Final report for Ofcom

Operational models for shared duct access

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analysys mason

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Analysys Mason Limited
Bush House, North West Wing
Aldwych
London WC2B 4PJ
UK
Tel: +44 (0)20 7395 9000
Fax: +44 (0)20 7395 9001
enquiries@analysysmason.com
www.analysysmason.com
Registered in England No. 5177472

1 Executive summary

In March 2010, Ofcom's wholesale local access (WLA) market review consultation was published indicating that BT has significant market power in the UK WLA market. Ofcom proposed that BT should provide physical access to its underground ducts and overhead telegraph poles to other companies and allow them to lay their own fibre.

Critical to the success of any duct/pole offer is the definition of a comprehensive operational model that specifies each of the steps involved in obtaining access to existing ducts/poles. Analysys Mason was therefore commissioned to compile this report into potential operational models for shared duct access. The objective is to assist Ofcom in understanding the available options to implement a duct/pole access operational model in the UK, by applying examples of best practice from other countries to the specific characteristics of the UK's existing network infrastructure.

In the UK, the access network, operated by Openreach, includes a number of network nodes (metro nodes, local exchanges, street cabinets and end-user premises), each connected by either underground duct links or overhead poles.[1] The duct links are broken up by underground chambers, which allow cables to be accessed and directed along different duct routes. In some cases underground ducts run all the way to the end-user premises, while in others the last drop is made using a directly buried cable or an overhead cable from a telegraph pole.

The various sections of the UK network, e.g. backhaul, exchange side (E-side) and distribution side (D-side), are structured differently. The backhaul and E-side usually have a large number of ducts on each link and around one in four ducts is empty. In marked contrast, the D-side contains fewer ducts in each link, and very few of these are empty. Some D-side ducts also tend to be smaller (50mm instead of 90mm) that in the backhaul or in the E-side of the network. These observations are very important, as any coherent duct access offer will have to consider the different characteristics of different parts of the network.

When formulating the operational model for a duct access offer, it is important to clearly define its key constituents:

- framework to record infrastructure access requests
- mechanism for providing infrastructure plans
- approaches to determine available space and survey procedures
- approaches to and engineering principles for allocating space in ducts and poles
- procedures for cable deployments in shared infrastructure
- procedure to update infrastructure plans
- framework to monitor Service Level Agreement (SLAs)

[1] In urban and sub-urban environments, the use of overhead poles is restricted to the last drop to connect the end customer; all other network nodes are inter-connected by underground ducting infrastructure.

Each of these constituents of duct and pole access has been implemented in various ways in different countries as illustrated in Figure 1.1 below. The figure compares the case studies for France, Portugal and Spain, where a reference offer for sharing infrastructure is available. This study also considers the USA, where infrastructure sharing occurs by means of commercial agreement, and therefore cannot be directly compared with the other cases.

It should be noted that out of the studied countries, only Spain has mandated pole access. However, each pole access request requires a customised study by the infrastructure provider (IP). Therefore, the case studies have provided limited insight regarding best practice for implementing pole access in the UK.

Based on this understanding of the operational models studied and our understanding of the UK network[2], we have made a series of recommendations for implementing an optimum duct/pole access operational model in the UK, shown in Figure 1.2 below. Overall, we believe that an operational model that includes all the features specified in our recommendations should result from an *iterative* process, involving the feedback of all UK stakeholders. However, we recognise that it may not be feasible to implement all functionalities in the *initial* development of the operational model, because doing so may delay the introduction of the duct and pole offer, and would involve a significant upfront capex investment by the industry. Instead, an incremental approach should be adopted, each developmental stage drawing on the experience of both Openreach and communication providers (CPs) of earlier stages. In order to facilitate the incremental development of the operational model, we recommend monthly meetings between the Openreach, the CPs and the regulator to provide feedback on operational issues and provide input into how the model could be improved.

2 “Telecoms infrastructure access – sample survey of duct access”, Analysys Mason for Ofcom, March 2009, available at http://www.ofcom.org.uk/telecoms/discussnga/duct/ductreport.pdf

	Portugal	*France*	*Spain*
Framework to record infrastructure access requests	Semi-automated central portal Attachments and forms required	Semi-automated central portal Attachments and forms required	Semi-automated central portal CP must take a note of all infrastructure element to submit a survey request
Mechanisms used to access existing network plans/duct records	Coarse maps are available online but detailed maps required for planning are made available on request (pdf format)	Fully digitised network maps are made available on request (posted by FT on the portal)	Detailed maps are available online though the portal but CPs can only download pdf maps
Survey approach	Space availability available in PTC database and surveys are only carried out by PTC if desktop data is incomplete/unreliable	Whole-area surveying is mandatory and the CP carries out survey	Survey is mandatory and is carried out on a route basis in collaboration between Telefónica and the CP
Approaches to determining useable space	PTC performs the analysis of occupation Useable space is calculated according to a formula taking into account cable size and duct diameter	The CP performs the analysis of occupation and issues a request to FT for space reservation. Occupied space is explicitly defined in the offer, taking into account cable size and duct diameter	Useable space is determined by the site surveys and engineering rules
Approaches to engineering principles	As per space calculation described above	Physical separation using sub-ducts (or flexible inner ducts in some cases) Priority-based engineering rules specified where and how the cable should be installed, based on local configuration	Physical separation using sub-ducts (or flexible inner ducts in some cases) "Priority-based engineering rules" specified where and how the cable should be installed, based on local configuration
Procedures for duct access deployment	Sub-ducts (if required) are deployed by PTC. Cable deployment carried out by the CP with supervision from PTC Accreditation scheme in place	All infrastructure required is deployed by the CP (including sub-ducts) The CP has to submit an installation plan, covering all procedures and ways to mitigate operational issues	All infrastructure required is deployed by the CP (including sub-ducts) The CP needs to carried out a risk assessment analysis and prepare a detailed project plan before installing its infrastructure
Process for updating infrastructure plans	CP has to provide PTC with an "As built" design, 30 days after completion of the work to allow PT to upgrade their infrastructure	CP has to provide an "End of Works Submission", which is based on the Order Submission, updated with any changes that have occurred during the works phase	After the joint survey has been carried out, the CP needs to provide the technical specifications ('*memoria descriptiva*'), which contains detailed information regarding the intended installation
Frameworks to monitor SLAs	Time to respond to a request: 15 days	Time to respond to a request: 12 days	Time to respond to a request: 10 days

Figure 1.1: Main differences in duct/pole access operational models in France, Portugal and Spain [Source: Analysys Mason]

Process	*Recommendation*
Framework to record infrastructure access requests	• Implement a central and secure portal, using an incremental approach with the following characteristics: – unique and central point of contact – SLA monitoring capability – automation of request validation/ responses – integration of support for GIS tools if feasible
Mechanisms used to access existing network plans/duct records	• Openreach's Infrastructures plan should be available to CPs • Plans should preferably be in a digitised format. • Initially, requested plans should be uploaded on the portal on demand by Openreach, with a goal to make all plan available online real time • A limitation of the number of requests by each CP should be imposed, to avoid overloading Openreach. This limit should be increased as the system becomes more automated
Approaches to determining useable space and survey procedures	• Mandatory whole-area surveying at least for the first CP and the option of route surveying for subsequent CPs • CPs should be allowed to carry out surveys with the Openreach having the option to escort • Implementation of appropriate procedures to ensure network integrity – accreditation scheme, submission of CP's survey plans to Openreach or list of approved sub-contractors by Openreach
Approaches to engineering principles for allocating space in ducts	• Physical infrastructure separation but based on different techniques depending on network section • Engineering rules should account for space required by Openreach to maintain and expand their network • Engineering rules should account for operational space[3] to avoid potential delays during the installation period • Engineering rules should promote the efficient use of space by defining a set of "priority-based rules" which dictate what space should be used to deploy a cable, avoiding stranded space • Space should be allocated on a first come first serve basis, with consideration of a 1:1 matching principle to the first CP to avoid capacity hogging • Provisions should be made for co-operative space application from two or more CPs

[3] Operational space takes account of the fact that the cable arrangement far into the duct may be such that existing cables cross over, and may prevent any further cables being inserted in the duct, plus the size of the tools required to install a cable in a duct/sub-duct (e.g. rod).

	• In case of congestion, CP should find an alternative path, considering survey information • If an alternative path cannot be found, the offer should encourage Openreach to find alternative solutions for the CP (e.g. removing disused cables)
Procedures for duct access deployment	• Health & Safety requirements that CPs must meet when deploying their infrastructure • Clear set of engineering rules pertaining to the installation of sub-ducts and cables, including detailed recommendation on installation practices, especially regarding the use of rods, ropes and sub-duct • Detailed cable labelling procedure to ensure cables of different CPs can be easily identified • Detailed procedures regarding the dressing up of cables around the chamber to ensure access to the chamber and ducts is not restricted • Procedures to identify fragile cables and guidelines regarding how to mitigate possible risks before work commences • Procedures regarding how the installation can be stopped by Openreach, should the CP not follow the rules laid out in the offer • Procedures to solve issues encountered during the access request to ensure any additional delays are bound
Process for updating infrastructure plans	• After completion of the installation, the CP should provide an as-built drawing, to allow the infrastructure database to be updated
Frameworks to monitor Service Level Agreements (SLAs)	• Depending on the process proposed by duct/pole access stakeholders, the following SLAs should be included in the offer – Period allowed for a request to be fully formulated by the CP following a registering of interest, including all necessary documents – Period allowed for Openreach to supply the necessary infrastructure maps to allow the CP to plan its survey – Period allowed for the CP to submit a survey request, with all the necessary plans – Period allowed for the response to a request for survey from the CP – Period allowed to carry out survey – Period allowed for the validation of the feasibility study as submitted by the CP – Period allowed for the deployment of the cable (i.e. space reservation time) – Period allowed for the CP to provide as-built drawings • In addition, SLA for cable maintenance should be defined: – Period allowed for scheduling the supervision of non-urgent work to be carried out by the CP (installation, maintenance and removal of infrastructure)

  - Period allowed for scheduling the supervision of urgent work to be carried out by the CP (repairs)
- Finally, specific SLAs should be defined regarding resolution time of the potential problems that can be encountered during the provision of duct/pole access

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Figure 1.2: Summary of recommendations [Source: Analysys Mason]

2 Introduction

In March 2010, Ofcom released their wholesale local access (WLA) market review statement, which indicated that BT has significant market power (SMP) in the UK WLA market. As a remedy, Ofcom proposed that “BT should provide physical access to their underground ducts and overhead telegraph poles to other companies and allow them to lay their own fibre”[4], effectively mandating duct and pole access in the UK. This decision was informed by a number of studies, including two sample surveys of Openreach’s infrastructure that revealed that there was unoccupied space available that could potentially be used by a CP to install their own fibre cables.

As observed in other countries where pole/duct access is available, a key element to the success of a duct and pole offer is the definition of a comprehensive operational model that specifies each step in obtaining access to existing ducts and/or poles. The objective of this report is to assist Ofcom in understanding what options are available to implement a duct/pole access operational model in the UK, by applying examples of best practice from other countries to the specific characteristics of the UK’s existing network infrastructure.

The objective of this report is to assist Ofcom to understand the available options for implementing a duct/pole access operational model in the UK by considering both the characteristics of the UK network and duct/pole access operational models in other countries. This report is structured as follows:

- **Section 3** provides a guide regarding the key issues associated with existing telecoms infrastructure for the deployment of fibre-based access networks. Although this section focuses on the UK’s incumbent telecoms infrastructure, it also provides an understanding of how other types of network could be used to deliver telecoms services.
- **Section 4** provides an overview of the fundamental operational principles involved in a duct/pole access offer, and sets up an operational framework for the remainder of the report.
- **Section 5** provides an analysis of existing duct/pole access offers in Portugal, France and Spain, and compares the main operational differences between them.
- **Section 6** provides recommendations on the possible options available to implement a duct/pole access offer in the UK, based on the understanding of the characteristics of the UK infrastructure network and on the different duct/pole access operational models used in other countries.

4 ‘Review of the wholesale local access market’, Ofcom, March 2010 (www.ofcom.org.uk/consult/condocs/wla/)

3 Overview of telecoms networks infrastructure

3.1 Introduction

This section is a guide to the key issues associated with existing telecoms infrastructure for the deployment of fibre-based access networks. Although this section focuses on UK network infrastructure, many principles may be applicable to other incumbent networks in Europe and the rest of the world. This information is aimed at UK policy makers.

3.1.1 The need for infrastructure access

Next-generation access (NGA) networks (which include both fibre to the home (FTTH) and fibre to the cabinet (FTTC) architectures) have the ability to provide higher bandwidth and higher quality to end user, and therefore offer opportunities for new services and business models. The move to NGA networks will be one of the most fundamental changes in telecoms infrastructure since the introduction of market competition.

Although the cost of bandwidth in the active layer has reduced significantly in recent years, and continues to fall, the cost of the civil works – such as digging and trenching – represents a major barrier for operators to deploy NGA infrastructure. Previous studies have shown that the civil work can account for up to 80% of the total cost of the infrastructure being deployed.[5] Therefore, infrastructure re-use will be an important input to the economic deployment of NGA, making access to existing infrastructure (such as unused space in underground ducts) an important policy issue. Any increase in re-use will increase the amount by which NGA can be economically deployed by the market, and so reduce the need for public sector interventions. It is one solution to lowering the barrier to entry for communications providers (CPs), and therefore support competition.[6]

3.1.2 Content of this guide

We start this guide with an explanation of a reference network, detailing key infrastructure components. We then explain the requirements of FTTH networks, including the demands that different architectures place on the existing infrastructure. We give detail of the available options for deploying FTTH networks using existing infrastructure, and finally discuss the options for using alternative infrastructure to the copper network.

5 "The costs of deploying fibre-based next-generation broadband infrastructure", Analysys Mason for the Broadband Stakeholder Group, September 2008, available at http://www.broadbanduk.org/component/option,com_docman/task,doc_view/gid,1036/Itemid,63/

6 Note: this guide does not consider the regulatory or commercial terms which would need to be defined before access to existing infrastructure could take place.

This guide provides an overview of the key issues associated with infrastructure access. An important source for this guide has been the FTTH Handbook published by the FTTH Council. The Handbook is available at http://www.ftthcouncil.eu/documents/studies/FTTH_Handbook.pdf and is an excellent source of additional detail on the practicalities of FTTH network deployment.

3.2 Overview of the incumbent UK telecoms network

3.2.1 Openreach's access network

The incumbent telecoms network consists of a series of network nodes (metro nodes, local exchanges, street cabinets, and end-user premises). Each network node is connected by underground duct links. The duct links are connected by underground chambers, which allow cables to be accessed and directed along different duct routes. In some cases underground ducts run all the way to the end-user premises, while in others the "last drop" is made using an overhead wire and/or cable from a telegraph pole. An overview of the incumbent telecoms network in the UK is given in Figure 3.1 below; each of these network elements is described below.

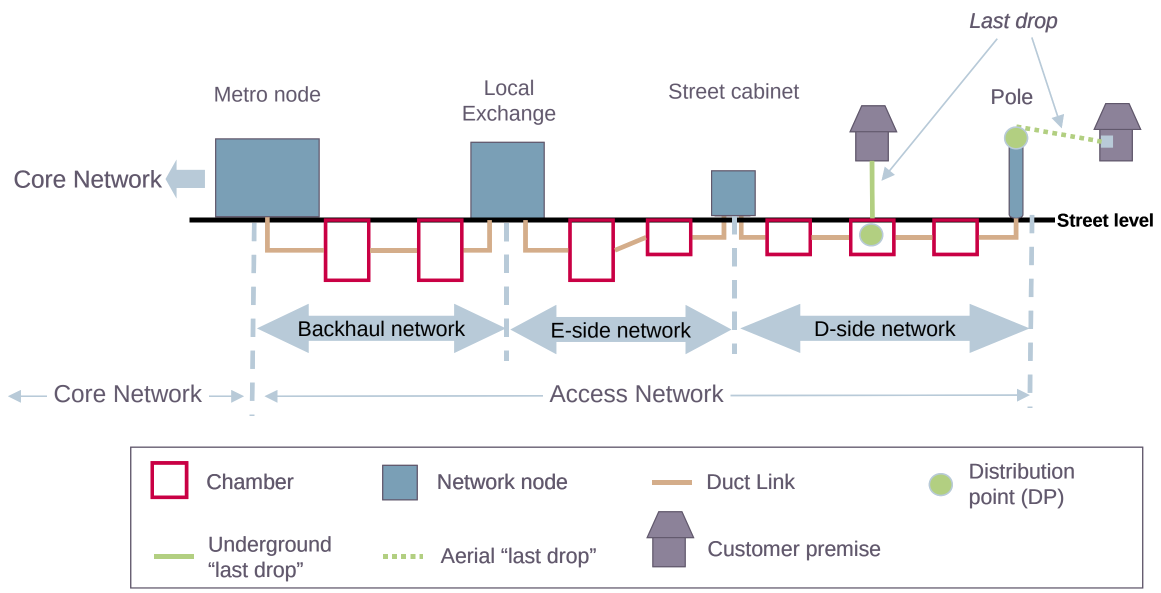


Figure 3.1: Diagrammatic representation of UK incumbent network [Source: Analysys Mason]

As shown above, the UK incumbent telecoms network comprises two main sections:

- the **core network –** nationwide infrastructure connecting all regions together
- the **access network –** regional/local infrastructure serving end-customers.

