchange (rather than closer to the consumer), where CPs interconnect with the active head-end equipment provided by the infrastructure owner. However, the use of the infrastructure owner's active equipment means that multiple CPs can deliver services over the same access network to the customer. An example of such an arrangement is BT's Generic Ethernet Access (GEA) product, which offers CPs a relatively low-cost vehicle for market entry, particularly

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[86] http://stakeholders.ofcom.org.uk/binaries/telecoms/policy/local-fibre-access.pdf
[87] http://www.openreach-communications.co.uk/superfast/where-and-when/
[88] http://www.bcs.org/upload/pdf/sfisher-090311.pdf
[89] http://www.tellabs.com/news/2011/index.cfm/nr/152.cfm

when compared with the current alternative of duplicate fibre build. Nonetheless, such a mechanism does impose a number of limitations on the nature of any offered product and hence service differentiation will be constrained by the specifications of the underlying GPON equipment.

8.14 Future developments in GPON standards may offer further competition opportunity through the use and subsequent unbundling of individual wavelengths within a next generation PON system. Although the unbundling of wavelengths within a shared optical network presents a number of complex technical, operational and practical challenges, the potential exists for CPs to take advantage of the existing optical infrastructure to offer innovative differentiated services to customers in a similar way that local loop unbundling (LLU) has been successful over copper lines. For example, it may be possible for CPs to use a dedicated frequency on the GPON and operate their own equipment in the exchange and the consumer's premises.

8.15 **Digital Subscriber Line (DSL).** The majority of BT's superfast broadband deployment programme to date has consisted of Very high speed DSL (VDSL) in which optical fibre is deployed to street cabinets and electronics are installed in an adjacent cabinet[90]. This approach has also been adopted by other organisations, the largest of these being South Yorkshire Digital Region[91]. Customers' existing phone lines are connected to the equipment in the cabinet and due to the shorter copper line, the broadband speeds available to the customer improve substantially. Recent Ofcom research indicates that customers' actual broadband speeds for VDSL are in the range of 32Mbit/s – 37Mbit/s[92] for services with "up to" speeds of 40Mbit/s.

8.16 The capability of VDSL technology can be further improved, and BT has stated that it intends to offer up to 80Mbit/s in the near future[93]. This will involve adjusting the frequency plan for the BT access network[94] to increase the range of frequencies that can be used by broadband services. Further enhancements are possible, which could offer some customers in excess of 100Mbit/s. Although such innovations would generally not require significant infrastructure deployment (mainly concentrated at the head-end electronics in the street cabinet and with the provision of enhanced customer modems), a combination of approaches would need to be adopted[95], each with potential drawbacks.

8.17 One approach for increasing DSL rates is known as 'vectoring' whereby the interference caused by the other copper lines in the cable is analysed and then mitigated in real-time by digital signal processing techniques. Such techniques alone could potentially double the bandwidth available for a VDSL deployment. However, to maximise the benefit of this approach all VDSL lines at a cabinet would need to be managed and controlled by a single operator, so that much of the interference that exists could be identified and eliminated[96]. This would limit access

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[90] This reduces the length of the copper access line, which previously would have been the distance between the customer's premises and the local exchange.
[91] http://www.thalesgroup.com/Press_Releases/2009-07-21_UK_PR_Official_Launch_SYDR/
[92] http://stakeholders.ofcom.org.uk/market-data-research/telecoms-research/broadband-speeds/broadband-speeds-may2011/
[93] http://www.btplc.com/Sharesandperformance/Annualreportandreview/pdf/BTGroupAnnualReport2011.pdf
[94] The ANFP – Access Network Frequency Plan
[95] http://www.alcatel-lucent.com/features/phantom/
[96] http://www.assia-inc.com/news-and-events/in-the-news/pdf/VDSL2Rescue_061510_web.pdf

to individual lines at the cabinet and restrict opportunities for competition at the cabinet (known as sub-loop unbundling).

8.18 Another approach to improving DSL line rates is employing multiple copper lines between the cabinet and the customer's premises, an approach known as 'bonding'. The practicality of this approach would depend on the amount of spare (and viable) copper lines between the cabinet and the customer, which may limit its widespread adoption. If an additional spare copper pair were available to a given customer, then a third technique ('phantom mode') might also be possible and could result in extremely high bandwidths being available to the customer if both vectoring and bonding techniques were also employed.

8.19 In summary, the continuing development of innovative approaches to maximise the bandwidth available to customers through the existing HFC and copper infrastructure offers CPs alternatives to Fibre to the Home for the provision of ultrafast broadband services to customers. However, for those customers outside Virgin's cable footprint, and far from their BT street cabinet location, these approaches will offer only limited benefit. Therefore these enhancements to existing access networks, while offering considerable broadband speed capabilities in the future for many customers, cannot be expected to address the needs of all customers, particularly those in remote rural locations.

Next generation mobile broadband

8.20 As consumer demand for mobile data increases, mobile network operators are considering the next stage in increasing the capacity of their network. With new spectrum being auctioned next year[97], it is likely that this spectrum will be used to roll out '4G' technologies, most probably Long Term Evolution (LTE). This technology has been designed to provide much faster download and upload rates, and in practice might achieve speeds approaching today's fixed broadband services. This technology has already been deployed in a number of countries in both USB dongles and handsets, and is being trialled in the UK. It could be used to provide additional capacity in mobile data networks where there is high demand.

8.21 Networks already deployed include TeliaSonera's 4G networks in Denmark, Estonia, Finland, Latvia, Lithuania, Norway and Sweden[98]. The first of these was rolled out in Stockholm in 2009, using LTE. South Korea was the first country to roll out a WiMax network (an alternative 4G technology) in 2006, with the introduction of WiBro[99]. In the USA, Clearwire has WiMAX coverage in over 70 cities[100], the first of which was launched in Portland, Oregon in 2009.

8.22 In the UK, Everything Everywhere and BT Wholesale[101] have begun a field trial of mobile broadband to 700 premises in Cornwall. This trial will use LTE technology, using BT's fixed assets in the area. It will test the use of LTE in mobile handsets as well as a means to deliver broadband to rural areas.

8.23 In a research project commissioned by Ofcom earlier this year, it was predicted that the peak data rates for 4G technologies will increase over time, from around

[97] http://stakeholders.ofcom.org.uk/consultations/combined-award/
[98] http://www.teliasonera.com/media/press-kits/4G/
[99] http://www.wibro.or.kr/new/overview01.jsp
[100] http://www.clearwire.com/company/our-company
[101] http://everythingeverywhere.com/2011/05/25/everything-everywhere-and-bt-wholesale-to-deliver-the-uk%E2%80%99s-first-live-customer-trial-of-4g-high-speed-broadband-technology/

20Mbit/s in 2011 to around 2900Mbit/s in 2020[102]. However, the report notes that the initial roll out of 4G technology will deliver only modest improvements compared to current high-end 3G networks.

Mobile data offloading

8.24 There is an ever-increasing number of data enabled mobile devices, including mobile phones and tablets. This places an increasing demand on data from mobile networks, as consumers use these devices for more bandwidth and data-hungry applications such as streaming and downloading audio and video content. Figures from Cisco[103] show that globally, mobile internet traffic has almost tripled every year for the last three years and Cisco predicts that mobile traffic will be 26 times greater in 2015 compared to 2010.

8.25 Many smartphones and tablets are able to operate on mobile data networks and on Wi-Fi networks such as those in the customer's home and public hotspots. Through offloading traffic onto Wi-Fi networks, mobile operators can reduce the demand placed on their mobile networks. Cisco estimates that around 30% of smartphone traffic is already offloaded onto fixed networks. Some MNOs encourage Wi-Fi offload by including Wi-Fi hotspot minutes as a part of their monthly contract packages. O2 is introducing a free Wi-Fi hotspot network by the end of this year, initially by installing hotspots its shops[104]. Fixed operators are also rolling out Wi-Fi hotspot networks of their own, to meet the growing consumer demand. Currently BT (through its Openzone network) and BSkyB (which bought The Cloud earlier this year[105]) own the two largest Wi-Fi hotspot networks in the UK.

8.26 Virgin Media has also recently announced plans to build a Wi-Fi network across London[106], which will provide free access to all at 0.5Mbit/s and faster access for its own broadband customers. This network will be rolled out using Virgin Media's existing infrastructure, by installing Wi-Fi hotspots on its assets such as street cabinets.

8.27 There are currently some limitations to off-loading mobile data traffic to a Wi-Fi hotspot, as mobile devices connect to each Wi-Fi hotspots individually; there is no automatic handover to an adjacent hotspot. Therefore use of Wi-Fi is largely static and not currently suitable for access to data on the move, which still relies on the mobile networks. The NICC, the industry forum that develops interoperability standards for UK public communications networks, has recently initiated a working group to consider whether more can be done to achieve a common approach to connecting to and securing Wi-Fi connections.

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[102] http://stakeholders.ofcom.org.uk/market-data-research/technology-research/2011/4G-Capacity-Gains/

[103] http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html

[104] http://www.o2.co.uk/wifi

[105] http://www.thecloud.net/about-us/News-and-PR/The%20Cloud%20Says/The%20Cloud%20to%20become%20part%20of%20the%20BSkyB%20Group.aspx

[106] http://www.telegraph.co.uk/technology/internet/8677182/Virgin-Media-to-take-a-punt-on-free-London-WiFi-network.html

Mobile voice offloading

8.28 Mobile offloading onto the fixed network is not only limited to data services. Orange uses Unlicensed Mobile Access (UMA) technology[107] in some of its handsets to allow customers to place mobile calls over a Wi-Fi network. This technology allows seamless handover of calls between a mobile and a Wi-Fi network and could potentially improve customers' ability to make calls on their mobile handset where the mobile coverage is poor, for example at home, where there is poor indoor coverage but a Wi-Fi network is present.

