Business Connectivity Market Assessment

NON-CONFIDENTIAL VERSION

Version 1.0

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Prepared for:

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Introduction and Scope

Ofcom engaged Cartesian to research how UK large enterprises are using communication services, assess their level of satisfaction, and investigate how they see their future needs evolving over the next 5 years. The research also aimed to provide insight into the business connectivity supply chain.

Approach

Between November 2017 and January 2018, Cartesian interviewed: 75 executives in technology and procurement roles of UK large enterprises, with responsibility for business connectivity; 16 senior personnel in Communication Service Providers (CSPs), with insight into the business connectivity supply chain; and 6 senior representatives of UK mobile network operators and mobile access Infrastructure providers, with insight into mobile backhaul connectivity. Cartesian identified and selected companies using a combination of a third-party business database, online research, and Cartesian's existing contact network.

The analysis was qualitative in nature, given the relatively small sample size. However, some questions required answers set on a scale (e.g. Likert scale) to assess their level of satisfaction with the services.

Large Enterprises Current Connectivity Needs: Overview of Findings

Interviewees were first asked about their current and future business connectivity needs, covering fixed data, fixed voice and mobile connectivity services. The key findings of the current needs are summarised below:

Criticality of fixed data services, especially leased lines and broadband	Fixed data connectivity was consistently regarded as the most critical communication service for businesses. Leased lines and fixed broadband were found to be the most prevalent services: the former to connect critical sites (e.g. HQ, Data Centres), and the latter to connect non-critical sites, such as regional or local offices.
Mixed views on the importance of fixed voice **SIP and Unified Communications were the key highlights**	The importance of fixed voice services varies by organisation; however, most concurred on the importance of migrating from legacy technologies to Session Initiation Protocol (SIP), a protocol that enables real-time voice, video and messaging over IP networks. Unified Communication (UC) platforms such as Microsoft Skype for Business are increasingly important for fixed voice due to their wider functionality and computer integration.
Mobile connectivity services important for a number of use cases	Mobile communications varied greatly in importance across the interview sample, however there is a trend towards greater use of mobile services as the workplace becomes increasingly flexible. The key use cases included field force, fleet management, home working, management and sales staff.

Overall, large enterprises were fairly satisfied with the business connectivity products and services they had contracted. On a scale from 1 to 10, the mean satisfaction score was 6.9 for fixed data, 7.1 for fixed voice, and 6.1 for mobile services. In the second part of the interview, we investigated their experiences and areas of dissatisfaction in more detail.

Large Enterprises Future Communication Needs: Overview of Findings

When asked about trends that would impact communication needs over a 5-year horizon, business interviewees mentioned a few interesting trends related to fixed data services, which are summarised in the table below:

Gradual capacity growth expected by most businesses	Companies generally anticipate fixed data capacity growth will be gradual and will be mostly driven by the move of applications to the cloud and increased use of video. However, in some specific cases volumes were forecast to decrease, e.g. due to rationalisation of office sites.
Move to Cloud-hosted Applications	Cloud hosting is changing business networking requirements, shifting the demand from dedicated site-to site connectivity to Internet connections. Storage, computing, telephony and CRM were the most common services on cloud migration roadmaps.
Increase of redundancy requirements	Network resiliency is expected to be increasingly important, fuelled by the shift towards 24/7 operations, as well as the growth in automation.
Increasing importance of SD-WAN[1]	A few businesses mentioned that they are starting to look into SD-WAN, with two objectives in mind: 1) reduce connectivity costs; and 2) more control over the network, being able to upgrade bandwidth faster and without disruption to the business.
New use cases enabled by IoT, Augmented and Virtual Reality (AR, VR)	Several businesses anticipated IoT enabling smart cities and autonomous vehicles, but only in the long term (5+ years). AR and VR are expected to enable new use cases, especially for entertainment and simulations.

For fixed voice, the most significant change forecasted is the steady decline of desk phones as soft clients and mobile phones replace them.

Replacement of traditional desk phones	Broad consensus that voice via soft clients such as Skype for Business are steadily becoming a viable alternatively to a traditional desk phone, due to their multifunctionality including screen sharing, instant messaging, group calls and email integration. The need for traditional fixed voice lines is further eroded by the rise of mobile as a suitable replacement.

Finally, future developments identified in mobile needs can be broadly classified in three categories:

Increase in number of mobile devices	A number of businesses (and especially those in the transportation sector) projected an increase in the number of work mobile devices. The push towards flexible, mobile and remote working was seen as the main driver.
Need for better coverage	Mobile coverage was commonly highlighted as a source of frustration. Irrespective of industry vertical, mobile coverage was perceived as being particularly poor in rural areas. Looking ahead, some respondents hoped for improved 4G coverage to be prioritised over deploying 5G.

[1] Software-defined WAN *(*SD-WAN*)* is a recent approach to wide area networks (WAN) that uses software-defined networking (SDN) concepts to efficiently carry traffic between company locations using a variety of connections including the public Internet.

Innovation to be brought by 5G	A handful of interviewees were excited about the potential opportunities that 5G could bring to their business. Real-time control in warehouses and data-connected vehicles were some of the examples given. One respondent wondered also if 5G connectivity could be used in the last mile as an alternative to fixed networks.

Large Enterprises Customer Experience: Summary Findings

The second part of the interviews covered business customer experiences in using communications services and interacting with suppliers. In the interviews we sought to identify any issues that business customers faced, and to understand causes of any dissatisfaction. The key findings are presented below:

Sufficient choice of service providers, good value for money but limited infrastructure options	Both fixed and mobile markets were generally perceived to be competitive, with sufficient choice of providers offering relatively good value for money. However, most interviewees expressed concerns about the lack of diversity of fixed infrastructure providers
Smaller organisations prefer to buy from Value-Added Resellers (VARs), while the largest organisations prefer to deal directly with network operators.	For smaller organisations (within the large enterprise segment) the main advantages cited by those buying from VARs include better customer service, their ability to source circuits from many network operators, as well as achieving a greater bargaining power than if the business went directly to a network operator. Some large organisations do not consider VARs to have sufficient scale to be able to deliver services to meet their needs and future growth prospects.
Fixed service provisioning was the most prevalent area of dissatisfaction	Provisioning of fixed services was the most prevalent area of dissatisfaction (mean satisfaction score of 5.3), particularly for fibre leased lines. The key problems include long lead times, delays, uncertain delivery deadlines and a lack of communication from the service providers. Wayleaves, the suppliers' organisational structure and lack of a seamless migration process perceived as the main contributing factors.
High in-life performance of fixed services, especially fibre leased lines	"Once the circuit is in, it works" was one of the most common responses when asking about the in-life performance of the fixed services (mean satisfaction score of 8.5). This was especially true for fibre leased lines, with outages being very few and far between. Copper-based circuits (EFM or broadband) were perceived to be less reliable.
Outdoor and indoor mobile coverage issues	Poor outdoor and indoor coverage, often in rural locations, was stressed as a serious concern, especially by businesses with a strong dependence on mobile communications (e.g. companies within the field engineering, transport and emergency services sectors).

Insights from interviews with Communication Service Providers

We classified Communication Service Providers (CSPs) into three categories from a supply chain point of view: network operators, network aggregators[2], and value-added resellers (VARs). During the course of the project, we interviewed five network operators, two network aggregators and nine VARs.

One of the key objectives was to gain insight into the business connectivity supply chain:

Complex dynamics in the indirect channel	Most CSPs purchase wholesale communications services from other CSPs, and use them as inputs to downstream services. It is not uncommon for the supply chain to include multiple CSPs (VAR, network aggregator, network operator).

CSPs were also asked to give their views on the wholesale connectivity purchase and provisioning processes, as well as their thoughts on the in-life performance of wholesale connectivity services:

Availability of service and price are the top criteria when choosing a wholesale connectivity service	Most CSPs purchasing wholesale connectivity use pricing portals to check which providers can serve the address(es) of the customer location(s), and to compare potential suppliers on a set of criteria (availability of service and price were the most important ones).
Major concern with the provisioning process for fixed services	Fixed service provisioning was a major concern, viewed as cumbersome and slow. Experiences varied on two main factors: 1) on-net faster than offnet circuits, and 2) fibre leased lines fared worse than copper-based products.
"Once the circuit is in, it works" was echoed by CSPs too	In-life performance was far less problematic than provisioning. Fibre leased lines were seen as more reliable than copper-based broadband.

When surveying CSPs on what trends will drive the connectivity market over the next five years, the two most commonly raised topics aligned with the views of large enterprises: ongoing capacity growth, and the move of services to the cloud:

(More aggressive) bandwidth growth	CSPs interviewed expect to see a more aggressive increase in capacity demand than large enterprises in the study, fuelled especially by the move of services to the cloud and the use of video.
Move to cloud-hosted applications	The views of most CSPs aligned with those of large enterprises in the study: the transition to cloud-hosted applications will continue.
FTTP rollout to accelerate	Interviewees referred specially to FTTP rollout programmes, which are expected to make fibre broadband services available to many businesses that currently can only subscribe to copper-based broadband services (e.g. FTTC at best, ADSL if FTTC not available).
Access to Openreach dark fibre	Access to dark fibre circuits from Openreach is seen as a key driver for service innovation (e.g. very high bandwidth services, which so far are very costly if they are purchased as third-party leased lines), and a number of CSPs would like to see it materialising in the next few years.

[2] Network aggregators fulfil an intermediary role in the value chain, sitting between upstream network operators and smaller downstream CSPs

5G as a technology for business connectivity in the last mile	A few CSPs believe that 5G will play a key role in business connectivity, either as a viable alternative to fibre circuits for the last mile, or at least as a complementary technology to provide resilience to existing fibre lines.

Mobile Backhaul connectivity: Summary Insights

We asked interviewees about their current mobile backhaul needs and how these were being met:

Cell site infrastructure ownership	In the UK there are three main operating models for cell site infrastructure ownership which coexist: 1) MNO solely operating a cell site, 2) Joint Venture between MNOs to share deployment costs, and 3) a neutral host model in which an Infrastructure Operator rents cell site to MNOs.
Mobile Backhaul Physical Layer	Fibre is the preferred and most common method, used where fibre is available or economical to install, followed by microwave, which is more present in rural areas. Finally, copper leased lines (e.g. multiple E1 circuits[3]) is used to connect a minority of locations, usually in rural areas.
UK supply of fibre Mobile Backhaul	BT Wholesale (BTW) is the main provider, followed by Virgin Media and CityFibre. MNOs used to purchase mobile backhaul only from BTW, but some operators in the last decade decided to incorporate new providers to secure more competitive prices. However, at least one MNO expressed concerns about the limits of competition, given Virgin Media's and CityFibre's smaller network footprint compared to BT's.
Provisioning Process and In-life Performance	Long lead times were raised by more than one MNO as an area of concern, and wayleaves was highlighted as one of the key underlying causes. However, one MNO believed typical lead times of 4 months were usually sufficient, as this could be factored into the network rollout plan. In-life performance of fibre backhaul circuits is not seen as an issue by MNOs. However, some expressed reservations regarding the level of in-life support provided.

When surveying the interviewees on what trends will drive the connectivity market over the next five years, 5G captured all the attention. Operators expect the first UK trials in 2019 or 2020, with first deployments following shortly after. The key 5G themes included the following:

Evolution of Radio Access Network (RAN)	MNOs are looking to evolve the RAN architecture to increase capacity and reduce latency for 5G in high-density areas. Centralised-RAN, Virtualised-RAN, Split-RAN and Massive MIMO are the main options being evaluated.
5G Backhaul capacity and physical layer options	MNOs expect traffic to grow exponentially with 5G. 10Gbps, and Nx10Gbps for sites concentrating traffic, will be the new norm in the next 3 – 5 years. Fibre is seen as the most important method to connect cell sites, whereas microwave will continue to play a small role, mainly in rural areas.

[3] E1 is a European format for dedicated digital transmission, supporting 2 Mbps.

Availability of Openreach 's ducts and dark fibre for 5G mobile backhaul	MNOs highlighted the importance of securing access to Openreach's dark fibre and ducts for mobile backhaul use. This would improve the economics of serving 5G cell sites with fibre (the preferred method given the high capacity bandwidth demands expected with 5G).
5G small cells	All interviewees agreed that 5G will require a wide deployment of small cells, to serve three key uses: 1) cover high-capacity urban areas, 2) specific event-based hotspots (e.g. football stadiums, train stations), and 3) indoor small cells.

1. Introduction

Context

1.1. Within Ofcom's wider programme of research, Cartesian was engaged to research and analyse communications market outcomes for UK large enterprise customers. This market includes fixed data products as well as fixed voice and mobile communication services.

1.2. The objectives of the project were to identify any possible areas of concern or poor outcomes to business consumers of fixed and mobile communications services. The results will be assessed and, if necessary, addressed by future Ofcom policy projects, for example, the upcoming Business Connectivity Market Review.

Scope

1.3. This study comprises two segments of the UK communications market: 1) large enterprise customers, and 2) wholesale backhaul customers. Ofcom defines large enterprises as those with 250 or more UK employees. Wholesale backhaul customers are defined as those that purchase wholesale communications services as inputs to downstream communications services.

1.4. For the large enterprise research, the objective is to provide an understanding of how large enterprises are using communication services in the UK, insight into how businesses see their needs evolving over the next 5 years, and views of large enterprises on the performance of CSPs and the market as a whole.

1.5. For the wholesale backhaul customers[4], the aim of the research is to provide insight into the connectivity supply chain. This includes customer-supplier relationships, product choices, expectations around future needs and perspectives on the performance of suppliers. The scope includes both fixed and mobile backhaul services.

Report Structure

1.6. This report is structured in 9 sections.

- **The executive summary** presents a summary of the key findings.
- **Section 1** introduces this report, covering context and scope.
- **Section 2** describes the large enterprise segment in the UK and the different players in the business connectivity supply chain.
- **Section 3** describes the research methodology, and provides an overview of the sample of organisations included in the primary research.
- **Section 4** examines how large enterprises currently use fixed data, fixed voice and mobile services in their business operations. Furthermore, this section details the overall satisfaction of respondents with their services.
- **Section 5** focuses on how large enterprises expect their connectivity requirements to change in the future.

[4] Cartesian interviewed UK Communication Service Providers that purchase wholesale communications services as inputs to downstream communications services, and included fixed and mobile network operators, as well as resellers of telecom services (more details about the interviewee types in paragraph 3.18)

- **Section 6** covers, in detail, insights from large enterprises during each stage of the customer life cycle. In total, six stages are covered: Learning, Buying, Provisioning, In-Life Use, Customer Service and Upgrades, Migration and Switching.
- **Section 7** outlines the insights that Cartesian obtained from CSPs regarding the supply chain. This section also includes interviewee perspectives on the future trends shaping the communications market.
- **Section 8** presents additional findings for the mobile backhaul market.
- **Appendix A** includes a Glossary of Terms.

2. Market Structure

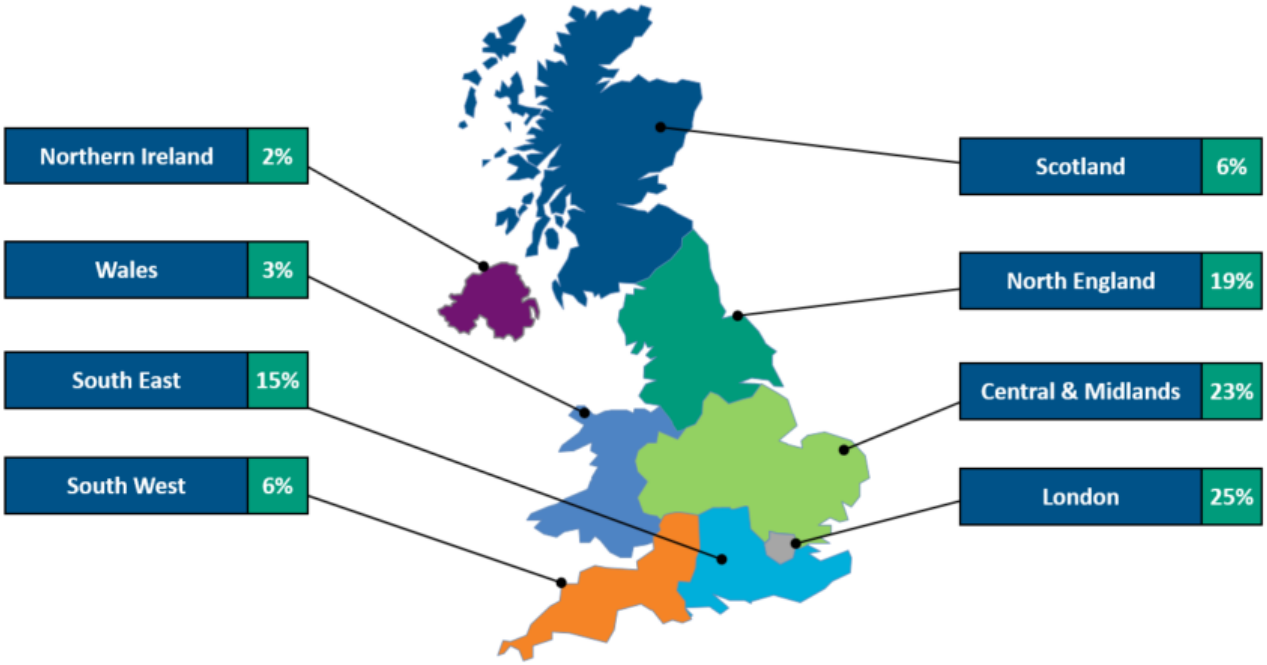
Demand: Large Enterprises in the UK

2.1. Ofcom defines large enterprises as organisations with 250 or more employees in the UK. Private, public and third-sector organisations are included in this definition. The Office of National Statistic (ONS) estimates that there are 30,275 large enterprises in the UK.

Geography

2.2. Figure 1. shows the distribution of large enterprises (the registered office) across the UK regions, with a majority (40%) concentrated in London and the South-East.

Figure 1. ***Distribution of UK Large Enterprises by Region***

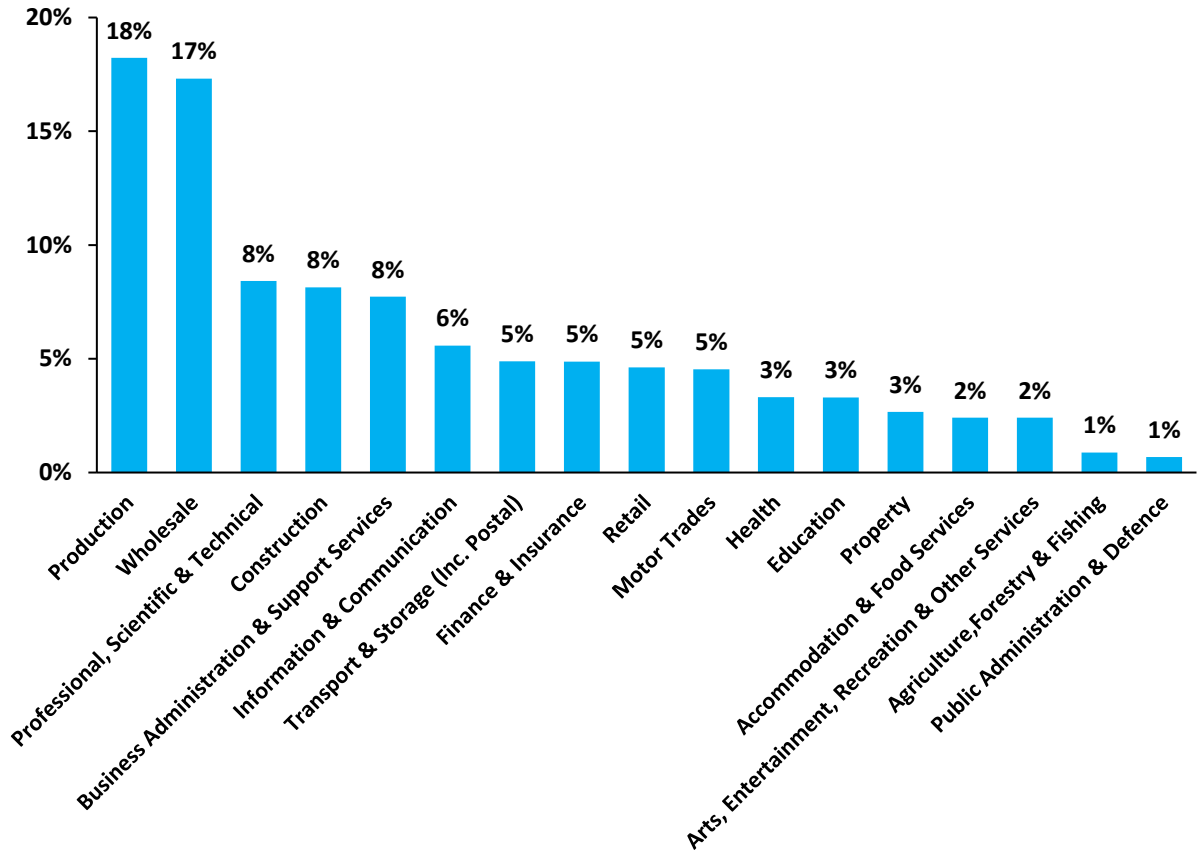


Source: ONS

Economic Activity

2.3. Figure 2. shows the distribution of these businesses by economic activity, using Standard Industrial Classification (SIC) codes. Cartesian has grouped the SIC codes into a total of 17 categories.