As the incumbent network was purpose-built for delivering a ubiquitous telecoms services, we will use this architecture as the reference network for this guide. Alternative networks (such as cable and utilities networks) are considered in Section 3.5. Below, we also concentrate on the access portion of the network, as the most important economic challenges are around next generation access networks (rather than next generation *core* networks). In the UK, the incumbent access network is operated by BT's Openreach division.

The **access network** is sub-divided into three sections:

- the **backhaul network** – infrastructure connecting the local exchange to the metro node[7]
- the **exchange-side (E-side) network** – infrastructure connecting the local exchange to the street cabinet
- the **distribution-side (D-side) network** – infrastructure connecting the street cabinet to the end user. The last cable connecting the end-customer is referred to as the 'last drop' in the rest of this document.

In reality, however, the telecoms network follows a more complicated tree and branch configuration than that shown in Figure 3.1, where chambers are used to branch cable runs off main routes. These main routes tend to follow public highways to allow easy access to the chambers. The tree and branch configuration is shown in Figure 3.2.

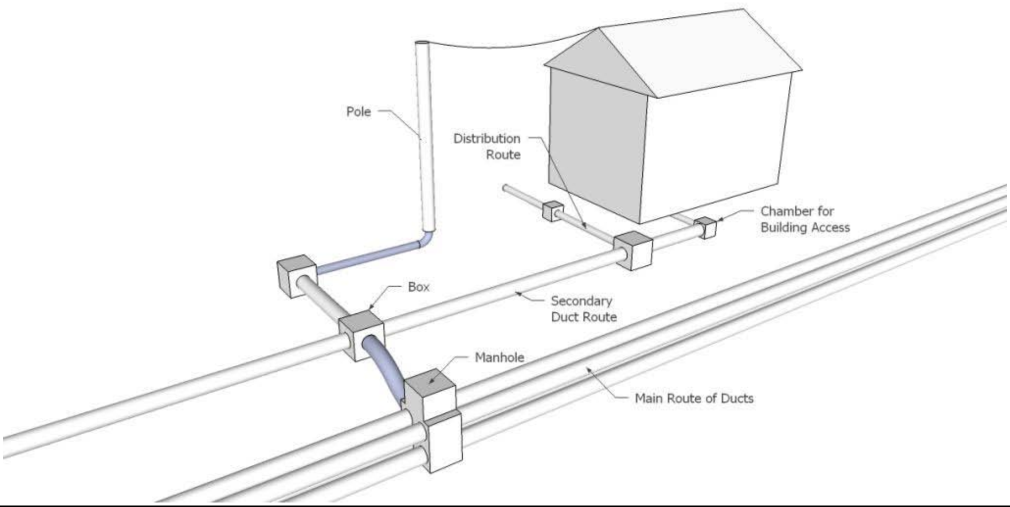


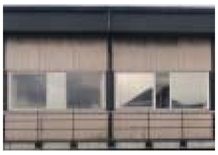
Figure 3.2: Tree and branch configuration of the access network [Source: Analysys Mason]

3.2.2 Network nodes

The various nodes of the reference network are described in Figure 3.3 below.

7 A metro node can also be co-located with a local exchange. In that case, no backhaul infrastructure is required.

Metro nodes are network nodes in the form of a communications room in a purpose-built building. Metro nodes connect Openreach's access and core networks, and are generally used by Openreach as a handover point to connect to CPs.



Local exchanges are network nodes in the form of a communications room in a purpose-built building[8], and mark the termination of the copper access network for current generation copper access networks. In Openreach's network, two types of local exchange exist: Tier 1 and Tier 2. Tier 1 exchanges are usually directly attached to one or several metro nodes and Tier 2 exchanges are usually attached to Tier 1 exchanges.

Street cabinets are network nodes providing direct or indirect interconnection between the access network and the customer premises, i.e. connect the E-side to the D-side cables of the infrastructure network. In fibre to the cabinet (FTTC) deployments, the role of the street cabinets is crucial, as they terminate the copper network, significantly shortening the copper local loop (referred to as the sub-loop). The street cabinet is also referred to as the primary connection point (PCP).

Distribution points (DPs) are the last interconnection point in the distribution network before the end customer (forming the start of 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*".[9] An overhead distribution point is recognisable by a small box mounted on a pole; an underground distribution point is typically located in a chamber.

Figure 3.3: Network nodes [Source: Analysys Mason]

3.2.3 Network connectivity

There are four components to the infrastructure that are used to link the nodes in the access network: chambers, ducts and/or direct burial sections, and poles. The specific nature of each of these components is different according to the section of the access network.

Chambers

A chamber is a piece of underground infrastructure that provides access to the ends of ducts and the cables running through them. There are two main types of chamber: boxes and manholes.

A **box** is an underground structure whose floor area is equal to and directly below its access opening. Figure 3.4 provides an illustration of a typical box.

8 It should be noted that the local exchange can be sometimes implemented underground in the form of a manhole.

9 Openreach's definition.

Figure 3.4:Open box [Source: Analysys Mason]

In contrast, a **manhole** is defined as an underground structure whose floor area is greater than the opening. Manholes are usually significantly larger (and extend significantly deeper) than boxes. Figure 3.5 provides an illustration of a typical manhole.

Figure 3.5: Open manhole [Source: Analysys Mason]

Manholes tend to be found on routes with large amounts of underground cable (and therefore large amounts of ducts). Manholes are often used at major junctions of cable routes; in contrast, boxes tend to be used at more minor junctions or where access to a linear cable route is required for maintenance. Due to the tree and branch nature of the telecoms network, manholes are more commonly found on routes close to the exchange and backhaul network, whereas boxes are more commonly found on routes in the distribution-side network and close to the end user.

Ducts

A **duct** is defined as a tube or conduit for enclosing cables under the ground. The vast majority of access network nodes and chambers are connected with ducts in the UK.[10] Ducting is the most conventional method of underground cable installation and once deployed, allows the subsequent installation and removal of cables by a variety of techniques (discussed in Section 3.4.1 below).

In the UK access network, ducts have been deployed in standard sizes: ducts in the backhaul or E-side ducts are usually 90mm in diameter. However, D-side comprises of a mix of ducts: 90mm in

10 Especially in urban and sub-urban environments.

diameter close the street cabinet and 50mm in diameter close the subscriber premise. The links between chambers are often made up of groups of ducts known as nests. Again, due to the tree and branch nature of the network, the number of ducts in a group tends to be larger between chambers close to the exchange than towards the end user. Some examples of the ends of ducts groups are shown in Figure 3.6.

Figure 3.6: Duct nests: close to end user (left) and close to exchange (right) [Source: Analysys Mason]

As the network grows, new cables are progressively pulled one over existing ones within the duct. In some cases, **sub-ducts** (of around 25mm diameter) are deployed inside the main ducts to facilitate the insertion or extraction of cables. Use of sub-ducts is shown in Figure 3.7.

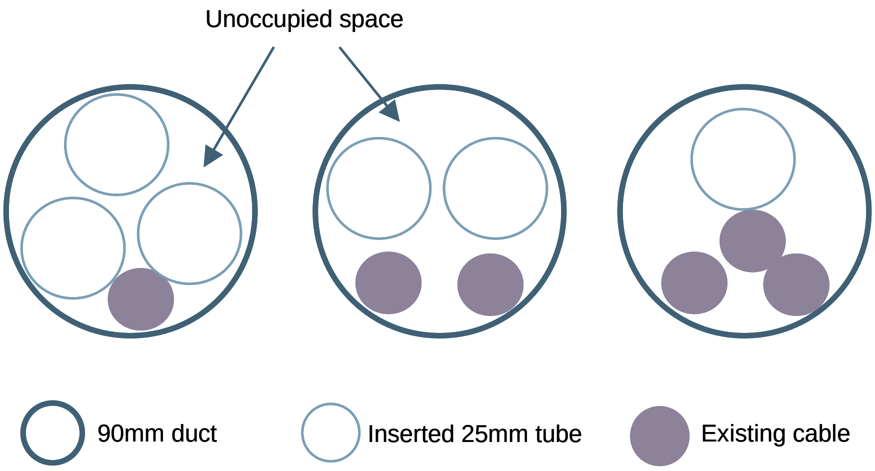


Figure 3.7: Examples of the use of sub-duct [Source: Analysys Mason]

While sub-ducts reduce the absolute capacity of the main duct, it is a useful device for allowing cables to be installed and removed without risking damage to existing cables. The use of sub-ducts may become essential if more than one operator plans to share the same duct.

Direct burial

In some parts of the network (e.g. close to the customer premises), cables are **directly buried** in the ground. This method of deployment is significantly less expensive than full duct deployment, as it usually only requires a narrow, shallow trench to be excavated in which to install the cable. However, this method requires additional armouring on the cable to protect it from being damaged, and the cable becomes difficult to access or remove once it is installed.

Poles

The deployment of Openreach's distribution network has evolved significantly to accommodate increasing telephone density and changing environmental and maintenance requirements. Before 1968, the standard distribution network was provided using poles and overhead wires and/or cables. After 1968, most new developments, whether industrial, business or residential, have been served by underground infrastructure. This change 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.[11]

In a significant portion of the UK, telegraph poles are still used to deliver the last drop to the end-user premises via an aerial cable (around 50% of Openreach's last drop network is carried overhead).[12] Aerial cable deployments are advantageous as they are easy to access. However, deployment of additional aerial infrastructure may be difficult due to planning laws. Overhead infrastructure also generates greater operational expenditure than underground infrastructure (mainly because it is exposed directly to the outside environment and therefore requires more maintenance). A telegraph pole is shown in Figure 3.8.

Figure 3.8: Telegraph pole [Source: Analysys Mason]

11 "Sample survey of ducts and poles in the UK access network", Analysys Mason for Ofcom, January 2010, available at: http://www.ofcom.org.uk/consult/condocs/wla/duct_pole.pdf.

12 "Delivering super-fast broadband in the UK", Ofcom, March 2009, available at: http://www.ofcom.org.uk/consult/condocs/nga_future_broadband/statement/statement.pdf

3.3 Requirements of FTTH deployments

3.3.1 Introduction

NGA networks require the deployment of fibre optic cable[13] in the access network. There are three infrastructure options for NGA networks:

- fibre to the home (FTTH): fibre is laid all the way between the exchange and the home
- fibre to the building (FTTB): fibre is laid as far as the basement of a multi-dwelling unit; then the existing copper is used to make the final connection to the home
- fibre to the cabinet (FTTC): fibre is laid as far as the cabinet; then the existing copper cable is used to make the final connection to the home).

These options are shown in Figure 3.9.

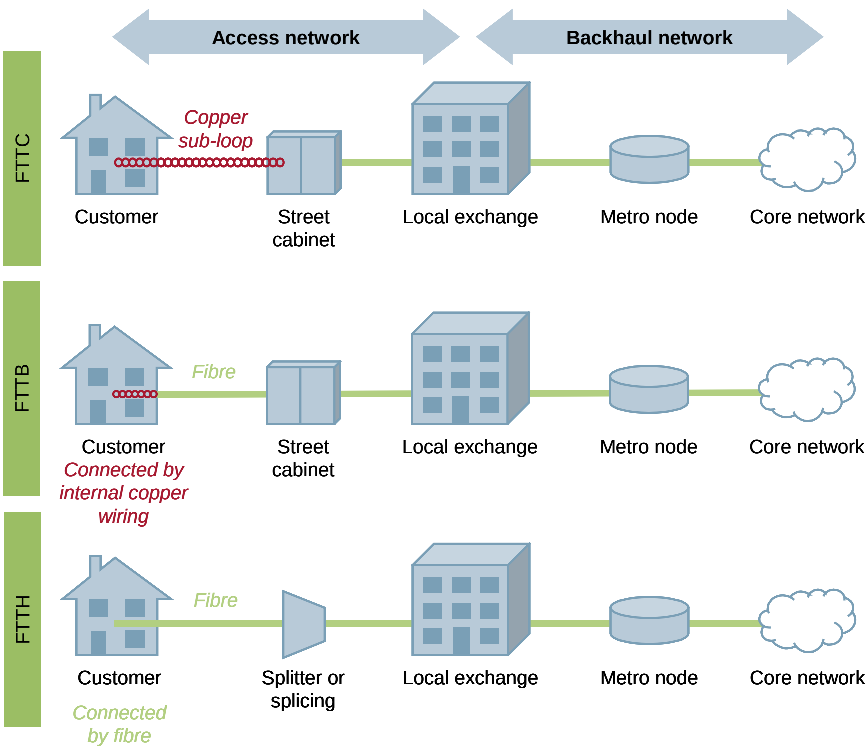


Figure 3.9: FTTx architectures [Source: Analysys Mason]

FTTC is significantly less expensive than FTTH, as new fibre only needs to be deployed in a portion of the access network. However, the bandwidth received by end users on FTTC is more limited due to the use of copper in the last section of the network. In this guide, we focus on the requirements of FTTH as this has the greatest potential for new services but also presents the greatest challenges.

13 For more detail on the different types of fibre optic cable, and the associated installation requirement, please refer to the FTTH handbook, published by FTTH council at http://www.ftthcouncil.eu/documents/studies/FTTH_Handbook.pdf.

3.3.2 Network elements

All FTTH networks have a set of common passive infrastructure elements, which are often used to describe the requirements of deployments. These elements are summarised in Figure 3.10 below.

FTTH Network Infrastructure Elements	*Typical physical form*
Access Node (or Point Of Presence)	Building communications room or separate POP building
Feeder Cabling	Large size optical cables and supporting infrastructure e.g. ducting or poles
Primary Fibre Concentration Point (FCP)	Easy access underground or pole mounted cable closure or external fibre cabinet (passive – no active equipment) with large fibre distribution capacity.
Distribution Cabling	Medium size optical cables and supporting infrastructure e.g. ducting or poles
Secondary Fibre Concentration Point (FCP)	Small easy access underground or pole mounted cable joint closure or external pedestal cabinet (passive– no active equipment) with medium/low fibre capacity & large drop cable capacity
(Last) Drop Cabling	Low fibre count cables or blown fibre units/ ducting or tubing to connecting subscriber premises
Internal Cabling	Includes external building fibre entry devices, internal fibre cabling and final termination unit, which may be part of the ONU

Figure 3.10: FTTH key infrastructure elements [Source: FTTH Handbook, Deployment & Operations Committee, FTTH Council, February 2009]

3.3.3 The requirements of PTP and PON architectures

When deploying FTTH infrastructure, there are two main architecture options for connecting end users: point-to-point fibre (PTP) and passive optical network networks (PON).

PTP networks involve deploying a single dedicated fibre between the exchange and every end-user premises, as shown in Figure 3.11.

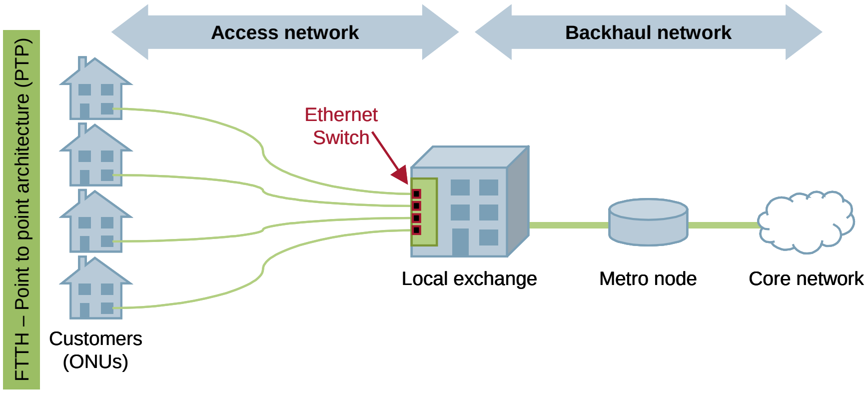


Figure 3.11: Typical PTP architecture [Source: Analysys Mason]

In a PON network, multiple end users share a single fibre from the exchange. Between the exchange and the end user, a passive optical splitter is used to split out the data stream from the fibre onto an individual fibre for each end user. The splitter may be located near the existing cabinet for low density housing, or in the basement of multi-dwelling units. This is shown in Figure 3.12.