8.29 Another method to offload mobile voice traffic onto a fixed network is through the use of femtocells (low powered access points that are connected to the consumer's fixed broadband in the home). Voice calls made on mobile handsets are carried to the operator's network via the consumer's broadband access line. Currently only Vodafone offers this product, requiring a one off fee for the additional equipment.

8.30 Both these approaches can improve indoor coverage for mobile calls. Mobile transmitters are nearly always installed in external locations and, due to the losses when electromagnetic radiation passes through walls, indoor coverage is less good. By introducing consumer equipment inside the home, mobile coverage indoors can be improved.

Convergence between fixed and mobile networks

8.31 Both types of offloading illustrated above are examples of mobile operators offloading their data onto fixed networks, either through additional equipment at the end user premises or through equipment the customer already owns at home[108]. At the same time, owners of fixed infrastructure (both fixed and mobile network operators) are using their street-side assets to roll out Wi-Fi access points outside the home. Fixed and mobile networks are converging as mobile networks reach inside the home and fixed networks move outside the home.

8.32 With the increasing number of Wi-Fi applications and Wi-Fi access points, there is a risk of congestion in the 2.4GHz band[109]. Wi-Fi spectrum is unlicensed so the number of users cannot be managed and historically all Wi-Fi devices have been configured to use the 2.4GHz band. But, there is now additional spectrum at 5GHz and other bands may become available: for example through the use of gaps or "White Spaces" in TV spectrum[110], which can be used to meet the demand for Wi-Fi or equivalent wireless technologies. The benefit of Wi-Fi use at 2.4GHz and 5GHz is that they are globally harmonised and therefore equipment is more readily available at these bands than in others.

8.33 All forms of wireless access ultimately rely on fixed networks to backhaul traffic back onto operators' core networks. As access speeds continue to increase, this backhaul will increasingly need to rely on fibre. Access to high quality spectrum, and the wide-area coverage it offers, has been a key advantage for mobile operators in

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[107] http://shop.orange.co.uk/shop/show/offer/uma

[108] It is estimated that 75% of households already use wireless routers for broadband access at home. http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr11/internet-web/4.15

[109] In 2009, Ofcom commissioned research on the utilisation of the 2.4GHz Wi-Fi band, which concluded that the majority of problems experienced by Wi-Fi users were not spectrum related. http://stakeholders.ofcom.org.uk/market-data-research/technology-research/research/exempt/wifi/

[110] http://stakeholders.ofcom.org.uk/consultations/geolocation/statement/

the past and this is likely to remain the case for the foreseeable future. However, if the importance of short-range wireless devices operating in freely available spectrum continues to grow, the ownership of the fibre link (or other high speed fixed link) to support the increase in demand may be an increasingly powerful advantage.

White spaces

8.34 One potential source of additional spectrum is the frequencies that are not in use by the licensee all of the time and at all locations. These are called whites space spectrum (or white spaces). They occur across a wide range of frequencies, but current work is concentrating on those between 470 and 790MHz (TV white spaces). A white space device (WSD) can make use of those frequencies provided interference is not caused to the licensed users of the spectrum. In situations where the location the WSD will be used in is not known in advance of its deployment, it may be fitted with location technology (such as GPS) and, once installed, establish a connection to a central database to query which frequencies it is able to use in that particular location. This flexibility could allow white space devices to be sold in the retail market and installed by consumers (rather than professional installers).

8.35 In September 2011, Ofcom published a statement *Implementing Geolocation*, in which we outlined plans for the introduction of white space devices in the UK. This was the latest in a line of consultations intended to identify options for the use of the UHF spectrum that will become available after the migration of terrestrial television services from analogue to digital transmission.

8.36 The main attraction of using TV white spaces, as opposed to other bands, is the propagation characteristics of this spectrum, affording greater range and penetration deep into buildings. While the technology is relatively immature, a view is forming in industry on the kinds of functions that WSDs will perform. They include enhanced range wireless local area networks, wireless broadband for rural locations and machine-to-machine (M2M) communications, such as industrial telemetry and smart meter applications.

8.37 We have decided to allow WSDs to access TV white spaces on a licence exempt basis, provided they do not cause harmful interference to existing spectrum users. WSDs will identify white spaces by consulting a geo-location database of information on existing spectrum assignments. We are now taking these plans forward, developing the necessary regulatory instruments to exempt WSDs from licensing and developing detailed requirements for geo-location databases and their providers. Based on industry feedback to our recent consultation, we believe that wide scale deployment of WSDs will happen around 2013-2014.

Broadcasting

8.38 To date, increased capacity on digital terrestrial television has been achieved through two types of technology improvement, in transmission and in digital encoding.

8.39 Improvements in transmission technologies have allowed significant increases in the amount of data that can be broadcast on one radio channel. The transmission standard used on the majority of the digital terrestrial multiplexes, DVB-T, allows each multiplex to transmit 24Mbit/s. In 2009 one multiplex was converted to a next generation technology, increasing the capacity of that multiplex to 40Mbit/s. DVB-T2 is designed to work with existing roof top antennas and any significant

improvements in transmission efficiency are likely to require changes to reception antennae and consumer equipment.

8.40 Improvements in digital encoding technologies have allowed digital television channels to be transmitted with less bandwidth without a loss in quality. The original encoding technology, MPEG2, initially required around 3.5Mbit/s to encode a standard definition TV channel, but over the last ten years developments by encoder manufacturers have reduced the bandwidth required by approximately 50% without having to change the consumer's equipment. The latest encoding technology, MPEG4, achieves further reductions for standard definition channels, but is primarily used to encode high-definition channels.

8.41 Both DVB-T2 and MPEG4 require new functionality in receiver equipment. The two technologies were introduced simultaneously on digital terrestrial TV to facilitate the launch of high definition TV services. The receivers based on this technology are also capable of supporting 3D broadcasts (as recently demonstrated by the BBC with its 3D transmission from Wimbledon[111]).

8.42 Additional capacity on the digital terrestrial platform is only possible in the short term through the use of additional spectrum. In the medium term, further improvements are possible through the transition of additional multiplexes to more efficient DVB-T2 and MPEG 4 standards with the wider adoption of compatible consumer receivers, and in the longer term the adoption of further generations of more efficient standards (beyond DVB-T2 and MPEG 4).

8.43 Beyond DVB-T2, there are opportunities to increase the effective capacity of multiplexes by introducing more complex transmission technologies that utilise multiple antennas and allow the capacity of a number of multiplexes to be combined to allow more channels to be statistically multiplexed. One report commissioned by Ofcom predicts that there could be a 20% improvement in transmission capacity by 2020[112].

8.44 Beyond MEPG4, new encoding standards (such as High Efficiency Video Coding (HEVC)) are being developed which make use of increased computing power and signal processing to further reduce the bit-rate required to encode television pictures. HEVC will be particularly important in encoding 3D and Ultra High Definition channels to allow multiple channels to be carried on the platform.

8.45 Whilst improvements in MPEG4 encoding techniques can be introduced without upgrades to consumer equipment, the introduction of new transmission and encoding technologies are likely to require hardware upgrades.

[111] http://www.bbc.co.uk/blogs/aboutthebbc/2011/06/3d-for-wimbledon-the-future-of-tv.shtml
[112] This was in an Ofcom commissioned report on the developments in broadcasting beyond HDTV. http://stakeholders.ofcom.org.uk/market-data-research/technology-research/research/emerging-tech/beyondhdtv/

Annex 1

Data assumptions

Fixed networks

Fixed coverage

A1.1 Due to the requirements of the Universal Service Obligation, it was assumed that premises coverage of fixed telephone lines was 100% except where an operator provided data on premises not connected. Neither incumbent (BT and KCOM) provided any information on residential premises that could not be served.

A1.2 Broadband data –See report on fixed broadband data: http://maps.ofcom.org.uk/broadband/downloads/ofcom-uk-broadband-speed-report-2011.pdf for details on the metrics we have used.

Fixed capacity demand

A1.3 Data were collected from the four operators making up over 80% of the fixed voice market and from KCOM for Hull. This was extrapolated, based on market share, to estimate the capacity demand for 100% of the market. The number of active telephone lines and total call duration were taken from the quarterly telecommunications market data[113] submitted by operators.

A1.4 For fixed broadband, data were collected from the operators making up over 90% of the residential fixed broadband market and from KCOM for Hull. This was extrapolated based on market share to estimate the capacity demand for 100% of the market. The broadband volumes reported are for the total amount of data uploaded and downloaded in the network by residential customers and the proportion of data that was uploaded and downloaded during peak hours (6pm to midnight). The number of active broadband connections was taken from the quarterly market data submitted to Ofcom.

Mobile networks

Mobile coverage

A1.5 Data were collected from mobile operators on predicted outdoor coverage of 2G and 3G networks. A signal strength of -92dBm was used as the threshold for making 2G calls and a threshold of -100 dBm (CPICH[114]) for 3G[115]. One operator did not provide data relating to a -92dBm threshold for 2G, but used instead a threshold of -94dBm. Similarly, for 3G, one operator did not provide data relating to -100 dBm for 3G. This operator provided two levels of coverage and we have used the more conservative (i.e. lower coverage value). The majority of the operators provided signal strength prediction with 90% confidence levels: e.g. where they

[113] http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/tables/q1_2011/

[114] Common Pilot Channel

[115] These thresholds are consistent with those used in Ofcom's Communications Market Reports. We are doing further research into how these thresholds relate to consumer experience, such as whether phone calls can be made.

predict a certain signal level, they are 90% confident that when measured in the field the signal will be equal to or stronger than the predicted signal (in 10% of cases the signal will fall below the predicted level).

A1.6 Geographic coverage has been calculated by assessing the percentage of land area in each local authority that is served by zero, one, two, three, four (and five for 3G) operators. While some local authority areas extend into river estuaries and sea inlets, the data were trimmed to the coastline to provide an accurate measure of land coverage. Analysis was based on aggregating 200mx200m grid squares, with each square deemed served or not served by each operator based on the predicted signal strength for the centre of that square.