Figure 2. ***Distribution of UK Large Enterprises by Industry***



Source: ONS

2.4. Section 2 describes the methodology used to ensure that the study included a representative range of businesses by region and industry sector.

Supply: Business Communication Supply Chain

2.5. In the UK, there are hundreds of Communication Service Providers (CSPs) which focus extensively and/or exclusively on providing voice and data communication services to UK businesses. In this study, we classify CSPs into three broad categories from a supply chain point of view: network operators, network aggregators, and Value-Added Resellers (VARs).

Network Operators

2.6. The primary business model of network operators is to invest in their own network infrastructure and use it to provide services to their customers. The extent of an operator's infrastructure will depend upon its scale and target market. Some operators in the UK have a nationwide footprint of aggregation points; some have invested in their own access networks. Most will use wholesale services from other network operators where it is uneconomical to build their own network. Wholesale services can be found in the core and aggregation segments of the network where they are typically on medium to long-term contracts (e.g. 3 – 5 years for leased lines, 15 years for dark fibre). In the access network, services include wholesale broadband access and leased lines. Contracts for access services have a shorter term, aligned to retail customer contracts (typically 1 – 3 years for leased lines).

2.7. Most network operators have a strong wholesale channel through which they offer connectivity services to other network operators, network aggregators and VARs. The majority of network operators also operate a direct channel for large enterprises. However, a few network operators sell exclusively through their wholesale channel.

2.8. [✂].

Network Aggregators

2.9. Network aggregators fulfil an intermediary role in the value chain, sitting between upstream network operators and smaller downstream CSPs. The primary business model of the network aggregator is to provide a marketplace for wholesale services offered by network operators. To achieve this, network aggregators will operate network infrastructure that interconnects with multiple network operators.

2.10. Most of the network aggregators revenue comes from their indirect channel: they offer their downstream wholesale customers (typically VARs) access to network circuits from an array of network operators. They might also operate a direct channel, typically serving medium-to-large businesses.

2.11. [✂].

VARs

2.12. Value-Added Resellers purchase connectivity services from either network operators and/or network aggregators, which they then resell to their end customer. In turn, VARs can be sub-divided into two types:

- *Telco-specific VARs:*
  These VARs usually operate a Core Network, usually smaller (e.g. 2 or 3 nodes) than that of network operators and aggregators. This allows them to offer their own communications products and services. [✂].

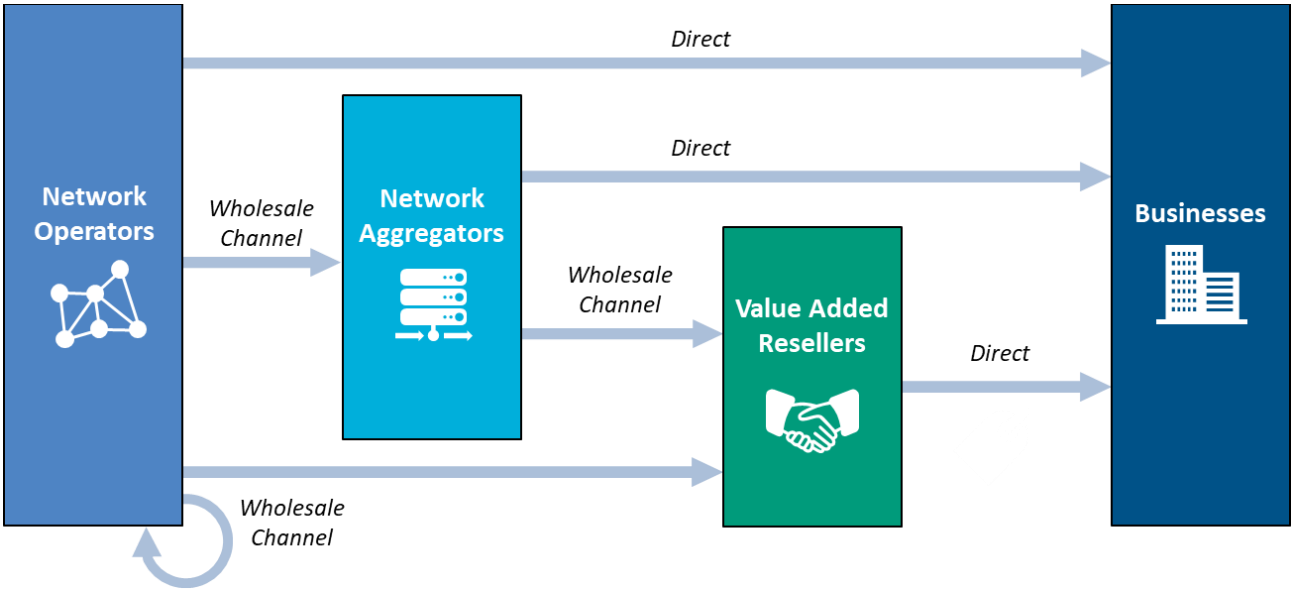
- *Non-telco resellers:*
  The core business of these companies can be as varied as IT equipment, utilities management, energy efficiency and facilities management. They typically purchase communication services as they see it as a new revenue stream (straight resell to their customers), or because connectivity is part of an end-to-end service (e.g. selling an IP CCTV system as opposed to just selling CCTV cameras). [✂].

2.13. VARs primarily focus on the direct channel, typically serving to small-to-medium businesses: businesses that might not have the scale, purchasing power and/or appetite to procure services directly from Networks Operators or Aggregators. We will explore these dynamics in more detail in paragraphs 7.1 - 7.8.

Overview of Supply Chain

2.14. The three types of CSPs described above are all *Wholesale backhaul customers*, defined by Ofcom as those CSPs that purchase wholesale communications services as inputs to downstream communications services.

Figure 3. ***High-level Overview of the Business Connectivity Supply Chain***[5]



Source: Cartesian

2.15. Figure 3. summarises the supply chain at high level. The diagram shows how the CSPs procure connectivity services from each other through wholesale channels in order to supply retail services to end-customers.

2.16. In section 3, we explain the methodology we followed to ensure the CSPs we interviewed provide a balanced representation of the supply chain, and in section 7 we present the insights from the interviews.

[5] Note that the diagram aims to provide a summarised version of the supply chain, so it will not necessarily be representative of all arrangements

3. Methodology of Research Study

3.1. Between November 2017 and January 2018, Cartesian interviewed 75 UK large enterprises and 16 business CSPs serving the UK market.

Large Enterprises

Recruitment

3.2. We used a third-party business database to identify and select companies meeting the relevant criteria. The database was also used to find relevant roles for the interviews.

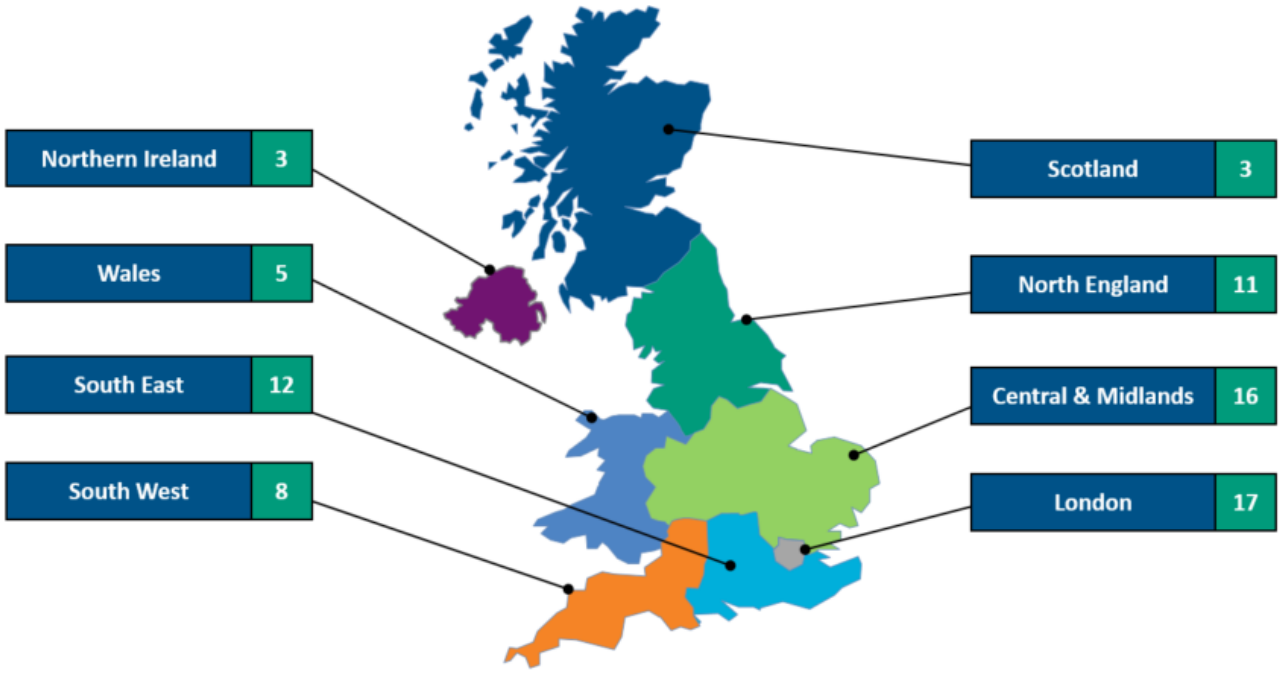
3.3. Cartesian and Ofcom agreed the content of the email template which was sent to all potential contacts. Respondents were informed that the research was being conducted by Cartesian on behalf of Ofcom.

3.4. Throughout the recruitment process we worked to ensure that the sample of large enterprises provided representation across a number of domains, including location, activity and size. The following sections provide an overview of the resulting sample.

Location Distribution

3.5. Identifying the location of large enterprises is not straightforward, as in most cases they will have multiple sites which may span regions, or even countries (i.e. multinational companies). In our study, we used the location of the UK headquarters as a proxy for the business location: Figure 4. shows the distribution of the headquarters of our large enterprises sample across eight UK regions. We aimed for a distribution that was broadly comparable to the distribution of all UK large enterprises, as shown in Figure 1.

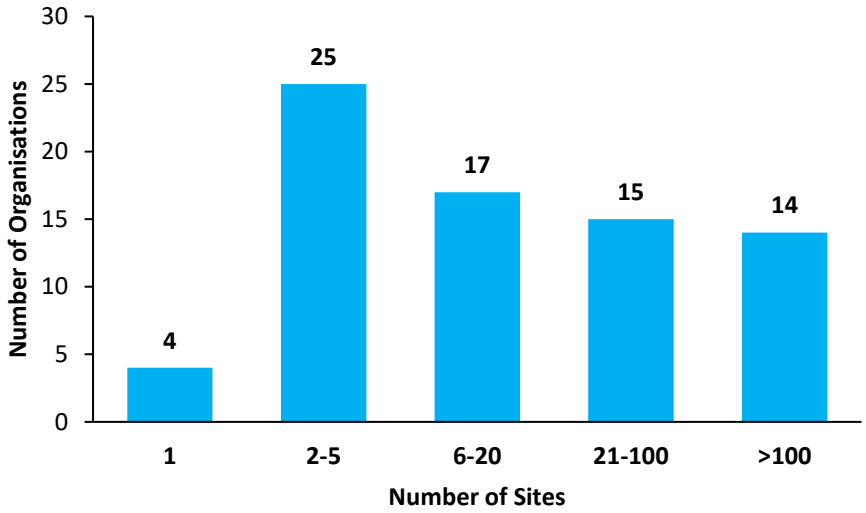
Figure 4. ***Headquarter Location of Large Enterprise Sample***



Source: Cartesian

3.6. In terms of their UK footprint, four businesses in the study (5%) had just one site. A third of respondents had 2–5 sites, and the remaining 60% of the businesses were approximately equally distributed across the segments 6–20, 20–100 and 100+ sites. See Figure 5. for more details.

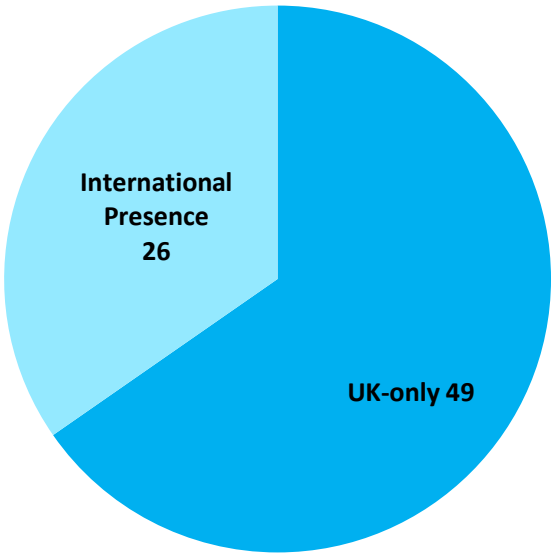
Figure 5. ***Number of UK Sites of the Large Enterprise Sample***



Source: Cartesian

3.7. With respect to international presence, over two thirds of the organisations had offices only in the UK. The remaining one third had offices outside of the UK: we interviewed both UK-registered companies with multinational operations, as well as international organisations with office(s) in the UK (Figure 6.

Figure 6. ***International Presence of Large Enterprise Sample***

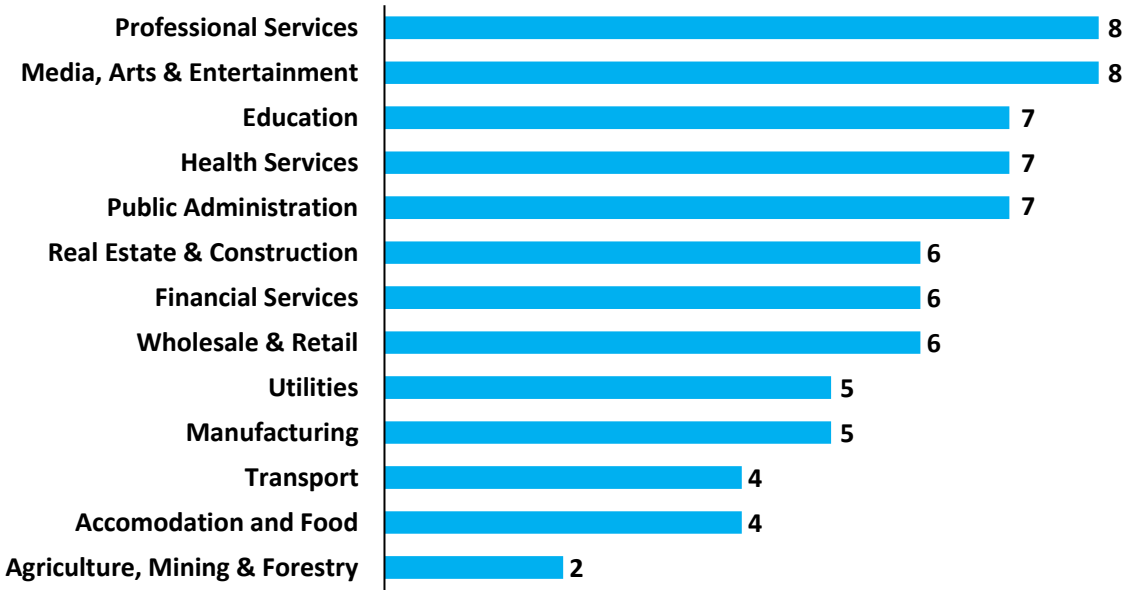


Source: Cartesian

Economic Activity Distribution

3.8. To select organisations for interview, we took guidance from ONS's estimated distribution of UK businesses across industries (see Figure 2.). We ensured the 75 large enterprise involved in the study provided a representation of these industry sectors, as can be seen on Figure 7.

Figure 7. ***Economic Activity of Large Enterprise Sample***



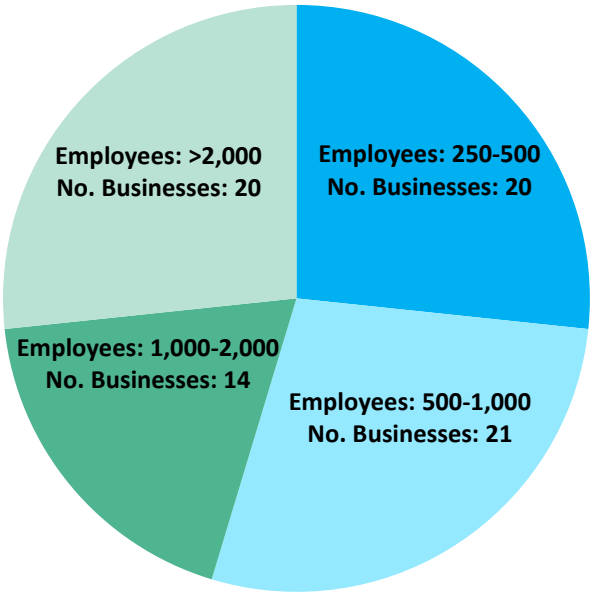
Source: Cartesian

Size Distribution

3.9. We used the number of employees and annual spend on communication services (both fixed and mobile) as proxies to determining the size of a business. We tracked these variables throughout the recruitment process to ensure a balanced representation of various sizes.

3.10. With regards to the number of employees, we created four segments: 250–500, 500–1,000, 1,000–2,000, and over 2,000 staff. Figure 8. shows that the sample was well balanced between these four segments.

