Final report for Ofcom

Sample survey of ducts and poles in the UK access network

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analysys mason

Contents

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1 Executive summary

1 Analysys Mason and Lythgoes Limited are pleased to present Ofcom with this report, which forms part of Ofcom's assessment of next-generation access infrastructure.

2 In August 2009, Ofcom engaged Analysys Mason and its partner, Lythgoes Limited, to undertake a sample survey of the duct and pole infrastructure of Openreach's distribution network (from the street cabinet to the premises – also referred to as the distribution side, or D-side), in order to help Ofcom inform its NGA regulatory policy. The main objective of the survey was to assess Openreach's duct and pole infrastructure to gain an insight into the space potentially available, and to determine whether or not it offers a viable option for deploying new fibre.

3 To achieve this objective, we surveyed 552 chambers, 320 poles in 7 different locations in the UK to be as indicative as possible of the national infrastructure network in urban and sub-urban areas. Note that the sample size only represents 0.013% of the total number of chambers and 0.008% of poles in Openreach's network, and hence the sample is only indicative. In comparison, the previous duct survey sample considered a similar number of sites, but only considered chamber sites (not poles), which represented 0.02% of Openreach's infrastructure network. It is therefore very important to recognise the limitations of the sample size when drawing any widespread conclusions from the results of the survey and local conditions may vary.

4 We found that, in urban areas, Openreach's distribution network is composed of ducts (underground infrastructure) and poles (overhead infrastructure); customer premises can therefore either be served by underground or overhead infrastructure. We define the last drop as the section of wire between the last interconnection point in the distribution network and the end customer.

5 There are two types of duct in the distribution network, serving different purposes:

- 90mm diameter duct used in the main routes of the distribution network (deployed from the street cabinet along the distribution route but excluding the last drop)
- 50mm diameter ducts used mainly for the last drop of underground-fed wires.[1]

6 As illustrated in Figure 1.1, where the last drop is delivered underground, the cables may either be buried or may be contained in a 50mm diameter duct. In overhead delivery, the pole delivering the last drop will usually be fed by underground cables from the adjacent chamber using a 50mm duct.

[1] According to Openreach, smaller ducts (e.g. 25mm) may also be present in this part of the network for infrastructure deployed before 1968 but we did not come across such ducts in our survey.

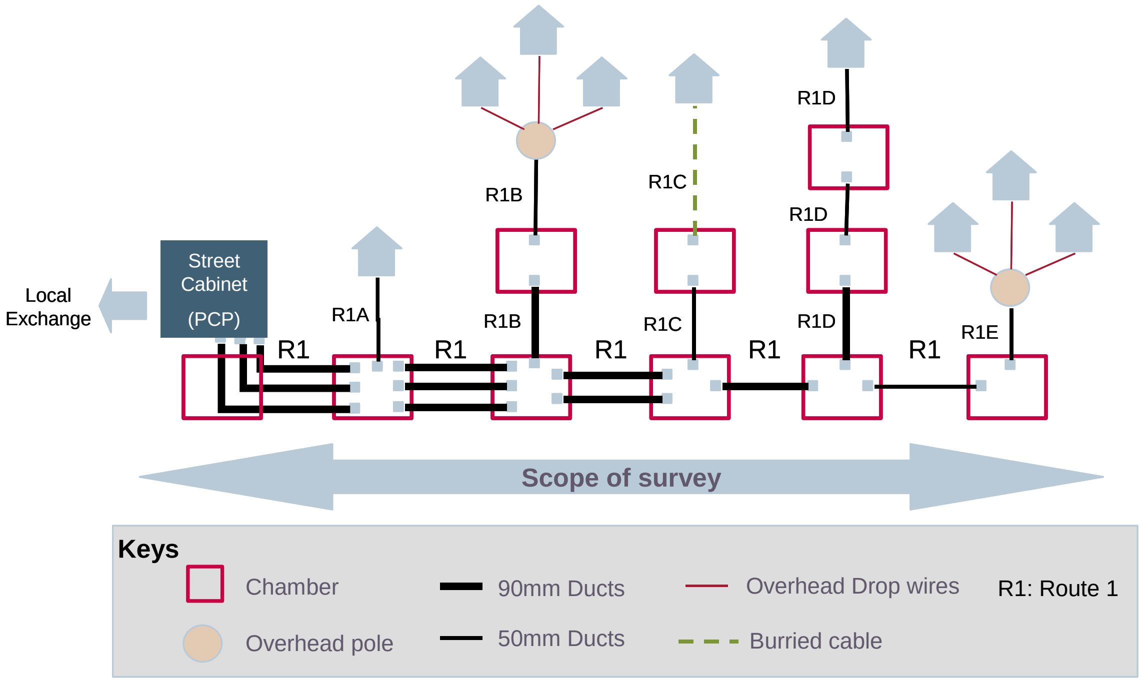

Figure 1.1: *Typical distribution infrastructure in urban and sub-urban areas [Source: Analysys Mason, 2010]*

7 We carried out three types of analysis to determine the unoccupied space in the D-side network:

- duct-end analysis for both distribution ducting and last drop ducting
- pole analysis
- route continuity analysis.

8 In the **duct-end analysis**, using our previous survey methodology, we measured more space on the D-side than on the E-side (exchange side) as illustrated in Figure 1.2:

	Previous survey		*Current survey*	
Parameter	*Metro node to exchange (E-side)*	*Exchange to PCP(E-side)*	*PCP to home/premises 90mm distribution ducting (D-side)*	*PCP to home/premises 50mm last drop[2] ducting (D-side)*
Average unoccupied space per duct end	36%	30%	40%	72% [15]

Figure 1.2: *Comparison of unoccupied space in the D-side and E-side ducting network [Source: Analysys Mason, 2010]*

2 As described in paragraph 3, 50mm ducts can also be used to feed overhead poles.

9 In addition, we found that:

- 63% of the 90mm duct ends surveyed have at least 42% of unoccupied space
- 97% of the 50mm duct ends surveyed have at least 42% of unoccupied space.

10 However, unoccupied duct-end space will not directly translate into **useable duct** space for a communication provider (CP) willing to use the ducts since:

- a duct might have collapsed in the middle of a section
- the cable arrangement far into the duct may be such that existing cable cross-over may prevent any further cables being inserted in the duct
- engineering rules may prevent unoccupied space being used (e.g. to limit disruption with other cables in the duct) – this result should be interpreted using current engineering rules, bearing in mind that the evolution of technology may affect useable space.

11 Regarding the last drop, the vast majority (80%) of the cables in the 50mm lead-in duct are less than 15mm in diameter, leaving significant space within the duct.

12 Any new network deployment will need to take account of the buried cable within the existing Openreach network. In this survey, we could not fully assess directly buried cables. In terms of the chambers surveyed, only around 1% of the cables observed in the chamber did not leave the chamber through a duct end, i.e. the cables are buried in the ground. However, our survey did not cover whether or not cables are ducted outside the chamber. A duct end might be present in a chamber, but may not extend all the way to the customer premises. However, directly buried cables are usually more than 15mm in diameter. In our survey, 41% of the cables surveyed in lead-in duct ends were less than 10mm, which may indicate that these cables are not directly buried but instead are ducted. Also, cables with a diameter greater than 15mm are likely to be armoured, and therefore will be directly buried. In our survey, 20% of the cables in lead-in ducts were 15mm or more in diameter, and therefore are likely to be directly buried. Under these assumptions, between 41% and 81% of the last-drop cables could be ducted.

13 In our **analysis of spare capacity on poles**, we found unused capacity in the overhead infrastructure that delivers the last drop to end customers:

- 85% of the poles surveyed could accommodate at least one additional dropwire
- 63% of the poles surveyed could accommodate at least double the amount of wires that is currently installed
- 58% of dwellings are served by a pole that can accommodate at least one additional dropwire for every dwelling served off the pole without modifying the existing pole infrastructure.
- 25% of the dwellings are served by a pole that can accommodate at least two additional dropwires for all dwellings served of the pole.

14 Note that these results were calculated using BT's engineering rules for an existing single occupancy pole network. It is likely that these engineering rules may need to change to allow for multiple occupancy or different cable specifications.

15 The most critical factor in the ability of existing poles to support new fibre deployment, will be the loading characteristics of the new fibre, e.g. diameter, weight and breaking load of fibre cables. In this report, we assumed that the loading imposed by fibre cables was similar to that imposed by copper cables, due to the lack of information regarding the characteristics of aerial fibre cable in the UK. We also assumed that for a scenario involving several providers that there is enough space at the top of the pole to accommodate extra fibre termination boxes. In reality, there is limited useable space at the top of the pole, as some space is required to allow the engineer to work safely.

16 Finally, in our route analysis, we analysed the end-to-end capacity availability of 17 routes, one for each street cabinet area surveyed. Only three routes achieved a "pass" at all infrastructure sections. This implies that any new network deployment may require the provision of additional infrastructure in a limited number of sections for each route to take full advantage of duct access (assuming all other surveyed sections have unoccupied space). Alternatively, technology used to install cables may need to be more efficient where unoccupied space is at a premium. For example, flexible inner ducts may be used to optimise the available space.

17 Despite the increased unoccupied duct space in the D-side compared to the E-side infrastructure network, there are still pinch points along a typical route. Our analysis has shown that on average there is a 70% to 80% chance of a section of infrastructure having unoccupied space that could potentially accommodate a new cable[3]; on a typical route of 10 chambers, there is likely to be two or three pinch points. Some routes will be completely free of pinch points, but other routes may contain several pinch points. The pre-empting of pinch points would serve to lessen the uncertainty on the costs of deployment of new fibre infrastructure. The likely location of pinch points are as follows:

- the first chamber connected to the PCP on the D-side on the network
- the chambers where the duct diameter leaving the chamber is less than the duct diameter entering the chamber (typically 90mm in, and 50mm out)
- the chamber where the number of ducts leaving the chamber is less than the number of ducts entering the chamber (for the chambers surveyed, this is typically where three ducts enter the chamber and only two leave the chamber).

18 Several solutions can be used to overcome the pinch points associated with new network deployment, such as:

- re-route the network to avoid the pinch point

[3] Please note that measurements relate to duct-ends and do not guarantee that the duct will be available from one chamber to the next, as it may have collapsed in the middle.

- re-direct a route to use overhead infrastructure to avoid underground pinch points[4], or use underground infrastructure to avoid overhead pinch points
- use deployment technology that optimises the use of unoccupied space (e.g. use of flexible inner ducts)
- provide replacement infrastructure (larger duct or stronger pole)
- provide new infrastructure (e.g. a new section of duct from chamber to chamber, or a new duplicate pole).

19 We encountered a number of operational difficulties as in the 2008 duct survey project, although the nature of the difficulties were typically less problematic this time around. For underground deployment, we found that some small boxes (chambers) had been entirely filled with earth due to the rain washing the earth into the chambers – this could, for example, increase costs and timing of a GPON deployment if these chambers were used to house the passive splitters. This issue was not observed in the E-side of the network as the chambers are significantly larger. For overhead deployment, we found trees obstructing poles to be the main difficulty. Any large-scale network development will require the support of field specialists (e.g. tree surgeons) to deal with the pruning, lopping and removal of trees. Dealing with trees will also involve professionals to manage the associated local authority planning, legal, and public relations aspects.

20 In this duct and pole survey report, we outline a number of key actions that would be required to implement a duct and pole access offer:

- development of engineering rules to dictate how unoccupied space may be used by a CP for both ducts and poles
- development of a duct and pole access framework, providing key end-to-end processes involved in a duct access product
- development of a governance model for CPs with a single point of contact in a multi-infrastructure provider environment
- development of a framework to monitor deployment key performance indicators (KPIs)
- development of training programmes for field forces to ensure they are properly qualified for all tasks involved in duct and pole access
- development of a reference database containing up to date digitised network plans, including duct and pole records useable by both infrastructure providers and CPs

4 Assuming planning permission can be granted to deploy additional cables on existing poles or new cables on new poles.

- extension of this survey to other telecommunication providers and utilities infrastructure to encourage competition and provide more options for a CP to deploy their NGA network.

21 Since the 2008 survey, there has been significant progress in duct access in France, where a regulated duct access offer is now available from France Telecom. The process involved in accessing ducts in France is in line with the key actions suggested in this report and indicates how issues could be resolved.

2 Introduction

22 As part of the review of next generation access (NGA) in the UK, Ofcom is considering how infrastructure competition might be maintained in an FTTx world. In this context, Ofcom commissioned a sample survey of Openreach's duct infrastructure, which was carried out by Analysys Mason in 2008.[5] This survey assessed available space in the duct network from the metro node to the street cabinet to evaluate the feasibility of third-party operators using this infrastructure to deploy their FTTx network. Re-using existing ducts may remove an entry barrier for communication providers, as extensive digging to install their own fibre would not be required.

23 The 2008 survey indicated that there is some unoccupied duct space, with more duct space available between the metro node and the local exchange than the ducts between the local exchange and the street cabinet. It also indicated that the amount of unoccupied space within the duct varied greatly, depending on the area/city. However, the survey showed that unoccupied space does not necessarily mean that the duct can be used for additional fibre as the duct could have collapsed somewhere, or empty ducts may have to be kept available for Openreach for maintenance or future expansion purposes.

24 While this survey was suitable for the fibre-to-the-cabinet (FTTC) network, it does not provide any indication of the infrastructure that is available in the distribution network (from the street cabinet to individual households) to deploy a fibre-to-the-home (FTTH) infrastructure for third-party operators.

25 In August 2009, Ofcom engaged Analysys Mason and its partner, Lythgoes Limited, to undertake another survey, this time a sample of the duct and pole infrastructure of Openreach's distribution network, in order to help Ofcom shape informed NGA regulatory policy. The main objective of the survey was to assess Openreach's duct and pole infrastructure to gain an insight into the space potentially available, and to determine whether or not it offers a viable option for deploying new fibre.

26 This report provides the results of that 2009 survey, along with Analysys Mason's views of what it would take practically to implement duct and pole access in the distribution network. It should be noted that communications providers and utilities companies may also have additional duct infrastructure which may be appropriate for NGA deployment, but this project focused exclusively on Openreach's infrastructure.

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5 "Telecoms infrastructure access – sample survey of duct access", Analysys Mason for Ofcom, March 2009, available at: http://www.ofcom.org.uk/telecoms/discussnga/duct/.

3 Survey scope and methodology

3.1 Scope of the survey

3.1.1 Survey structure

27 The samples selected for this survey were all from Openreach's distribution network. The distribution network, also known as the 'D-side', uses the infrastructure located between the street cabinet and individual premises. This infrastructure is typically a mixture of poles and overhead wires, and underground ducts and buried wires, as illustrated in Figure 3.1.

28 A typical distribution network architecture includes two main functional network nodes:

- **Street cabinets** – also known as primary connection points (PCPs) – are network nodes providing direct or indirect interconnection between the access network and the customer premises. In NGA networks, the street cabinets are crucial, as they are the termination point of the copper network for fibre-to-the-cabinet (FTTC) deployments, significantly shortening the copper local loop.
- **Distribution points** (DPs) are the last interconnection point in the distribution network before the end customer that provides the last drop. A distribution point is also defined as "*the flexibility point in the distribution network where a multiple tenancy cable is split into single tenancy cables*"[6]. An overhead distribution point is recognisable by a small box mounted on a pole and an underground distribution point is typically located in a chamber.

29 Figure 3.1 below shows the scope of the project, identifying the categories of distribution points surveyed and the components of those distribution point types.

6 Openreach's definition.

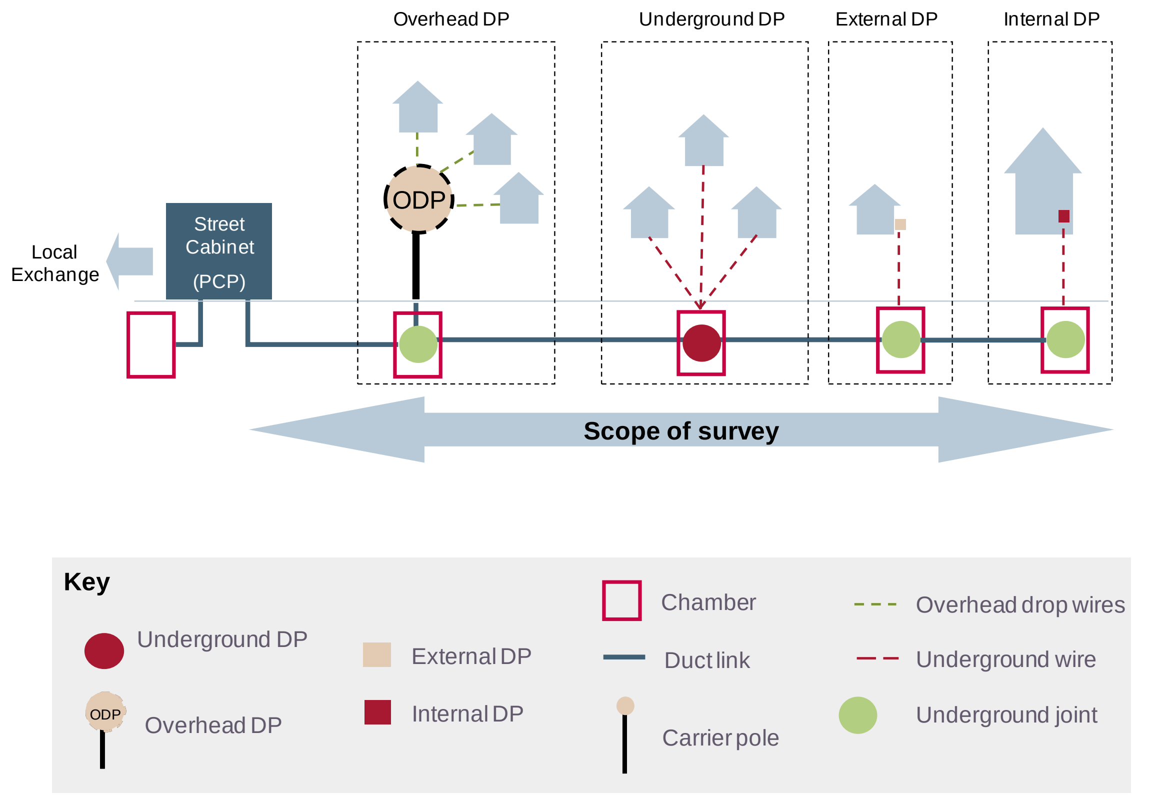

Figure 3.1: Survey scope [Source: Analysys Mason, 2010]

30 In the above Figure 3.1, a chamber can be either a manhole or a box. A box is usually defined as a structure with a floor area equal to, and directly below, its opening, and with a volume governed by the depth. In contrast, a manhole is defined as an underground structure with a volume that need not be limited, and usually having one standard opening and a ceiling.