A1.7 Premises coverage has been calculated by overlaying the location of each postal delivery address in Great Britain (aggregated into 200mx200m grid squares) with the predicted outdoor coverage of each 2G and 3G operator. The proportion of premises served by zero, one, two, three, four (and five for 3G) operators was then calculated. For Northern Ireland, we did not hold data on the location of individual premises, so coverage was based on postcodes' centres (if the centre of the postcode was served, we have assumed that all premises in the postcode were served). Data have been aggregated up to county/unitary authority level.

A1.8 It should be noted that the methodology used differs from that used for our annual Communications Market Report (CMR). The CMR assesses coverage based on postcode district areas and assumes an entire postcode district is not served unless the operator has at least 90% geographic coverage or more. The difference in methodology means that the data presented in this report and that presented in the CMR are not directly comparable.

Mobile capacity demand

A1.9 Data were gathered from all four network operators relating to voice and data traffic throughput at the level of postcode district. The figures represented the number and duration of voice calls and the data throughput of both their operator's customers and their wholesale customers. Therefore the data collected represent 100% of the mobile market. Some operators reported on the calls originating on their networks and others reported on all the calls on their network. A common metric was established by estimating the number of originating calls from those operators who reported on all calls on their network. The numbers of active connections were taken from the quarterly telecommunications market data submitted by providers, excluding the connections used for mobile broadband dongles.

A1.10 The total demand for each local authority area was calculated by aggregating the demand in each postcode district falling within the local authority area. Where a postcode district fell into two or more local authority areas, the total demand in that postcode was divided proportionally, according to the proportion of households in each local authority area. The data on the number of active 3G connections was taken from the market data submitted by operators and it includes active connections for mobile broadband dongles.

Mobile infrastructure

A1.11 Using the geographical data submitted by the mobile operators we were able to calculate the total number of base station sites in each local authority area. This figure does not account for any locations that are shared between two or more operators. The total location figure was then divided by the household population in

the local authority, to give a value of the number of base stations per 100,000 households.

A1.12 The population density of each local authority was calculated using the household population and geographical area for each local authority (except for Northern Ireland where this information was not available). These were then ranked from the least dense region to the most densely populated area. The data for the local authorities was grouped into tenth percentiles.

Broadcast networks

Digital Terrestrial Television

A1.13 As the Public Service Broadcasting (PSB) multiplexes and the commercial multiplexes have different network coverage, these data report the coverage of the three PSB multiplexes and the six DTT multiplexes. We report on the coverage in June 2011 (during the process of digital switchover) and the coverage of DTT services once digital switchover is completed.

A1.14 The capacity of the services is based on the transmission technology currently in use.

Digital radio

A1.15 This report focuses on Digital Audio Broadcast (DAB) as the technology for digital radio services. There are two national DAB networks and the metrics of household and road coverage of each provide data on coverage in areas where radio broadcasts are most likely to be listened to.

A1.16 The total capacity of the networks is based on the current transmission technology.

Annex 2

Coverage data

Figure A-1: 2G Mobile coverage data

This table has been removed as part of the December 2012 amendment (see paragraph 1.16).

The table is available for download at:

http://maps.ofcom.org.uk/mobile-services/mobile-services-map-2011/

Figure A-2: 3G Mobile coverage data

This table has been removed as part of the December 2012 amendment (see paragraph 1.16).

The table is available for download at:

http://maps.ofcom.org.uk/mobile-services/mobile-services-map-2011/

Figure A-3: DAB Digital Radio National Multiplexes

Local Authority	BBC household coverage	BBC road coverage	Commercial household coverage	Commercial road coverage
Aberdeen City	96%	98%	65%	83%
Aberdeenshire	83%	69%	37%	37%
Angus	77%	69%	93%	95%
Antrim	94%	81%	0%	0%
Ards	40%	18%	0%	0%
Argyll & Bute	56%	22%	35%	12%
Armagh	90%	82%	0%	0%
Ballymena	91%	79%	0%	0%
Ballymoney	89%	95%	0%	0%
Banbridge	60%	56%	0%	0%
Barnsley	99%	89%	89%	80%
Bath and North East Somerset	98%	91%	98%	92%
Bedford	100%	96%	100%	97%
Belfast	99%	97%	0%	0%
Birmingham	99%	95%	99%	97%
Blackburn with Darwen	94%	94%	90%	91%
Blackpool	99%	98%	98%	93%
Blaenau Gwent	89%	95%	1%	1%
Bolton	100%	100%	100%	99%
Bournemouth	100%	97%	92%	79%
Bracknell Forest	76%	96%	100%	98%
Bradford	98%	96%	94%	93%
Bridgend	79%	73%	58%	55%
Brighton and Hove	98%	96%	97%	97%
Bristol, City of	99%	97%	100%	99%
Buckinghamshire County	88%	84%	94%	88%
Bury	100%	99%	95%	88%
Caerphilly	94%	99%	26%	35%
Calderdale	74%	62%	72%	60%
Cambridgeshire County	96%	86%	97%	84%
Cardiff	100%	100%	100%	99%
Carmarthenshire	63%	54%	49%	42%
Carrickfergus	87%	72%	0%	0%
Castlereagh	98%	79%	0%	0%
Central Bedfordshire	99%	95%	100%	97%
Ceredigion	56%	45%	38%	30%
Cheshire East	98%	96%	98%	97%
Cheshire West and Chester	99%	100%	99%	99%
Clackmannanshire	74%	89%	67%	88%
Coleraine	95%	89%	0%	0%

Local Authority	BBC household coverage	BBC road coverage	Commercial household coverage	Commercial road coverage
Conwy	61%	21%	48%	18%
Cookstown	71%	62%	0%	0%
Cornwall	77%	88%	55%	68%
County Durham	82%	75%	78%	66%
Coventry	97%	94%	100%	100%
Craigavon	100%	98%	0%	0%
Cumbria County	83%	56%	66%	46%
Darlington	93%	94%	92%	92%
Denbighshire	92%	80%	72%	45%
Derby	88%	88%	97%	100%
Derbyshire County	81%	68%	80%	64%
Derry	98%	98%	0%	0%
Devon County	79%	79%	66%	62%
Doncaster	98%	99%	95%	92%
Dorset County	73%	59%	63%	57%
Down	23%	8%	0%	0%
Dudley	99%	95%	99%	96%
Dumfries & Galloway	72%	36%	9%	6%
Dundee City	100%	96%	90%	95%
Dungannon	87%	87%	0%	0%
East Ayrshire	85%	81%	79%	72%
East Dunbartonshire	95%	95%	91%	96%
East Lothian	99%	100%	88%	98%
East Renfrewshire	91%	97%	88%	82%
East Riding of Yorkshire	94%	83%	83%	63%
East Sussex County	90%	92%	90%	91%
Edinburgh, City of	99%	100%	99%	100%
Essex County	90%	91%	95%	93%
Falkirk	93%	100%	94%	100%
Fermanagh	60%	61%	0%	0%
Fife	98%	97%	95%	98%
Flintshire	87%	63%	76%	50%
Gateshead	98%	100%	97%	98%
Glasgow City	86%	100%	82%	100%
Gloucestershire County	87%	75%	86%	71%
Greater London Authority	98%	99%	100%	99%
Gwynedd	72%	50%	46%	32%
Halton	100%	100%	100%	99%
Hampshire County	89%	92%	92%	86%
Hartlepool	97%	79%	85%	36%
Herefordshire, County of	84%	56%	80%	61%
Hertfordshire County	87%	80%	97%	87%

Local Authority	BBC household coverage	BBC road coverage	Commercial household coverage	Commercial road coverage
Highland	71%	26%	50%	13%
Inverclyde	94%	95%	84%	71%
Isle of Anglesey	78%	71%	56%	48%
Isle of Wight	80%	63%	77%	69%
Isles of Scilly	0%	1%	0%	0%
Kent County	90%	90%	79%	76%
Kingston upon Hull, City of	99%	96%	92%	55%
Kirklees	96%	89%	97%	90%
Knowsley	99%	96%	100%	97%
Lancashire County	95%	89%	92%	91%
Larne	66%	14%	0%	0%
Leeds	99%	95%	97%	91%
Leicester	88%	82%	100%	99%
Leicestershire County	95%	81%	99%	94%
Limavady	96%	95%	0%	0%
Lincolnshire County	86%	72%	85%	66%
Lisburn	98%	86%	0%	0%
Liverpool	98%	98%	100%	99%
Luton	97%	87%	99%	98%
Magherafelt	75%	72%	0%	0%
Manchester	100%	100%	100%	100%
Medway	94%	97%	78%	77%
Merthyr Tydfil	57%	65%	9%	15%
Middlesbrough	100%	100%	97%	94%
Midlothian	85%	96%	78%	65%
Milton Keynes	97%	97%	99%	98%
Monmouthshire	83%	72%	47%	44%
Moray	48%	50%	20%	28%
Moyle	31%	23%	0%	0%
Na h-Eileanan an Iar	49%	37%	0%	0%
Neath Port Talbot	79%	63%	64%	44%
Newcastle upon Tyne	98%	99%	92%	95%
Newport	100%	99%	99%	99%
Newry And Mourne	8%	4%	0%	0%
Newtownabbey	90%	80%	0%	0%
Norfolk County	71%	41%	64%	39%
North Ayrshire	73%	82%	47%	62%
North Down	37%	30%	0%	0%
North East Lincolnshire	97%	88%	95%	74%
North Lanarkshire	98%	99%	96%	99%
North Lincolnshire	94%	89%	71%	49%
North Somerset	96%	91%	95%	82%