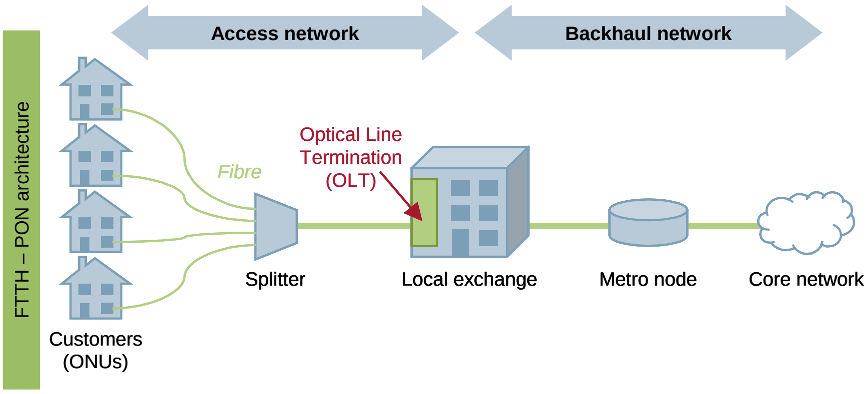


Figure 3.12: Passive optical network architecture [Source: Analysys Mason]

PTP and GPON place different requirements on access to the existing infrastructure. In the feeder section of the network (i.e. fibre between the local exchange and the splitter), a PON will require significantly less duct space as many end users are sharing each fibre (many PON deployments have a sharing ratio of 1:64). At the same point in the network, a PTP deployment would require enough duct space for one fibre for each end user. Close to the end user, both architectures have the same fibre/space requirements.

It should be noted that PTP does offer some advantages over PON. PTP is generally considered to be more future-proof in terms of bandwidth, and due to the single fibre per end user, is better suited to dark fibre business model than PON. In areas where a large amount of new duct infrastructure needs to be deployed, PTP may be a feasible option.

3.4 Options for infrastructure deployment

This section provides an overview of available infrastructure deployment options for NGA, concentrating on terrestrial (ducting) and aerial infrastructure.

3.4.1 Terrestrial infrastructure

The majority of new fibre infrastructure will be deployed terrestrially. As there are no plans to remove the copper of the existing telecoms infrastructure (at least in the short to medium term), a deploying operator must find *additional* underground capacity to deploy new fibre.

Deployment of new ducts

Where there is no space in an existing duct, new duct infrastructure may need to be deployed. As stated above, the costs of deploying new duct infrastructure are driven mainly by the cost of digging trenches. This cost varies according to terrain and geotype, but is estimated to be around GBP100 per metre to deploy along roads in urban areas.[14]

Use of existing ducts

Where there is space in existing ducts, there are a number of techniques for installing new fibre:

Pulling Cables can be pulled into a duct using a winch. A draw rope must be installed into the duct prior to cable winching, and the cable is fitted with a swivel that allows the cable to freely twist as it is installed. A mechanical fuse rated at or below the cable's tensile strength is used to ensure that the cables rated pulling strength is not exceeded. Installation along long sections can be achieved if the cable can withstand a high tensile load, or by using intermediate push/pull mechanisms. Cable lubricants can be used to reduce the friction between the cable and the sub-duct, hence reducing the tensile load.

Air blowing Cables can be blown into sub-ducts with the use of a cable 'blowing head'. A seal is attached around one end of the cable. A blowing head is then used to both blow and push the cable into the duct. The pushing overcomes the friction between the cable-seal and duct in the first few hundred metres and hauls off the cable from the drum. Compressed air is used to force the cable down the entire length of the duct or sub-duct. The ducts and seal connections must be sufficiently air tight to ensure an appropriate flow of air through the duct. This is likely to be appropriate for newly built deployments but may not be achievable with legacy networks.

Floating Floating is a similar method to blowing, and uses similar machinery as air is simply replaced by water. Compared to blowing, floating enables the deployment of cables over longer distances without intermediate access points. Floating is thought to be less hazardous than blowing for removing existing cables from duct because the water acts as a lubricant, inducing less friction on

14 "The costs of deploying fibre-based next-generation broadband infrastructure", Analysys Mason for the Broadband Stakeholder Group, September 2008, available at http://www.broadbanduk.org.

	the installed cable(s).
Micro-duct	A small tube can be installed in the ducts/sub-ducts, ready to accept individual fibres. The small tubes are usually referred to as micro-ducts and the fibre installed into them as micro-cable. The advantage of sub-duct/micro-duct infrastructure is that it allows the infrastructure provider (IP) to spread its initial investment by delaying the installation of individual fibres until a subscriber takes a service.
De-coring	A special lubricating fluid is pumped under pressure into the space between the existing cable sheath and cable core wrapping, detaching the core from the sheath. This allows the old cable core to be mechanically extracted. An empty, accurately fitting sheath for new fibre optics cable is then drawn into the old cable sheath. Afterwards the micro-ducts can be refilled with fibre.
Flexible inner duct	The use of fabric ducts may increase the number of cables that can fit into a given duct space, as the fabric can bend to the shape of cables placed within and so reduce the unused space associated with rigid sub-ducts.[15]

Direct burial

Where there is not space in existing duct, but only a limited amount of cable is required to be deployed, direct burial may be a lower cost alternative to deploying full size ducting. There are several techniques for direct burial, including mole ploughing, open trenching, slot cutting and directional boring.

3.4.2 Aerial cable infrastructure

In conventional FTTH networks, the feeder cable is usually deployed using terrestrial infrastructure. However, the last drop cable used in the final link to the customer may be deployed using either terrestrial or aerial distribution systems. In the UK, aerial cable has limited use due to concerns from local authorities about visual impact. However, aerial deployment avoids the costs of civil works for terrestrial deployment, and could be an important component for the economic deployment of NGA infrastructure. Many residential last drops are already aerial, and there may be some limited scope for additional deployments.

3.5 Alternative infrastructure options

This guide has focused on the incumbent telecoms access network as the main source of existing infrastructure for the economic deployment of NGA. However, there are other access networks in the UK which could be used, either as an alternative end-to-end route, or on a more selective basis

15 Maxcell Innerduct, http://www.maxcellinnerduct.com/learn-about-maxcell.asp?lang=eng.

(for example to bypass a congested route) in the incumbent's network. In this section we discuss two types of alternative networks in the UK: the cable network (operated by Virgin Media) and the various other utilities networks. Both of these types of networks will run fairly close to the incumbent telecoms network as they were deployed according to a common driver (to cover homes and businesses). However, each network will differ from the incumbent network; this is discussed below.

Other telecoms infrastructure

In the UK there are alternative telecoms infrastructure networks that could provide underground duct space for the economic deployment of NGA. These networks include those focused on serving business premises, some independent backhaul networks and the cable network.

Alternative telecoms infrastructure will share similar characteristics to Openreach's network in that it was deployed to achieve population coverage, and routes will usually flow back to a central point. Business and backhaul networks are likely to focus on the centres of cities, and providing links between those centres. The cable network provides more comprehensive population coverage, but this is focused on areas of high population density. However, there may also be some local variations in the coverage of the cable network. As the cable network was originally constructed by separate franchises, there may be some areas where deployment was uniform, and other areas where deployment was more selective (e.g. deploying to one side of the street but not the other).

It should be noted that the existing use of fibre in the access portion of the cable network is likely to mean that those ducts are smaller than the incumbent copper equivalent. The lack of aerial deployment may mean that ducts extend all the way to the home in some areas (although it is not known how much directly buried ducting is used).

Utilities and other networks

Re-using existing non-telecom utilities infrastructure may significantly alleviate or avoid the cost of deploying a fibre network. Utility access networks in the UK include the sewers, drinking water and gas, and tend to cover most urban dwellings. All of these networks will connect to a central point, but it is more likely to be on the edge of a town (unlike a telecoms network). Furthermore, it may be difficult to suspend the operations of these networks, so fibre installation must take place concurrently with normal operation. Other networks which may assist in the deployment of fibre include canals and waterways, and metro transport networks. These are described below.[13]

Sewer systems	There are two types of sewer system: sanitary and water run-off. Sanitary systems will tend to route back to a central point (treatment works) out of town, whereas run-off sewers will route to the nearest water course. Tunnel sizes in public sewers range from a few hundred mm in diameter to those that can be entered by boat. Various cable installation schemes exist, depending on the sewer cross section.

Sewer networks may not be present in all areas (some rural dwellings may use local storage) and may be less likely to follow the public highway than telecoms networks (which may present difficulties in gaining access to private land).

Electricity distribution As fibre optic cable is glass based, it can be routed alongside existing electricity distribution networks with no risk of electromagnetic interference. The electricity network is also driven by household coverage, and uses both underground ducts and overhead poles to reach dwellings. Some telecoms providers already use elements of the electricity network to route their cables, for example by using the overhead electricity routes in rural areas. It should be noted that the installation of fibre alongside live electricity cables will have significantly different health and safety requirements to using telecoms infrastructure.

Gas pipes Gas pipelines can also be used for deploying optical fibre networks by using a specially developed in/out port to guide the cable into and out of the gas pipe and bypass the gas valves. The cable is blown into the gas pipes by means of a stabilised parachute driven by either the natural gas flow or by using compressed air.

Drinking water pipes Drinking water pipes can be used in a similar way to gas pipes.

Canals and waterways Canals and waterways can be used to deploy fibre, as the cables are largely insensitive to water.

Metro transport Underground/metro tunnels can be used to install fibre optic cable, often alongside power and other data cabling. Typically, they are installed on hangers on the wall of the tunnel, and fixed in a similar manner to sewer installation. Two key concerns for underground installation are complying with fire regulations and withstanding rodent attack.

Overland metro networks can also be used, with the cable routed alongside the overhead power cables used to drive trams.

4 Operational considerations in access to existing infrastructure

4.1 Introduction

As discussed in the previous section, the civil works required to deploy NGA infrastructure represents a significant part of the business case of any NGA deployment. Although it is not the only option, providing access to existing duct and pole infrastructure that may lower the barriers to entry for CPs, and therefore support competition, as recommended by Ofcom in its WLA market review.

In this context, a number of regulators across the world have implemented policies that aim to facilitate network sharing to allow communications providers to re-use existing infrastructure (ducts, chambers and poles). For example, a number of regulators in European countries (including Spain, France and Portugal) have implemented infrastructure access offers which provide CPs with standard regulated services allowing them to re-use ducts (and poles) from IPs. Although infrastructure access offers vary from country to country in their detailed implementation, there are fundamental principles and processes that are common to all duct/pole access offers.

This section aims to provide the reader with an understanding of the fundamental operational principles and key steps involved in any duct/pole access offer, by considering the end-to-end process (i.e. from the access request of the CP to installation of the cable in the shared infrastructure). Common fundamental principles must be defined in the following areas to ensure a robust infrastructure offer:

- framework to record infrastructure access requests
- mechanism for providing infrastructure plans
- approaches to determine available space and survey procedures
- approaches to and engineering principles for allocating space in ducts
- procedures for cable deployments in shared infrastructure
- procedure to update infrastructure plans
- frameworks to monitor Service Level Agreement (SLAs)

In the remainder of this section, we analyse all the options available to implement the required principles and describe operational issues for each of these options.

4.2 Framework to record access requests and responses

The first step in any infrastructure access offer is to implement a framework to allow CPs to request access to infrastructure in a given area. The framework can take one of several forms and its degree of automation can vary significantly.

- **Manual request framework with no central portal –** requests can be made by email using standard template documents (e.g. MS Word, MS Excel, other) sent by the CPs to the IP. This access request framework is very labour-intensive for both the CP and the IP, and makes it very difficult to keep track of the status of requests.
- **Semi-automated request framework using a central portal** – requests can be made through a central portal (e.g. secure website) and involve the upload of standard template documents (e.g. MS Word, MS Excel, other) to validate/complete the request. The use of a portal provides a useful central point of contact for both the CP and the IP to keep track of progress, as responses from the IP can be linked to the corresponding requests. However, the requirement to upload external documents means that the process can still be labour intensive as it may require a manual check by the IP to check their conformity with template guidelines or other criteria.
- **Fully integrated request framework using a central portal** – requests can be made through a central portal (e.g. secure website) and all necessary forms could be integrated into the portal, and access provided through a standard web interface. In this case, the conformity of the request can be checked automatically by the system, saving time for both the communications provider and IP. With this option, the infrastructure maps necessary for the CP to plan its deployment could also be integrated on the same website, facilitating consideration of the existing infrastructure throughout the application process.

A fully integrated and automated portal, where infrastructure requests can be made by CPs and where an IP can provide its response for different steps of the process is the most efficient option. However, the degree of automation and integration of actually implemented access request frameworks is variable (see Section 5). The implementation of an access request framework **is an iterative process** that takes into account feedback on its practical use from different stakeholders. Regardless of the country of implementation, regular meetings to share feedback between stakeholders is an essential step to ensure the successful development of access request framework.

4.3 Mechanisms used to access existing network plans/duct records

Once a CP has recorded its interest to use existing infrastructure in a particular area, it needs to access infrastructure plans to understand what infrastructure is available. In countries where infrastructure access has been regulated, plans typically contain information regarding:

- the location and types of chambers
- the location number and diameter of ducts
- the location and type of pole (if pole access is available).

Mechanism for providing infrastructure plans

The mechanism to provide infrastructure plans to the CP can vary significantly:

- **Manual infrastructure plan provision** – relevant infrastructure maps could be provided by the IP to the CP in the form of an email attachment. This is extremely labour intensive, especially for IP.

- **Semi-automated plan provision** – relevant high-level infrastructure maps are made available as part of the central web portal, and more detailed maps are uploaded to the portal by the IP on request from the CP with a slight delay (e.g. within a few days).

- **Fully automated plan provision** – relevant high-level and detailed infrastructure maps are available to the CP in real time as part of the central web portal. In this case, the CP can proceed with its design with minimal delay.

The fully automated system would ensure that the CPs get timely access to the infrastructure plans, and also ensures that the effort required by the IP is minimised, once the system is set up (once established, there is little need for intervention). However, the development of a fully integrated system would require a large upfront investment and requires that the IP has digitised infrastructure plans available.

Infrastructure plans format

Irrespective of the delivery mechanism, plans can be provided to the CP in three main formats:

- paper format (e.g. A3, A2 or A1)
- static electronic format (e.g. jpeg or pdf)
- fully digitised format (e.g. maps can be imported directly into a geographic information system (GIS) by the CP)

From a CP's perspective, a fully digitised format is optimal as they can import the IPs' network plans directly into their GIS tool, allowing their planned cable routes to be overlaid on the existing network infrastructure. This allows CPs to plan the deployment of their new infrastructure more efficiently. Also, fully digitised infrastructure plans are easier to update when new architecture is deployed. In the case of paper format or static electronic plan, updates are very difficult to implement, which could lead to inaccuracies as the network evolves.

It should be noted that many IPs do not have a fully digitised records of their infrastructure, and achieving this is both time consuming (involving a physical survey of every item part of the infrastructure[16]) and has a significant cost associated with it. Therefore, the automated provision of a more static format may be a useful compromise to facilitate infrastructure access in the short term.

16 For example, in the UK, Openreach has around 4.2 million chambers.

4.4 Approaches to determining useable space and survey procedures

Once plans are available to the CP, the availability of space has to be determined – i.e. is there enough space in the target infrastructure for the CP to install its cable.

Space definition

In this report we differentiate between unoccupied space, available space and useable space, as defined below:

- **unoccupied space** is defined as the space that is not taken by existing cables
- **available space** accounts for the fact that all unoccupied space may not be available to CPs, due to the maintenance requirements from the infrastructure (spare capacity required to deal with cable faults), or due to the obstruction of other cables in the duct nest
- **useable space** relates to how the available space can be used, considering cable sizes, installation methods, and infrastructure deployment engineering rules.

Unoccupied space determination

Unoccupied space can be determined in one of two ways, depending on whether or not the IP has an accurate and *reliable* record of space occupancy for its infrastructure.

- If the IP has a reliable record of space occupancy for its infrastructure, then unoccupied space can be determined from those records, and useable space can be determined using a desktop study approach.
- If the IP does not have a reliable record of space occupancy for its infrastructure, then a field survey must be performed to determine the unoccupied space.

In practice, most IPs do not have a reliable record of the unoccupied space in their infrastructure[17], and therefore a field survey has to be carried out. It should be noted that field surveys represents a significant cost of the overall infrastructure access process.[18]

From a CP's perspective, it is very valuable to receive reliable information on the amount of unoccupied space from the IP. However, from the IP's perspective, this information can be viewed as commercially sensitive.

Although available, the IP may be reluctant to provide this information to the CP.

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17 Portugal Telecom is one of the few infrastructure providers to have a reliable record of availability of space in its infrastructure, for which surveys are not mandatory.

18 One stakeholder commented that field surveys costs represent up to 25% of the overall cost of deploying a cable to a user.

Field survey options

If a field study does need to be carried out, either party may carry out the survey, with or without collaboration from the other:

- the IP (or associated sub-contractors) with and without collaboration from the CP (or associated sub-contractors)
- the CP (or associated sub-contractors) with or without supervision from the IP (or associated sub-contractors).

There are a number of operational advantages for the IPs to undertake the survey of their own infrastructure. First, IPs already use professional surveyors (either in the form of their own staff or in the form of approved sub-contractors) that are very familiar with the infrastructure in the area they serve, and they know how to mitigate the risks of damage to the existing infrastructure (see operational issues in the next sub-section). Also, when the IP (or associated sub-contractors) performs surveys, issues around network security (e.g. access to secure sites and strategic parts of the infrastructure network) are easily overcome.