31 It should also be noted that, for the purpose of this survey, we differentiate between a dropwire and an aerial cable. A dropwire can be one pair of steel wires, two pairs of steel wires, or more recently four twisted pairs of copper wires. The dropwire is the 'last drop' that provides the connection between the distribution point and the customer termination point. In contrast, an aerial cable is defined as the cable[7] that provides the overhead distribution of the D-side network, and comprises of several wires (not represented on Figure 3.1 for clarity).

32 The main types of site falling within the scope of this survey were chambers and overhead poles. As shown in Figure 3.1, these sites may or may not host a distribution point.

[7] For the existing Openreach network, there are three categories of aerial cable: lightweight, heavyweight, and optical fibre. Aerial cables are generally larger in diameter and heavier than dropwires.

3.2 Openreach's distribution network infrastructure

33 The deployment of Openreach's distribution network has evolved significantly to accommodate increasing telephone density and changing environmental and maintenance requirements.

34 Before 1968, the standard distribution network was provided using poles and overhead wires and/or cables. However, post-1968, most new property developments, whether industrial, business or residential, were served by underground infrastructure. This move to underground distribution was implemented in a number of steps and as a consequence, a number of different distribution network architectures can be found today in their network.

35 Figure 3.2 below provides a summary of this evolution. Figure 3.4 to Figure 3.8 illustrate the distribution infrastructure architectures 1 to 5 described in Figure 3.2. In these figures, an underground joint is the joint between cables. Figure 3.3 is a key to those diagrams.

Distribution infrastructure type	*Figure*	*Description*	*Deployment period*
1	Figure 3.4	Radially distributed overhead distribution points, with overhead pole route for wires and/or aerial cable	Pre 1968, generally only deployed today in relief schemes for existing areas similarly served (mainly semi-rural and rural locations)
2	Figure 3.5	Radially distributed overhead distribution points linked with underground infrastructure (mainly urban and sub-urban locations)	Pre and post 1968; still in use and probably forms the majority distribution type in residential and light industrial areas
3	Figure 3.6	Linearly distributed 'frontage tee' direct underground distribution point, cables buried direct in ground or in duct (mainly urban and sub-urban locations)	Post 1968, last deployment estimated 1975–1978
4	Figure 3.7	Linearly distributed direct underground distribution point, cables buried direct in the ground or in duct. The main difference with the previous scenario is that individual cables serve households direct from the distribution point (mainly urban and sub-urban locations)	Post 1968, last deployment estimated 1975–1978
5	Figure 3.8	Radially distributed direct underground distribution point, cables buried direct in ground or in duct (mainly urban and sub-urban locations)	Deployed post 1968; currently used

Figure 3.2: Evolution of Openreach's distribution network infrastructure [Source: Analysys Mason, 2010]

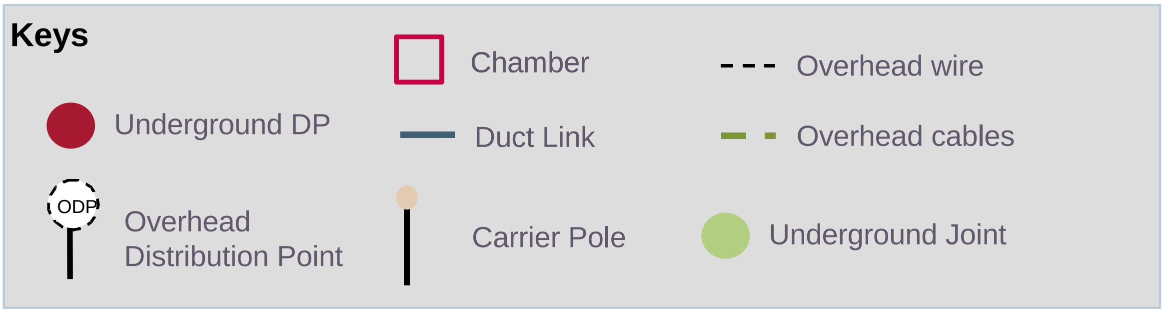

Figure 3.3: *Key to Figure 3.4 to Figure 3.8 [Source: Analysys Mason, 2010]*

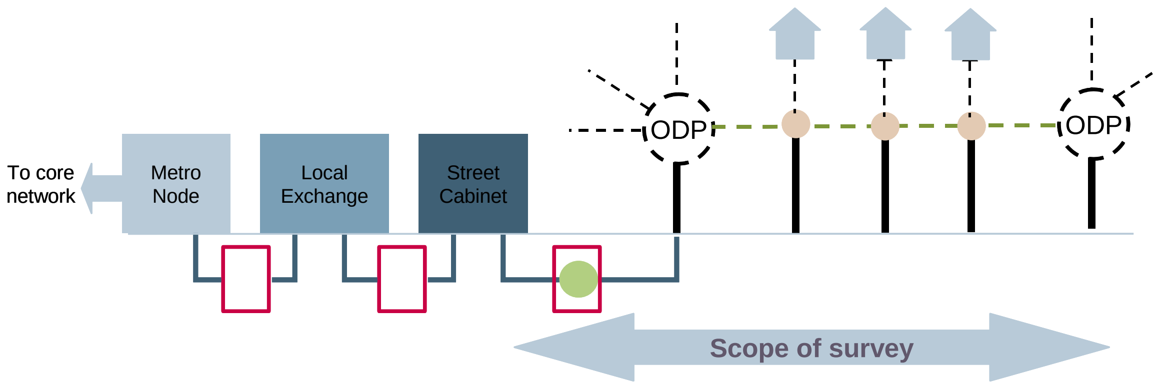

Figure 3.4: *Radially distributed overhead distribution point [Source: Lythgoes Ltd, 2009]*

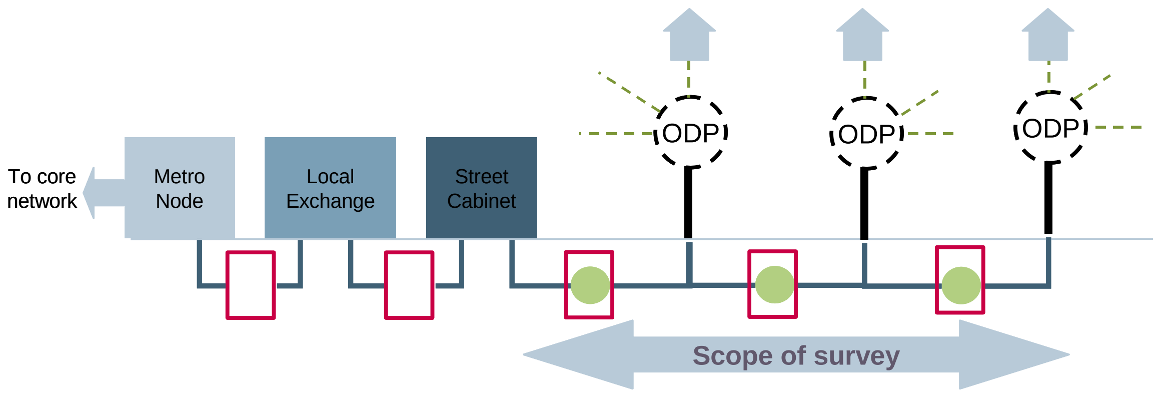

Figure 3.5: *Radially distributed overhead distribution point linked underground [Source: Lythgoes Ltd, 2009]*

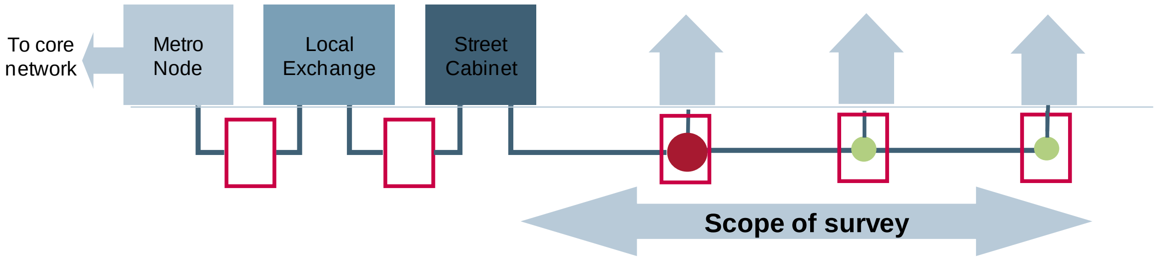

Figure 3.6: *Linearly distributed 'frontage tee' direct underground distribution point [Source: Lythgoes Ltd, 2009]*

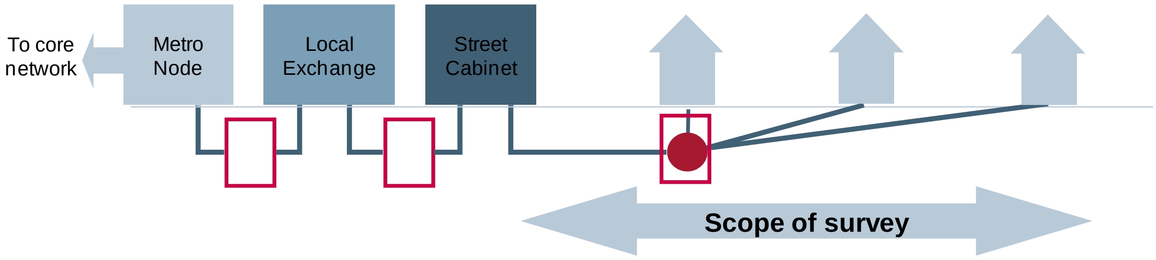

Figure 3.7: *Linearly distributed direct underground distribution point [Source: Lythgoes Ltd, 2009]*

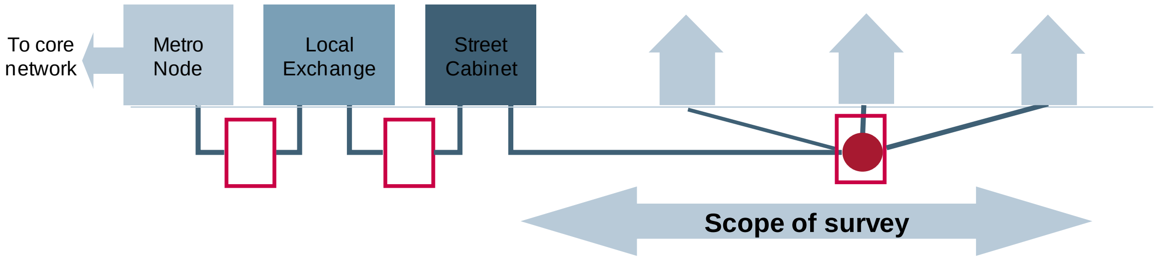

Figure 3.8: *Radially distributed direct underground distribution point [Source: Lythgoes Ltd, 2009]*

36 There are various types of distribution point (already broadly identified in Figure 3.1). The types of distribution point we expected to survey in Openreach's infrastructure are described in Figure 3.9 below.

DP type (designation)	*Definition*
Overhead (O,OH)	An overhead distribution point providing dropwires to premises in a non-radial pattern
Overhead radial ring (R)	An overhead distribution point providing dropwires to premises in a radial pattern.
Underground (U)	Underground distribution point is a distribution point located in a chamber or which could be directly buried with the premises fed by frontage tees.
Underground radial (UR)	Radial underground distribution point is where each premises is served by a separate cable from the underground distribution point
External (E)	External distribution point usually a Terminal Block on an external wall e.g. the distribution point sited on the front of a row of shops or flats, with feeds to each premises
Internal (I)	A distribution point sited within a building, normally in a block of offices or flats

Figure 3.9: Openreach's distribution point types [Source: Analysys Mason, 2010]

37 In order to simplify the selection process, we have grouped the distribution points into four distinct categories:

- overhead (including O, OH and R types) – all defined as O
- underground (including U, UR types) – all defined as U
- external – E
- internal – I.

3.3 Methodology for selecting sites

3.3.1 Introduction

38 The sample survey was designed to illustrate the range of Openreach's infrastructure distribution network nationally. This was important in order to form a balanced view of the availability and accessibility of the infrastructure throughout the UK. In this section, we explain in detail the selection methodology and criteria used to derive the optimum sample, involving the selection of locations and the selection of PCP areas.

39 The overall sample selection process followed the process shown in Figure 3.10 below.

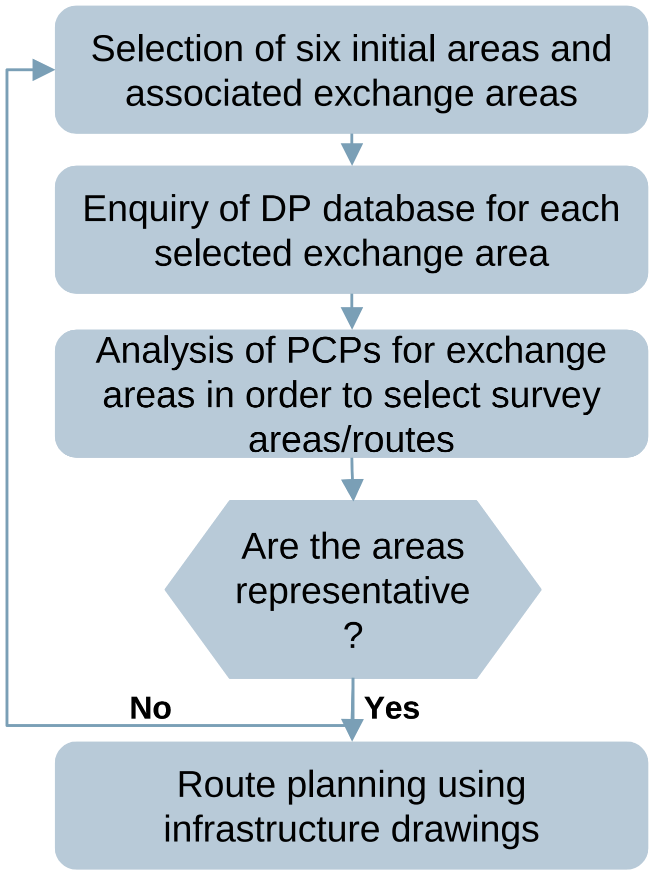

Figure 3.10: High-level sample selection process [Source: Analysys Mason, 2010]

3.3.2 Site selection criteria

40 The selection criteria for the sample survey of the distribution network were:

- geographical spread throughout the UK to be indicative of the 27 BT districts[8]
- type of dwelling (detached, semi-detached, MDU) and premises (residential or business) served by the infrastructure
- type of infrastructure in the D-side of the network (as defined in Section 3.2).

Geographical spread

41 It was very important to have a sample of infrastructure sites spanning different BT districts, and therefore different cities/area in the UK. This is because although Openreach has common infrastructure design guidelines for throughout the UK, individual planning managers may interpret the guidelines in different ways based on their experience; consequently, infrastructure design is likely to vary from district to district. It was therefore important to capture in our survey

[8] It should be noted that the 27 BT districts have now been consolidated into 5 BT operational regions (Midlands, Wales and West; Scotland; North England; London and Home Counties; and South East).

this variation in infrastructure design, to assess as accurately as possible whether additional fibre cables could be installed in the surveyed infrastructure.

Type of dwelling

42 Analysys Mason's report for the BSG on deploying fibre-based next generation broadband infrastructure[9] shows that the distribution of dwelling type significantly influences the cost of deploying FTTH network. A significant proportion of the cost of deploying FTTH is internal wiring and last drop, which significantly varies between dwelling types. Therefore dwelling type is an important consideration in scale economies.

43 The distribution of dwelling types for England and Wales can be obtained from the Office of National Statistics (ONS) and the distribution of dwelling types for Scotland can be obtained from the Housing Survey for Scotland.[10] Both distribution are illustrated in Figure 3.11.

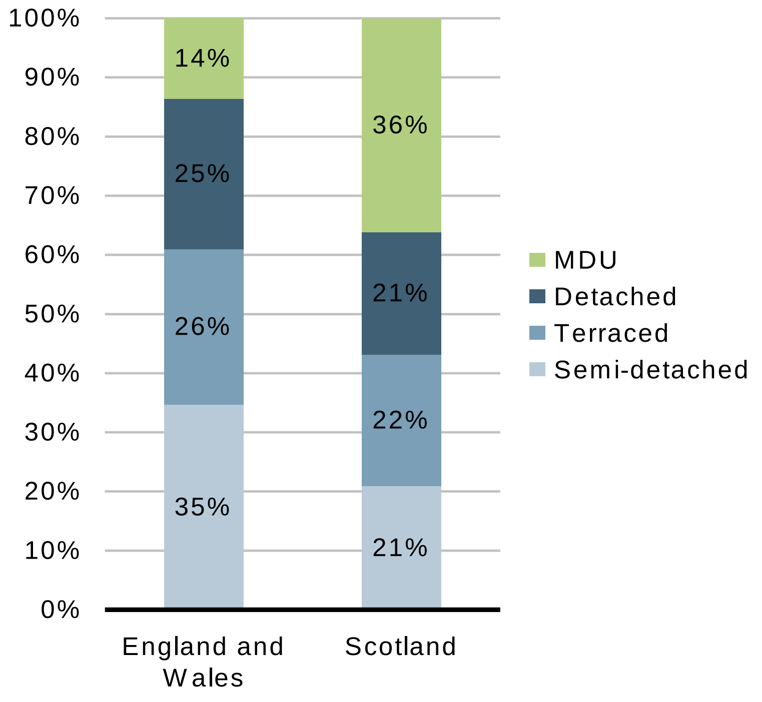

Figure 3.11: Dwelling type distribution for England and Wales [Sources: Office of National Statistics and Housing survey for Scotland, 2009]

9 "The cost of deploying fibre-based next-generation broadband infrastructure", Analysys Mason for BSG, September 2008.

10 Scottish House condition survey, Scottish Government, 2007

44 Figure 3.11 shows there is a significant difference between the distribution of dwelling types in England and Wales, and Scotland. This is because in Scotland's major cities, the principal type of accommodation is tenements buildings, typically comprising around 10 households per building. This is in contrast to England and Wales, where only 14% of the households are located in multi-dwelling units.[11]

45 In our survey, we ensured that the area surveyed are as indicative as possible of the national dwelling type distributions as explained in our methodology.

Type of infrastructure

46 As explained in Section 3.2, mainly due to the evolution of the network, different distribution network infrastructures exist; both overhead and underground infrastructure is found in the UK.

47 In urban and sub-urban areas, overhead infrastructure is served by cables from the PCP which are contained within the underground infrastructure (see Figure 3.5), and overhead poles are used to deliver the last drop to the customers[12].