Local Authority	BBC household coverage	BBC road coverage	Commercial household coverage	Commercial road coverage
North Tyneside	92%	87%	79%	61%
North Yorkshire County	84%	75%	83%	76%
Northamptonshire County	95%	89%	95%	85%
Northumberland	76%	60%	41%	35%
Nottingham	100%	100%	100%	100%
Nottinghamshire County	94%	97%	98%	95%
Oldham	91%	65%	91%	75%
Omagh	82%	94%	0%	0%
Orkney Islands	77%	63%	0%	0%
Oxfordshire County	90%	71%	92%	74%
Pembrokeshire	32%	29%	15%	17%
Perth & Kinross	86%	60%	81%	60%
Peterborough	99%	96%	99%	96%
Plymouth	98%	99%	90%	96%
Poole	100%	94%	97%	82%
Portsmouth	91%	99%	86%	83%
Powys	20%	12%	3%	2%
Reading	99%	100%	100%	100%
Redcar and Cleveland	94%	80%	71%	75%
Renfrewshire	97%	90%	96%	91%
Rhondda Cynon Taf	75%	80%	26%	37%
Rochdale	99%	88%	93%	89%
Rotherham	100%	98%	95%	92%
Rutland	91%	71%	87%	47%
Salford	100%	100%	100%	100%
Sandwell	100%	99%	100%	100%
Scottish Borders	58%	61%	46%	51%
Sefton	98%	100%	100%	100%
Sheffield	97%	89%	95%	87%
Shetland Islands	0%	0%	0%	0%
Shropshire	81%	71%	77%	60%
Slough	99%	100%	100%	100%
Solihull	99%	94%	99%	97%
Somerset County	80%	72%	75%	66%
South Ayrshire	71%	68%	34%	35%
South Gloucestershire	97%	86%	93%	81%
South Lanarkshire	94%	66%	90%	62%
South Tyneside	97%	95%	88%	67%
Southampton	98%	100%	98%	100%
Southend-on-Sea	91%	100%	97%	100%
St. Helens	98%	91%	98%	90%
Staffordshire County	92%	83%	95%	88%

Local Authority	BBC household coverage	BBC road coverage	Commercial household coverage	Commercial road coverage
Stirling	55%	52%	51%	51%
Stockport	98%	99%	99%	99%
Stockton-on-Tees	99%	99%	96%	89%
Stoke-on-Trent	96%	94%	92%	89%
Strabane	73%	100%	0%	0%
Suffolk County	74%	54%	57%	45%
Sunderland	78%	81%	89%	76%
Surrey County	93%	95%	97%	97%
Swansea	91%	77%	94%	83%
Swindon	99%	84%	98%	72%
Tameside	91%	85%	92%	88%
Telford and Wrekin	96%	84%	98%	90%
The Vale of Glamorgan	99%	97%	97%	93%
Thurrock	100%	100%	100%	100%
Torbay	83%	69%	82%	68%
Torfaen	80%	53%	80%	58%
Trafford	100%	100%	100%	100%
Wakefield	100%	99%	100%	99%
Walsall	100%	100%	100%	100%
Warrington	98%	100%	100%	100%
Warwickshire County	95%	90%	97%	93%
West Berkshire	98%	88%	83%	56%
West Dunbartonshire	99%	97%	72%	84%
West Lothian	99%	100%	99%	100%
West Sussex County	92%	94%	90%	89%
Wigan	99%	98%	99%	98%
Wiltshire	92%	85%	83%	72%
Windsor and Maidenhead	90%	100%	99%	100%
Wirral	97%	92%	100%	98%
Wokingham	84%	97%	100%	100%
Wolverhampton	96%	76%	98%	83%
Worcestershire County	97%	89%	96%	87%
Wrexham	63%	56%	86%	64%
York	98%	96%	93%	80%

Figure A-4: Digital Terrestrial Television

Local Authority	PSB channels (June 2011)	All channels (June 2011)	PSB channels (Nov 2012)	PSB channels (Nov 2012)
Aberdeen City	100%	95%	100%	94%
Aberdeenshire	97%	61%	97%	57%
Angus	99%	99%	99%	99%
Antrim	97%	96%	100%	100%
Ards	67%	59%	99%	85%
Argyll & Bute	90%	54%	91%	55%
Armagh	41%	27%	98%	87%
Ballymena	34%	31%	99%	97%
Ballymoney	52%	28%	99%	99%
Banbridge	58%	30%	99%	90%
Barnsley	99%	96%	100%	100%
Bath and North East Somerset	100%	21%	100%	92%
Bedford	100%	0%	100%	100%
Belfast	97%	97%	100%	97%
Birmingham	97%	94%	100%	100%
Blackburn with Darwen	99%	88%	99%	93%
Blackpool	99%	99%	99%	99%
Blaenau Gwent	100%	4%	100%	9%
Bolton	100%	100%	100%	100%
Bournemouth	66%	51%	100%	95%
Bracknell Forest	64%	25%	100%	86%
Bradford	87%	75%	100%	95%
Bridgend	100%	80%	100%	78%
Brighton and Hove	83%	73%	100%	90%
Bristol, City of	100%	86%	100%	98%
Buckinghamshire County	81%	63%	98%	83%
Bury	100%	92%	100%	96%
Caerphilly	100%	53%	100%	55%
Calderdale	76%	72%	100%	85%
Cambridgeshire County	100%	11%	100%	100%
Cardiff	100%	100%	100%	100%
Carmarthenshire	98%	86%	98%	86%
Carrickfergus	64%	43%	100%	84%
Castlereagh	100%	99%	100%	100%
Central Bedfordshire	100%	6%	99%	96%
Ceredigion	95%	78%	93%	70%
Cheshire East	100%	97%	100%	99%
Cheshire West and Chester	100%	98%	100%	100%
Clackmannanshire	100%	99%	100%	99%
Coleraine	56%	23%	100%	96%

Local Authority	PSB channels (June 2011)	All channels (June 2011)	PSB channels (Nov 2012)	PSB channels (Nov 2012)
Conwy	95%	69%	95%	71%
Cookstown	44%	34%	99%	80%
Cornwall	98%	85%	98%	81%
County Durham	90%	86%	100%	97%
Coventry	80%	54%	100%	98%
Craigavon	89%	81%	100%	99%
Cumbria County	98%	63%	98%	63%
Darlington	100%	100%	100%	100%
Denbighshire	93%	79%	92%	82%
Derby	97%	96%	100%	100%
Derbyshire County	70%	52%	100%	82%
Derry	32%	22%	99%	62%
Devon County	98%	70%	98%	72%
Doncaster	99%	94%	100%	100%
Dorset County	69%	19%	97%	71%
Down	44%	38%	97%	66%
Dudley	99%	85%	100%	99%
Dumfries & Galloway	97%	47%	97%	53%
Dundee City	100%	95%	100%	95%
Dungannon	46%	26%	96%	78%
East Ayrshire	100%	92%	100%	87%
East Dunbartonshire	100%	100%	100%	100%
East Lothian	100%	99%	100%	99%
East Renfrewshire	100%	99%	100%	99%
East Riding of Yorkshire	81%	46%	95%	91%
East Sussex County	33%	29%	96%	76%
Edinburgh, City of	100%	100%	100%	100%
Essex County	40%	23%	98%	86%
Falkirk	100%	100%	100%	100%
Fermanagh	50%	50%	96%	51%
Fife	100%	97%	100%	97%
Flintshire	100%	96%	100%	99%
Gateshead	97%	94%	100%	100%
Glasgow City	100%	100%	100%	100%
Gloucestershire County	97%	72%	99%	89%
Greater London Authority	97%	94%	100%	99%
Gwynedd	94%	42%	94%	42%
Halton	100%	100%	100%	100%
Hampshire County	62%	58%	100%	94%
Hartlepool	100%	96%	100%	100%
Herefordshire, County of	98%	90%	98%	93%
Hertfordshire County	93%	54%	100%	96%

Local Authority	PSB channels (June 2011)	All channels (June 2011)	PSB channels (Nov 2012)	PSB channels (Nov 2012)
Highland	93%	68%	93%	68%
Inverclyde	100%	92%	100%	92%
Isle of Anglesey	96%	64%	96%	66%
Isle of Wight	64%	62%	96%	85%
Isles of Scilly	95%	0%	88%	0%
Kent County	57%	51%	99%	88%
Kingston upon Hull, City of	97%	77%	100%	100%
Kirklees	97%	95%	100%	99%
Knowsley	100%	100%	100%	100%
Lancashire County	98%	94%	99%	95%
Larne	8%	2%	98%	27%
Leeds	95%	92%	100%	98%
Leicester	92%	91%	100%	100%
Leicestershire County	95%	87%	100%	99%
Limavady	90%	86%	100%	95%
Lincolnshire County	97%	81%	100%	100%
Lisburn	93%	91%	100%	98%
Liverpool	100%	100%	100%	100%
Luton	100%	4%	99%	91%
Magherafelt	81%	69%	100%	91%
Manchester	100%	100%	100%	100%
Medway	49%	47%	100%	85%
Merthyr Tydfil	100%	24%	100%	24%
Middlesbrough	100%	100%	100%	100%
Midlothian	100%	81%	100%	81%
Milton Keynes	100%	3%	100%	99%
Monmouthshire	98%	54%	97%	72%
Moray	98%	95%	98%	95%
Moyle	13%	2%	95%	37%
Na h-Eileanan an Iar	92%	64%	92%	64%
Neath Port Talbot	100%	70%	100%	70%
Newcastle upon Tyne	100%	100%	100%	100%
Newport	100%	91%	100%	99%
Newry And Mourne	15%	6%	88%	44%
Newtownabbey	43%	39%	100%	57%
Norfolk County	79%	57%	97%	86%
North Ayrshire	97%	67%	98%	50%
North Down	77%	63%	100%	95%
North East Lincolnshire	99%	65%	100%	100%
North Lanarkshire	100%	100%	100%	100%
North Lincolnshire	96%	81%	100%	99%
North Somerset	100%	83%	100%	99%