However, it is important to note that there could be advantages if the survey is carried out by the CP (or associated sub-contractors):

- it makes the process more transparent (space can be directly observed by CP), limiting future potential disputes
- it allows the CP to schedule the visit independently of the IP (and the CP can contract a survey team that is more available/more efficient)
- it allows the CP to price the survey independently of the IP (the CP can contract a survey team that is more cost effective than the IP's team).

Survey scope

In terms of survey scope, depending on the offer available, two different approaches can be adopted:

- surveying all infrastructure in the area of interest
- surveying only the infrastructure along the route identified by the CP.

There are benefits and drawbacks in surveying all infrastructure in the area of interest (as opposed to only the main route)

► *Benefits of whole-area surveying*

Whole-area surveying provides a mechanism to update comprehensively the availability of infrastructure on a per area basis, especially for areas where digitised information does not exist. If one or several sections of the infrastructure network are too congested, an alternative route can easily be identified (since all available routes are surveyed at the first visit[19]).

► *Drawbacks of whole-area surveying*

It is very costly because all infrastructure nodes and links have to be surveyed, including those that may not be used by the CP.

It should be noted that surveying all infrastructure in the area of interest or surveying only the route identified by the CP are not mutually exclusive and could both be supported by an infrastructure access offer, allowing a CP to choose between the two options.[20]

Survey operational issues

In the context of the field surveys, a number of operational issues were identified in our report *Telecoms infrastructure access – sample survey of duct access.*[21] These operational issues include:

- presence of residual gas in chambers
- presence of sewage in chamber
- presence of water in chamber
- presence of obstructing objects (cars, scaffoldings, etc) on the top of chambers
- presence of electric cables in chamber or on poles
- presence of trees preventing poles to be surveyed
- potential damage caused to existing cables during survey.

It should be emphasised that the above operational issues will need to be addressed by the CP if it undertakes the survey itself, as IPs are trained to deal with these issues on a daily basis.

As mentioned in our previous report, all of these issues can be mitigated against by ensuring that:

- surveyors have received adequate training on all of the above issues
- surveyors have the appropriate equipment (water pumps to remove the water, gas detectors to ensure there is no residual gas, etc.)
- the surveys are carefully planned in advance, taking into account any planning permission required from local authorities.

19 Which prevents a situation in which surveyors have to come back because the surveyed route was too congested to allow the installation of a cable.

20 However, we could not identify any country where this choice is available to the CP.

21 See: http://www.ofcom.org.uk/telecoms/discussnga/duct/ductreport.pdf.

Infrastructure congestion and potential solutions

Once the survey has been performed[22], the useable space can be determined in all sections of the route where the CP wants to deploy its infrastructure. The outcome of the space availability process may show that one or several sections of the infrastructure might be too congested to accommodate any additional cables (because ducts are full or there is no space available on poles to deploy additional cables). In this case, an alternative solution is required to overcome bottlenecks around congested infrastructure sections. These potential solutions include:

- use of an alternative route in the IP network
- use of existing infrastructure belonging to other CPs or utility companies
- removal of unused cables to free some space in the IP's network
- provision of dark fibre by the IP
- new civil works to bypass the congested section.

Identifying an alternative route can be quickly achieved if the whole-area surveying approach is adopted. However, if only one route was surveyed, surveyors may have to come back to survey potential alternative routes. The duct access offer could include a cap on the cost associated with the alternative route, since it is likely to be longer than the main route (see Figure 4.3), and therefore could potentially be more expensive if access pricing is based on distance.

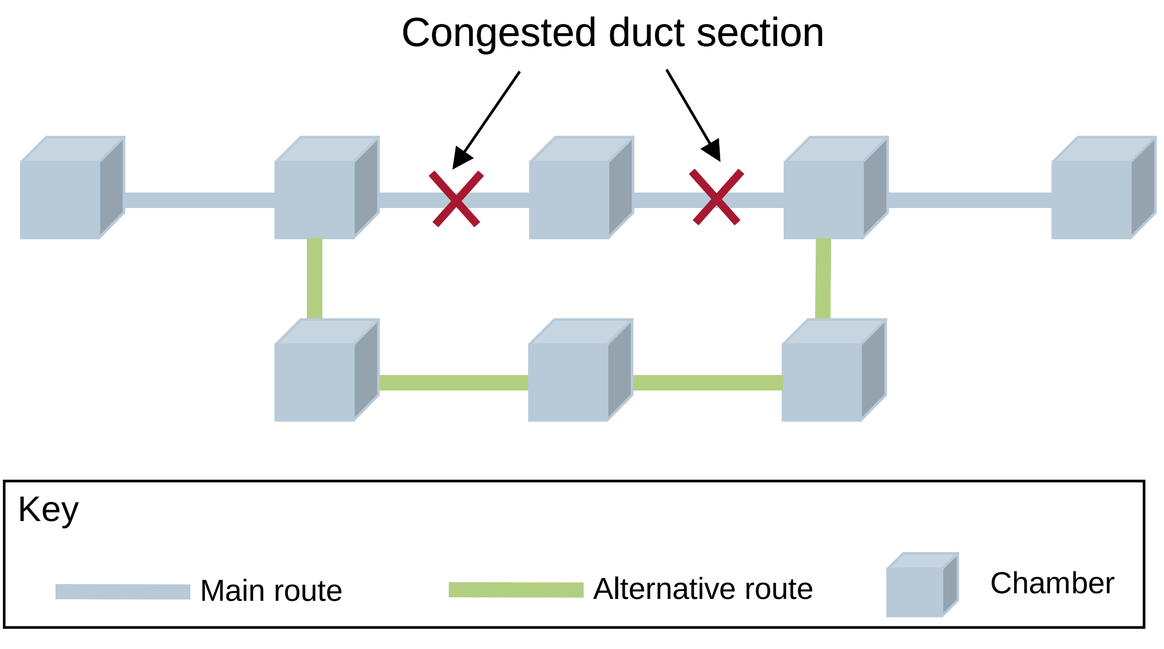

Figure 4.1: Use of alternative route [Source: Analysys Mason]

22 When space occupancy is available from the infrastructure provider, no survey is required.

The removal of unused cables from the IPs' network is another solution to combat congestion. However, in practice, it may be difficult to implement as these cables may be large in size and their removal could damage other existing cables that share the same duct infrastructure. Cable de-coring (see Section 3.4.1) should also be considered as a solution to free up capacity. If none of the above alternative solutions are possible, the CP or the IP may have to carry out some civil works to bypass the congested area.

In order to illustrate how congestion can be dealt with, let us consider the case of Spain as shown in Figure 4.2 (see section 5.4 for more information regarding the Spanish case study).

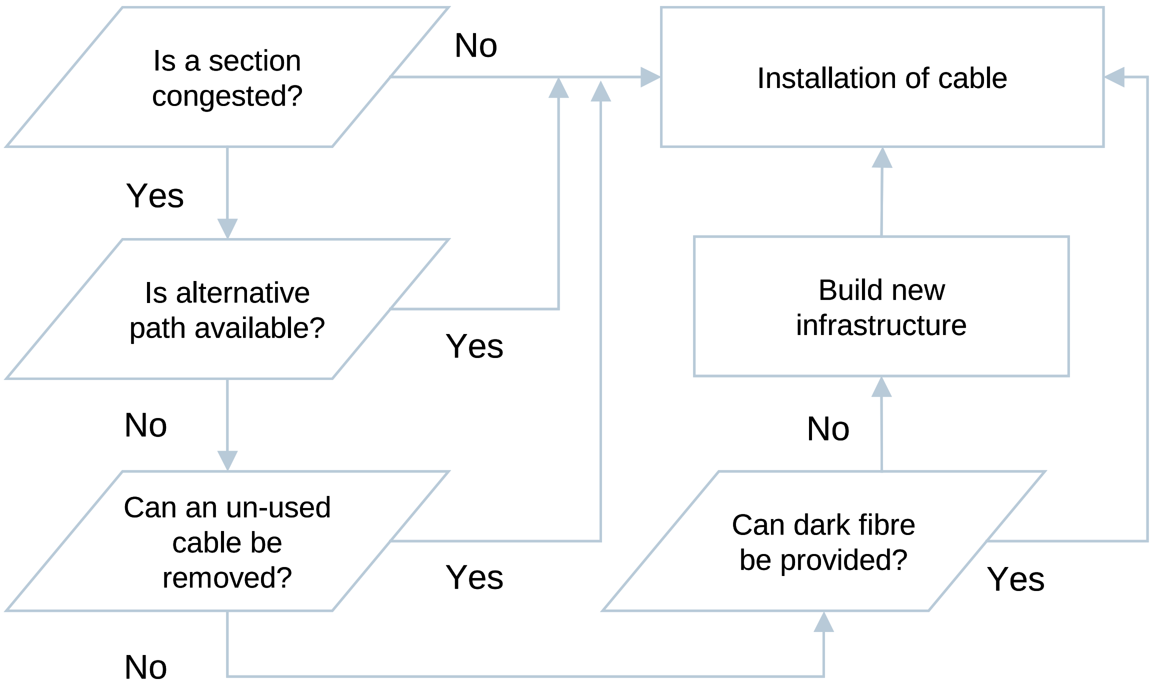

Figure 4.2: Options available in case of congestion: example of Spain [Source: Analysys Mason]

In Spain, when congestion occurs and no alternative path can be found, Telefónica has to investigate the possibility of removing its unused cable to free up some capacity. If no cables can be removed (e.g. because other cables in the duct could be damaged by it), then Telefónica has to investigate the feasibility of providing dark fibre to the CP in the congested areas. If none of the above options are available, new infrastructure may need to be built around the congested area or to increase the network capacity by Telefónica.

This operational model is quite interesting as it provides an incentive to Telefónica to proactively manage its unused cables to free up some space in its network, as providing dark fibre or engaging in civil work is not a preferred option from the IP's perspective.

4.5 Approaches to engineering principles for allocating space in ducts

An important part of any duct/pole access offer is the engineering rules, which dictate how the infrastructure can be deployed in existing infrastructure networks. Engineering rules are usually tailored to the specific infrastructure network characteristics of each country.

The first consideration when devising the engineering rules is the principle of **physical separation**. In many countries, IPs want to separate their infrastructure from the CPs to mitigate the risks associated with damaging cables, thereby preserving the integrity of their own network. In duct networks, physical separation of cables can be achieved in three ways:

- install cable of different CPs in different ducts
- install cable of different CPs in different rigid sub-ducts/micro-ducts
- install cable of different CPs in different flexible inner ducts.

First, different CPs could be separated by different ducts. However, if the principle of physical separation between CPs is applied, it means that no other CPs can install their cable in the same duct, wasting precious space in the infrastructure network, where space is at a premium.

Sub-ducts

A more efficient way to use space in a duct is to physically sub-divide the space using sub-ducts. Sub-ducts are usually rigid tubes; Figure 4.3 provides an example of how three cables from three separate CPs can be physically separated using rigid sub-ducts.

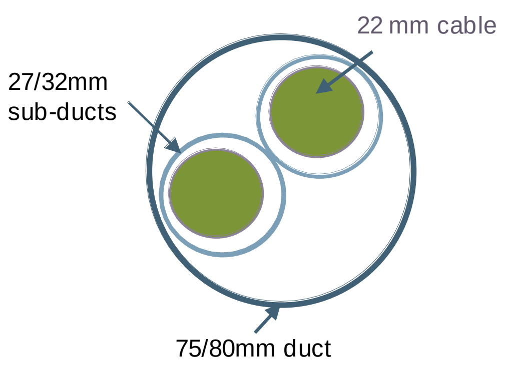

Figure 4.3: Sub-ducting of an 80mm duct for a 22mm cable [Source: Analysys Mason]

It can be seen in Figure 4.3 that rigid sub-ducts do not use the space available in ducts very efficiently as they create many stranded pockets of unusable space.

Micro-ducts and micro-cables

Sub-ducts can be further segmented using micro-ducts. Micro-ducts include a number of cavities in which fibre cables can be inserted. Figure 4.4 illustrates a four-cavity micro-duct.

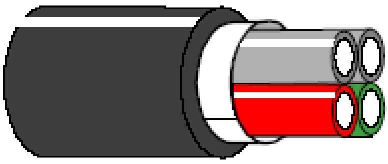

Figure 4.4: Protected micro-duct with four cavities [Source: FTTH Council]

To summarise, we therefore have four potential layers of ducting in the various forms identified, resulting in the following configuration:

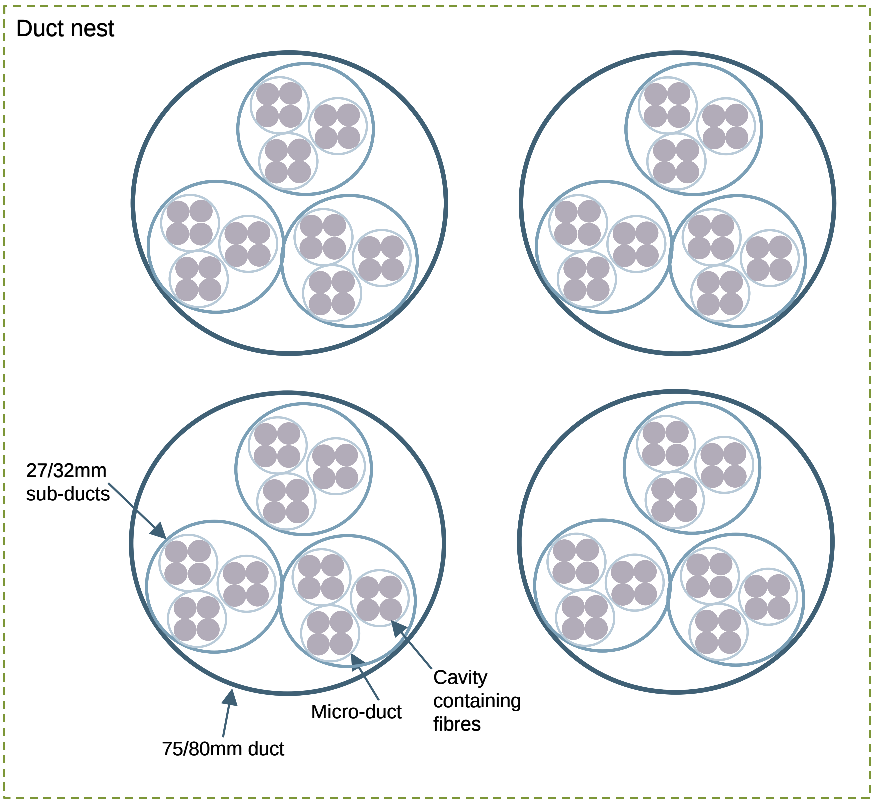

Figure 4.5: Duct nest showing potential layers of ducting within a duct nest [Source: Analysys Mason]

The inserted fibre cables in each cavity of the micro-duct are typically less than 10mm in diameter, and can each have a fibre count of up to 144 fibres, resulting in an efficiency use of space in the sub-ducts.

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Typical combinations of cable size and micro-duct size are illustrated in Figure 4.6.

Micro-duct diameter Outer/inner diameter (mm)	*Typical fibre count*	*Typical cable diameter (mm)*
16/12	24–144	9.2
12/10	12–144	7–8
10/8	72–96	6–6.5
7/5.5	48–72	2.5
5/3.5	6–24	1–1.6
4/3	2–12	1–1.6

Figure 4.6 Typical micro duct configuration [Source: FTTH Council]

Micro-cable is the equivalent of micro-duct, but in the form of a flexible cable.

Flexible inner ducts

Recently, some vendors[23] have started to offer flexible ducts made of fabric, which further optimises the use of space in a single duct or sub-duct, as illustrated in Figure 4.7. Flexible inner ducts are particularly useful in smaller ducts, (typically close to the end user), where usable space is likely to be scarce.

Figure 4.7: Flexible inner ducts configurations [Source: MaxCell]

Flexible inner ducts consist of material to wrap the cables (which could be a micro-cable consisting of many fibres) so that cables are not in direct contact with each other. It should be noted that, since flexible inner ducts are relatively new on the market, their lifetime has not been fully tested yet and it is possible that they could degrade after a number of years. A number of IPs are currently testing flexible inner ducts.

23 Maxcell (http://www.maxcellinnerduct.com/).

Key principles in space allocation

Another important principle is to ensure that engineering rules support the efficient allocation of space to mitigate against space saturation. For example, consider a four-duct nest, with three completely empty ducts and one duct with a single empty sub-duct. In this case, the space in the sub-duct should be used first. Using partially full ducts instead of empty ducts optimises the use of unoccupied space, delaying the risk of congestion, by systematically filling in the gaps.

Space must be allocated fairly, especially when more than one CP is seeking to use shared infrastructure in a particular area. There are a variety of possible mechanisms for allocating the space:

- first-come, first-served
- co-operative methods such as cable sharing (which involve co-operative planning between CPs)
- methods allowing competition for the space between potential users such as auction, beauty contest (e.g. coverage promises), and lottery (i.e. random).

