making communications work
for everyone

Hull Area Wholesale Fixed Telecoms Market Review 2021-26

Annexes 1-4

STATEMENT:

Publication date: 28 October 2021

Contents

Annex

A1. Regulatory framework

A1.1 This annex provides an overview of the regulatory framework relevant to the market review process, to give some additional context to the matters discussed in this document, including the legal instruments published in Volume 4.

A1.2 Market review regulation is technical and complex; and requires us to apply legislation. We may also have regard to a number of relevant recommendations and guidelines. This overview identifies some of the key aspects of materials relevant to this market review but does not purport to give a full and exhaustive account of all materials that we have considered in reaching our decision for these markets.

A1.3 Since the publication of the 2020 Hull Area WFTMR Consultation the regulatory framework relevant for market reviews has been amended. In particular the Communications Act (2003)[1] (the 'Act') was amended in December 2020 to reflect the transposition of the relevant provisions of the European Electronic Communications Code (the 'EECC') and the end of the Brexit transition period.[2] By virtue of section 2(1) of the European Union (Withdrawal) Act 2018, the Act continues to have effect in UK law as it did prior to the UK's departure from the European Union.[3]

Market review concept

A1.4 A market review is a process by which, at regular intervals, we identify relevant markets and carry out analyses of these markets to determine whether they are effectively competitive. Where an operator has significant market power (SMP) in a market, we impose appropriate remedies, known as SMP obligations or conditions, to address this. We explain the concept of SMP below.

A1.5 In carrying out this work, we act in our capacity as the sector-specific regulator for the UK communications industries, including telecommunications. Our functions in this regard are to be found in Part 2 of the Act.

A1.6 The Act requires Ofcom to carry out reviews of competition in communications markets[4] to ensure that SMP regulation remains appropriate and proportionate in the light of changing market conditions.

---

[1] Communications Act 2003 [accessed 19 October 2021].
[2] The EECC, established by Directive EU 2018/1972, entered into force on 20 December 2018. In July 2020, following public consultation, the UK government set out its approach to implementing the EECC into national law. See Department for Digital, Culture, Media & Sport, 2020. Government response to the public consultation on implementing the European Electronic Communications Code [accessed 19 October 2021].
[3] Subsection 6(3) also provides that "any question as to the validity, meaning or effect of any retained EU law is to be decided, so far as that law is unmodified on or after IP completion day and so far as they are relevant to it—
(a) in accordance with any retained case law and any retained general principles of EU law, and
(b) having regard (among other things) to the limits, immediately before IP completion day, of EU competences". European Union (Withdrawal) Act 2018 [accessed 19 October 2021].
[4] Section 84(A) of the Act.

A1.7 Each market review normally involves three analytical stages:

- the identification and definition of the relevant markets (the market definition stage);
- the assessment of competition in each market, in particular whether the relevant market is effectively competitive (the market analysis stage); and
- the assessment of appropriate regulatory obligations (the remedies stage).

Market definition

Relevant markets

A1.8 The Act provides that, before making a market power determination[5], we must identify "the markets which in [our] opinion are the ones which in the circumstances of the United Kingdom are the markets in relation to which it is appropriate to consider whether to make such a determination"[6] and analyse those markets.

A1.9 In identifying or analysing markets, the Act provides that we may have regard to EECC materials relating to market identification and analysis[7], such as the 2020 Recommendation on Relevant Markets (2020 EC Recommendation).[8]

A1.10 We may only identify a market for the purpose of assessing market power where we consider the three criteria set out in section 79(2B) of the Act (the three criteria test) are met.

A1.11 The three criteria, which are cumulative, are:

- the presence of high and non-transitory structural, legal or regulatory barriers to entry;
- a market structure which does not tend towards effective competition within the relevant time horizon[9], having regard to the state of infrastructure-based and other competition behind the barriers to entry; and
- competition law alone is insufficient to adequately address the identified market failure(s).

A1.12 The 2020 EC Recommendation, which we may have regard to, identifies a set of product and service markets within the electronic communications sector in which *ex ante* regulation may be warranted within the EU. These are the markets which the European Commission has found to meet the three criteria test[10], after observing overall trends across the EU. This provides a useful indicator of the markets which exhibit competition

[5] The market power determination concept is used in the Act to refer to a determination that a person has SMP in an identified services market.
[6] Section 79(1) of the Act.
[7] Section 79(2ZA) of the Act. Section 79(6A) of the Act defines EECC materials as "recommendations or guidelines published by the European Commission, and guidelines published by BEREC, under the Framework Directions or EECC Directive including those published after IP completion day" i.e. after 31 December 2020.
[8] Commission Recommendation of 18 December 2020 on relevant product and service markets within the electronic communications sector susceptible to *ex ante* regulation in accordance with Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Code [accessed 19 October 2020].
[9] Such time period as we determine to be appropriate in relation to the review.
[10] The three criteria test applied by the European Commission is equivalent to that set out in section 79(2B) of the Act.

issues in neighbouring countries (and those which do not) and a consideration of the reasons for this and the trends observed, which may also be relevant to UK circumstances. We make clear in the relevant sections of this Statement where we have had regard to the 2020 EC Recommendation.

A1.13 The fact that we identify product and service markets that meet the three criteria test does not automatically mean that regulation is warranted. Market definition is not an end in itself but rather one input into assessing effective competition.

Sufficiency of competition law

A1.14 In considering the third limb of the three criteria test, that competition law alone is insufficient to adequately address the identified market failure(s), we bear in mind the specific characteristics of the relevant markets we have defined. Generally, the case for *ex ante* regulation is based on the existence of market failures which, by themselves or in combination, mean that the establishment of effective competition might not be possible if the regulator relied solely on *ex post* competition law powers which are not specifically tailored to the sector. Therefore, it may be appropriate for *ex ante* regulation to be used to address such market failures along with any entry barriers that might otherwise prevent effective competition from becoming established within the relevant markets we have defined. By imposing *ex ante* regulation that promotes competition, it may be possible to reduce such regulation over time as markets become more competitive, allowing greater reliance on *ex post* competition law.

A1.15 *Ex post* competition law is also unlikely in itself to bring about (or promote) effective competition, as it prohibits the abuse of dominance rather than the holding of a dominant position itself. In contrast, *ex ante* regulation is normally aimed at actively promoting the development of competition through attempting to reduce the level of market power (or dominance) in the identified relevant markets, thereby encouraging the establishment of effective competition.

A1.16 We generally take the view that *ex ante* regulation provides additional legal certainty for the market under review and may also better enable us to intervene in a timely manner. We also consider that certain obligations are needed as competition law would not remedy the particular market failure, or that the specific clarity and detail of the obligation is required to achieve a particular result.

Forward look

A1.17 Market definition is not a mechanical or abstract process. It requires an analysis of any available evidence of past market behaviour and an overall understanding of the mechanics of a given market sector. The Act requires that Ofcom must conduct a forward-looking assessment of the market, taking into account expected or foreseeable developments that may affect competition in the market.[11]

[11] Section 79(1A) of the Act.

Approach to market analysis and modified greenfield

A1.18 When identifying and analysing markets, we apply the following two principles.

A1.19 First, when identifying wholesale markets for the purposes of section 79(1) of the Act, we start with an analysis of corresponding retail (or other downstream) market(s). We do not formally define the retail market(s) but consider if it is (they are) prospectively competitive in the absence of wholesale regulation based on a finding of SMP, and therefore whether any lack of effective competition is durable.

A1.20 If the underlying retail market(s) is (are) prospectively competitive under these circumstances, we would conclude that regulation is no longer needed at the wholesale level. If the underlying retail market(s) is (are) not prospectively competitive, then we identify the corresponding wholesale market(s). Where wholesale markets are vertically linked, we identify and analyse the most upstream market first, followed by a subsequent analysis of the markets that are downstream, to determine whether they would be effectively competitive in the presence of regulation upstream.

A1.21 Second, when identifying and analysing a market, we assume that no SMP regulation exists in that particular market. This avoids the risk of circularity in our assessment – i.e. a finding of no SMP in a market which is predicated on pre-existing *ex ante* regulation of that market (this is often referred to as the "modified greenfield approach").[12]

A1.22 We note that this approach is consistent with that set out in the EC SMP Guidelines.[13]

Product and geographic dimensions

A1.23 We use competition law methodologies in the market review analysis. In particular, there are two dimensions to the definition of a relevant market: the relevant products to be included in the same market and the geographic extent of the market.

A1.24 The boundaries between markets are determined by identifying competitive constraints on the price setting behaviour of firms. There are two main constraints to consider:

- to what extent it is possible for a customer to substitute other services for those in question in response to a price increase (demand-side substitution); and
- to what extent suppliers can switch, or increase, production to supply the relevant products or services in response to a price increase (supply-side substitution).

A1.25 The hypothetical monopolist test is a tool used to identify good demand-side and supply-side substitutes. In this test, a product is considered to constitute a separate market if the hypothetical monopolist supplier could impose a small but significant non-transitory increase in price (SSNIP) above the competitive level without losing sales to such a degree

[12] Hutchison 3G UK Ltd v The Office of Communications [2009] EWCA Civ 683, Judgement of 16 July 2009, paragraphs 64-66 [accessed 19 October 2021].
[13] Communication from the Commission — Guidelines on market analysis and the assessment of significant market power under the EU regulatory framework for electronic communications networks and services (EC SMP Guidelines), paragraphs 15-18.

as to make this price rise unprofitable. If such a price rise would be unprofitable, because consumers would switch to other products or because suppliers of other products would begin to compete with the hypothetical monopolist, then the market definition should be expanded to include the substitute products.

A1.26 The starting point for the application of the hypothetical monopolist test can be referred to as the "focal product",[14] and typically starts from the narrowest potential market definition.[15]

A1.27 We may consider both demand-side substitution and supply-side substitution possibilities to consider whether either provides additional constraints on the pricing behaviour of the hypothetical monopolist. In this assessment, supply-side substitution is considered to be a low-cost form of entry which can take place within a reasonable timeframe (e.g. up to 12 months). For supply-side substitution to be relevant not only must suppliers be able, in theory, to enter the market quickly and at low cost by virtue of their existing position in the supply of other products or geographic areas, but there must also be an additional competitive constraint arising from such entry into the supply of the service in question.

A1.28 In relation to defining the relevant geographic markets, this comprises an area in which the undertakings concerned are involved in the supply and demand of the relevant products or services, in which the conditions of competition are sufficiently homogeneous, and which can be distinguished from neighbouring areas in which the prevailing conditions of competition are significantly different. Areas in which the conditions of competition are heterogeneous do not constitute a uniform market.

A1.29 Our approach to market definition follows that used by the UK competition authorities, and is consistent with the EC SMP Guidelines. We make clear in the relevant sections of this statement how we have regard to the EC SMP Guidelines.

Relationship with *ex post* competition law

A1.30 While competition law methodologies are used in identifying the relevant markets *ex ante*, the markets identified will not necessarily be identical to markets defined in *ex post* competition law cases, especially as (i) the markets identified *ex ante* are based on an overall forward-looking assessment of the structure and the functioning of the market under examination, and (ii) as noted above, in carrying out an *ex ante* assessment, we assume there is no SMP regulation in place in the market under examination. Accordingly, the economic analysis carried out for the purpose of this review, including the markets we have identified, is without prejudice to any analysis that may be carried out in relation to

[14] This reflects the terminology used by the UK competition authorities. See Office of Fair Trading (OFT), 2004. Market definition: OFT403, which has subsequently been adopted by the CMA Board [accessed 19 October 2021].
[15] The OFT Market Definition Guidelines explains that "previous experience and common sense will normally indicate the narrowest potential market definition, which will be taken as the starting point for the analysis". OFT, 2004. Market definition: OFT 403, paragraph 3.2 [accessed 19 October 2021].

any investigation pursuant to the Competition Act 1998[16] (relating to the application of the Chapter I or II prohibitions) or the Enterprise Act 2002.[17]

Market analysis

Effective competition

A1.31 The Act requires that we carry out market analyses of identified markets for the purpose of making or reviewing market power determinations. The Act requires that such analyses are normally to be carried out within five years from the publication of a previous market power determination relating to that market. Exceptionally, the five-year period may be extended for one additional year.[18]

A1.32 In carrying out a market analysis, the key issue for Ofcom is to determine whether any one or more operator(s) has SMP.

A1.33 The definition of SMP is equivalent to the concept of dominance as defined in competition law.[19] In essence, it means that an undertaking in the relevant market is in a position of economic strength affording it the power to behave to an appreciable extent independently of competitors, customers, and ultimately consumers.

A1.34 The Act provides that, in considering whether to make or revise a market power determination, we may have regard to EECC materials relating to market analysis or the determination of what constitutes significant market power, such as the EC SMP Guidelines.[20]

A1.35 The EC SMP Guidelines consider the specific application of competition law principles to the electronic communications sector. They reflect our understanding of the factors driving competitive conditions in the markets we are reviewing. We have therefore had regard to the EC SMP Guidelines in considering whether to make or revise market power determinations in this Statement.

A1.36 In line with the EC SMP Guidelines we consider that market shares provide a useful first indicator of competitive conditions in the market, and that they should however be interpreted in light of the relevant market conditions.[21] The EC SMP Guidelines note that, according to established case law, a market share in excess of 50% is itself evidence of a dominant position, save in exceptional circumstances.[22] On this point, we have also had regard to the judgment of the Competition Appeal Tribunal in BCMR 2019. The Tribunal

[16] Competition Act 1998 [accessed 19 October 2021].
[17] Enterprise Act 2002, Chapter 40 [accessed 19 October 2021].
[18] Section 84A of the Act.
[19] Section 78(1) of the Act. References in section 78 to dominance of a market are to be construed, so far as it is appropriate to do so, in the same way as the reference in section 18(1) of the Competition Act 1998 to a dominant position in a market.
[20] Section 79(2BA) of the Act.
[21] EC SMP Guidelines, paragraph 54.
[22] EC SMP Guidelines, paragraph 55.

confirmed that the existence of a high market share is to be a trigger for a full assessment, but not to be determinative in itself.[23]

A1.37 The EC SMP Guidelines set out, additionally to market shares, criteria that can be used to measure the power of an operator to behave to an appreciable extent independently of its competitors, customers, and consumers, including:

a) barriers to entry;

b) barriers to expansion;

c) absolute and relative size of the undertaking;

d) control of infrastructure not easily duplicated;

e) technological and commercial advantages or superiority;

f) absence of or low countervailing buying power;

g) easy or privileged access to capital markets/financial resources;

h) product/services diversification (for example, bundled products or services);

i) economies of scale and economies of scope;

j) direct and indirect network effects;

k) vertical integration;

l) a highly developed distribution and sales network;

m) conclusion of long-term and sustainable access agreements;

n) engagement in contractual relations with other market players that could lead to market foreclosure; and

o) absence of potential competition.[24]

A1.38 A dominant position can derive from a combination of these criteria which when taken separately may not necessarily be determinative.