48 In our survey, we based our analysis on distribution points, which provide an indication of whether the infrastructure is overhead or underground (see Figure 3.12). Figure 3.13 provides an indication of the national distribution of DP types. In order for our survey to be indicative of the national infrastructure, we selected a sample that had a similar distribution of DPs to the national distribution.

DP type	*Underground*	*Overhead*	*Internal*	*External*
UK statistics	24%	47%	22%	7%

Figure 3.12: National distribution of DP types [Source: Openreach]

Selection of cites/areas

49 The characteristics of the cities/towns selected is listed in Figure 3.13 below. It should be noted that this survey concentrated on urban areas, as NGA is expected to be deployed first in the most commercially attractive areas (i.e. areas of highest line density).

[11] This is low compared to some European markets.

[12] In more rural environments, aerial cables are carried from pole to pole with no underground infrastructure, but the focus of this report is urban and sub-urban areas where FTTH is likely to be deployed.

City (Area)	*Geographical spread - BT district*	*Density and dwelling type*	*Infrastructure type*	*Other comments*
Cardiff (Whitchurch)	South Wales	Mixed dwelling types including social housing	Mixed pre- and post-1968 properties	Part of Openreach's NGA deployment (phase 1)
Glasgow (Scotstoun)	West Scotland	Large proportion of social housing	Mixed pre- and post-1968 properties	Scotland has a different spread of dwelling compared to the UK
Manchester (Eccles)	Manchester (North)	Variety of geo-types within a relatively small area	Mixed pre- and post-1968 properties[1]. Parts have been substantially re-developed in the last 40 years	
Manchester (Didsbury)	Manchester (South)	Conversions of large detached houses to MDUs	Mixed pre- and post-1968 properties	Part of Openreach's NGA deployment (phase 2)
Milton Keynes (Central)	South Midlands	Mixed of residential and light business premises	New town – mostly post 1968	
Milton Keynes (Shenley Church End)	South Midlands	Mixed of residential and light business premises	New town – mostly post 1968	
London (Finchley)	London	High population density. Semi detached and detached properties	Mixed pre- and post-1968 properties	

Figure 3.13: Selection criteria for cities/areas [Source: Analysys Mason, 2010]

3.3.3 Route and PCP area selection

50 Once the areas were identified (see Figure 3.13), it was possible to obtain a list of PCPs (street cabinets) and associated DPs from Openreach for each PCP. The PCP and DP data provided by Openreach included the following parameters:

- PCP ID
- DP ID (unique DP identifier)
- DP type (e.g. O, OH, R, U, UR, E or I)
- Capacity (maximum number of dropwires that can be accommodated by the DP)
- Spare (number of unused dropwires)
- Property type (residential or business).

51 A typical PCP/DP list for an exchange area provided by Openreach is illustrated in Figure 3.14.

PCP ID	*DP ID*	*DP type*[13]	*Premises served (**R**esidential/ **B**usiness)*
1	1	I	R
1	2	U	R
1	3	I	R
1	4	I	R
2	5	I	B
2	6	O	R
2	7	O	R
2	8	U	R
2	9	U	R
3	10	U	R
3	11	O	R
3	12	U	B
3	13	U	R
3	14	O	R
4	15	E	B
4	16	O	R
4	17	O	R
4	18	U	R
5	19	E	R
5	20	O	B

Figure 3.14: illustrative PCP/DP data for each local exchange areas [Source: Openreach]

52 Each exchange area has a large number of PCPs (typically 60 PCPs per exchange area in our sample) and a large number of DPs (typically 60 DPs per PCP in our sample), so it was necessary to refine each to a smaller sub-set for the survey. In order to make this selection, we considered all PCPs and DPs in a particular exchange area and determined the distribution of DP types within that area. We then selected one or two PCPs with its associated DPs that had a similar distribution of DP type as the overall exchange area. For example, if we consider the distribution of DP types in Figure 3.14, then selecting PCP 2 and PCP 4 provides a representation distribution of DP types in that particular area as illustrated in Figure 3.15. This process ensured that the sample within a particular area was representative of the DP type and therefore infrastructure, in that area.

13 See DP type definition in Figure 3.9.

	Number of Overhead DPs (O)	*Number of Underground DPs (U)*	*Number of External DPs (E)*	*Number of Internal DPs (I)*
PCP 2	2	2	0	2
PCP 4	2	1	1	0
Percentage of DP type in sample	40%	30%	10%	20%
Percentage of DP type in local exchange area	38%	33%	10%	19%

Figure 3.15: Illustrative selection of PCP areas [Sources: Openreach and Analysys Mason, 2009]

53 Once the set of PCP areas to be surveyed had been chosen, Openreach provided Ordnance and duct diagrams, including PCP ID, DP ID and all sites (poles and chambers) to be surveyed in that area. The survey team used these diagrams to identify all routes and sub-routes to be surveyed in that area. By adopting a naming convention that reflected the site number, site type and route/sub-route each site belonged to, it was possible to capture the sequence of sites along each route/sub-route. This is illustrated in Figure 3.16.

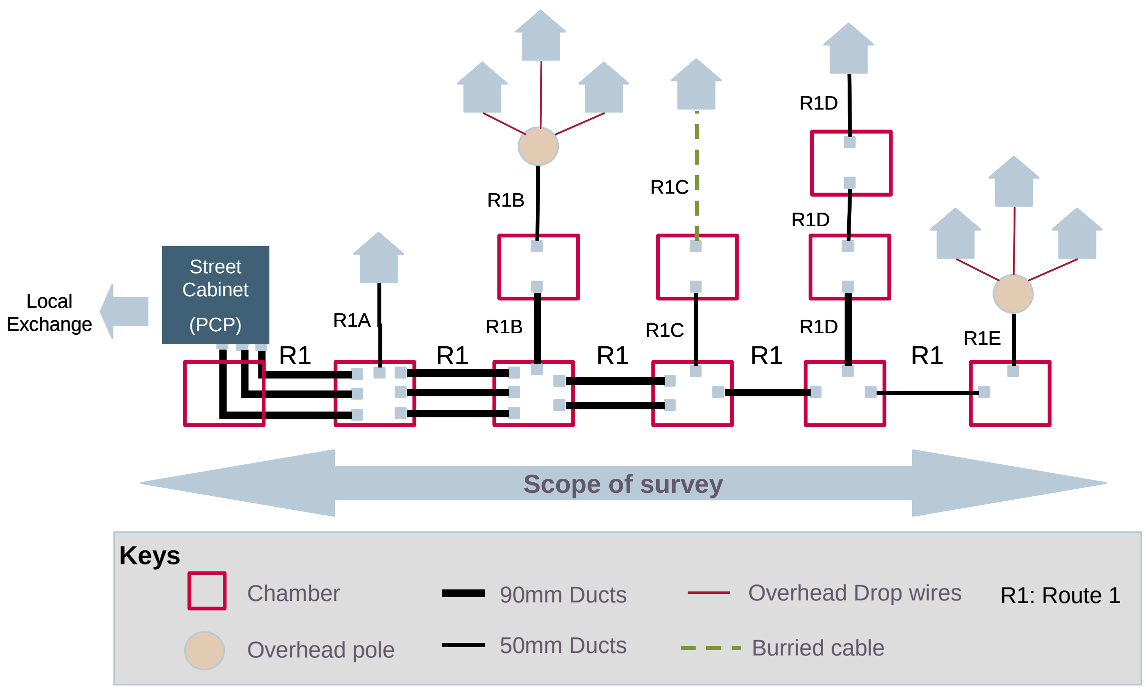

Figure 3.16: Typical PCP and DP arrangement [Source: Lythgoes Ltd]

54 Once all samples were selected, a check was carried out to ensure that the total sample was indicative of the infrastructure deployed nationally by BT in the distribution network (in terms of types of DPs). Our results are provided in Section 3.3.4.

55 To ensure the sample was representative of the infrastructure *in that area*, we also ensured that the overall sample was indicative of the national distribution of dwelling types by carrying out an indicative virtual survey of dwelling types by using Google satellite and street view. The dwelling type distribution in our survey is discussed in Section 3.3.4.

3.3.4 Site selection summary

56 In this section, we summarise the sites selected to form the sample, highlighting how representative it is in terms of the selection criteria identified in Section 3.3.2.

57 For this sample survey, seven areas from five UK cities/towns were considered together to represent Openreach's national infrastructure network. Overall, **320 poles, 552 chambers and 3293 overhead dropwires were surveyed**. In addition, 135 buildings with external or internal DP were also surveyed. Figure 3.17 provides a summary of the range of the survey that was conducted.

Scope	*Comments*
7 areas in 5 different cities	The seven areas were: Cardiff (Whitchurch), Glasgow (Scotstoun), Manchester (Didsbury), Manchester (Eccles), Milton Keynes (Central), Milton Keynes (Shenley Church End), London (Finchley)
552 chambers surveyed: • 5 manholes • 547 boxes	In the distribution network, the proportion of manholes is small compared to the proportion of boxes due to the fact that the cables deployed are generally smaller than in the E-side of the network
320 poles surveyed: • 221 radial poles • 99 non-radial poles	69% of the poles surveyed were radial and 31% were non-radial. In general, radial poles can take a larger dropwire loading than non-radial poles.
3293 dropwires surveyed: • 2634 dropwires on radial poles • 659 dropwires on non-radial poles	As radial poles support more dropwires than non-radial poles, 80% of the dropwires surveyed were on radial poles (compared to 69% of radial poles)
135 buildings with internal/external DP	As illustrated in Section 3.2, DPs can also be located at the customer premises

Figure 3.17: Survey range [Source: Analysys Mason, 2010]

58 A breakdown of the chambers and poles surveyed by area is provided in Figure 3.18.

City (Area)	*Number of poles*	*Number of chambers*	*Number of buildings with external or internal DP*
Cardiff (Whitchurch)	99	113	1
Glasgow (Scotstoun)	6	139	46

Manchester (Didsbury)	46	64	26
Manchester (Eccles)	113	104	17
Milton Keynes (Central)	24	43	8
Milton Keynes (Shenley Church End)	0	36	4
London (Finchley)	32	53	33
Total	320	552	135

Figure 3.18: Survey sample by area [Source: Analysys Mason, 2010]

Infrastructure type / DP type

59 Figure 3.12 provides a distribution of the DPs surveyed and compares it with the national distribution of DP types provided by Openreach. Our sample is reasonably representative of the national distribution of DP types. The only small discrepancy between the proportion of DPs surveyed and the national distribution of DPs is for internal DPs, which are difficult to locate and survey as they are located inside the customer premises and other buildings. Given the small size of the sample, we believe it is indicative of the Openreach infrastructure type.

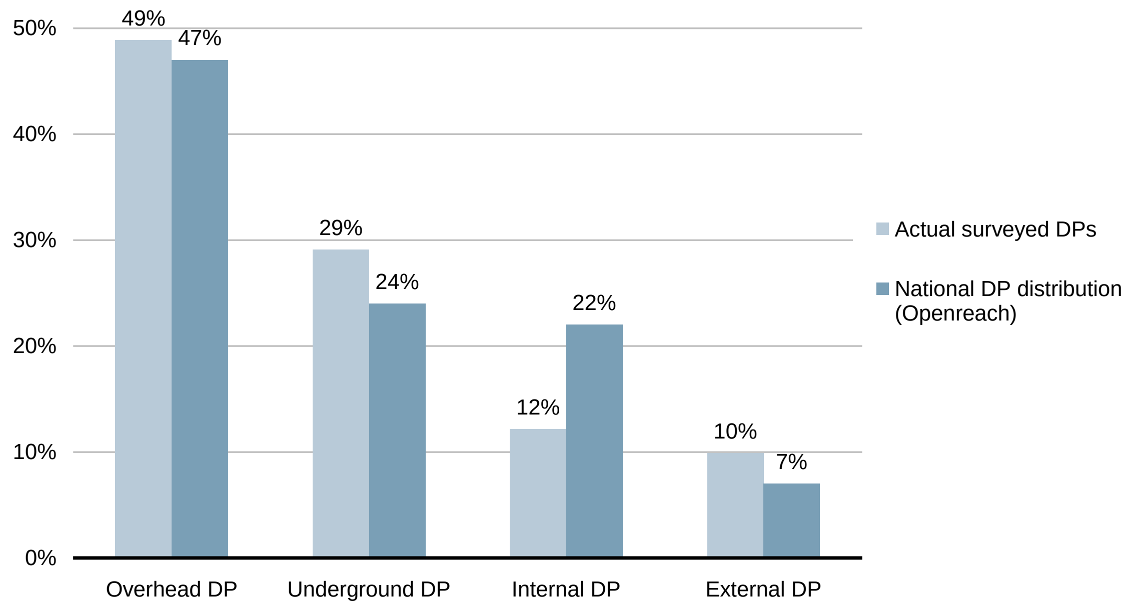

Figure 3.19: DP type distribution versus predicted DP type distribution on selected sample [Source: Analysys Mason, 2010]

Dwelling types

60 As discussed in Section 3.3.2 above, it was also important that the survey was indicative of the distribution of dwelling types, as this affects the economics relating to where a fibre operator may deploy fibre infrastructure. Figure 3.20 below provides a comparison of the dwelling type distribution between the survey and national statistics. Scotland is considered separately due to its specific dwelling type distribution.

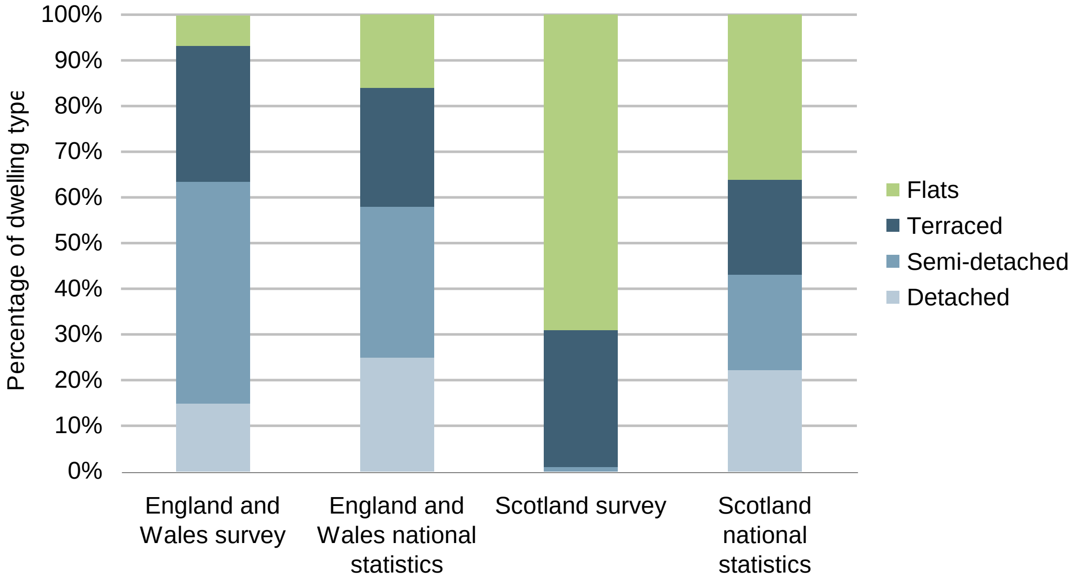

Figure 3.20: Comparison of national and sample dwelling type distribution [Source: Analysys Mason, 2010]

61 Overall, given the size of the sample, we believe that the survey is indicative of the range of dwelling types for England and Wales. Our survey of Scotstoun in Glasgow shows that we surveyed areas with more flats and terraced houses than the national distribution in Scotland. We believe that communication providers are more likely to deploy fibre infrastructure in locations with a population higher density (i.e. flats and terraced houses), and therefore we believe that our sample survey for Scotland is appropriate. Furthermore, given that Scotland represents less than 10% of households in the UK, it was not possible to survey another Scottish area without introducing a bias compared to the rest of the regions surveyed in the UK.

62 Overall, Openreach estimate that there are 4.2 million chambers (for both D-side and E-side networks) in its network and 3.8million poles. This means that our survey represents **0.0131% of the chambers** and **0.008% of poles**, which shows that this sample is very small compared to the overall Openreach infrastructure. In comparison, in our previous duct survey was 0.02% of the total number of chambers present in the Openreach network[14].

14 Note that in the last survey, only chambers were surveyed.

3.4 Surveys

3.4.1 Survey recorded data

63 The sites surveyed included two main types of infrastructure: chambers and poles.

Survey forms for chambers

64 For each chamber surveyed, survey information was recorded using two different forms, illustrated in Figure 3.21 and Figure 3.22:

- general chamber information survey form
- duct-end information survey form.

Route	Site reference number	Address	Chamber info						U' DP exists (if known)		Property type & number where 'U' Dp exi Chamber				
			Location 'C', 'F', 'V'	Chamber type	Space for additional splices	Number of existing splices	Estimated Percentage occupation	PCP exists;	U' DP exists (if known)	U' DP type (if known)	Detached	Semi-detached	Terraced	Low rise mdu	High rise MDU
2	C8	13 Cranberry Rd	F	F4	Y	1	50	N							

Figure 3.21: Extract of general chamber information survey form [Source: Lythgoes Ltd]

Site reference	Wall	Duct no	Sub-duct	To	Duct Dia (mm)	# cables by cable diameter					Potential number of 25 mm tubes that can be inserted into the duct						
						=<5	>5<11	>10<16	>15<21	>20<26	0	1	2	3	4	5	>5
2C8	2	1			90			1	1					✓			

Figure 3.22: Extract of duct-end information survey form [Source: Lythgoes Ltd][15]

65 The general chamber information survey form (Figure 3.21) captured:

- site reference number including route and PCP area reference numbers
- location (address)
- chamber type (i.e. box or manhole)
- percentage of occupation (see Section 3.4.3 below)

15 Entries for cable of diameter 26mm and above are not shown on the form for clarity but the survey form used in the field allowed diameters of up to 70mm and above to be recorded.

- presence of a DP and its type
- type of property served (e.g. detached, semi-detached, terraced, MDU, business).

66 For each chamber recorded in the general chamber information survey form, a corresponding duct information survey form (Figure 3.22) was provided to record the following information regarding each duct end present in this chamber:

- site reference including route and PCP area reference numbers
- number of duct ends on each wall
- destination of duct (if known)
- duct-end diameter
- number and diameter of cables in each duct end
- unoccupied space (number of 25mm tube that could be inserted in duct ends, see Section 3.4.3).