Each of these possible mechanisms differs in the speed of implementation, fairness, allocative efficiency, and cost and complexity to administer. As a result, the first-come first-served allocation mechanism is currently implemented in all countries that have a duct access offer.

Reserving available space

Usually, when the IP grants access to infrastructure, the cable deployment by the CP will take place within a defined period of time. In most countries where a duct/pole access offer is available, CPs have a limited period of time in which they can reserve the identified space before deploying their cables. The reservation period should provide the CP with enough time to make the necessary application for planning permission (if required) and to plan the deployment of their fibre. When the reservation period expires, if the CP has not deployed its cable, then the space becomes available for any other CPs wishing to deploy using that space. If the initial CP still wants to deploy after the expiry of the reservation period, it typically needs to re-apply for the space. The reservation principle could be symmetrical (applying equally to the IP if it wants to reserve some space) to ensure that the IP does not have an unfair advantage over CPs.

It is also important that the reservation period should be minimised to ensure CPs do not block access to competition while not deploying their cables (e.g. three to six months is typical in countries where a duct access offer is available).

The IP will typically need to reserve three types of space in its network:

- maintenance space
- expansion space
- operational space.

Maintenance space is fully or partially available ducts required to deploy a new cable while an older cable is being removed from the infrastructure. Another example of where maintenance space might be required is where a duct has collapsed in the middle of a section and a new empty duct is required to re-deploy the cables that had been deployed in the collapsed ducts.

Expansion space is the space typically required for new deployment programmes such as NGA. If the IP needs some space for expansion, it should have to apply for it and be provided with a space reservation duration.

Operational space is the space required to allow cables far into the duct to cross over, reducing the amount of effective useable space, as well as space required by the tool to insert a cable (i.e. size of the rod).

4.6 Procedures for duct access deployment

Process and responsibility

Similar to our discussion in Section 4.4, regarding the infrastructure survey process, two main options that are available in terms of the party responsible to deploy the CP's cable:

- the IP (or associated sub-contractors) with and without collaboration from the CP (or associated sub-contractors)
- the CP (or associated sub-contractors) with or without supervision from the IP (or associated sub-contractors).

The choice of who is responsible for deploying the CP's cables may be influenced by a number of considerations:

- security and competition concerns regarding infrastructure integrity of the IP
- ensuring compliance with the engineering rules
- the resources required from the IP (or associated sub-contractor)
- the willingness of the CP to be constrained by the IP in the timescales, cost and methodology of the deployment.

Although in a number of countries where duct/pole access is implemented, the CP is responsible for the deployment of its own cable, there are **significant concerns from the IP** regarding a third-party accessing their infrastructure for two main reasons:

- the CP may damage existing infrastructure
- the CP may gain competitive knowledge of the location and type of infrastructure of the provider.

For these reasons, IPs may prefer to undertake/supervise the deployment of new cables in their infrastructure network. This decision has to be balanced by the requirement for additional resources from the IP.

Another important consideration is to ensure that engineering rules defined in the duct/pole access offer are adhered to. It could be the case that, if a CP is allowed to deploy its cable in the infrastructure's provider network, the team of sub-contractors in the field does not install the cable as specified in the design, taking short cuts when meeting operational problems. This would impact not only the capacity of the used infrastructure but, it would also mean that the infrastructure records may not be updated correctly[24] (see Section 4.7).

Finally, there are a number of incentives for CPs to deploy their own cable in the IP's network. For example, the CP may not want to rely on the availability of the IP (or associated sub-contractor) to deploy its cables as it could lead to delays, especially in areas where several CPs have applied for access. Also, being responsible for deploying its own cable, the CP is in a better position to negotiate with its sub-contractor, potentially leading to more cost effective deployments.

Certification programmes, approved lists and submission of detailed operational plans

As discussed in Section 4.4, allowing a CP to deploy its own cable may lead to potential operational issues if they are not suitably trained and or qualified to undertake the assignment. In order to reassure the IP that the CP is going to maintain the integrity of its networks, different infrastructure access offers implement different schemes, including:

- establishing an accreditation training scheme for the field force
- sub-contractors have to be chosen from an approved list by the IP
- sub-contractors have to submit detailed operational plans to the IP prior to undertaking the installation of the cable.

In general, a range of skills and competencies 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 (e.g. qualifications to splice fibre)
- working methodologies to protect existing infrastructure
- operating a permit-to-work system
- working in confined spaces
- working at height
- working in a street environment, with traffic restrictions in place.

[24] If such an update is performed on the basis of the design received from the duct access user.

4.7 Process for updating infrastructure plans

In order for the IP to update its infrastructure plans when new sub-ducts/cables have been laid, it is important that a process is in place to allow the CP to provide its post-deployment design to the IP. Without a suitable process in place, it will be difficult for the IP to keep track of the availability of its network.

In some countries where duct access is implemented, a new division had to be created by the IP to ensure that infrastructure plans were updated correctly, taking into account new infrastructure deployment of CPs as well as new deployment of the IP.

4.8 Frameworks to monitor Service Level Agreements (SLAs)

SLA definition

A key requirement of any successful duct and pole access offer is the definition of a clear set of Service Level Agreements to ensure that each stage of the access process is completed within a reasonable timescale. The implementation of SLAs is beneficial to both IPs and CPs. It will ensure that the duct/pole access user understands the timeframe involved when deploying new infrastructure and therefore can make a firm commitment to their end-customers; also, SLAs will ensure that IP receives responses from the CP in an agreed timeframe, which will allow it to effectively manage the relevant resource and to update the infrastructure plans, for instance.

SLA monitoring

Once all SLAs have been fully defined and their target set, it is important to have a transparent system in place that is able to monitor these KPIs, where both CPs and IP can check progress against set targets for each step of the process.

The implementation of a central portal (as defined in Section 4.2) is a very efficient way to keep track of the SLAs for both parties. In all countries that allow duct access, penalties for not meeting SLAs are defined in the infrastructure access offer.

5 International case studies on operational models for duct/pole access

5.1 Introduction

In order to better understand how duct access has been implemented in other countries, and how potential operational issues have been solved, we interviewed a number of duct/pole access stakeholders in the following countries:

- Portugal
- France
- Spain
- the USA.

In this section, we summarise for each studied country the main features of the duct/pole access offer[25] for each of the seven key steps identified in Section 4 of this report:

- framework to record access requests and responses
- mechanisms used to access existing network plans/duct records
- approaches to determining useable space and survey procedures
- approaches to engineering principles for allocating space in ducts
- procedures for duct access deployment
- process for updating infrastructure plans
- frameworks to monitor Service Level Agreements (SLAs).

5.2 Case study for Portugal

5.2.1 Introduction

In Portugal, the ducts owned by the incumbent, Portugal Telecom Comunicações (PTC), are available for sharing as stipulated by a law drawn up while PTC was being privatised in 2001 and which came into effect in 2004. As a result, ANACOM, the Portuguese telecoms regulator, did not have to argue the case for the feasibility of duct sharing but only had to use its powers to oblige PTC to publish a reference offer for duct sharing. The offer, referred to as ORAC (Reference Conduit Access Offer), was initially published in 2004 but did not meet all the obligations. Only after PTC revised the offer and ANACOM was satisfied that it fulfilled the spirit and terms of the law, fostering the use of PTC’s ducts by competitive operators, was it enforced in 2006.

[25] Please note that in the USA, there is no duct/pole access offer but commercial agreements in place to facilitate the sharing of infrastructure.

ORAC is a well-defined framework for duct sharing that, in principle, should foster use of the incumbent's duct. The framework specifies all the key operational aspects and processes for enabling duct sharing: application, pricing parameters, information availability, co-ordination procedures, accreditation, service level agreements, and the parameters for assessing feasibility. The framework is equally applied to new buildings with the additional requirement that in new buildings PTC has to invite all interested parties to share the cost of investing in ducts and hence share the benefits arising from owning the duct.

In the following section, we provide more detail regarding the specification an implementation of each of the necessary steps involved in the provision of fibre cable for CPs, as specified in the offer.

5.2.2 Operational process and issues

Framework to record infrastructure access requests

Any duct access request starts with the CPs requesting maps for the area of interest. The access request portal and system providing map information is fully integrated. (see next sub-section).

Mechanisms used to access existing network plans/duct records

From November 2008, PTC provided access to a database which contains underground infrastructure information.[26] The database is accessible through PTC's wholesale web portal (extranet), which allows CPs to view high-level infrastructure plan in the area(s) of interest. The detailed plans required to identify a route along which a cable could be deployed, are made available by PTC on the extranet one day after the CP had requested it. Moreover, the service connection duct (also known as building entry duct), which is generally managed by PTC but owned by the building owner, is not within the scope of ORAC. Finally, access to ducts sometimes requires co-ordination with the local council which operates different timescales to PTC.

The plans provided to CPs are provided as pdfs and contain the following information:

- duct location
- duct diameter
- chamber location.

According to our stakeholders, the plans are fairly accurate (consensus on 90% accuracy) and are available for all areas of Portugal.

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26 The order management procedure is in schedule 3 of the ORAC offer.

It should be noted that pole access is not part of the ORAC offer, but IPs are encouraged to enter into commercial agreement with CPs. The process to acquire pole information (location, type, availability) is very labour intensive, involving a large number of forms to be filled in by the potential pole access user. Also, no SLAs are yet specified for accessing poles which means that poles are not widely used in practice.

Approaches to determining useable space and survey procedures

PTC carried out a nationwide survey of space, and therefore has information on space availability for most of its infrastructure. This means that, in most cases, when a route has been selected by a CP, the space availability study can be carried out by PTC without the requirement for field surveys, which is time efficient and cost effective. However, when PTC believes that its record is not accurate enough, a field survey may be carried out. It should be noted that the information on space availability is not made available to CPs.

According to ORAC, space is assessed according to the diameter of the cables in relation to the diameter of the duct using a mathematical formula. This formula and examples of how to calculate useable capacity can be found in Annex A of this report.

The space to be reserved by PTC for maintenance and repair purposes is also well defined in the ORAC offer (the maintenance space reserved for PTC is equal to the occupied space by the cable with the greatest diameter in each duct segment).

Approaches to engineering principles for allocating space in ducts

Engineering principles in Portugal are not as proscriptive as in other countries. We understand that, during the request phase, the CP has to indicate which ducts it aims to use in each section of the network to deploy its cable, and PTC, based on a feasibility study, approves or rejects the proposed design.

Procedures for duct access deployment

PTC provides access to its ducts and related infrastructure, which can be requested by the CP through an order form for accessing ducts. Physical access to the chambers, ducts and other infrastructure may be permitted by the CP or associated sub-contractors, provided that they are accredited to perform the work.

A formal accreditation scheme is in place to ensure that CPs (and associated sub-contractors) understand the operational risks involved when accessing PTC's infrastructure and have sufficient training to mitigate those risks. The accreditation is based on theoretical and practical exams. The accreditation is valid for three years.

During the cable installation process, duct obstruction may arise, due to sand deposits in ducts and damaged ducts. A CP can ask PTC to remove the obstruction or to study alternative duct paths on the CP's behalf. Such requests are subjected to a viability analysis and pricing is defined on a case-by-case basis and shared with other operators using the same duct.

Process for updating infrastructure plans

At the end of the cable installation process, the CP has to provide to PTC with the blueprint and the specific form filled reflecting the installation, in order for the infrastructure records to be correctly updated. The information submitted by the CP includes:

- maps with the indication of the requested duct path
- access points to chambers with the identification of the chamber facet, ducts to
- access to buildings and type of hole to build
- cable joints and spare cables with the indication of length
- number, exterior section and type of cables installed
- schemes of the holes of ducts aggregation in the facet of the chamber
- schemes or table of cable joint connections.

Frameworks to monitor Service Level Agreements (SLAs)

The main SLAs defined in ORAC are summarised in Figure 5.1.

Level of service	*Definition*	*Target*	*Occurrence*
Period allowed for response to a request for information concerning ducts and associated infrastructure	Length of time, in working days, between the receipt of the request by PTC and the time the CP receives a full response to the request for information.	5 working days	100%
Period allowed for response to a request for a feasibility study for the use of ducts and access chambers	Length of time, in calendar days, between the receipt by PTC of a request from the CP for access to and use of ducts and access chambers and the time the CP receives a response concerning the feasibility of granting the request.	15 calendar days	100%
Period allowed for scheduling the supervision of non-urgent work to be carried out by the CP (installation, maintenance and removal of infrastructures)	Length of time, in consecutive hours, between the time at which the licence holder receives a request for work to be carried out and the time arranged by the licence holder for the necessary supervision.	24 consecutive hours	100%
Period allowed for scheduling the supervision of urgent work to be carried out by the CP (repairs)	Length of time, in consecutive hours, between the time at which the licence holder receives a request for repair work to be carried out and the time arranged by the licence holder for the necessary supervision.	8 consecutive hours	100%
Availability of supervision service	Availability of the supervision service, which is to be calculated on the basis of the following formula: (Number of supervision operations carried out on the dates agreed by the licence holder / Total number of supervision operations carried out).	95%	100%

Figure 5.1: SLA definition and target [Source: Portugal Telecom, duct access reference offer, August 2008]

In addition, ORAC also defines SLAs regarding obligations for the CP, including:

- the CP has 60 days to place the order starting from the response day
- the CP has 30 days to provide the "as built" drawings back to PTC to enable them to update their infrastructure records.

5.3 Case study for France

5.3.1 Introduction

In France, the duct access offer "Offre D'accès Aux Installations De Genie Civil De France Télécom Pour Les Reseaux FTTx"[27] was made available in April 2009 by France Télécom (FT), to allow FTTx CPs to use FT infrastructure. This offer is aimed at operators wishing to deploy public last-mile, FTTx-type fibre-optic networks by the pulling of fibre-optic cables only. It specifies the principles governing the use of FT's civil engineering installations in the context of the deployment of very high-speed fibre-optic networks for buildings principally comprising residential accommodation. It also specifies the pricing associated with each of the services.

It should be noted that, although access to poles is not currently part of the offer, a pilot project is underway in the town of Bondy (Paris region), where FT and SFR are collaborating on the deployment of aerial fibre using poles.

Below we provide more detail on the specification an implementation of each of the necessary steps involved in the provision of fibre cable for CPs, as specified in the offer.

5.3.2 Operational process and issues

Framework to record infrastructure access requests

In France, a central portal called "Frontal de Commandes Integrées" (FCI) is used to record infrastructure access requests. This web-based portal is the point of contact for all requests and orders from CPs. The same portal is also used by the IP to post their response to CPs' requests. In order to avoid overloading of the IP, a single order cannot exceed 500 chambers and the maximum cumulative number of chambers nationwide in process at any given moment cannot exceed 1000.

According to the definition provided in Section 4.2, the request framework in France is semi-automatic and requires a number of external documents to be uploaded onto the FCI system to support the formal request. These external documents typically include an Excel spreadsheet indicating the towns and streets where the CP wishes to survey.

The FCI system is not made publicly available for obvious reasons and CPs have to pay an annual fee to be able to access the portal, and therefore to place a duct access order.

Mechanisms used to access existing network plans/duct records

Once the orders has been recorded onto the FCI system, maps corresponding to the areas the CP wants to deploy its cable will be uploaded (typically as compressed files) onto the system so that the CP can plan the survey of all chambers in the area of interest.

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27 http://www.francetelecom.com/fr_FR/groupe/reseau/documentation/att00005989/Offre_GC_version_du_29_04_2009_publiee.pdf

The vast majority (in excess of 70% according to our survey) of infrastructure maps provided by the IP are fully digitised and directly useable by CP in a Geographical Information System (GIS). Where digitised maps are not available, jpeg maps are provided.

It should be noted that space availability is available for some of the cities in France but is not very reliable.[28] Therefore this information, which carries an additional charge, is not often used by CPs, who prefer to plan their network based on observed infrastructure during the survey phase.

Approaches to determining useable space and survey procedures

In France, CPs have to carry out site surveys[29] to establish the amount of unoccupied space in the infrastructure. Also, all infrastructure (chambers and ducts) in an area of interest have to be surveyed by the CP (and not only the main route). Although not very cost effective, this allows CPs to plan their networks around potentially congested sections of the network, as explained in Section 4.4 above.

In order to ensure that the procedures undertaken by the CP (or associated sub-contractor) do not jeopardise the integrity of the network, a detailed survey plan has to be submitted to FT in advance of the surveys. In this context, the CP (or associated sub-contractor) must draw up suitable safety prevention plans, for which it is solely liable. These prevention plans must be sent to FT in advance. If these plans are not deemed suitable, FT can refuse the CP access to its infrastructure.

The measure of occupied space is explicitly defined[30] in the FT offer by means of a table showing duct diameters against cable diameters as illustrated in Figure 5.2:

			Duct occupancy		
Cable diameter (mm)	*28*	*33*	*45*	*60*	*80*
1	0.2%	0.1%	0.1%	0%	0%
2	1%	1%	0.3%	0.2%	0.1%
3	2%	1%	0.6%	0.4%	0.2%
4	3%	2%	1.1%	0.6%	0.3%
5	5%	3%	1.7%	1.0%	0.5%
10	21%	14%	7%	4%	2.0%
15	46%	31%	16%	9%	5%
20	N/A	N/A	28%	16%	8%

Figure 5.2: Duct occupancy [Source: France Telecom]

28 According to some of the CPs interviewed.

29 Even if a survey was previously carried out by a different CP in the same area.

30 http://www.francetelecom.com/fr_FR/groupe/reseau/documentation/att00005989/Offre_GC_version_du_29_04_2009_publiee.pdf, Annexe 1.