Remedies

Powers and legal tests

A1.39 Section 87(1) of the Act provides that where we have made a determination that a person has SMP in an identified services market, we shall set such SMP conditions authorised by

[23] TalkTalk Telecom Group plc and Vodafone Limited v Ofcom (BCMR 2019) [2020] CAT 8, Judgment of 5 March 2020, paragraphs 163-171 and 282-283.
[24] EC SMP Guidelines, paragraph 58.

section 87 as we consider it appropriate to apply to that person in respect of the relevant network or relevant facilities.[25]

A1.40 The Act identifies a number of SMP obligations, including transparency, non-discrimination, accounting separation, access to and use of specific network elements and facilities, price control and cost accounting.[26]

A1.41 For each and every SMP obligation, we explain why it satisfies the requirement in section 47(2) of the Act that the obligation is:

a) objectively justifiable in relation to the networks, services, facilities, apparatus or directories to which it relates;

b) not such so as to discriminate unduly against particular persons or against a particular description of persons;

c) proportionate to what the condition or modification is intended to achieve; and

d) transparent in relation to what is intended to be achieved.

A1.42 As part of ensuring that an SMP obligation meets this requirement, we consider whether it is based on the nature of the competition problem(s) we have identified in our market analysis.

A1.43 Additional legal requirements may also need to be satisfied depending on the SMP obligation in question. For example, we are subject to additional requirements when imposing price controls and cost recovery obligations.

A1.44 Specifically, we explain why any such SMP obligation satisfies the requirements of section 88 of the Act. Namely:

a) our analysis indicates a risk that the telecoms provider concerned might fix and maintain prices at an excessively high level or impose a price squeeze so as to have adverse consequences for end-users of public electronic communications services;

b) we consider the setting of the obligation is appropriate for the purposes of:

(i) promoting efficiency;
(ii) promoting sustainable competition;
(iii) conferring the greatest possible benefits on the end-users of public electronic communications services having regard where relevant to the market analysis, to the long term interests of end-users in the use of next-generation networks; and
(iv) where relevant to the market analysis, promoting the availability and use of new and enhanced networks.[27] In setting such an SMP condition we also take account of:

[25] Section 84(4) of the Act provides that where Ofcom determine that an undertaking to whom any SMP conditions apply is no longer a person with significant market power in that market, Ofcom must revoke every SMP services condition applied to that person by reference to the market power determination made on the basis of the earlier analysis.
[26] Sections 87 and 88 of the Act.
[27] Section 88(1) of the Act.

a. the extent of investment by the telecoms provider in the matters to which the SMP obligation relates;
b. where the condition involves price controls on the provision of network access to existing network elements, the benefits of predicable and stable whole prices in ensuring:
    i. efficient market entry; and
    sufficient incentives for all undertakings to bring into operation new and enhanced networks.[28]

A1.45 Where an obligation to provide third parties with network access is considered appropriate, we must take into account factors including:

a) the feasibility of the provision of the proposed network access;

b) the technical and economic viability having regard to the state of market development, of installing and using facilities that would make the network access unnecessary;

c) any technological developments that, in our opinion, are likely to affect the design and management of the relevant network or facilities;

d) the need to ensure that the provision of the proposed network access does not have the effect of favouring one form of technology over another in relation to the design and management of the electronic communications networks;

e) the investment of the network operator who is required to provide access (taking account of any public investment made);

f) the need to secure effective competition (including, where it appears to us to be appropriate, economically efficient infrastructure-based competition) in the long term and to support innovative business models that support sustainable competition; and

g) any rights to intellectual property that are relevant to our proposals.[29]

A1.46 We demonstrate the application of the relevant requirements to the SMP obligations we are imposing, in this statement. In doing so, we also set out our assessment of how, in our opinion, the performance of our general duties under section 3 of the Act will be secured or furthered by our regulatory intervention, and that it is in accordance with the six requirements in section 4 of the Act (see below). This is also relevant to our assessment of the likely impact of implementing our decisions.

Ofcom's general duties – section 3 of the Act

A1.47 Under the Act, our principal duty in carrying out our functions is to further the interests of citizens in relation to communications matters and to further the interests of consumers in relevant markets, where appropriate by promoting competition.

[28] Section 88(2) of the Act.
[29] Section 87 of the Act.

A1.48 In doing so, we are required to secure a number of specific objectives and to have regard to a number of matters set out in section 3 of the Act.

A1.49 In performing our duties, we are also required to have regard to a range of other considerations, as appear to us to be relevant in the circumstances. For the purpose of this review, we consider that a number of such considerations are relevant, in particular:

- the desirability of promoting competition in relevant markets;
- the desirability of encouraging investment and innovation in relevant markets;
- the desirability of encouraging the availability and use of high-speed data transfer services throughout the UK; and
- the desirability of ensuring that relevant markets facilitate end-to-end connectivity in the interests of consumers in those markets.[30]

A1.50 We are also required to have regard to the principles under which regulatory activities should be transparent, accountable, proportionate, consistent, and targeted only at cases in which action is needed, as well as to the interest of consumers in respect of choice, price, quality of service and value for money.

A1.51 However, we have a wide measure of discretion in balancing our statutory duties and objectives. In doing so, we take account of all relevant considerations, including responses received during our consultation process, in reaching our conclusions.

Duties for the purposes of fulfilling obligations – section 4 of the Act

A1.52 Section 4 of the Act requires us, when carrying out our market review functions, act in accordance with six requirements for regulation which are in summary:

a) to promote competition in the provision of electronic communications networks and services, associated facilities and the supply of directories;

b) to promote the interests of all members of the public in the United Kingdom;

c) to take account of the desirability of Ofcom's carrying out of its functions in a manner which, so far as practicable, does not favour one form of or means of providing electronic communications networks, services or associated facilities over another (i.e. to be technologically neutral);

d) to encourage, to such extent as Ofcom considers appropriate the provision of network access and service interoperability for the purpose of securing efficient and sustainable competition; efficient investment and innovation; and the maximum benefit for customers of telecoms providers and of persons who make associated facilities available;

e) to encourage compliance with certain standards in order to facilitate service interoperability, end-to-end connectivity, and secure freedom of choice for the customers of telecoms providers; and

[30] Section 3(4)(eb) of the Act.

f) to promote connectivity and access to very high capacity networks[31] by members of the public and businesses in the United Kingdom.

A1.53 We consider that the first, second, third, fourth, and sixth of those requirements are of particular relevance to the matters under review and that no conflict arises in this regard with those specific objectives in section 3 of the Act that we consider are particularly relevant in this context.

A1.54 Section 4A of the Act provides that in carrying out our functions (including, among others, our functions in relation to market reviews), we may take account of recommendations issued by the EC under Article 19(1) of the Framework Directive or Article 38(1) of the EECC Directive if the recommendations appear to us to be relevant to those functions.

Impact assessment – section 7 of the Act

A1.55 The analysis presented in the 2020 Hull Area WFTMR Consultation document entitled Hull Area Wholesale Fixed Telecoms Market Review 2021-26 represents an impact assessment, as defined in section 7 of the Act.

A1.56 Impact assessments provide a valuable way of assessing different options for regulation and showing why the preferred option was chosen. They form part of best practice policy making. This is reflected in section 7 of the Act, which means that generally we have to carry out impact assessments where there is likely to be a significant effect on businesses or the general public, or when there is a major change in our activities. However, as a matter of policy, Ofcom is committed to carrying out and publishing impact assessments in relation to the majority of its policy decisions.[32]

A1.57 Specifically, pursuant to section 7, an impact assessment must set out how, in our opinion, the performance of our general duties (within the meaning of section 3 of the Act) is secured or furthered by or in relation to the regulation we impose.

A1.58 We are separately required by statute to assess the potential impact of all our functions, policies, projects, and practices on equality.[33] This assessment is set out in Section 4 of Volume 1.

UK Government's Statement of Strategic Priorities

A1.59 Under section 2B(2) of the Act, when exercising our functions relating to telecoms, management of radio spectrum and postal services, we are required to have regard to the

[31] A "very high capacity network" is set out in the Act as meaning "an electronic communications network which— (a) consists wholly of optical fibre elements at least up to the distribution point at the serving location; or (b) is capable of delivering, under usual peak-time conditions, network performance that, in OFCOM's opinion, is similar, in terms of available downlink and uplink bandwidth, resilience, error-related parameters and latency and its variation, to the network performance of a network falling within paragraph (a)." Section 4(12A) of the Act.

[32] For further information about Ofcom's approach to impact assessments, see the guidelines set out in Ofcom, 2005. Better Policy Making: Ofcom's approach to Impact Assessment.

[33] Ofcom has a general duty under the 2010 Equality Act to advance equality of opportunity in relation to age, disability, sex, gender reassignment, pregnancy and maternity, race, religion or belief, and sexual orientation. Equality Act 2010 [accessed 19 October 2021].

UK Government's Statement of Strategic Priorities (SSP).[34] The SSP for telecommunications, the management of radio spectrum, and postal services was designated on 29 October 2019, having been laid in draft before Parliament on 18 July 2019. We set out in Section 1 of Volume 3 further details of how we have done this.

Regulated entity

A1.60 The power in the Act to impose an SMP obligation by means of an SMP services condition provides that it is to be applied only to a "person" whom we have determined to be a person having SMP in a specific market for electronic communications networks, electronic communications services or associated facilities (i.e. the "services market").[35]

A1.61 We consider it appropriate to prevent a dominant provider to whom an SMP services condition is applied, which is part of a group of companies, exploiting the principle of corporate separation. The dominant provider should not use another member of its group to carry out activities or to fail to comply with a condition, which would otherwise render the dominant provider in breach of its obligations.

A1.62 To secure that aim, we apply the SMP conditions to the person in relation to which we have made the market power determination in question by reference to the so-called "Dominant Provider", which we define as "KCOM Group Limited, whose registered company number is 02150618, and any of its subsidiaries as defined in section 1159 of the Companies Act 2006".

[34] Department for Digital, Culture, Media and Sport, 2019. Statement of Strategic Priorities for telecommunications, the management of radio spectrum, and postal services [accessed 19 October 2021].
[35] Section 46(8) of the Act.

A2. Overview of telecoms networks

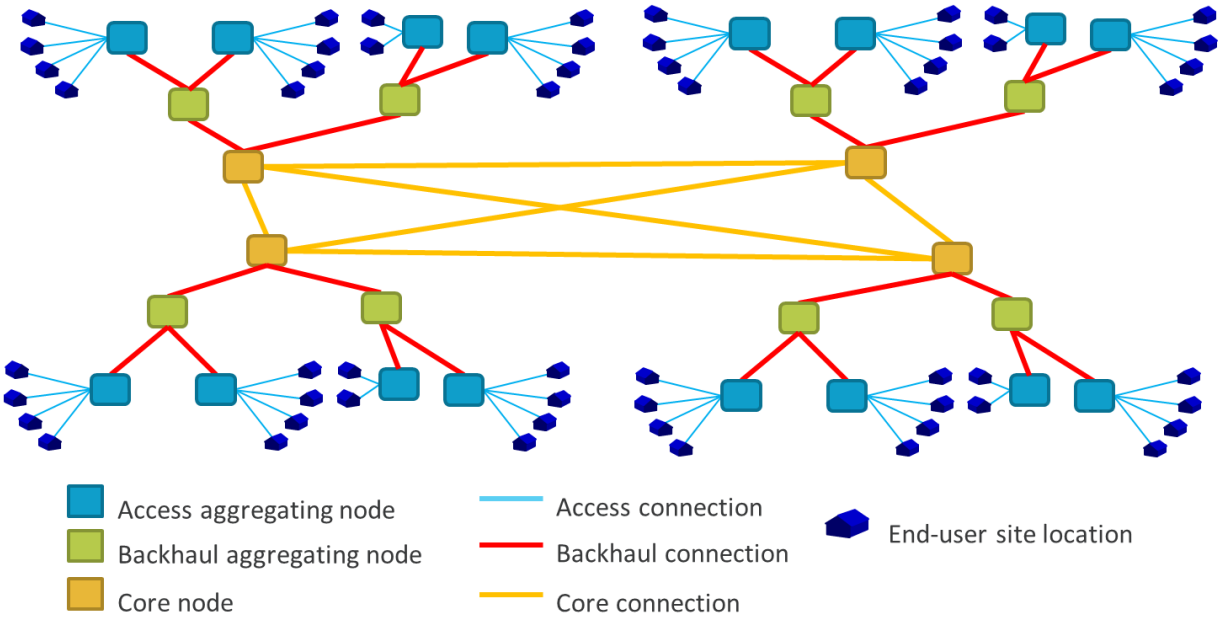
General overview

A2.1 A communications network provides the services that enable end-users to exchange information. A network is comprised of a number of elements:

- access connections;
- backhaul and core connections; and
- network nodes which house equipment.

A2.2 Figure A2.1 sets out a high-level view of how networks are typically structured.

Figure A2.1: Illustration of logical arrangement of a communications network



Source: Ofcom.