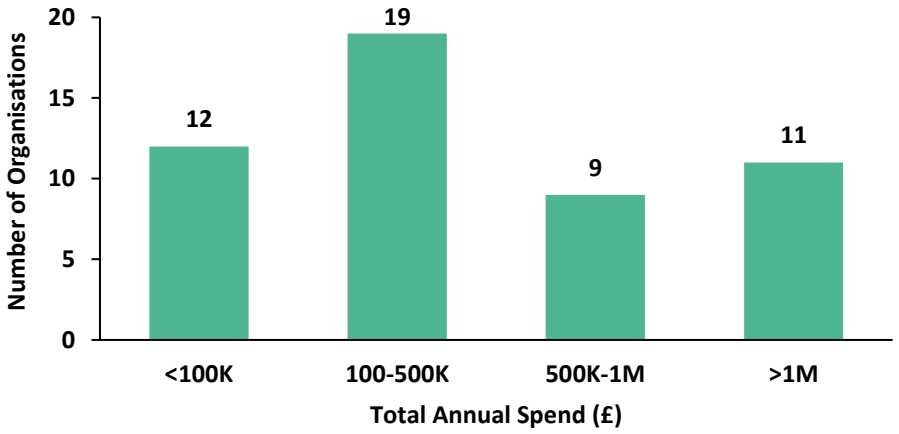
Figure 8. ***Number of Employees of Large Enterprise Sample***



Source: Cartesian

3.11. With respect to the annual spend on communication services, most companies in the study had a total annual spend of less than £500,000, with the most common spend range being £100,000–£500,000 (Figure 9.

Figure 9. ***Annual Spend on Fixed and Mobile Services of Large Enterprise Sample***[6]



Source: Cartesian

Interviewee Job Function

3.12. Interviewee recruitment focused on senior roles that would have visibility of their company's communication needs and roadmap, as well as the decision-making on how to procure the services. Interviewee roles included CTO, CIO, Head of IT, Senior Technology Strategy and Senior IT Procurement. In some cases, more than one representative from the firm joined the interview, to provide coverage across the scope of our research.

Interview Format

3.13. The interviews were structured to last one hour. Key areas covered in the interview included:

- Details of current connectivity services (including fixed and mobile, voice and data), as well as use cases.
- Future evolution of both mobile and fixed needs over the next 5 years.
- Methods and resources used to learn / research the services in the market.
- Supplier choice and on-boarding experience.
- Experience of using the service.

3.14. The research focused on gaining an in-depth, qualitative understanding of evolving needs, and issues across different steps of the lifecycle. In addition, a number of questions with answers set on a 10-point Likert scale were included to assess satisfaction levels. However, it should be noted that not all interviewees answered all questions due to commercial sensitivity, therefore numbers presented may not total 75 in some instances.

3.15. Where we observed noticeable differences between companies in specific regions/sectors/sizes, these were called out although the sample size is small, so readers should be careful not to attach too much weight to these observations in making inferences about the wider market.

[6] 51 out of 75 interviewees disclosed the annual spend on business connectivity

3.16. Approximately one third of organisations interviewed were international corporations; the interview focused on their use and experience of the UK business communications market, although some of these organisations offered comparative comments on how the UK market compared with their experiences in other countries.

Wholesale Backhaul Customers

Recruitment

3.17. We used Cartesian's contact network and online research to recruit interviewees in relevant roles at UK-based CSPs. Cartesian and Ofcom agreed the content of the email template which was sent to all potential contacts.

Distribution of CSPs

3.18. In order to have a balanced distribution of W*holesale Backhaul Customers*, we aimed to speak to the four types of CSPs described in paragraphs 2.6 - 2.13. Ofcom indicated that VARs were of particular interest. The final distribution is shown in the table below:

Figure 10. ***Distribution of Wholesale Backhaul Customers by Type of CSP***

CSP type	Interviews
Network operator	5
Network aggregator	2
Resellers: - VAR - Non-telco reseller	 7 2
Total	**16**

Source: Cartesian

Interviewee Job Function

3.19. Interviewee recruitment focused on senior roles that would have visibility of the CSPs wholesale connectivity needs, procurement decision-making, and experience with suppliers. Interviewee roles included CTO, CIO, Head of Networks, Senior Network Procurement. In some cases, more than one representative from the firm joined the interview, to provide coverage across the scope of our research.

Interview Format

3.20. The interviews were structured to last one hour. Key areas covered in the interview for wholesale backhaul customers included:

- Connectivity services bought from other providers, including experience and issues;
- Product and service portfolio;
- Emerging technology trends which will shape the demand for connectivity.

3.21. As with large enterprises, it should be noted that not all interviewees answered all questions due to sensitivity reasons, lack of time and/or information. Therefore, some charts with quantitative analysis may not total to 16 responses.

4. Current Business Communication Needs

Fixed Data

4.1. The businesses interviewed purchase a wide variety of connectivity products to meet their fixed data communication needs. These vary across use cases and the type of sites that need to be connected.

4.2. Site types include headquarters, data centres, regional offices and satellite sites. Figure 11. summarises the responses of the interviewees with regards to the typical data rates for each type of site, as well as the most common Access Connectivity products.

Figure 11. ***Overview of Most Common Contracted Fixed Data Connectivity Products***

Use Case	Typical Staff Numbers	Most Common Access Connectivity Products*					Typical Data Rate
		Dark Fibre	Leased Lines	FTTC/ADSL Broadband	3G/4G Broadband	Wireless (P2P, Sat)	
HQ	100s	◔	◕	◔	○	○	100Mbps – 1Gbps
Data Centre	–	◔	●	○	○	○	1 – 10 Gbps
Regional Offices	30 - 100	○	◑	◑	◔	◔	10Mbps – 1Gbps
Local Offices	3 - 30	○	◔	◕	◔	◔	10 – 100 Mbps

Low ○ → ● High

*Values of Harvey balls are qualitative based on the responses of the 75 large enterprises interview, and should only be used as a guidance

Source: Cartesian

Leased Lines

4.3. Leased lines were the most common connectivity product, and are typically used to connect sites of critical importance, such as headquarters or data centres, due to their uncontended capacity. Most leased lines used fibre as the physical layer, although some smaller sites have copper-based leased lines due to lower cost and faster provisioning times.

Broadband

4.4. Fixed broadband is typically used to connect smaller, non-critical sites, such as regional offices or satellite sites. Another common use case is as a secondary connection of larger sites.

4.5. Interviewees mentioned they prefer to use Fibre-to-the-cabinet (FTTC) where available, as it delivers speeds of up to 80/20 Mbps (Download/Upload); Asymmetric Digital Subscriber Line (ADSL) is used in those sites where FTTC was not available. In isolated instances, ADSL was chosen because the use case required less bandwidth (e.g. few people at a site, measuring instruments) and ADSL is more cost effective.

4.6. Some companies also use 4G routers as a temporary connection whilst waiting for a fixed solution to be provisioned (typically, leased line or fixed broadband). Purchase of a Business Enhanced Care add-on service from BT, with guaranteed response and resolution times, was commonly mentioned by the interviewees.

Dark Fibre

4.7. Dark fibre is used by a minority of organisations, where the connectivity equipment at each end of the circuit is owned by the large enterprise. Some interviewees expressed appetite to use dark fibre to be able to scale bandwidth without incurring higher costs from their supplier, but could not source it from their communication service providers.

Point-to-Point Wireless and Satellite

4.8. The least common access connectivity products are point-to-point wireless and satellite. These products are mainly used to connect sites in remote, uninhabited areas, where there are no other alternatives (e.g. offshore plants, landfill, etc.).

Fixed Voice

4.9. The importance of fixed voice services varied significantly by organisation. A few interviewees rated them as their most mission-critical communication service, particularly those in care services for vulnerable groups. On the other hand, a larger number of participants rated it as the least important of all. As an example, the ICT director of a manufacturing company explained that the whole telephony system recently went down for 2–3 days, in a site with ~1,000 employees, and only 6 complaints were made.

4.10. Regardless of the varied views on the importance of the services, we identified three major trends across a majority of the interviewees.

Shift to SIP

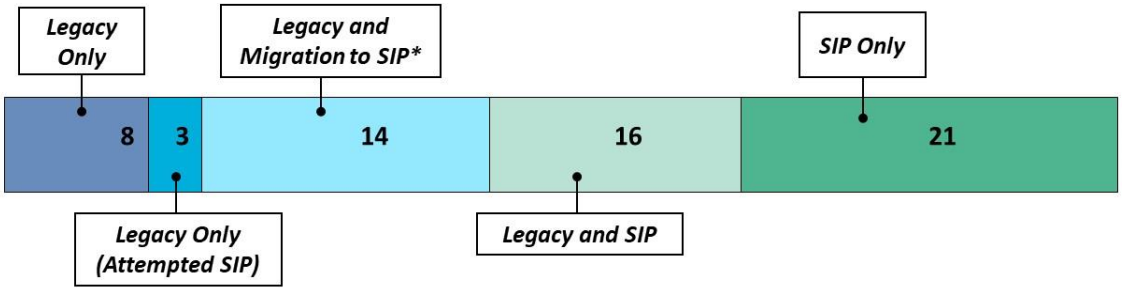
4.11. There was broad consensus across interviewees that the shift from legacy telephony technologies (mostly ISDN30, with ISDN2 and analogue lines for some small sites) to SIP is a major trend.

4.12. The majority of companies in the study (37 out of 62 that responded to this question) had already migrated to SIP or were in the process of doing so. Those who had moved to Internet Protocol (IP) telephony advocated the advanced features (e.g. fixed mobile convergence, call handoff and ability to work remotely), as well as cost savings.

4.13. Some companies (14) employed both legacy and SIP technologies across their sites. These organisations usually still had ISDN30s in call centres and had deployed IP telephony at the main sites, as the SIP migration business case limited a more widespread rollout.

A minority of companies (11) had only ISDN and/or analogue voice services. This was mostly where the use of fixed voice was not high enough to justify the cost of migrating to SIP. For some companies in rural areas, the lack of fibre leased lines meant only these products were feasible. Three businesses mentioned that they had unsuccessful experiences when trying to move to SIP, so they rolled back to ISDN. Examples given included poor voice quality, and the incumbent provider unable to offer features such as Calling Line Identification (CLI).

Figure 12. ***SIP Migration Plans from Organisations Interviewed***



Source: Cartesian

Shift from Desk Phone to Skype or Webex

4.14. Whether using SIP or ISDN as the voice transport mechanism, the vast majority of businesses in the study still have desk phones for their employees. However, a large number of interviewees agreed that Unified Communication (UC) platforms such as Microsoft Skype for Business or Cisco Webex are increasingly important for their voice (and video) communications.

4.15. In one interview, the interviewee mentioned the migration of fixed lines was problematic. This issue is more acute given one of the numbers that was ported during the migration was an emergency, 'life-and-limb' line.

Majority of Interviewees Operating Call Centres

4.16. Over half of the interviewees (37 out of 71) indicated that they had a call centre. In most cases, the call centre is on-premise; a minority explained that they had migrated to a cloud-based call centre software solution which enabled agents to work remotely; and some respondents confirmed their call centre is outsourced to a third-party organisation.

Mobile

4.17. Mobile communication varied greatly in importance across all the companies interviewed, however there is a trend towards using more mobile communication services as the workplace becomes increasingly flexible. The use cases for mobile connectivity are considerably diverse depending on the type of companies interviewed, and include home working, field force, fleet management and others, as can be seen on Figure 13.

Figure 13. ***Mobile Communication Needs and Use Cases***

Use Case	Description	Device	Mobile Services
Management Staff	Constant need to travel across sites in the UK and / or abroad, therefore need for communication on the move to maintain productivity.	Smartphone	Voice and Data
Sales Staff	Travelling to meet potential clients in the UK and / or abroad, therefore need access to up-to-date information for meetings.	Smartphone, tablets	Voice and Data

Use Case	Description	Device	Mobile Services
Home Working	Increasingly flexible workplaces that allow working from home, requiring same functionalities as the office.	Smartphone	Mostly Voice
Field Force	Frequent journeys to perform engineering tasks (e.g. repairs, installs) and need access to job scheduling apps, contact with main office, etc.	Smartphone	Voice and Data
Fleet Management	Frequent journeys carrying cargo and need navigation, contact with main office and active job scheduling.	In-built devices in vehicles, smartphones, tablets	Mostly Data

Source: Cartesian

4.18. Industries which quoted mobility as having great importance include transportation, councils and charities, due to the presence of a large fleet and/or field force such as engineers, trucks, and carers. However, few interviewees placed mobile services as the most "mission critical" out of all communication services.

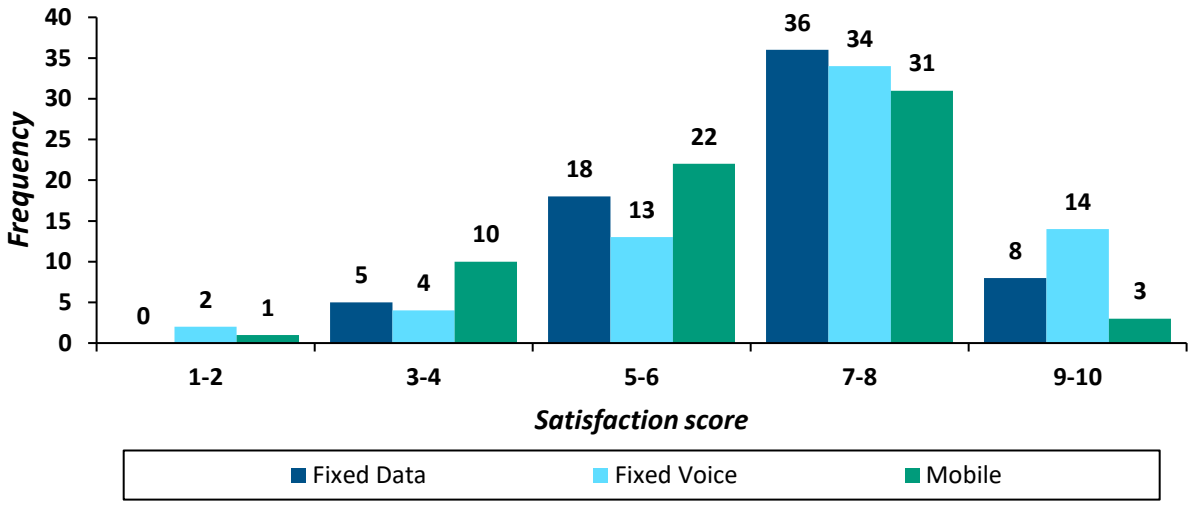
4.19. Some of the sample businesses permit "Bring Your Own Device (BYOD)", however most give staff company phones in order to avoid security and device management issues. The number of devices varies greatly from company to company, depending on both the size of the organisation and the degree of mobility of staff.

Overall satisfaction

4.20. After discussing their business connectivity needs, we asked interviewees how satisfied they were with the contracted services, in a scale from 1 to 10, and why. This question was fairly vague on purpose, as it allowed us to gather the key areas of satisfaction and/or dissatisfaction with the various services, which we would explore in more detail in a subsequent part of the interview.

4.21. Overall, businesses were fairly satisfied with the business connectivity products and services they had contracted; on a scale from 1 to 10, the mean satisfaction score was 6.9 for fixed data, 7.1 for fixed voice, and 6.1 for mobile services (see figure below).

Figure 14. ***Overall satisfaction scores with contracted services***



Source: Cartesian

4.22. Fixed services scored considerably higher than mobile services, as interviewees praised the overall reliability of the services when they have been installed. Conversely, mobile scored lower across the board due to numerous coverage problems. As an example, only 3 respondents rated mobile services with 9 or 10, whereas 14 companies gave this score to their contracted fixed voice services. A minority of respondents did give low scores to their fixed connectivity services. The main reasons behind these scores included long delivery lead times (fixed data services), poor quality of service and customer service (fixed voice).

5. Future Business Communication Needs

Fixed Data

5.1. When asked about trends impacting their fixed data communication needs over a 5-year horizon, businesses mentioned a few interesting trends. Data capacity growth and an acceleration of the move towards cloud-hosted applications were frequently cited across the majority of interviewees.

Figure 15. ***Future Trends in Fixed Data Needs***

Trend	Frequency*
Gradual Data Capacity Growth	
Move to the Cloud	
Growth in Redundancy Needs	
Move to Software-Defined WAN (SD-WAN)	
IoT Evolution	
Virtual Reality and Augmented Reality Use	

Low High

*Frequency refers to how prevalent a topic was across the 75 companies' interviewees. Values of Harvey balls are qualitative and should be used only as guidance

Source: Cartesian

Gradual Data Capacity Growth

5.2. Companies generally anticipate gradual growth in data capacity to come from both increased usage (e.g. company expansion) and more intensive usage (e.g. move of applications to the cloud, increase in use of video). As such, most interviewees were confident that their suppliers could meet their needs and facilitate capacity increases.

5.3. However, there were a handful of organisations that did not foresee an increase in demand for fixed data as they look to streamline their sites and encourage flexible working for their employees. In these instances, businesses expect mobile communications to grow to the detriment of fixed communications.

Move to the Cloud

5.4. The migration to Cloud-Hosted applications was mentioned as one of the key trends for the next 5 years. Even though it is a journey that started years ago, few interviewees have completed their Cloud migration plans.

5.5. Importantly, cloud hosting is changing the businesses networking requirements, shifting the demand from dedicated site-to site connectivity to Internet connections. Storage was the most

common service in their roadmaps, followed by computing, telephony and Customer Relationship Management (CRM).

5.6. However, several respondents expressed some reservations about such a move. One interviewee highlighted their business would not start hosting services in the cloud until the connectivity was more reliable, and another one felt there were still some security concerns that need to be resolved by the industry.

Growth in Redundancy Needs

5.7. A few interviewees mentioned that resilient communications will become more critical over the next few years, mainly due to two factors:

- Growth in automation will lead to less staff on-site to fix faults as they arise;
- Increasing expectation for businesses to be running 24/7.

5.8. Additionally, a significant number of organisations expressed they would like to see the prices of resilient circuits decreasing over the next few years, so that they can afford to provide resiliency to circuits currently unprotected.

Move to SD-WAN

5.9. A few businesses mentioned that they are starting, or will start over the next few years, to look into SD-WAN, with two objectives in mind: 1) reduce connectivity costs and 2) more control over the network, being able to upgrade bandwidth quickly and without disruption to the business.

5.10. The organisations interested in SD-WAN had two points in common. On the one hand, they all wanted to be able to onboard new sites quickly, either because they had a large number of sites in the UK, or because they had an aggressive Merger and Acquisition (M&A) strategy. Secondly, the organisations were all multinational.

5.11. One interviewee believes SD-WAN will enable the decoupling of the Internet connectivity provision from the SD-WAN management, so that he might look into managing the SD-WAN himself or via a third-party. However, he thinks that the technology still needs to mature.

IoT Evolution

5.12. Several interviewees highlighted IoT as a potential source of innovation in the horizon. An organisation owning a large fleet of vehicles was looking forward to IoT enabling *smart cities* and autonomous vehicles, even though he did not expect this technology to materialise in the next 5 years. One interviewee indicated that IoT required the establishment of realistic pricing models in order to reach mass adoption by businesses.

Virtual / Augmented Reality Use

5.13. Similarly, VR/AR was also discussed by several interviewees in the Hospitality sector (as part of expectations for resident entertainment) and both the Utility and Video Games sector (developing lifelike simulations). They expect both technologies to greatly increase the bandwidth requirements.

Fixed Voice

5.14. Although significant change is anticipated in fixed data needs over the next five years, organisations did not see similar movement with respect to fixed voice. The “biggest” change

forecasted would be the steady decline of desk phones as soft clients and mobile phones replace them.

Substitution of Traditional Desk Phones with Soft UC Clients and Mobile Phones

5.15. There was a broad consensus that voice via soft UC clients, such as Skype for Business, is steadily becoming a viable alternative to a traditional desk phone. Soft clients have grown in popularity due to their multifunctionality, including screen sharing, instant messaging, group calls and email integration.

5.16. The need for traditional fixed voice lines is further eroded by the rise of mobile as a suitable replacement. Some interviewees had strong beliefs that the only fixed voice lines in their organisation in the future would be those required for a broadband internet connection. Only a handful envisaged that legacy systems will still be in place, with the main reasons for continuing to use these being the low price and the reliability their traditional telephony offered.