Survey form for poles

67 For each pole surveyed, survey information was recorded using a pole survey form (see Figure 3.23) to capture:

- site reference number including route and PCP area reference numbers
- location (address)
- whether it was located on the public highway or private land
- pole type, height and class (class of a pole is defined by its diameter)
- radial versus non-radial (see Figure 3.26)
- number of dropwires
- means of access and potential hazards (e.g. ladder or mobile elevating platform)
- presence of aerial cables
- presence of a DP and its type
- type of property served (e.g. detached, semi-detached, terraced, MDU, business).

Route	Site reference number	Address	Pole											Cables			DP type	Property type & numbers								
			D'p or 'S'ub dp or 'C'arrier	Location; 'P'ublic or 'L'private	Height (m)	Pole type; 'W', 'S', 'F'	Class; 'XL', 'L', 'M', 'S' (wood poles only)	Central to property or one sided; 'C' or 'O'	Number of wires	Access by; L'adder or 'E'levating platform	Hazards; 'S', 'T', 'G', 'F', 'R', 'O', 'L', 'P', 'B'	Joint use (Y)	Photo number	Distribution cable	Through' Distribution A/c	Sub-Dp aerial cable		Detached	Semi-detached	Terraced	Low rise multi dwelling unit	High rise multi dwelling unit	Converted MDU	Industrial	Business
1	3V	o/s 13 Blueberry Rd	236	P	9	W	M	C	13	L			6	1			O	5	8						

Figure 3.23: Pole survey form [Source: Lythgoes Ltd]

3.4.2 Survey planning and execution with Openreach's team

68 In Openreach's network, the infrastructure is segregated into districts. Each regional team is responsible for deploying and maintaining the infrastructure in its own district. The detailed planning and execution of each area survey therefore involved close liaison with the regional Openreach team responsible for each area surveyed.

69 This stage of the project involved:

- communicating the selected survey routes to Openreach
- checking for any traffic-sensitive areas (the responsibility of Openreach), or other local restrictions, and applying for any necessary work permits, and/or opening-up notices
- allocating an Openreach survey support team
- agreeing meeting points and programmes of work
- opening up of the chambers by Openreach, ready for the survey team (this included removing manhole/box covers, testing for gas, pumping out of water, if necessary, and generally providing safe access
- closing the chambers by Openreach after the survey was completed.

70 It should be noted that, for the survey of poles, no particular assistance was required from Openreach as the assessment was made from the ground, to reduce the operational risks of this survey. However, potential hazards that would prevent an engineer from accessing the pole were recorded in the pole survey form.

3.4.3 Assessment of unoccupied duct space

71 In this report we differentiate between unoccupied space, available space and useable space, as specified below.

- **Unoccupied space** is defined as the space not used by existing cables.
- **Available space** takes into account that unoccupied space may not be available for fibre deployment, due to the planning requirements from Openreach (needing spare capacity), or due to obstruction by other cables.
- **Useable space** indicates how the available space can be used, considering cable sizes, installation methods and infrastructure deployment engineering rules.

72 Based on the 2008 survey carried out for Ofcom, we used a tube with 25 mm inner diameter as the basic unit of measuring unoccupied space (in 90mm diameter duct used in much of the E- and D-side network). The selection of the size of the tube was based on two operational considerations:

- the vast majority of sub-ducts in Openreach's network have a diameter of 25mm

- the size of the pulling rod required to pull a rope or a cable from one chamber to the next adjacent chamber is 25mm (smaller pulling rods are more flexible and tend to bend and jam in the middle of the ducts).

73 The 25mm tube methodology offers a consistent, objective and practical approach. The diameter of the tube to be used would vary with new cable installation technologies, but 25mm offers a reasonable proxy for current installation techniques and sub-duct sizes used in Openreach's network.

74 There are two types of ducts in the distribution network, serving different purposes:

- **50mm diameter ducts** used mainly for the last drop of underground-fed wires, and the lead-in to overhead DPs (to connect end customers to the distribution network).
- **90mm diameter duct** used in the main routes of the distribution network (excluding the last drop).

75 For the 90mm ducts, a maximum of seven 25mm tubes (sub-ducts) can be inserted. Therefore, we assume that each tube that can be inserted in a duct represents 14.2% (100/7) of unoccupied space in a 90mm duct. The unoccupied space, defined according to the number of 25mm tubes that can be inserted in a duct, is provided in Figure 3.24.

Number of 25mm tubes that be inserted in a 90mm duct	*Unoccupied space (%)*
0	0
1	14
2	28
3	42
4	56
5	70
6	84
7	100

Figure 3.24: Unoccupied space definition for 90mm ducts [Source: Analysys Mason, 2010]

76 Figure 3.25 provides illustrative examples of 90mm ducts with 28% of unoccupied space (i.e. two 25mm tubes can be inserted in addition to the existing cables).

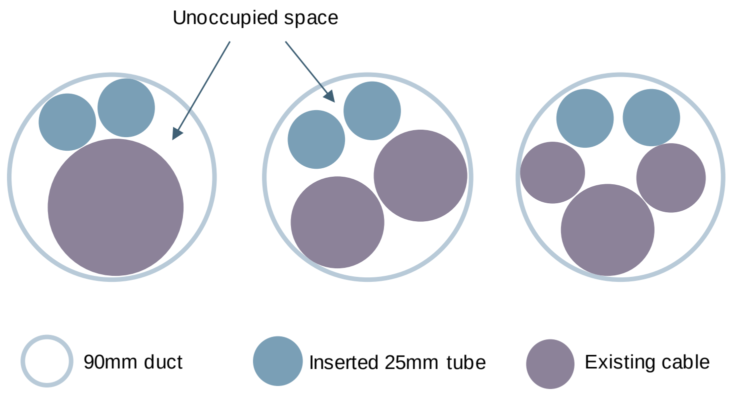

Figure 3.25: 28% unoccupied space [Source: Analysys Mason, 2010]

77 For 50mm ducts, a more granular approach to measuring unoccupied space (i.e. smaller than the 25mm tube) is required. This is due to the fact that at most, a single 25 mm internal diameter tube could be inserted in a 50mm internal diameter duct, which only represents 25% of unoccupied space. Therefore, in order to assess the unoccupied space of 50mm duct, we calculated the cross-section area occupied by existing wires and compared it with the total cross-section area of the duct. Furthermore, in order to take into account the stranded unoccupied space between the cables themselves, we considered that 15% of the total duct space could not be utilised leading to the following equation:

50mm duct unoccupied space = 85% of duct area - Sum(cable area)

78 Therefore, if in a 50mm duct, there were two cables, one of 15mm diameter and the other one of 10mm diameter, the unoccupied space would be 72%.

79 For both 50mm and 90mm ducts, our methodology dictates that the measured unoccupied space will always be less than the *actual* unoccupied space. This is consistent with the fact that, for practical reasons, the small areas of unoccupied space around existing cables are not available for use.

80 In the surveys, duct ends that contained no cables (empty duct ends) would have 'zero' recorded on the survey form in the 'number of existing cables' box. However, not all empty ducts would be fully accessible to allow the maximum number of tubes to be inserted. For example, ducts at the bottom of a chamber could be obscured by cables above, or across, them, preventing tubes from being inserted.

3.4.4 Assessment of pole capacity

81 The aim of this pole capacity assessment is to investigate the feasibility of installing new fibres on existing poles. It was therefore important to this survey to understand the design parameters and engineering rules that are used to assess new and existing overhead pole infrastructure deployed by Openreach.

82 For the purpose of this section, we define two concepts:

- wind loading
- breaking load.

83 **Wind loading** represents the load imposed by the wind on dropwires and aerial cable (cable) deployed in the network. The wind pressures to be resisted will depend upon a number of environmental factors, in particular the degree of exposure of the dropwire/cable, e.g. sheltered, normal or exposed environments. The dropwires/cables can also be affected by ice, which can lead to an increase in wind loading, (the formation of ice on the wire increases the effective cross-sectional area of the dropwire/cable, whilst increasing the tension by contraction and by the increased weight).

84 The **breaking load** is defined as the load imposed by external objects on the cable that will make it break. For example, if there are trees or branches liable to fall on the wire/cable route, Openreach standards require the pole designer to consider the breaking load of the wire/cable. Where applicable, the pole must be able to withstand the breaking load of the wire/cable so that the wire/cable breaks before failure of the pole.

85 We also define two types of poles:

- radial poles
- non-radial poles (single-sided poles).

86 A **radial pole** is defined as a pole where dropwires are distributed all around the pole (i.e. dropwires distributed over more than 180 degrees). It is worth noting that radial poles do not need to be symmetrically spaced.

87 **Non-radial poles** are defined as poles where the dropwires are concentrated on one side of a pole, i.e. dropwires distributed over 180 degrees or less.

88 Figure 3.26 illustrates the difference between radial and non-radial poles.

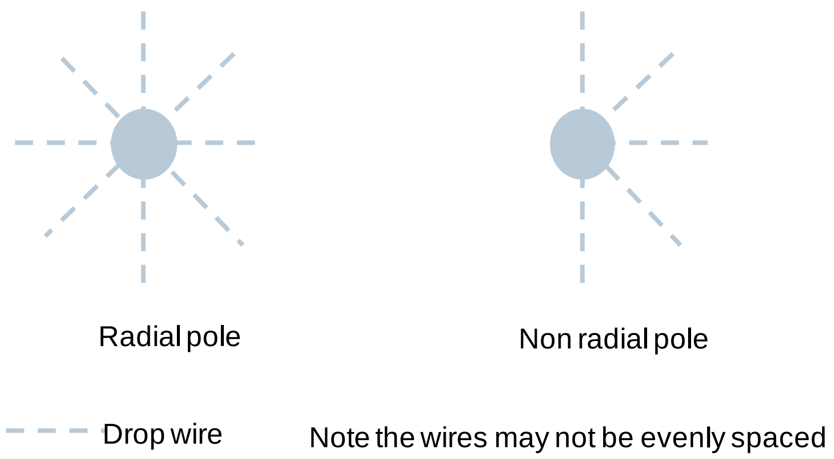

Figure 3.26: Plans of radial and non-radial poles [Source: Analysys Mason, 2010]

89 Finally, it is important to note that several design parameters govern the design of poles supporting dropwires and or aerial cables. These are the:

- height of pole
- type of pole
- size of cables and wires
- type of cables and wires
- cable specification, e.g. cable/wire breaking load
- number of cables
- environmental factors for the pole location, e.g. wind and ice loading
- cable/wire span
- the deployment of stays to support the pole.

Pole engineering rules – poles supporting dropwires

90 Structural failure of poles supporting dropwires can occur either due to buckling due to vertical loads, e.g. the weight of cables, or bending due to horizontal loads, e.g. cable tensions and wind loads, or a combination of buckling and bending.

91 Openreach's engineering rules for poles supporting dropwires are stated in EPT/ANS/A011 "Specification for Dropwire Work, particularly Section 4.3 "Dropwire Loadings on Poles". These engineering rules reflect the design parameters defined in the above section.

92 Non-radial poles will be subject to asymmetrical loading which is more constraining than symmetrical loading of a radial pole. As a result, Openreach has defined different engineering rules for radial and non-radial poles.

► *Radial poles*

93 Due to the more symmetrical nature of the loading on radial poles, the net load is more vertical than as the case for non-radial poles. Engineering rules for radial poles are provided in Figure 3.27.

94 The engineering rules differentiate between two types of radial poles – 'light poles' and 'medium poles'. The diameter of the pole determines the classification and consequentially the permitted loading. Depending on the environment, light radial poles can support between 12 and 40 dropwires and medium poles between 20 and 40 dropwires, depending on the type of distribution point, as shown in the table below. Given that the scope of the survey is urban and sub-urban areas, we assume for the analysis of the results that light poles can support between 28 and 40 dropwires and medium poles can support 40 dropwires.

Category	Type of distribution point	Maximum number of wires	
		Light poles	Medium poles
1	Urban -terraced houses/apartment blocks	40	40
2	Urban - semi detached houses	28	40
3	Semi-rural DPs. Houses reasonably spread	24	40
4	Rural DPs	20	30
5	Exposed rural	12	20

Figure 3.27: Engineering rule for radial poles [Source: Openreach]

► *Non-radial poles*

95 For non-radial poles, the governing loads are horizontal, and the governing factors are the number of wires, and the arrangement of wires. The key engineering rules for non-radial poles are expressed in Figure 3.28.

	Light poles	Medium poles
Max number of dropwires within a 180 degree arc	7 dropwires	15 dropwires
Max number of dropwires within a 30 degree arc	3 dropwires	3 dropwires

Figure 3.28: Engineering rule for non-radial poles [Source: Openreach]

96 It should be noted that for non-radial poles, both set of rules illustrated in Figure 3.28 must be satisfied simultaneously i.e. for light poles, there should be no more than 7 dropwires within a 180 degree arc **and** there should be no more than 3 dropwires within a 30 degree arc.

Pole engineering rules – poles supporting aerial cables

97 Openreach's engineering rules are given in EPT/ANS/A014 "Specification for Overhead Route Stability".

98 Openreach's approach to the design of poles supporting aerial cables is very different to the approach for poles supporting dropwires, as in essence, it involves the design of a pole route, considering the load between groups of poles along the route. Therefore, in addition to the design parameters considered at the beginning of this section, the design of poles supporting aerial cable must also take into consideration the following:

- length of the route (number of poles between termination points)
- deployment of stays to support poles, wherever necessary.

99 As a result, the design of poles supporting aerial cables involves a complex set of design processes, which requires a qualified structural engineer.

100 A detailed consideration of overhead stability and the capacity of poles supporting aerial cables are beyond the scope of this report, but it would be an important design stage consideration for any future use of the existing overhead infrastructure.

101 For the purpose of this report a simplified methodology for the assessment of poles supporting aerial cables will be utilised as explained in the next section.

Poles supporting dropwires and aerial cables

102 The type of methodology used for the assessment of poles supporting both dropwires and aerial cables will depend upon the ratio of dropwires to aerial cables, and will involve those design parameters and engineering rules applicable only to dropwires, and only to aerial cables. For the D-side infrastructure considered in this report (predominantly urban areas) the vast majority of cables supported are dropwires (98%) and only 2% aerial cables were observed (see Figure 5.14).

103 For the purpose of this report, given the very low number of aerial cables surveyed, we used simplifying engineering rules to take into account the loading imposed by aerial cables on poles. According to the engineering rules:

- The wind loading per metre of aerial cables is typically twice that of a dropwire (for the type of aerial cables and dropwires surveyed in our sample).
- The breaking load for aerial cables is typically five times that of a dropwire (for the type of aerial cables and dropwires surveyed in our sample).

104 Based upon the above parameters, we have assumed that the load imposed on poles by aerial is four times that of a dropwire. Hence, in our analysis, an aerial cable was considered to be the equivalent to four dropwires. We applied the dropwire engineering rules illustrated in Figure 3.27 and Figure 3.28 with the additional aerial cable loading. It must be emphasised that this approximation is purely for the purpose of analysing the results of this survey and that results are not very sensitive to this approximation since aerial cables only represent 2% of the total aerial feeds surveyed.

105 In reality, the overhead infrastructure will support a hybrid of dropwires and aerial cables: in the urban environment dropwires will be prevalent, but in the rural environment the poles will support mainly aerial cable. Any new fibre provider planning to use existing overhead infrastructure will require the appropriate level of structural engineering expertise (as Openreach do currently and will be using for their NGA deployment) to assess the suitability of the infrastructure, and to design any new elements of infrastructure, e.g. pole stays.

106 The most critical factor in the ability of existing poles to support new fibre deployment will be the loading characteristics of the new fibre, e.g. diameter, weight and breaking load of the fibre cables. In this report, we assumed that the loading imposed by fibre cables was similar to that imposed by

copper cables, due to the lack of information regarding the characteristics of aerial fibre cables in the UK.

107 In this study, we also assumed that there is limited useable space at the top of the pole to accommodate extra fibre termination boxes in the case of a multi-communication provider scenario. In reality, there is only a small amount of useable space at the top of the pole, as some space is required to allow the engineer to work safely, as required by Openreach's procedures.

108 In this study, we assumed that fibre drop-tube would be attached to existing poles using the same methodology as copper dropwires, i.e. clamped onto the single metal ring-head, fixed 200mm down from the pole tip, using spiral restraining clamps.

4 Operational issues

4.1 Introduction

109 The study has demonstrated that there is a wide range of operational issues and success factors involved in the field survey of underground duct networks and overhead poles. These issues are not only pertinent for communications providers considering duct access in order to deploy their own fibre network, but also for the infrastructure provider who wishes to install, upgrade or expand its infrastructure network.

4.2 Operational issues associated with underground infrastructure

110 The survey teams encountered a number of similar operational issues as in the 2008 duct survey project, specifically:

- climatic conditions
- restrictions in traffic-sensitive areas
- special event restrictions placed by local authorities
- health and safety issues (sewage)
- health and safety issues (residual gas)
- accuracy of infrastructure drawings
- chambers located in dense pedestrian areas
- high cable density in chambers (especially in chambers close to the PCP).

111 In addition to the above operational constraints, we found that small boxes (chambers) had been entirely filled with earth due to the rain washing the earth into the chambers; an example is shown in Figure 4.1 below. Smaller chambers are more prone to filling up with earth than larger chambers. This operational issue was not observed in the exchange side (E-side) of the network as the chambers are significantly larger. As a consequence, access to boxes filled with earth required Openreach to dig to locate the duct ends in each of the walls which can add significant survey time.

Figure 4.1: Chamber filled in with earth [Source: Analysys Mason, 2010]

4.3 Operational issues associated with overhead infrastructure

112 We also found specific operational issues relating to poles in the distribution network including:

- trees obstructing poles
- access to the pole itself
- fragile roofs
- nearby overhead power lines.