A2.3 Each end-user site is connected to one of the network's access aggregating nodes.[36] This is referred to as the 'access connection'. Each access node is connected to at least one core node, either directly or indirectly, via a backhaul aggregating node using a backhaul connection.[37] Core nodes are then connected to one or more core nodes to form a core network.[38] In general, there are more access nodes than backhaul nodes and more backhaul nodes than core nodes.

[36] Access aggregating nodes (access nodes) aggregate the traffic from multiple access connections. They may be connected to one or more network nodes to create a more resilient network in the event of a failure in the network equipment or connection.
[37] Backhaul aggregating nodes (backhaul nodes) combine the traffic from multiple access nodes onto a single backhaul connection. They are then connected to other backhaul or core nodes or to several if resilience is required.
[38] Core nodes are used to route or switch traffic between other core nodes and may often link to backhaul aggregation nodes. Most core nodes have at least two connections between them using separate physical routes to provide resilience.

A2.4 This structure is common to the networks used to provide most voice and data telecoms services – including telephony, fixed broadband, mobile, and leased lines. These networks differ in scale (numbers of each type of node), the number of stages of access and backhaul aggregation (zero, one or more than one) and the structure of the core.

A2.5 Access nodes are generally placed where end-users are grouped most closely and can be easily reached (such as the centre of cities, towns, and villages) and are used to connect end-users, using access connections, to the network.[39]

A2.6 For residential broadband services, the point-of-handover is likely to be near to the entrance of a residential home.[40] For leased lines, the point-of-handover for the access connection at the end-user site can be located in, for example, the communications room of a business, in the basement of a multi dwelling unit (MDU), or within a suitable enclosure at a mobile base station site.

A2.7 Backhaul nodes have higher capacity as they aggregate traffic from multiple access nodes and can act as the point of connection between access nodes which can be many kilometres apart. Backhaul connections will have higher capacity than access connections as they aggregate traffic from multiple end-user and services.

A2.8 Core connections (and nodes) transport multiple telecoms services aggregated from all the services provided to end-users and generally have higher capacity than backhaul connections (and nodes). Core nodes are used to route (or switch) traffic from backhaul connections onto the core network, or between backhaul nodes or other core nodes.

A2.9 Core nodes are often located in a city of significant population within the geographic area covered by the network. These can then be linked to other core nodes to create a national or regional core network.

A2.10 Most locations or sites housing core nodes also contain backhaul and access aggregating nodes, the latter for serving the area immediately surrounding the site.[41] Similarly, a site containing a backhaul node may also contain one or more access nodes to provide connectivity to the surrounding area. More remote network sites may only contain an access node.

A2.11 To enable end-users on different networks to communicate with each other or to access services [42], networks are interconnected between designated nodes. The network-to-network interconnect may be at a site (network point of handover) where both networks are present, such as at a KCOM exchange or a data centre, or via a dedicated point-to-point

[39] The access connection may be transmitted over radio, fibre, or copper.
[40] A point-of-handover is where the customer can 'plug in' a connection between their own equipment, such as a customer's fixed or wireless router, and the network terminating equipment.
[41] Aggregation nodes (access, backhaul, and core) can be sited in, for example, a telecoms provider's operational building, in a BT or KCOM exchange, or in a data centre. Some sites may have more than one type of aggregation node at the same location.
[42] For example, between two different business users, or between a business user and a serving computer such as a web server in a data centre, or simply between two network operators.

connection between two network sites where the interconnection or handover takes place.[43]

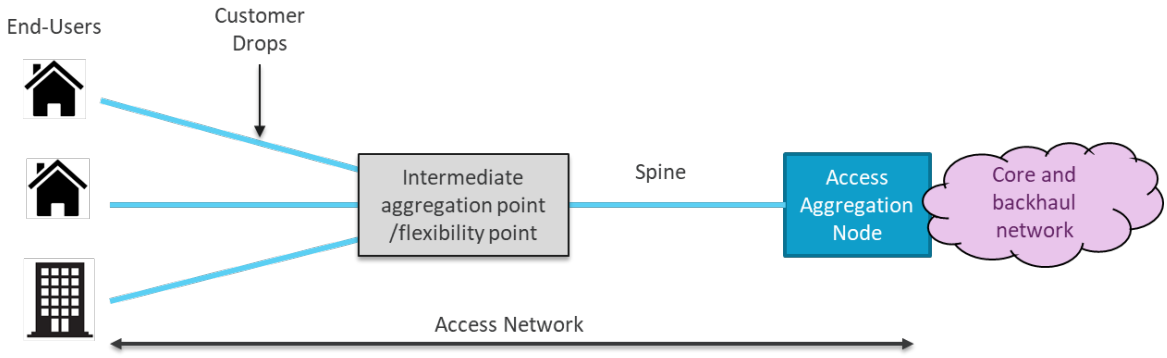
Access networks

Access network overview

A2.12 Access networks provide the connection to the end-user. The connection to the end-user from the access node may be realised all, or in part, using fixed connectivity (fibre, copper, coaxial cables) or using wireless connectivity.

A2.13 While there are a number of different types of access network, all share certain common attributes which make up the access connection between end-user sites and an access aggregation node, such as customer drops, intermediate aggregation/flexibility points, and spine links. Figure A2.2 illustrates how these constituent elements relate to one another.

Figure A2.2: Generic fixed access network



Source: Ofcom.

A2.14 Customer drops, or lead-ins[44], are the dedicated physical bearer (or radio links in the case of wireless networks) connecting an end-user's equipment (also referred to as customer premises equipment or CPE) to a network over which the customer's data is carried.

A2.15 Aggregation or flexibility points can connect to several customer drops and are often placed near to the end-user's premises. Their purpose is to aggregate these multiple drops into a smaller number of bearers (spine links) which are then taken back to the main access node within a local area. A main access aggregation node is likely be connected to multiple intermediate aggregation or flexibility points in a given area.

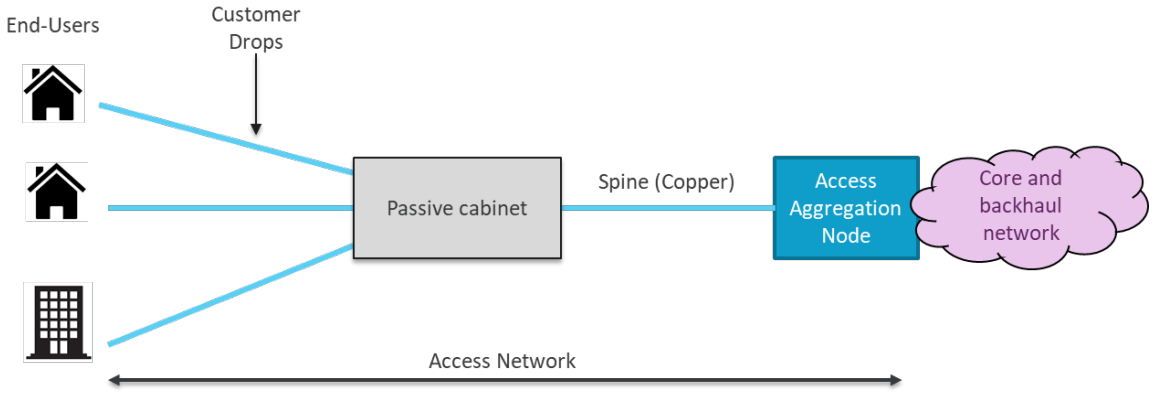
[43] KCOM provides products to connect between nodes within a KCOM exchange (Internal Ethernet Connect Access Service, ECAS) and to connect to other networks nearby (External Ethernet Connect Access Service, ECAS).
[44] A lead-in is the final section of a physical infrastructure network, housing the connection between the distribution point and the Customer's Premises Equipment.

A2.16 In some cases, intermediate points use active electronics which aggregate traffic from several customer connections. This aggregated traffic is then carried over a dedicated circuit back to the main access node (see Figure A2.4 further below as an example).

Copper access network

A2.17 Networks were initially deployed using copper connections to the end-user's premises as shown in Figure A2.3. These copper networks were initially deployed to provide telephony services using a multi-strand cable to a 'passive' cabinet, connecting directly to end-users using individual copper connections ('drops').[45]

Figure A2.3: Copper access network



Source: Ofcom.

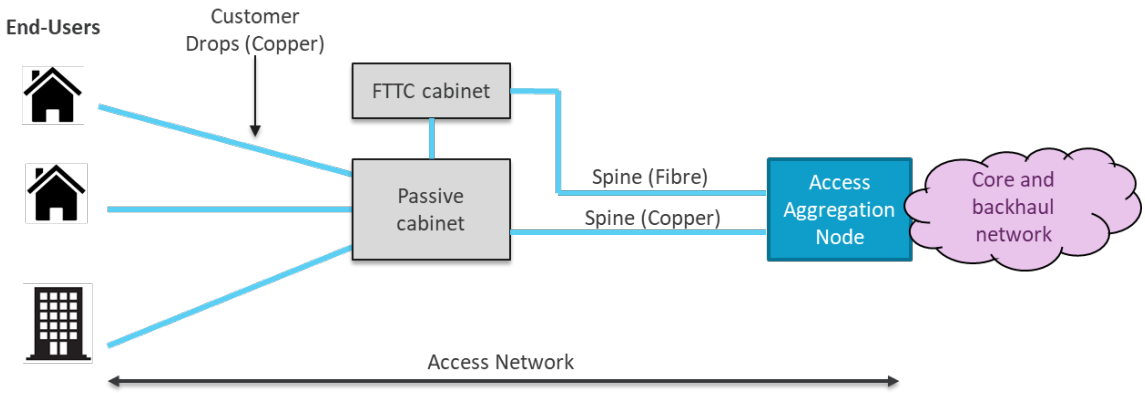
A2.18 Initially, broadband services were added by providing broadband equipment at the local exchange using ADSL technology.[46] The characteristics of this equipment and the copper line limited the speed available on the network, with speeds of up to 24Mbit/s using ADSL2+ (customers typically experience less than this with speeds diminishing with distance). The copper network is also more affected by faults than modern fibre networks, in part due to the age of the network which can also be affected by the weather.

Fibre to the cabinet (FTTC) access network

A2.19 Some copper networks, such as BT's, have been upgraded to support higher speeds by deploying broadband equipment (electronics) nearer to the customer, at a cabinet rather than in the exchange (Figure A2.4). The broadband equipment is then connected to the end-user copper connection via the existing passive cabinet which is located nearby, and to the access aggregation node using a fibre connection. This design is known as fibre to the cabinet (FTTC). KCOM uses FTTC to provide broadband services in some instances.[47]

[45] We refer to the cabinet as 'passive' as it uses simple physical copper connections to connect between the spine cable and customer drop rather than using electronics.
[46] ADSL – asynchronous digital subscriber line. This is a technology for transmitting data over copper lines to an end-user and is part of a family of technologies e.g. ADSL, ADSL2+, SDSL (symmetric DSL), and VDSL (very high bit rate DSL).
[47] KCOM's response dated 5 February to the s135 notice dated 8 January 2020, question 1. See also KCOM, 2021. Broadband and pricing packages [accessed 19 October 2021].

Figure A2.4: Fibre to the cabinet access network



Source: Ofcom.

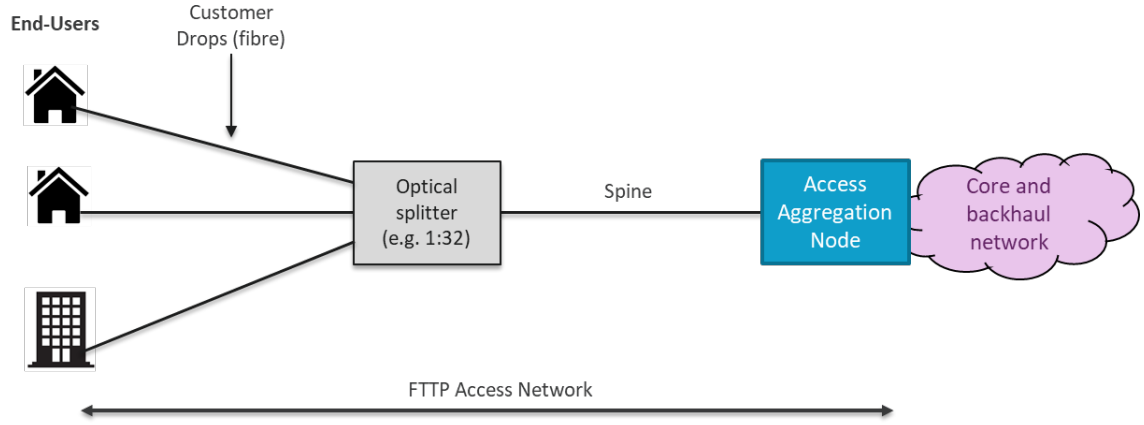
A2.20 FTTC networks can provide broadband services with speeds of up to 80Mbit/s downstream depending on the length of the copper line between the end-user and the cabinet. These higher speeds are achieved using VDSL technology over shorter copper connections (compared to exchange-based broadband), which is why the VDSL equipment is placed in street cabinets rather than further away in an exchange building.

Fibre to the premises (FTTP) access networks.

A2.21 Copper access networks are in the process of being superseded by fibre to the premises (FTTP). KCOM has completed its rollout of FTTP in the Hull Area but continues to operate its copper network to support legacy services.

A2.22 A PON is a shared fibre network (see Figure A2.5). Each customer has a dedicated fibre connecting to an optical splitter which then connects to optical line terminal (OLT) equipment at the access aggregation node. As several customers are connected to the same splitter (e.g. 8, 16 or 32), the capacity for each PON connected to the OLT is shared between them.

Figure A2.5: Fibre to the premises passive optical network



Source: Ofcom.

A2.23 Initial PON deployments generally use gigabit PON technology (GPON), with speeds of 2.5Gbit/s downstream and 1Gbit/s upstream. While the majority of FTTP deployments are GPONs, the expectation is that these can be upgraded fairly straightforwardly to faster 10Gbit/s systems (e.g. XG-PON).[48] This can be done as demand for faster speeds grows and as equipment costs fall and without the need to replace the optical fibres and splitters.