Local Authority	PSB channels (June 2011)	All channels (June 2011)	PSB channels (Nov 2012)	PSB channels (Nov 2012)
North Tyneside	98%	97%	100%	99%
North Yorkshire County	81%	73%	99%	89%
Northamptonshire County	96%	7%	100%	91%
Northumberland	86%	81%	99%	87%
Nottingham	98%	72%	100%	100%
Nottinghamshire County	88%	69%	100%	99%
Oldham	99%	97%	99%	98%
Omagh	60%	60%	98%	60%
Orkney Islands	95%	90%	95%	90%
Oxfordshire County	93%	83%	99%	95%
Pembrokeshire	96%	46%	96%	46%
Perth & Kinross	97%	58%	97%	58%
Peterborough	100%	41%	100%	99%
Plymouth	100%	99%	100%	99%
Poole	38%	11%	100%	65%
Portsmouth	69%	69%	100%	97%
Powys	91%	3%	90%	9%
Reading	90%	85%	100%	99%
Redcar and Cleveland	82%	67%	100%	90%
Renfrewshire	100%	99%	100%	99%
Rhondda Cynon Taf	100%	68%	100%	68%
Rochdale	100%	94%	100%	97%
Rotherham	95%	88%	100%	100%
Rutland	99%	79%	100%	99%
Salford	100%	100%	100%	100%
Sandwell	99%	96%	100%	100%
Scottish Borders	96%	63%	96%	63%
Sefton	100%	100%	100%	100%
Sheffield	93%	83%	100%	99%
Shetland Islands	84%	49%	84%	49%
Shropshire	98%	27%	99%	90%
Slough	96%	96%	100%	100%
Solihull	93%	85%	100%	100%
Somerset County	100%	50%	100%	96%
South Ayrshire	99%	81%	99%	78%
South Gloucestershire	100%	72%	100%	99%
South Lanarkshire	100%	99%	100%	99%
South Tyneside	100%	100%	100%	100%
Southampton	80%	79%	100%	100%
Southend-on-Sea	24%	8%	100%	72%
St. Helens	100%	100%	100%	100%
Staffordshire County	96%	72%	100%	98%

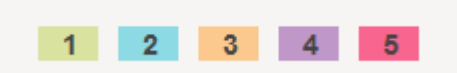
Local Authority	PSB channels (June 2011)	All channels (June 2011)	PSB channels (Nov 2012)	PSB channels (Nov 2012)
Stirling	98%	88%	98%	85%
Stockport	100%	98%	100%	99%
Stockton-on-Tees	100%	100%	100%	100%
Stoke-on-Trent	97%	84%	100%	99%
Strabane	1%	1%	98%	2%
Suffolk County	40%	22%	95%	77%
Sunderland	88%	87%	100%	99%
Surrey County	86%	79%	100%	96%
Swansea	100%	94%	100%	94%
Swindon	98%	23%	98%	88%
Tameside	99%	95%	99%	96%
Telford and Wrekin	100%	68%	100%	100%
The Vale of Glamorgan	100%	99%	100%	100%
Thurrock	87%	85%	100%	100%
Torbay	99%	92%	99%	91%
Torfaen	100%	71%	99%	94%
Trafford	100%	100%	100%	100%
Wakefield	100%	100%	100%	100%
Walsall	100%	100%	100%	100%
Warrington	100%	100%	100%	100%
Warwickshire County	88%	55%	100%	99%
West Berkshire	97%	96%	99%	97%
West Dunbartonshire	100%	76%	100%	79%
West Lothian	100%	100%	100%	100%
West Sussex County	49%	22%	100%	80%
Wigan	100%	100%	100%	100%
Wiltshire	95%	19%	99%	93%
Windsor and Maidenhead	92%	87%	100%	99%
Wirral	100%	100%	100%	100%
Wokingham	76%	56%	100%	91%
Wolverhampton	100%	64%	100%	100%
Worcestershire County	96%	62%	100%	98%
Wrexham	99%	60%	100%	96%
York	97%	93%	100%	100%

Annex 3

Coverage maps

Key

For the maps in this annex the colours represent different levels of coverage. Five bands of coverage of used, represented by colours and the value 1 through to 5.



Premises coverage maps

1 represents a coverage of 95% or more
2 represents a coverage of between 90% up to 95%
3 represents a coverage of between 80% up to 90%
4 represents a coverage of between 60% up to 80%
5 represents a coverage of less than 60%

Geographic area coverage maps (for mobile networks)

1 represents a coverage of 90% or more
2 represents a coverage of between 70% up to 90%
3 represents a coverage of between 50% up to 70%
4 represents a coverage of between 25% up to 50%
5 represents a coverage of less than 25%

Premises coverage maps (for DTT and DAB networks)

1 represents a coverage of 98% or more
2 represents a coverage of between 95% up to 98%
3 represents a coverage of between 90% up to 95%
4 represents a coverage of between 70% up to 90%
5 represents a coverage of less than 70%

Interactive versions of the maps are available on our website at http://maps.ofcom.org.uk

Figure A-5: 2G coverage by premises

This map has been removed as part of the December 2012 amendment (see paragraph 1.16).

The map is available for at:

http://maps.ofcom.org.uk/mobile-services/mobile-services-map-2011/

Figure A-6: 2G coverage by geographic area

This map has been removed as part of the December 2012 amendment (see paragraph 1.16).

The map is available for at:

http://maps.ofcom.org.uk/mobile-services/mobile-services-map-2011/

Figure A-7: 3G coverage by premises

This map has been removed as part of the December 2012 amendment (see paragraph 1.16).

The map is available for at:

http://maps.ofcom.org.uk/mobile-services/mobile-services-map-2011/

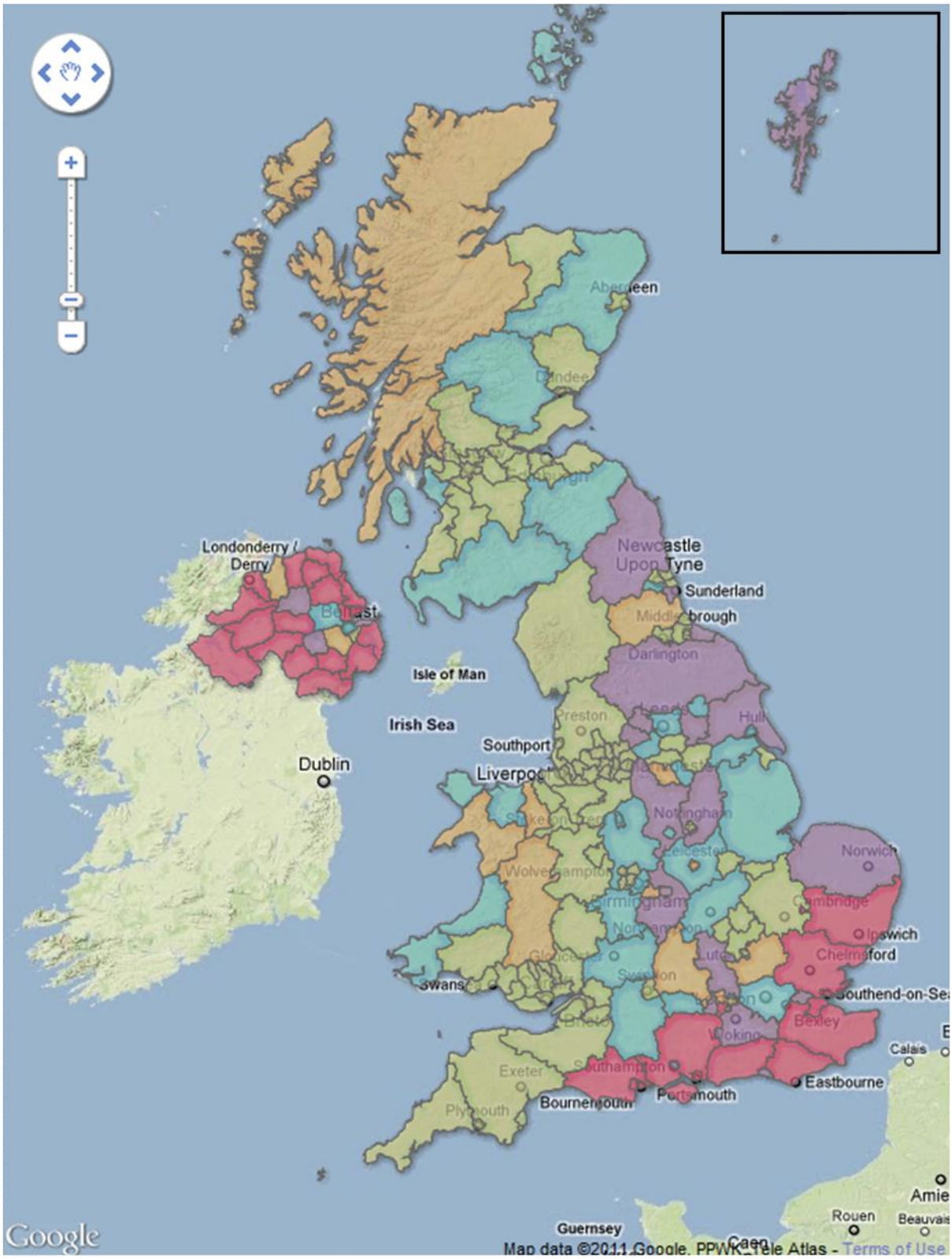
Figure A-8: 3G coverage by geographic area

This map has been removed as part of the December 2012 amendment (see paragraph 1.16).