113 The percentage of poles affected by each of these operational issues is illustrated in Figure 4.2.[16]

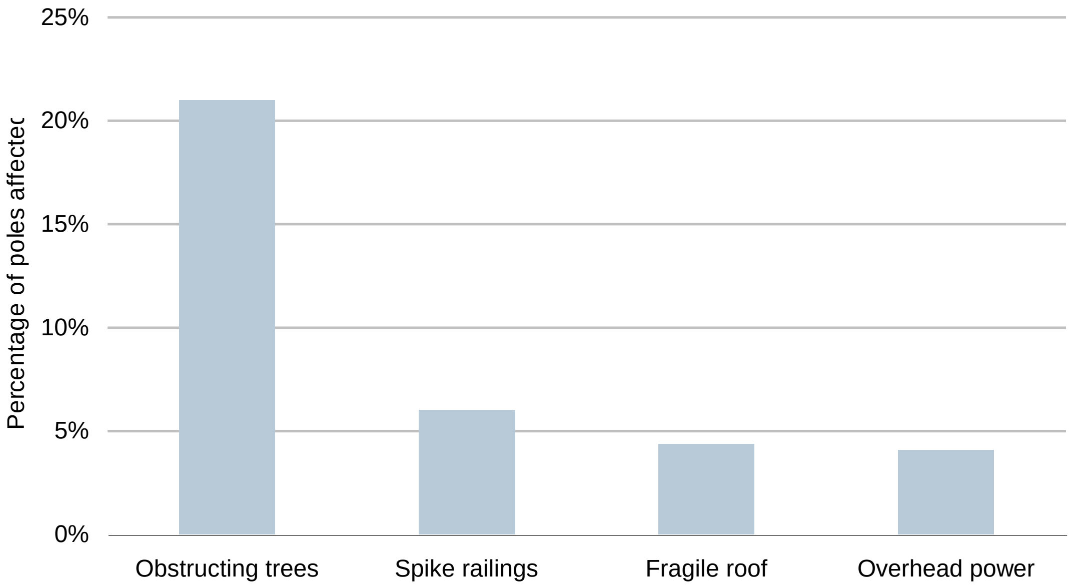

Figure 4.2: Hazards on poles [Source: Analysys Mason, 2010]

16 A total of 320 poles were surveyed.

114 **Trees obstructing poles** – a significant proportion of poles (21%) were located close to trees, with, in some instances, branches touching overhead wires and cables, as illustrated in Figure 4.3.

Figure 4.3: Pole located in the proximity of obstructing trees [Source: Analysys Mason, 2010]

115 Trees present a significant operational risk as branches impose a load on the cable/dropwire that lead to the cable/wire breaking. We believe that pro-active maintenance of the surrounding vegetation would not only be costly to Openreach but would also be difficult to implement as trees for example, are often located in private land. If overhead infrastructure was to be used to install the last drop of fibre connecting individual households, trees would certainly represent the one of the main operational difficulties facing new infrastructure deployment, and processes would have to be put in place to mitigate this.

116 A number of poles (6%) are immediately adjacent to spiked railings, hence access to the pole is only by means of an elevated platform.

117 A number of poles could be accessed from a rooftop. This has a potential security implications and a number of additional health and safety risks. However, according to Openreach, this has not proven to be a major operational issue to date.

118 The presence of overhead power on poles was observed for 4% of the poles surveyed. Joint use of poles between power and telecoms usually results in lower achievable heights for dropwires, which can inhibit the reach of the dropwires. It should be noted that this issue is more prevalent in rural areas.

119 It should be noted that the lower parts of poles can be subject to vandalism/damage.

120 Openreach has a clear set of guidelines for accessing poles which minimise health and safety risks. Any prospective third-party operator would need abide by these if they were to be given access to the poles to install cable infrastructure.

121 Openreach operates to height clearance standards to maintain a height of cables across the road, e.g. for feeds to bungalows and low buildings, additional sub-poles may be required, leading to additional expenditure.

4.4 Other operational issues and considerations

122 We found that it was difficult to locate and access internal and external DPs (representing a total of 19% of the DPs surveyed) mainly because these were located inside or just outside customer premises. However, it is not anticipated that this would be an operational issue of any significance for communication providers. However, it could be an important operational issue for multi-dwelling units (MDU) which are likely to be served by an internal DP. Depending on the size of the MDU, and the architecture used to deliver FTTH (e.g. passive equipment such as splitters in the case of passive optical networks), an internal DP would have to be installed inside premises and planning would be required.

123 We found that the drawings provided by Openreach for the D-side infrastructure were reasonably accurate. However, drawings do not indicate whether last drop underground cable is ducted or directly buried, which represents a significant issue. During the survey, it was very difficult to assess whether a last drop cable is ducted or buried, as a duct end may be present in last chamber but may not extend to the customer premises. Without intrusive testing, it is not possible to determine if the duct goes all the way to the premises. This issue is very significant as, ideally, communication providers would want to re-use the existing infrastructure, including the last drop. If no duct is available to deliver the last drop, the communication provider would have to dig[17] to install the last drop fibre, significantly increasing its costs to deliver FTTH to that customer. The unpredictable nature of whether or not duct for the last drop exists makes the business case more difficult to predict for communication providers.

124 In one of the areas surveyed, we found that the Openreach's duct contained co-axial cable in use by another communication provider. This is a one-off arrangement arising from the previous ownership of cable franchises by BT Group and the subsequent leasing of assets in the early 1990s to the current operator. There is no physical access by the operator and the cables are maintained by Openreach, and hence represent a unique arrangement in the Openreach network.

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17 Alternatively, when the last cable drop is directly buried, communication providers may want to install fibre overhead for the last drop. However, this method may not always be permissible due to planning regulation and other operational constraints.

4.5 Operational lessons learned in the distribution network environment

125 Overall, we found the distribution network less challenging to survey than the E-side of the infrastructure network. The main reasons were:

- chambers in the distribution network (mainly boxes) tend to be significantly smaller than chambers in the E-side of the network and fewer cables and ducts have to be surveyed
- we used walk-over surveys to identify any potential operational issues and try and mitigate them, including the reconciliation of the infrastructure shown on the maps provided by Openreach with the actual infrastructure present on the ground
- a very large proportion of the chambers surveyed were located on the pavement (as opposed to the carriageway), which resulted in faster set up times for the survey
- the D-side network is located in largely residential areas where there are fewer vehicles and pedestrians during the working day.

126 All observations made in Section 4.5 of the previous duct survey remain valid for the underground infrastructure of the distribution network, especially:

- **Business continuity policies and approaches** – Openreach has a responsibility to build risk management into its infrastructure. Currently unused duct/pole capacity can represent management of risk in the face of failures in other ducts and the need to act remedially and responsively (e.g. in times of natural disaster or emergency situations, spare duct capacity should be readily available for Openreach to install new cables).
- **Security** – Openreach's duct infrastructure is part of the UK critical national infrastructure and therefore the management of its integrity is very important.

5 Pole and ducts survey analysis of results

5.1 Introduction

127 The survey data set supports the analysis of three different types of result:

- **duct-end analysis** for both distribution ducting and lead-in (last drop) ducting
- **pole analysis**
- **route continuity analysis**.

128 The **duct-end analysis** considers the 552 chambers surveyed during this exercise and considers the duct ends located on all four walls of each chamber surveyed. We differentiate between 90mm duct ends and 50mm duct end because they are present in different parts of the distribution network: 90mm ducts are usually installed along the main distribution route and 50mm are usually installed in the lead-in to the customer (either as the underground last drop, or the lead-in to an overhead last drop).

129 The **pole analysis** considers all 320 poles surveyed during this exercise and considers all dropwires and aerial cables attached to each pole. In total 3293 dropwires and 358 aerial cables were surveyed.

130 The **route continuity analysis** considers end-to-end routes from street cabinet (PCP) to distribution point (DP). Since we have surveyed 17 PCP areas, we have considered 17 routes in this analysis, one for each PCP. The routes considered are the main routes (maximum length in terms of number of sites surveyed) within each PCP area, and contain a combination of underground ducting and chambers, and overhead poles. The route continuity analysis provides a good indication of the potential capacity pinch points that could be encountered by a communication provider deploying fibre along that route. Finally, it should be noted that for this analysis, only duct ends located on the two walls of each chamber surveyed that are in the direction of the route surveyed are considered. Duct ends located on walls that are orthogonal to the route are not considered.

5.2 Duct end analysis

5.2.1 Overall survey results

131 We start our duct analysis by comparing the main survey results obtained from this D-side survey with our previous results obtained for the E-side infrastructure. This is illustrated in Figure 5.1, where the first two column relate to the E-side infrastructure14 and the last two columns relate the D-side infrastructure (scope of this report).

132 Comparing the D-side infrastructure surveyed to the E-side infrastructure previously surveyed in Figure 5.1, it can be seen that the average number of duct ends *per chamber* reduces considerably, but the average number of cables *per duct end* is similar. We can also see that, in the D-side, there is more unoccupied space per duct end compared to the E-side. This is because on the D-side, the installed cables tend to be smaller cables than on the E-side, but they both use similar duct sizes (i.e. 90mm diameter duct).

	Previous survey		*Current survey*	
Parameter	*Metro node to exchange (E-side)*	*Exchange to PCP (E-side)*	*PCP to home/premises 90mm distribution ducting (D-side)*	*PCP to home/premises 50mm lead-in ducting (D-side)*
Average number of duct ends per chamber	29.3	10.8	4.5	4.5
Average number of empty duct ends	28%	17%	8%	2%
Average number of cables per duct end	1.9	2.2	3.1	1.5
Average unoccupied space per duct end	36%	30%	40%	72% [15]

Figure 5.1: Comparison of E-side and D-side duct surveys[18] [Source: Analysys Mason, 2010]

133 The average **number of duct ends per chamber** in the D-side surveyed is 4.4, which is significantly fewer than the number of ducts per chamber observed on the E-side of the network. This is supported by the fact that, in our survey, the two most common chamber layouts were:

- **A 5 duct end chamber**: 2 ingress duct ends on the main route, 2 egress duct ends on the main, and one duct end perpendicular to the main route to serve the final customer (lead-in duct).
- **A 3 duct end chamber**: 1 ingress duct end on the main route, 1 egress duct end on the main, and one duct end perpendicular to the main route to serve the final customer (lead-in duct).

134 The distribution of number of duct end per chamber is illustrated in Figure 5.2.

[18] The calculation of unoccupied space for the 50mm duct end uses a different methodology as discussed in Section 3.4.3.

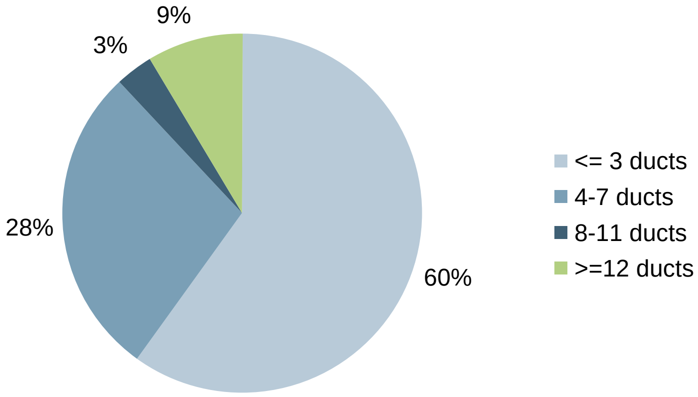

Figure 5.2: Distribution of number of duct ends per chamber [Source: Analysys Mason, 2010]

135 **The average percentage of empty duct ends** was 8% for the 90mm ducting, and only 2% for the 50mm ducting. This illustrates the fact that the majority of the D-side ducting is occupied by at least 1 small cable, and any new network deployment would need to work around the existing cabling infrastructure. This will be an important consideration for communication providers wanting to deploy new fibre.

136 **The average number of cables per duct** is 3.1 in the 90mm duct end, and 1.5 in the 50mm duct end. The majority of the 50mm duct ends contained only one cable (the lead-in cable). The distribution of number of cables per 90mm and 50mm duct end is illustrated in Figure 5.3 and Figure 5.4 respectively. For the 90mm duct end, 60% contained less than 3 cables. In comparison, 89% of 50mm duct ends contains less than three cables, with the majority only carrying a single cable.

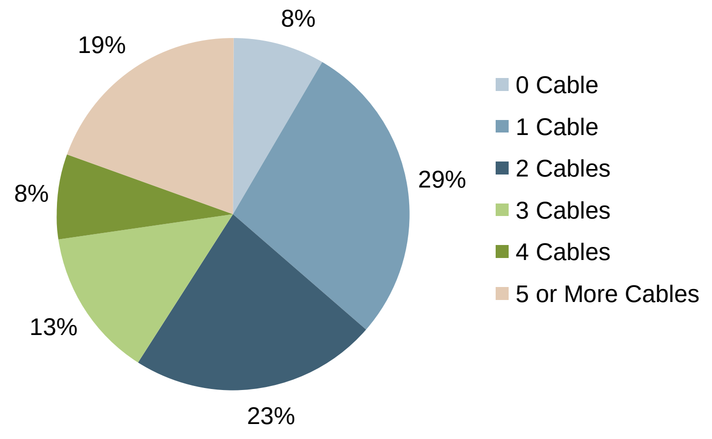

Figure 5.3: *Number of cables per 90mm duct end [Source: Analysys Mason, 2010]*

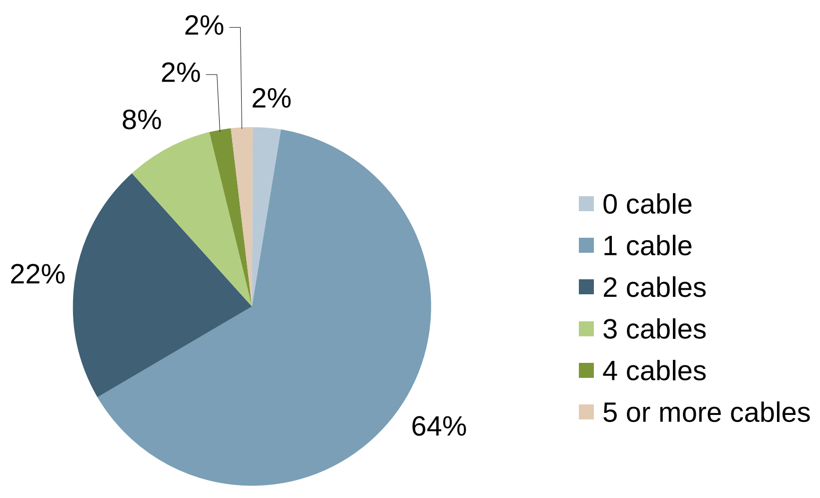

Figure 5.4: *Number of cables per 50mm duct end [Source: Analysys Mason, 2010]*

137 Finally, using our methodology to measure unoccupied space presented in Section 3.4.3, we observed **an average of 40% of unoccupied space in the 90mm ducts and an average of 72% of unoccupied space in 50mm ducts.** This is considerably more than on the E-side[19], but again is explained by the combination of smaller cables and the same duct size for 90mm duct ends and the fact that the majority of 50mm ducts only have a single cable.

138 In addition to these main observations, it can be noted that space for additional splices within the chamber was available in 77% of the chambers surveyed (assuming additional splices would take the same space as existing splices). Space in the chamber could be an important parameter, e.g. when deploying a GPON fibre infrastructure with passive splitters in existing chambers.

5.2.2 Detailed survey results

139 As discussed in the previous section, **the average number of duct ends per chamber** was 4.5. It should be noted that a chamber may contain both 90mm and 50mm duct ends, and therefore we considered the total number of duct end per chamber, without differentiating between 50mm and 90mm chambers. As illustrated in Figure 5.5, we observed little deviation between the different areas surveyed. This consistency reflects the original planning of the network, and provides a useful starting point for any future network deployment. Any new outline planning for new network deployment can be based upon the fact that the existing infrastructure is reasonably consistent.

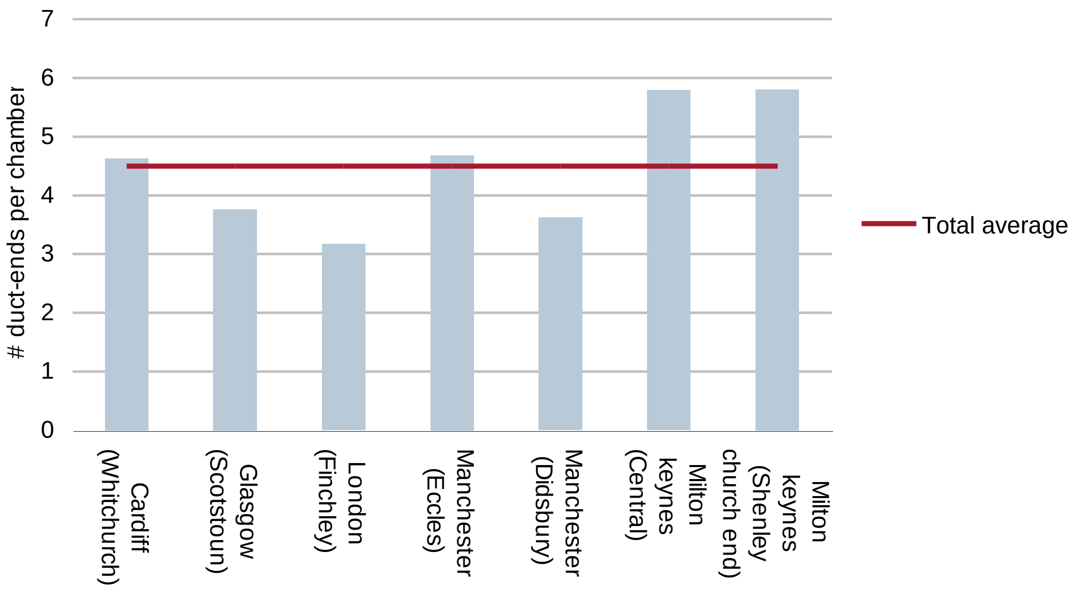

Figure 5.5: Average duct end per chamber [Source: Analysys Mason, 2010]

19 As shown in Figure 5.1, the average unoccupied space in ducts observed on the E-side was between 30% and 36%.

140 As shown in Figure 5.6**,** there was little deviation between the different areas surveyed in terms of **average cables per duct end**. Again, this consistency reflects the original planning of the network, and provides a useful starting point for any future network deployment. However, it is interesting to note that the minimum and maximum average cable per duct end was observed in the two areas surveyed in Milton Keynes (Central and Shenley Church End). This reflects the fact that the Central area was deployed using different infrastructure planning rules than Shenley Church End area. In the Central area, the 50mm lead-in ducts contain only a single cable meaning that the cable is split underground between the chamber and the houses. In marked contrast, in the Shenley Church End area, the 50mm lead-in ducts contain multiple cables, where each cable is dedicated to a house. This clearly shows the difference in infrastructure deployment deployed at different period of time.