A2.24 GPON capacity is shared, so although peak speeds (typically 1Gbit/s as seen by the customer) may be achieved in short bursts (peak speeds), the average capacity available to an end-user may be less. The maximum average speed depends on the number of active users on the network at any one time. For example, the Openreach FTTP 1000/220 GPON product offers peak speeds of 1Gbit/s downstream – 220Mbit/s upstream, although the average speed at peak times is likely to be nearer the prioritised rate of 330Mbit/s downstream – 110Mbit/s upstream.[49] Other FTTP networks may be configured to have fewer users connected and so can offer higher average speeds.

A2.25 To take advantage of these high-speed, high capacity, access networks, the backhaul and core networks must be configured to provide sufficient capacity at peak times. Similarly, any services being accessed such as data storage at a data centre must be configured to provide the capacity and speeds needed to meet user demand and avoid capacity bottlenecks in delivering an end-to-end service.

A2.26 FTTP networks, although often used to denote PON networks, can also be deployed using a dedicated point-to-point fibre connection rather than shared across multiple end-users as used in a PON. These point-to-point connections are covered in more detail in the following description of leased lines and, although they can be used to connect to residential customers with high speed requirements, they are generally used to connect to businesses.

Specific characteristics of KCOM's fixed access network in the Hull Area

A2.27 KCOM's residential fixed access network in the Hull Area differs from the equivalent Openreach access network throughout the rest of the UK in a number of ways. KCOM's access network is also evolving.

A2.28 The overwhelming majority of residential premises in the Hull Area are currently served by two fixed access networks from KCOM and therefore (depending on the services they subscribe to) premises could be connected by a legacy twisted-pair copper cable and a

[48] Faster PON systems such as XG-PON and XGS-PON offer 10Gbit/s downstream (X i.e. 10) and 2.5Gbit/s upstream, with XGS-PON also being able to be configured to provide 10Gbit/s symmetric services (S for symmetric). 10G-EPON is an alternative PON system providing 10Gbit/s downstream and is an alternative to, but not compatible with, XG-PON.
[49] The average speed per end-user is often more than the PON capacity divided by the number of users. This is because users with large demands at a point in time can use capacity from users with low demand at that moment - a process known as statistical multiplexing.

fibre-optic cable. These twin cables into each premises are bonded together and referred to as 'shot-gun' cables.[50]

A2.29 The copper lines are used to deliver voice and older, DSL-based broadband services, while the fibre cables deliver KCOM's higher-speed FTTP-based broadband services.

A2.30 KCOM's fixed access network is evolving from an all-copper, circuit-switched PSTN – referred to by KCOM as its 'Stage 1' network (equivalent in all key respects to BT's legacy PSTN) to an all IP FTTP-based network supporting all fixed residential services – its so-called 'Stage 4' all IP FTTP network.

A2.31 This access network evolution, from the Stage 1 legacy PSTN to the target all-IP FTTP network Stage 4, passes through two intermediate stages:

a) 'Stage 2': IP core network with TDM interconnects and legacy copper service delivery to end-users; and

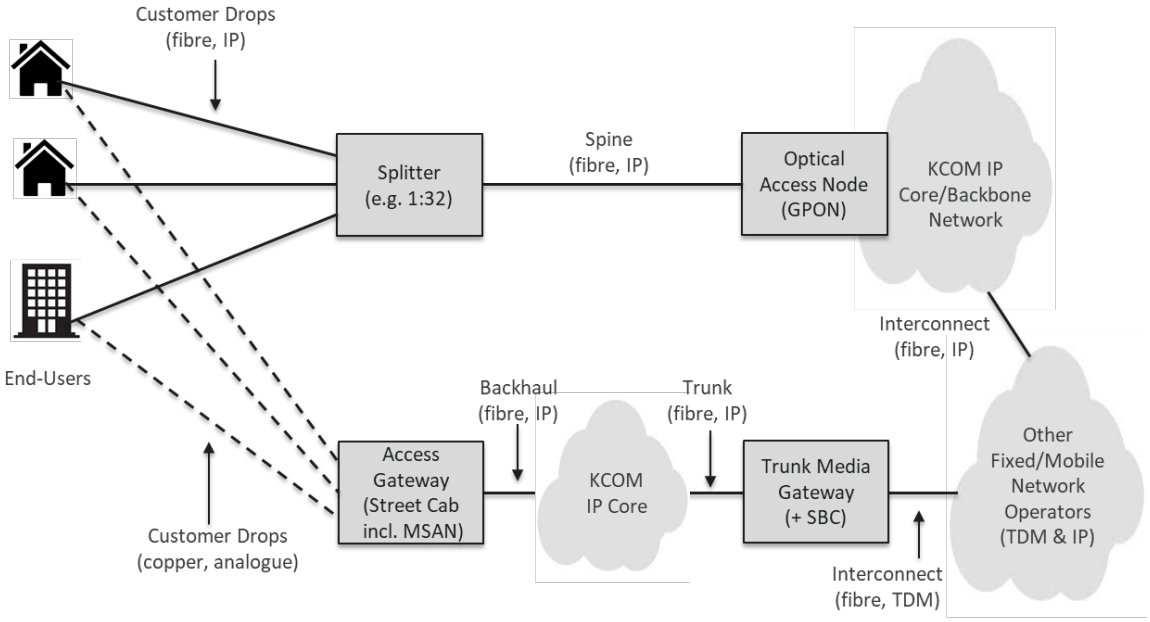
b) 'Stage 3': as per Stage 2, but with TDM interconnects replaced by IP interconnects.

A2.32 KCOM intends to maintain PSTN services until 2025, and like BT, from September 2023, it will no longer install or add lines to existing ISDN or PSTN services. KCOM is currently at Stage 2 of its network evolution, as illustrated in Figure A2.6 below.

A2.33 KCOM's GPON FTTP access network is shown across the top of Figure A2.6, while along the bottom the copper access network is set out. The current Stage 2 network distinguishes itself by having an IP-based core network, with gateway devices on both the end-user access and trunk interconnect sides of the network to convert IP packets to and from legacy analogue, circuit-switched transmission.

[50] An exception to this is new-build estates within the Hull Area where legacy copper cables are not deployed and therefore premises are only served by fibre-optic cables which provide all residential services (such as voice and broadband).

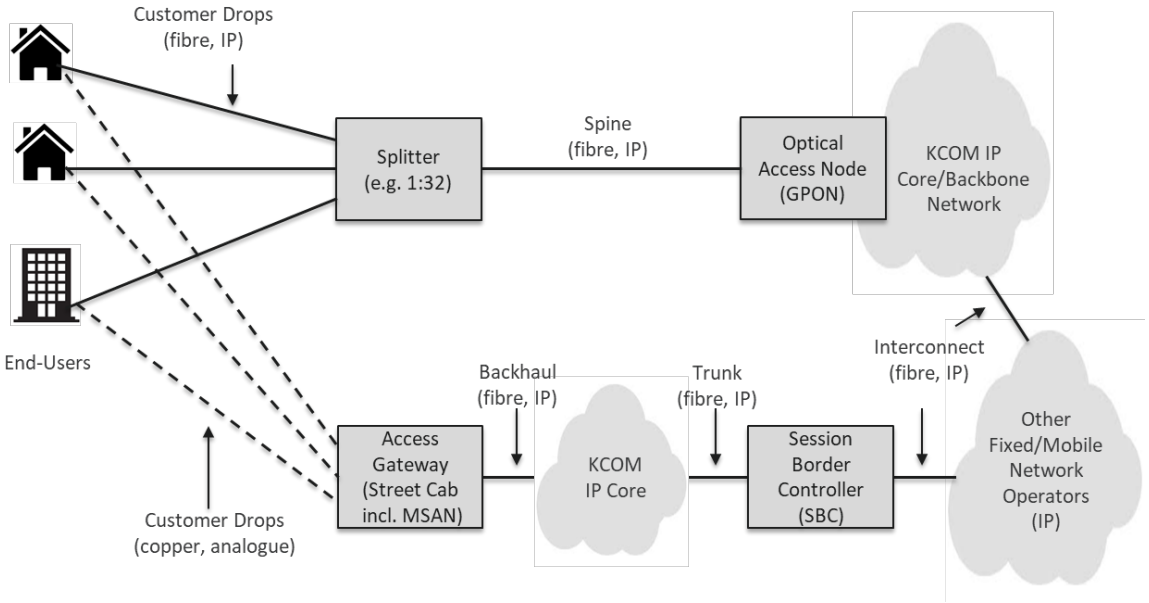
Figure A2.6: KCOM Hull Area access network (Stage 2, current)



Source: Ofcom analysis based on KCOM's s.135 response.[51]

A2.34 Figure A2.7 illustrates Stage 3 of KCOM's access network evolution, which differs from Stage 2 primarily by moving to an IP-based interconnect solution; all other aspects of the network remain unchanged.

Figure A2.7: KCOM Hull Area access network (Stage 3, IP interconnect)

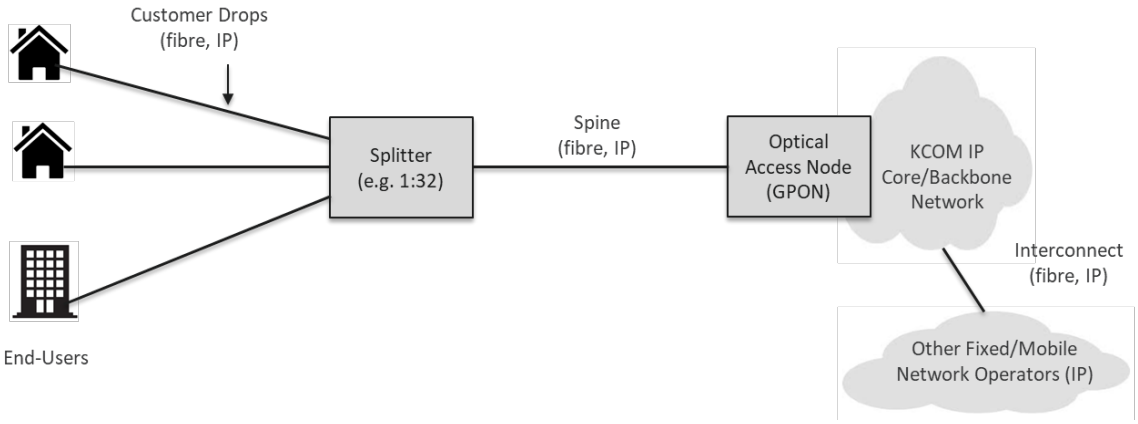


135 response.[52]

[51] KCOM response dated 30 June 2020 to the confirmatory s.135 notice dated 22 June 2020, Ofcom technical teach-in slideset, page 12.
[52] KCOM response dated 30 June 2020 to the confirmatory s.135 notice dated 22 June 2020, Ofcom technical teach-in slideset, page 12.

A2.35 Figure A2.8 shows the intended Stage 4 end-state for KCOM's access network, one based entirely on all services being delivered over the GPON-based FTTP access network, with the legacy copper network no longer in use.

Figure A2.8: KCOM Hull Area access network (Stage 4, all IP)



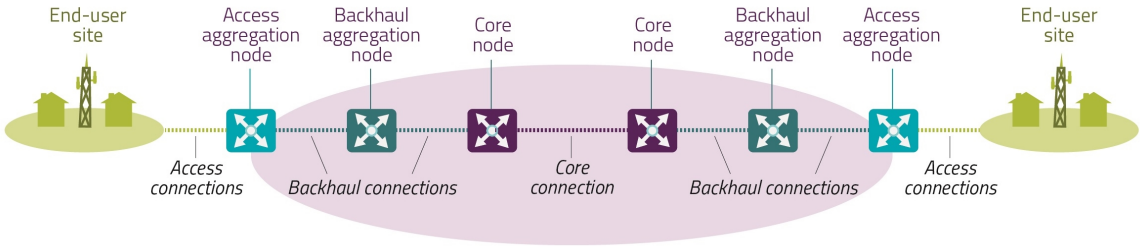
Source: Ofcom analysis based on KCOM's s.135 response.[53]

Leased lines connectivity

A2.36 When considering leased lines services, access, backhaul, and core connections have different functions and are illustrated in the Figure A2.9 below:

- access connections are typically between end-user sites and an access aggregation node or, in some cases, between end-user sites;
- backhaul connections are between access and backhaul nodes, between backhaul nodes (not shown), and from a backhaul aggregation node to a core node; and
- core connections are between core nodes.

Figure A2.9: Access, backhaul, and core connectivity



Source: Ofcom.

A2.37 A leased line network can be configured in several ways, using leased lines as the building blocks, to create an end-to-end service which can be optimised to meet a particular service requirement. We cover the following example configurations:

[53] KCOM response dated 30 June 2020 to the confirmatory s.135 notice dated 22 June 2020, Ofcom technical teach-in slideset, page 12.

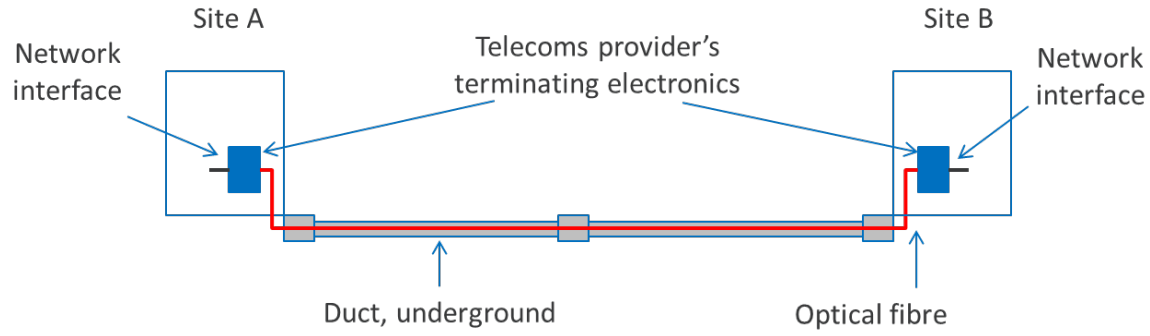
- a dedicated leased line network;
- business virtual private networks (VPNs);
- mobile leased line networks; and
- broadband leased line networks.