Once the surveys have been carried out, the feasibility study to determine whether or not there is enough useable space can be transparently carried out.

Approaches to engineering principles for allocating space in ducts

In France, the principle of physical separation must be observed whenever possible: a cable cannot be installed in a duct occupied by a third-party operator until sub-ducts have been inserted into the ducts.[31] All the cables of a single operator must be contained in the same duct wherever possible. An occupied duct must always be used before the last free duct in a section.

When inserting tubes into an occupied duct, a duct that does *not* contain cables must always be used first. If, when applying the rules below, the operator has a choice between several ducts, it must use the duct with the smallest possible diameter situated on the level that is lowest and closest to the welding panel. In any case, engineering rules specified in Figure 5.3 must be applied or order of priority when choosing the space to install new cable.

Priority	*Situation*	*Requirements*
Priority 1	Duct nest containing a duct which is less than 50% occupied by one or more cables which already belong to the CP that is conducting the survey	The CP installs its fibre-optic cable(s) in this duct without prior sub-ducting. The CP may, where appropriate, exceed the 50% occupancy rate, in compliance with the principles of non-saturation
Priority 2	Duct nest containing sub-ducts where tubes are available	The CP uses the available sub-duct with the smallest diameter compatible with its fibre-optic cable(s)
Priority 3	Duct nest containing at least four free ducts	The CP installs its fibre-optic cable(s) directly in the free duct with the smallest diameter.
Priority 4	Duct nest containing fewer than four free ducts and ducts occupied by another CP with an occupancy rate of less than 30%	The CP selects the occupied duct with the smallest diameter, inserts multiple tubes and then installs its fibre-optic cable(s)
Priority 5	Duct nest containing fewer than four free ducts and ducts occupied by another CP with an occupancy rate of between 30% and 50%	The CP selects the occupied duct with the smallest diameter, inserts a single Tube and then installs its fibre-optic cable(s)
Priority 6	Duct nest containing fewer than four free ducts and containing only ducts which are more than 50% occupied	The CP selects the free duct with the smallest diameter, inserts multiple tubes and then installs its fibre-optic cable(s)
Saturation	Duct nest with no free ducts and which contains only ducts which are more than 50% occupied	Possibility of using flexible tubing, otherwise the section is deemed to be saturated: search for alternative solutions

Figure 5.3: Engineering rules for duct access in France [Source: France Telecom]

31 On the condition that the duct is not more than 50% occupied and does not contain a cable with a diameter of more than 21mm in the case of ducts with multiple tubes.

The FT offer[32] specifies the number of sub-ducts to be fitted in the ducts, according to their respective diameters (see Annex B). Flexible inner ducts are currently being trialled by FT and the offer makes provision for the use of flexible inner ducts (see Section 4.5). However, flexible inner ducts can only be used in distribution networks for particular scenarios, to help when a route is too congested to use rigid inner ducts.

Procedures for duct access deployment

Once the site surveys are complete and all the chambers have been opened, the operator will complete the Order Submission for Access to FT's Civil Engineering Installations, through the FCI portal.[33] Once the order for access has been accepted by FT, the operator can carry out the work within a maximum of three calendar months (in the case of main orders). During this time the resource will be reserved for this CP. After this period, the CP has to re-apply for the space. Cables must be deployed in agreement with the engineering rules mentioned in the previous section. Physical access to the chambers, ducts and other infrastructure may be performed by the CP or associated sub-contractors, provided they submit suitable safety plans. Typically, FT does not accompany the CP.

Procedure for updating infrastructure plans

Once it has completed the work associated with the deployment of its FTTx network in FT's civil engineering installations, the CP has to prepare an "End of Works Submission", which is based on the Order Submission, updated with any changes that have occurred during the works phase. This submission, which is intended to demonstrate compliance with the Order Submission for access comprises Excel files, photos and a new overlay of the digitised record, illustrating how the infrastructure was modified. This process allows FT to update the records of their infrastructure.

Frameworks to monitor Service Level Agreements (SLAs)

For each step of the process, clear SLAs[34] have been defined in the FT offer. For example SLAs are defined for:

- the time it takes for FT to acknowledge an order submitted on the FCI portal
- the time it takes for a CP to submit all the necessary attachments in order for FT to process the order
- the time it takes for FT to send infrastructure maps to the CP
- the time it takes for FT to validate access to its infrastructure
- the time it takes for the CP to carry out the necessary work

[32] http://www.francetelecom.com/fr_FR/groupe/reseau/documentation/att00005989/Offre_GC_version_du_29_04_2009_publiee.pdf, Annexe 2.

[33] All forms and document to be submitted for this process are detailed in Section 10 of the offer.

[34] http://www.francetelecom.com/fr_FR/groupe/reseau/documentation/att00005989/Offre_GC_version_du_29_04_2009_publiee.pdf

- the time it takes for the CP to submit its End of Works dossier (to allow the update of the infrastructure).

5.4 Case study for Spain

5.4.1 Introduction

In Spain, a duct and pole access offer was first submitted by Telefónica to CMT, the Spanish telecoms regulator, in March 2009 and was revised and validated in December 2009. This reference offer, known as Marco, is aimed at operators wishing to deploy fibre- or cable-based networks and excludes the deployment of copper local loops. The offer specifies the principles governing the use of Telefónica's civil engineering installations as well as the pricing associated with each of the services. The scope of the offer is limited to infrastructure located in the public land in urban areas.

Below, we provide more detail regarding the specification and implementation of each of the necessary steps, as specified in the offer.

5.4.2 Operational process and issues

Framework to record infrastructure access requests

A semi-automated portal with a web front-end integrates a number of request forms to allow a CP to request space in Telefónica's infrastructure network. The request process is quite labour intensive as the CP has to manually identify each infrastructure node along the route it wishes to use and keep a note of its unique identification number using the online GIS tool. The CP has then to submit a design that contain all infrastructure elements (include their identification number) that will be encountered along the intended route.

It should be noted that there is a limit on the number of requests that can be submitted by the CP: a maximum number of 40 items per request and a maximum of 100 requests per week.

Mechanisms used to access existing network plans/duct records

The portal provides an online Geographical Information System (GIS) that enables CPs to view Telefónica's existing infrastructure. It is used by CPs to obtain network infrastructure element characteristics required for the submission of the design to Telefónica (see above). The graphical representation of the infrastructure network includes:

- location, type and identification of chambers
- location, number and diameter of ducts linking the chambers
- indicative utilisation of ducts (which is often not accurate)
- location and types of poles.

The infrastructure information is arranged by exchange areas (an exchange area might have several maps associated with it), and at present, only NGA-enabled exchange areas are available. The way maps are arranged has practical implications for the CP, who must manually determine which exchange area(s) will be required in order to obtain the necessary information of all infrastructure nodes along the intended route of deployment.[35]

It should also be noted that although the maps are available online through the portal, only a pdf version can be downloaded by the CP (not a fully digitised version). According to stakeholder interviews, maps provided on the online portal are fairly accurate.[36] However, the offer states that the accuracy of these maps cannot be guaranteed.

Approaches to determining useable space and survey procedures

Site surveys are mandatory and are usually carried out along the requested route (i.e. a whole-area surveying approach is *not* used). These surveys are conducted as a collaboration between Telefónica and the CP (with Telefónica leading the survey to mitigate against operational issues).

Approaches to engineering principles for allocating space in ducts

In Spain, physical network separation is mandatory except for the last drop. For example, the Marco offer mandates the installation of sub-ducts inside ducts whenever possible. It is interesting to note that sub-ducts are installed by the CP and any unused sub-ducts become Telefónica's property (even though the CP has paid for its provision and installation).

The Marco offer provides precise engineering rules to dictate how the CP should install its cable, based on the Spanish set of technical standards, UNE (Una Norma Española by AENOR, the Spanish Association of Certification and Normalisation) and the National Laws for Common Telecommunications Infrastructure.

It is interesting to note that different rules apply to different parts of the network due to the difference in infrastructure.

► *Engineering rules for the E-side network*

In the **E-side** (*'Red de alimentación'*), physical separation must be applied whenever possible (i.e. the CP needs to install sub-ducts in existing ducts to keep its infrastructure separate from Telefónica and from other CPs). The Marco offer also makes some provision for the reservation of common operational space and expansion space required by Telefónica. Common operational space is to provide space for the maintenance of the duct section for all CPs (including Telefónica). The expansion space relates to the expansion space need by Telefónica to deploy new cables to fulfil its Universal Service Obligation (USO). Provision of such space can be a full duct

35 A CP route can start and terminate at any points in the infrastructure network.

36 90% accuracy was mentioned regarding the location of the infrastructure.

or a percentage of the space of a duct, depending on the amount of duct present in the duct nest. These rules are summarised in Figure 5.4.

Scenario	*Number of empty sub-ducts*	*Process*
I	Zero empty sub-duct and there are one or two empty ducts	No sub-ducts is available for CP to use.
II	Zero empty sub-duct, and there are three or more empty ducts	The CP will install three sub-ducts of 40mm in one of the empty ducts. Two of the ducts must always remain empty
III	Any number of empty sub-ducts but no free ducts	All sub-ducts can be used by CPs except for two
IV	Any number of empty sub-ducts and one empty duct	All sub-ducts can be used by CPs except for one
V	Any number of empty sub-ducts and two empty duct	All the available sub-ducts can be let

Figure 5.4: Marco Engineering rules regarding the use of ducts and sub-ducts by CPs [Source: Marco]

In addition to the above rules, Marco also makes provisions to use of flexible inner ducts (see Section 4.5 for description) in cases where the number of empty ducts (excluding the space reserve for operations and maintenance and USO) is as per the following table:

Number of ducts present in the duct section	*Number of completely empty ducts*
1-5	1 or less
6-10	2 or less
11-20	3 or less
>20	4 or less

Figure 5.5: Engineering rules regarding the use of flexible inner ducts [Source: Marco Offer]

When the CP installs 40mm ducts, these must comply with requirement specification ER.f3.012 and the installation must be carried out according to the installation method MC.f3.001. Both these specifications are reflected in the set of Spanish laws regulating the development of ‘common telecommunications infrastructure’.

Additionally the CP has to anchor the sub-ducts ends to the duct end in the chambers, as per the UNE 133.100-1 (Spanish set of technical standards: Una Norma Española).

► *Engineering rules for the D-side network*

For the D-side *(‘Red de distribución)* of the network, different engineering rules apply. In the D-side, two further sub-sections have to be distinguished:

- the distribution main duct route (*canalización lateral*), which consists of ducts and sub-ducts along the distribution route
- the lead-in duct or "side exit" (*salida lateral*), which is the last duct providing connectivity to the customer premise. (In our reference model described in Section 3.2.1 above, this corresponds to the last drop.)

Reservation of common operational space and USO expansion space for Telefónica is less stringent for the lead-in duct or last drop as for any other part of the network. Engineering rules regarding the amount of space required by Telefónica for both Common Operational space and USO expansion space is provided in Figure 5.6.

Number of ducts present in the duct section	*Space reserve*
Side exits	No reserve
2	1/3 of a duct
3-7	2/3 of a duct
≥8	One duct

Figure 5.6: Space reserve rules in side ducts and exits [Source: Marco Offer]

Equally, there are also rules for sharing the last drop network (*red de dispersion*) and determining whether there is space available and how much.

► *Congested routes*

In the Marco offer, clear guidelines are defined to help CPs with congested routes. In case of congestion, Telefónica is obliged to find an alternative route for the CP, without further delay. In practice, the alternative path may be longer than the preferred path and therefore more expensive. In order to alleviate this problem, the offer does not allow Telefónica to charge for the alternative path more than twice the price of the original route.

If, in case of congestion, no alternative route can be found by Telefónica and if Telefónica is unable to free up some space in the congested section by removing unused cable, Telefónica has to increase the network capacity of the congested section. An increase in capacity will typically involve some civil works, and therefore be more expensive for Telefónica to implement. This provides an incentive for Telefónica to use their space efficiently and try, for example, to proactively remove unused cables, whenever possible. Also, the offer now makes provision for Telefónica to offer dark fibre to a CP in the case of congestion, but according to our stakeholder interviews, this is not actually being implemented yet.

Procedures for duct access deployment

After the feasibility study, the CP may be granted access to Telefónica's infrastructure to deploy its cables. As in other countries where duct access is implemented, the CP has to deploy its infrastructure within a defined period of time before the space booked for that CP is released.

As part of the contract with Telefónica, the CP (or associated sub-contractor) needs to carry out a risk assessment and has to prepare a detailed project plan for all activities to be performed for the installation of its cable. The CP also needs to prove that it has personnel that have been sufficiently and adequately trained for the tasks; that have the necessary equipment; that there is a person designated responsible for the works; and a person(s) designated as 'preventive resource' to deal with health and safety issues as per the Royal Decree 604/2006.

Process for updating infrastructure plans

After the joint survey has been carried out and the record of the survey has been compiled, the CP needs to provide the technical specifications ('*memoria descriptiva*'), which contains a sketch of the installation the access seeker intends to carry out and the necessary information for the SUC (request for shared use). The sketch needs to contain the chambers, ducts, and other elements of Telefónica's network that will be used by the access seeker, how they will be used and where the entry and exit points are. Once the access seeker has finished its installation, it needs to notify the operations centre (Telefónica's GGCAN), which will register the network elements.

Frameworks to monitor Service Level Agreements (SLAs)

The Marco offer defines strict SLAs for every step of the process. It should be noted that SLAs defined in the Marco offer are not fully symmetrical: Telefónica's retail arm is not formally obliged to follow the same procedures as any other CP seeking access to the infrastructure. The SLAs applicable to CP (excluding Telefónica's retail arm) are described below.

Telefónica has 10 days to validate the conformity of the request of access from, then has a further 10 days to arrange plans and dates for the surveys to be carried out. Once a date has been agreed, Telefónica has to carry out the physical survey within 30 days. Once the survey has been carried out, Telefónica has 30 days to issue its "submission of technical specifications" to the CP regarding the outcome of the survey. The CP is allowed up to four months before issuing a notification to Telefónica as to when it intends to start the installation of its cables and has a maximum of six months after an agreement has been settled to install its cable in the identified space. Beyond those six months, the space reserved for the CP's use reverts to Telefónica again.

However, if an issue occurs during the course of the project, the maximum resolution times are not specified, but left to be agreed between Telefónica and the CP. It should also be noted that, in case of a problem, Telefónica is allowed to "stop the clock", provided it is done on "reasonable grounds". In practice, this may lead to further delays in the provisioning time of services by Telefónica.

As well as service provisioning time, the offer also enforces some quantitative indicators including:

- the number of requests rejected
- the length of alternative paths provided
- additional costs invoiced to provide alternative path in case of congestion.

These qualitative indicators are then compared with Telefónica's own quality indicators regarding FTTH deployment for Telefónica's retail arm, to ensure there is no discrimination in the provision of services to CPs (although the obligations for Telefónica's retail arm are different, as mentioned at the beginning of this section).

5.5 Case study for the USA

5.5.1 Introduction

The USA is quite different from the three previous case studies as no duct and/or pole access reference offer is available. Instead, the USA has had a regulatory framework in place for over 30 years that encourages IPs to share their poles on a commercial agreement basis.[37] In 1996, Congress expanded the reach of section 224 of the Telecommunications Act in several notable ways including the inclusion of ducts, conduits and rights-of-way to the facilities covered by section 224 with the objective of fostering competition in the sector. As a result, cable and telecommunications companies are now free to enter into commercial agreements regarding pole/duct access, and the FCC has put in place specific rules designed to efficiently resolve any disputes between the parties.

Below, we provide more detail regarding the specification and implementation of duct and pole access in the USA.

5.5.2 Operational process and issues

Framework to record infrastructure access requests

In the USA, the framework in place to allow CPs to register interest in accessing infrastructure differs from IP to IP and from state to state. Typically, this process is very manual, with no central repository for information. A typical request would start with an email or a phone call to the IP.

Mechanisms used to access existing network plans/duct records

The mechanism for accessing existing network plan and records is not standardised and varies widely between IPs and between states. However, according to the stakeholders interviewed, a

37 For this reason, the USA case study does not appear in the summary table in Section 5.6, where we concentrate on infrastructure reference offers.

common procedure is for the CP to arrange a visit to the planning office of the infrastructure provider and look at paper-based plans to determine whether or not there is infrastructure that can be used in the area of interest. It is therefore a labour-intensive process.

It should be noted that the level of digitisation of infrastructure records also widely varies, but, according to our interviews, some of the largest incumbents have digitised almost all of their infrastructure plans, which they use for their own deployment purposes, but are not usually made available to CPs.