The map is available for at:

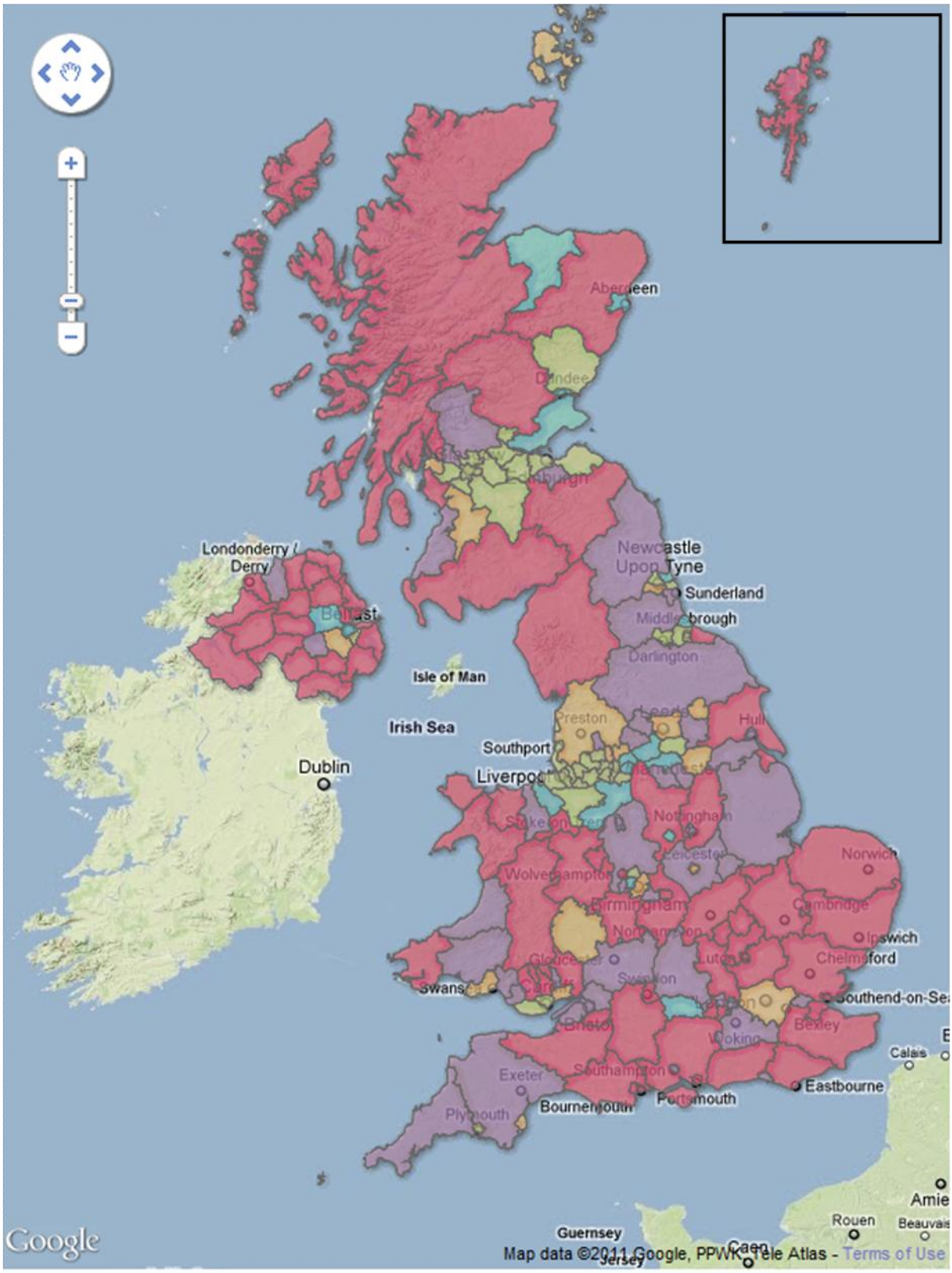
http://maps.ofcom.org.uk/mobile-services/mobile-services-map-2011/

Figure A-9: Digital terrestrial television coverage (PSB channels) June 2011



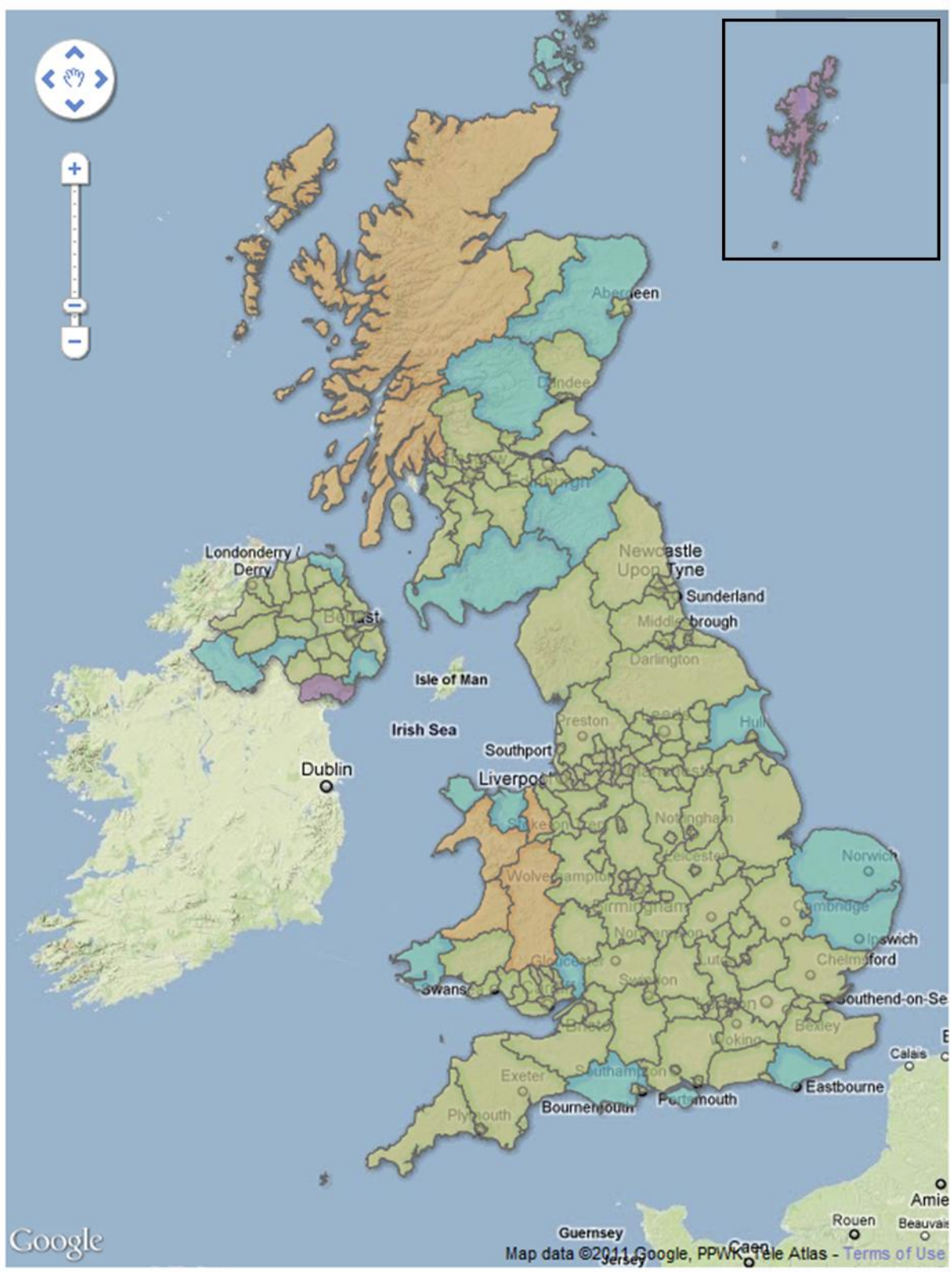
Map data copyright of Google 2011, PPWK and TeleAtlas 2011

Figure A-10: Digital terrestrial television coverage (All channels) June 2011



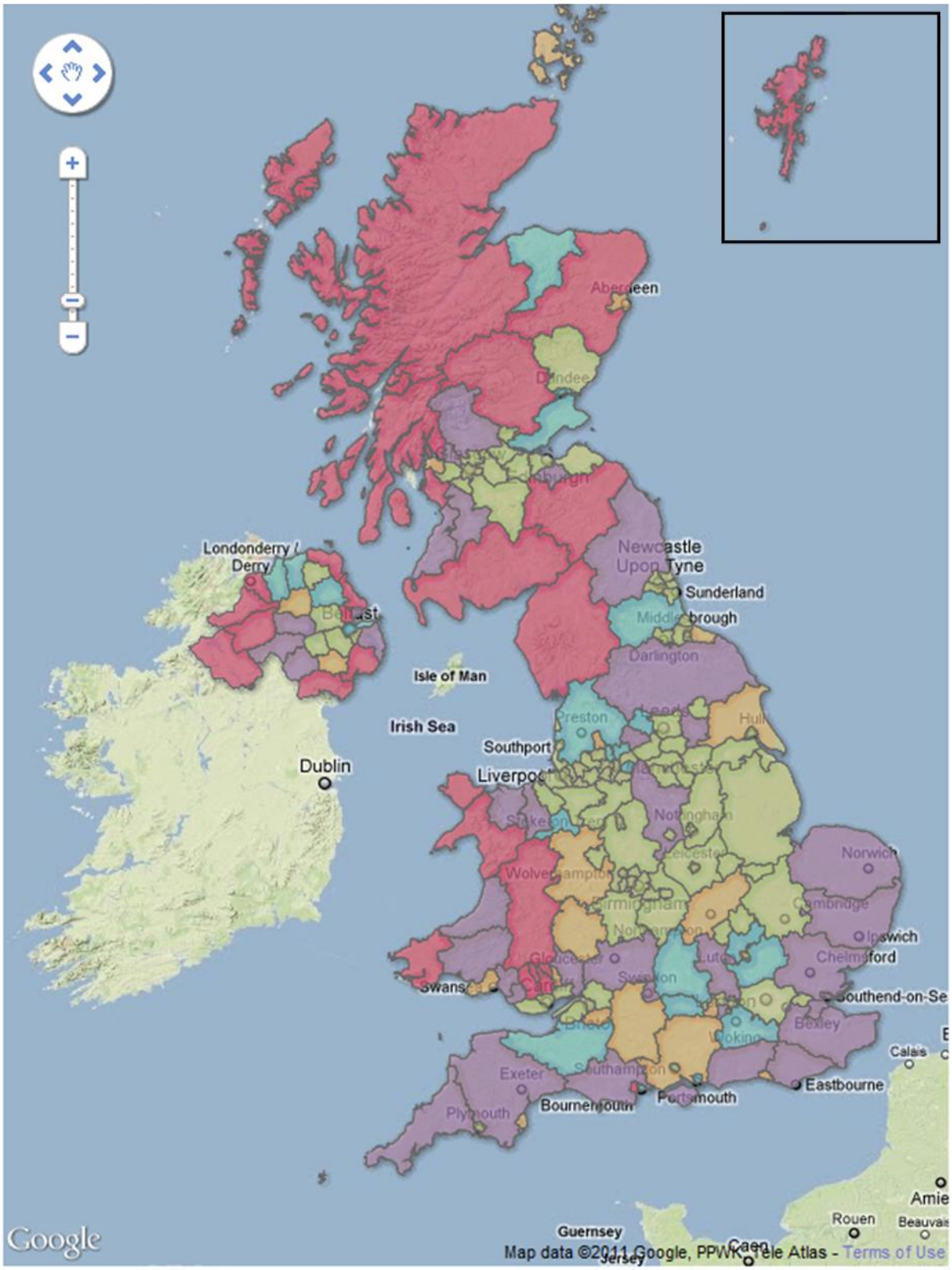
Map data copyright of Google 2011, PPWK and TeleAtlas 2011