Mobile

5.17. Future developments in mobile needs could be broadly classified in three categories: increase in the number of devices (and therefore usage), the need for better 4G coverage, and interest in 5G innovation.

Increase in the Number of Mobile Devices

5.18. The interviewees' main argument for a projected increase in the number of work mobile devices was the general push towards flexible, mobile and remote working; smartphones are considered an essential tool for a seamless collaborative working environment. Transportation was one of the verticals expecting to see greater growth in the number of smartphone and in-built mobile devices. Tablets were hardly mentioned, mostly restricted to sales personnel as well as some field employees.

5.19. Conversely, there were some organisations that expected the number of devices and usage to stay constant. These companies typically did not rely heavily on mobility in their day-to-day needs.

5.20. Convergence of fixed and mobile services, but also between equipment, was also mentioned as a feature that some companies would like to move towards, but feel the market is not yet mature enough.

Need for Better 4G Coverage

5.21. Coverage issues were highlighted as a common source of frustration with mobile communication services (more details in paragraph 6.37). Looking into the future, most companies stressed that 4G coverage needs to improve over the coming years. Some went as far as saying that they would rather 4G coverage be prioritised over rolling out 5G.

5G Innovation

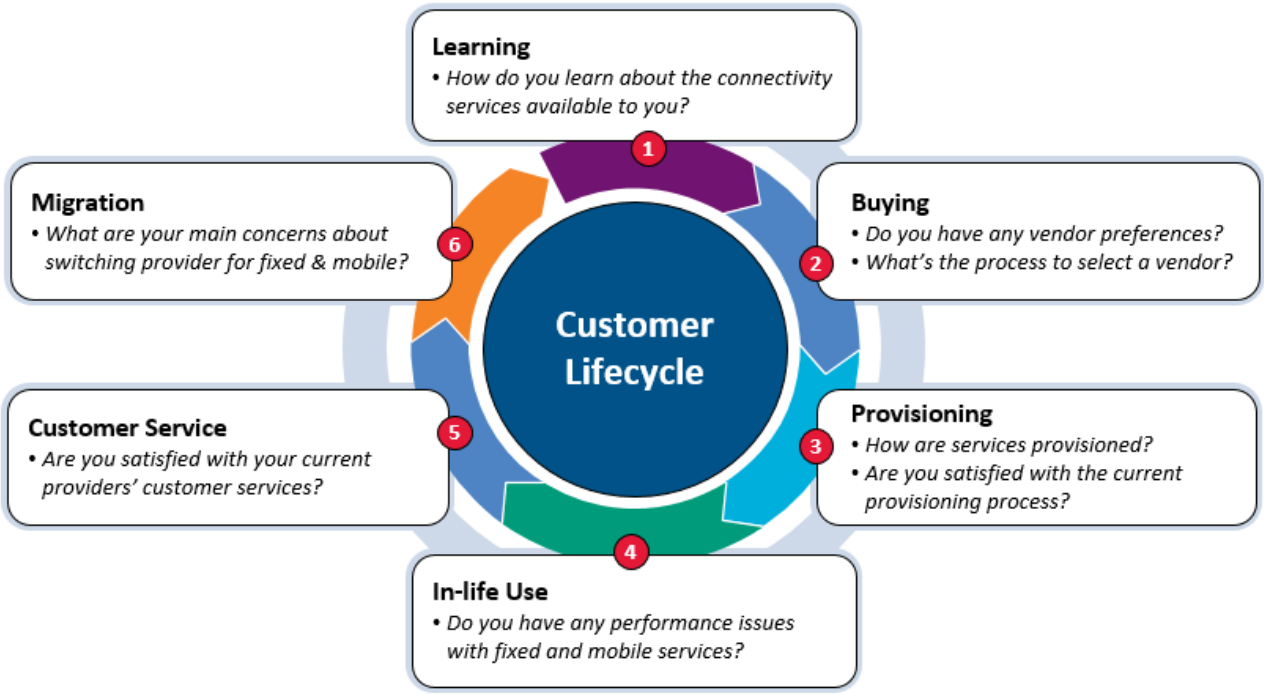
5.22. A handful of interviewees were excited about the opportunity 5G could bring to their business. An interviewee in the food retail industry highlighted real-time control in warehouses and data-connected vehicles as welcome improvements to their processes. 5G is not limited to operational efficiencies, with one respondent pondering whether 5G could be used as the last mile for business connectivity in the future as a secondary redundant link and thus obviating the need for additional fibre deployment.

6. Customer Lifecycle: Experience from Large Enterprises

Interview Structure

6.1. Interviews were structured to follow a typical customer lifecycle journey to draw out key insights from each step of the process, from learning about the services through to use and migration (see Figure 16.

Figure 16. ***Business Communication Services Customer Lifecycle***



Source: Cartesian

Learning Process

6.2. IT Managers typically employ a combination of methods to learn about new products and services available on the market. Internally, all organisations carry out online research to find out what is available in their area. They generally agree there is enough information available to reasonably educate themselves. However, a large proportion of the information received by companies is from the providers offering the services, and some organisations expressed concern around the lack of a clear objective source.

6.3. Externally, organisations often have calls with suppliers (usually with their incumbent, and sometimes with others) to learn about new developments. This is recognised as a good opportunity for companies to discuss their technology roadmap with suppliers and understand how they can help with future business needs. Another method mentioned to directly meet suppliers is attending seminars, webinars and trade events. Seminars and webinars further aid online research as subject experts discuss industry-wide matters that may prompt a rethink for IT Managers on what to consider buying.

6.4. A minority of interviewees mentioned the use of consulting firms and research houses in helping them learn more about the market. Typically, a consultancy would help develop foresight into where the market is moving and / or make specific recommendations to meet the business needs.

6.5. Differences in the learning process between the smaller and larger organisations included in the study are minimal. The only difference observed was the size of the team responsible for learning about the IT connectivity products and services: the larger the company, the more numerous the IT team typically is.

Buying Process

Single vs Multiple Providers

6.6. Most organisations expressed a preference for having a single supplier for each connectivity service, i.e. only one supplier of fixed data services, one supplier of fixed voice, and one supplier of mobile services. Having a single supplier for each service was preferred due to the convenience and accountability of having one point of contact.

6.7. An exception to this was with regards to their redundancy requirements. When purchasing a secondary link, most prefer to use a different provider where the cost can be justified as they perceive that this offers better resilience. In this situation, some interviewees purchase these circuits separately from each supplier, whereas other respondents purchase both circuits from a single supplier (i.e. this supplier will in turn procure the circuit via their upstream wholesale channel).

6.8. Some businesses also prefer having a single supplier for multiple connectivity services, such as fixed data, voice and mobile. Having multiple services with the same supplier can be more cost-effective due to economies of scale. Moreover, most interviewees believe that higher spend with a single supplier often leads to better focus and customer service experience from providers.

6.9. A minority of interviewees bundle their connectivity services with other non-connectivity services as part of a single contract, such as cloud storage, security, IT device management, etc. In general, there was a preference amongst interviewees for choosing a specialist for each different service and avoiding bundling. Each service tends to be tendered separately, and if the same provider happens to win more than one tender, then a bundle might be considered, however it is not an important requirement. Some companies avoided bundling services as this could make switching more problematic and thus lock them in with one provider.

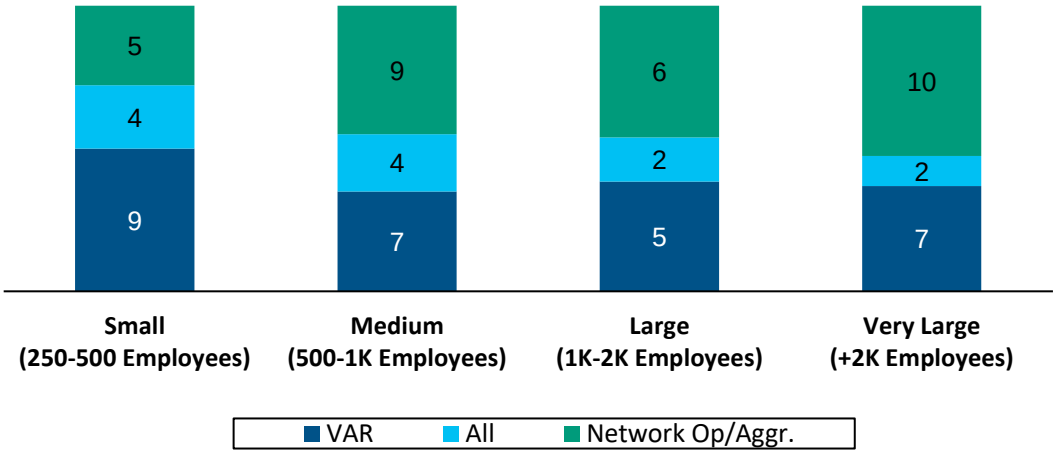
Value Added Resellers vs Network Operators/Aggregators

6.10. It seems network operators/aggregators tend to sell directly to larger organisations more than Value-Added Resellers (VARs), as seen in paragraphs 2.6 - 2.13. We tried to validate this hypothesis against the interviewee sample, dividing the large enterprise interviewees into four size segments according to their employee count (250-500, 500-1,000, 1,000-2,000, and 2000+) and asking them if they preferred to contract communication services from network operators/aggregators or from VARs.

6.11. Figure 17. below shows that smaller organisations tend to favour VARs, whilst larger organisations prefer dealing directly with network operators/aggregators. From the organisations with 250–500 employees, half of them contract their services to a VAR, whereas less than half of the organisations with over 2,000 employees do so. Conversely, more than half

of the organisations with over 2,000 employees go directly to the network operators/aggregators, whilst less than a third do so in organisations with 250–500 employees (see Figure 17.).

Figure 17. ***Companies by Type of Provider Contracted***



Source: Cartesian

6.12. There were mixed views on the value that VARs can provide, with some organisations expressing various advantages and others deeming them unnecessary. In particular, smaller organisations believe they receive better customer service from VARs, as well as achieving a higher purchase power than if they went directly to the network operators (see Figure 18.).

Figure 18. ***Interviewee Views on Value Added Resellers***

Positive Perceptions	Negative Perceptions
Better Customer Service: • VARs sometimes seen as offering a better customer service, partly as they are smaller. • Some organisations believe that network operators/aggregators will not be interested in selling to them because they are too small, or they will deliver poor customer service.	**Less Control and Accountability:** • VARs need to work with their upstream suppliers in resolving network faults and provisioning, and some issues can only be resolved by the end-provider. • As a result, VARs are seen as a potential cause of additional delays when fixing network faults.
More Negotiation Power: • VARs often perceived to provide lower pricing, especially for smaller organisations, as they have a stronger commercial leverage with the CSPs that they buy the services from.	**More Costly:** • VARs could be more expensive as they add a margin to the services supplied by the end-providers.

Positive Perceptions	Negative Perceptions
Provider Diversity: • VARs portrayed as provider-agnostic, leveraging assets from several wholesale providers ("best-in-breed" in each location).	**Insufficient Scale:** • Some larger organisations do not consider VARs to have sufficient scale to be able to deliver services to meet their needs and future growth prospects, especially those with a multinational footprint.
Liaise with Final Supplier: • Some organisations appreciate the fact that the VAR will liaise with the network operators, who tend to be harder to communicate with, and VARs can have stronger relationships with them.	**Less Expertise and Knowledge:** • Some organisations prefer to deal with traditional network operators/aggregators as they are perceived as the experts in the telecom space.

Source: Cartesian

Level of Choice

6.13. The fixed and mobile markets were generally perceived as offering sufficient choice with regards to service providers, particularly in urban areas, however there were some concerns regarding fixed and mobile infrastructure coverage.

Fixed Market

6.14. The fixed data and voice markets were perceived to be competitive by most companies interviewed, as they felt there were generally a sufficient number of service providers to choose from. Respondents in urban areas had higher satisfaction with the choice of service providers as there tends to be multiple credible alternatives. This was not only true for large cities like London, but also included respondents located in sites in other cities and towns, e.g. Cambridge, Cardiff, Chorley, Coventry, High Wycombe, Manchester. Conversely, interviewees complained about the lack of provider choice in some rural areas, where only one, two, or at best three CSPs were available to offer their services.

6.15. In terms of physical infrastructure, almost all interviewees expressed concerns about the lack of diversity, more prevalent in rural areas. This was a major concern for a considerable number of organisations, as they felt that redundant connections from the same supplier would eventually lead to a loss of service if the provider's network was to experience massive disruption. This view was not universal though; some companies would rather purchase diverse routes from the same supplier, as long as they knew the exact routes, as different suppliers could end using the same route (or at least parts of it). On the other hand, some companies were only interested in getting a reliable service and were not concerned about who owned the underlying infrastructure.

6.16. Many interviewees had to make some compromises with regards to the level of resilience depending on their budgets. The strictest levels of resiliency were two (or even three in few instances) full redundant circuits into critical sites, from either different suppliers or the same supplier (e.g. Resilient Option 2, RO2, from Openreach). Others would settle with an inferior secondary back-up connection (e.g. EFM, FTTC broadband), to secure a minimum level of service

in the event of an outage. Some companies expressed they could not afford to install a redundant circuit, especially with regards to installing a secondary leased line. In particular, organisations including care homes, hospitals or those offering residential support had high requirements for solid resiliency as failures in connecting customers to the company could pose life threatening risks. Interviewees expressed that achieving an appropriate level of resiliency can be extremely costly.

Mobile Market

6.17. The mobile market was perceived to be competitive and offering a significant amount of choice between providers, both Mobile Network Operators (MNOs) and resellers. Poor coverage was commonly quoted as a major issue, both in rural and urban areas, irrespective of provider. Coverage of 4G, and even 3G, is an issue for many sampled businesses in most rural areas and some urban areas. In this respect, there is a lack of choice in terms of providers offering widespread coverage.

Procurement Process

6.18. Organisations generally go through a tender process with a formal RFP phase where proposals are evaluated against key selection criteria, and finally a negotiation takes place with the final provider on certain elements of the contract.

6.19. The tender process varies by organization. We found examples of framework contracts and Master Services Agreements (MSAs) in use in public and (typically larger) private organisations; subsidiaries may also be required to use a parent company MSA. Some interviewees also mentioned an increasing trend among smaller firms to form a consortium and increase their overall purchasing power.

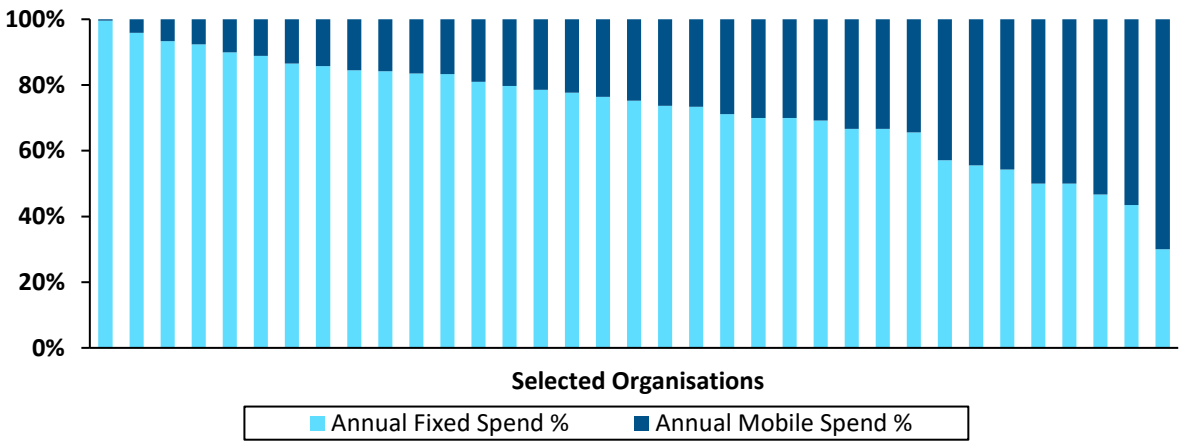
6.20. One key criterion when choosing a vendor is price, as both the fixed and mobile market are generally competitive, although price is considered within the context of perceived quality of service offered. Another important consideration tends to be the CSP's product portfolio, with regards to how well the offering aligns to the needs of the business. In this respect, CSPs at the forefront of innovation are often well regarded. Additionally, having a strong relationship with provider and receiving good customer service is also an important consideration. A number of organisations have expressed their willingness to pay a premium to obtain a superior service.

6.21. Regarding the agreement of contracts with providers, overall cost and/or payment structure are negotiable elements for the vast majority of interviewees. Some companies will also negotiate on Service Level Agreements (SLA) (e.g. resolution time), but in many cases they use industry-standard SLAs. Financially-backed SLAs are common, but they are not thought to compensate for the negative impact of the loss of service in most cases. Contract terms tend to be around 3 or 3 + 2 years for fixed, and 1–2 years for mobile.

Spend on Communication Services

6.22. Fixed services attract a larger spend than mobile for the majority of organisations surveyed, as can be seen on Figure 19. The relationship between business vertical and weighted communications spend is aligned by the use cases of all services. Organisations with a majority of spend on mobile all had a significant field force (e.g. Transportation, Councils), as well as sales and management staff (generally sector-agnostic) constantly travelling, both nationally and abroad, thus, incurring significant roaming charges.

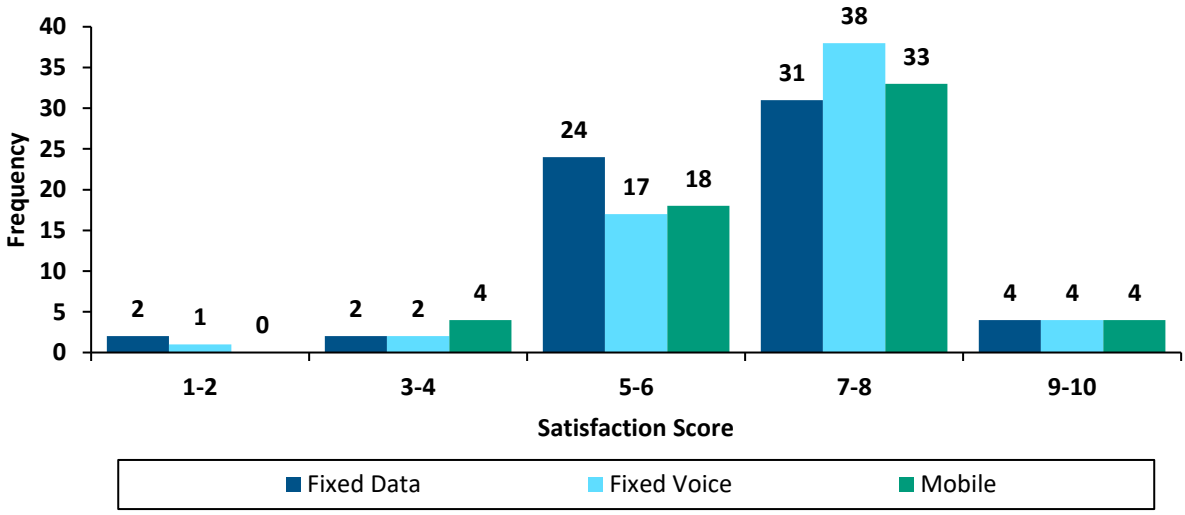
Figure 19. ***Proportion of Annual Spend for Fixed and Mobile***



Source: Cartesian

6.23. Interviewees were asked to rate their satisfaction with the value for money on a scale from 1 to 10, with 1 being not at all satisfied and 10 being completely satisfied. Fixed and mobile services received similar scores of perceived value for money across interviewees, as shown in Figure 20. The main areas of concern for organisations who scored value for money under a 5 included better value seen in other countries, termination fees incurred when switching services, and a lack of offering for data pooling across mobile devices. Conversely, organisations who gave scores of above 8 quoted the perceived competitive nature of the market as resulting in cost-effective solutions.