A2.38 Leased lines can be significantly more expensive per end-user than broadband services as they are provided over dedicated infrastructure rather than the infrastructure, and costs, being shared by multiple customers.

Leased line overview

A2.39 Leased lines generally use optical fibre to make the physical connection between two points or, increasingly less common, using copper. These connections can be buried directly in the ground, carried overhead, or run as a multi-strand cable inside a duct (as illustrated in Figure A2.10).

Figure A2.10: Structure of a typical leased line[54]



Source: Ofcom.

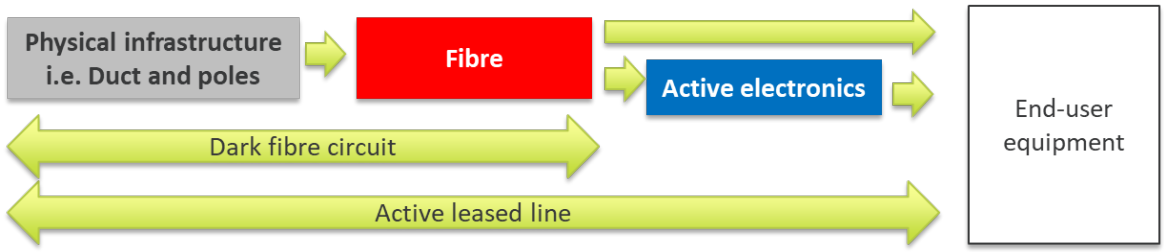
A2.40 Leased lines can be provided by a supplier with or without active electronics. The electronics, whether provided by the supplier or end-user, can use several different technologies such as Ethernet and wavelength division multiplexing (WDM).[55] These technologies are covered in more detail below.

A2.41 A circuit without active electronics is often referred to as a dark fibre connection.[56] The customer creates an active leased line by connecting the dark fibre into their own electronic equipment, eliminating the need for intermediate electronics in the end-to-end circuit. This can give technical benefits such as improved reliability and reduced latency. Customers using dark fibre will need expertise to specify, install, and manage the end-user equipment and fault management on the dark fibre connection.

[54] The route between two points in a network can be referred to interchangeably as circuits or connections.
[55] These types of technologies have also been referred to as contemporary interface (CI) in previous market reviews.
[56] Dark fibre is a term used to describe a fibre optic cable that has not been connected to any electronic equipment. It is called a 'dark fibre' product as the electronic equipment which 'lights' the fibre and enables the circuit to receive and transmit data is not included as part of the dark fibre connection.

A2.42 A leased line can also be created by using third-party physical infrastructure, with the network provider supplying its own fibre cables and electronics to connect to an end-user. The relationship between the building blocks used to provide a dark fibre circuit and an active leased line is shown in Figure A2.11.

Figure A2.11: Main building blocks of a leased line



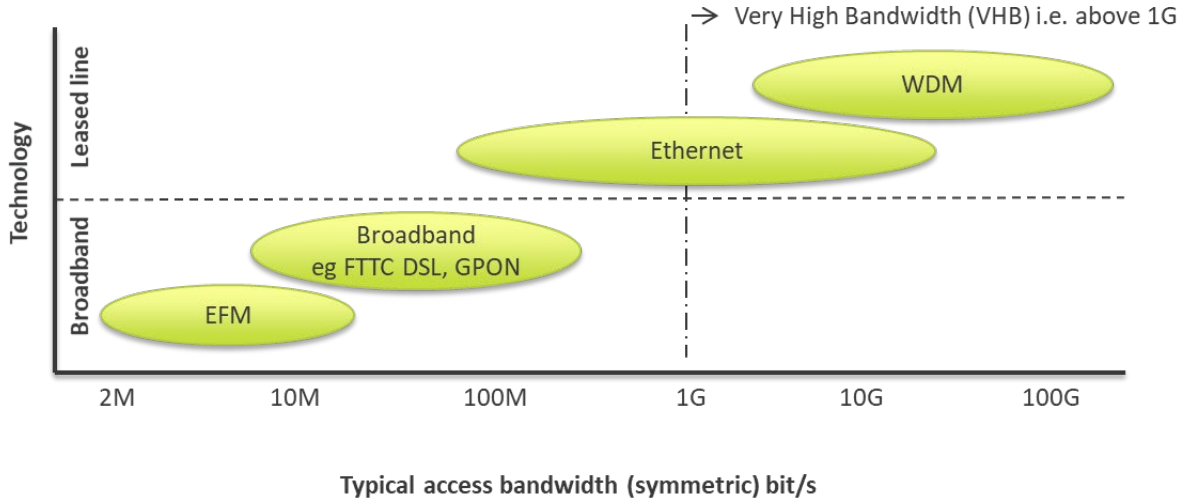
Source: Ofcom.

Leased line technologies

A2.43 The two main types of technology used to deliver leased line products are Ethernet and WDM. Leased lines are typically provided with the equipment, such as Ethernet and WDM, provided by the supplier, or as a dark fibre connection with the equipment to create an end-to-end service provided by the customer.

A2.44 We provide a short overview of Ethernet, WDM, and other leased line technologies below. A stylised picture illustrating the different range of symmetric speeds that can typically be achieved by these technologies is shown in Figure 2.12.

Figure A2.12: Stylised summary of business connectivity services by bandwidth[57] and technology



Source: Ofcom.

[57] For broadband, the diagram uses the upstream speed as a proxy for the maximum symmetric speed available e.g. a 20Mbit/s upstream, 80Mbit/s downstream product could be used as the basis for a 20Mbit/s symmetric product.

Ethernet

A2.45 The widespread use of Ethernet services and the availability of Ethernet equipment means that Ethernet is the preferred technology for the majority of installed leased line circuits in the UK. Point-to-point leased lines are generally based on Ethernet standards[58] and are specified by bandwidth (e.g. 100Mbit/s, 1Gbit/s or 10Gbit/s).[59] Ethernet leased lines are typically delivered over fibre and changing the bandwidth involves changing, or reconfiguring, the electronics at both ends. For example, KCOM provides leased line Ethernet services using its range of EDAS (Ethernet Direct Access Direct Service) and ECAS (Ethernet Connect Access Service) products.

Wavelength division multiplex (WDM)

A2.46 WDM is also a fibre-based technology with features suited for high capacity routes (e.g. between core nodes and to data centres) and for higher capacity backhaul connections. WDM is a technology that uses different wavelengths (colours) of light to create separate virtual circuits over the same fibre, or pairs of fibre. WDM circuits generally require electronics and optical lasers built to a higher specification than lower speed circuits.

A2.47 WDM is particularly attractive where demand is expected to grow over time, as extra capacity can be provided quickly without the need to add more fibres. Once the first circuit is installed, additional circuits can be added simply by adding or lighting an extra wavelength. WDM also offers more flexibility for customers by supporting data transmission technologies other than Ethernet.[60] Different transmission technologies can run over different wavelengths on a single fibre. WDM supports network sharing by allowing different wavelengths to be allocated to different end users.

A2.48 WDM systems can provide capacity from 10Gbit/s to as much as 400Gbit/s. For example, KCOM offers a WDM product called OWAS (Optical Wave Access Service), which comes with up to two managed 10Gbit/s Ethernet service and access to 14 wavelengths to which the telecoms provider can add their own termination equipment.

Other technologies

A2.49 Ethernet over broadband can be used to emulate lower speed, point-to-point leased line connections. However, this technology shares capacity among multiple users, rather than providing a dedicated point-to-point service. Ethernet over broadband is an asymmetric service, meaning speeds are generally limited by the upstream capability of the technology. For example, a shared fibre GPON service can provide a 100-300Mbit/s

[58] Ethernet as a technology is described by a set of standards (e.g. 802.3) organised by the Institute of Electrical and Electronics Engineers (IEEE). More information can be found at the IEEE Standards website [accessed 19 October 2021]. These standards cover many things including: how the data is structured, the transmission medium used (copper, fibre, wireless), and the bandwidth speeds (e.g. 100Mbit/s, 1Gbit/s, 10Gbit/s).
[59] 100Mbit/s Ethernet services can also support legacy 10Mbit/s speeds, using a feature known as '10/100 autosensing'.
[60] WDM can support a wide range of data transmission technologies including Ethernet, Fibre channel, and legacy technologies such as SDH (e.g. Cisco, 2000. Introduction to DWDM technology [accessed 19 October 2021]).

symmetric-like service,[61] with "burstable" download and upload speeds of, typically, 1Gbit/s.

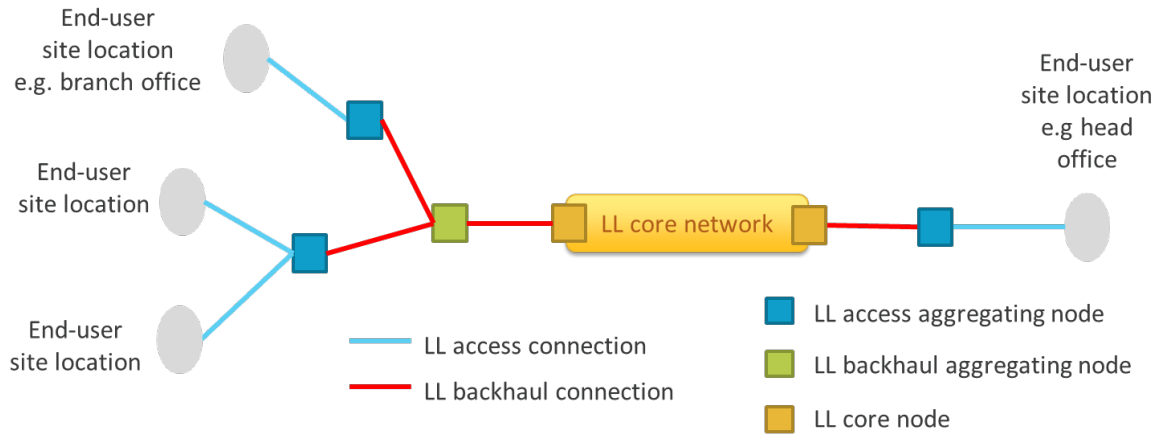
A2.50 Ethernet in the first mile (EFM) is a copper-based technology, offering speeds typically in the range of 20-30Mbit/s. EFM relies on access to BT's copper access network (via the local loop unbundling remedy), which is available at all BT exchanges. However, the availability of EFM is typically limited to larger exchanges where business site density is higher. EFM is not suitable for backhaul or core connections. These services are being superseded by Ethernet over broadband.

Leased line networks

Dedicated leased line network

A2.51 A dedicated leased line network (see Figure A2.13) provides dedicated end-to-end connectivity used as a closed network i.e. circuits are not shared. This model is becoming less common but may still be used when security or network features, such as low end-to-end latency, are a key concern. These networks have mainly been superseded by VPNs (see Figure A2.14 further below).

Figure A2.13: Dedicated end-to-end connectivity



Source: Ofcom. LL is short for leased line.

Business VPNs

A2.52 Business VPNs provide any-to-any connections between multiple business sites which can be spread over a wide geographic area (see Figure A2.14). These networks are likely to include internet connectivity and connections to outsourced cloud computing services.

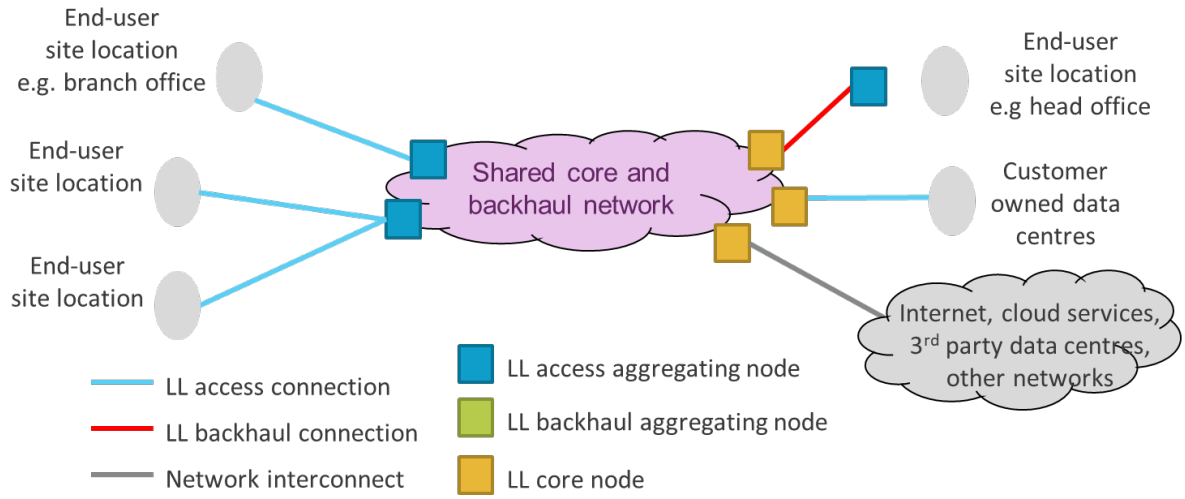
A2.53 Figure A2.14 also shows the end-user sites connected with leased lines to provide high speed dedicated capacity. Although not shown, end-user sites can also be connected using a business broadband connection where a high-speed high-quality connection may be of less importance – such as to a small branch office.

[61] For a PON, the upstream shared capacity is determined by the number of users connected to the PON which can typically be between 8 and 32, depending on the PON design and the number of users active at any one time.

A2.54 Unlike a dedicated leased line network, a VPN shares backhaul and core capacity across multiple business customers. The same core and backhaul network may also be used to carry traffic for other services such as broadband and mobile. The data for each customer is separated using virtual paths on a shared physical connection, and so appears as a "private" network from a customer's perspective.