Figure A-11: Digital terrestrial television coverage (PSB channels) November 2012



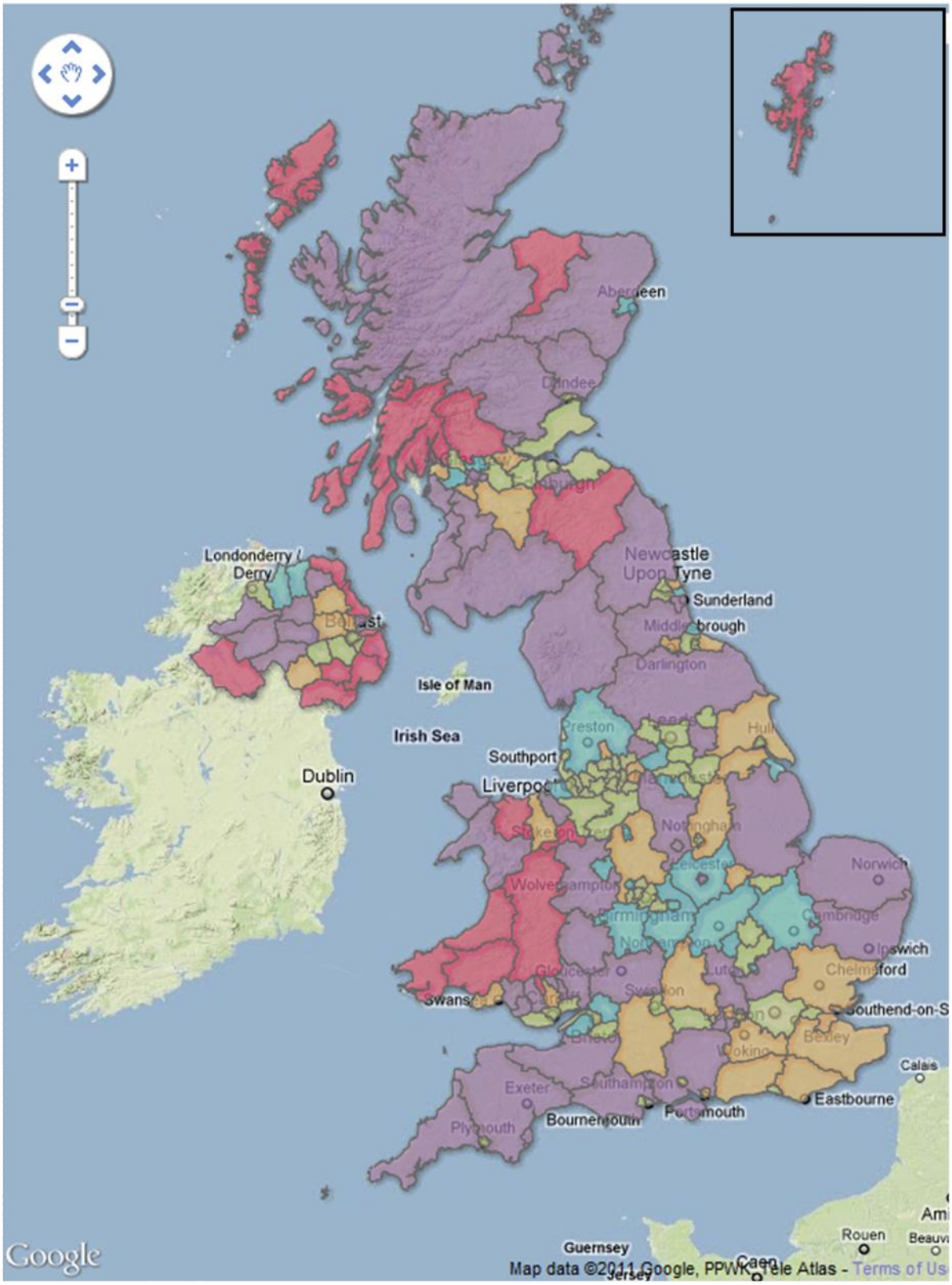
Map data copyright of Google 2011, PPWK and TeleAtlas 2011

Figure A-12: Digital terrestrial television coverage (All channels) November 2012



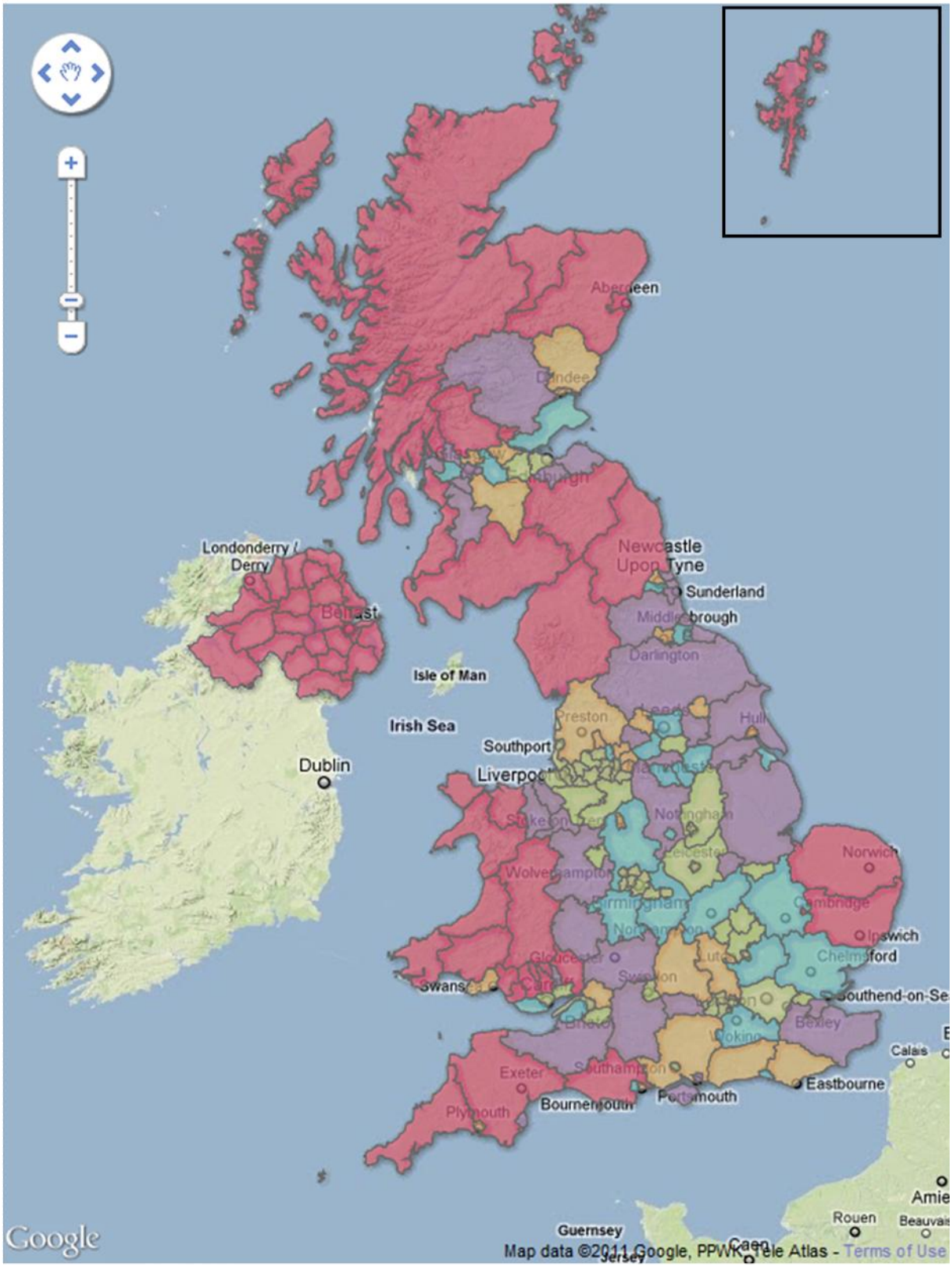
Map data copyright of Google 2011, PPWK and TeleAtlas 2011

Figure A-13: Digital radio BBC national multiplex coverage



Map data copyright of Google 2011, PPWK and TeleAtlas 2011

Figure A-14: Digital radio commercial national multiplex coverage



Map data copyright of Google 2011, PPWK and TeleAtlas 2011

Annex 4

Glossary

2G Second generation of mobile telephony systems. Uses digital transmission to support voice, low-speed data communications, and short messaging services.