However, some IPs are part of the National Joint Utilities Notification System (NJUNS) which, through an online system, provides efficient communication and work co-ordination while promoting co-operation and partnering to manage pole transfers, joint trench construction, pole attachments, and project notification.

Approaches to determining useable space and survey procedures

In general, at least regarding poles, ducts and conduits subject to FCC regulation, the IP generally performs a survey or inspection to determine whether access can be provided, and whether prior work is needed to enable such access.[38] This process might involve consultation with local network planners and/or field staff who have a good understanding of the space available in the infrastructure they manage and/or operate.

However, it should be noted that, historically, both incumbent local telephone companies and electric utilities owned a significant number of poles, and in some cases entered "joint use" agreements or other arrangements to secure access to others' poles. Some of those agreements could mean the incumbent local telephone companies are better able to perform surveys or other preparatory work themselves than CPs.

Approaches to engineering principles for allocating space in ducts

Typically, as part of the contract, IPs provide customised engineering documents on a project-to-project basis, indicating where cables can be installed. In this context, the infrastructure user does not receive a set of engineering rules but a prescriptive documentation explaining where the cable should be installed.

According to our interviews, duct access users have to leave at least one empty duct in a duct nest for maintenance purposes. Also, physical separation with rigid sub-ducts is usual, but is decided on a case-by-case basis.

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38 See, 'Implementation Of Section 224 Of The Act; Amendment Of The Commission's Rules And Policies Governing Pole Attachments', FCC 07-187, para. 37 & n.112 (2007) (discussing concerns expressed by some parties about the survey process) available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-07-187A1.pdf

Procedures for infrastructure deployment

Although this significantly varies from state to state and IP to IP, the duct/pole access user is generally allowed to install its own infrastructure, once the IP has agreed to grant access. The IP grants access to the duct/pole user on the condition that they use a sub-contractor from an approved list. Alternatively, the duct/pole access user can commission the IP to carry out the installation.

Typically, the IP appoints a project manager for each individual project to oversee the deployment of the new infrastructure, and ensures that the deployment of the cable(s) is in line with the specifications provided in the contract by the IP. The project manager also ensures that the pole/duct access users adhere to all health and safety procedures.

Standards governing access to infrastructure can be based on a number of sources, including federal, state or local safety or engineering regulations, industry codes, or other requirements. To the extent that there is insufficient capacity under these standards, the FCC has required the IP to make certain modifications if possible to enable access, such as "rearranging existing facilities to make room for a new attachment".[39]

Process for updating infrastructure plans

Infrastructure plans are updated post cable installation, but according to the stakeholders we interviewed there is no requirement for the pole/duct access user to provide as-built drawings to the IP. Instead, the IP ensures that the information is updated correctly in the IP's database.

Frameworks to monitor Service Level Agreements (SLAs)

As the access is negotiated by commercial agreement, no strict SLAs are in place. If a CP believes it is taking too long for the IP to arrange access to its infrastructure, a dispute procedure is available.

[39] *Implementation of the Local Competition Provisions of the 1996 Act*, FCC 96-325, para. 1161 (1996) available at http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-96-325A1.pdf

5.6 Summary

	Portugal	*France*	*Spain*
Framework to record infrastructure access requests	Semi-automated central portal Attachments and forms required	Semi-automated central portal Attachments and forms required	Semi-automated central portal CP must take a note of all infrastructure element to submit a survey request
Mechanisms used to access existing network plans/duct records	Coarse maps are available online but detailed maps required for planning are made available on request (pdf format)	Fully digitised network maps are made available on request (posted by FT on the portal)	Detailed maps are available online though the portal but CPs can only download pdf maps
Survey approach	Space availability available in PTC database and surveys are only carried out by PTC if desktop data is incomplete/unreliable	Whole-area surveying is mandatory and the CP carries out survey	Survey is mandatory and is carried out on a route basis in collaboration between Telefónica and the CP
Approaches to determining useable space	PTC performs the analysis of occupation Useable space is calculated according to a formula taking into account cable size and duct diameter	The CP performs the analysis of occupation and issues a request to FT for space reservation. Occupied space is explicitly defined in the offer, taking into account cable size and duct diameter.	Useable space is determined by the site surveys and engineering rules
Approaches to engineering principles	As per space calculation described above	Physical separation using sub-ducts (or flexible inner ducts in some cases) Priority-based engineering rules specified where and how the cable should be installed, based on local configuration	Physical separation using sub-ducts (or flexible inner ducts in some cases) "Priority-based engineering rules" specified where and how the cable should be installed, based on local configuration
Procedures for duct access deployment	Sub-ducts (if required) are deployed by PTC. Cable deployment carried out by the CP with supervision from PTC Accreditation scheme in place	All infrastructure required is deployed by the CP (including sub-ducts) The CP has to submit an installation plan, covering all procedures and ways to mitigate operational issues	All infrastructure required is deployed by the CP (including sub-ducts) The CP needs to carried out a risk assessment analysis and prepare a detailed project plan before installing its infrastructure
Process for updating infrastructure plans	CP has to provide PTC with an "As built" design, 30 days after completion of the work to allow PT to upgrade their infrastructure	CP has to provide an "End of Works Submission", which is based on the Order Submission, updated with any changes that have occurred during the works phase	After the joint survey has been carried out, the CP needs to provide the technical specifications ('*memoria descriptiva*'), which contains detailed information regarding the intended installation
Frameworks to monitor SLAs	Time to respond to a request: 15 days	Time to respond to a request: 12 days	Time to respond to a request: 10 days

Figure 5.7: Comparison of duct/pole access offers [Source: Analysys Mason]

6 Recommendations for the UK

6.1 Introduction

As defined in Section 5, a number of options are available to implement the UK operational model of duct and Pole access. Based on the principles observed in the four countries identified and our understanding of the UK infrastructure, we provide insight into the implications for the UK of selecting each option. In order to be consistent, our assessment and recommendations are arranged according to the seven key steps identified in Section 4 of this report:

- framework to record access requests and responses
- mechanisms used to access existing network plans/duct records
- approaches to determining useable space and survey procedures
- approaches to engineering principles for allocating space in ducts
- procedures for duct access deployment
- process for updating infrastructure plans
- frameworks to monitor Service Level Agreements (SLAs).

A summary of our recommendations is provided in a table in Section 6.9.

It should be noted that out of the studied countries, only Spain has mandated access to poles, where the procedure for accessing poles requires a customised study by the IP. Therefore, the case studies have provided limited insight regarding best practice for implementing pole access in the UK. However, we make recommendations where possible.

6.2 Framework to record infrastructure access requests

In the UK, we believe that the first steps in the implementation of a duct access reference offer is the implementation of a central portal that needs to be developed for CPs and IP(s) to submit their requests/responses. The implementation of such a portal would have to be a balance between the functionality required by the industry and its associated cost. However, according to the results of our international survey of duct access offers, the key design criteria for such a portal are:

- the portal should provide a interface between CPs and IPs and be standard for both parties (a web-based interface seems to be a consensus in countries where duct/pole access is implemented)

- the portal should provide some level of security such that only authorised users could access it (e.g. an extranet-based system)

- the portal should provide a monitoring facility to ensure defined SLAs can be tracked by both IPs and CPs.

- the portal should provide a degree of automation regarding the submission of request, where the use of external forms (e.g. in Excel or Word) is minimised. Instead, the portal should provide web-based order forms that could be automatically checked, improving submission consistency and ultimately reducing the workload for both CPs and IPs.
- the portal should integrate a GIS tool to provide infrastructure maps to CPs in areas of interest.

We believe that it may not be feasible to implement *all* functionalities in the *initial* development of the portal, because it would take too long and may delay the introduction of the duct offer. Instead, an incremental approach should be adopted, leveraging the practical experience gained by both parties when using the system while it evolves.

In order to facilitate the incremental development of the portal, we recommend monthly meetings between the CPs, the IP and the regulator to provide feedback on operational issues and provide input into how the portal could be improved.

6.3 Mechanisms used to access existing network plans/duct records

Ideally, the portal should provide a GIS tool with associated digitised infrastructure plans, which would enable CPs to access Openreach's infrastructure maps in real time. Infrastructure maps should contain, as a minimum, the following information:

- chamber and pole location
- chamber and pole type
- duct and sub-duct location
- duct and sub-duct number (on a route)
- duct and sub-duct diameter.

As an option, an indication of the occupancy of the duct and pole would also be useful for communication providers. However, according to our case studies review, providing reliable occupancy information can be quite challenging, and the best way to determine the unoccupied space in the infrastructure of interest is to carry out a field survey (see Section 6.4). It should be noted that surveying the IP infrastructure comes at a significant cost (e.g. in France, one CP believes that 25% of the cost of shared infrastructure is associated with the surveys).

However, there are a number of operational difficulties to consider before it can be implemented, including the availability of digitised infrastructure records and accuracy of these plans. The status of digitisation of the UK infrastructure network is not clear at the time of writing this report, but in previous projects[40], the only format of infrastructure maps available[41] was in static electronic format (generated from scanned paper-based plans). Also, these plans did not prove to be very reliable due to their lack of maintenance (i.e. new infrastructure was not on the maps).

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40 See: 'Sample survey of ducts and poles in the UK access network', Analysys Mason for Ofcom, 15 January 2010.

41 For the sample areas in our survey.

We suggest that initially, infrastructure plans could be uploaded by the IP (Openreach) onto the portal in a fully digitised format (if available) or in a static electronic format (pdf or jpeg), in response to an order request. These plans should show, as a minimum, the location and diameters of the ducts as well as the location and type of chambers in the areas of interests. These plans should also show the location and types of poles that are available. As more areas are surveyed, fully digitised record with up to date infrastructure data could be created and ultimately, made available through a GIS tool, fully integrated to the portal.

We also recommend the number of orders that can be placed by an IP to be limited in terms of the number of chambers, to avoid overloading the IP (Openreach), especially at the initial stage of the duct/pole access process which may be quite labour intensive (due to the potential lack of automation of the system). This limit could be raised and eventually removed as the portal becomes more and more automated. Examples of the maximum number of orders that can be placed by individual CPs in other countries where duct and pole access has been implemented can be found in Section 5 of this report.

6.4 Approaches to determining useable space and survey procedures

In order to determine the space available, we recommend that mandatory field surveys should be used to assess space. This is because we believe that little information is readily available regarding unoccupied space in the ducts in the UK, based on our experience of the sample surveys conducted on the behalf of Ofcom.

We also recommend that, for the first survey in a particular area, a whole-area surveying approach should be adopted, inspecting all chambers, ducts, and possibly poles, available in the area. This approach would facilitate the creation of consistent and accurate digitised infrastructure records, that could be then used by other CPs, should they want to make use of the duct/pole offer in the same area. We believe that the whole-area surveying approach should *not* be mandatory for a second CP willing to deploy infrastructure in an area that has already been surveyed, as updated plans should be able to determine the probability of congestion in all infrastructure section of a given area. Instead the second CP should have to carry out a route-only survey, given the amount of information gained from previous surveys. This raises the issue of pricing (the first CP may need to pay more than the second CP), which could be solved by the implementation of various pricing policies but such policies are not in the scope of the present report.

We also recommend that the offer should allow the CP to carry out its own survey, for reasons mentioned in Section 4.4, with the option for the IP to supervise the survey. As network integrity is a main concern amongst IPs, we recommend adopting **one or a combination of the following three options** to mitigate operational risks and ensure all procedures specified in the offer are adhered to:

- establishment of accreditation training schemes for field force (e.g. process implemented in Portugal)
- sub-contractors have to be chosen from an approved list by the IP

- sub-contractors have to submit detailed operational plans to the IP prior to undertaking the installation of the cable, in which the CPs (or associated sub-contractor) must draw up suitable safety prevention plans (e.g. process implemented in France).

More details regarding each option can be found in Section 4.4 of this report.

It should be noted that the above options are not necessarily mutually exclusive, and a combination of policies may have to be applied simultaneously in the initial phase of the implementation of a duct/pole access offer, to provide the necessary comfort to Openreach that the integrity of its network is not at risk.

It is worth noting that some operational issues regarding site surveys were identified in our previous duct and pole access report[42] including the presence of:

- residual gas in chambers
- sewage in chambers
- water in chambers
- obstructing objects (cars, scaffoldings, etc.) on the top of chambers
- electric cables in chamber or on poles
- trees preventing poles to be surveyed
- potential damage caused to existing cables during survey.

However, according to international stakeholders interviewed in the process of this project, these issues are *not* perceived to be major barriers to the completion of surveys. In fact, CPs often transfer these risks to their sub-contractors who have to demonstrate that:

- they have received adequate training on all of the above issues

- they have the appropriate equipment to carry out the surveys (water pumps to remove the water, gas detectors to ensure there is no residual gas, etc.)

- they are able to carefully plan surveys in advance, taking into account planning permission time required from local authorities.

Once the survey is completed, the portal should provide the necessary interface for the CP to be able to submit the results to the IP, indicating where it plans to install its cable, in-line with the engineering principles set out in the offer.

6.5 Approaches to engineering principles for allocating space in ducts

The definition of a comprehensive set of engineering rules that dictates how unoccupied space may be used by a CP is one of the most challenging processes in the implementation of a duct/pole access offer. In France, for example, it took in excess of 18 months to define an agreeable set of

[42] Ibid. 40.

engineering rules between the different stakeholders, involving regular detailed discussions between the IP, CPs and ARCEP. We suggest that a similar approach be adopted in the UK.

However, the specific engineering rules applicable to the network infrastructure of a particular country may not be suitable for the UK, due to differences in architecture. Therefore, rather than recommending a set of precise engineering rules, we discuss the fundamental principles that should be considered for defining a set of engineering rules in the UK:

- physical separation of infrastructure
- definition of useable space
- optimisation of useable space
- fair and non- discriminatory allocation of space
- network congestion.

Below we discuss each, considering the specific infrastructure of the UK network.

6.5.1 Physical separation of infrastructure

One of the first principles to be agreed between the UK stakeholders is that of physical separation. As explained in Section 4.5, in some countries IPs want to separate their infrastructure from the CPs in order to mitigate the risks associated with damaging cables and to preserve the integrity of their own network.

In general, we believe that physical separation is a sound principle but the decision to separate infrastructure also has to take into account that physical separation does not promote the efficient use of the space[43], which can cause significant issues in more congested parts of the network. Also, it is important to note that, if the stakeholders agree on applying physical separation whenever possible, it should **not be restricted** to empty ducts, in order to optimise the use of space.

We also believe it should not be adopted systematically in all parts of the networks, and for all configurations of chambers and duct nests. For example, during our physical sample surveys of the UK infrastructure network, we observed major differences between the E-side and D-side of the network, that would need to be considered when devising the physical separation policy. These differences are highlighted in Figure 6.1 below.

43 If a duct or sub-duct is dedicated to a CP, there might be stranded available space which cannot be used by another CP.

Parameter	*backhaul network*	*E-side network*	*D-side network (90mm ducts)*	*D-side network (50mm ducts)*
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 unoccupied space per duct end	36%	30%	40%	72%
Percentage of 90mm ducts	>95%-	>95%-	66.5%	NA
Percentage of 50mm ducts	NA	NA	NA	29%

Figure 6.1: Summary of the sample survey of the UK infrastructure network [Source: Analysys Mason]

In our sample survey, we found that most of the ducts in the E-side were 90mm in diameter and that, in average, one in four ducts was empty in that part of the network. For these ducts, physical separation using 25mm sub-ducts for example, would be feasible.[44] However, in the E-side of the network, the infrastructure network is less homogeneous, with two-thirds of the ducts being 90mm in diameter and the remaining third (infrastructure closer to the end-user) only 50mm in diameter. Furthermore, since there are only 4.5 duct-ends per chamber and usually, 2 or 3 used walls[45] per chamber, it means that there will be only one to two ducts per duct nest on each wall, limiting the amount of options that a CP has to deploy its own cable. Therefore, on the D-side, physical separation should be achieved by other means than rigid sub-ducts, e.g. micro-ducts, micro-cables or potentially flexible inner ducts as described in Section 4.5.

6.5.2 Definition of useable space

Unoccupied space (see Section 4.4) observed at the duct end may not be useable by the CP for the following reasons:

- the cable arrangement far into the duct may be such that existing cables cross over, and may prevent any further cables being inserted in the duct i.e. operational space
- the IP needs to reserve maintenance space and expansion space for its own network
- the engineering rules may prevent unoccupied space being used (e.g. to limit disruption with other cables in the duct)

44 Depending on the space required for maintenance and expansion of the network.

45 Walls containing at least one duct end.

- a duct might have collapsed somewhere in the section.

Therefore, when defining the rules regarding what space is useable for other CPs, it is important to take into account maintenance, expansion and operational space.

In our review of duct access implementation in other countries, it was shown that maintenance space and expansion space were generally taken into account by reserving a full duct or a proportion of the total duct area for the IP, depending on the number of ducts present in a chamber and their availability. However, operational space[46] is not explicitly defined in many existing offers, which can lead to operational issues when installing the cable in the infrastructure network, resulting in further delays.