A2.55 Access to cloud-based services such as data storage, application hosting, and data processing can also be provided as part of an overall service. Although Figure A2.14 shows a single connection to this cloud, these services can be placed nearer to the customers' access connections (such as at core nodes) to improve reliability, reduce core capacity requirements, and speed up response times. This can be referred to as edge or distributed computing.[62]

Figure A2.14: Business VPN with internet & cloud computing connectivity



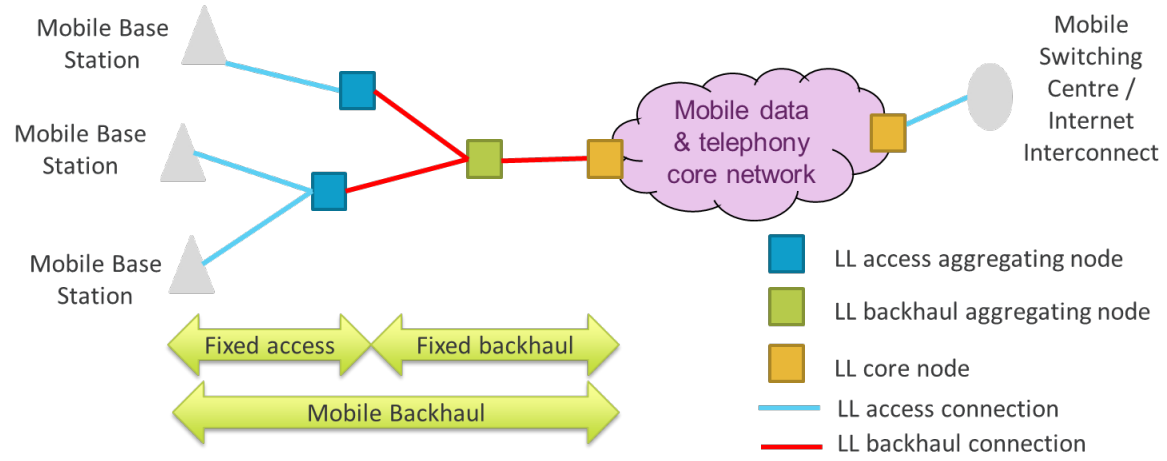
Source: Ofcom. LL is short for leased line.

Mobile leased line networks

A2.56 Leased lines can be used by mobile network operators (MNOs) to connect their base stations[63] to their core network nodes using access and backhaul connections (see Figure A2.15).[64] The term 'mobile backhaul' is often used to refer to the combination of access and backhaul leased line connections between the mobile base station and the mobile core node. MNOs may also use leased lines to provide connectivity between their core sites, and connections to the internet and other networks, to support mobile services.

[62] Content distribution networks for video streaming as part of a broadband network is another example where network access is placed nearer to the customer rather than being centralised.
[63] These are the radio masts that provide the communications between the mobile handset and the fixed mobile network.
[64] In this example, the baseband mobile controllers (or baseband units) are placed at the mobile base station i.e. a distributed radio access network (DRAN) typical of 4G architectures. Where the baseband controller is placed away from the base station, say at an aggregation node, the link between the more centralised baseband controller and the mobile base station site antenna is known as "fronthaul" forming part of a centralised radio access network (CRAN) architecture.

Figure A2.15: Mobile network connectivity



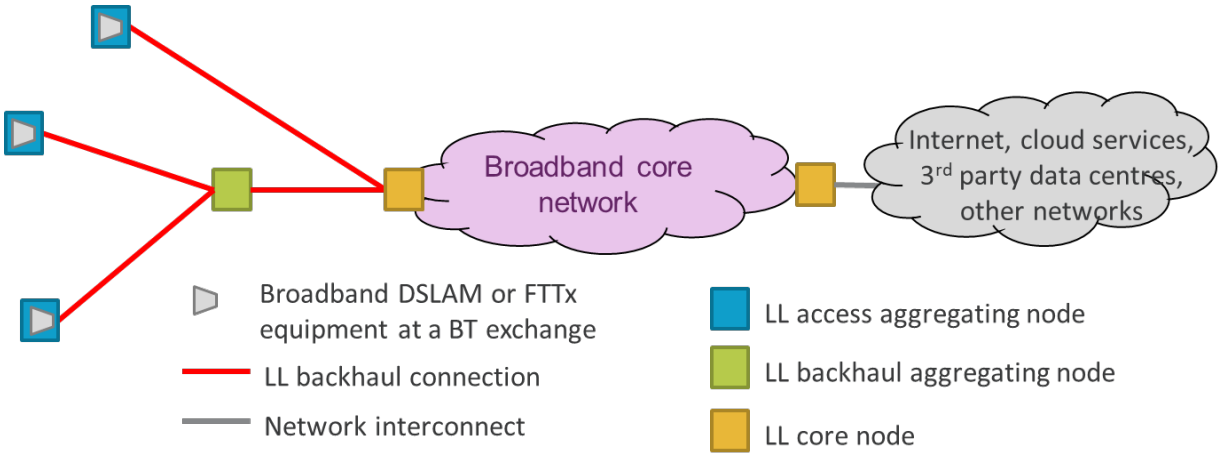
Source: Ofcom. LL is short for leased line.

A2.57 The term mobile backhaul can be a source of confusion. Mobile backhaul is often used by MNOs to refer to both the fixed access and fixed backhaul leased line connections (i.e. the arrow labelled 'mobile backhaul' in Figure A2.15). For other fixed network customers, backhaul is used to refer to the connections from fixed access aggregation nodes to, or between, backhaul aggregation nodes (i.e. the arrow labelled 'fixed backhaul').

Broadband leased line networks

A2.58 Fixed broadband operators can build their own broadband network using leased lines to create core and backhaul networks which are then connected to broadband access connections (see Figure A2.16). This is sometimes referred to as local loop unbundling (LLU) backhaul. An operator may choose to build their own access connections (for example Virgin Media's network) or use access network connections owned by another operator such as BT.

Figure A2.16: Broadband network connectivity



Source: Ofcom. LL is short for leased line.

A2.59 For example, a broadband operator may site their network equipment to connect to BT's access network (i.e. their access aggregating node) at a BT local exchange. These are then connected to a core and backhaul network which can be connected to the internet at suitable locations to provide an end-to-end broadband service. This is illustrated in Figure A2.16. As with VPNs earlier, the core and backhaul network may also carry traffic for other access services such as high-quality leased line services.

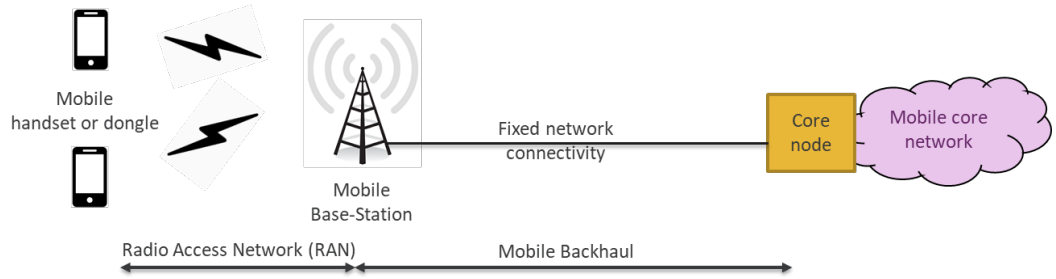
Wireless technologies

A2.60 The previous discussion describes networks that provide services at a fixed end-user location using a wired (either copper, coaxial cable or fibre) connection all the way. Services can also be connected to end-users using wireless technology: mobile, fixed wireless access (FWA), and satellite which we discuss below.

Internet access over a mobile network

A2.61 Use of mobile data services can be a convenient way for customers to access the internet and can be used as an alternative to fixed broadband. Customers in this category can connect to a 4G or 5G mobile network using their mobile phone, a dongle or similar equipment (Figure A2.17).

Figure A2.17: Typical mobile network topology



Source: Ofcom.

A2.62 While very high speeds are possible, due to the shared nature of the network and the fact that speed will depend on the quality of signal being received, speeds are likely to be much lower in many cases. On a 4G network, these could typically be around 30Mbit/s on average, and on its 5G network, around 150Mbit/s.

A2.63 Mobile coverage is another factor that needs to be considered, with coverage poorest in more rural areas. Although 91% of the UK has good 4G coverage from at least one operator, 5G is not as widespread yet. Within Hull, 5G was installed by EE in December 2019,[65] followed by O2, and made available by other major operators,[66] with the footprint expected to be expanded over time to more rural areas around Hull in line with national roll out plans.

[65] HullCCNews, 2019. 5G switched on in Hull as UK's most digitally connected city gets new mobile tech [accessed 19 October 2021].
[66] 5G.co.uk, 2021. 5G Coverage and Rollout [accessed 19 October 2021].

FWA

A2.64 FWA networks use a wireless link for the final connection to a fixed point at the customer's site. This avoids the need to install a cable (a fixed access connection) between the customer and a broadband or leased line network. It is therefore suited to, for example, situations where a fixed access connection is not available or is relatively expensive to provide.

A2.65 FWA services can be grouped into two broad categories:

- services using existing licensed 4G and 5G mobile spectrum (i.e. over a mobile 4G/5G network), provided alongside other **point-to-multipoint** mobile voice and internet services. These tend to be used for residential customers or for small businesses where price and convenience are likely to be the main considerations.
- services using light-licensed and license-exempt spectrum using **standalone point-to-point, point to multi-point connections, or multipoint mesh connections**.[67,68] These types of connections are particularly useful in more remote, difficult to reach areas where fixed network coverage may be poor and where FWA can be an attractive solution. For example, they can be used to provide residential broadband connections, connections to business sites, and connections to (and between) mobile base stations.

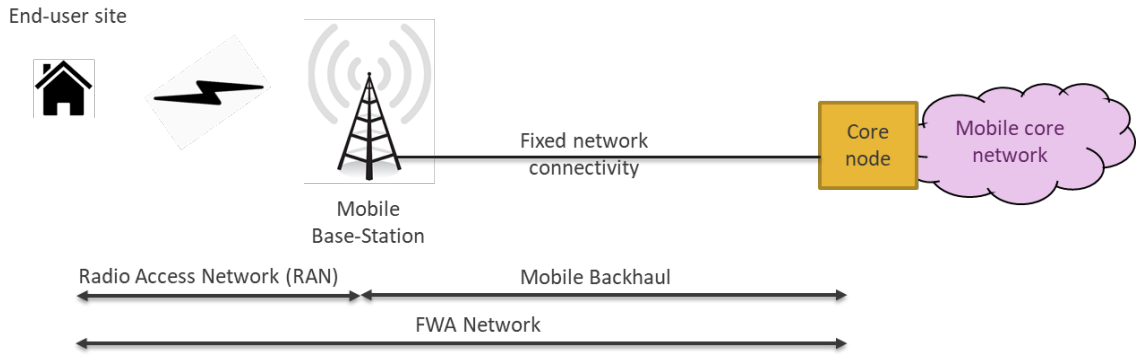
4G/5G FWA

A2.66 FWA over 4G/5G provides a connection between a mobile base station and receiving equipment at the customers' sites (Figure A2.18). This type of service shares many of the characteristics with mobile broadband described in the previous text but optimised for home usage. For example, the receiving equipment can be placed at a suitable fixed location within a customer's site to allow connections to customer equipment (e.g. smart TVs, computers) and to enable WiFi connectivity.

A2.67 The receiving equipment is usually mains powered and provide a better in-home WiFi experience compared to a smaller portable mobile WiFi router. These powered routers generally use an integral internal antenna for receiving the 4G/5G signal, although many routers have the option for connecting to an external router if required.

[67] Point-to-point FWA connections are sometimes referred to as microwave links.
[68] Ofcom, 2018. Statement: Review of spectrum used by fixed wireless services, section 2 [accessed 19 October 2021].

Figure A2.18: Typical 4G/5G FWA network topology



A2.68 As discussed for mobile internet access, depending on traffic and capacity in the network, speeds can vary and are currently around 30Mbit/s for 4G and 150Mbit/s for 5G for an average user experience.[69] In addition, and as discussed earlier, coverage for 4G services is poorest in rural areas and 5G coverage, although expanding, has limited reach.

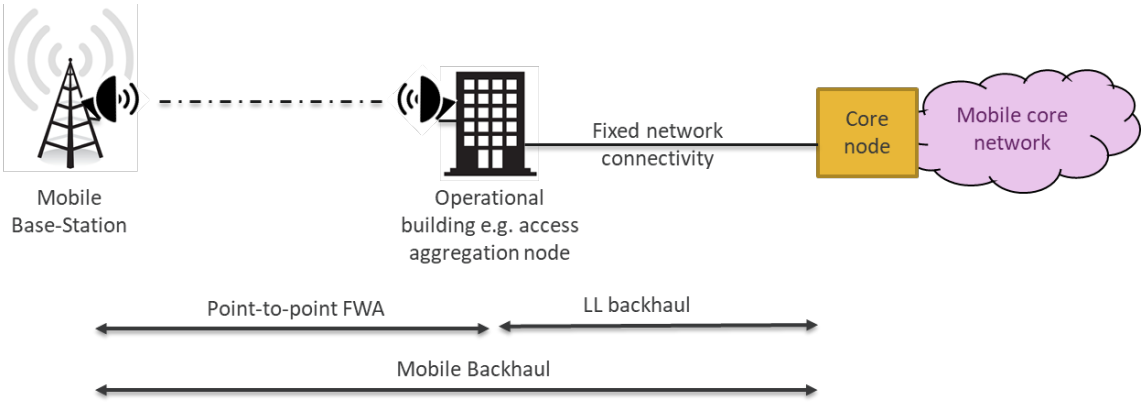
Point-to-point and point-to-multipoint FWA

A2.69 Point-to-point and point-to-multipoint FWA services can be provided using lightly-licensed and license-exempt spectrum such as the 5 GHz, 23-26 GHz and more recently, the 65 GHz bands.[70] These services are "line of sight" between the network and end-user and so can be difficult to deploy in built up areas. As a result, this type of FWA service are less likely to be found in built up areas such as city centres.