Figure 20. ***Perceived Value for Money for Fixed Data, Fixed Voice and Mobile Services***



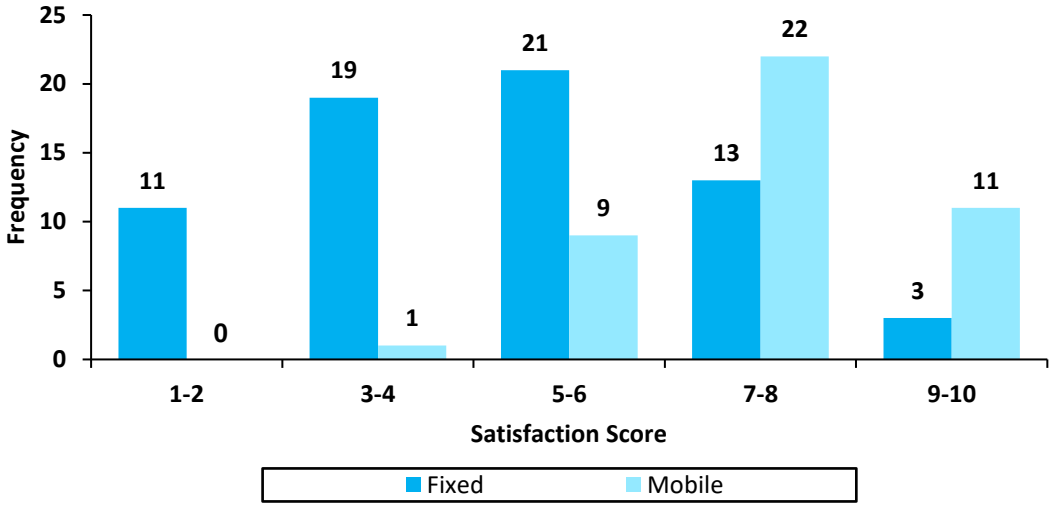
Source: Cartesian

Provisioning Process

6.24. The provisioning of fixed connectivity services was the most frequent and frustrating issue raised throughout the interview process, affecting both urban and rural areas alike. Only 13 out of 67 interviewees who responded to this question rated the fixed provisioning experience higher than

6 out of 10. Conversely, interviewees were far more satisfied with the provisioning of mobile services, as shown in Figure 21.

Figure 21. ***Satisfaction with the Fixed and Mobile Services Provisioning Process***



Source: Cartesian

Issues During the Provisioning of Fixed Services

6.25. The key issues cited for fixed service provisions were long lead times, delays, uncertain delivery deadlines and a lack of communication from the service providers. These problems lead to the delivery of some connections taking a number of months and significantly impacting the business.

6.26. Analysing the qualitative responses given by respondents on the fixed provisioning process offers some broad themes:

- While interviewees are generally dissatisfied with service provision, smaller companies highlighted they did not feel important given that they are a small account to the provider.
- A number of interviewees highlighted that booking an engineer was a frustrating experience, with missed / incorrect visits causing unnecessary delays.
- Some issues were common to specific sectors. We show three examples below:
  - *Retail*: various interviewees mentioned numerous anecdotal cases where they had a retail shop ready to open but their plans were set back because circuits (leased lines or broadband) had not been installed on time.
  - *Construction*: interviewees in this sector claimed that the business communication market lacks a solid model for construction sites, as these often need temporary connectivity for just a few months during the construction phase. The lack of a system to pre-plan provisioning and undertake a survey before the project has started can make connectivity to these sites unviable: provisioning can sometimes take even longer than the construction phase. Moreover, contract lengths are not suitable for these temporary projects and there is a lack of flexibility to move services to a new site once projects are completed. Due to these issues, IT managers rely in many instances on a prepaid 4G broadband connection to serve the site, which is viewed as insufficient.
  - Housing development: house buyers and tenants expect their property to be have connectivity when they move in, and a failure to do so can damage the developer's reputation.

6.27. The consensus is that fixed service provision needs a complete overhaul. When probed further, the majority of respondents emphasised that installation times have not improved and a few interviewees believed that the time to provision had worsened. A few interviewees complained about the target provisioning SLAs being too long in the first place; they felt that the standard SLAs were effectively being set by Openreach, and other CSPs would largely use very similar ones, as most would rely on Openreach for the last-mile connectivity.

6.28. Some interviewees at international organisations were able to compare the UK experience against that in other countries, with very mixed views. As an example, one believed that the provisioning experience in the UK was one of the worst, lagging behind countries such as Spain, the USA and Singapore. Conversely, two businesses rated the UK experience typically better than in other countries (they did not confirm which countries, but one of them had a large presence in developing economies).

Perceived Underlying Causes

6.29. When asked what they thought the underlying causes of fixed provisioning problems were, three reasons emerged:

- *Wayleaves:* acceptance among interviewees that wayleaves are in most instances beyond the operator's control.
- *Supplier's organisational structure*: perceived inefficiencies in the supplier, with interviewees expressing their frustration at how a process that according to them should be fairly smooth, can encounter a multitude of problems. This frustration is amplified by the opaqueness of the process, with firms having to be proactive to find out the current status of the installation, as opposed to be notified.
- *No seamless migration process:* There was frustration amongst several interviewees that there is no migration process for switching between suppliers of leased lines. If a customer wants to change supplier, they must follow a "cease and re-provide" process, where the original service is cancelled and the new one is ordered separately. In practice, a "make before break" approach is usually taken with a period of parallel working to avoid a site outage. Interviewees claimed that even when Openreach was supplying both services, a new installation would occur rather than "re-using" the old fibre.

Mitigation Strategies

6.30. Organizations employ a variety of approaches to mitigate the impact of long lead times for fixed services, which can be split by a technical or managerial approach. Technical solutions include using a 4G broadband service for temporary connectivity, or to install copper-based connectivity, such as Ethernet in the First Mile (EFM), as these have a shorter lead time.

6.31. Alternatively, some interviewees chose to take more active management of the overall process, liaising directly with the service provider to try and accelerate the delivery.

Provisioning of Mobile Services

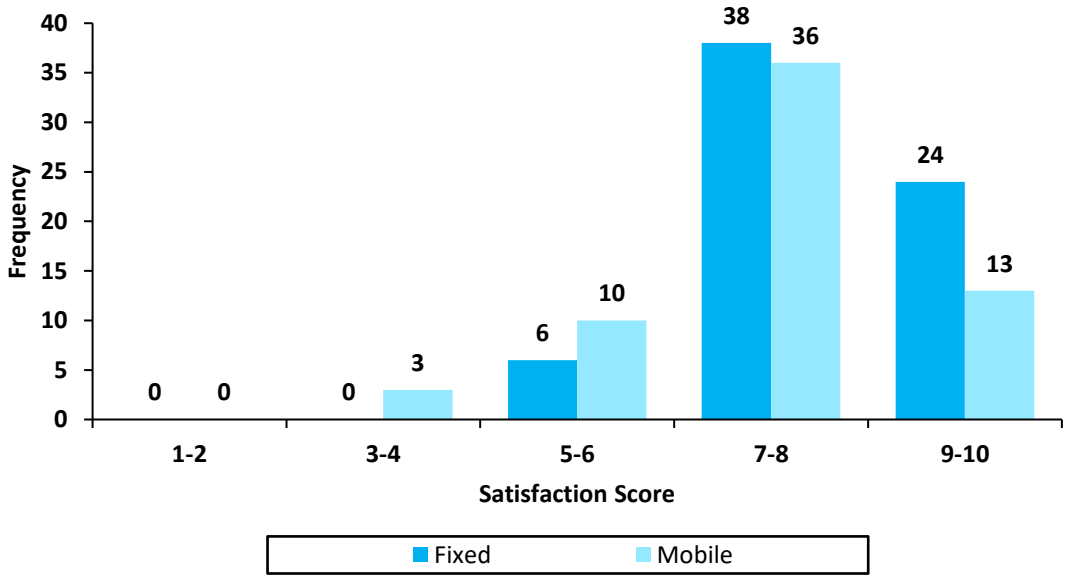
6.32. The provision of mobile services is generally a straightforward process. Only a handful of respondents experienced problems, and these related to porting numbers; this was mostly due to employees not following the instructions correctly and logistics (especially true of companies with a large field force, as employees must come back to the office to pick up the new SIM cards). Some interviewees highlighted the usefulness of having spare SIM cards on site and an account manager assisting the process, which expedites mobile provision.

In-Life Use

6.33. Although interviewees considered the provisioning experience of fixed services to be relatively poor, when it comes to in-life performance, the overall impression can be aptly summarised by the common sentiment of, *"Once you get [the circuit] in, it works"*, which many interviewees mentioned.

6.34. The overall satisfaction with in-life performances is generally high for both fixed and mobile services (slightly higher with fixed services). See Figure 22. for the breakdown of the responses.

Figure 22. ***In-Life Performance Satisfaction with Fixed and Mobile Services***



Source: Cartesian

In-Life Performance of Fixed Services

6.35. Interviewees noted that in-life performance is not equal across all fixed products: fibre leased lines are seen as more reliable than copper leased lines or broadband lines.

6.36. Fibre leased line outages are few and far between. Where interviewees had experienced outages, these were due to physical damage (e.g. from civil works) or human error (accidentally ceasing an active line). Both types of outage can take a long time (hours or days) to resolve. As noted above, large enterprises customers typically have redundant connections for critical sites.

In-Life Performance of Mobile Services

6.37. Satisfaction with mobile performance is generally acceptable, faring slightly worse than with fixed services. The following list summarises the most common issues, with poor mobile coverage at the top of the list:

- *Outdoor mobile coverage*: Nearly all organisations have problems with mobile coverage, which are most acute in rural areas (non-spots in urban areas were also been raised as an issue). There is a natural correlation between the level of mobility in an organisation and the impact of poor mobile coverage on their business operations. Companies with a large fleet of vehicles (e.g. companies in the Engineering, Transport and Emergency Services sectors) are the most adversely impacted by this issue.

- *In-building mobile coverage:* A few interviewees commented that coverage is also poor inside buildings. Metal structures of modern office sites have further exacerbated this issue, converting them into Faraday cages[7]. In extreme situations, some companies have installed in-building mobile solutions to rectify this (some businesses agreed to co-invest with a Mobile Network Operator (MNO) to install them). Other mitigation strategies included the signature of contracts with more than one MNO, and giving their employees multiple SIM cards, or the SIM card of the operator with better coverage levels at their primary location.
- *Data speeds:* some interviewees highlighted the lack of 4G coverage as an issue; they receive sufficient 2G/3G coverage for phone calls, but insufficient for mobile data access. This issue was more prevalent amongst businesses located in rural areas.
- *Cellular—Wi-Fi interaction:* given the ubiquitous presence of Wi-Fi through both indoor and outdoor Wi-Fi hotspots, some interviewees mentioned that some MNOs did not offer a reliable Wi-Fi calling service, and that cellular-to-Wi-Fi handover should be smoother.

Customer Service

Billing Issues

6.38. The majority of interviewees experience billing issues on a regular basis from their communication providers for both fixed and mobile services. Billing issues appear common across many providers, as well as size and vertical of customers, although they tend to be improved by having a single supplier.

6.39. Typical problems include overcharging, charging for decommissioned or non-existent circuits, incorrect roaming charges and not keeping to contractual agreements (e.g. agreed discounts).

6.40. The lack of transparency in billing was also commonly expressed, as bills are complex and / or opaque, which leads to more time spent investigating charges. In some cases, the providers lack a clear online billing portal and have outdated billing processes like paper bills. For some organisations, the time to investigate a bill has led to having dedicated staff for this function or employing a third party or specialist software to validate the charges.

6.41. Some interviewees also experienced inflexibility from providers with regards to billing, such as inability to add new sites / numbers onto an existing contract. This resulted in having multiple bills rather than an aggregated one, adding to the complexity of the process. In particular, some mobile providers were seen to lack the flexibility to offer features such as data pooling across a flexible number of mobile devices.

6.42. Refunds, when due, are generally honoured but the experience varies greatly across the interviewees. Some companies have received refunds efficiently and timely, whilst others have waited months. Even when they are issued as credit for next month's bill, it does not always appear on the statement.

Relationship with Providers and Role of Account Manager

6.43. Customer service experiences vary significantly across organisations interviewed and are highly dependent on the relationship and quality of the account manager. If customer service is

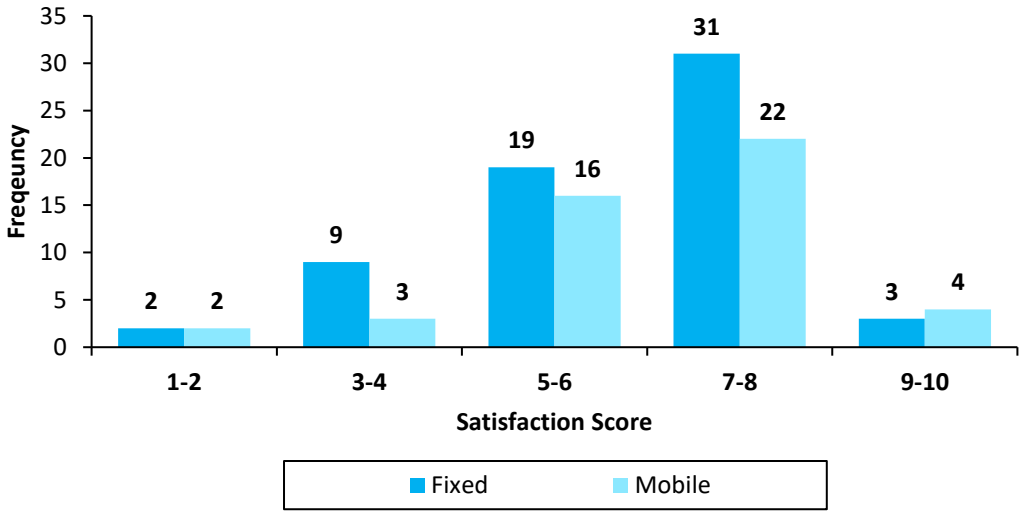
[7] Effect by which buildings or rooms with metallic conducting frames and walls suffer from a loss of signal for users of cellular phones, radios, and other electronic devices that require external electromagnetic signals

satisfactory, it tends to be due to having a stable account manager with knowledge of the business.

6.44. However, a significant number of companies had negative experiences with their providers' customer service, mostly around lack of engagement from account managers, as well as frequent change of account managers with no prior notification. Some linked customer service experience to how close the contract negotiation was, i.e. high-quality senior account managers would be appointed when a contract is up for renewal, to be replaced by less experienced ones later on. In some cases, escalation to provider's senior management was required to improve the customer service.

6.45. There were no significant differences in the customer service satisfaction levels between fixed and mobile services providers (see Figure 23.). The scores are fairly mixed and mostly driven by interviewee sentiment with their account managers.

Figure 23. ***Satisfaction with Customer Service from Communications Providers***



Source: Cartesian

Upgrades, Migration and Switching

6.46. Given the disruption that switching connectivity services can incur, organisations carefully weigh up the pros and cons of a potential switch before doing so. Interviewees were asked which experiences would hypothetically make them consider a switch of providers, and conversely what barriers to switching they perceived, if any.

6.47. Triggers to Switching:

- *Quality of service drop:* a material reduction in a supplier's quality of service can trigger IT directors to actively seek to switch providers (e.g. throughput, packet loss, etc.).
- *Customer service deterioration:* given the central role of an account manager (as discussed in the previous section), a deterioration of the relationship with the incumbent supplier can also motivate a switch.
- *Pricing re-evaluation*: competitor offering a better price and / or value for money would cause the interviewee to evaluate such a proposal.

- *Innovative product roadmap:* a competitor offering an innovative product or service which meets an outstanding current or future need will be another trigger for a business to switch service providers, especially if it is not offered by the incumbent.
- *Improved coverage*: for mobile services, business will look to switching providers if competitor has better coverage, or investment in coverage, especially with 4G. This will become increasingly important as the reliance on mobile grows.

6.48. Barriers to Switching

- *High costs of leased lines migrations*: some interviewees found the complexity and cost involved in migrating leased lines to be a significant barrier to switching. An impact analysis is usually performed prior to any decision, comparing the cost savings offered by the potential new provider against the actual migration costs (e.g. need for additional resources, parallel running of circuits during the migration, etc). Other providers, typically in larger businesses with a bigger IT team, seemed more open to switching providers, provided that the business case was favourable.
- *Complexity of porting fixed number:* some interviewees with a high reliance on fixed voice (e.g. companies that have a lot of customer-facing interactions) mentioned the process to port fixed numbers for businesses to be complex, especially for SIP trunks.
- *Cumbersome mobile switching*: some interviewees highlighted that swapping SIM cards and obtaining Porting Authorisation Code (PAC) can still be cumbersome, so they expressed reservations in switching suppliers unless there was a major reason for doing so. Businesses with large fleets of vehicles were especially wary; with vehicles being out of the office for days or weeks, it could take a long time to ensure all vehicles changed their SIM cards.
- *Co-investment in indoor coverage boosters:* In paragraph 6.37, we mentioned that some companies co-invested with their mobile service provider to install devices to boost indoor coverage in their sites. The same interviewees mentioned that this one-off investment can represent a barrier to switching providers, as they would likely have to incur similar costs should they also need to install these devices with the new provider.

6.49. Additionally, a subset of interviewees had been involved in an actual service migration in their current business, so we asked them to comment on the triggers that made them decide to switch providers. These were the main responses with regards to fixed service migrations:

- Drop in quality of service of the incumbent provider
- Bad customer service from the incumbent provider
- Better pricing with the new provider
- Innovative products offered by the new provider

6.50. Several interviewees shared that they had recently changed mobile service providers because insufficient coverage and a poor quality of service of the mobile network (e.g. dropped calls). One interviewee clarified that it was taking the incumbent provider more than 3 months to investigate the issues, so decided to change providers as a result.

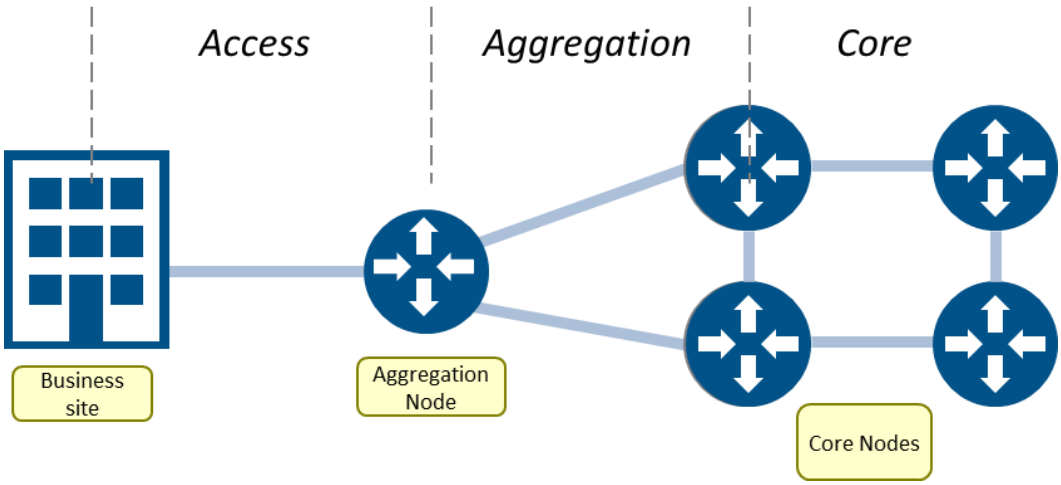
7. Insights from Interviews with CSPs

Types of Connectivity Services Purchased on a Wholesale Basis

7.1. A CSP network can be segregated into three high-level segments (see Figure 24.):

- *Access*: also referred to as *last mile*; connects the customer premises to an Aggregation Node. The circuits are typically copper or fibre.
- *Aggregation*: fibre circuits in this segment aggregate the traffic from the Aggregation Nodes and carry it to the Core Network. There might be more than one level of traffic aggregation
- *Core:* the fibre circuits in this segment typically form a ring or mesh to connect the Core Nodes, where CSPs host their systems and applications, and where they interconnect with other CSPs (e.g. for voice and Internet traffic).