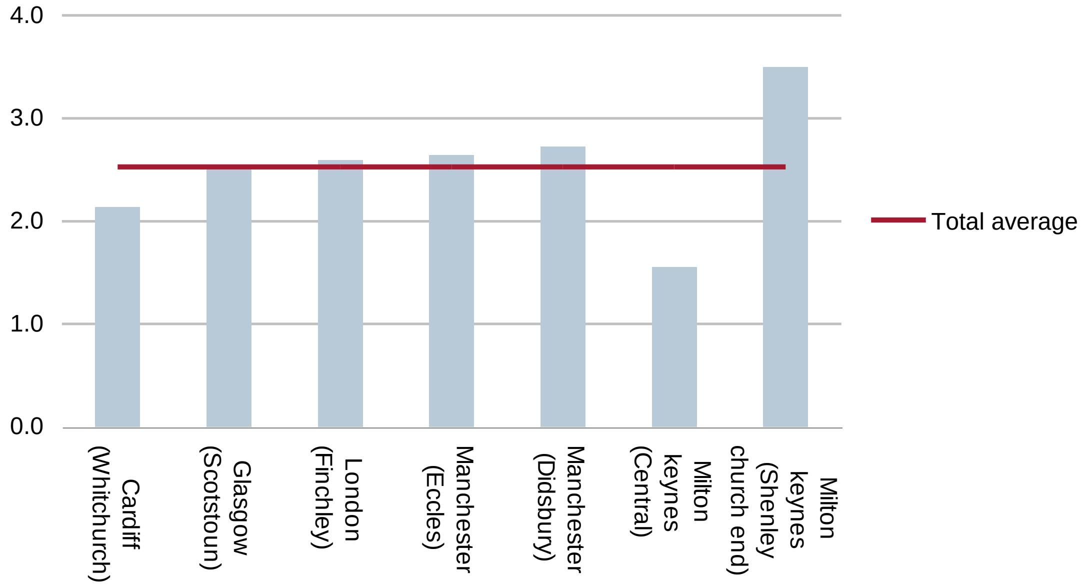

Figure 5.6: Average cable per duct end [Source: Analysys Mason, 2010]

141 **The range of the installed cable diameters in the duct ends** varied from 75mm to 5mm. The cables installed in the 50mm ducting are considerably smaller that the cables installed in the 90mm ducting as illustrated in Figure 5.7 and Figure 5.8. This result was expected as the cable diameters reduce along the main route from street cabinet to distribution point. **The vast majority (80%) of the cables in the 50mm duct are less than 15mm in diameter, leaving unoccupied space according to our methodology**.

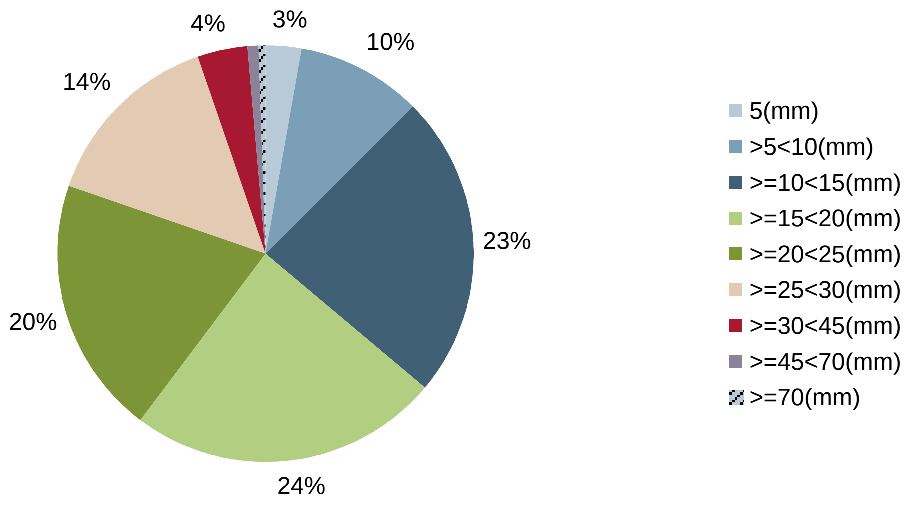

Figure 5.7: Range of installed cables in 90mm duct end [Source: Analysys Mason, 2010]

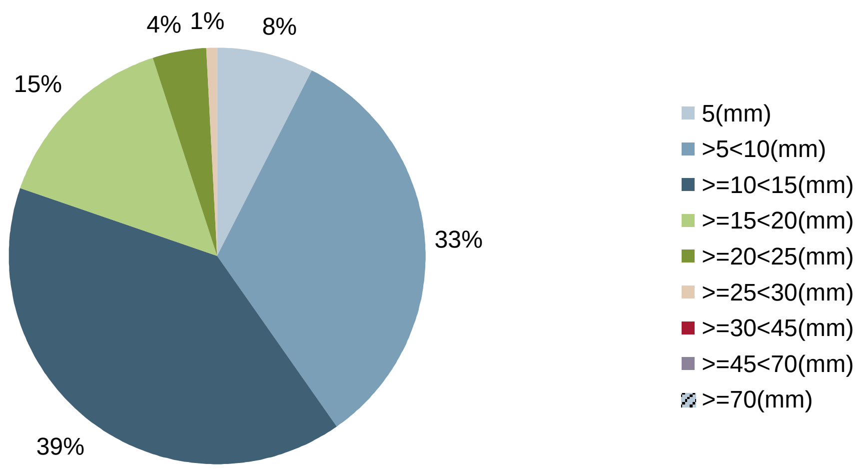

Figure 5.8: Range of installed cables in 50mm duct end [Source: Analysys Mason, 2010]

142 **The average distribution of unoccupied space per 90mm duct end** was measured using the 25mm tube methodology described in Section 3.4.3 to objectively assess the unoccupied space in the duct ends. The distribution of unoccupied space is illustrated in Figure 5.9, which shows that **for the 90mm ducting, 63% of duct ends can accommodate three 25mm tubes or more, which represents 42% of unoccupied space or more**.

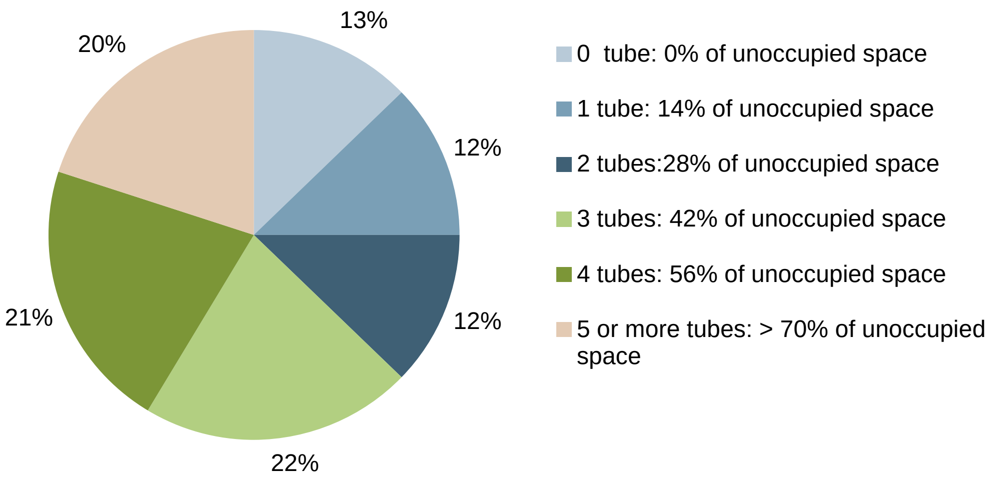

Figure 5.9: Distribution of unoccupied space in 90mm duct end [Source: Analysys Mason, 2010]

143 The average distribution of unoccupied space per duct end for the 50mm duct was assessed using the size and diameter of cables observed during the survey. The distribution of unoccupied space is illustrated in Figure 5.10, which shows that for the **50mm ducting 83% of the of duct ends have 70% or more unoccupied space,** which represents significantly more unoccupied space than on the D-side as illustrated in figure 5.1[20].

[20] It should be noted that the methodology to measure space in 50mm ducts was based on cable cross-section area and not on the 25mm tube methodology.

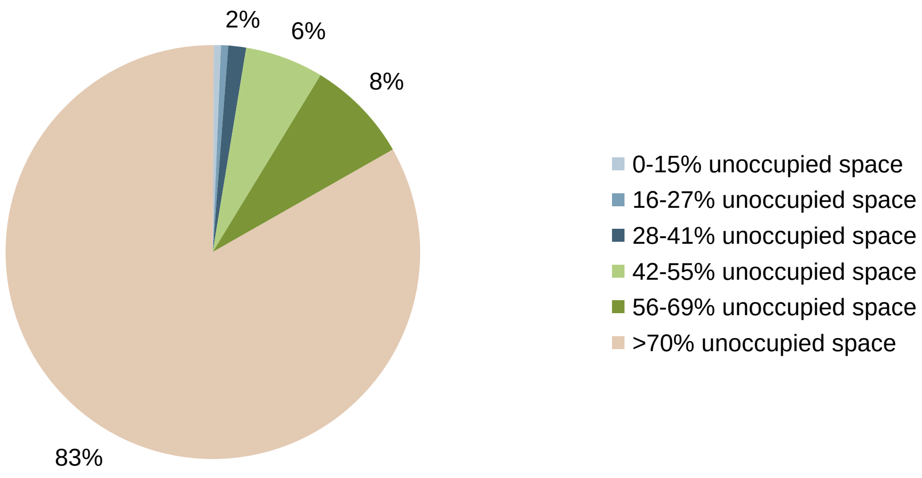

Figure 5.10: Distribution of unoccupied space in 50mm duct end [Source: Analysys Mason, 2010]

5.3 Pole analysis

5.3.1 Overall survey results

144 In the pole analysis, we concentrate on the two following metrics which provide an indication of the space available on the pole:

- the range of the number of dropwires per pole
- the proportion of aerial cables and dropwires.

145 The range of the number of dropwires per pole is shown in Figure 5.11. The maximum number of dropwires recorded on a radial pole was 29, and the maximum number of dropwires recorded on a non-radial pole was 21.

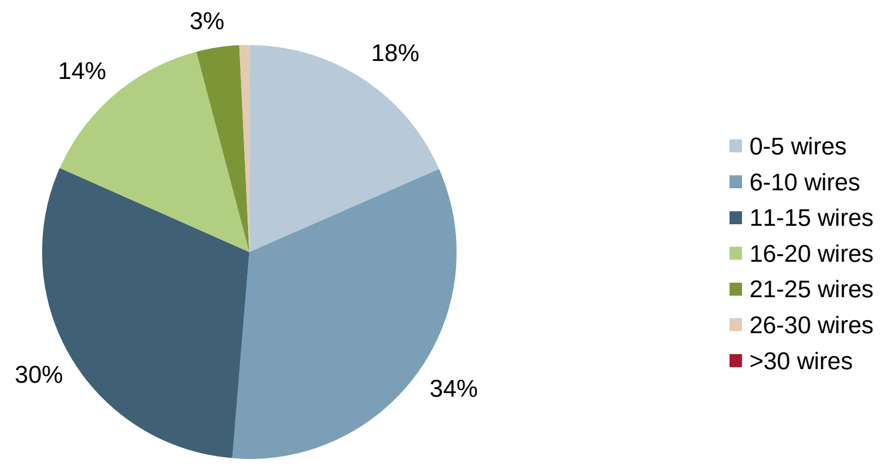

Figure 5.11: Range of number of wires on poles surveyed [Source: Analysys Mason, 2010]

146 **The distribution of dropwires on radial poles and non-radial poles** is shown in Figure 5.12 and Figure 5.13. The survey showed that in general non-radial poles support fewer dropwires than radial poles: this is consistent with the Openreach engineering rules described in Section 3.4.4. Figure 5.12, shows that 93% of radial poles have 20 wires or fewer, which only represents half the load they could carry (see poles engineering rules in Section 3.4.4).

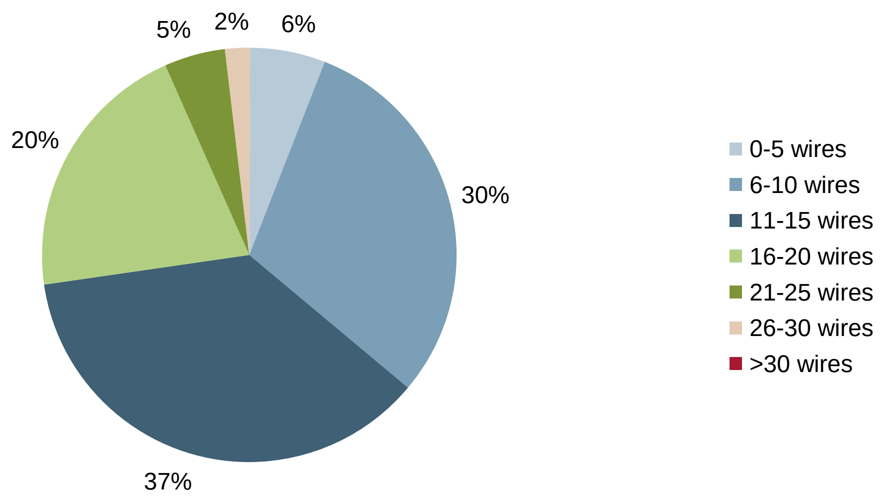

Figure 5.12: Distribution of dropwires on radial poles [Source: Analysys Mason, 2010]

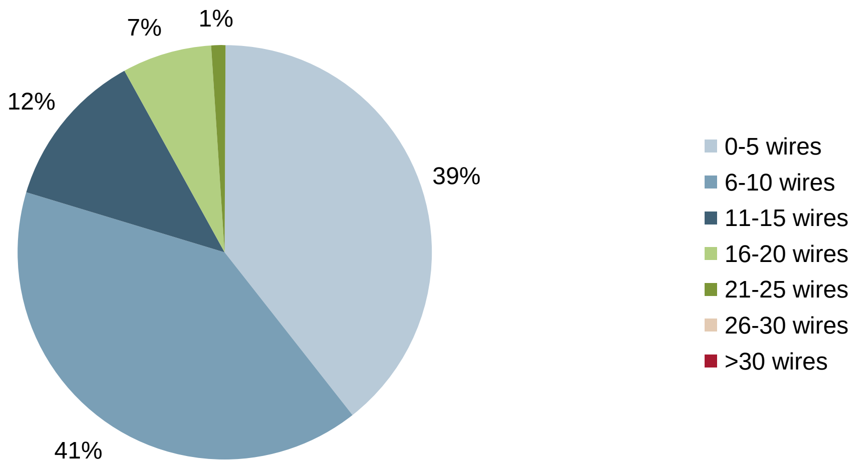

Figure 5.13: Distribution of dropwires on non-radial poles [Source: Analysys Mason, 2010]

147 **The number of aerial cables** recorded during the surveys was low compared to the number of dropwires, and the majority of the aerial cables observed were distribution cables secured to the pole between the underground chamber and the overhead DP which did not affect the horizontal loading of the pole. This pattern of infrastructure is typical of the urban areas surveyed where the distribution cables are mainly underground, and the function of the pole is to support the overhead DP and associated dropwires.

148 **The proportion of aerial cables and dropwires** is illustrated in Figure 5.14. In Figure 5.14, the distribution cable is the cable that comes from the last chamber and goes up the pole to feed individual dropwires, not imposing any horizontal loading on the pole. The aerial cable is typical from pole to pole and imposes a horizontal loading, estimated to be equivalent to the load imposed by 4 dropwires as described in Section 3.4.4. Since aerial cable only represents 2% of the total aerial cable and dropwire combined, our results are not sensitive regarding our loading assumption for aerial cable (see Section 3.4.4 for assumption definition).

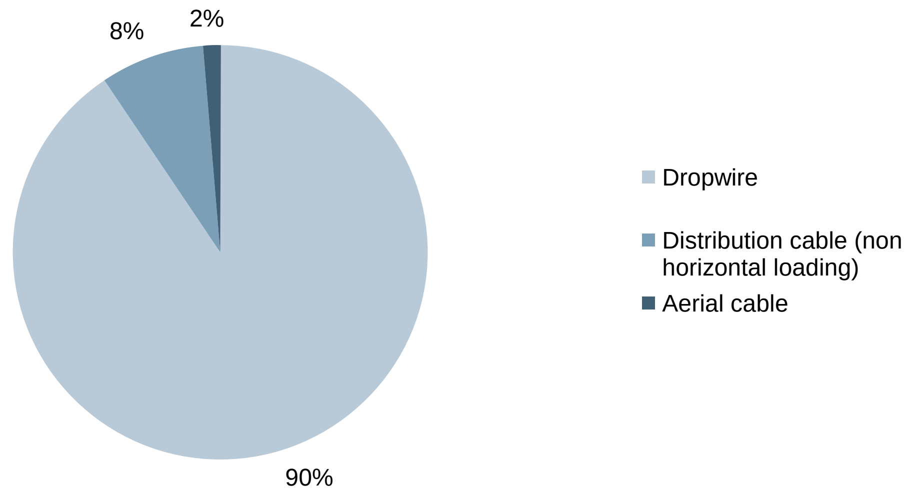

Figure 5.14: Distribution of dropwires and aerial cables [Source: Analysys Mason, 2010]

5.3.2 Detailed survey results

149 Considering Openreach's engineering rules for poles, we determined the percentage of poles that could take any additional loading (at least 1 extra dropwire), while retaining the existing loading. The results are shown in Figure 5.15, where "*fail*" means that the poles cannot take any additional loading and "*pass*" means that the poles could take additional loading.

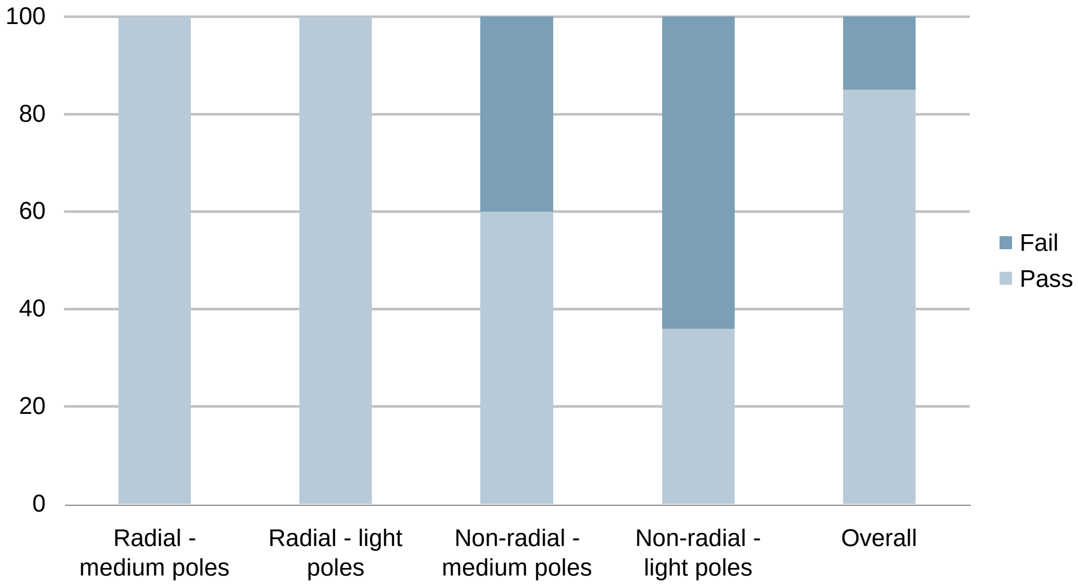

Figure 5.15: Percentage of pole which could accommodate extra capacity under existing loading [Source: Analysys Mason, 2010]

150 In Figure 5.15, we can observe that, overall, **85% of the poles surveyed could carry additional loading.** However, this is likely to be an under-assessment based upon our conservative interpretation of the engineering rules. **All of the radial poles surveyed could take additional loading, but only 49% of non-radial poles could take additional loading.** This discrepancy between radial and non radial poles is because the maximum number of dropwires that can be accommodated in a 30 degree arc is a constraining factor for non-radial poles.