A2.70 Figure A2.19 shows a point-to-point FWA being used for connecting a mobile base station to an access aggregation node as part of mobile backhaul network.[71] These point-to-point connections tend to be used for higher speed connections, using the spectrum bands above 5 GHz. For point-to multipoint service, an antenna array at the operational building (which can serve multiple customers) is used to connect to fixed external antennas at the end-user site and tend to rely on the 5 GHz license exempt spectrum.

[69] See, for example, see EE's average download speeds as summarised in Ofcom, December 2020. Connected Nations 2020 UK Report, page 19 [accessed 19 October 2021].
[70] 26 GHz is used currently for point to point FWA services. However, Ofcom is working towards making 26 GHz band available as a "global pioneer" band for 5G. Users of FWA should therefore consider alternative fixed wireless link bands to meet their requirements where possible. This is set out in Ofcom, 2018. Statement: Review of spectrum used by fixed wireless services, page 33 and 34. [accessed 19 October 2021].
[71] Connections from a mobile base station to one or more remote base stations can also be configured as a "daisy-chain", as part of a resilient ring.

Figure A2.19: Example of point-to-point FWA used for mobile backhaul



Source: Ofcom. LL is short for leased line.

A2.71 Using an FWA microwave link for connecting base stations to a mobile network can be a useful alternative to a fixed access connection, particularly in more remote, difficult to reach areas where coverage may be poor. FWA can also be used in other situations, such as residential broadband connections – particularly using point-to-multipoint equipment - and connections to business sites. These residential point-to-multipoint services tend to be supplied by specialists, sometimes referred to as "WISPs" (wholesale internet service providers).

A2.72 Higher speed FWA connections typically use the 23-26 GHz band for links of up to 1Gbit/s and are generally used in a point-to-point configuration. The more recent 65 GHz band can potentially offer speeds of 10Gbit/s. However, compared to a leased line, microwave links have several limitations such as:[72]

- ability to support lower capacity links compared to fibre based backhaul;
- requirement for line of sight connectivity;
- significantly lower transmission range than fibre-based backhaul links; and
- higher risk of failure because microwave antennas are exposed.

A2.73 As highlighted, FWA is distance limited compared to a fixed access connection, decreasing as frequencies (and signal attenuation) increases. In addition, lower bands, such as 5 GHz, are commonly prone to interference from nearby services, such as WiFi, operating on the same frequencies. Higher frequencies (e.g. above 11 GHz) also can also be affected by environmental conditions (e.g. rain, ice).

A2.74 Residential and small office offerings are also available offering speeds up to 50Mbit/s using point-to-multipoint 5 GHz technology. Most packages have data caps, although more expensive packages offer higher or unlimited data. These FWA services usually come with setup fees which can vary quite significantly (e.g. £30-200 depending on the service used and the provider).

[72] Ofcom, 2019. Statement: Promoting competition and investment in fibre networks – review of the physical infrastructure and business connectivity markets (2019 BCMR Statement), Annex 9 [accessed 19 October 2021].

Multipoint mesh FWA

A2.75 Multipoint mesh FWA services can be provided using the 57-64 GHz band license-exempt spectrum, which is sometimes simply referred to as the 60 GHz band. These types of services use a number of small base stations connected wirelessly along with a shared fixed connection to provide internet access.[73]

A2.76 The availability and deployment of the equipment using mesh FWA services has generally been limited in the UK. Market developments include the release of equipment for the 60 GHz band by Cambium Networks, a vendor used by many WISPs. The Cambium solution uses wireless meshing technology developed by Facebook's Terragraph project service with the potential to deliver gigabit speeds.[74, 75]

A2.77 Although trials have taken place using this mesh technology, such as in Bath and Wales, [76, 77] it is still in early stage of development as a service compared with other existing wireless technologies.

Satellite

A2.78 Satellite coverage is available almost everywhere in the UK, offering an alternative for customers that receive poor broadband, such as those located in remote rural areas.

A2.79 There are two main types of satellite broadband, either a GEO (geostationary earth orbit) satellite or a LEO (low earth orbit) satellite. GEO satellites are fixed at a position on the geostationary belt moving with the Earth as it rotates. They are positioned at a very large distance from the Earth, being able to cover large areas. This results in delays in response times and slow speeds.

A2.80 LEO satellites, on the other hand, are positioned much closer to the Earth, covering smaller areas than GEO satellites and allowing for faster connections. As they are not at a fixed location, a network of hundreds of constantly moving satellites is necessary to provide consistent and constant coverage. In order to track and connect to the best satellite as they move overhead, user terminals require expensive antennas compared to, for example, fixed broadband network terminating equipment (e.g. routers).

A2.81 GEO satellite services tend to offer services with lower bandwidth than fixed broadband services, typically 30Mbit/s or less. In addition, traditional GEO satellite services have higher latency than fixed broadband services.[78] This could affect some users who have requirements for low latency, e.g. customers wishing to make VoIP calls or gamers.

A2.82 Performance could be improved with the use of LEO satellites. Although not all are currently available as a commercial service, companies like SpaceX, OneWeb and Telesat

[73] CCS Metnet, 2019. Unlicensed, unlimited 60 GHz mmWave [accessed 19 October 2021].
[74] ISPreview, 2020. Cambium Networks Launch 60GHz multi-Gigabit Wireless Tech [accessed 19 October 2021].
[75] Ofcom, 2020. Connected Nations 2020 UK Report, page 24 [accessed 19 October 2021].
[76] ISPReview, 2019. Rural wales wireless broadband trial hits near gigabit speeds [accessed 19 October 2021].
[77] Cambridge Wireless, 2018. CCS 60GHz mmWave trial goes live in city of Bath [accessed 19 October 2021].
[78] Latency refers to the time taken for data to traverse the network. Geo-stationary satellites tend to have high latency due to the signal having to travel the long distance to and from the satellite.

have already launched LEO constellations for broadband. For example, Space X has launched more than 1,600 LEO satellites as of August 2021, with its Starlink services currently being trialled in the UK and around the world.[79] In theory, LEO satellites will offer low latency and higher speeds compared to GEO services, ranging from 100Mbit/s to gigabits per second.

A2.83 Compared to GEO services, upfront charges for equipment are likely to be similar for LEO services, with customer terminal costs of £400-£600, but with higher rental prices.[80] Whilst the new LEO satellites are expected to deliver increased performance compared to traditional satellite broadband, it is not yet clear that whether it will be sufficient to move from being a valuable solution for some customers, such as in hard to reach areas, to being a mainstream service and alternative to fixed broadband.

[79] ISPReview, Starlink Sets Tentative Plans for Gen2 LEO Broadband Satellites [accessed 19 October 2021].
[80] For example, Freedomsat charges £395 plus shipping for hardware and installation, with monthly fees from £25.00 to £169.50 (Freedomsat, 2021. Satellite broadband for the home [accessed 19 October 2021]). Starlink charges £439 plus shipping for hardware, with an £89 monthly service fee (Starlink, 2021. Order Starlink [accessed 19 October 2021]).

A3. Glossary

A3.1 This glossary provides a brief explanation of terms used throughout this statement and is provided for convenience.

Term	Description
Active leased lines	Permanently connected communications links between two sites, dedicated to the customers' exclusive use, and provided with active electronics at either end of the connection.
Additional Financial Information (AFI)	Detailed financial information provided in confidence to Ofcom as part of KCOM's Regulatory Financial Statements.
Backhaul	Transmission links, typically between access and core elements within a network.
Bandwidth	The rate at which data can be transmitted. Usually expressed in bits per second (bit/s).
Bearer	A transmission link that carries one or more multiplexed smaller capacity connections.
BEREC	Body of European Regulators for Electronic Communications.
Current Cost Accounting (CCA)	An accounting convention, where assets are valued and depreciated according to their current replacement cost while maintaining the operating or financial capital of the business entity.
Contemporary Interface (CI)	A set of modern technologies used for delivery of leased lines services (e.g. Ethernet or wavelength-division multiplexing).
Dark fibre	A service which allows telecoms providers to lease only the fibre element of leased lines from a supplier, allowing them to attach equipment of their own choosing at either end to 'light' the fibre and use it as the basis for offering a range of leased lines products.
Distribution point	A flexibility point in KCOM's access network to which final connections to customer premises are connected. Usually either an underground joint or a connection point on a pole where dropwires are terminated.
EC	The European Commission.
Ethernet	A frame-based technology originally developed for use in Local Area Networks (LANs) but now also widely used in

	telecoms providers' networks for the transmission of data services.
Ethernet Connect Access Service (ECAS)	KCOM's Ethernet Connect Access Service which comprises Ethernet point to point data circuits (similar to EDAS service but permitted for use where there is onward connection to a point outside of the Hull Area).
Ethernet Direct Access Service (EDAS)	KCOM's Ethernet Direct Access Service which comprises Ethernet point to point data circuits
Excess construction charges	A charge levied by KCOM where additional construction of duct and fibre or copper is required to provide service to customer site.
Exchange	The KCOM telephone exchange, to which customers are directly connected.
Fibre to the Cabinet (FTTC)	An access network structure in which the optical fibre extends from the exchange to the street cabinet. The street cabinet is usually located only a few hundred metres from the subscriber's premises. The remaining part of the access network from the cabinet to the customer is usually copper wire but could use another technology, such as wireless.
Fibre to the Premises (FTTP)	An access network structure in which the optical fibre network runs from the local exchange to the end-user's house or business premises. The optical fibre may be point-to-point (there is one dedicated fibre connection for each home) or may use a shared infrastructure such as a GPON. Sometimes also referred to as Fibre-to-the-home (FTTH), Fibre to the Business (FTTB) or full-fibre.
Fixed Wireless Access (FWA)	An access service where the connection between the network and the equipment located at the customer premises is provided over the radio access medium.
Fully Allocated Cost (FAC)	An accounting approach under which all the costs of the company are distributed between its various products and services. The fully allocated cost of a product or service may therefore include some common costs that are not directly attributable to the service.
Gbit/s	Gigabits per second (1 Gigabit = 1,000,000,000 bits). A measure of bandwidth in a digital system.
Gigabit Passive Optical Network (GPON)	A shared FTTP network technology.

Hull Area	The area defined as the "Licensed Area" in the licence granted on 30 November 1987 by the Secretary of State under section 7 of the Telecommunications Act 1984 to Kingston upon Hull City Council and Kingston Communications (Hull) plc (KCOM).
Integrated Services Digital Network (ISDN)	A digital telephone service that supports telephone and switched data services.
kbit/s	Kilobits per second (1 kilobit = 1,000 bits). A measure of bandwidth in a digital system.
KCOM Line Rental (KLR)	A line rental product covering analogue lines, ISDN2 and ISDN30.
KPIs (Key Performance Indicators)	Specified information to be provided for the purposes of assessing performance and providing transparency of service provision by a dominant provider.
Latency	A measure of delay in transmission over a transmission path.
Leased lines	Permanently connected communications links between two sites dedicated to the customers' exclusive use.
LL Access	Leased lines access.
Local Loop Unbundling (LLU)	A process by which a dominant provider's local loops are physically disconnected from its network and connected to competing providers' networks. This enables operators other than the incumbent to use the local loop to provide services directly to customers.
Main Distribution Frame (MDF)	A wiring flexibility frame where copper local loops are terminated and interconnected.
Mbit/s	Megabits per second (1 Megabit = 1 million bits). A measure of bandwidth in a digital system.
Mobile Network Operator (MNO)	A provider which operates a cellular mobile network.
Modified greenfield approach	An approach to analysing markets, where we consider a hypothetical scenario in which there are no *ex ante* SMP remedies in the market being considered or in any markets downstream of it.
Metallic Path Facility (MPF)	The provision of access to the copper wires from the customer site to a KCOM MDF that covers the full available frequency range, including both narrowband and broadband channels, allowing a competing provider to provide the customer with both voice and/or data services over such copper wires.

Net Current Assets (NCA)	A measure of the amount of capital being used in day-to-day activities by the company. It is equal to current assets less current liabilities.
NICC	A technical forum for the UK communications sector that develops interoperability standards for public communications networks and services in the UK. It is an independent organisation owned and run by its members. Ofcom participates in NICC as an observer.
ODF Site	The site of an operational building of the provider with significant market power that houses an optical distribution frame.
Physical Infrastructure Access (PIA)	A remedy requiring KCOM to provide telecoms providers with access to its physical infrastructure (i.e. ducts and poles).
Passive Optical Network (PON)	A point to multipoint fibre-optic network architecture that uses passive optical splitters.
Point of presence (PoP)	A node in a telecoms provider's network (such as an exchange or other operational building), generally one used to serve customers in a particular locality.
Public Switch Telephony Network (PSTN)	The telephony network used to provide telephone calls using (or emulating) circuit-switching and using telephone numbers to identify subscribers or called locations, allowing all customers connection to the network to call all other customers.
Pricing Transparency Report (PTR)	A report detailing the charges that a telecoms provider makes to its customers for certain services.
Quality of Service (QoS)	A measure of the performance of the dominant provider's wholesale access service operations such as the installation of new connections and repair of faulty connections.
Resellers	Resellers are telecoms providers that buy retail-minus products from KCOM and resell these products under a white-label arrangement, predominantly to business customers. Resellers provide aspects such as billing and customer service, but do not provide any technical elements.