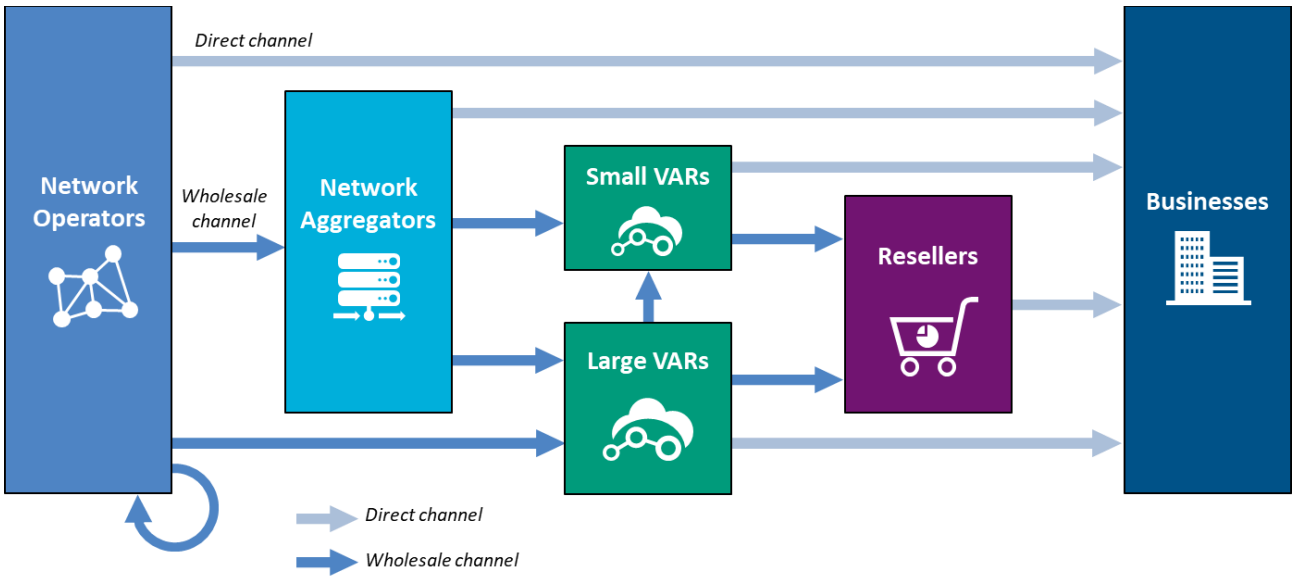
Figure 24. ***High Level Network Architecture Segments***



Source: Cartesian

7.2. In each of the three segments, CSPs can follow one of these strategies: self-build, purchase from a third-party supplier, or a combination of both. Generally, only a small set of CSPs construct their networks entirely via self-build, whereas the vast majority purchase circuits from third-party providers on a wholesale basis, for at least part of their network footprint. Gaining insight into the connectivity supply chain of these providers was a key objective of this study. Figure 25. below shows a diagram of the supply chain, a more granular version than the introductory diagram in **Error! Reference source not found.**

Figure 25. ***Overview of the Business Connectivity Supply Chain***



Source: Cartesian

7.3. The types of services that the CSPs purchase from their upstream wholesale suppliers will depend on their position in the supply chain:

Network Operators and Network Aggregators

7.4. There is a wide variety of network operators and network aggregators in the UK business connectivity supply chain. As discussed above, some of these CSPs purchase connectivity from other network operators. This can occur at any segment within the network, depending on the CSP's scale and business strategy.

- *Core Network:* Dark Fibre, or leased wavelengths in its absence, are the preferred products for high capacity core networks, as they are more cost effective and scalable than leased lines. CSPs tend to install capacities of multiples of 10G, 40G or even 100G. Indefensible Right of Use[8] (IRU) contracts of up to 15 or 20 years are common with Dark fibre circuits.
- *Aggregation Network:* traditionally leased lines have been used in this segment, but the increasing demand for capacity makes Dark Fibre, where available, increasingly more attractive. 1Gbps capacities were usual, but 10G services and above are increasingly more common in this segment. Contracts are usually between 3 and 7 years, unless operators are seeking to upgrade to Dark Fibre when it becomes available in a specific location, in which case they sign shorter contracts with the incumbent leased line providers.
- *Access Networks:* CSPs purchase the access service indicated by the customer, which is typically leased lines (100Mbps is the most common contracted capacity, but demand for 1Gbps is growing) or broadband services. Most network operators, including those with their own access network, will consider buying wholesale access circuits to reach customers that are beyond their network footprint ("off net"). The build versus buy decision is made on commercial grounds.

[8] In telecommunications, Indefeasible Right of Use (IRU) is the effective long-term lease (temporary ownership) of a cable (in this case, dark fibre).

Large VARs

7.5. Large VARs do not have their own access network. Instead they buy wholesale access services from network operators and/or network aggregators to connect customers to their services.

- *Core Network:* even though their core network may be smaller than that of network operators and aggregators (is common to have just two or three core nodes in the UK's main data centres), the supply chain is similar. Dark Fibre or leased wavelengths are preferred.
- *Aggregation Network:* VARs do not have Aggregation Networks *per se*. They interconnect with network operators in a few central locations.
- *Access Networks:* Large VARs are able to purchase access circuits from network operators, as they have enough purchasing scale to deal with them directly. Additionally, they usually sign contracts with network aggregators, and use them if their pricing is more attractive: it is not rare for a circuit from a specific operator to be less costly when purchased indirectly via an aggregator. 100Mbps capacity leased lines and broadband (FTTC/ADSL) are the most common services.

Small VARs

7.6. Small VARs usually purchase access circuits from network aggregators:

- *Core and Aggregation Network:* some small VARs do not operate their own core network. For those who do, it generally consists of 2 or 3 Core Nodes, from where they interconnect to the network aggregators they have partnered with.
- *Access Networks:* these providers usually do not have sufficient purchasing scale to deal directly with the network operators. Therefore, they secure access to their last-mile circuits via use of Aggregators. 100Mbps capacity leased lines and broadband (FTTC/ADSL) are the most common services.

7.7. Additionally, some small VARs (especially those without a Core Network), may also purchase other services as inputs to their retail offerings. They usually purchase these services from larger VARs which are specialists on specific services. A prime example would be purchasing Voice over IP (VoIP) services from VoIP-specialist VAR.

Non-telco Resellers

7.8. The core business of non-telco resellers is not communications services. These resellers do not operate a network, and connectivity is usually an add-on to their core business. They resell connectivity services from VARs, as they are usually too small to deal directly with network operators or aggregators, and sometimes connectivity services would be just offered to the customer on a referral basis (i.e. obtaining sales commissions from the VAR). Typical products include leased lines and broadband.

Views on Supplier Diversity

7.9. The majority of respondents agreed that having good supplier diversity is important. A variety of reasons were given. Firstly, some end customers have high resiliency requirements which may include carrier diversity. To deliver this, resellers need to have strong partnerships with multiple providers.

7.10. Secondly, some interviewees believed that having multiple suppliers pushes better customer service as there are strong incentives for providers to maintain a good relationship. Finally, there

is the perceived added commercial risk of working with only one provider. Whilst having choice was viewed as important, some companies chose to have a limited number of suppliers as doing so increased their bargaining power.

7.11. There were mixed views amongst respondents around the satisfaction levels with the choice of suppliers. Many interviewees claimed supplier choice was limited. Whilst some did not express major concerns about this, others felt the market requires more supplier choice on the last mile. There was a common sentiment that there are a significant number of small suppliers that lack the scale to compete effectively, and thus more large national suppliers are needed in the market.

7.12. The annulment of Ofcom's obligation on Openreach to provide Dark Fibre Access (DFA)[9] consequential to the CAT's judgement on BCMR market definition was identified as a limitation within the market by a number of the CSP interviewees. They believed that DFA, in its initial unrestricted form, would have given Service Providers real product choice and brought innovation to the market, given the limited choice of national network infrastructure beyond Openreach.

Products and Services Sold by Service Providers

7.13. Most of the CSPs who participated in the study aim to sell a comprehensive portfolio of services, from basic connectivity to hosted telephony and other value-added services. There are some providers which specialise in certain products, such as VoIP or hosting.

7.14. The main connectivity services supplied to large enterprises have been discussed in detail in paragraphs 7.3 - 7.8, whereas in this section we explore the range of value-added services in the market. It should be noted that the services detailed below include those most commonly offered, however CSPs do not necessarily offer them all. As an example, several of the CSPs that we interviewed did not offer mobile services at all.

Figure 26. ***Products and Services Typically Sold on Top of Connectivity***

Products and Services	Overview of Findings
Multi-site Networks	• On top of Point-to-Point connectivity, CSPs often offer value-added services to cater for networking needs between multiple sites, including: – Virtual Private Network (VPN) – Multi-Protocol Label Switching[10] (MPLS) – SD-WAN, etc.
Redundancy	• Value added via aggregating offering circuits from diverse CSPs, as well as dual technology, e.g. Ethernet over FTTC (EoFTTC) as back-up for a 100Mbps Ethernet leased line.
Internet Access	• CSPs use business connectivity services to provide Dedicated Internet Access[11] (DIA).

[9] https://www.openreach.co.uk/**darkfibreaccess**

[10] MPLS is network transport mechanism which uses path labels to route traffic. Advantages include the ability to control where and how traffic is routed on the network, capacity management, service traffic prioritisation, and prevention of congestion

[11] DIA provides uncontended access to the Internet using point-to-point Ethernet leased lines from the business premises to an Aggregation Node / Exchange

Products and Services	Overview of Findings
Telephony	• Fixed telephony solutions, either on-premise or hosted, with SIP trunks or traditional bearers (ISDN, analogue lines). This includes full contact centre solutions, as well as security services for telephony.
Unified Communications	• Integration of enterprise internal communication services such as instant messaging, audio and video conferencing, collaborative interactive tools, etc. Skype for Business and WebEx were the primary services mentioned by CSPs.
Mobile	• Includes both provisioning of mobile devices as well as data and voice connectivity services.
Hosting & Colocation	• Solutions to house customers' servers and networking equipment in the CSP's data centre.
Cloud Services	• Includes services such as cloud storage, cloud security, hosted applications (Customer Relationship Management (CRM), Enterprise Resource Planning (ERP), etc.), cloud computing, Office 365/SharePoint…
Security	• Range of security products and services from Firewalls to authentication and Distributed Denial of Service (DDoS) protection.
IT Office Services	• IT support services such as maintenance, network support, PC installations, IT device management, software licenses, local networking (e.g. WiFi, Local Area Network (LAN), etc.), network monitoring and reporting, etc.

Source: Cartesian

7.15. Additionally, we spoke to two non-telco resellers whose main business was in a different vertical (e.g. energy management, facilities management, other utilities) and offered communication services as an additional service.

Views on the Process to Purchase Connectivity Services

7.16. The process for choosing supplier varies on whether the services procured are access services to connect customers, or internal Aggregation/Core Network circuits.

Backhaul and Core Network Supplier Selection Process

7.17. In the build-out of the Backhaul and Core Network, network operators typically engage in-depth with potential suppliers (usually other network operators) in order to determine whether they can meet their needs. These discussions consider elements such as network architecture and physical routes. There are a few reasons why the process is very manual:

- There is a relatively a low number of providers that have enough network capillarity to be considered in the process.

- Given the critical importance of the network physical routes to design a resilient network, a thorough due diligence process is required. Workshop sessions with the potential providers are a good way to ensure the exact network routes are understood (some CSPs might be less transparent about the actual routes when providing information over a pricing portal).
- There are multiple ways to design aggregation and core networks: detailed workshops with the potential providers will help discuss different network design possibilities.

Customer Access Circuits Supplier Selection Process

7.18. For customer access circuits, most interviewees confirmed they use a pricing portal to check which providers can serve the address(es) of the customer location(s), and to compare potential suppliers against a set of criteria. Whilst the criteria used varied between wholesale customers, the most commonly quoted included the following:

- Availability of service / geography covered: one of the most common criteria. It refers to whether the CSP operates in that area and has the capability to serve the business site. The provider is usually prioritised if their circuit to the building is on-net, as it will likely benefit from shorter delivery lead times.
- Price: the most important criteria highlighted by CSPs, alongside *circuit availability*.
- Quality of service (e.g. jitter, latency): less important the first two criteria, but usually mentioned by most CSPs.
- Customer service: The relationship built with suppliers was also an important consideration, with some interviewees mentioning a set of suppliers they would go to first, before considering others.

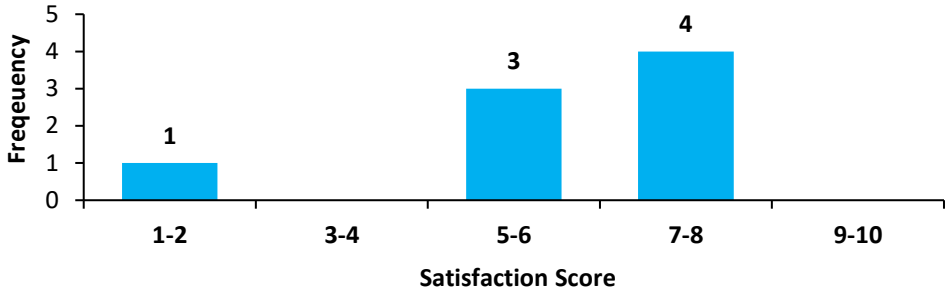
7.19. Some service providers also considered previous experiences on provisioning lead times, as well as performance on escalations / outages, with one provider using these as inputs in their pricing portal, e.g. the tool automatically increases the quote from a provider if they have a poor track record of circuit delivery. Some interviewees mentioned they have stopped using certain service providers altogether.

7.20. Another very important consideration is whether the customer has specific supplier preferences. Most interviewees agreed that most customers do not express any preference, but some do (typically larger businesses). Preferences are mainly driven by two criteria: prior customer experience, and diversity requirements. A very negative (or positive) past experience with a supplier makes some customers want to avoid (or choose) them this time around. With regards to diversity, in some instances the customers already have a primary circuit, and they want to ensure that the secondary link they are purchasing is from another network operator.

Provisioning Process

7.21. Provisioning of fixed connectivity services was one of the major concerns for a large number of interviewees. Of the 16 CSPs that we interviewed, only eight provided an overall score for their satisfaction with the connectivity provisioning process for backhaul (see Figure 27.).

Figure 27. ***Satisfaction with the Connectivity Provisioning Process for Backhaul***



Source: Cartesian

7.22. Those that did not provide an overall score felt the experience varied greatly on a number of factors:

- On-net / off-net: one interviewee said that provision of on-net circuits fared much higher than off-net circuits, giving a score of 7 and 1, respectively.
- Provider specific: four interviewees rated their provision experience on a supplier basis. The scores amongst the largest providers were mixed, between 1 and 7. Openreach fared better than the alternative providers for two respondents, and worse for the other two. Only one respondent gave a score of 9 to a provider for their provisioning process.
- Product: one CSPs gave higher provisioning satisfaction scores to copper-based products such as EFM and FTTC (7 out of 10) than to fibre-based leased lines (score of 3).

7.23. The operators we interviewed may have agreements with different partners, but the last mile infrastructure is owned by Openreach in the vast majority of cases. Most interviewees acknowledged that Openreach's internal planning and provisioning processes have been improving over recent years. Some interviewees also commented positively on Openreach's infrastructure discovery tool, which help companies understand the process involved in connecting certain buildings, and some claimed it has been improving in accuracy.

7.24. That said, several concerns regarding the overall provisioning process persist.

7.25. The most common concerns on provisioning were around inefficiencies in the process, which often lead to delays and uncertainties in deadlines. Interviewees believed the most common sources of delays were due to construction, civils, blocked ducts and wayleaves issues, as well as the inability to plan and manage these events properly by Openreach.

7.26. Some companies believe the lack of a more automated provisioning process contributes to issues during this phase. Delays can also be due to resource and appointment availability from Openreach, as well as missed appointments. Some interviewees mentioned that specific instructions in the order forms to are sometimes ignored, and that equipment is sometimes installed in the wrong place. Delays, when they occur, are often unpredictable and thus create uncertainties around delivery deadlines, making planning challenging. Companies have often attributed these issues to the amount of red tape internally in Openreach, which lead to inefficiencies in the process.

7.27. Other major areas of dissatisfaction were around the lack of communication and accountability. A number of interviewees believed that some providers do not communicate effectively throughout the provisioning process with regards to updates on status, amount of digging work

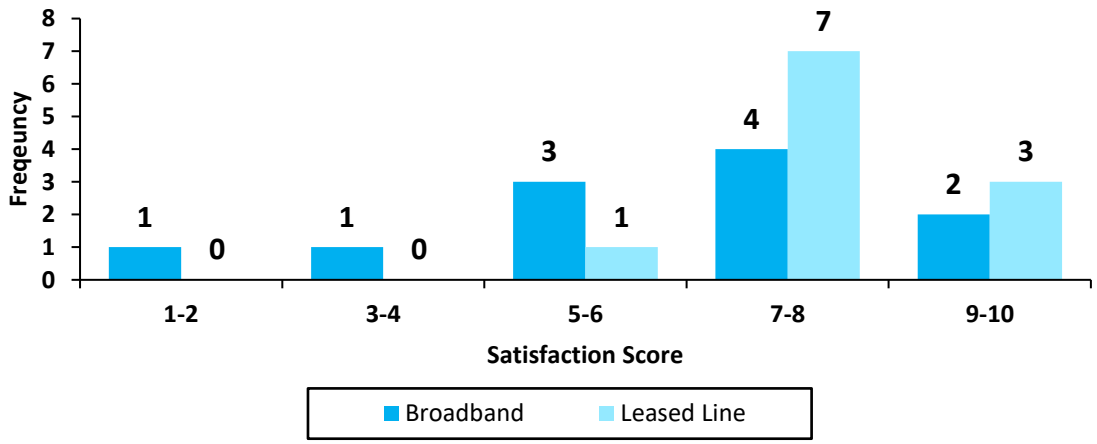
that needs to be completed, significant gaps in infrastructure, etc. Local councils are also seen by some to be responsible for delays as they n be perceived to be uncooperative and not sufficiently flexible with communications providers for street works.

7.28. Minimum Service Level (MSL) agreements imposed on Openreach were deemed counter-productive by one interviewee, perceiving that Openreach are more likely to reject orders that do not have every field in the order form fully completed, whereas before there was greater tolerance for unknown details. Several CSPs believe industry benchmarks and standard SLAs are generally poor in the first place, and even so they are also sometimes not met.

In-Life Performance

7.29. When CSPs were asked about the in-life performance of the connectivity circuits purchased on a wholesale basis, they broadly agreed with the views from the end-customers, as seen in paragraphs 6.33 - 6.37. "Provisioning is the main issue; performance in-life is good". CSPs also observed noticeable differences between broadband and leased lines, as seen in Figure 28.

Figure 28. ***Satisfaction with In-Life Performance for Service Providers***



7.30. Respondents noted the very high reliability of fibre leased lines. In comparison, copper-based broadband products (e.g. ADSL, FTTC) were seen as less reliable and more fault-prone, mainly due to the characteristics of copper: poor performance caused by rain, humidity or interferences from other lines. Other issues with copper services include human errors, e.g. accidental disconnection of a copper pair at the Cabinet. Interviewees felt that it took significantly longer for copper issues to be resolved versus fibre.