151 To understand the extend to which poles can be used to support additional cable from a communication provider, we carried out a desktop analysis whereby we doubled the load on existing poles and determine the percentage of poles that still add additional capacity. The results of this analysis are illustrated in Figure 5.16.

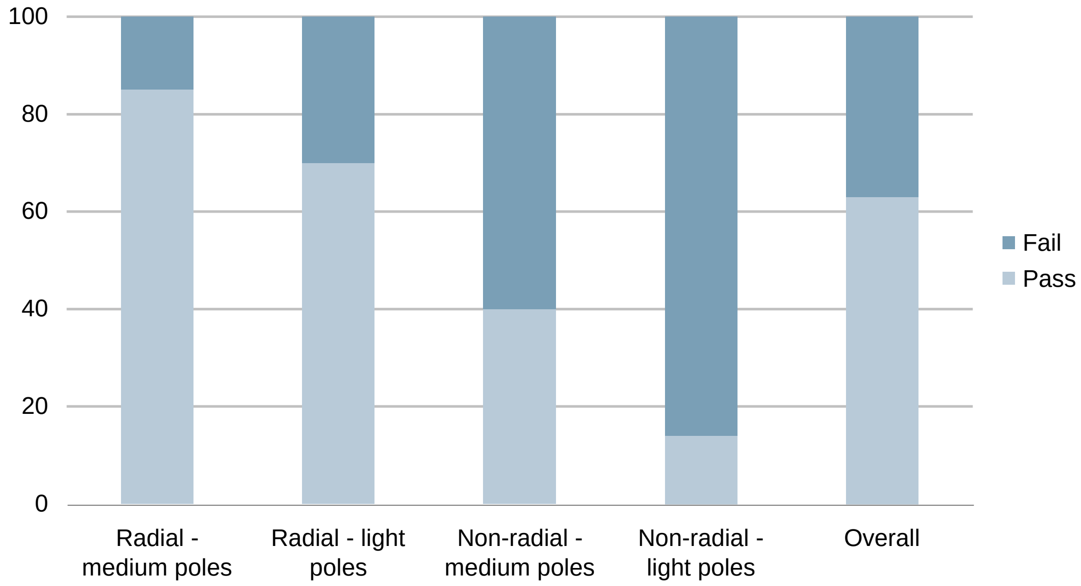

Figure 5.16: Percentage of poles which could accommodate extra capacity when existing loading is doubled [Source: Analysys Mason, 2010]

152 Overall, if the existing load is doubled on every pole surveyed, 63% of the poles will still be able to accommodate extra capacity (at least one dropwire) according to Openreach's engineering rules. This means that two-thirds of the poles could accommodate more than double the existing number of wire, or more than double the load. Assuming that an aerial fibre last drop imposes the same loading as existing dropwires, it means that a communication provider could install an overlay fibre network on at least two-thirds of the poles. As shown in Figure 5.17, we found that 78% of radial poles could take more than double the exiting loading compared to only 27% for non-radial poles.

153 Finally, in order to relate the spare capacity on poles to served dwellings, we analysed the percentage of dwellings served by overhead poles that could be delivered additional dropwires. This is illustrated in Figure 5.17 below.

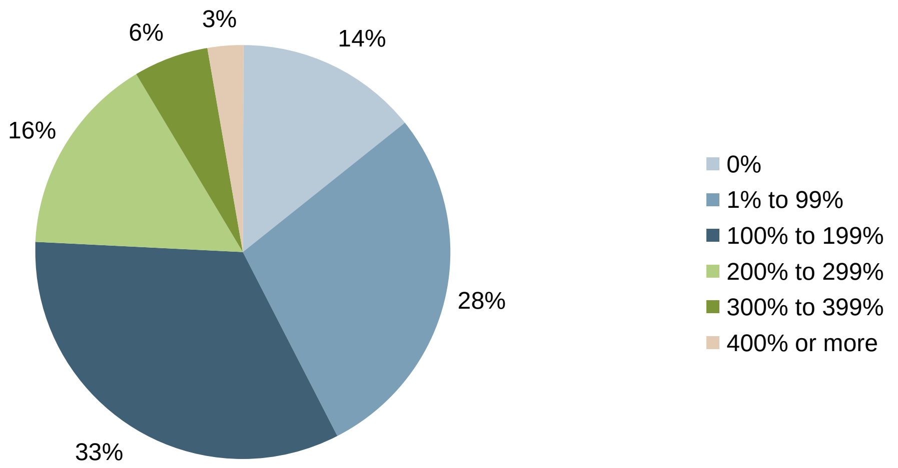

Figure 5.17: Percentage of dwellings served by overhead poles with spare capacity (e.g. 33% of dwellings have 100%–199% spare capacity) [Source: Analysys Mason, 2010]

154 In Figure 5.17, it can be seen that **58% of the dwellings are served by a pole that can accommodate an additional dropwire for every dwelling served off the pole** (100% spare capacity or more) without modifying the existing pole infrastructure. This implies that, if we consider the load imposed by a fibre on the pole to be equivalent to that of a dropwire, 58% of dwellings are served by poles that can provide the existing dropwire *and* an additional fibre to all the dwellings served by the pole. From Figure 5.17, it is apparent that 25% of the dwellings are served by a pole that can accommodate at least two additional dropwires for all dwellings served off the pole.

155 If, in the long term, all communication services were to be delivered over fibre, existing copper dropwires could be removed from poles, freeing up capacity in the overhead network. As an illustration, the pole infrastructure surveyed in our sample maybe be able to support two communication providers delivering a fibre-based service to 58% of premises and three communication providers delivering fibre based service to 25% of premises, each using their own fibre drop. Again, it should be emphasised that the underlying assumption is that fibre cables would impose the same loading and would be subject to the same engineering rules as existing dropwires (which could not be ascertained at the time of writing this report). Also, this illustrative scenario assumes that there is enough space at the top of the pole to host different fibre termination boxes to terminate the connections of each communication provider. The space at the top of the pole to accommodate extra termination boxes from alternative communication providers was not assessed during the survey.

5.3.3 Other observations from the pole survey

156 The spare capacity of poles across the network varies between routes, and between PCPs, (due to the effect of local demographics, and infrastructure layouts on the number of existing dropwires on poles), but in general, it can be seen that the pole infrastructure has been designed to engineering rules. This will be of assistance to any future network deployment.

157 It should be noted that the current engineering rules are relatively new and the majority of the poles were installed before they took effect. Hence, new rules are applied to legacy infrastructure. Also note that our assessment of non-radial poles did not take account of any strengthening works that may have been carried out on the poles surveyed, which would increase the capacity the poles can support.

158 The balance of aerial cables to dropwires will change in a rural environment (not in scope for this survey) as the extent of the overhead distribution network (as opposed to last drop) will increase. Rural areas are characterised by fewer dropwires per pole (fewer adjacent premises), and more aerial cables per pole (more distribution from pole to pole)

5.4 Route continuity analysis

159 The route continuity analysis considers end-to-end routes from street cabinet (PCP) to distribution point (DP), encompassing both underground and overhead infrastructure. Since we have surveyed 17 PCP areas, we have considered 17 routes in this analysis, one for each PCP. The routes considered are the main routes (maximum length in terms of number of sites surveyed) within each PCP area, and contain a combination of underground ducting and chambers, and overhead poles. The route continuity analysis provides a good indication of the potential capacity pinch points that maybe encountered by a communication provider deploying a fibre along that route.

160 The number of sites (chambers and poles) considered for the route analysis represents 22% of the total number of chambers surveyed (and 2% of the poles surveyed), and since it considers routes in each of the different areas surveyed, we consider it to be representative of the survey. In addition, the general outcomes of the route analysis are consistent with the overall survey results, as we will describe in the subsequent section.

5.4.1 Pass/fail criteria definition

161 In order to define whether additional capacity (unoccupied space) is available along each section of the route, we define pass/fail criteria for both the 90mm duct infrastructure and the 50mm duct infrastructure:

- For **90mm ducting** (distribution) the pass criteria is that in the wall of the chamber along the route there must be one duct end with space for a minimum of two 25mm tubes to be inserted.

- For **50mm ducting** (lead-in) the pass criteria is that the duct end is empty, or one 25mm tube can be inserted.

162 It should be noted that the higher pass rate percentage for a route, the less congested.

163 We also defined pass/fail criteria for poles:

- if the pole can accommodate at least one additional dropwire, it passes
- if not, it fails.

5.4.2 Summary of route continuity analysis

164 Figure 5.18 summarises the number of pass/fail sections found for each of the selected routes.

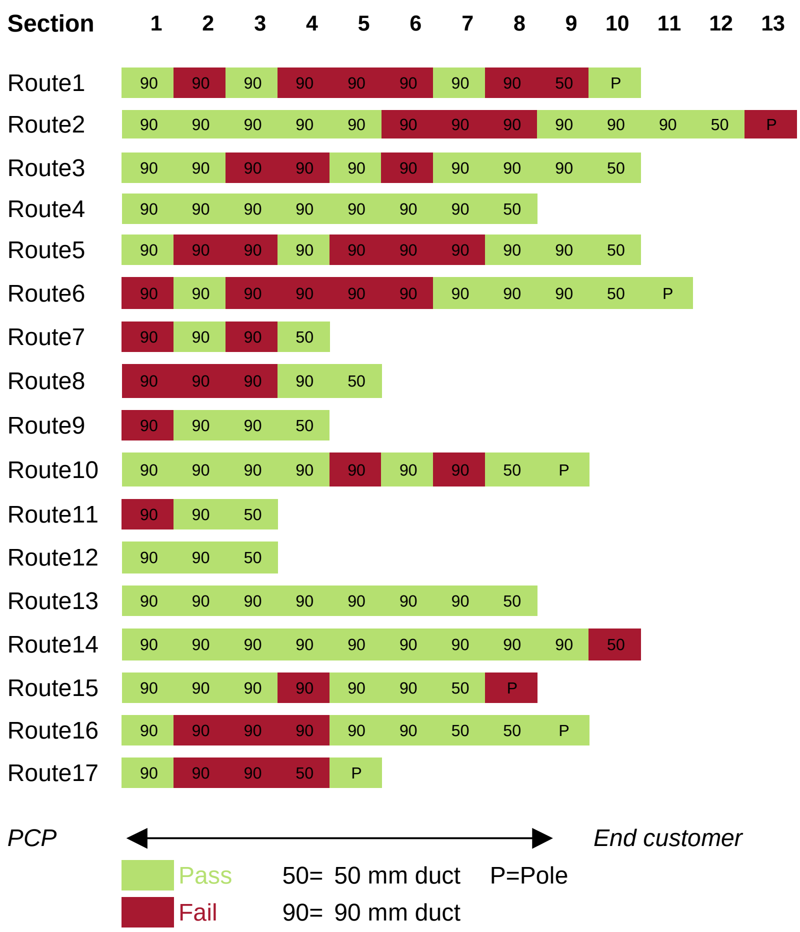

Figure 5.18: Route analysis summary [Source: Analysys Mason, 2010]

165 **Of the 17 routes analysed, only 3 routes achieved a "pass" at all infrastructure points (100% pass)**. This implies that any new network deployment may require the provision of additional infrastructure in a small number of areas to take full advantage of duct access. Alternatively, technology used to install cables may need to be more efficient where unoccupied space is at a premium. For example, flexible inner ducts may be used to optimise the available space.

166 As illustrated in Figure 5.18, an important result of the route continuity analysis is that space is not uniformly distributed across all sections of the routes: there are a number of specific pinch points that can occur at different locations:

- The first chamber connected to the PCP on the D-side on the network can be congested (see routes 6, 7, 8, 9 and 11).
- Where the duct diameter leaving the chamber is less than the duct diameter entering the chamber (typically 90mm in, and 50mm out), congestion is likely to occur. (see routes 1, 10, 14 and 17).
- Another pinch point in the network usually occurs where the number of ducts leaving the chamber is fewer than the number of ducts entering the chamber (for the chambers surveyed, this is typically where three ducts enter the chamber and only two leave the chamber). This often occurs one, two or three chambers down the route from the street cabinet (see routes 1, 3, 5, 6, 8, 15, 16 and 17).
- Also, for three of the routes, there is no capacity in the last drop connecting the subscriber which can happen for both poles and underground last drop.

167 Figure 5.19 represents the simple average pass rate[21] per site for all routes depicted in Figure 5.18. The average pass rate over the 17 routes is 70% which is consistent with the observed average characteristics of the individual infrastructure items:

- 75% of 90mm ducts can accommodate at least two 25mm tube (see Figure 5.9)
- 98% of 50mm ducts have at least 28% of unoccupied space which is equivalent to a single 25mm tube (see Figure 5.10)
- 85% of poles can accommodate extra capacity (see Figure 5.15).

[21] The higher the pass rate, the less congested the route is.

Area (PCP)	*Route*	*Percentage pass*	*Percentage fail*	*Number of sections*
Eccles (PCP 6)	1	40%	60%	10
Eccles (PCP 9)	1c	78%	22%	9
Eccles (PCP 12)	1	69%	31%	13
Didsbury (PCP 10)	1	55%	45%	11
Didsbury (PCP 19)	1	50%	50%	10
Finchley (PCP 5)	1	75%	25%	4
Finchley (PCP 8)	1	40%	60%	5
Finchley (PCP 16)	1b	50%	50%	4
Milton Keynes (PCP 2)	1a	100%	0%	8
Milton Keynes (PCP 19)	1	67%	33%	3
Shenley Church End (PCP 14)	1	90%	10%	10
Shenley Church End (PCP 18)	1	100%	0%	3
Scotstoun (PCP 8)	1	70%	30%	10
Scotstoun (PCP 19)	1	100%	0%	8
Whitchurch (PCP 31)	1	75%	25%	8
Whitchurch (PCP 34)	1	67%	33%	9
Whitchurch (PCP 39)	1	40%	60%	5
Overhaul		**70%**	**30%**	**130**

Figure 5.19: Summary of route analysis for the distribution network [Source: Analysys Mason, 2010]

6 Further analysis and conclusions

168 This section extends the analysis of the results from the duct and pole surveys, bearing in mind that the sample size only represents 0.013% of the total number of chambers and 0.008% of poles in Openreach's network, and, hence, the sample is only indicative. In comparison, the previous duct survey sample considered a similar number of sites but only considered chambers (not poles), which represented 0.02% of Openreach's infrastructure network.

6.1 General observations on D-side infrastructure

169 In urban areas, the Openreach distribution network is composed of ducts (underground infrastructure) and poles (overhead infrastructure) as illustrated in Figure 6.1. 90mm ducts are usually deployed from the PCP along the distribution route, and end customers can either be served by underground or overhead infrastructure. In the case of underground lead-in, the ducts are usually 50mm in diameter (see Route 1D in Figure 6.1). In the case of overhead delivery of the last drop, the pole will usually be fed by underground infrastructure from the adjacent chamber (see Route 1 B and 1E in Figure 6.1).

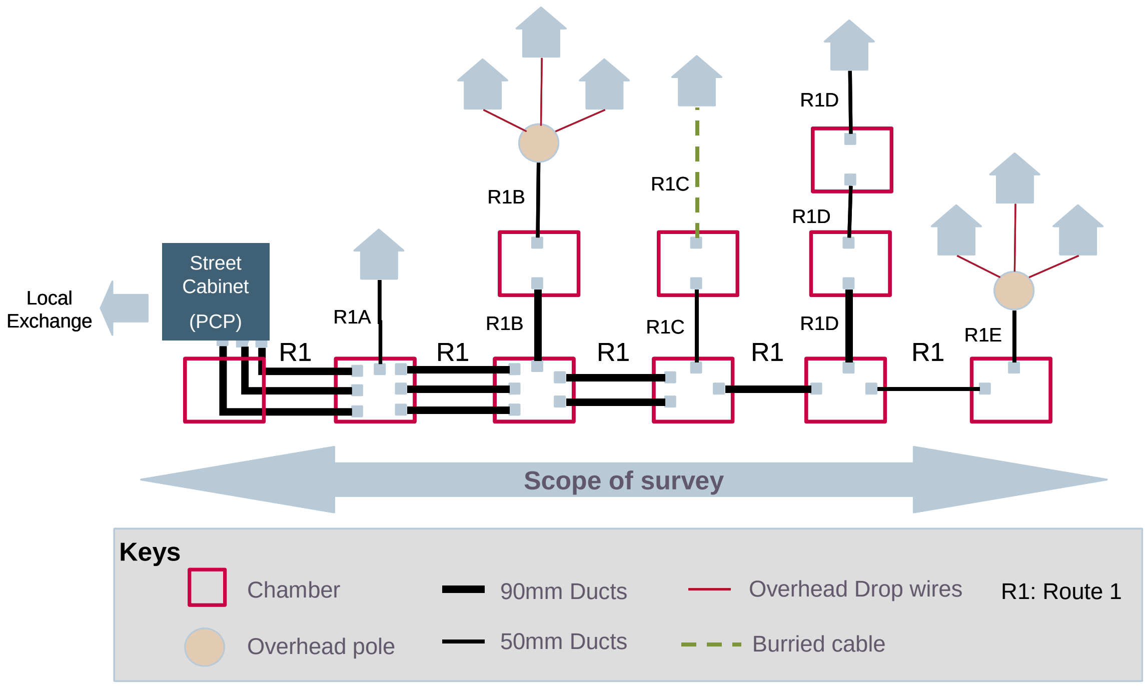

Figure 6.1: Typical distribution infrastructure [Source: Analysys Mason, 2010]

170 We found that the last drop to end customers was likely to be delivered by the underground infrastructure for areas where the infrastructure network was deployed after 1968. Typical examples are the so-called 'new towns' such as Milton Keynes.