Regarding the potential collapse of ducts somewhere in a section of the network, the only real solution to ensure that the duct is useable, is to perform a continuity test at survey time, which consists, for example, of introducing a rod attached to a rope at one end of a duct and pulling it to the other end of the duct. The implication is that, if not carefully performed, the continuity test may damage existing cables. However, this would need to be done at installation time anyway, and one advantage is that a rope could be left in the duct to accelerate delivery time. Duct continuity is tested in France by CPs to check whether an alternative path can be used.

Therefore, we recommend that, if duct access is implemented in the UK, the offer should clearly define the provisions made for maintenance space, expansion space and operational space, so that the useable space is clearly defined for the CP. This will avoid potential delays during the installation period. Also, we do not recommend continuity tests be systematically carried out on every section of a surveyed area, as it would delay the overall process significantly, but should be considered as an option to test alternative path in case of congestion.

6.5.3 Optimisation of useable space

In practice, a CP may have several options to deploy its cable in a duct section of the network. If the CP is left to deploy its cable without prioritising the use of space, stranded space could be created in the infrastructure network. One option to solve this problem is to define a set of priority-based engineering rules which dictate what space should be used to deploy a cable, depending on the configuration and occupancy of the ducts.

The French duct access offer (see Figure 5.3), and, to some extent, the Spanish duct access offer (See Figure 5.4), provide good illustrations of how “priority-based engineering rules” could be implemented. In addition to the efficient use of space, priority-based engineering rules have a number of other advantages:

46 In some countries, a contingency is applied to the calculation of occupied space by applying an uplift factor.

- they create a consolidated set of rules that covers all scenarios a CP may encounter in different sections of the network[47]
- they ensure that the installation by different CPs (or associated sub-contractors) are consistent, resulting in a pseudo-homogeneous network
- they provides comprehensive thresholds in terms of number of free ducts and available space that dictate where the CP should install its cable.

We believe that similar principles could easily be adopted in the UK network to try to optimise space in the infrastructure network.

6.5.4 Fair allocation of space

It is evident that space allocation should be provided on a non-discriminatory basis, which raises the following questions:

- What method should be used to fairly allocate space to CPs and could space be allocated to collaborating CPs?
- Should space required by the IP for its own requirements (e.g. expansion space) be treated in the same way as the space required by the CPs?

We discuss these questions in detail below.

Space allocation methodology

There are a number of options to allocate space including:

- first-come first-served
- co-operative methods such as cable sharing (which involve co-operative planning between CPs)
- methods allowing competition for the space between potential users such as an auction, beauty contest (e.g. coverage promises) or lottery (i.e. random).

Each of these possible mechanisms differs in the speed of implementation, fairness, allocative efficiency, and cost and complexity to administer.

As a result, the most common space allocation method is first-come first-served, where the first CP to apply for a space is the first one to be allocated that space. In this scenario, if a second CP also requires some space in the infrastructure and if the first CP has taken all the useable space, then the

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47 Except for the lead in duct (last duct section before the customer premises).

duct section is considered to be saturated and the second CP will have to find an alternative solution.

In order to avoid this problem, some countries, such as France, have adopted a "1:1 matching" principle. This principle means that, for any CPs to be granted space by the IP, there should be enough space to install at least twice the amount of infrastructure the CP wants to deploy. This ensures that there will always be some useable space for the next CP to deploy its infrastructure.

We believe that, in the UK, the principle of first-come first-served should also be adopted, as it is relatively easy to implement (compared to an auction-based allocation of space). We also believe that the 1:1 matching principle could be beneficial in the UK to prevent space being hogged by one CP, but should be restricted to the first CP (excluding the IP) to ensure that the first CP does not hog the useable space. If applied to all CPs, the 1:1 matching principle could leave some stranded useable space, where there is only space for one additional CP to deploy its infrastructure but not enough space for two. This is illustrated in Figure 6.2. We understand the different duct access stakeholders in France are currently debating this issue.

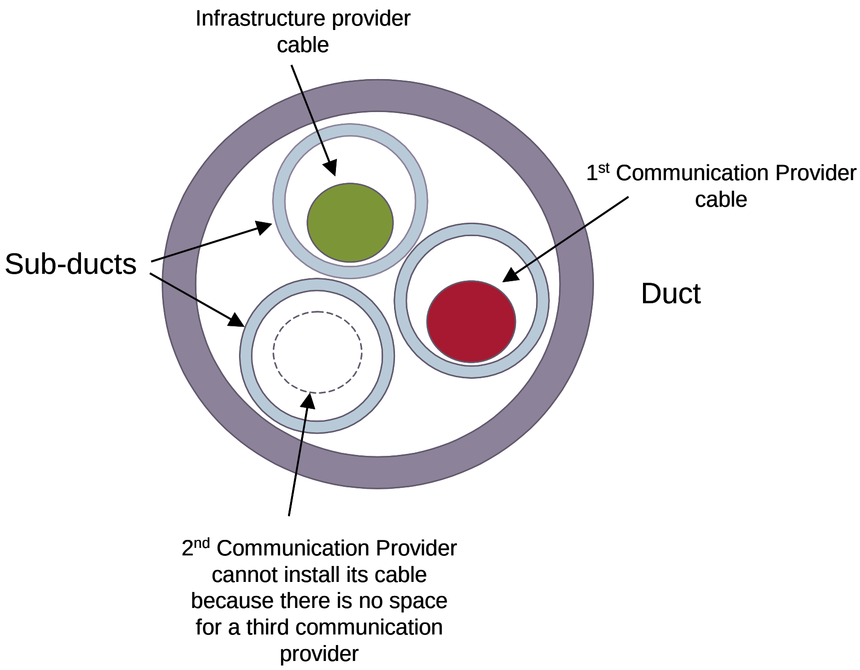

Figure 6.2: Limitations of 1:1 matching principle [Source: Analysys Mason]

We also believe that co-operative space application should also be encouraged in the UK, should a duct and pole access offer be implemented, as this reduces costs for CPs and also encourages the efficient use of space.

Allocation of space required by the IP

As discussed in the Spanish case study (Section 5.4), although the offer is supposed to be provided on a non-discriminatory basis, requests for accessing the infrastructure from Telefónica's retail arm are not treated in the same way as requests from other CPs, as they do not have to follow the same procedures.

The UK is different from its European neighbours because the incumbent operator has a functionally separate division that provides equality of access to all operators, i.e. BT's own downstream business and all other CPs. We believe the same would apply should duct access be implemented, as the wholesale product would reside within Openreach.

6.5.5 Network congestion

Approaches to solving network congestion are key in any duct access offer. First, in order to mitigate the risks of encountering network congestion, the principles of optimising the use of the space should be adhered to by both the IP and the CPs. However, in some cases, sections of the infrastructure network will be congested and alternative solutions will be required for the CP as described in Section 4.4. There are a number of options available to solve congestion in terms of limits of responsibility.

First, we recommend that the offer clearly establishes who is responsible for removing congestion in the network. Given that we recommend a whole-area surveying approach (at least for the first CP), it should be the responsibility of the CP to find an alternative route if the main route is congested. This is because, after the survey, the CP would have all the required data (observed unoccupied space and engineering rules) to make this decision.

However, if no alternative route is available, then the offer should clearly specify how removing congestion in the network should be implemented, setting out the steps to be followed as illustrated in Figure 4.2 regarding Spain.[48]

6.6 Procedures for duct access deployment

In essence, our recommendations regarding the deployment of infrastructure are in-line with other European duct access operational models and similar to our recommendations made in Section 6.4 regarding the survey of the infrastructure network:

The CP (or associated sub-contractor) should be allowed to deploy its own infrastructure with an optional escort from Openreach, but should demonstrate that it is qualified for the task and is not posing a significant threat to Openreach's infrastructure network integrity. This could be demonstrated by one of the following:

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48 We do not suggest that the same model should be adopted for the UK.

- being accredited for deploying infrastructure (if an accreditation scheme is in place) with the correct accreditation
- being part of Openreach's approved list of sub-contractors
- submitting a detailed project plan to Openreach prior to the deployment, demonstrating sufficient understanding of the risks involved and having appropriate mitigating actions in place.

To further minimise the risks associated with a third party installing infrastructure in Openreach's network, we also recommend that precise rules should be included in the offer as a minimum:

- health & safety requirements that CPs must meet when deploying their infrastructure
- a clear set of engineering rules pertaining to the installation of sub-ducts and cables, including detailed recommendation on installation practices, especially regarding the use of rods, ropes and sub-duct
- detailed cable labelling procedure to ensure the cables of different CPs can be easily identified
- detailed procedures regarding the dressing up of cables around the chamber to ensure access to the chamber and ducts is not restricted
- procedures to identify fragile cables and guidelines regarding how to mitigate possible risks before work commences
- procedures regarding how the installation can be stopped by Openreach, should he CP not follow the rules laid out in the offer.

Finally, we believe it is very important to specify procedures and associated SLAs to ensure that any problems encountered during the access request have to be resolved within a specific time period.

6.7 Process for updating infrastructure plans

In order to keep infrastructure plans up to date, we recommend that, after completing the work, the CP should provide an as-built drawing to Openreach, which reflects how the cable/ infrastructure was modified/installed. The format should be standard so that it can be automatically imported into a digitised network plan database to minimise Openreach's manual operation (e.g. the as-built could be a layer of digitised plan).

6.8 Frameworks to monitor Service Level Agreements (SLAs)

A very important part of the offer is the specification of Service Level Agreements, which dictate the maximum time for the provisioning of the different services associated with duct access. We therefore recommend detailed SLAs, specifying the maximum allowable time for:

- the IP to provide its response to any requests
- the CP to supply its requests and implement its deployment (i.e. reservation time).

Depending on the process proposed by infrastructure access stakeholders, the following SLAs should be included in the offer (the brackets indicate who would be subject to the limitation):

- period allowed for a request to be fully formulated by the CP, including all necessary documents (CP)
- period allowed for Openreach to supply the necessary infrastructure maps to allow the CP to plan its survey[49] (Openreach)
- period allowed for the CP to submit a survey request, with all the necessary plans (CP)
- period allowed for the response to a request for survey from the CP (Openreach)
- period allowed to carry out survey (CP)
- period allowed for the validation of the feasibility study as submitted by the CP (Openreach)
- period allowed for the deployment of the cable (i.e. space reservation time) (CP)
- period allowed for the CP to provide as-built drawings (CP).

In addition, SLAs should also be defined regarding the maintenance of the cable that may be carried out by the CP. Examples of maintenance SLAs include:

- period allowed for scheduling the supervision of non-urgent work to be carried out by the CP (installation, maintenance and removal of infrastructures)

- period allowed for scheduling the supervision of urgent work to be carried out by the CP (repairs).

Finally, specific SLAs should be defined regarding the resolution time of problems encountered to avoid a situation where the clock can be stopped by either party, leading to further delays in the implementation of the required services.

[49] If a fully automated GIS system is not in place.

6.9 Summary of recommendations

Process	*Recommendation*
Framework to record infrastructure access requests	• Implement a central and secure portal, using an incremental approach with the following characteristics: – unique and central point of contact – SLA monitoring capability – automation of request validation/ responses – integration of support for GIS tools if feasible
Mechanisms used to access existing network plans/duct records	• Openreach's Infrastructures plan should be available to CPs • Plans should preferably be in a digitised format • Initially, requested plans should be uploaded on the portal on demand by Openreach, with a goal to make all plan available online real time • A limitation of the number of requests by each CP should be imposed, to avoid overloading Openreach. This limit should be increased as the system becomes more automated
Approaches to determining useable space and survey procedures	• Mandatory whole-area surveying at least for the first CP and the option of secondary route surveying for subsequent CPs • CPs should be allowed to carry out surveys with Openreach having the option to escort • Implementation of appropriate procedures to ensure network integrity – accreditation scheme, submission of CP's survey plans to Openreach or list of approved sub-contractors by Openreach
Approaches to engineering principles for allocating space in ducts	• Physical infrastructure separation but based on different techniques depending on network section • Engineering rules should account for space required by Openreach to maintain and expand their network • Engineering rules should account for operational space[50] to avoid potential delays during the installation period • Engineering rules should promote the efficient use of space by defining a set of "priority-based rules" which dictate what space should be used to deploy a cable, avoiding stranded space • Space should be allocated on a first come first serve basis, with consideration of a 1:1 matching principle to the first CP to avoid

50 Operational space takes account of the fact that the cable arrangement far into the duct may be such that existing cables cross over, and may prevent any further cables being inserted in the duct, plus the size of the tools required to install a cable in a duct/sub-duct (e.g. rod).

	capacity hogging • Provisions should be made for co-operative space application from two or more CPs • In case of congestion, CP should find an alternative path, considering survey information • If an alternative path cannot be found, the offer should encourage Openreach to find alternative solutions for the CP (e.g. removing disused cables)
Procedures for duct access deployment	• Health & Safety requirements that CPs must meet when deploying their infrastructure • Clear set of engineering rules pertaining to the installation of sub-ducts and cables, including detailed recommendation on installation practices, especially regarding the use of rods, ropes and sub-duct • Detailed cable labelling procedure to ensure cables of different CPs can be easily identified • Detailed procedures regarding the dressing up of cables around the chamber to ensure access to the chamber and ducts is not restricted • Procedures to identify fragile cables and guidelines regarding how to mitigate possible risks before work commences • Procedures regarding how the installation can be stopped by Openreach, should he CP not follow the rules laid out in the offer • Procedures to solve issues encountered during the access request to ensure any additional delays are bound
Process for updating infrastructure plans	• After completion of the installation, the CP should provide an as-built drawing, to allow the infrastructure database to be updated
Frameworks to monitor Service Level Agreements (SLAs)	• Depending on the process proposed by duct/pole access stakeholders, the following SLAs should be included in the offer – Period allowed for a request to be fully formulated by the CP following a registering of interest, including all necessary documents – Period allowed for Openreach to supply the necessary infrastructure maps to allow the CP to plan its survey – Period allowed for the CP to submit a survey request, with all the necessary plans – Period allowed for the response to a request for survey from the CP – Period allowed to carry out survey – Period allowed for the validation of the feasibility study as submitted by the CP – Period allowed for the deployment of the cable (i.e. space reservation time) – Period allowed for the CP to provide as-built drawings

- In addition, SLA for cable maintenance should be defined:
  - Period allowed for scheduling the supervision of non-urgent work to be carried out by the CP (installation, maintenance and removal of infrastructures)
  - Period allowed for scheduling the supervision of urgent work to be carried out by the CP (repairs)
- Finally, specific SLAs should be defined regarding resolution time of the potential problems that can be encountered during the provision of duct/pole access

Figure 6.3: Summary of recommendations [Source: Analysys Mason]

Annex A: Space availability calculation in the ORAC offer in Portugal

The formula is as follows:

$$DPipe = 1.6x\sqrt{d1^2 + d2^2 + ... + dn^2}$$

Where:

- D Pipe: Represents the nominal internal diameter of the pipe needed for the coexistence of the n cables under technically acceptable conditions
- d1, d2, ..., dn: Represent the various nominal external diameters in millimetres of the n cables installed in the pipe in the duct;

The term ‘free space’ means the difference between the total space in the duct/sub-duct and the occupied space in the duct/sub-duct.

- Total space = π x R^2, where R = Diameter of the duct/sub-duct/2
- Occupied space in the duct/sub-duct = π x $(D\ Pipe/2)^2$

Example of the calculation of space:

- Pipe with internal diameter of 90mm 3 cables with diameter of 30mm
- D Pipe = 83.14mm
- Occupied space in the pipe = 5428.67mm^2
- Percentage of occupied space in the pipe = 85.3% Free space = 933.05mm^2
- Maximum diameter of the cable which can be laid in the pipe = 21.55mm.

Annex B: FT installation guidelines

Tubing		Free duct 28	Free duct 33	Free duct 45	Free duct 60	Free duct 80	Occupied duct 28	Occupied duct 33	Occupied duct 45	Occupied duct 60	Occupied duct 80	Occupied duct 100	Occupied duct 150
		Usage (area of application)											
8/10mm	Single tube												
	Double tube			x4					x2				
	Triple tube												
	4-tube assembly			x2					x1				
11/14mm	Single tube												
	Double tube			x2					x2	x2			
	Triple tube												
	4-tube assembly			x1						x1			
13/16mm	Single tube												
	Double tube												
	Triple tube			x1						x1			
	4-tube assembly												
15/18mm	Single tube												
	Double tube								x1(*)	x1			
	Triple tube			x1									
	Quadruple tube												
16/20mm	Single tube												
	Double tube				x2						x2	x2	
	Triple tube												
	Quadruple tube				x1								
21/25mm	Single tube					x5					x2	x2	x4
	Double tube										x1	x1	x2
	Triple tube												
	Quadruple tube												
27/32mm	Single tube												x2
	Double tube												x1
	Triple tube					x1							
	Quadruple tube												

Double tube: 2-tube assembly
Triple tube: 3 separate tubes packaged together on the same reel
Quadruple tube: 4 separate tubes packaged together on the same reel
(*) If occupancy ≤15%