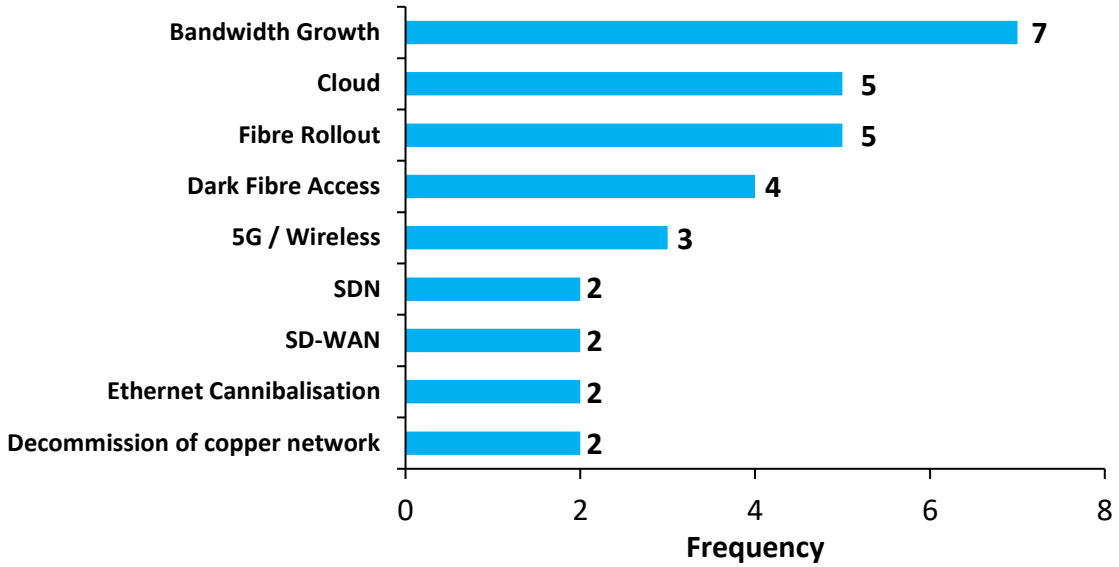
7.31. Two issues were raised regarding fibre leased lines: (i) fibre breaks are rare but can lead to lengthy outages when they do occur; and (ii), packet loss issues can occur which may be difficult to resolve due to their unclear root cause. One CSP believed that packet loss was mostly due to insufficient capacity in the wholesale providers' aggregation networks; another complained that when raising such issues, the wholesale provider's only answer was to "check again in one hour".

7.32. A number of comments about in-life performance pointed to Openreach, as the owners of the majority of last mile circuits used by the CSPs. Some interviewees complained about poor customer service at Openreach during the resolution of an issue. Another interviewee said they would appreciate a degree of flexibility when arranging engineer appointments, as customer premises visits can be difficult to arrange (e.g. if the office is closed).

Future Evolution of Communication Market Needs

7.33. Surveying CSPs on what trends they expect to emerge in the connectivity market over the next 5 years revealed wide-ranging answers (see Figure 29.

Figure 29. ***Emerging Connectivity Trends, According to CSPs in Study***



Source: Cartesian

7.34. The two most common topics raised by CSPs were also highlighted by large enterprises. The table below provides an overview of the main themes that interviewees believe will shape the connectivity market over the next few years.

Figure 30. ***Key Trends Affecting the Connectivity Market, as Viewed by the CSPs in Study***

Trend	Description	Mentioned by Large Enterprises
Bandwidth Growth	• CSPs highlighting this trend expect to see a more aggressive increase in capacity demand than the gradual increase forecasted by the large enterprises in the study, fuelled especially by the move of services to the cloud and the use of video • Interviewees mentioned that customer demand for 10Gbps circuits is growing, and some have started to request 100Gbps • At the lower end, CSPs estimated that many small and medium enterprises will upgrade from broadband to leased lines, as they become more affordable	✓
Cloud	• The transition to the cloud hosted applications will continue	✓
Fibre Rollout	• Fibre rollout programmes will accelerate, especially FTTP, according to some interviewees, making fibre broadband services available to many businesses that currently can only	

Trend	Description	Mentioned by Large Enterprises
	subscribe to copper-based broadband services (e.g. FTTC at best, ADSL if FTTC not available)	
Access to Openreach dark fibre	• Access to Openreach dark fibre is seen as a key driver for innovation, and a number of CSPs would like to see it materialising in the next few year • CSPs highlighted that access to Openreach dark fibre would help them to provide very high bandwidth services. The wholesale leased lines that are currently available are seen as expensive and limited in performance, e.g. maximum throughput of 10 Gbps offered by Openreach	
5G / Wireless	• A few CSPs believe that 5G will play a key role in business connectivity, either as a viable alternative to fibre circuits for the last mile, or at least as a complementary technology to provide resilience to existing fibre leased lines	
Software Defined Networks (SDN)	• Some CSPs have strong views about the central role SDN will play in the next few years: a future with Network APIs[12], a high degree of automation and minimal manual intervention • A few respondents have already invested in, or are looking into, SDN	
SD-WAN	• SD-WAN is a hot topic for a few interviewees; they expect this product to be very successful in the near future • Faster circuit provisioning, flexible upgrades and more Internet Access circuits as opposed to site-to-site connections, leading to cost savings are a few of the advantages observed by some interviewees	✓
Ethernet Cannibalisation	• Some CSPs were concerned about the gradual price decline in connectivity ("a *race to the bottom*") • One provider saw evidence of EoFTTC replacing EFM, as it can deliver higher top speeds with a *near-uncontended* experience, at a lower cost than EFM. The *near-uncontended* experience is achieved by applying traffic management rules which prioritise certain types of traffic. His concern was that when EoFTTP is available, it might replace dedicated leased lines for a segment of the market, lowering overall revenues	
Decommission of Copper Network	• Several CSPs would like to see the decommission of the legacy copper networks over the next few years • One of them mentioned that copper *"is being phased out around the world"*, so the UK should take a lead role as well	

Source: Cartesian

[12] Network Application Programming Interfaces (APIs) are core components of SDN networks, as they form an abstraction layer to communicate between the network controller and the services and applications running over the network

8. Insights from the Mobile Backhaul Supply Chain

Context and Methodology

8.1. Between November 2017 and January 2018, Cartesian interviewed six senior representatives of five UK Mobile network operators and Mobile Access Infrastructure providers. The objective of these interviews was to provide Ofcom with insights into Mobile Backhaul connectivity.

8.2. To recruit the interviewees, Cartesian used its existing contact network. Interviewee recruitment focused on senior roles that would have visibility of their company's mobile network architecture strategy, as well as their wholesale mobile backhaul procurement decision-making. In some cases, we performed more than one interview with the same firm, to provide coverage across the scope of our research.

8.3. The interviews were structured to last one hour. Key areas covered in the interview included:

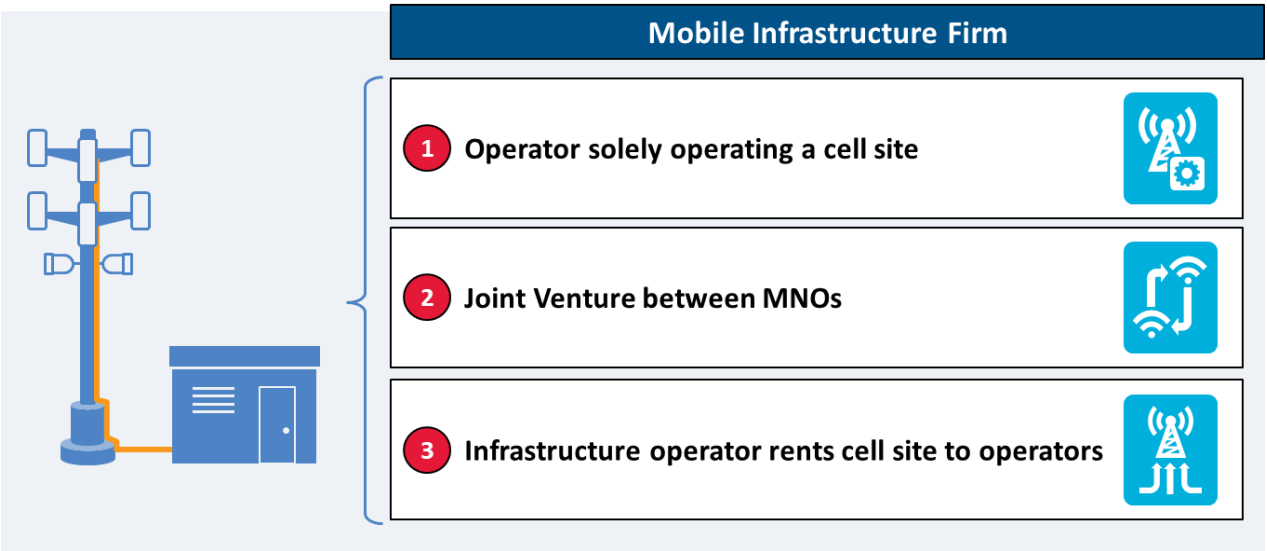
- Current backhaul solutions and connectivity services;
- Experiences as a customer of wholesale connectivity services;
- Decision making process to select wholesale connectivity providers; and,
- Emerging technology trends which will shape the mobile backhaul market over the next 5 years.

Views on Current Mobile Backhaul Needs

Cell Site Passive Infrastructure

8.4. In the UK there are three main operating models for *cell site infrastructure* with regards to deployment and ownership (see figure below).

Figure 31. ***Cell Site Infrastructure Ownership***



Source: Cartesian

8.5. The simplest model consists of an MNO solely operating a cell site. The operator negotiates the fee to be paid to the land/building owner, and installs cell site equipment (antenna, Base Station) and pays for own power.

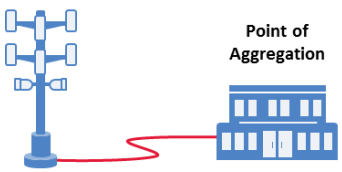
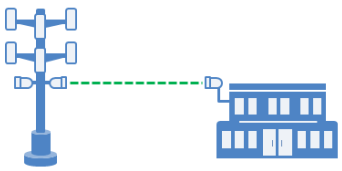
8.6. In the second model, MNOs partner with each other to share cell sites. This is frequently achieved through a joint venture (JV) company. The goal is to maximise the coverage rollout of the operators involved, while maximising cost efficiencies and maintaining a certain level of independence. In the UK, two JVs have been established to this end. In 2007, mobile operators T-Mobile and 3UK formed a JV, MBNL, to manage their shared access network[13]. (MBNL is today owned by BT and 3UK following BT's acquisition of EE.) A second JV, Cornerstone Telecommunications Infrastructure Limited (CTIL), was formed by Vodafone and O2 in 2012[14].

8.7. The third type of arrangement consists of a neutral, mobile infrastructure firm owning the cell site and charging MNOs for access. MNOs pay the infrastructure firm for the colocation of their network equipment at the mast and the cabinet, the maintenance of the tower, and the power consumed. We include Tower Companies and Neutral Hosts in this category. UK examples include Arqiva, Cellnex and the Wireless Infrastructure Group (WIG).

Mobile Backhaul Connectivity: Physical Layer

8.8. UK MNOs currently use three methods for backhaul connectivity to the cell sites: fibre, microwave and copper (see high-level summary below).

Figure 32. ***Mobile Backhaul Physical Layer Options***

		Cell Sites Share	Installed Capacity
Fibre		50-70%	1 Gbps (minority 10 Gbps)
Microwave		25-45%	150-800 Mbps
Copper		2-7%	< 100 Mbps

Source: Cartesian

8.9. **Fibre** is the most commonly used medium and is the preferred choice in locations where it is available at reasonable cost. Over the last decade, operators have undertaken large programmes

[13] http://www.hutchison-whampoa.com/en/media/press_each.php?id=2166
[14] https://www.telegeography.com/products/commsupdate/articles/2012/06/07/vodafone-uk-and-telefonica-uk-to-merge-network-infrastructure/

to upgrade copper and microwave backhaul connections to fibre. It is now used in 50 – 70% of the cell sites, depending on MNO. The most common connection type is 1Gbps Ethernet; however, some operators have started to install 10Gbps Ethernet bearers in locations with high demand. Upgrading from 1Gbps to 10Gbps is more cost effective and offers better scalability than multiple 1Gbps circuits.

8.10. **Microwave** links are used to connect cell sites where a fibre connection is not economic. Microwave technology can also be used as a temporary solution if there is a long lead time on a fibre connection. Currently, the share of microwave backhaul stands at 25 – 45%, depending on the operator. Microwave is more commonly used in rural areas than in urban areas, due to the higher availability of fibre in urban geographies. In some cases, multiple microwave hops will be used to reach remote sites. Frequencies currently used are typically in the 10 – 30GHz bracket. The UK mobile operators we interviewed operate microwave backhaul at data rates in the 150 – 800Mbps range.

8.11. **Copper**-based leased lines used to be commonplace for connecting cell sites, but they have been rapidly replaced by fibre circuits. Currently, UK mobile operators have only a few hundred sites still on copper services, typically using multiple E1 (2Mbps) circuits. These are mostly in rural areas and represent 2 – 7% of the total number of cell sites. Operators are aiming to replace these circuits with fibre solutions, but at least one of the MNOs highlighted that this can prove difficult in some cases due to the unavailability of suitable alternative fibre products, especially in remote rural areas.

Mobile Backhaul Connectivity Market in the UK

8.12. In terms of sourcing backhaul connectivity, MNOs have a choice between building their own backhaul network (self-supply) or buying connectivity services from a fixed network operator. From our interviews, microwave backhaul is always self-supplied; fibre-based connectivity is often purchased from fixed network operators as most of the MNOs do not have an extensive fibre network of their own to self-supply.

UK Suppliers of Fibre-Based Mobile Backhaul

8.13. The MNOs that we interviewed identified three suppliers of fibre-based mobile backhaul:

- BT Wholesale supplies fibre-based Ethernet services for mobile backhaul using Openreach network products. BT Wholesale is used by all MNOs, given BT's extensive network footprint in the UK[15].
- Virgin Media supplies fibre-based Ethernet services for mobile backhaul to some MNOs[16].
- CityFibre supplies dark fibre for mobile backhaul to some MNOs[17].

8.14. MNOs purchase mobile backhaul circuits directly from these three providers. In addition, it is also possible for a site-sharing JV to purchase the connectivity.

Views on Mobile Backhaul Market and Supplier Diversity

8.15. Historically, MNOs purchased mobile backhaul circuits only from BT. Some MNOs later decided to expand the list of providers in order to secure more competitive prices. The process to select the provider is quite straightforward: the provider offering the most attractive commercial terms is

[15] https://www.telegeography.com/products/commsupdate/articles/2008/10/06/t-mobile-and-3-sign-deal-with-bt-wholesale-for-base-station-links/
[16] http://telecoms.com/32422/mbnl-signs-100m-deal-with-virgin-media-business/
[17] https://www.cityfibre.com/news/20141112cityfibre-signs-dark-fibre-deals-with-ee-and-three-to-enhance-mobile-networks/

normally selected. MNOs also mentioned that the contracts usually include clauses with volume commitments (e.g. number of circuits they will order annually). Therefore, these arrangements also play an important role when deciding which provider to use.

8.16. At least one MNO expressed concerns about the lack of competition, given that many cell sites can currently only be served by BT. They saw Virgin Media's network footprint, in comparison, as relatively limited; City Fibre's coverage even more so.

8.17. According to the same respondent(s), the key benefits of having increased competition in this market were the following:

- Improved pricing.
- Better customer service and responsiveness, especially if the provider perceives a tangible threat of MNO changing mobile backhaul providers.
- Better product capability and innovation: a perception of less appetite for innovation, with longer development lifecycle than if there was competition.

8.18. In general, MNOs confirmed that cell sites do not have redundant backhaul circuits. The only exception is the Emergency Services Network (ESN)[18]. The MNOs therefore have no need for supplier diversity for redundancy at the level of an individual site.

Provisioning Process

8.19. Long lead times for delivery of fibre mobile backhaul circuits were raised by more than one of the MNOs. Achieving a sustainable volume of mobile backhaul circuit delivery from BT Wholesale was also seen as a challenge, given that BT Wholesale has to deliver many circuits to many Fixed and Mobile network operators. One operator believed that mobile backhaul circuit delivery timelines had improved since the introduction of additional measures on Openreach by Ofcom in the last BCMR review, but that further improvement was still required.

8.20. However, one interviewee highlighted that the overall lead times for deploying backhaul connectivity to cell-sites are usually quite predictable, typically around 4 months from survey to circuit installation. Therefore, these lead times can be factored into the MNO cell-site overall planning process. This observation contrasts with the views from large enterprises as described in paragraphs 6.24 - 6.31, with some organisations deciding to open new sites with notice periods as short as few weeks in some instances.

8.21. Obtaining wayleaves was highlighted as an issue by all MNOs interviewed, and affects all mobile backhaul providers. At least one MNO suggested that Virgin Media's smaller network footprint may mean that civil works and therefore wayleaves are required more often to reach cell sites.

8.22. One of the MNOs observed that the number of new mobile backhaul circuit volumes being deployed each year was relatively small; as an example, in 2017 they only installed a few hundred sites.

In-life Performance

8.23. In-life performance of fibre-based backhaul circuits is not seen as an issue by MNOs. Like the large enterprise interviewees, the view that "once it's in, it works" prevailed.

[18] https://www.gov.uk/government/publications/the-emergency-services-mobile-communications-programme/emergency-services-network

8.24. Although issues are rare, one MNO interviewee expressed his dissatisfaction with the level of in-life support provided by their supplier when there was a problem.

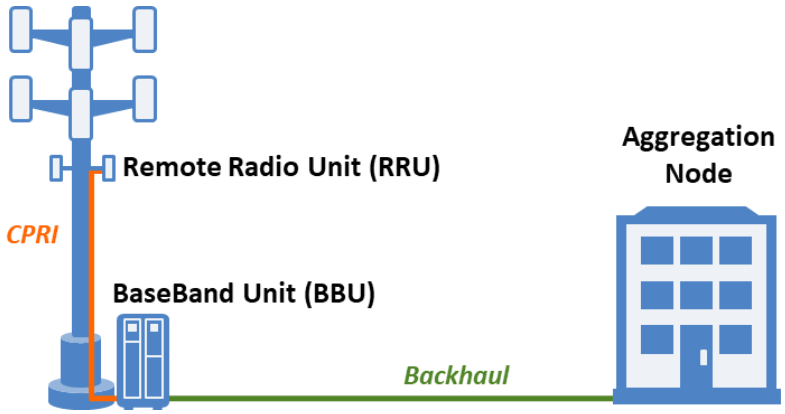
8.25. One interviewee highlighted that where the MNO installs its own Ethernet terminal equipment at esach end of a third-party fibre leased line from the cell site to the Aggregation Node, it obtains greater visibility of the circuit performance (e.g. packet loss).

Future Trends Shaping the Mobile Backhaul Market

8.26. Our discussions with the interviewees on what trends they expect to emerge in the mobile backhaul connectivity market over the next 5 years covered several topics, with an overarching focus on 5G. Perspectives on the evolution of mobile backhaul considered changes to the radio access network (RAN) architecture.

8.27. The most common RAN configuration today for new sites is the distributed RAN (dRAN), in which the Baseband Unit (BBU) and the Remote Radio Unit (RRU) are both located at the cell site. In dRAN, the RRU is mounted on the mast with the antenna and radio amplifier, whereas the BBU is housed in a cabinet at ground level. The BBU and the RRU are interconnected by fibre cable that typically uses a protocol such as Common Public Radio Interface (CPRI). The BBU then has a backhaul connection to the MNO Aggregation Note, typically using a high-speed Ethernet link (fibre or microwave).