3G Third generation of mobile systems. Provides high-speed data transmission and supports multi-media applications such as video, audio and internet access, alongside conventional voice services.

4G Fourth generation of mobile systems. It is designed to provide faster data download and upload speeds on mobile networks.

3DTV Three-dimensional television. A television viewing system whereby a 3D effect is created for the viewer. The 3D image is generated by a 'left' and a 'right' image and which is filtered for each eye.

Access network An electronic communications network which connects end-users to a service provider; running from the end-user's premises to a local access node and supporting the provision of access-based services. It is sometimes referred to as the 'local loop' or the 'last mile'.

ADSL Asymmetric Digital Subscriber Line. A digital technology that allows the use of a standard telephone line to provide high-speed data communications. Allows higher speeds in one direction ('downstream' towards the customer) than the other.

Backhaul The part of the communications network which connects the local exchange to the ISP's core network

Base station This is the active equipment installed at a mobile transmitter site. The equipment installed determines the types of access technology which are used at that site.

Bit-rates The rate at which digital information is carried within a specified communications channel.

Bonding A technique which could be used in DSL networks to improve data speeds by using multiple copper lines between the cabinet and the customer's premises.

Broadband A service or connection generally defined as being 'always on' and providing a bandwidth greater than narrowband.

Core network The central part of any network aggregating traffic from multiple backhaul and access networks.

DAB Digital Audio Broadcasting. A set of internationally accepted standards for the technology by which terrestrial digital radio multiplex services are broadcast in the UK.

Data packet In networking, the smallest unit of information transmitted as a discrete entity from one node on the network to another.

DCMS Department for Culture, Media and Sport.

Digital radio See DAB

Digital switchover The process of switching over the analogue television or radio broadcasting system to digital.

DOCSIS Data Over Cable Service Interface Specification. It is a standard for the high speed transmission of data over cable networks.

DSL Digital Subscriber Line. A family of technologies generally referred to as DSL, or xDSL, capable of transforming ordinary phone lines (also known as 'twisted copper pairs') into high-speed digital lines, capable of supporting advanced services such as fast internet access and video on demand. ADSL and VDSL (very high speed digital subscriber line) are variants of xDSL).

DTT Digital Terrestrial Television. The television technology that carries the Freeview service.

DVB Digital Video Broadcasting. A set of internationally accepted open standards for digital broadcasting, including standards for distribution by satellite, cable, radio and hand-held devices (the latter known as DVB-H). The DVB project develops the standards.

DVB-T2 The latest digital terrestrial transmission technology developed by DVB. The technology is being used to facilitate the introduction of HDTV on DTT in the UK. DVB-S2 (satellite) and DVB-C2 (cable) are also available.

EDGE Enhanced Data Rates for GSM Evolution. This is a protocol designed to provide faster data speeds on GSM networks.

FTTC Fibre to the Cabinet. Access network consisting of optical fibre extending from the access node to the street cabinet. The street cabinet is usually located only a few hundred metres from the subscribers' premises. The remaining segment of the access network from the cabinet to the customer is usually a copper pair.

FTTH Fibre to the Home. A form of fibre optic communication delivery in which the optical signal reaches the end user's home.

Free to air Broadcast content that people can watch or listen to without having to pay a subscription.

GPON Gigabit Passive Optical Network. A point to multipoint network (as opposed to a point to point network), where a single optical fibre is used to serve multiple premises using passive splitters at higher speeds.

GPRS General Packet Radio Service. A packet data service designed as an improvement to 2G networks.

GSM Global Standard for Mobile telephony. This is the standard used for 2G mobile systems.

HDTV High-definition Television. A technology that provides viewers with better quality, high resolution pictures.

Headline connection speed The theoretical maximum data speed that can be achieved by a given broadband line. A number of factors, such as the quality and length of the physical line from the exchange to the customer, mean that a given customer may not experience this headline speed in practice.

HFC Hybrid Fibre Coaxial. A combined optical fibre and coaxial cable (a cable made up of a conductor and a tubular insulating layer) commonly used in cable networks.

HSPA High Speed Packet Access. This is a technology standard for 3G mobile networks to support faster upload and download speeds for data. The downstream variant is called High Speed Downlink Packet Access (HSDPA) and the upstream variant is High Speed Uplink Packet Access (HSUPA).

IP Internet Protocol. This is the packet data protocol used for routing and carrying data across the internet and similar networks.

L-band A range of frequencies within which an allocation has been made in much of the world for broadcasting (1452 to 1492 MHz), generally by satellite, but in Europe the range 1452 to 1480 MHz is made available for terrestrial digital sound broadcasting. Some DAB digital radio receivers can tune to this range.

Leased lines A transmission facility which is leased by an end user from a public carrier, and which is dedicated to that user's traffic.

LLU Local Loop Unbundling. LLU is the process where incumbent operators (in the UK this is BT and KCom) make their local network (the lines that run from the customers' premises to the telephone exchange) available to other communications providers. The process requires the competitor to deploy its own equipment in the incumbent's local exchange and to establish a backhaul connection between this equipment and its core network.

LTE Long Term Evolution. This is a 4G technology which is designed to provide faster upload and downloads speeds for data on mobile networks.

MNO Mobile Network Operator, a provider who owns a cellular mobile network.

Mobile Broadband Various types of wireless, high speed internet access through a mobile telephone or a mobile data dongle.

MPEG Moving Picture Experts Group. A set of international standards for compression and transmission of digital audio-visual content. Most digital television services in the UK use MPEG2 but MPEG4 offers greater efficiently and is used in high definition TV.

Multicast This is a way of delivering the same content to multiple end users on the same network without the need to send duplicate data packets end to end.

Multiplex A device that sends multiple streams of information on a carrier frequency at the same time, in the form of a single, complex signal. The separate signals are then recovered at the receiving end.

MVNO Mobile Virtual Network Operator. An organisation which provides mobile telephony services to its customers, but does not have allocation of spectrum or its own wireless network and instead, buys a wholesale service from a mobile network operator.

Narrowband A service or connection providing data speeds up to 128kbit/s, for example via an analogue telephone line.

Not-spot An area which is not covered by any mobile networks.

Point-to-Point A network topology where the end user is connected to the network via a dedicated fibre.

PSB Public Service Broadcasting or Public Service Broadcaster. The Communications Act in the UK defines the PSBs as the BBC, ITV, Channel 4, Five and S4C.

PSTN Public Switched Telephone Network. The network that manages circuit switched fixed-line telephone systems.

QAM Quadrature Amplitude Modulation. A modulation (signal encoding) technique used in digital television transmissions.

SIM Subscriber Identity Module. A SIM is a small flat electronic chip that identifies a mobile customer and the mobile operator. A mobile phone must have a SIM before it can be used.

Smartphone A mobile phone that offers more advanced computing ability and connectivity than a contemporary basic 'feature' phone.

SFBB Super-Fast Broadband. The next generation of faster broadband services, which delivers headline download speeds of greater than 24Mbit/s.

SFN Single Frequency Networks. A broadcast network where transmitters broadcast the same signal on the same frequency channel.

SLU Sub-Loop Unbundling. This is where the unbundling of the access line takes place at the street side cabinet (rather than the exchange as for LLU) for a communications provider to gain control of the access line to the customer.

Statistical multiplexing A technique which dynamically allocates bandwidth for the multiple streams of data which are carried on the same multiplex.

Telecommunications Conveyance over distance of speech, music and other sounds, visual images or signals by electric, magnetic or electro-magnetic means.

Transmitter A device which amplifies an electrical signal at a frequency to be converted, by means of an aerial, into an electromagnetic wave (or radio wave). The term is commonly used to include other, attached devices, which impose a more simple signal onto the frequency, which is then sent as a radio wave. The term is sometimes also used to include the cable and aerial system referred to above, and indeed the whole electrical, electronic and physical system at the site of the transmitter.

UHDTV Ultra High Definition TV. A range of technology standards which will provide better resolution than HDTV

UMA Unlicensed Mobile Access. A technology that provides roaming between GSM and 802.11 Wi-Fi

UMTS Universal Mobile Telecommunications System. The 3G mobile technology most commonly used in the UK and across Europe.

Unbundled A local exchange that has been subject to local loop unbundling (LLU).

Usage cap Monthly limit on the amount of data that users can download, imposed by fixed and mobile operators for some of their packages.

VDSL Very High Speed DSL. A high speed variant of DSL technology, which provides a high headline speed through reducing the length of the access line copper by connecting to fibre at the cabinet.

Vectoring A technique used in DSL networks to increase the data speeds by using real time digital signal processing techniques to reduce the interference on the line.

VHF Very High Frequency. The part of the spectrum between 30 MHz and 300 MHz. FM and DAB radio services and broadcast on parts of this band

White Spaces Frequencies in the radio spectrum that are not in use by the licensee all of the time and in all locations. These frequencies can be used by a white space device so that interference is not caused to the licensed user of the spectrum.

Wi-Fi A short range wireless access technology that allows devices to connect to a network through using any of the 802.11 standards. These technologies allow an over-the-air connection between a wireless client and a base station or between two wireless clients.

WiMAX A wireless MAN (metropolitan area network) technology, based on the 802.16 standard. It can be used for both fixed and mobile data applications.

WLR Wholesale Line Rental. This is a regulatory instrument requiring the operator of local access lines to make services available to competing providers at a wholesale price.