171 Any new network deployment will need to take account of the buried cable within the existing Openreach network. In terms of the chambers surveyed, only around 1% of the cables observed in the chamber did not leave the chamber through a duct end, i.e. the cables are buried in the ground. However, our survey did not investigate whether or not cables are ducted outside the chamber. A duct end might be present in a chamber, but may not extend all the way to the customers' premises. However, directly buried cables are usually more than 15mm in diameter. In our survey, 41% of the cables surveyed in lead-in duct ends were less than 10mm, which may indicate that these cables are not directly buried but instead are ducted. Also, cables with a diameter greater than 15mm are likely to be armoured, and therefore will be directly buried. In our survey, 20% of the cables in lead-in ducts were 15mm or more in diameter, and therefore are likely to be directly buried. Under these assumptions, between 41% and 81% of the last-drop cables could be ducted.

172 The infrastructure surveyed has been in general agreement with the infrastructure represented on the Openreach record drawings, and DP schedules. The Openreach records can be inaccurate if recent repair/upgrade works have changed the network, and/or new property developments have been added to existing network areas. However, the existing Openreach records will be of assistance in planning and implementing new network deployments.

173 The field force to be engaged to implement any network development will require a wide range of operational skills:

- working in confined spaces
- working at height, including the use of ladders, restraint belts, and mobile elevated working platforms
- working adjacent to power lines
- working in traffic-sensitive areas
- working in areas usually occupied by the public
- working in areas affected by trees, e.g. branches interfering with overhead cables, and tree roots blocking underground chambers/ducting.

6.2 Key findings from the duct analysis

174 The assessment of unoccupied space suggests that there is more unoccupied space in the duct-ends on the D-side than on the E-side. We found that:

- the average unoccupied space for 90mm ducts was 40%
- 63% of the 90mm duct ends surveyed have at least 42% of unoccupied space
- the average unoccupied space for 50mm ducts was 72%
- 97% of the 50mm duct ends surveyed have at least 42% of unoccupied space.

175 Any assessment of duct-end space availability would need an understanding of the operational requirements of both the duct owner, and the potential new operator that wants to use the duct.

Engineering rules that would be developed to provide duct access would also significantly influence the way space would be used within the ducts.

176 In general, very few ducts are completely unoccupied (only 8% of 90mm ducts and 2% of 50mm ducts are unoccupied in the considered sample). This is an important result since it demonstrates that, if duct access was to be used on the D-side of the network, the engineering rules would have to consider the risks associated with damaging existing cables for the communication provider to deploy its new infrastructure.

177 It should be noted that unoccupied duct-end space will not directly translate into **useable duct** space for a CP willing to use the ducts since:

- a duct might have collapsed in the middle of a section
- the cable arrangement far into the duct may be such that existing cable cross-over may prevent any further cables being inserted in the duct
- engineering rules may prevent unoccupied space being used (e.g. to limit disruption with other cables in the duct) – this result should be interpreted using current engineering rules, bearing in mind that the evolution of technology may affect useable space.

178 We also found that the distribution of space in the ducting network was broadly consistent between the different areas investigated. This is in marked contrast with our previous duct survey of the E-side network, where a great variability in space from city to city, exchange to exchange, route to route, and chamber to chamber was observed. The predictability of the space in such infrastructure will be an important investment consideration for communication providers.

6.3 Key findings from the pole analysis

179 The assessment of spare capacity in the overhead infrastructure to deliver the last drop to end customers suggests that there is spare capacity. We found that:

- 85% of the survey poles could accommodate at least one additional dropwire
- 63% of the survey poles could accommodate at least double the amount of wires that is currently installed
- 58% of dwellings are served by a pole that can accommodate at least **one** additional dropwire for every dwelling served off the pole without modifying the existing pole infrastructure.
- 25% of the dwellings are served by a pole that can accommodate at least **two** additional dropwires for all dwellings served off the pole.

180 If, in the long term, all communication services were to be delivered over fibre, existing copper dropwires could be removed from poles, freeing up capacity in the overhead network. In this hypothetical scenario, the pole infrastructure surveyed in our sample may be able to support two communication providers delivering a fibre-based service to 58% of premises and three communication providers delivering fibre-based service to 25% of premises, each using their own fibre drop. Again, it should be emphasised that the underlying assumption is that fibre cables

would impose the same loading and would be subject to the same engineering rules as existing dropwires (which could not be ascertained at the time of writing this report).

181 Any new network deployment will require the assessment of existing poles to support additional loading. For poles supporting dropwires, this assessment can be carried out by field technicians, but poles supporting aerial cables will require the input of a structural engineer. In urban areas, most poles predominantly support dropwires and simplified engineering rules can be applied, but if the network deployment is outside of urban areas the design process for poles supporting aerial cables will apply.

182 Poles that are non-radially loaded (the dropwires are predominantly on one side of the pole) have the most stringent engineering rules, and have the least capacity to support additional network deployment.

183 The most critical factor in the ability of existing poles to support new fibre deployment will be the loading characteristics of the new fibre, e.g. diameter of fibre cable, weight of fibre cable, and breaking load of fibre cables. The method of installation of the fibre will also be important, e.g. the extent of pre-tensioning required. Further research into the development of 'efficient' overhead fibre cable could deliver benefits in terms of reducing the occurrence of future network deployment requiring replacement or additional poles.

184 The evolution of aerial fibre cable technology will help reduce the loading imposed by an overhead fibre on a particular pole. There has been a significant reduction in the size of fibre cable for deployment in ducts, and it is possible that the size of fibre cable for overhead deployment will also be reduced in the future.

185 Our survey showed that over 20% of poles are affected by tree branches. We believe that Openreach does not use any pre-emptive process to prevent trees from breaking dropwires/aerial cables, due to the scale and hence cost of any possible monitoring process; Openreach therefore tends to manage the issue on a reactive basis. Any large scale network development will require the support of field specialists (e.g. tree surgeons) to deal with the pruning, lopping and removal of trees. Dealing with trees will also involve professionals to manage the associated local authority planning, legal and public-relations aspects.

6.4 Key findings from the route analysis

186 As demonstrated by the route analysis section of this report, despite the increased unoccupied duct space in the D-side compared to the E-side infrastructure network, there are still pinch points along a typical route from PCP to DP. Our analysis has shown that on average there is a 70% to 80% chance of an infrastructure item having potential capacity to accommodate a new cable; on a typical route of 10 chambers, there is likely to be 2 or 3 pinch points. Some routes will be completely free of pinch points, but other routes may contain several pinch points. The pre-

empting of pinch points will be a significant advantage for a communication provider, decreasing its investment risks. The likely location of pinch points are as follows:

- the first chamber connected to the PCP on the D-side on the network
- the chambers where the duct diameter leaving the chamber is less than the duct diameter entering the chamber (typically 90mm in, and 50mm out)
- the chamber where the number of ducts leaving the chamber is less than the number of ducts entering the chamber (for the chambers surveyed, this is typically where three ducts enter the chamber and only two leave the chamber).

187 There are several solutions that can be used to overcome the pinch points associated with new network deployment such as:

- re-route the network to avoid the pinch point
- re-direct a route to use overhead infrastructure to avoid underground pinch points, or use underground infrastructure to avoid overhead pinch points
- use deployment technology that optimises the use of unoccupied space (e.g. use of flexible inner ducts)
- provide replacement infrastructure (larger duct or stronger pole)
- provide new infrastructure, e.g. a new section of duct from chamber to chamber, or a new duplicate pole.

188 Our survey only covered urban areas. Some of the results and observations can be extended towards rural areas, but many of the network parameters in the rural areas will be very different. Any communication provider willing to re-use the existing infrastructure network will need a good understanding of the characteristics of the rural areas in order to efficiently roll out a network from urban to sub-urban to semi-rural to rural areas. The areas where there is a transition between different network topologies could present pinch points at a network level.

6.5 Key findings, next steps and conclusions

189 In our survey of the D-side network, we found, on average, more unoccupied space than on the E-side network. Figure 6.2 illustrates the differences found.

	Previous survey		*Current survey*	
Parameter	*Metro node to exchange (E-side)*	*Exchange to PCP (E-side)*	*PCP to home/premises 90mm distribution ducting (D-side)*	*PCP to home/premises 50mm lead-in ducting (D-side)*
Average unoccupied space per duct end	36%	30%	40%	72%[15]

Figure 6.2: Comparison of unoccupied space in the D-side and E-side ducting network [Source: Analysys Mason, 2010]

190 As highlighted in our previous report, engineering rules have to be developed to ensure efficient use of unoccupied space in ducting. In our study, a number of assumptions were made regarding how the unoccupied space in the ducts could be used i.e. the use of a 25mm tube to define the unit of unoccupied space. This was based on the observation that most sub-ducts currently used within the Openreach network have a diameter of 25mm and that the rod required to pull some ropes/cables in a duct also has a 25mm diameter. In the case of a real deployment, more sophisticated engineering rules would have to be developed to account for the fact that:

- the infrastructure provider(s) may require some spare capacity for maintenance and route diversity
- some existing copper cables are old and fragile and the engineering rules should ensure that the risk of damaging these cables is limited
- the available space in the duct infrastructure has to be efficiently used in order not to lead to premature congestion.

191 The translation of unoccupied space in ducting into useable space for CPs will largely depend upon the engineering rules that will be defined in the context of a duct access offer. For example, in France a set of engineering rules has been developed by France Telecom to dictate how space in its ducts can be used by CPs in the context of a duct access offer.[22] Examples of such engineering rules are provided in Figure 6.3.

Duct status	*Engineering rule*
Duct nest with sub-ducted ducts where one or more sub-ducts is empty.	The CP is allowed to install its cable in the sub-duct with the smallest diameter.
Duct nest with at least five empty ducts.	The CP is allowed to install its cable in the duct with the smallest diameter.
Duct nest without any empty ducts, and where all ducts are 50% occupied or more.	The CP is not allowed to install any cables and has to look for alternative options.

Figure 6.3: Sample of France Telecom's engineering rules for duct access [Source: France Telecom]

192 Our report has established the need to review and develop engineering rules for pole design and capacity assessment. Efficient and robust design standards and processes for the use of existing poles will be critical to the use of the poles for new network deployment, especially in the hypothetical scenario of a multi-communication provider environment, where the maintenance of poles may be difficult if not managed centrally.

193 As part of the engineering rules discussion, we recommend the following next steps:

- review of existing technologies to deploy fibre, and a review of the roadmap of future available technologies in terms of fibre cables, conduits, poles and deployment techniques

[22] Offre d'accès aux Installations de Génie Civil de France Télécom pour les Réseaux FTTX.

- full review of the application of engineering rules and design processes for pole design currently used by Openreach
- full review of engineering rules in countries where duct and/or pole access is available (e.g. France and Portugal)
- consultation with duct and pole access stakeholders to:
  - anticipate the requirements of CPs
  - better understand infrastructure providers' current engineering rules and operational constraints.

6.5.1 Duct and pole access operational processes

Framework governance model for duct and pole access

194 Our sample survey experience suggests that a number of processes need to be adopted, to promote efficient communication between the different parties involved (survey/installation team, infrastructure provider security staff and planning staff as well as local authorities). For instance, a successful duct and pole offer could be process-driven, whereby the CPs and the infrastructure provider would have to go through a number of steps before a given duct or pole could be accessed. Introducing an optimal level of management by process would greatly help in the successful implementation of duct and pole access; a process with too many overheads will discourage CPs from using the service while a lack of processes would lead to an unmanageable situation.

195 An example of such processes can be found in Portugal, where a duct access offer is available from the incumbent. The steps involved are outlined below.

- First, the CP looking at using duct access uses a Web-based geographical database (incumbent extranet), to identify where the incumbent's infrastructure is located. The CP pays an annual fee to gain access to this database. Based on the database information, the CP identifies the ducts it wants to use to connect its business clients, indicating the type of fibre cable it needs to accommodate in the ducts.
- In a second step, the incumbent performs a feasibility study on that section of ducts and provides the CP with the result of the feasibility study. If duct access is not feasible, the incumbent has to be able to justify why this is the case (full, obstructed, reserved for incumbent's plan, etc.).
- In a third step, if duct access *is* feasible, the CP has to survey the section of the ducts it wants to use, identifying potential blockages along the ducts. If a duct does not offer full continuity

(collapsed or blocked), the CP has to undertake some civil work to repair the duct at its own expense.

- Finally, the CP can deploy its fibre in the identified duct to connect to its end customer, respecting the engineering rules set out in the duct offer. On completion of the installation, the alternative operator has to provide the incumbent with the 'as built' documentation, clearly indicating which duct is occupied. This allows the incumbent to update its database accordingly.

196 According to the experience gained from our sample survey, a similar process would be difficult and expensive to implement in the UK at the moment, given that it relies on an electronically maintained database, which is currently not available (see the section on digitising network plans and duct records below – starting at paragraph 206).

197 It is also worth noting that, in the UK, duct access could be provided by more than one infrastructure provider. Determining the governance model that would allow ducts from different infrastructure providers to be provided on a wholesale scheme would be key. One model for consideration could be that a CP looking to use duct access should not have to determine what infrastructure provider should be used in a particular geographical area. Instead, the CP would have a single point of contact that would co-ordinate this activity for it. In the mobile industry, the Mobile Operators Association (MOA) is a good example of a governance model that allows the co-ordination of different operators when sharing infrastructure. One of the key roles of the MOA is to track each key milestone in the implementation of infrastructure (sites and towers) sharing between the different parties involved. This activity is further illustrated in the next section.

Key performance indicator monitoring

198 In the event that communication providers were given access to Openreach's infrastructure, and once processes have been agreed between infrastructure providers and CPs, it will be important to define and agree key performance indicators (KPIs) for each key milestone in the duct and pole access process. Tracking KPI performance will also be important to ensure that duct and pole access work is progressing as anticipated. KPI analysis will help improve the process and performance for the benefit of all participants on an ongoing basis.

199 The benefits of KPI tracking are illustrated by the governance used for site sharing in the mobile network operator (MNO) market. Initially, site sharing between MNOs, while encouraged by national and local government policy, was only seriously considered by the MNO looking for a site if there was no other feasible option. Operators preferred to be in control of their own destiny rather than relying on a competitor to complete the lease amendment work, planning applications, site design and preparation works necessary to accommodate their antennas and equipment. Intervention by the Office of the Deputy Prime Minister led to the formation of the MOA by all five MNOs. One of the many outputs from the MOA was a set of agreed KPIs and processes that are monitored via an independent website. MNOs submit sharing applications to one another

through the website, which then tracks each key milestone through to either termination or completion of the site share work. KPI statistics are presented via a standard report on a quarterly basis, which encourages professional co-operation between the MNOs for their mutual benefit.

200 We would therefore recommend, as a next step, that a feasibility study be undertaken to consider how KPIs could be tracked.

Access facilitation and operational constraints

201 A key process in our sample survey was the facilitation of access to the duct and pole network between the survey team and the various departments involved in the infrastructure provider (i.e. Openreach in the context of our survey). A process regulating access to the ducts and poles to ensure surveyors and cable installers operate in a safe environment, and that national security is not breached, is of paramount importance. For example, it is important that a member of staff of the infrastructure provider team, or other suitably qualified and experienced third-party person, is present when the survey/installation is conducted, to ensure the safe removal of any gases before opening a chamber, and to ensure that the installer does not affect national security. This process could take a number of forms, and include several parties, e.g. an independent third party to facilitate and manage access.

202 We identified a number of measures that can be used to mitigate the operational difficulties encountered during the survey. For example, we identified that walk-over surveys, prior to commencing full surveys, would significantly improve the efficiency of the overall surveying process. We also found that a close collaboration with local authorities was key in improving the efficiency of survey planning to avoid areas that are shut off during special events, and to facilitate surveys in traffic-sensitive areas. In most cases, operational issues can be mitigated during duct and pole access roll-out by robust processes, sound engineering rules and co-operative planning.

Field force competencies and training

203 In our sample survey, we identified a range of skills and competencies that are required to survey, install and maintain infrastructure when deployed in the context of a duct and pole access offer. Common examples of competencies include the qualifications and experience required for cabling (qualified to splice fibre), working methodologies to protect existing infrastructure, operating a permit-to-work system, working in confined spaces, working at height and working in a street works environment. Clearly identifying and defining these competencies would facilitate the future work of CPs within infrastructure providers' network, or the infrastructure provider working on behalf of the CP, and would probably lead to the establishment of accredited training schemes for the field force.

204 The field force will also need specific training to ensure it fully understands the application of engineering rules to site activities, and to ensure each installation is compliant with these defined engineering rules (see paragraph 191 for example engineering rules).

205 We therefore recommend as a next step, a study on the required competencies and associated training programmes for infrastructure providers and third-party CPs willing to use duct and pole access.

Digitising network plans and duct records

206 In the event that communication providers were given access to Openreach's infrastructure, it would be desirable that a record of the infrastructure is maintained and held in an electronic format to facilitate access to the data by both the infrastructure provider and the CP wanting to use duct and pole access. However, based on the experience of our sample survey, the current Openreach drawings and duct records have not always been maintained and updated, particularly in recent years, and, hence, are not accurate in terms of recent changes to the network. In addition, the Openreach drawings and duct records are in many different formats on a local and regional basis, and do not always cross-reference from drawing to drawing, or record to record. Any drawings/records in any format/condition are always of some value to an infrastructure developer or a communication provider, but all parties need to be aware of the planning and operational limitations of the Openreach drawings. These limitations may restrict the effectiveness of applying engineering rules via the current Openreach drawings/records.

207 During duct and pole access roll-out, a database of digitised duct plans surveyed and '*as built*', produced by the CPs would be established and developed. This database would support any further duct and pole access requirements, and facilitate the application of engineering rules.

208 As illustrated in the case of Portugal Telecom in paragraph 195, it will also be very important for CPs to provide 'as built' information back to the infrastructure provider to allow the proper maintenance of the infrastructure records. The format of these records needs to be consistent and standards based, between the infrastructure provider and the CP.

209 We therefore recommend, as a next step, a feasibility study including:

- an audit of the extent and format of the current records of infrastructure provider networks
- a definition of a common standards-based record
- a feasibility assessment of the cost and time involved in digitising the infrastructure provider's records to create a coherent and referenced set of duct plans that would be of value to the planning process of a CP
- a feasibility assessment of linking engineering rules to digitised drawings
- defining the survey and drawing information that would be required from CPs after initial survey, and at the 'as-built' stage.

6.5.2 Extension of the survey scope to other infrastructure providers

210 In this study, we solely concentrated upon the infrastructure of Openreach. However, other network operators and utilities have infrastructure that could be used by CPs to deploy NGA infrastructure, and any government policies regarding duct and pole access would have to consider all infrastructure available.

211 We therefore recommend an extension of this survey to other telecommunications providers and utilities' infrastructure. Considering more than one infrastructure provider will encourage competition and provide more options for CPs to deploy their NGA network, especially in congested sections of the infrastructure network (i.e. access network).