Figure 33. ***Overview of Distributed RAN Architecture***



Source: Cartesian

Changes in the Radio Access Network Architecture

8.28. MNOs are looking to evolve the RAN architecture in order to increase capacity and reduce latency for 5G in high-density areas. The following options are being evaluated by the MNOs consulted. They may end up deploying a subset, or a combination, of these RAN variations. Most MNOs highlighted that all these variations of RAN architecture would require wide availability of dark fibre in the UK, given the high capacity requirements for fronthaul (i.e. between the RRU and the BBU) and backhaul (between the BBU and the Aggregation Node).

Centralised RAN

8.29. In the Centralised RAN (cRAN) architecture, only the RRU equipment is located at the cell site. The BBU is housed in a local centre with the BBUs for a number of neighbouring cell sites. By centralising

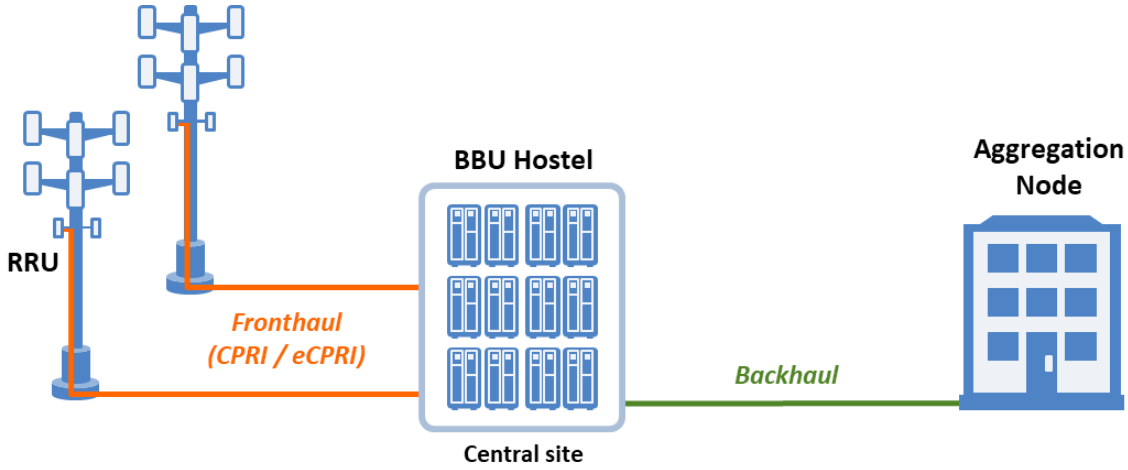
the BBU, the MNO can reduce operational costs (e.g. cooling). The MNOs interviewed highlighted that BBUs can also be interconnected, facilitating the coordination and signalling between the different cell sites to improve network performance.

8.30. The central site may be referred to as a BBU Hostel, particularly if the facility it is provided by a neutral host to accommodate BBUs from multiple MNOs.

8.31. The fibre connection between the cell site and the BBU hostel is usually referred to as *fronthaul*. Using protocols such as CPRI, and taking into account the latency requirements, these fronthaul links have a typical maximum length in the order of 3 – 6 km. Therefore, these links would need to be purchased from a third-party provider, as digging the roads would normally be uneconomical. Hence the reason why MNOs insisted that availability of dark fibre is critical to ensure the viability of fronthaul-based RAN solutions.

8.32. In order to minimise the capacity requirements on the fronthaul link, MNOs interviewed highlighted the development of eCPRI, evolution of the CPRI protocol. This standard, still under development, will allow a ten-fold reduction of the required bandwidth, as well as supporting commonplace transport technologies such as Ethernet. eCPRI will be relevant to Centralised RAN as well as the other RAN options described below.

Figure 34. ***Overview of Centralised RAN Architecture***



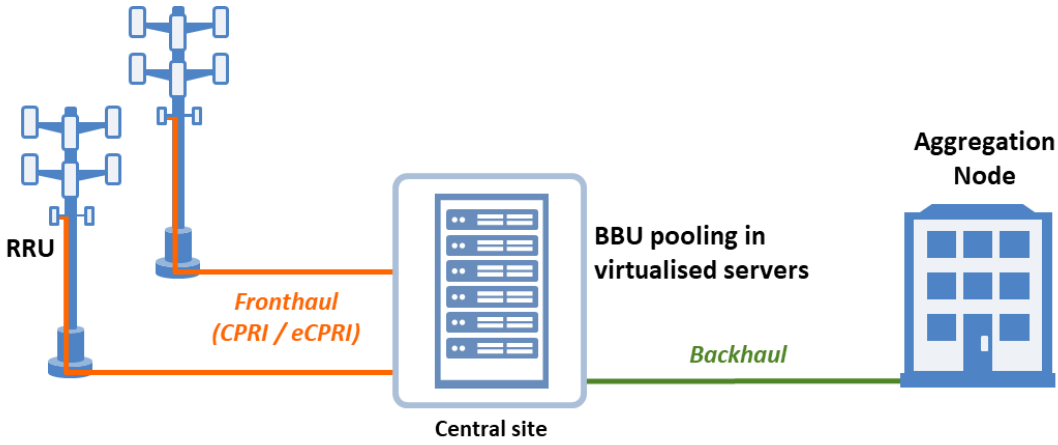
Source: Cartesian

Virtualised RAN

8.33. The Virtualised RAN (vRAN) architecture goes one step further from cRAN and uses virtualised pools of BBU in the central site. As the BBU resources are shared, they can be allocated to the cell sites depending on their needs, leading to additional cost savings. This technology can be also referred to as Cloud-RAN.

8.34. MNOs consulted were enthusiastic about vRAN, as while it still a nascent technology, it is seen as an enabler for Multi-access Edge Computing (MEC). With this new paradigm, applications can be hosted closer to the point of concentration, allowing more intelligence to be placed on the edge of the network as opposed to the core. One of the interviewees provided an example of a MEC use case, whereby the operator could inform Google of the codec rate to use when displaying a Youtube video on a smartphone, based on the radio conditions at the time of transmission.

Figure 35. ***Overview of Virtualised RAN Architecture***



Source: Cartesian

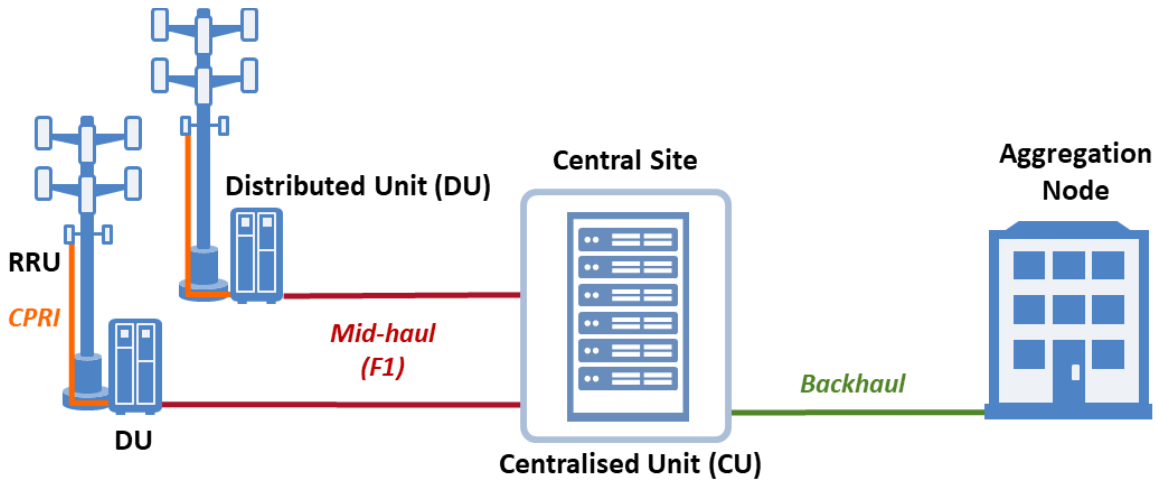
Split RAN

8.35. The Split RAN (sRAN) architecture was highlighted by one of the MNOs as a key area of interest. Split RAN is a more recent architecture under development, which combines the advantages of cRAN with the cost-effective transport of dRAN. The functions of the BBU are separated into two separate components: the lower layer protocol functions remain at the cell site in a distributed unit (DU), with a high-speed CPRI-like interface connecting this to the antenna.

8.36. The other half of the BBU – the Packet Data Conversion Protocol (PDCP) function – is a centralised unit (CU) to provide coordination and load balancing across multiple cell sites. Splitting the BBU in this way greatly reduces the capacity requirements of the *mid-haul* link between the cell site and the central site. A new Ethernet interface called F1 is being defined for this link to support 5G[19]. The diagram below shows a high-level diagram of sRAN.

[19] https://5g.ieee.org/tech-focus/june-2017/standards-for-5g-and-beyond

Figure 36. ***Overview of Split RAN Architecture***

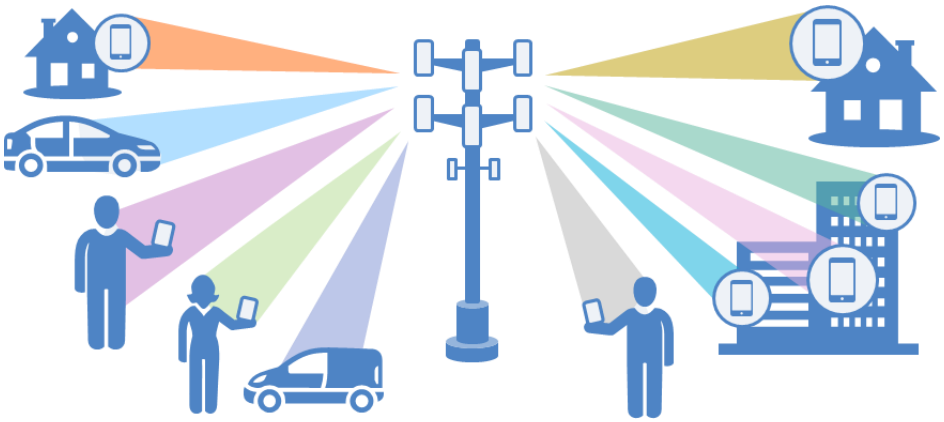


Source: Cartesian

Massive MIMO

8.37. MIMO (Multiple-Input Multiple-Output) consists of multiple antennae linked in an array which can be controlled to increase the efficiency of a network. Massive MIMO, currently in trial development, is expected to become an essential 5G technology. It will greatly increase the network capacity by locating tens (or even more than a hundred) small antennae at the Base Station, which will form multiple signal beams directed at the devices connected to it (see illustration below).

Figure 37. ***Massive MIMO Beam Forming***



Source: Cartesian

8.38. MNOs interviewed believe that rather than impacting the overall RAN architecture, Massive MIMO will mostly be deployed in dense areas with high traffic demands, and will be installed in conjunction with the RAN architectures described above (cRAN, vRAN and sRAN).

8.39. The high transmission capacities achieved by Massive MIMO are expected to require high mobile backhaul capacities. As a result, some interviewed MNOs stressed the importance of dark fibre availability.

5G Backhaul Capacity and Architecture

8.40. In addition to changes in the RAN, operators are also looking at backhaul architecture options as part of their preparation for 5G.

5G fronthaul and backhaul capacity and physical layer options

8.41. Mobile backhaul demand has continued its rapid growth since the introduction of 4G. One operator highlighted that in some locations, cell sites increase their traffic by 50% year on year. The current mobile backhaul capacities of 1Gbps might be sufficient for a year or two, according to one of our interviewees; but 1Gbps will not be able to meet the 5G capacity requirements, which operators expect to grow exponentially. Operators believe that 10Gbps mobile fronthaul and backhaul will become the new norm, with a number of sites requiring multiple blocks of 10Gbps, up to 100 Gbps in cases where multiple sites are aggregated.

8.42. In light of the high-capacity requirements of 5G, operators expect a large shift from microwave towards fibre, especially in urban and suburban areas. In rural areas, they also expect a transition to fibre to increase, but more modestly, as availability improves. Most mobile operators we spoke to believed that wider availability of dark fibre would help accelerate the shift from microwave to fibre backhaul. The high costs and lack of scalability of leased lines (e.g. Openreach's EAD product) will be increasingly unattractive according to some MNOs, especially with 5G requiring very high capacities.

8.43. MNOs believe that microwave fronthaul/backhaul will continue to be required in those sites where installing fibre is uneconomic, or where fibre installation has very long lead times. One of the operators we spoke to estimated that their overall share of microwave will decrease from the current levels of 45% of cell sites down to 10% over the next 5 – 10 years.

8.44. In order to be able to deliver sufficient capacity, microwave backhaul will start to use higher frequency bands, e.g. E-band at 70 – 80 GHz (also referred to as millimetre wave). These higher frequencies have a shorter reach versus the lower bands which will require some re-planning of the RAN backhaul architecture.

8.45. MNOs offered mixed views on the best backhaul architecture for 5G. One operator expected macro cells to serve as aggregation points for nearby small cells, forming a tree architecture. Another operator, in contrast, believed that as capacity grows, it becomes less viable to use cell sites as intermediate aggregation points, as the overall backhaul capacity would quickly scale to over 100Gbps.

8.46. To achieve increased coordination between clusters, as seen in the *Changes in the RAN* section (paragraphs 8.28 - 8.39), operators may choose to locally aggregate the control plane data from the cell sites, with the user data taking a separate path.

Passive Optical Network (PON) as a backhaul topology

8.47. One interviewee indicated that he had looked at Passive Optical Network[20] (PON) systems capable of delivering 10 Gbps (e.g. XG-PON) to see if it could be a viable architecture to deliver mobile backhaul capacity in a cost-effective manner. However, his view was the technology was quite limited for mobile backhaul, lacking flexibility and scalability to deliver sufficient capacities.

[20] A PON is a telecommunications network that uses unpowered splitters (hence 'passive') to route data sent from a central location to multiple destinations. PON is a cost-effective way to provide Internet access for customers since it is a point-to-multipoint system

Using of Duct Access to deploy connectivity to the cell sites

8.48. Interviewees were also asked whether they would be interested in using BT's existing ducts in order to deploy their own fibre to the cell sites. The MNOs pointed out that mobile backhaul is specifically excluded from the list of use cases of Openreach's current Duct and Pole Access (DPA) product[21], but that they would very much welcome a change in this decision.

8.49. [✂].

Densification with Small Cells

8.50. The majority of cell sites currently deployed in the UK for 2G, 3G and 4G are macro cells with coverage radii of up to 30km. *Small cells* transmit at lower power than macro cells, and their coverage radius ranges from a few dozen metres to typically less than 1km. Mobile operators and infrastructure providers are already deploying 4G small cells, mainly to improve indoor coverage in areas such as shopping centres and office buildings.

Use cases for 5G small cells

8.51. All interviewees agreed that 5G will require a wide deployment of small cells, with one mobile operator estimating that up to 30,000 – 50,000 small cells could be required. Mobile operators observed three main use cases for the use of small cells in 5G:

8.51.1. High-capacity urban areas, where mobile traffic will be offloaded from the macro cells onto small cells.

8.51.2. Specific hotspots, including bus stops, train stations and football stadiums. These are very localised, and could operate for a limited time, switching off when not required (e.g. football stadia when there are no games).

8.51.3. Indoor small cells, to improve in-building performance. MNOs are already doing this for 4G (see paragraph 8.50). However, 5G is likely to require more small cells due to increased capacity and the use of higher frequencies which have lower signal penetration through walls. Unlike high-capacity cells, which mostly apply to urban areas, indoor small cells are expected to be required in all geographies.

Small cells backhaul method

8.52. Deploying large volumes of 5G small cells that require high-capacity backhaul connectivity will pose a challenge to mobile operators. Operators expect some small cells will require backhaul capacities of up to 10 or 20 Gbps in 6 – 10 years.

8.53. Fibre is widely seen as the preferred backhaul method for small cells. Some MNOs stressed that dark fibre availability will be key to ensure that the business case for 5G small cell deployment is viable. One MNO interviewee said, "we will not be able to pay the same amount of money we pay for macro-cell leased circuits if we are to deploy 30,000 – 50,000 small cells; so we will need dark fibre to keep costs manageable".

8.54. While fibre-based backhaul will be dominant, operators accept that microwave backhaul will still play a role, specifically for outdoor small cells where fibre is not available or uneconomic. One of the operators indicated that not only C-band (50 – 80 GHz) frequencies would be used, but potentially even higher D-band frequencies (140 – 170 GHz), for very high capacity and short ranges.

[21] https://www.openreach.co.uk/orpg/home/products/ductandpoleaccess/ductandpoleaccess/downloads/DuctandPoleAccessOverview.pdf

The same respondent highlighted some promising results of wireless link simulations on the D-band achieving transmission data rates of multiple 10Gbps over short links of a few hundred metres.

5G Timelines

Interviewees were finally asked when they expected to see the first deployments of 5G in the UK. They all provided similar views, with trials expected around 2020 (one interviewee believed trials will come as early as 2019) and initial deployments shortly thereafter. However, their views were speculative, as they believed that there is still uncertainty around the definition of the 5G standards.

9. Appendix A – Glossary of Terms

Abbreviation	Definition
ADSL	Asymmetric Digital Subscriber Line
API	Application Programming Interface
BCMR	Business Connectivity Market Review
BBU	Baseband Unit
BTW	BT Wholesale
BYOD	Bring Your Own Device
CLI	Calling Line Identification
CPRI	Common Public Radio Interface
CRM	Customer Relationship Management
CSP	Communication Service Provider
CTIL	Cornerstone Telecommunications Infrastructure Limited
CU	Centralised Unit
DDOS	Distributed Denial of Service
DFA	Dark Fibre Access
DPA	Duct and Pole Access
DU	Distributed Unit
EAD	Ethernet Access Direct
EFM	Ethernet First Mile
EoFTTC	Ethernet over FTTC
EoFTTP	Ethernet over FTTP
ERP	Enterprise Resource Planning
ESN	Emergency Services Network
FTTC	Fibre to the Cabinet
FTTP	Fibre to the Premise
IoT	Internet of Things
IP	Internet Protocol
IRU	Indefeasible Right of Use
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
JV	Joint Venture
LAN	Local Area Network
MBNL	Mobile Broadband Network Limited
MIMO	Multiple-Input Multiple-Output
MNO	Mobile Network Operator
MPLS	Multi-Protocol Label Switching
MSA	Master Service Agreement
MSL	Minimum Service Level
ONS	Office for National Statistics
PAC	Porting Authorization Code

PDCP	Packet Data Conversion Protocol
PON	Passive Optical Network
POP	Point of Presence
PSTN	Public Switched Telephone Network
RAN	Radio Access Network
RRU	Remote Radio Unit
SDN	Software Defined Network
SD-WAN	Software Defined WAN
SIC	Standard Industrial Classification
SIP	Session Initiation Protocol
SLA	Service Level Agreement
UC	Unified Communications
VAR	Value Added Resellers
VoIP	Voice over IP
VPN	Virtual Private Network
WAN	Wide Area Network
WIG	Wireless Infrastructure Group
XG-PON	10 Gbps – Passive Optical Network

Cartesian is a specialist provider of consulting services and managed solutions to leaders in the global communications, technology and digital media industries. For over 20 years, we have advised clients worldwide in strategy development and assisted them in execution against their goals. Our unique portfolio of consulting services and managed solutions are tailored to the specific challenges faced by executives in these fast-moving industries. Combining strategic thinking, robust analytics, and practical experience, Cartesian delivers superior results.

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