Regulatory Financial Statements (RFS)	The financial statements that KCOM is required to prepare by Ofcom. They include the published RFS and AFI provided to Ofcom in confidence.[81]
Reference Offer (RO)	A document or set of documents published by a telecoms provider setting out matters such as the product definition, technical specifications, the terms and conditions for provisioning, SLAs and SLGs, and availability of other related services such as accommodation.
Rest of the UK (RoUK)	The geographic markets set out in the 2021 WFTMR Statement which exclude the Hull Area.
Service Level Agreement (SLA)	A contractual commitment provided by KCOM to telecoms providers about service standards.
Service Level Guarantee (SLG)	A contractual commitment by KCOM to telecoms providers specifying the amount of compensation payable by KCOM to a telecoms provider for a failure to adhere to an SLA.
Significant Market Power (SMP)	Where an undertaking in the relevant market is in a position of economic strength affording it the power to behave to an appreciable extent independently of competitors, customers, and ultimately consumers.
Statement of Requirement (SoR)	A KCOM process for submission and processing of requests for product/service enhancements.
Small but Significant Non-transitory Increase in Price (SSNIP) test	An element of the hypothetical monopolist test used in market definition analysis, in which the competitive constraints posed by potential substitutes for the service in question are tested by considering switching to the substitutes if the price of the service was increased by a small but significant non-transitory amount (often 5 to 10 per cent).
Time Division Multiplexing (TDM)	A method of combining multiple data channels for transmission over a shared transmission path by means of time-sharing. The multiplexor shares the transmission path by repeatedly allowing each data channel in turn to transmit data for a short period.
Telecoms provider	An organisation which provides an electronic communications network or provides an electronic communications service.

[81] See KCOM, 2021. Regulatory accounts [accessed 19 October 2021].

Third Party	A person, other than KCOM, providing a public electronic communications service or a person providing a public electronic communications network
Voice Over Internet Protocol (VoIP)	A technology for encoding and transmitting voice calls over IP fixed and mobile networks.
Virtual Private Network (VPN)	A technology allowing users to make inter-site connections over a public telecommunications network that is software partitioned to emulate the service offered by a physically distinct private network.
Wholesale Broadband Access (WBA) market	The WBA market concerns the wholesale broadband products that telecoms providers provide for themselves and sell to each other.
Wholesale Call Origination (WCO)	Wholesale fixed call origination services.
Wavelength Division Multiplex (WDM)	An optical frequency division multiplexing transmission technology that enables multiple high capacity circuits, to share an optical fibre pair by modulating each on a different optical wavelength.
Wholesale Fixed Analogue Exchange Lines (WFAEL)	A narrowband analogue access connection between a customer's premises and a local exchange.
Wholesale FibreLine Local Access (WFLLA)	KCOM fibre-based wholesale line access service.
Wireless Internet Service Provider (WISP)	An telecoms provider using unlicensed/lightly licensed spectrum to deliver a wireless broadband connection to a fixed location.
Wholesale Local Access (WLA)	The provision of broadband and telephony services at a fixed location from a point of aggregation of subscriber connections to a home or business premises.
5G	The term used to describe the next generation of wireless networks beyond 4G LTE mobile networks. 5G is expected to deliver faster data rates and better user experience.

A4. Sources of evidence

A4.1 We have noted throughout this statement the external evidence we have collected to inform our analysis and how we have relied upon that evidence. This annex provides a list of the main sources of external evidence used and, where possible, the web links to where that information is published online.

A4.2 While this annex lists the main evidence we have relied upon, the list is for convenience only and is not intended to be exhaustive.

Consultation responses

Responses to the July 2020 Consultation on the Hull Area Wholesale Fixed Telecoms Market Review 2021-26

A4.3 On 16 July 2020, we published a consultation (2020 Hull Area WFTMR Consultation), setting out our proposals for the regulation of two markets in the Hull Area from 2021 to 2026.

A4.4 Nine stakeholders provided written responses to this consultation:

- Connexin
- Federation of Communications Services (FCS)
- Hull City Council
- KCOM
- Purebroadband
- Vodafone
- Three respondents whose names are withheld.[82]

A4.5 Where available, we have published non-confidential versions of the responses from the stakeholders listed above. These can be found on our website.

Information gathered using statutory powers

A4.6 During this market review, we have issued several notices under section 135 of the Communications Act 2003 requiring various telecoms providers to provide specified information as set out in the relevant notice. We have set out the information requests below by stakeholder.

A4.7 We also wrote to various telecoms providers notifying them that we intended to base some of analysis on information derived partly from data submitted to us previously as part of other information gathering processes. We have set out these notification letters below by stakeholder.

[82] This includes two emails which we received from private individuals after the closure of our consultation in September 2020.

Information requests

Notice addressed to and response received from CityFibre Infrastructure Holdings Limited.

A4.8 Notice of 31 January 2020 regarding CityFibre's network, use of PIA, connections, requests for network access, business strategies and research. Response received on 21 February 2020.

Notice addressed to and response received from Connexin Limited.

A4.9 Notice of 29 January 2020 regarding products, requests for network access and business strategies. Response received on 19 February 2020.

Notice addressed to and response received from Daisy Group Holdings Limited.

A4.10 Notice of 28 February 2020 regarding products, requests for network access and business strategies. Response received on 20 March 2020.

Notice addressed to and response received from Excel Telecom Limited.

A4.11 Notice of 24 January 2020 regarding products, requests for network access and business strategies. Response received on 24 February 2020.

Notices addressed to and responses received from KCOM Group Limited.

A4.12 Notice of 8 January 2020 regarding KCOM's network, products, PSTN migration plans, requests for network access, market research and business strategies. Responses received on 27 January 2020 and 3 February 2020.

A4.13 Notice of 22 June 2020 regarding confirmation of information previously submitted. Responses received on 29 June 2020 and 30 June 2020.

A4.14 Notice of 7 October 2021 regarding confirmation of information previously submitted. Response received 14 October 2021.

Notice addressed to and response received from MS3 Networks Limited.

A4.15 Notice of 31 January 2020 regarding MS3's network, use of PIA, products, requests for network access, business strategies and research. Response received on 22 June 2020.

Notice addressed to and response received from Purebroadband Limited.

A4.16 Notice of 29 January 2020 regarding products, requests for network access and business strategies. Response received on 14 February 2020.

Notice addressed to and response received from Quickline Communications Limited.

A4.17 Notice of 5 February 2020 regarding products, requests for network access and business strategies. Response received on 26 February 2020.

Notice addressed to and response received from River Business Services Limited.

A4.18 Notice of 24 January 2020 regarding products, requests for network access and business strategies. Response received on 18 February 2020.

Notice addressed to and response received from The One Point Limited.

A4.19 Notice of 29 January 2020 regarding products, requests for network access and business strategies. Response received on 18 February 2020.

Notice addressed to and response received from Wisper Broadband Limited.

A4.20 Notice of 11 February 2020 regarding products, requests for network access and business strategies. Response received on 24 February 2020.

Notification letters

A4.21 Letter to BT Group plc dated 10 June 2020 regarding information provided in response to a statutory notice dated 5 December 2019.

A4.22 Letter to Sky UK Ltd dated 10 June 2020 regarding information provided in response to a statutory notice dated 6 December 2019.

A4.23 Letter to TalkTalk Telecom Group plc dated 10 June 2020 regarding information provided in response to a statutory notice dated 5 December 2019.

A4.24 Letter to Virgin Media Limited dated 10 June 2020 regarding information provided in response to a statutory notice dated 5 December 2019.

UK legislation

A4.25 Communications Act 2003 (the Act), as amended.

Ofcom documents

A4.26 Ofcom, February 2016. Strategic Review of Digital Communications.

A4.27 Ofcom, November 2017. Narrowband Market Review: Statement.

A4.28 Ofcom, July 2018. Wholesale Local Access and Wholesale Broadband Access Market Reviews: Statement.

A4.29 Ofcom, February 2019. KCOM Regulatory Financial Reporting: Statement.

A4.30 Ofcom, May 2019. Helping consumers get better deals: Statement and Annex 4.

A4.31 Ofcom, June 2019. Business Connectivity Market Review: Statement and Annex 6.

A4.32 Ofcom, September 2019. Connected Nations Update: Summer 2019.

A4.33 Ofcom, December 2019. Connected Nations 2019: Report.

A4.34 Ofcom, January 2020. Wholesale Fixed Telecoms Market Review 2021-26: Consultation.

A4.35 Ofcom, April 2020. Ofcom's Plan of Work 2020/21.

A4.36 Ofcom, June 2020. Proposed Consent for KCOM to defer its 2019/20 and 2020/21 Regulatory Financial Statements: Consultation.

A4.37 Ofcom, July 2020. Hull Area Wholesale Fixed Telecoms Market Review 2021-26: Consultation.

A4.38 Ofcom, March 2021. Wholesale Fixed Telecoms Market Review 2021-26: Statement.

A4.39 Ofcom, March 2021. Ofcom's Plan of Work 2021/22.

Ofcom research

A4.40 Ofcom, 2017. Ofcom Nations & Regions Technology Tracker – H1 2017. 3 January to 28 February 2017.

A4.41 Ofcom, 2020. Ofcom Nations and Regions Technology Tracker – 2020. 9 January to 7 March 2020.

A4.42 Ofcom, 2021. Ofcom, 2021. Ofcom Technology Tracker 2021. 14 January to 31 March 2021.

A4.43 Ofcom, September 2019. Connection Nations update: Summer 2019 data downloads and data on fixed local unitary authority.

A4.44 Ofcom, September 2021. Connected Nations update: Summer 2021 data downloads and data on fixed local unitary authority.

Ofcom website

A4.45 Ofcom, April 2020. How broadband and mobile firms are serving customers during the coronavirus pandemic.

European Commission legislation and guidance

A4.46 Directive 2002/19/EC of the European Parliament and of the Council of 7 March 2002 on access to, and interconnection of, electronic communications networks and associated facilities.

A4.47 Directive 2002/20/EC of the European Parliament and of the Council of 7 March 2002 on the authorisation of electronic communications networks and services.

A4.48 Directive 2002/21/EC of the European Parliament and of the Council of 7 March 2002 on a common regulatory framework for electronic communications networks and services.

A4.49 Directive 2002/22/EC of the European Parliament and of the Council of 7 March 2002 on universal service and users' rights relating to electronic communications networks and services.

A4.50 Directive 2014/61/EU of the European Parliament and of the Council of 15 May 2014 on measures to reduce the cost of deploying high-speed electronic communications networks.

A4.51 Commission Recommendation of 19 September 2005 on accounting separation and cost accounting systems under the regulatory framework for electronic communications (2005/698/EC).

A4.52 Commission Recommendation of 11 September 2013 on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment environment (2013/466/EU).

A4.53 Commission Recommendation of 9 October 2014 on relevant product and service markets within the electronic communications sector susceptible to *ex ante* regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services (2014/710/EU).

A4.54 Guidelines on market analysis and the assessment of significant market power under the EU regulatory framework for electronic communications networks and services (2018/C 159/01).

A4.55 European Commission, 2018. Directive 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code (Recast).

A4.56 European Commission, 2020. Commission Recommendation 2020/2245 of 18 December 2020 on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive (EU) 2018/1972 of the European Parliament and of the Council establishing the European Electronic Communications Code.

A4.57 European Commission, 2020. Explanatory note accompanying the Commission Recommendation on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code.

Other sources

BEREC

A4.58 BEREC, 2012. BEREC Common Position on best practice in remedies imposed as a consequence of a position of significant market power in the relevant markets for wholesale leased lines.

A4.59 BEREC, 2012. BEREC Common Position on best practice in remedies on the market for wholesale (physical) network infrastructure access (including shared or fully unbundled access) at a fixed location imposed as a consequence of a position of significant market power in the relevant market.

A4.60 Regulation (EC) No 1211/2009 of the European Parliament and of the Council of 25 November 2009 establishing the Body of European Regulators of Electronic Communications (BEREC) and the Office (the BEREC Regulation).

Government

A4.61 Department for Digital, Culture, Media and Sport, 16 July 2019. Implementing the European Electronic Communications Code.

A4.62 Department for Digital, Culture, Media and Sport, 29 October 2019. Statement of Strategic Priorities for telecommunications, the management of radio spectrum, and postal services.

London Stock Exchange

A4.63 London Stock Exchange, 2019. Recommended Cash Offer for KCOM Group Plc.

Other websites

BT

A4.64 BT Consumer Price Guide.

A4.65 Financial reporting & news: Annual Review 2020.

A4.66 Landline deals.

A4.67 Managing your budget.

CityFibre

A4.68 CityFibre, 2014. CityFibre signs 'dark fibre' deals with EE and Three to enhance mobile networks.

A4.69 CityFibre, 2017. Vodafone and CityFibre bring gigabit-speed fibre to the UK.

A4.70 CityFibre, 2020. CityFibre acquires FibreNation and adds TalkTalk as strategic customer, increasing its rollout plans to pass up to 8 million premises.

Connexin

A4.71 Connexin Home: Our packages.

Digital TV Europe

A4.72 Digital TV Europe, 2020. CityFibre announces restructured Vodafone deal.

EE

A4.73 Pay monthly mobile broadband devices.

KCOM

A4.74 Ethernet Connect Access Service.

A4.75 Ethernet Direct Access Service.

A4.76 Description of Cost Accounting System (DOCAS): Representing the Primary and Secondary Accounting Statement Together with Wholesale and Retail Catalogues.

A4.77 KCOM Group PLC Regulatory Financial Statements for the year ended 31 March 2019.

A4.78 Keeping you connected – message from KCOM Chief Executive Officer Dale Raneberg.

A4.79 Previous strategic IT development notices.

A4.80 Products: calls.

A4.81 Products: Lightstream.

A4.82 Reference Offer for the Provision of Accommodation Services, Schedule 1: Definitions.

A4.83 Reference Offer Wholesale FibreLine Local Access, Schedule 2: WFLLA CableConnect Service.

A4.84 Wholesale FibreLine Local Access Price List.

Liberty Global

A4.85 Liberty Global, 2021. Virgin Media O2 announces 2028 full fibre upgrade plan

Macquarie

A4.86 Macquarie, 2019. Macquarie Infrastructure and Real Assets finalises acquisition of KCOM Group.

Openreach

A4.87 Superfast and Ultrafast Fibre Access price list.

A4.88 Ethernet services price list.

A4.89 Dark fibre price list.

Post Office

A4.90 Home phone deals.

Purebroadband

A4.91 PureHome broadband packages.

Three

A4.92 4G home broadband packages.

Vodafone

A4.93 5G GigaCube home broadband packages.

Wisper

A4.94 Wisper Broadband internet packages.